Performance and Analysis of Masonry Infill in R.C. Frame Structure

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Abstract - *Masonry infill are used to fill the spans between the vertical and horizontal resisting elements of building frames, presuming that these infill will not take part in resisting any kind of load either axial or lateral. In contrary, an infill wall considerably enhances the rigidity and strength of the frame structure. It has been observed through various assessments, that the frame considering no infill has comparatively lesser stiffness and strength than the infill frame and therefore their ignorance cause failure in many multi-storey buildings when subjected to seismic loads that acts out of plane. Masonry materials are considered brittle in nature thus usually referred to be as non-structural element, they contribute to increase in stiffness and rigidity and attract vulnerability to lateral and seismic loadings. Also there is loss of ductility. To observe the effect of masonry infill panel, it is modeled as an equivalent diagonal strut for G+7 and G+12 buildings using ETABS. In present study the responses of infill materials mentioned are to be compared with the storey shear, storey drift, displacements and lateral force for bare frame RC frame; to conclude the work. Cost implications are discussed.*

***Key Words*: Bricks, AAC blocks, Solid cement blocks, Equivalent Diagonal Struts ETABS.**

1. INTRODUCTION

Less- ductile RC frames with Infill is not a rare sight nowadays. Masonry infills are widely used to fill in the voids in Reinforced Concrete Frames. It is presumed that masonry infill is non-structural member of a structure due to brittleness in nature. Hence its consideration while analysis of frame is neglected. In fact, the masonry infill between horizontal and vertical members of frame helps to provide rigidity to the structure. The infills are merely considered as architectural component or just a partition but in fact there is utter need to advance in the analysis and performance check for the infill used.

1.1 Parametric Study

The increase in rigidity and stiffness lead to vulnerability in out plane loadings like lateral loads and seismic loads. Thus it becomes important to consider the loads other than only wind and gravity loads, the seismic events act in 3 Dimensions to all members of structure leaving the infill the weakest component. Thus equivalent diagonal strut approach is adapted to estimate the stiffness provided to the whole structure. The change in results will be seen with change in the material used in filling the voids between beams and columns. Traditional clay bricks , aerated blocks and solid cement bricks are to be checked for. Further the plan is to check for efficiency in stresses and cost. The base shear , storey drifts , storey displacements and lateral loadings are to be compared for each model of G+7 and g+12 and compiled at the end of work.

2. METHODOLOGY

2.1 Model

Polyakov (1960)[6] experimented tests on masonry infilled frames, first proposing that the infill system works as a braced frame, with the wall forming compression struts. Thus enables truss-action. Stafford-Smith (1962)[2] and Mainstone (1971)[3], among others, proposed methods for calculating the effective width of the diagonal strut, supported by test results from mortar panels and infilled frames, respectively. Stafford-Smith and Carter (1969) [7]worked out on analytical techniques to estimate the effective width of the strut, and cracking and crushing loads, as a function of the contact length between frame and wall elements. Other scientists have developed a finite element method to guide the widths of equivalent diagonal struts for infills.

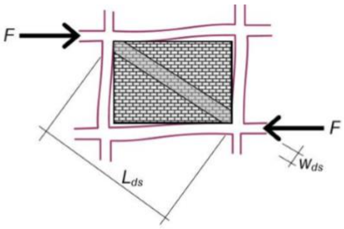


Fig-2.1: Equivalent diagonal strut dimensioning

As per sixth revision of IS 1893(part 1)-2002 draft codes states that the unreinforced masonry infill wall shall be modelled by using equivalent diagonal strut. The diagonals have pinned connection replacing the wall sections. Provide Modulus of elasticity as per Cl.7.9 Thickness of strut may equal the thickness of the wall provided.(sixth revision IS 1893 2002 Cl.7.9.2.2)
Equivalent diagonal strut dimensioning,
Where F = Forces applied, Lds = Length of diagonal, Wds = Width of diagonal
The width is proposed to be taken as one-third of the diagonal length i.e length of strut, which is same as proposed by experimental results of Holmes in 1963[8]. For masonry with openings width Wdo of equivalent diagonal strut shall be taken as Wdo= ρw Wds . Presently we have considered fully infilled frames for this study.

2.2 Analysis

Response Spectrum Method using Etabs: The seismic analysis for all models buildings are carried out by response spectrum method by using IS: 1893(part-I) – 2002. The other parameters used in seismic analysis are, seismic zone (III), zone factor 0.16, importance factor 1 and response reduction factor 5.0, the building frame system is special RC moment-resisting frame (SMRF) frame for all configurations and height of buildings. Time period is ($t=0.075h^{0.75}$) & ($t=0.09h/\sqrt{d}$).

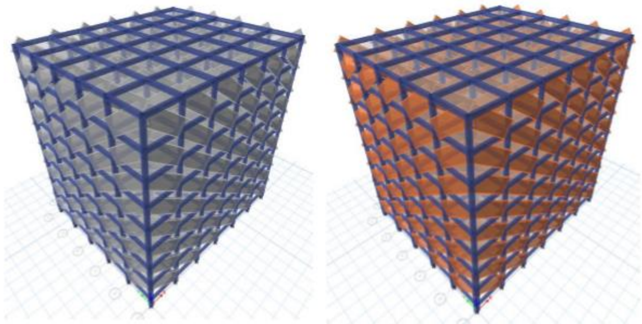


Fig-2.2: (a)AAC infill 3d (b)Brick infill 3d

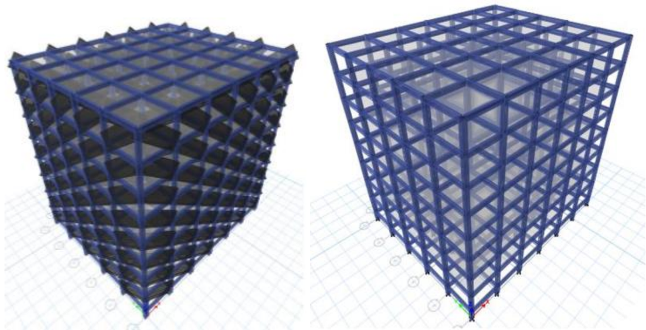


Fig-2.2: (c)Solid Block Infill (d)Bare Frame

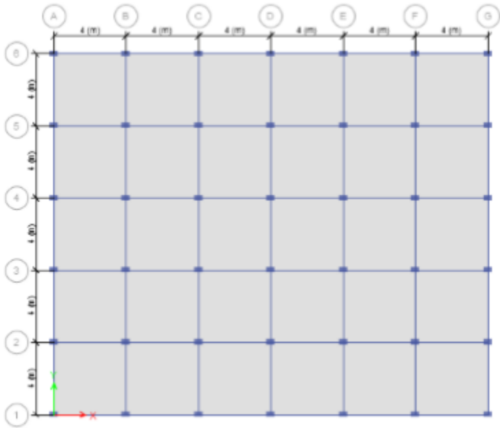


Fig-2.2(e): Plan

Table -1: Input Data

Length x Width	24x20(6 x 5 bays)
Storey Height	3m
No. of stories	G+7 and G+12
Slab	120mm
External wall	230mm
Internal wall	115mm
DL on all storeys	1.5kN/m2
Water proofing	0.8kN/m2
LL on all storeys except roof	3kN/m2
LL on roof	2kN/m2
Beam Dimensions	230x450mm
Grade of Concrete Beam	M25
Grade of Concrete Slab	M20
Grade of Concrete Column	M30
Elasticity modulus of bricks	858Mpa
Elasticity modulus of AAC	2040Mpa
Elasticity modulus of solid blocks	5000Mpa
Compressive strength of bricks	4N/mm2
Compressive strength of Solid blocks	5N/mm2
Compressive strength of AAC blocks	5N/mm2

2.3 Seismic Responses

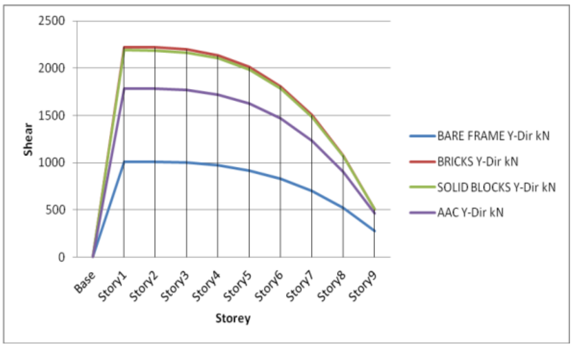


Fig2.3(a) : Storey shears G+7

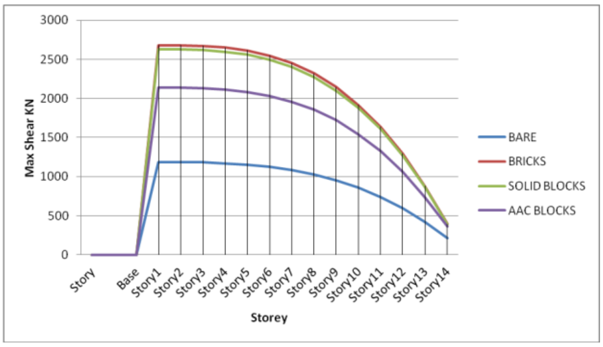


Fig 2.3(b) : Storey shears G+12

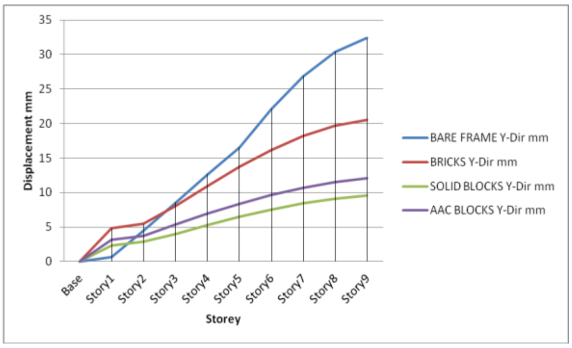


Fig 2.4(a) Displacements G+7

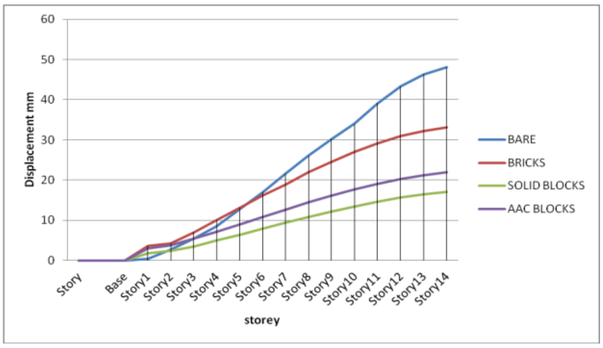


Fig 2.4(b) Displacements G+12

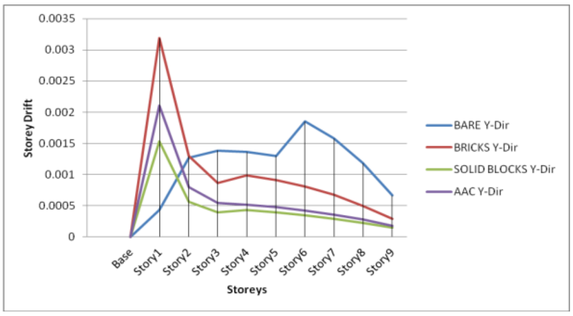


Fig 2.5(a) Drifts G+7

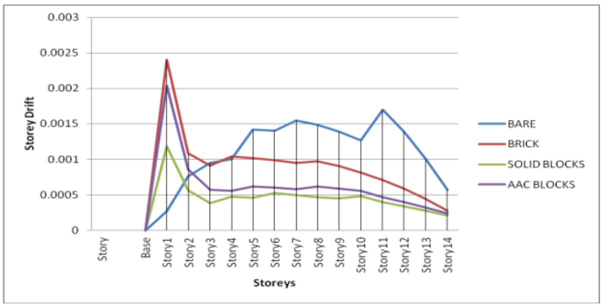


Fig 2.5(b) Drifts G+12

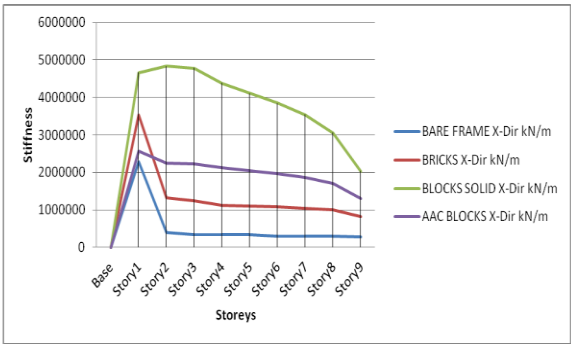


Fig 2.6(a) Stiffness G+7

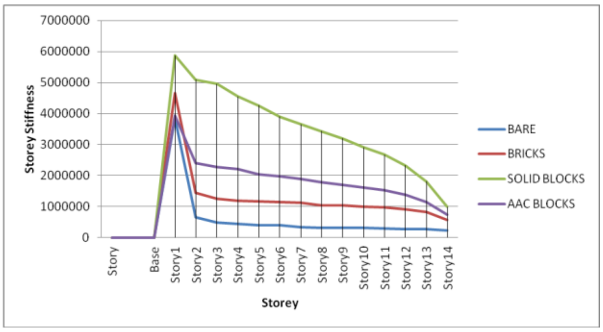
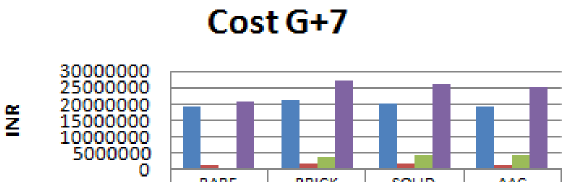
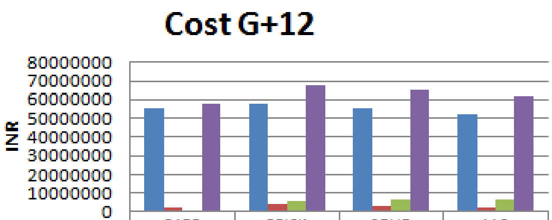


Fig 2.6(b) Stiffness G+12



	BARE FRAME	BRICK FRAME	SOLID BLOCKS	AAC BLOCKS
COST OF FRAME	19334735	21190688	20006200	19168304
COST OF FOOTING	1318140	2081983	1990897	1570409
COST OF MASONRY	0	4022709	4207255	4466498
TOTAL COST	20652875	27295380	26204352	25205211

Fig 2.7(a) Cost Summary G+7



	BARE FRAME	BRICK FRAME	SOLID BLOCKS	AAC BLOCKS
COST OF FRAME	55579108	57680818	55083834	52185718
COST FOOTING	2300588	3665036	3479680	2686799
COST OF MASONRY	0	6034063	6310883	6699748
TOTAL COST	57879696	67379917	64874397	61572265

Fig 2.7(b) Cost Summary G+12

3. CONCLUSIONS

1. The weight of structure is less, the smaller the base shear is experienced. The base shear is larger for bricks infill and least for bare frame structure. We can use ACC blocks to gain lightweight structures.

2. Displacement is better controlled with presence of infill. The solid concrete blocks act most efficiently to reduce the displacement than in case of brick infill or bare frame due to increase in mass and stiffness.

3. The drifts are maximum for the bottom most storey of a structure for all infilled frames. The drifts for bare frame is low initially and increases eventually to a value greater than that of infilled structure as we go higher. Solid blocks give the best performance to reduce the drift values.

4. Stiffness of the structure depend on the elasticity modulus of the infill. The stiffer the building the greater will be base shear, the presence of infills increase the stiffness of frame. The solid blocks increase stiffness so high that the ductility of frame is lost. Thus for a balanced structure with ductile design we need to provide AAC blocks to enhance the performance.

5. The lateral loads are minimum at the base but as we go up with the height we see that lateral loads increase and the lateral load is directly proportional to the base shear , the greater the shear the higher is lateral load. Decrease upto 19-23% by use of AAC blocks.

6. Though the cost of solid and AAC block infill is higher by 0.7% and 1.7% compared to brick infill respectively for G+7 building, the reduction in base reaction of the whole structure is achieved and that could help to save total structure cost of 4 % by using solid blocks and 7.66 % by using AAC.
The cost of upgrading from brick to solid blocks and AAC blocks are 0.46% and 1.12% respectively for G+12 storey structure, whereas the saving achieved in structural cost due to lightweight infill and better performance comes around 3.72 % and 8.62 % respectively.

7. The truss action is enabled for frame structure and thus the load transmission has become lenient. This helps us to reduce the size of column and beams and thus optimizing the structure.
Thus better resistance to lateral loadings and seismic events can be achieved with use of AAC block modeled as equivalent diagonal struts over traditional bricks or bare frame structure and also reflects significant economy as we advance with high rise constructions.

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REFERENCES

[1] Diptesh Das , C V R Murty "Brick Masonry Infills in seismic design of RC building", Indian Concrete Journal, ISSN 0019-4565, 2004
[2] Stafford Smith, B., Lateral Stiffness of Infilled Frames, Proc. A.S.C.E., Vol. 88, No. S.T.6., pp. 183-99, 1962

[3] Mainstone, R. J., On the stiffness and strengths of infilled frames, Proceedings, Institution of Civil Engineers, Supplement IV, 57–90,1971
[4] Dayaratnam, P., Brick and Reinforced Brick Structures, Oxford and IBH, New Delhi, 1987
[5] Meharbi, A. B., and Shing, P. B.,Seismic analysis of masonry infilled reinforced concrete frames, Masonry Soc. J. 21, 81–94,2003
[6] Polyakov, S. V., 1956. Masonry in Framed Buildings (An investigation into the strength and stiffness of masonry infilling)., National Lending Library for Science and Technology, Boston, Yorkshire, England, 1963
[7] Smith, B. S., and Carter, C., A method of analysis for infilled frames, Proceedings of the Institute of Civil Engineers 44, Paper No. 7218, 31–48,1969
[8] Holmes, M., Steel frames with brickwork and concrete infilling, Proceedings of the Institution of Civil Engineers 19, 473–478 (eISSN 1753-7789), 1961.
[9] Abolghasem Saneinejad and Brian Hobbs "Inelastic design of infilled frames" Journal of Structural Engineering, Vol. 121, No.4, ASCE, 1995
[10] Kaushik, H. B., Rai, D. C., and Jain, S. K., Code approaches to seismic design of masonry-infilled reinforced concrete frames: A state-of-the-art review, Earthquake Spectra 22, 961–983, 2006
[11] IS:1893 (Part 1), (2007), Indian Standard Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi
[12] IS:456, (2000), Indian Standard Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards, New Delhi
[13] IS:13920, (1993), Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces, Bureau of Indian Standards, New Delhi
[14] IS 1077 (1992)_ Common Burnt Clay Building Bricks –Specification
[15] IS 1905 (1987)_ Code of Practice for Structural use of Unreinforced Masonry
[16] IS 2185-2 (1983)_ concrete masonry units, Part 2_ Hollow and solid light weight concrete blocks
[17] IS 2185-3 (1984)_ concrete masonry units, Part 3_ Autoclaved cellular Aerated concrete blocks
[18] IS 2250 (1981)_ Code of Practice for Preparation and Use of Masonry Mortars
[19] ASTM C 1314-00a, Standard test method for compressive strength of masonry prisms. In Masonry Test Methods and Specifications for the Building Industry, American Society for Testing and Materials (ASTM), Pennsylvania, 2001, 4th edn
[20] EN 1996-1-1_ Eurocode 6_ Design of masonry structures - Part 1-1_ General rules for reinforced and unreinforced masonry structures
[21] BIS sixth edition 1893 2002 CED 39(7975)WC

BIOGRAPHIES

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