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Analysis of Masonry Infilled R.C.Frame with & without Opening Including Soft Storey by using "Equivalent Diagonal Strut Method"

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Abstract- Infilled frame structures are commonly used in buildings. Masonry infilled RC frames are the most common type of structures used for multi-storeyed constructions in the developing countries, even in those which are located in seismically active regions also**.** Masonry infill walls are mainly used to increase initial stiffness and strength of reinforced concrete (RC) frame buildings. In the present study, it is attempt to highlights the performance of masonry infilled reinforced concrete (RC) frames including open first storey of with and without opening. This opening is express in terms of various percentages here, in this paper, symmetrical frame of college building (G+5) located in seismic zone-III is considered by modelling of initial frame.According to FEMA-273, & ATC-40 which contain the provisions of calculation of stiffness of infilled frames by modelling infill as"Equivalent diagonal strut method". This analysis is to be carried out on the models such as bare frame, strut frame, strut frame with 15% centre &corner opening, which is performed by using computer software STAAD-Pro from which different parameters are computed. In which it shows that infill panels increase the stiffness of the structure.

Index Terms- Masonry infilled frame, Stiffness, Equivalent Diagonal Strut Method, RC Frame, Opening percentage.

I. Introduction

The behaviour of masonry in filled frame structures has been studied in the last four decades in attempts to develop a rational approach for design of such frames. Present code of practice does not include provision of taking into consideration the effect of infill. It can be understood that if the effect of infill is taken into account in the analysis and design of frame, the resulting structures may be significantly different. Again when a sudden change in stiffness takes place along the building height,the storey at which this drastic change of stiffness occurs is called a soft storey. Many urban multistorey buildings in India today have open first storey as an unavoidable feature. This leave the open first storey of masonry infilled reinforced concrete frame building primarily to generate parking or reception lobbies in the first stories. It has been known for long time that masonry infill walls affect the strength & stiffness of infilled frame structures. There are plenty of researches done so far for infilled frames, however partially infill frames are still the topic of interest.Though it has been understood that the infill's play significant role in enhancing the lateral stiffness of complete structures. Infills have been generally considered as non-structural elements, although there are codes such as the Eurocode-8 that include rather detailed procedures for designing infilled R/C frames, presence of infills has been ignored in most of the current seismic codes except their weight. However, even though they are considered non-structural elements & their influence was neglected during the modelling phase of the structure leading to substantial inaccuracy in predicting the actual seismic response of framed structures. The performance of the structure can be significantly improved by the increase of strength and dissipation capacity due to the masonry infill's even if in presence of an increasing in earthquake inertia forces. the presence of infills in the reinforced concrete frames can substantially change the seismic response of buildings in certain cases producing undesirable effects like torsional effects, dangerous collapse mechanisms, soft storey etc. or other favourable effects of increasing the seismic resistance capacity of the building.As per Indian standard 1893 (part –I) 2002 code (BIS-2002) some design criteria are to be adopted after carrying out the earthquake analysis ,in which the columns and beams of the soft stories are the designed for 2.5 times the storey shears and moments calculated under seismic loads. The infill components increase the lateral stiffness and serve as a transfer medium of horizontal inertia forces. From this conception the floors that have no infill component has less stiffness regarding other floors. This paper discusses top and bottom moment for a 5 storey RC college building designed for load cases considering the three revisions of IS: 1893-2002,IS: 456-2000 & IS13920-1993 codes.

II. Analytical Method

Static or dynamic analysis can be classified into three broad categories, namely elastic analysis, plastic analysis and nonlinear analysis. Elastic analysis refers to the analysis where a linear elastic behaviour is assumed for the frame and the infill, and geometric and material nonlinearities are not included. In the case of a plastic analysis, an elastic-plastic stress-strain relationship is assumed for the materials, and the failure load of the infilled frame corresponding to collapse stage is determined.In the nonlinear analysis, the different sources of nonlinearity are included, and the response of the structure is traced in the entire loading range, from precracking to collapse. For most applications, codes of practice recommend an elastic analysis, because of the inherent complexity of a nonlinear analysis. The different models available for the elastic analysis of infilled frames can be classified into four groups based on their complexity. They are the stress function method, the equivalent diagonal strut method, the equivalent frame method and the finite element method.

III. Equivalent Diagonal Strut Methods

Type of structure	COLLEGE BUILDING (G+5)
ZONE	III
FOUNDATION LEVEL TO GROUND LEVEL	1 M
FLOOR TO FLOOR HEIGHT	4M
EXTERNAL WALL	230 MM
INTERNAL WALL	230 MM
LIVE LOAD	5 KN/M^2
MATERIAL	M20 AND Fe415
SEISMIC ANALYSIS	EQUIVALENT STATIC METHOD (IS 1893 (Part I) - 2002)
SIZE OF COLUMN	C1= 300X700 C2= 400X750
SIZE OF BEAM	B1=300X500 B2=300X400
DEPTH OF SLAB	140 MM
DESIGN PHILOSOPHY	LIMIT STATE METHOD CONFORMING (IS 456-2000)
DUCTILE DETAILING CODE	**IS 13920-1993**

The simplest equivalent strut model includes a single pin-jointed strut. Holmes who replaced the infill by an equivalent pin-jointed diagonal strut made of the same material and having the same thickness as the infill panel suggest a width defined by,

$\frac{w}{d} = \frac{1}{3}$ ……………. (3.3.1)

Paulay and Priestley [32] suggested the width of equivalent strut as,

$w = 0.25d$ ……………. (3.3.2)

Where,

d = Diagonal length of infill panel
w = Depth of diagonal strut

However, researchers later found that this model overestimates the actual stiffness of infilled frames and give upper bound values. Another model for masonry infill panels was proposed by Mainstone in 1971 where the cross sectional area of strut was calculated by considering the sectional properties of the adjoining columns. The details of model are as shown in Fig. 4.2. The strut area *as* was given by the following equation..

$A_e = W\,t$

$$W = 0.175\,(\lambda H)^{-0.4}\,D$$

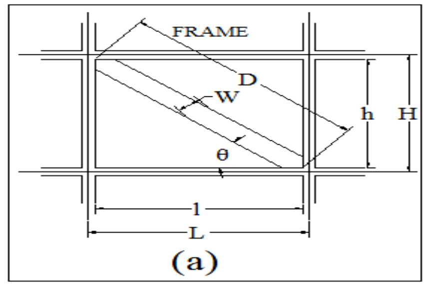


Fig.1 Brick Infill Panel as Equivalent Diagonal Strut

$$\lambda = \sqrt[4]{\frac{E_i\, t\, \sin(2\theta)}{4\, E_f\, I_c\, h}}$$

Where,

E_i = the modules of elasticity of the infill material, N/mm^2
E_f = the modules of elasticity of the frame material, N/mm^2
I_c = the moment of inertia of column, mm^4
t = the thickness of infill, mm
H =the centre line height of frames
h = the height of infill
L =the centre line width of frames
l = the width of infill
D = the diagonal length of infill panel
θ = the slope of infill diagonal to the horizontal.

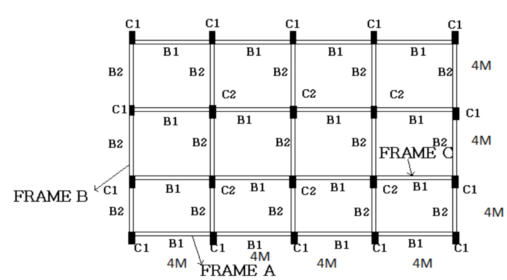
Infills frame with Opening: Area of opening, A_{op} is normalized with respect to area of infill panel, A_{infill} and the ratio is termed as opening percentage (%).

$$\text{Opening percentage (\%)} = \frac{\text{Area of openning } (A_{op})}{\text{Area of infill} (A_{infill})}$$

IV. Analysis Example

STRUCTURAL DETAIL

Symmetrical View of Building



SYMMETRIC
PLAN

The above mentioned frame has been designed by using STAAD-Pro software. For getting results some column has been selected for getting results and they are as column no.1,2the results shown in the form of

- DEFLECTION
- AXIAL FORCE
- MOMENT
- AST

V. Analytical Models Considered

1) Model I. Bare Frame (RC frame with infill Masonry,but effect of masonry infill not considered)

2) Model II. Open Ground Storey of Complete Strut Frame.

3) Model III. Open Ground Storey of Strut Frame With 15% Centre Opening (RC Frame with Masonry Infill S.M.R.F. Frame)

4) Model IV. Open Ground Storey of Strut Frame With 15% Corner Opening (RC Frame with Masonry Infill S.M.R.F. Frame)

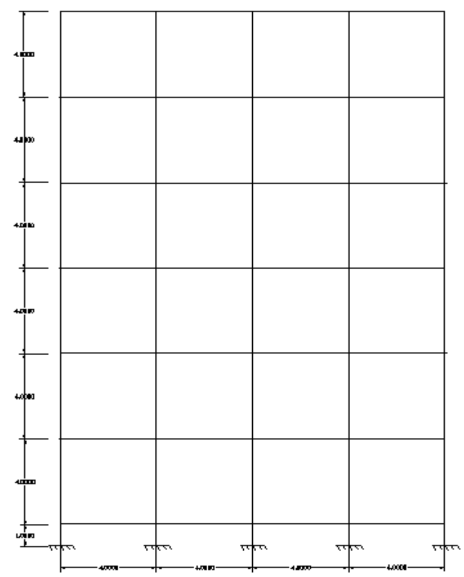


Fig6.1; MODEL I: BARE FRAME

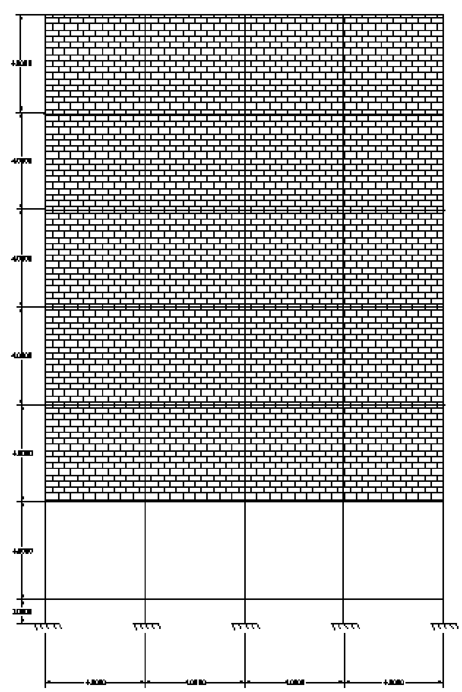


Fig6.2;MODEL II: WITH FULLY INFILLED FRAME

VI. Materials

a) Concrete:

Concrete with following properties is considered for study.

- Characteristic compressive strength (fck) = 20 MPa
- Poissons Ratio = 0.3
- Density = 25 kN/m^3
- Modulus of Elasticity (E) = 5000 x √ fck = 22360.67 MPa

b)Steel:

Steel with following properties is considered for study.

- Yield Stress (fy) = 415 MPa
- Modulus of Elasticity (E) = $2x10^5$MPa

c)Masonry infill

- Clay burnt brick, Class A, confined unreinforced masonry
- Compressive strength of Brick, fm = 10 MPa
- Modulus of Elasticity of masonry (Ei) = 550 x fm = 5500MPa
- Poissons Ratio = 0.15

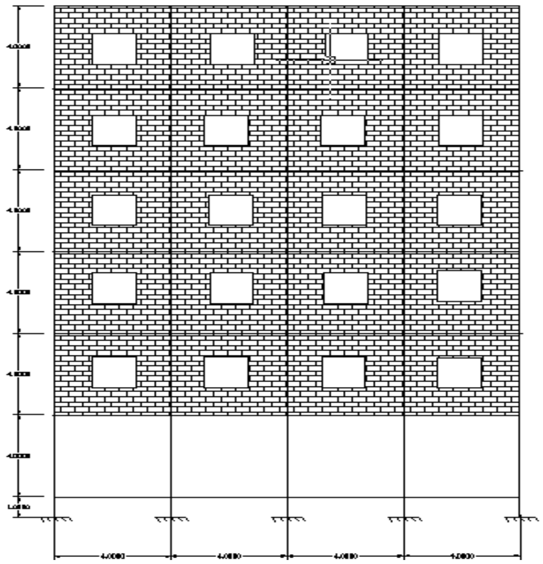


Fig6.3; MODEL III:INFILLED FRAME WITH CENTREOPENING

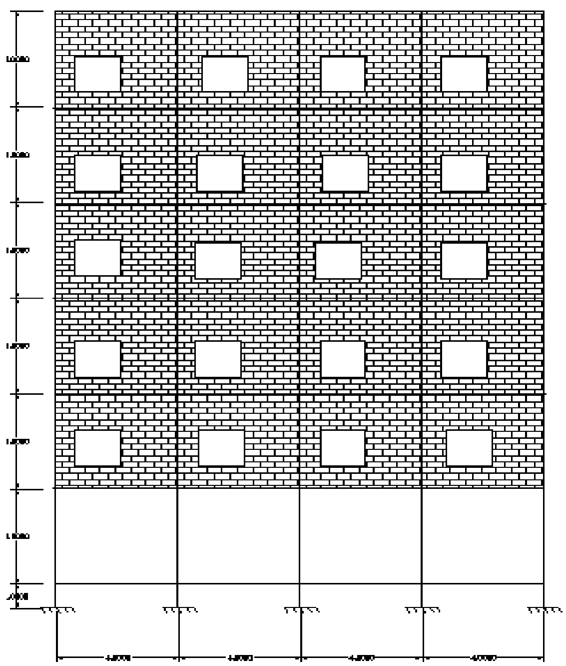


Fig6.4; MODEL IV: INFILLED FRAME WITH CORNER OPENING

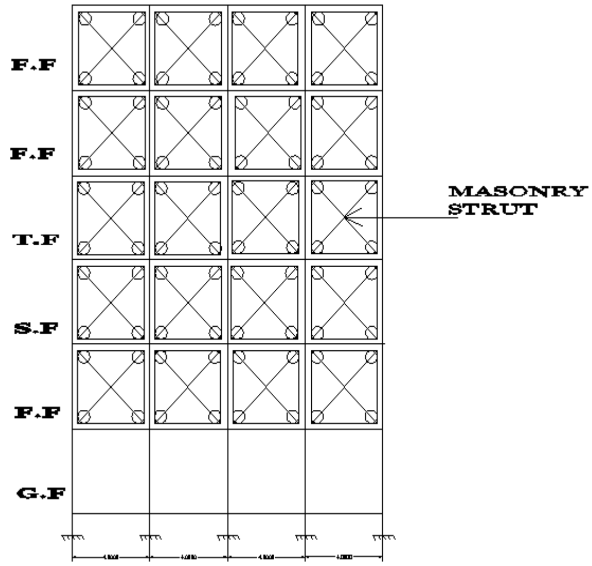


Fig6.5; EXAMPLE OF STRUT FRAME MODEL

VII. COMPARISON OF RESULTS

Here, Comparison is done in between bare frame and centre and corner opening only**.** And it is shown with the help of graph.

GRAPH FOR STRUT FRAME WITH 15% CENTRE AND CORNER OPENING COLUMN-1(300X700)

On X-Axis there is a different parameter of Deflection, Moment, Axial Force;Area of steel and on Y-Axis Height of building is fixed in all cases.

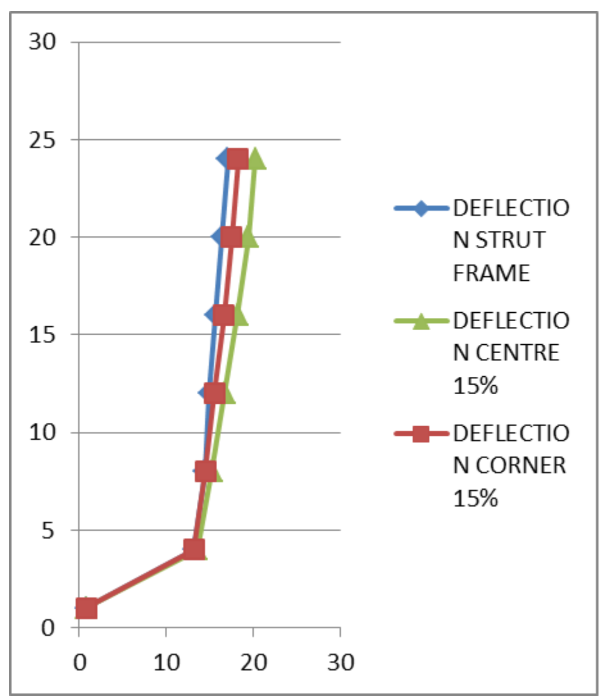


Fig7.1: Deflection in (mm) for column No.1

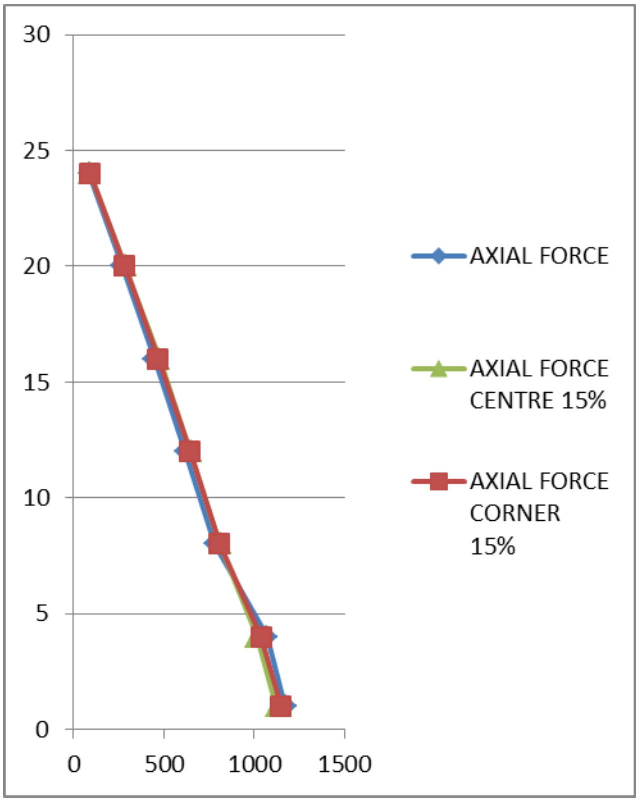


Fig 7.2:Axial Force in (kN) for column No. 1

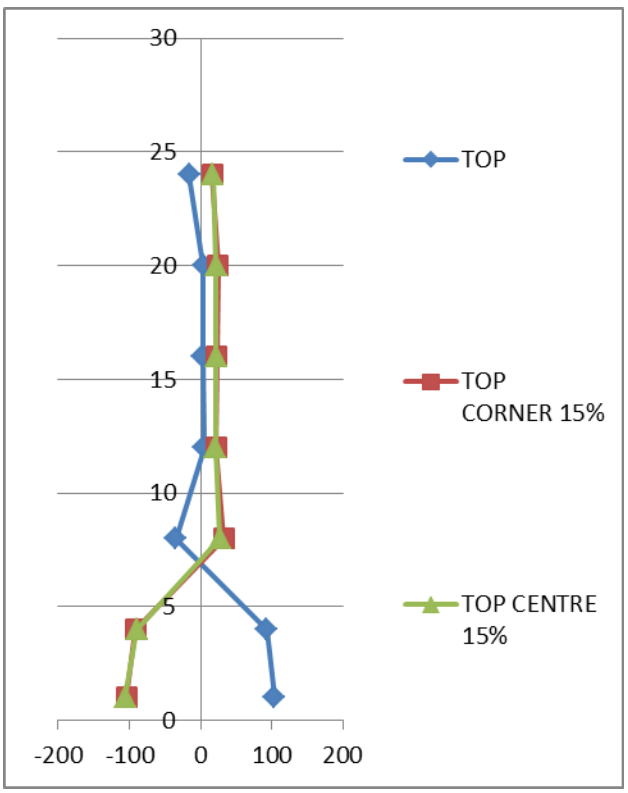


Fig7.3: B.M (Top) in (kN-M) for column No.1

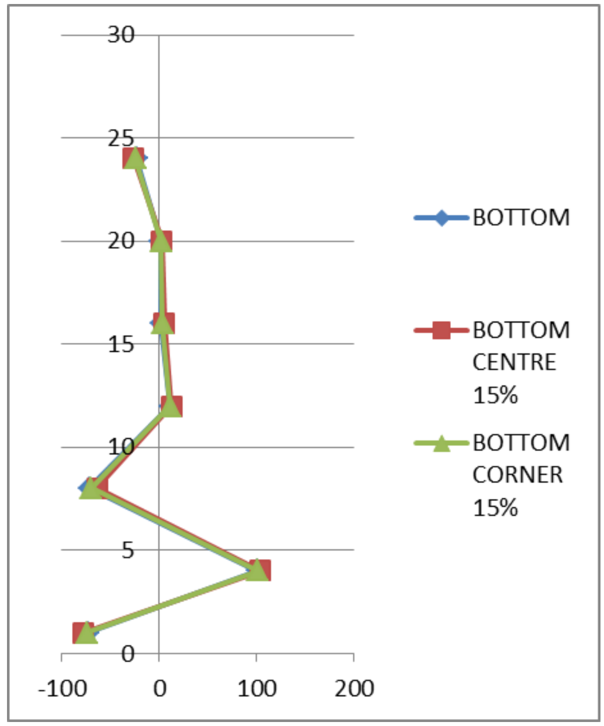


Fig7.4:B.M (Bottom) in (kN-M) for column No.1

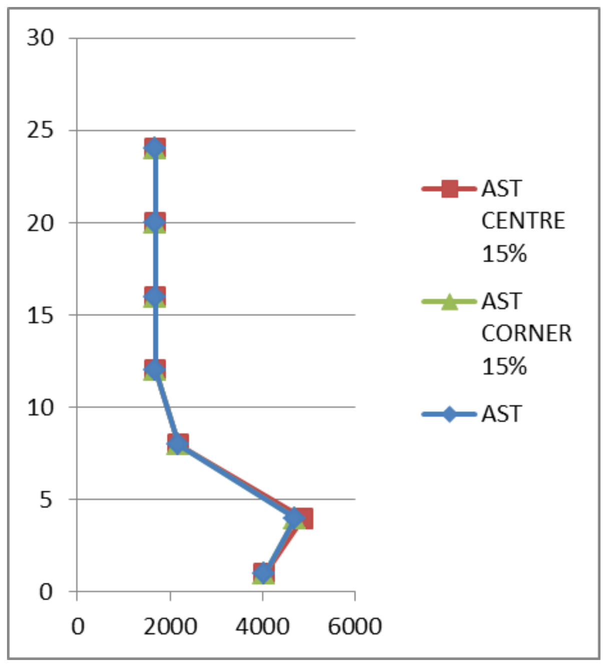


Fig7.5: Area of steel in (mm2) for column No.1

GRAPH FOR STRUT FRAME WITH 15% CENTRE AND CORNER OPENING COLUMN-2(300X700)

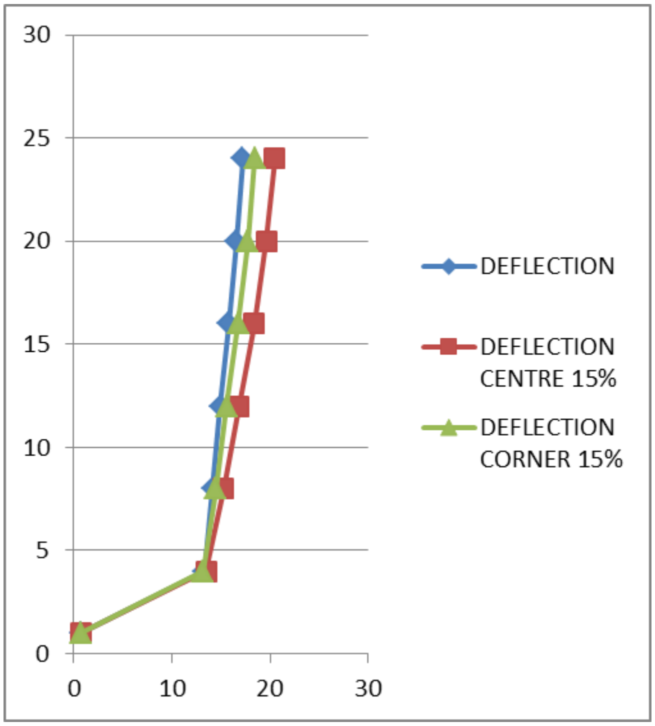


Fig7.6:Deflection in (mm) for column No.2

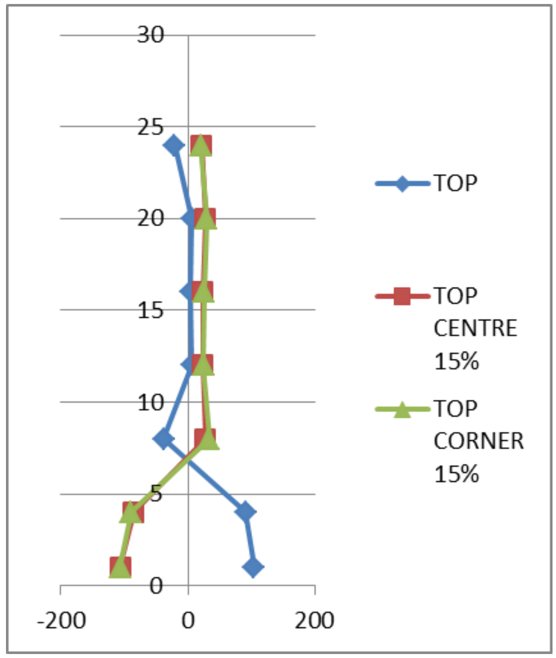


Fig 7.8:B.M (Top) in (kN-M) for column No. 2

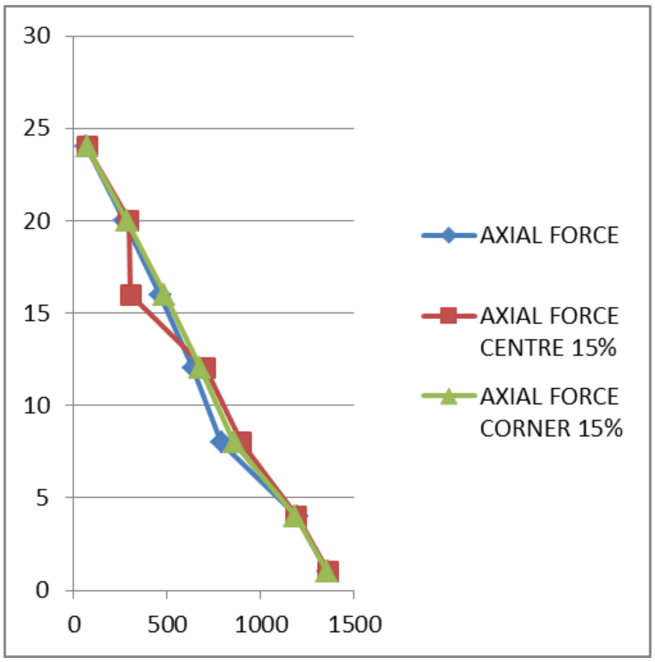


Fig7.7: Axial Force in (kN) for column No.2

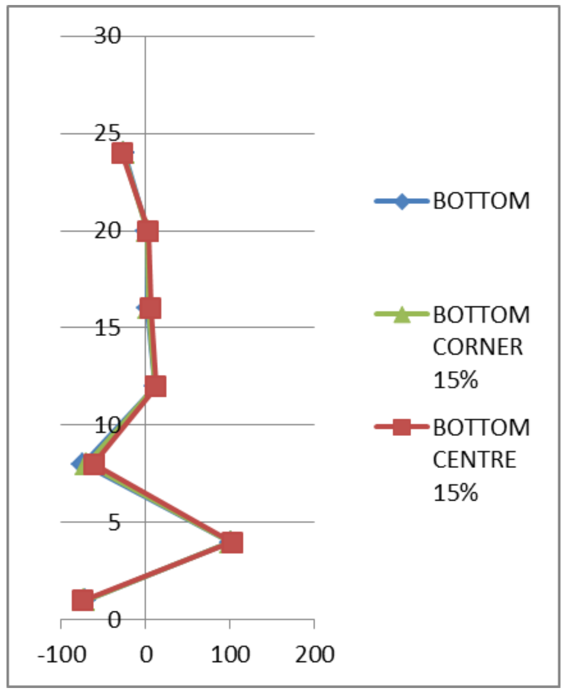


Fig 7.9: B.M (Bottom) in (kN-M) for columnNo.2

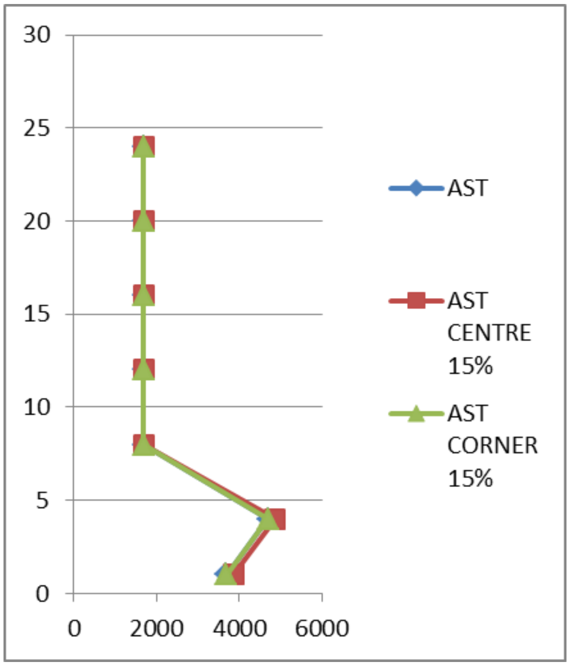


Fig 7.10: Area of steel in (mm2) for column No.2

VIII. CONCLUSION

1. Infill panels increase stiffness of the structure.
2. The Maximum Deflection in infilled frame for (G+5) with 15% centre opening is 21.05 mm and 18.44mm in 15% corner opening. Thus the deflection in centre opening is more than the corner opening.
3. Axial force in case of strut frame is 2159.40 KN and in Infilled Frame with 15% centre opening is2217.03kN.because of infill wall effect, there is drastic decrease in the value of axial force in column.
4. The Maximum Deflection in bare frame for (G+5) is 105.05 mm and infilled frame with 15% centre opening is 21.05mm. Thus the deflection in bare frame is more than the infilled frame.
5. The increase in the opening percentage leads to a decrease on the lateral stiffness of infilled frame.
6. From this present result it shows that, deflection is very large in case of bare frame as compare to that of infill frame with opening. If the effect of infill wall is considered then the deflection has reduced drastically. And also deflection is more at last storey because earthquake force acting on it more effectively.
7. In columns, without considering infill wall effects the value of, B.M and Ast are maximum above 1m height because of soft storey present.
8. Deflection in case of centre opening is large compare to corner opening.

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