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Analysis of Masonry Infilled Frame with &without Different Percentage of Opening

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Abstract- *In the analysis and design of building frames it is commonly assumed that the masonry infill which acts as a non structural elements do not contribute to their strength and stiffness. But as a matter of fact, behavior of the structure is affected by non structural elements in earthquake loads, thus a mathematical model is required to design structures. The deficiencies in current approach of modeling are more pronounced during dynamic response such as in the event of earthquake. Thus contribution of non structural elements needs to be accounted for realistically. The scope of the present study is limited to masonry in filled RC frames with and without opening. In this paper collage building (g+3) and (g+5) located in seismic zone III is considered by modeling of frame and infill. The infill panels are modeled as a diagonal struts and surrounding frames as a frame elements. Static analysis is carried out on the models such as bare frame, strut frame, strut frame with centre and corner opening and are performed by software Staad-Pro from which different parameters are computed.*

Keywords- *Infilled frame; Stiffness; Equivalent Diagonal Strut Method; Seismic Effect; Opening area*

I. INTRODUCTION

As it is known, in many countries situated in seismic regions, reinforce concrete (RC) frames are infilled by brick or concrete-block masonry walls. For decades now, these infill walls were not taken into account when designing the bearing structures. However, an extensive experimental and analytical investigation has been made. Recently, it has been shown that there is a strong interaction between the infill masonry wall and the surrounding frame leading to:
1. Considerable increase of the overall stiffness (and, in many cases, higher base shear force).
2. Increase of dissipated energy.
3. Redistribution of action-effects and, sometimes, unpredictable damages along the frame.
4. Considerable reduction of the probability of collapse, even in cases of defective infilled frames, when they are properly designed.

The main goal of this paper is to establish the relationships between the parameters of a wall opening (such as position and opening percentage), as well as the comparison of different percentage of opening of plane infilled frames under earthquake loads. For the analysis, a equivalent diagonal strut method has been used. The static analysis has been performed as per IS: 1893-2002.For that college building (G+3) and (G+5) is considered by modeling of frame and Infills. Modeling of infills is done as per actual size of openings say 15%, 20% and 25% for the various models such as bare frame, infill frame and infill frame with centre and corner opening. Also the comparison of opening percentage has been made. The analysis is carried out by software STAAD-PRO and different parameter has been computed.

II. OBJECTIVES

The primary objective of this work is to study the seismic response of RC frame building using the role of infill wall. The effect of earthquake forces on three and five storey building with and without the effect of brick infill with different percentage of opening for various parameters is proposed to be carried out with the help of static analysis. The various parameters are computed. The major objectives of the research work are as follows
1. To develop simple analytical guidelines which can be used by practicing engineers in the seismic design of infilled frames by taking infills into account.
2. To study the behavior of frame with brick masonry infill by modeling masonry infill as a diagonal strut.
3. To access the performance of RC frames with infill panels for which various building will be considered by modeling frame and infills.
4. To compute parameters of model with and without infill wall, with different % of opening with the help of structural analysis software STAAD-PRO.
5. To compare all analytical model with help of graph.

III. ANALYTICAL MODEL

Analytical Models Considered for (G+3) & (G+5)

Type of structure	**COLLEGE BUILDING (G+3)**
Zone	III
Foundation level to Ground level	0.9M
Floor to floor height	3.65m
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(no.1 to 7 & 10 to 16) 350x750 C2(no. 17 to 23) 380x450 C3(no. 8 & 9) 300x600
Size of beam	B1=230x500,b2=230x300, B3=230x800
Depth of slab	140 mm
Design philosophy	Limit state method conforming (is 456-2000)
Ductile detailing code	Is 13920-1993

IV. ANALYTICAL METHODS

Static and dynamic analysis can be used to design infilled frames subjected to a seismic loading. The static analysis involves the analysis of the frame for the equivalent static loads arising from seismic activity, while the dynamic analysis requires analysis in the time domain. It is widely accepted, by current codes of practice, that the equivalent static analysis will be sufficient for the seismic design of general multi storey structures. This is because the dynamic analysis, though accurate, is quite complex in nature and requires considerable skill, effort, and judgment. Accounting for the infills in the analysis and design requires the determination of the loads of the total composite system and the analysis of the entire infilled frame. Such an approach requires the knowledge of the various models. The different analytical methods available for the analysis of infilled frames are presented in the following section. Static or dynamic analysis can be classified into three broad categories, namely elastic analysis, plastic analysis and nonlinear analysis.

V. EQUIVALENT DIAGONAL STRUT METHODS

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,

$$W/d=1/3 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

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

$$w=0.25d \quad \ldots\ldots\ldots\ldots\ldots (2)$$

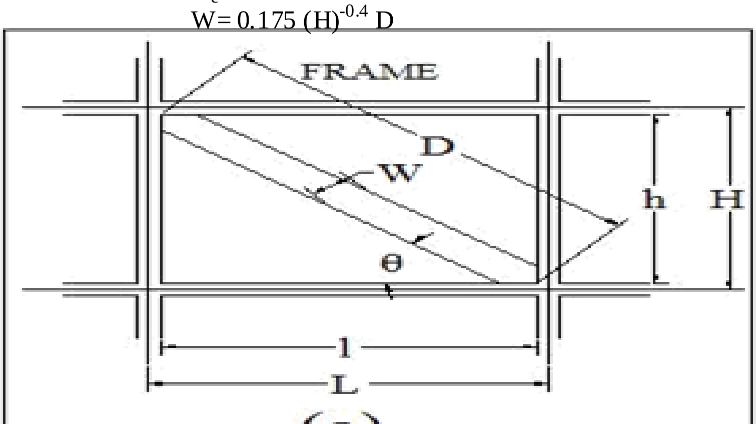
Where,

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 Main stone 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 A_s was given by the following equation.

$$A_e = W\,t$$

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



(a)

"Figure.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,
Ei = the modules of elasticity of the infill material, N/mm2
Ef= the modules of elasticity of the frame material, N/mm2
Ic= the moment of inertia of column, mm4 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 (Aop) is normalized with respect to area of infill panel, an infill and the ratio is termed as opening percentage (%).

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

VI. ANALYTICAL MODELS CONSIDERED

1. Model I. Bare Frame (RC frame with infill masonry, but effect of masonry infill not considered)
2. Model II. Fully Infilled frame.
3. Model III. Infilled framed with 15% centre opening.
4. Model IV. Infilled framed with 15% corner opening.
5. Model III. Infilled framed with 20% centre opening.
6. Model IV. Infilled framed with 20% corner opening.
7. Model III. Infilled framed with 25% centre opening.
8. Model IV. Infilled framed with 25% corner opening.

VII. MATERIALS

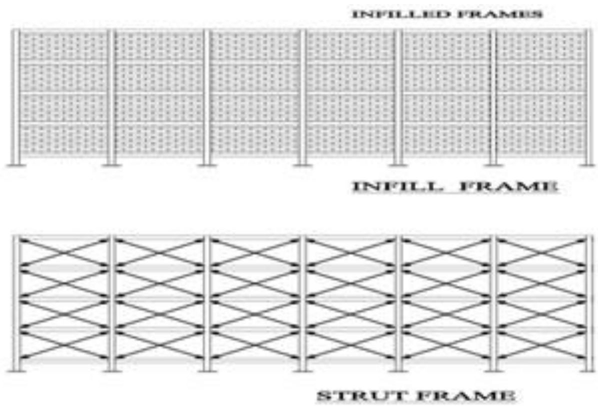
a) Concrete:
1. Concrete with following properties is considered for study.
2. Characteristic compressive strength (fck) = 20 MPa
3. Poisson Ratio = 0.3
4. Density = 25 KN/m^3
5. Modulus of Elasticity (E) = 5000 x √ fck = 22360.67 MPa

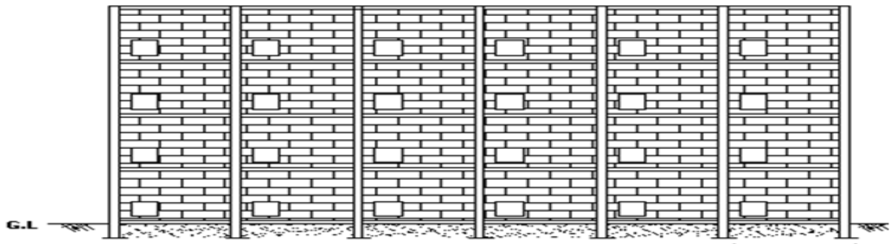
b) Steel:
Steel with following properties is considered for study.
1. Yield Stress (fy) = 415 MPa
2. Modulus of Elasticity (E) = $2x10^5$ MPa

c) Masonry infill
1. Clay burnt brick, Class A, confined unreinforced masonry
2. Compressive strength of Brick, fm = 10 MPa
3. Modulus of Elasticity of masonry (Ei)=550 x fm = 5500MPa
4. Poisson Ratio = 0.15

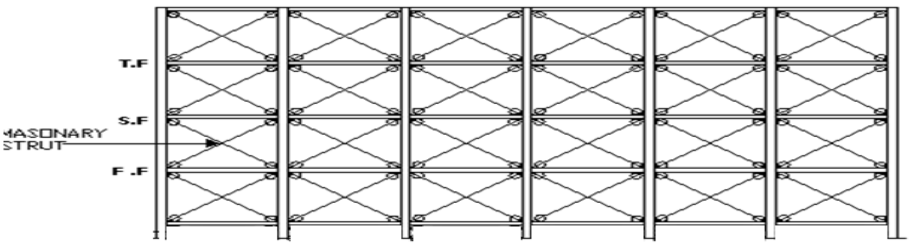
VIII. PLAN AND ELEVATION

In below plan and elevation of G+3 model as well as model of infill frame with centre and corner opening with strut frame also shown here

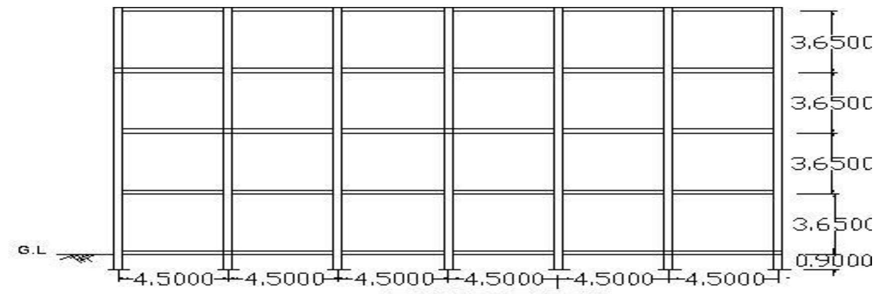




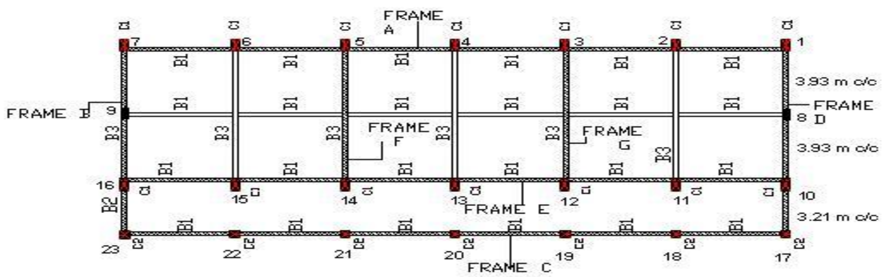
MODEL OF INFILLED FRAME WITH CORNER OPENING



STRUT FRAME



ELEVATION

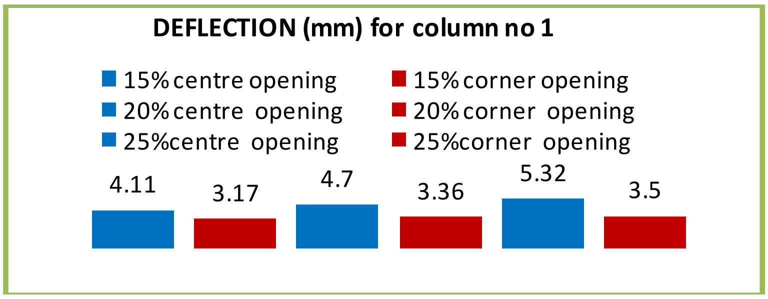


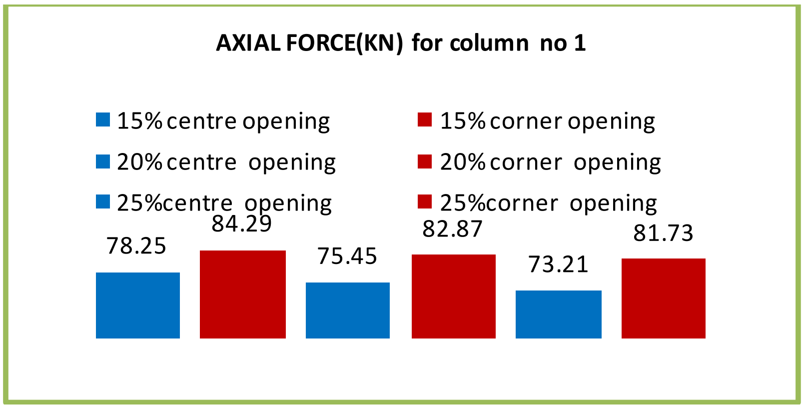
PLAN

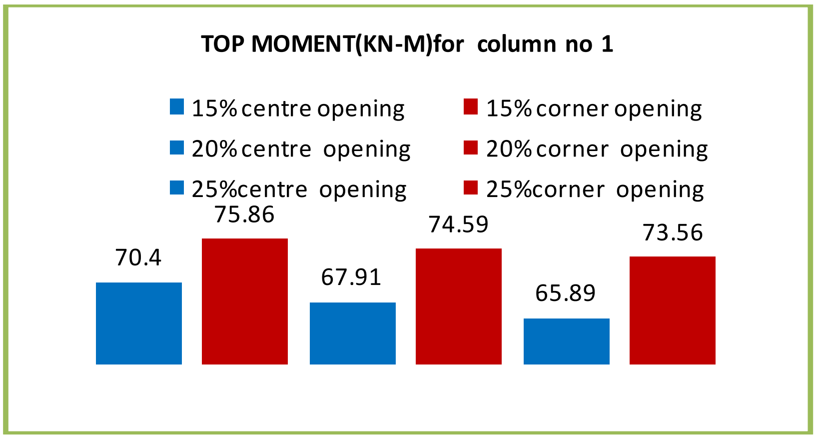
IX. RESULT

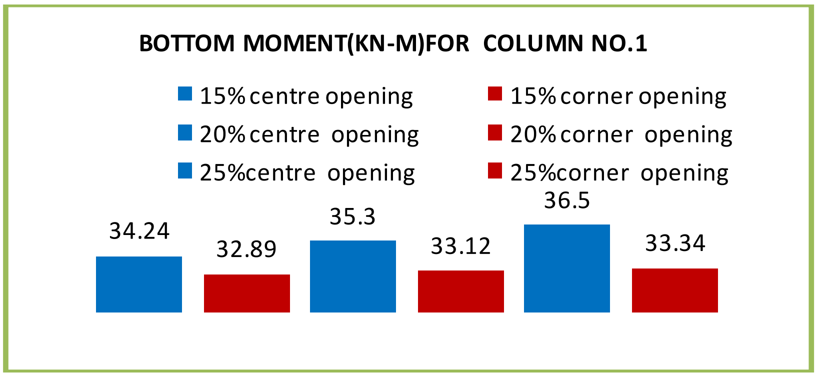
In the case study I, 4 models are prepared out of which three models are with infill wall and 1 model without infill walls. All models are analyzed with the help of structural analysis software STAAD-Pro. In (G+3) and (G+5) model Column no.1 is considered which is at right side of corner and the wall connecting column no.1 is without effect of infill and thus obtained the variation in parameters such as Deflection, Shear force & Moment for all models and comparison of different opening percentage is carried out with the help of bar graph.

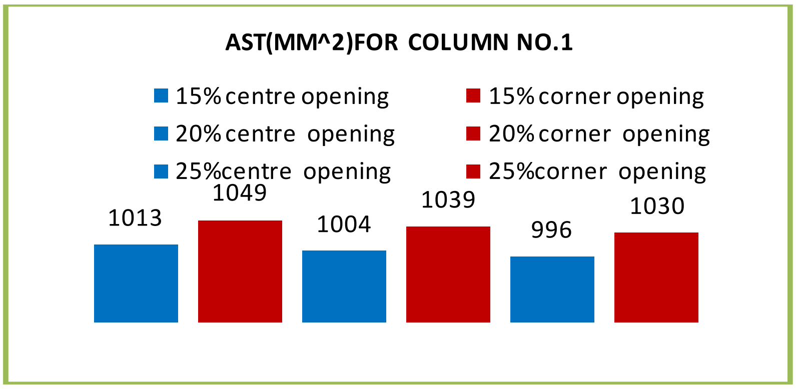
Result for G+3



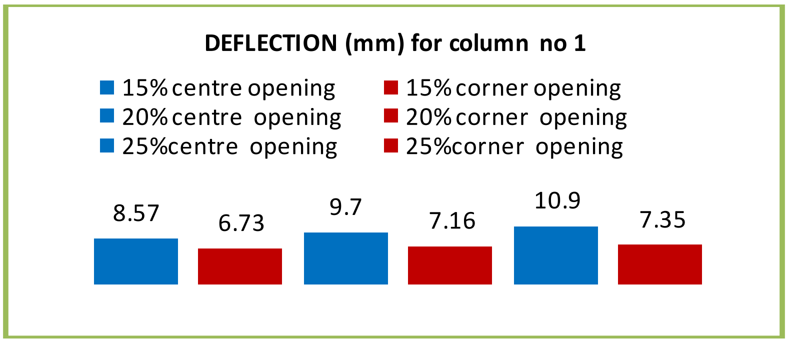


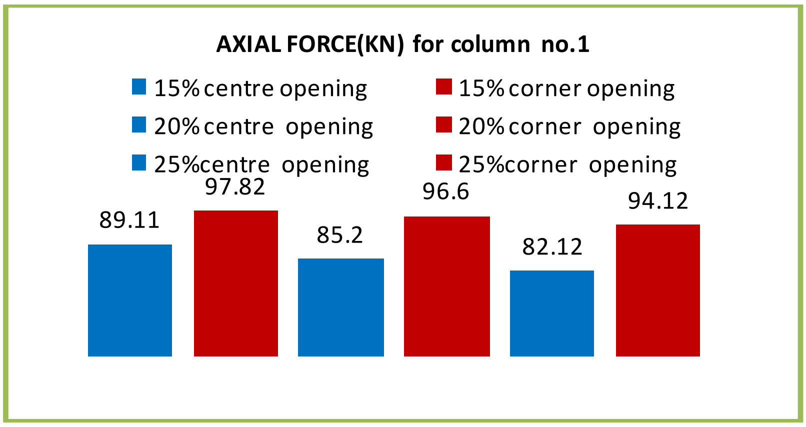


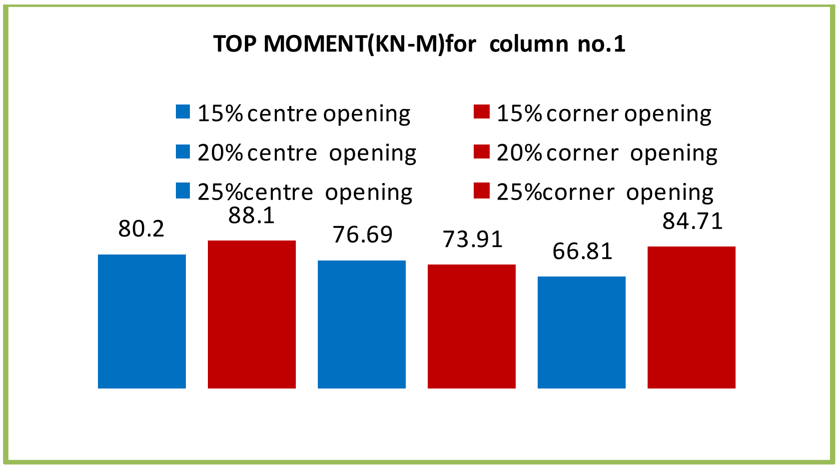


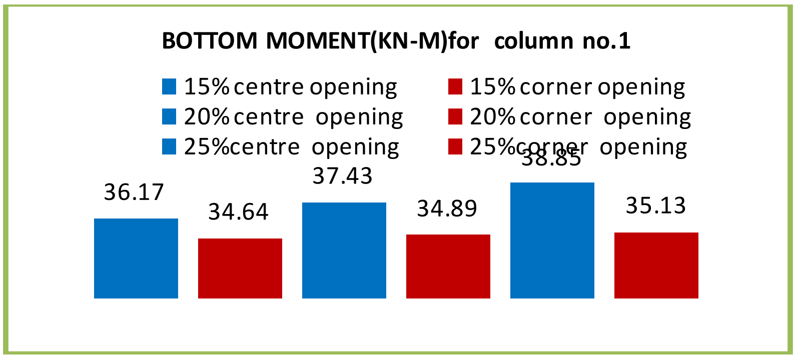


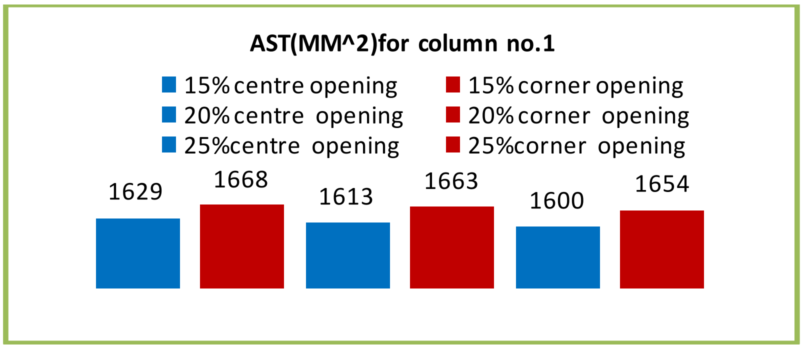
Result for G+5











X. CONCLUSION

1. The Maximum in Deflection in bare frame for (G+3) is 35.6 mm and in infilled frame it is minimum which 2.71 mm is and for (G+5) it is 58.93mm in bare frame and 5.84mm for infilled frame. if the effect of infill wall is considered then the deflection has reduced drastically.
2. The Maximum Deflection in infilled frame for (G+3) with 15% centre opening is 4.11mm which is 4.7 mm in 20% centre opening and 5.32 mm in 25% centre opening. Hence as the opening percentage increases it leads to increased in deflection respectively.
3. The Maximum shear force in infilled frame for (G+3) with 15% centre opening is 78.21 kN which is 75.45 kN in 20% centre opening and kN in 25% centre opening. Hence as the Opening percentage increases it leads to decreased in axial force respectively.
4. The Maximum Deflection in infilled frame for (G+3) with 15% centre opening is 4.11 mm and mm in 15% corner opening. Thus the deflection in centre opening is more than the corner opening.
5. In column considering infill wall effect the value of shear force, bending moment is less compared to bare frame.
6. Shear force in case of infilled frame is 89.28 KN and in Infilled Frame with 15% centre opening is 78.21kN because of infill wall effect wall, there is drastic decrease in the value of axial force in column.
7. Due to reduction of shear force and bending moment there is drastic reduction in requirement of steel in fully infilled frame and infilled frame with 15% opening model.
8. The Maximum Deflection in bare frame for (G+3) is 35.5 mm and infilled frame with 15% centre opening is 2.71mm. Thus the deflection in bare frame is more than the infilled frame.
9. The Maximum Deflection in bare frame for (G+3) is 35.5 mm and in bare frame for (G+5) is 58.93mm. As no effect of infill is considered the deflection increases.
10. Shear force in case of infilled frame for (G+5) is 104.98kN and in Infilled Frame with 15% centre opening is 89.11 KN because of infill wall effect wall, there is drastic decrease in the value of axial force in column.
11. The increase in the opening percentage leads to a decrease on the lateral stiffness of infilled frame. It is found that stiffness increases in fully infilled frame compared to infilled frame with opening.
12. In columns, without considering infill walls effect the values of shear force, bending Moment are maximum at 0.9m height.
13. Above 5 m panel dimension infill frame is less effective.

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