Effect of Magnification Factor in Column and Bean in Open Ground Storey Buildings Frame

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Abstract— Presence of infill walls within the frames refers the behavior of the building under lateral loads. However, its common experience observe to ignore the stiffness of infill wall for analysis of framed building. The infill wall strut is provided the ability to reduce the lateral load in structures. In this investigation, the infill wall strut has been placed at open first storey building to provide the maximum stiffness to the structure as compared to bare frame or normal OGS frame structure. The present work is done in STAAD.Pro software, which is good agreement for seismic structure analysis and the magnification factor are calculated in columns and beam of structure due to maximum bending moment and shear force using response spectrum method. The results are validated and compared with good literature and improve the design for future application. The main purpose of the investigation is to find the effect of magnification factor for open ground storey buildings in seismic condition as per as Indian standard.

Key words: Infill Wall, Strut, Magnification Factor, STAAD.Pro

I. Introduction

Infilled RC frames have been used in many parts of the world over a long time. It is a structural composite system which consists of a reinforced concrete frame with masonry or concrete panels filling the planar rectangular voids between lower and upper beams and side columns. In these structures, the infill walls are typically considered as non-structural elements and are often overlooked in the structural analysis and design [2]. However, they can interact with the bounding frames under seismic loads and alter the load resisting mechanism and failure pattern of the RC frame. For modelling infills, several methods have been developed. They are grouped in two main categories: macro-models, and micro-models. The first one is based on the equivalent strut method (Figure 1) and the second is based on the finite element method. The main advantages of macro-modelling are computational simplicity and the use of structural mechanical properties obtained from masonry tests, since the masonry is a very heterogeneous material and the distribution of material properties of its constituent elements is difficult to predict [3].

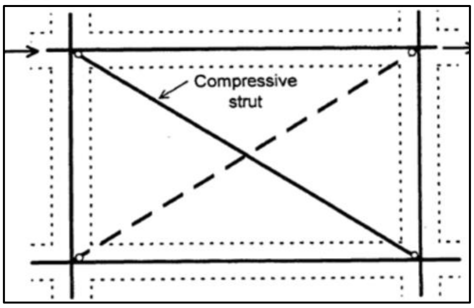

Fig. 1: Diagonal strut model for infilled frames

The single strut model is most widely used as it is simple and evidently most suitable for large structures [4]. Thus, R.C. frames with masonry infilled walls can be modeled as equivalent braced frames with infill walls replaced by equivalent diagonal strut which can be used in rigorous nonlinear pushover analysis. The basic parameter of these struts is their equivalent width, which affects their stiffness and strength. Polyakov [5], [6] conducted one of the first analytical studies based on elastic theory.

II. Problem Identification

The most damaging and sadly the foremost general irregularity in India stock of building structures that because collapse is actually the soft story irregularity. The industrial and parking areas with higher story heights and less infill walls scale back the stiffness of the lateral load resisting system at that story and progressive collapse becomes inevitable in a severe earthquake for such buildings.

III. Methodology

In this section, the methodology can be defined for solving the problem.

A. *Modeling of Infill Wall*

In Macro modeling the infill is model as diagonal strut in frame. The dimension of strut is given by the many researchers. Since the primary trial to model the response of the composite infilled frames structures, experimental and conceptual observations have indicated that a diagonal strut with acceptable geometrical and mechanical characteristics may probably give a solution to the problem [9], [10]. In this investigation, we used empirical formula given by Hendry (1998)

1) *Equivalent width (W)*

$$W = \frac{1}{2}\sqrt{\alpha_h^2 + \alpha_l^2} \qquad (1)$$

To determine α_h and α_l which depends on the relative stiffness of the frame and on the geometry of the panel.

$$\alpha_h = \frac{\pi}{2}\left[\frac{4E_f I_C h}{E_m t \sin 2\theta}\right]^{\frac{1}{4}} \qquad (2)$$

$$\alpha_l = \frac{\pi}{2}\left[\frac{4E_f I_b l}{E_m t \sin 2\theta}\right]^{\frac{1}{4}} \qquad (3)$$

Where,

Em and Ef = Elastic modulus of the masonry wall and frame material, respectively

t, h, l = Thickness, height and length of the infill wall, respectively

Ic, Ib = Moment of inertia of the column and the beam of the frame, respectively

$$\theta = \tan^{-1}(h/L)$$

Column Stiffness = $\frac{12EI}{L^3}$

Stiffness of Infill Wall = $(AE_m \cos^2\theta)/ l_d$

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A = Area of Diagonal Strut
E = Elastic Modulus of the Concrete.

The modulus of elasticity for the bricks is calculated as per Masonry Institute of America, (MIA 1998).

B. STAAD.Pro Analysis

STAAD or (STAAD.Pro® V8i) is a structural analysis and design computer program originally developed by Research Engineers International in Yorba Linda, CA. In late 2005, Research Engineers International was bought by Bentley Systems. It is the World's #1 Structural Analysis and Design Software. The analysis is done in a numerical way by the STAND.PRO program, a finite element package, which enables us to solve the linear and the nonlinear PDE's and thus the modulus of elasticity of the beam material is obtained.

1) Geometry

The building model is as shown in the Figure 2 and Figure 3 having number of bays according to different models and cases in the X and Y directions with a bay width.

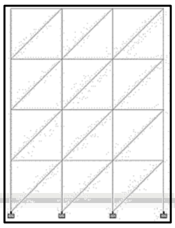

Fig. 2: Open ground storey building with all storey infill strut wall (proposed model)

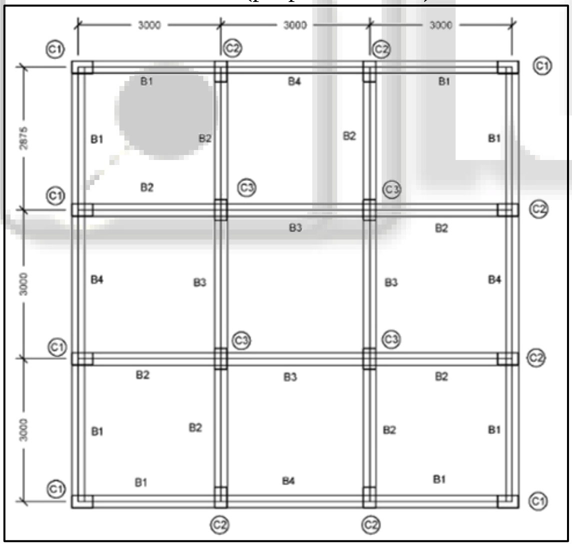

Fig. 3: Plan view of proposed model

2) Material Properties

M30 grade of concrete and Fe415 grade of reinforcing bars are used for all the members considered under study. Unit weights of concrete and masonry are 25kN/m2 and 17.65kN/m2 respectively. Modulus of elasticity of masonry is taken as 3.5GPa with a poisons ratio of 0.17.

S. No.	Content	Detail
1	Type of Structure	Multi-storey rigid jointed plane frame (SMRF)
2	Seismic Zone	V
3	Number of stories	Four (G+3)
4	Floors Height	3.0m
5	Infill wall	300mm thick brick masonry wall along X direction and Y direction
6	Type of soil	Medium
7	Size of column	300 mm X 450mm
8	Size of Beam	300 mm X 450mm
9	Depth of Slab	120 mm
10	Live load	3.0 KN/ m^2
11	Floor Finishes	6 mm thick
12	Material	M 20 Grade concrete & Fe 415 Reinforcement
13	Unit weights	a) Concrete = 25KN/Cum b) Masonry = 20KN/Cum
14	Total Height of Building	12m for G+3
15	Clear Cover of Beam	25 mm
16	Clear Cover of Column	40 mm
17	Damping in Structure	5%
18	Importance factor	1.5

Table 1: Detail of Models

IV. RESULTS AND DISCUSSIONS

In this chapter, we should have discussed about the open storey building frame considered for the investigation.

A. Validation

The Table 2, Table 3, Table 4 and Table 5 indicates that the validation of bending moment and shear force in column and beam of models (existing model). In this table, it is clear that the percentage difference between literature [1] and present work is up to 2%, it is under consideration hence the results are validated.

Building	Column	Maximum B.M. (OGS) kN-m		
		Karemore and Rayadu (Existing Model)	Validation	% Difference
Bending Moment (kN-m)	C1	151.23	151.4	-0.11
	C2	160.23	157.71	1.57
	C3	165.45	164.01	0.87

Table 2: Validation of bending moment of column of open ground storey

Building	Column	Maximum B.M. (OGS) kN-m		
		Karemore and Rayadu (Existing Model)	Validation	% Difference
Bending Moment (kN-m)	B1	125.418	126.48	-0.85
	B2	125.418	125.89	-0.38
	B3	124.125	125.59	-1.18
	B4	126.679	125.99	0.54

Table 3: Validation of bending moment of beam of open ground storey

Building	Colu	Maximum S.F. (OGS) kN		
		Karemore and	Validation	% Difference

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	mn	Rayadu (Existing Model)		
Bending Moment (kN-m)	C1	123.189	123.98	-0.64
	C2	141.806	141.64	0.12
	C3	140.562	141.42	-0.61

Table 4: Validation of shear force of column of open ground storey

Building	Column	Maximum S.F. (OGS) kN		
		Karemore and Rayadu (Existing Model)	Validation	% Difference
Bending Moment (kN-m)	B1	101.871	102.86	-0.97
	B2	56.156	57.45	-2.30
	B3	96.421	95.43	1.03
	B4	56.87	57.12	-0.44

Table 5: Validation of shear force of beam of open ground storey

B. *Improvement*

In this section, the improvement in proposed model are shows with comparison between existing model and proposed model.

Building	Column	Maximum B.M. (OGS) kN-m		
		Karemore and Rayadu (Existing Model)	Proposed Model	% Difference
Bending Moment (kN-m)	C1	151.23	94.62	37.43
	C2	160.23	126.8	20.86
	C3	165.45	129.32	21.84

Table 6: Bending moment of column of open ground storey

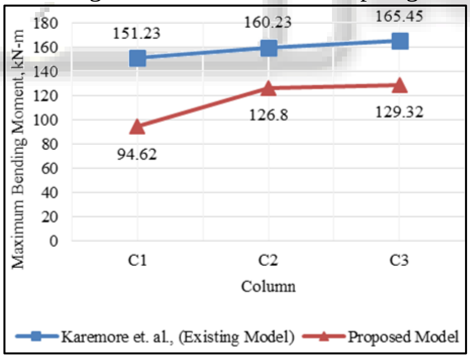

Fig. 4: Graph plotted between maximum bending moment for column in Karemore and Rayadu [1] and proposed model

From Figure 4 and Table 6, clearly shows that the output value of the maximum bending moment in column (C1, C2, and C3) on existing model was lower than the present model. The percentage different between existing model [1] and proposed model was 37.43%, 20.86% and 21.84% respectively.

Building	Column	Maximum B.M. (OGS) kN-m		
		Karemore and Rayadu (Existing Model)	Proposed Model	% Difference
	B1	125.418	100.79	19.64
	B2	125.418	102.48	18.29
Bending Moment (kN-m)	B3	124.125	107.5	13.39
	B4	126.679	109	13.96

Table 7: Bending moment of beam of open ground storey

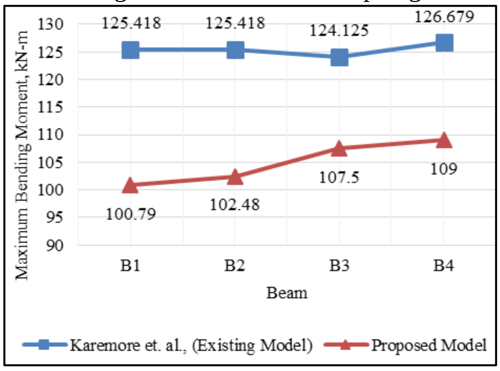

Fig. 5: Graph plotted between maximum bending moment for beam in Karemore and Rayadu [1] and proposed model

From Figure 5 and Table 7, clearly shows that the output value of the maximum bending moment in beam (B1, B2, B3 and B4) on existing model was lower than the present model. The percentage different between existing model [1] and proposed model was 19.64%, 18.29%, 13.39% and 13.96% respectively.

Building	Column	Maximum S.F. (OGS) kN		
		Karemore and Rayadu (Existing Model)	Proposed Model	% Difference
Bending Moment (kN-m)	C1	123.189	94.13	23.59
	C2	141.806	116.14	18.10
	C3	140.562	115.85	17.58

Table 8: Shear force of column of open ground storey

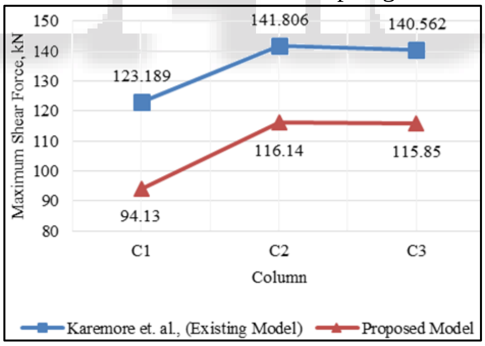

Fig. 6: Graph plotted between maximum shear force for column in Karemore and Rayadu [1] and proposed model

From Figure 6 and Table 8, clearly shows that the output value of the maximum shear force in column (C1, C2, and C3) on existing model [1] was lower than the present model. The percentage different between existing model and proposed model was 23.59%, 18.10% and 17.58% respectively.

Building	Column	Maximum S.F. (OGS) kN		
		Karemore and Rayadu (Existing Model)	Proposed Model	% Difference
Bending Moment (kN-m)	B1	101.871	90.62	11.04
	B2	56.156	47.65	15.15
	B3	96.421	87.15	9.62
	B4	56.87	49.89	12.27

Table 9: Shear force of beam of open ground storey

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From Figure 7 and Table 9 clearly shows that the output value of the maximum bending moment in beam (B1, B2, B3 and B4) on existing model [1] was lower than the present model. The percentage different between existing model and proposed model was 11.04%, 15.15%, 9.62% and 12.27% respectively.

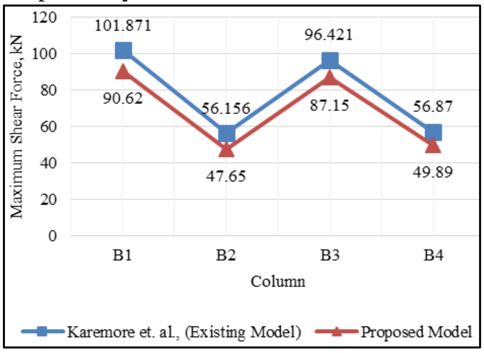


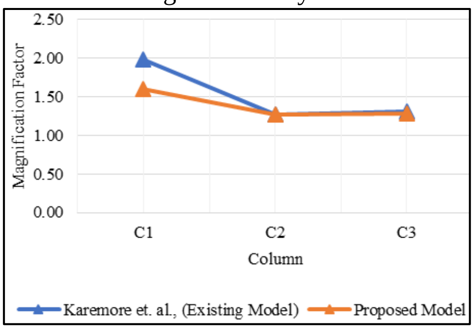
Fig. 7: Graph plotted between maximum shear force for beam in Karemore and Rayadu [1] and proposed model

Building	Column	Magnification Factor	
		Karemore and Rayadu (Existing Model)	Proposed Model
Bending Moment (kN-m)	C1	1.98	1.60
	C2	1.27	1.26
	C3	1.31	1.28

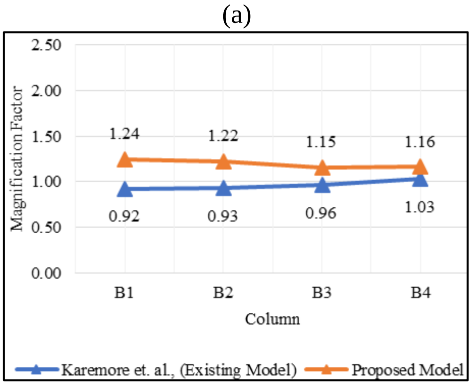
Table 10: Magnification factor for B. M. of column of open ground storey

Building	Column	Magnification factor	
		Karemore and Rayadu (Existing Model)	Proposed Model
Bending Moment (kN-m)	B1	0.92	1.24
	B2	0.93	1.22
	B3	0.96	1.15
	B4	1.03	1.16

Table 11: Magnification factor for B. M. of beam of open ground storey



(a)



(b)

Fig. 8: Magnification factor for maximum bending moment in columns (a) and beam (b)

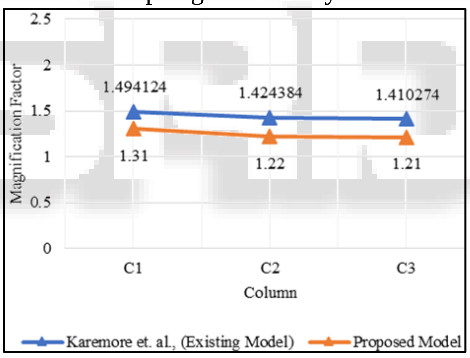
From Figure 8, Table 10 and Table 11, indicated that the magnification factor (M.F.) due to maximum bending moment in columns and beams. In this table, it was clear that the value of magnification factor was less than 2.5 (As per as Indian standard the value of magnification factor is under 2.5).

Building	Column	Magnification factor	
		Karemore and Rayadu (Existing Model)	Proposed Model
Bending Moment (kN-m)	C1	1.494124	1.31
	C2	1.424384	1.22
	C3	1.410274	1.21

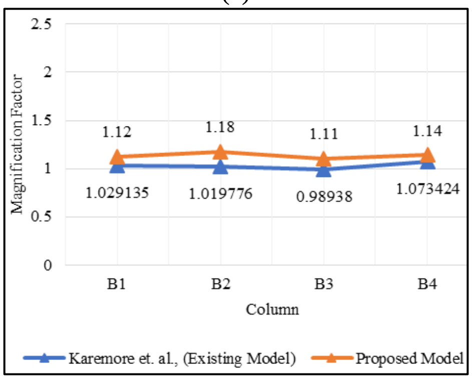
Table 12: Magnification factor for Shear force of column of open ground storey

Building	Column	Magnification factor	
		Karemore and Rayadu (Existing Model)	Proposed Model
Bending Moment (kN-m)	B1	1.029135	1.12
	B2	1.019776	1.18
	B3	0.98938	1.11
	B4	1.073424	1.14

Table 13: Magnification factor for Shear force of beam of open ground storey



(a)



(b)

Fig. 9: Magnification factor for maximum shear force in columns (a) and beam (b)

From Figure 9, Table 12 and Table 13, indicated that the magnification factor (M.F.) due to maximum shear force in columns and beams. In this table, it was clear that the value of magnification factor was less than 2.5 (As per as Indian standard the value of magnification factor is under 2.5).

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From above all statement, it was clear that the proposed model was gives the maximum efficient compared to existing model Karemore and Rayadu [1]

V. CONCLUSION AND SCOPE OF FUTURE WORK

A. Conclusion

- Through various literatures it is clear that there is a possibility to enhance the quality of structure with the help of proposed model (modified of existing structure).
- There is a good agreement to the Response spectrum analysis was carried out to gives effect of infill on seismic behaviour of building and find the maximum bending moment and shear force in column and beam with located in structure.
- The open first storey building (OGS) are considered as vertical irregular shape building structure as per as IS 1893:2002 requires for analysis considering strength and stiffness of the infill walls, provided a multiplication factor of 2.5 is applied on the design forces (bending moments and shear forces) in the ground storey columns and beams.
- For maximum bending moment, the magnification factor for columns and beams are range from 1.28-1.6 for column and 1.16-1.24 for beam.
- For maximum shear force, the magnification factor for columns and beams are range from 1.21-1.31 for column and 1.12-1.14 for beam.
- The application of infill wall increased stiffness which decreased lateral displacement.
- From these analysis results, it is concluded that, the magnification factor (M.F.) for maximum bending moment and shear force for column and beam was under 2.5, which was suitable for further application.

B. Scope of Future Work

- Open ground storey (OGS) buildings have been most common nowadays and are constructed heavily in high populated countries like India since they provide much needed parking space in an urban environment.
- The scope of this work was to non-integrated infill wall with RC frame.
- Below 10 storey buildings can be designed without shear wall.
- The plan concept was to not take into account of masonry.
- The presence of infill wall can affect the seismic behavior of frame structure to large extent, and the infill wall increases the strength and stiffness of the structure. Due to better performance of infill wall for open ground storey building, it is used in future.

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