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INVESTIGATION OF COLUMN SHEAR DEMAND IN OPEN GROUND STOREY STRUCTURES SUBJECTED TO EARTHQUAKE LOADS

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Keywords

Open Ground Storey, Soft Storey Effect, Seismic Analysis, Reinforced Concrete Frames, Shear Walls, Shear Force

Abstract

Open Ground Storey (OGS) buildings are known to be highly susceptible to seismic damage due to the development of a soft story at the ground level, which leads to a considerable reduction in lateral stiffness and a corresponding increase in shear demand on columns. This research investigates the distribution of shear forces in columns of three-dimensional (3D) reinforced concrete (RC) OGS frames subjected to earthquake loading. The study primarily evaluates the performance of two lateral load-resisting systems (LLRS), namely the provision of strengthened ground floor columns and the incorporation of shear walls arranged in different configurations. A comparative assessment is carried out between conventional OGS frames, bare frames, and infilled frames to understand the influence of masonry infill on seismic response. The analysis indicates that the presence of infill walls considerably enhances structural stiffness, resulting in a significant reduction in column shear forces—up to approximately 70% when compared to bare frame conditions. In contrast, OGS configurations without infill at the ground level exhibit an increase in shear forces of nearly 78% in ground floor columns relative to fully

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Distribution, Lateral Load Resisting System.	infilled frames, highlighting the adverse effect of stiffness discontinuity. The introduction of shear walls in OGS structures proves to be an effective strategy in mitigating these increased shear demands. The ratio of shear force in ground floor columns to that in the first floor, which ranges between 6.25 and 8.60 in typical OGS models, is substantially reduced to values between 0.52 and 5.74 when shear walls are incorporated. Additionally, it is observed that peripheral and corner columns experience approximately 10% higher shear forces compared to interior columns, indicating the need for careful design considerations in these critical locations. The study further reveals that an increase in ground floor height by 1meter leads to an approximate 25% rise in shear forces in the ground storey columns, emphasizing the influence of geometric parameters on seismic behavior. Overall, the findings highlight the necessity of appropriate structural interventions, such as optimal shear wall placement and enhanced column design, to improve the seismic performance and safety of OGS buildings.

1.0 INTRODUCTION

Open Ground Storey (OGS) buildings are widely adopted in modern urban construction to accommodate functional requirements such as parking and commercial spaces at the ground level. Although this configuration offers practical advantages, it introduces a significant vertical irregularity in stiffness due to the absence of infill walls at the ground storey. This results in the formation of a soft storey, where the ground floor possesses considerably lower lateral stiffness and strength compared to the upper floors. Consequently, during seismic events, large inter-storey drifts and excessive shear forces are concentrated in the ground floor columns, increasing the likelihood of structural damage or collapse.

The vulnerability of OGS structures has been clearly demonstrated during past earthquakes, such as the 2001 Bhuj earthquake in India and the 1999 Kocaeli earthquake in Turkey, where numerous buildings experienced severe failures due to the soft storey mechanism . The lack of adequate lateral resistance at the ground level leads to disproportionate deformation demands, making these structures highly susceptible to seismic actions[1],[2].

To mitigate these deficiencies, several lateral load-resisting systems (LLRS) have been proposed, among which the provision of stiffened ground floor columns and the incorporation of shear walls are the most prominent. Stiff columns enhance the load-carrying capacity and stiffness of the ground storey, while shear walls contribute to improved global stiffness and efficient redistribution of seismic forces. Despite extensive research on LLRS, most studies have primarily focused on overall structural response, with limited attention given to the distribution of shear forces in columns, which is a critical parameter governing failure in OGS buildings[3],[4].

Furthermore, a significant portion of the existing literature is based on two-dimensional analytical models, which do not adequately capture the complex three-dimensional behavior of real structures under seismic loading[5]. The influence of shear wall location and configuration—whether at corners, edges, or core regions—on shear force distribution remains insufficiently explored[6]. In addition, the effects of key parameters such as building height, variation in ground storey height, and seismic zone on column shear forces have not been comprehensively investigated. Although IS 1893:2016 provides general design guidelines, it lacks detailed recommendations regarding optimal LLRS configurations for OGS structures[7],[8],[9].

In this context, the present study aims to evaluate the shear forces in columns of three-dimensional (3D) reinforced concrete OGS frames subjected to seismic loading. A total of 96 analytical models are considered, including low-rise (G+6), medium-rise (G+14), and high-rise (G+18) buildings. The study investigates the effectiveness of different LLRS, namely masonry infill and shear walls in various configurations, in reducing shear forces compared to conventional OGS and fully infilled frames.

The objectives of the study include assessing the influence of ground storey height, building height, and seismic zones on shear force distribution, as well as comparing the efficiency of different LLRS in mitigating seismic effects. By addressing existing research gaps, this study aims to provide insights into optimal structural configurations that enhance the seismic performance of OGS buildings. The findings are expected to contribute to the development of improved design strategies for safer and more resilient structures in earthquake-prone regions.

2. MODELLING AND ANALYTICAL FRAMEWORK

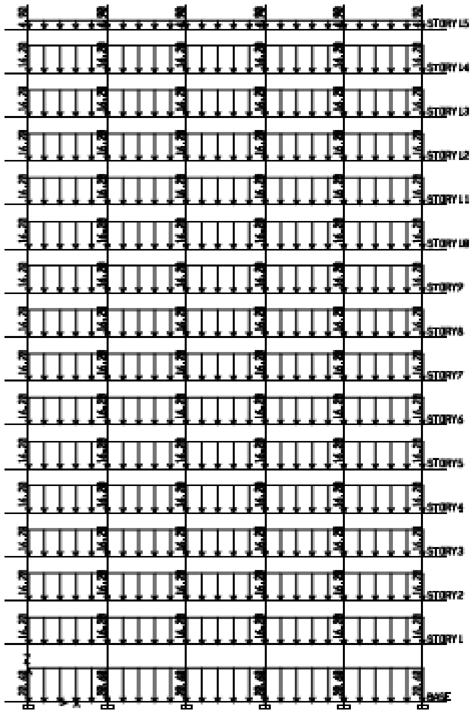
2.1 Structural Configuration and Model Description

The present study considers three categories of building configurations to evaluate seismic response: medium-rise (G+14), high-rise (G+18), and low-rise (G+6) structures. The total heights of the G+14 models vary as 49 m, 48 m, and 47.36 m, while the G+18 and G+6 buildings have heights of 61.8 m and 23.4 m, respectively. All structures are modeled with a uniform plan layout consisting of five bays in the X-direction and seven bays in the Y-direction, with each bay having a span of 5 m, ensuring geometric consistency across all models.

A total of twelve analytical models are developed to investigate the seismic behaviour of Open Ground Storey (OGS) frames with different lateral load-resisting systems (LLRS), as illustrated in Figures 1–12. Model 1 represents a bare frame without any infill or lateral strengthening system. Model 2 corresponds to a fully infilled frame, where the contribution of masonry infill is incorporated. Model 3 considers an OGS configuration with infill present only in the upper storeys, while Model 4 represents a conventional OGS frame without any additional strengthening measures.

To improve the seismic performance, several strengthened configurations are introduced. Model 5 incorporates stiffened columns at the ground floor to enhance lateral stiffness. Models 6, 7, and 8 include shear walls placed at different locations, such as corners and sides, providing resistance in both principal directions. Model 9 consists of shear walls located at the central core region of the structure. Model 10 introduces shear walls at corner locations with partial span coverage, whereas Model 11 combines shear walls at both corner and core positions. Model 12 integrates shear walls along both corners and sides to achieve improved overall stability and load distribution.

H S Vishwanatha, Sreekeshava K S **(2024).** ***Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads.*** *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*



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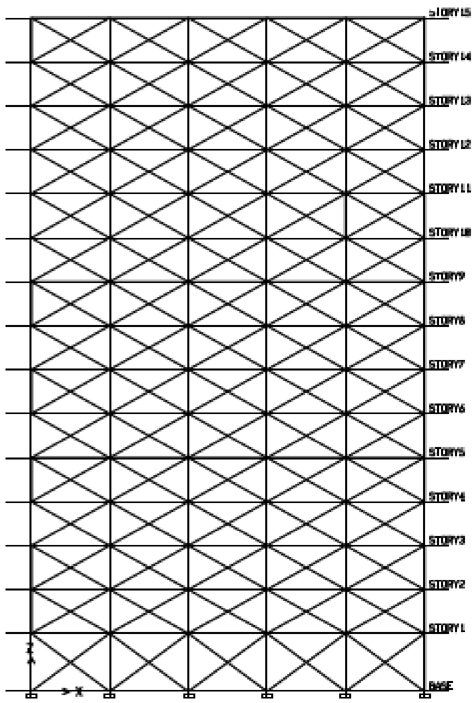

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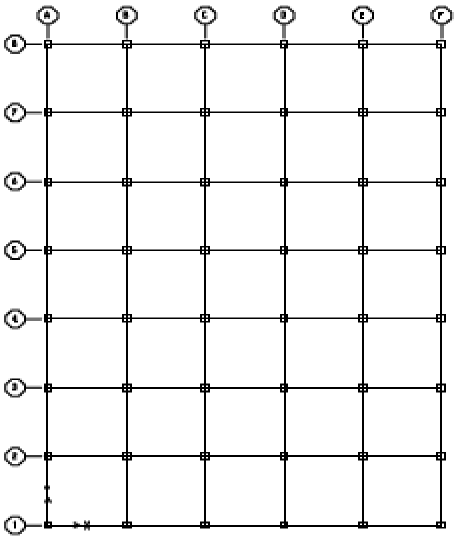
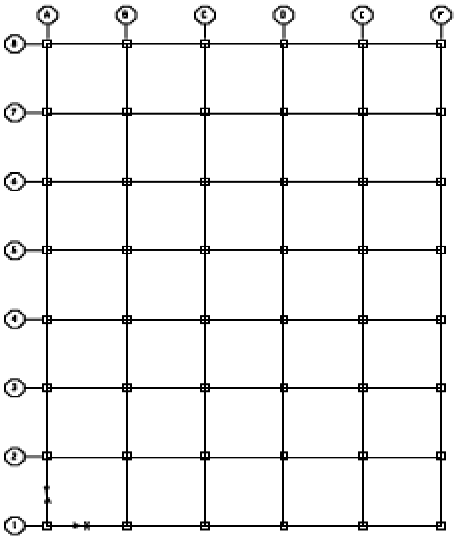


b)Plan

Fig. 1: Model-1 Bare Frame

(Infill mass considered)



b)Plan

Fig. 2: Model-2 Frame with full infill

(Infilled frame effect considered)

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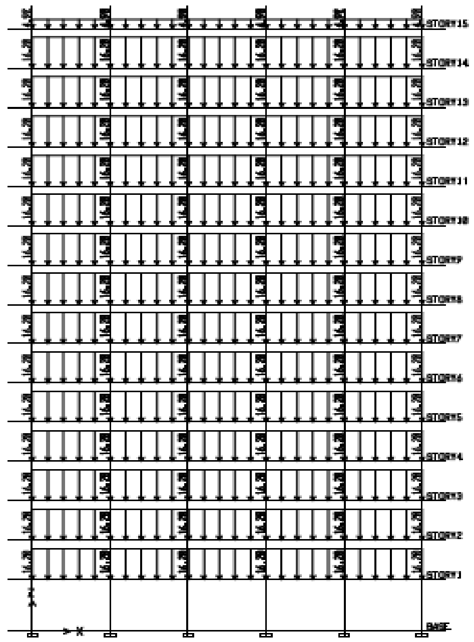

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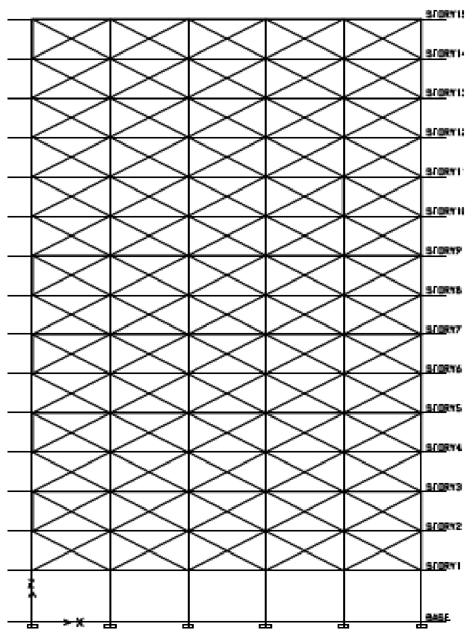

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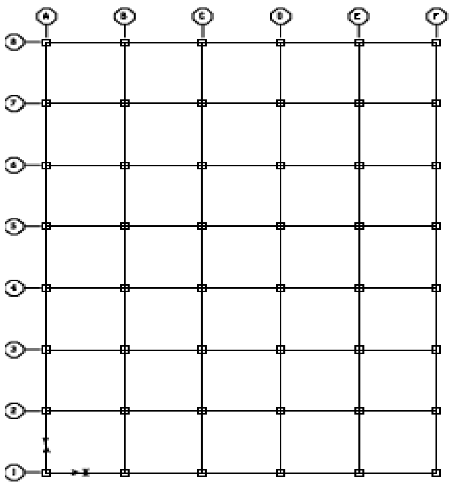

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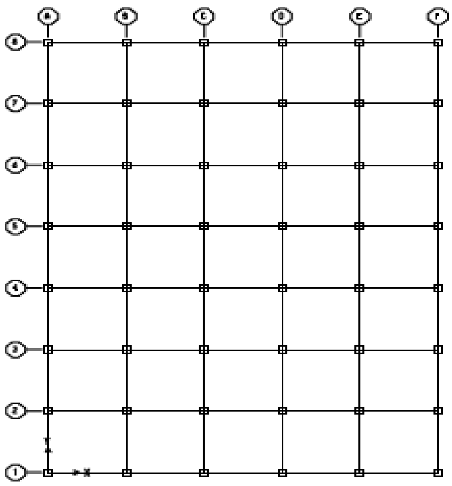
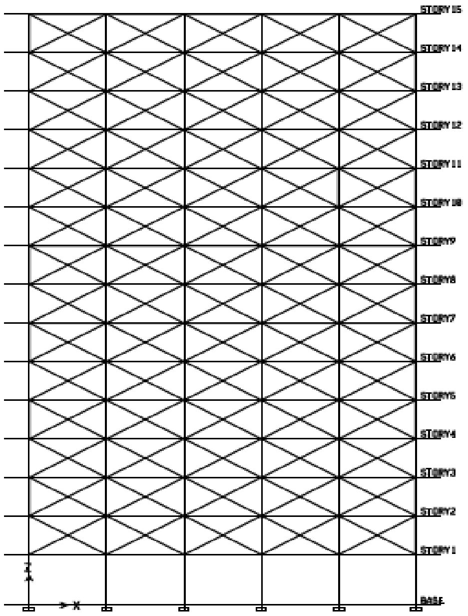


b)Plan

Fig. 3: Model-3 Frame with Open Ground Storey (OGS) without any LLRS (Infill mass considered)

Fig. 4: Model-4 Frame with OGS (Infilled frame effect at Rest floors considered)

H S Vishwanatha, Sreekeshava K S **(2024)**. ***Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads.*** *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*



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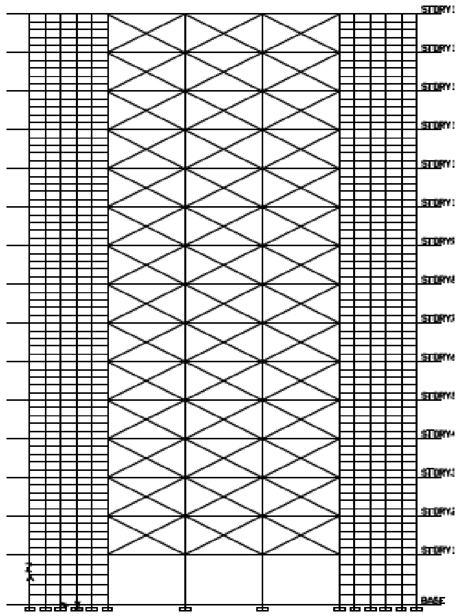

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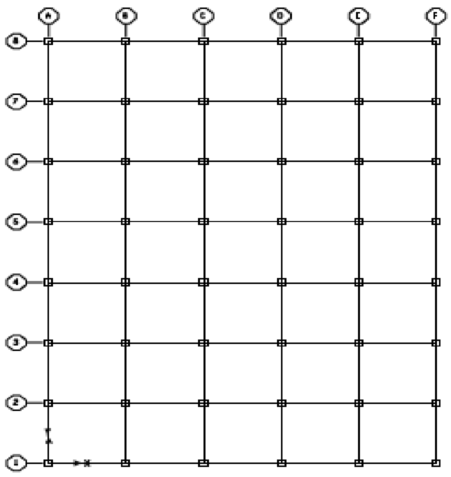

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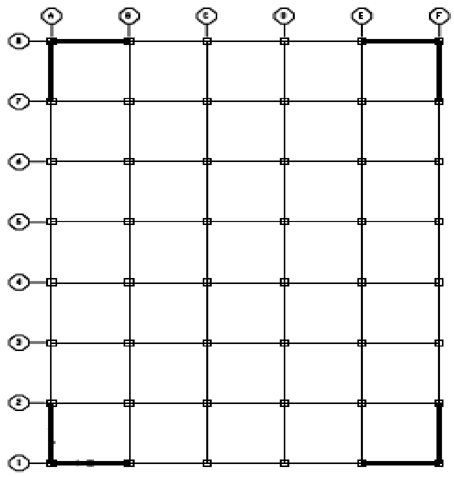

b)Plan

Fig. 5: Model-5 OGS Frame with stiff columns provided at ground floor

Fig. 6: Model-6 OGS Frame with Shear walls at Corners spans

ISSN (ELECTRONIC): 2945-3135

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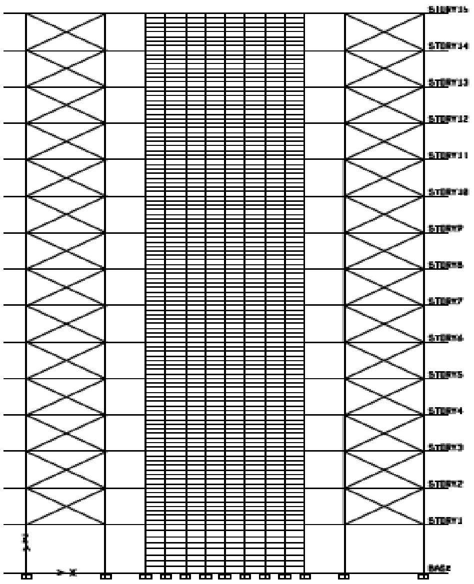

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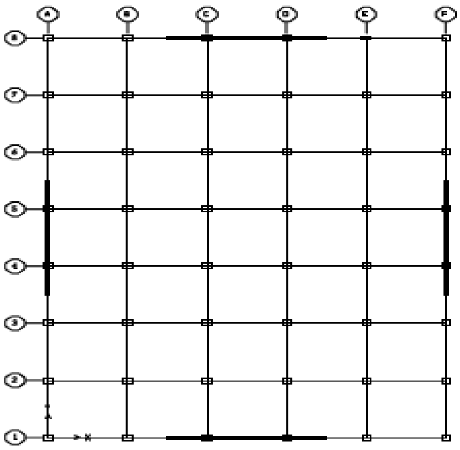

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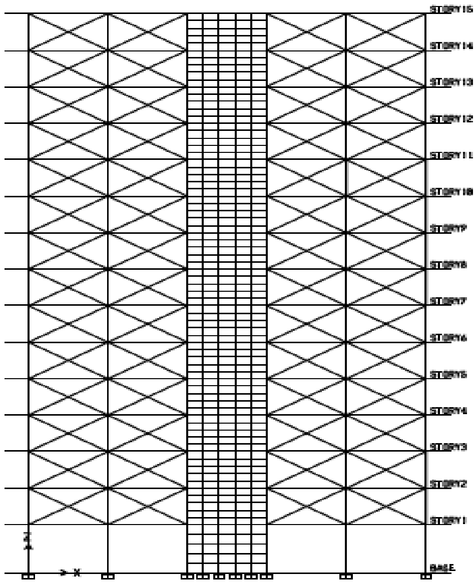
Fig. 7: Model-7 OGS Frame with Shear wall at Sides (Central peripheral 1 ½ span provided with shear wall)



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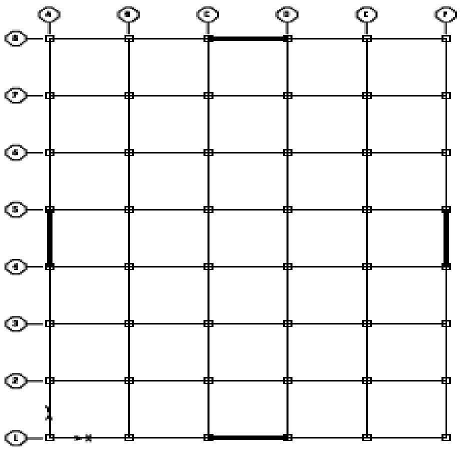

b)Plan

Fig. 8: Model-8 OGS Frame with Shear wall at Sides (Central peripheral span provided with shear wall)

ISSN (ELECTRONIC): 2945-3135

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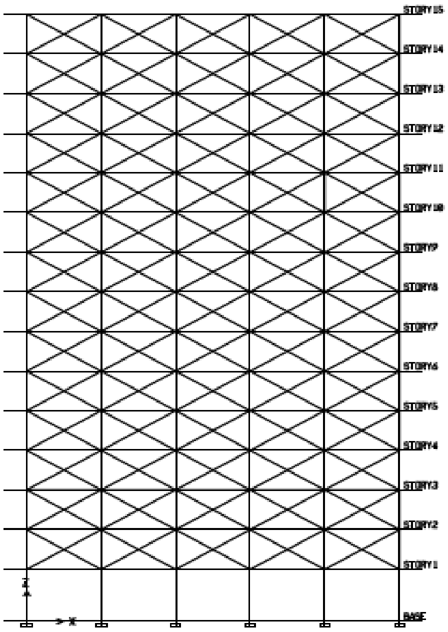

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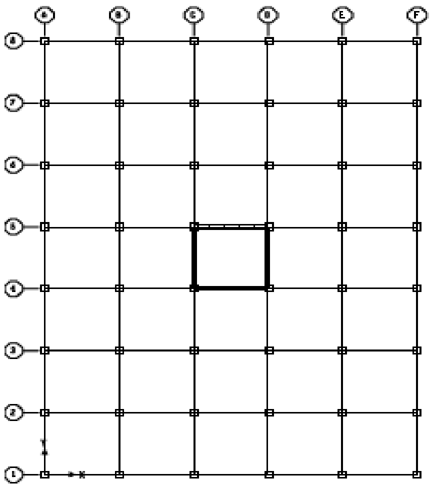
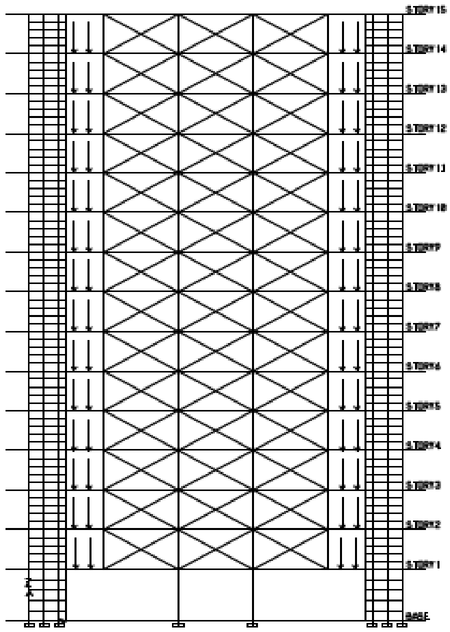


b)Plan

Fig. 9: Model-9 OGS Frame with Shear wall at Core (Central core provided with shear wall)



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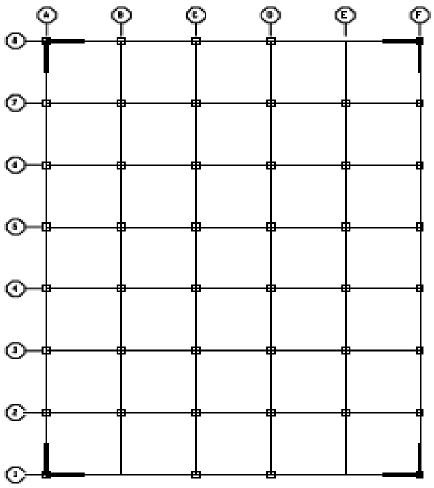

b)Plan

Fig. 10: Model-10 OGS Frame with Shear wall at Corner half span

ISSN (ELECTRONIC): 2945-3135

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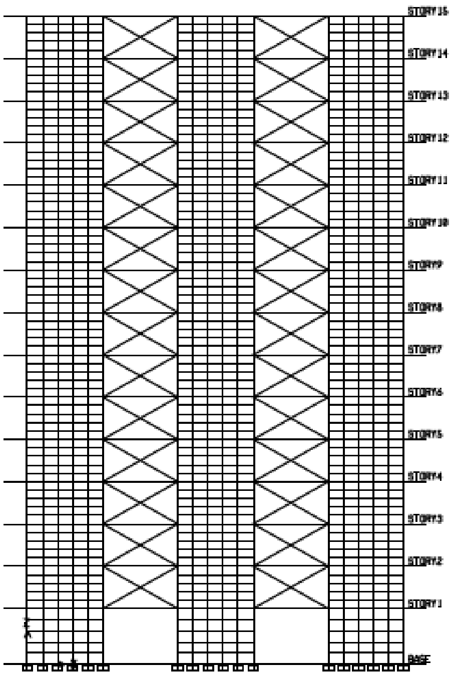

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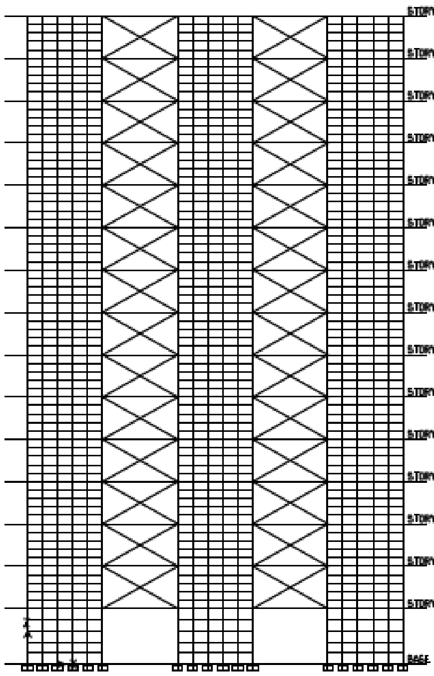

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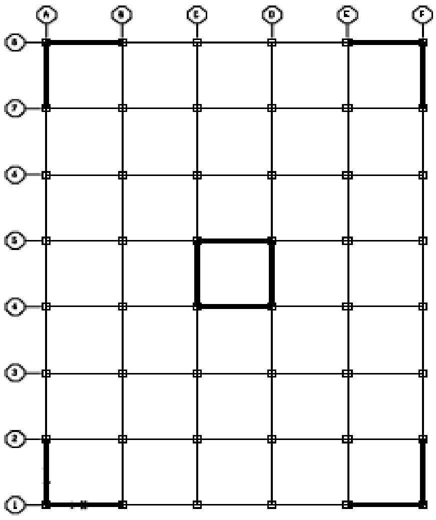

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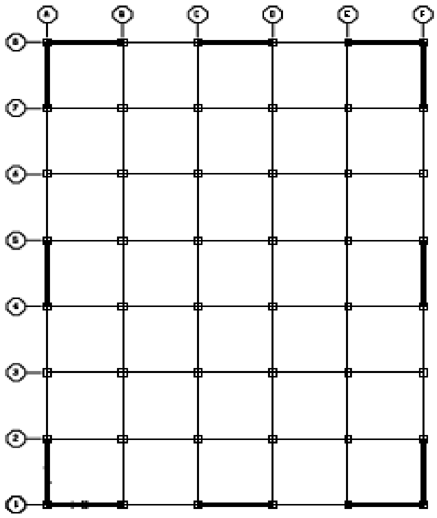

b)Plan

Fig. 11: Model-11 OGS Frame with Shear wall at Corner and Core

Fig. 12: Model-12 OGS Frame with Shear wall at Corner and Side

ISSN (ELECTRONIC): 2945-3135

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In this study, SAP2000 was utilized with a mesh size of 0.5 meters was utilized for the SAP2000 models.

2.2 Column and Beam Classification

To understand the behavior of the structural elements, columns and beams are classified based on their locations within the model. This classification is detailed in Table 1, and their designations are illustrated in Figure 13. By categorizing the columns and beams, the analysis can more effectively address the specific responses of different elements under seismic loading conditions.

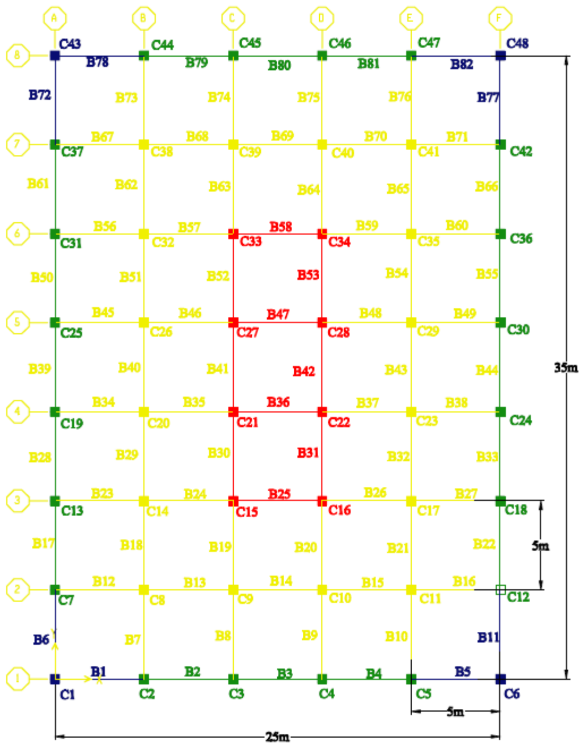

Fig. 13: The beam and column designation adopted

Table 1: Column and Beam Classification

CLASSIFICATION	COLUMN / BEAM DESIGNATION
CORNER COLUMNS	C1, C6, C43, C48- 4Nos.
PERIPHERAL COLUMNS	C2, C3, C4, C5, C7, C12, C13, C18, C19, C24, C25, C30, C31, C36, C37, C42, C44, C45, C46, C47- 20Nos.
INNER PERIPHERAL COLUMNS	C8, C9, C10, C11, C14, C17, C20, C23, C26, C29, C32, C35, C38, C39, C40, C41-16Nos.

H S Vishwanatha, Sreekeshava K S **(2024). *Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads.*** *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*

CORE COLUMNS	C15, C16, C21, C22, C27, C28, C33, C34 - 8Nos.
CORNER BEAMS	B1, B5, B6, B11, B72, B77, B78, B82- 8Nos.
PERIPHERAL BEAMS	B2, B3, B4, B17, B22, B28, B33, B39, B44, B50, B55, B61, B66, B79, B80, B81- 16Nos.
INNER PERIPHERAL BEAMS	B13, B14, B15, B18, B21, B29, B32, B40, B43, B51, B54, B62, B65, B68, B69, B70, B7, B8, B9, B10, B73, B74, B75, B76, B12, B16, B23, B27, B34, B38, B45, B49, B56, B60, B67, B71 -36Nos.
CORE BEAMS	B24, B25, B26, B35, B36, B37, B46, B47, B48, B57, B58, B59, B19, B30, B41, B52, B63, B20, B31, B42, B53, B64- 22Nos.

2.3 Cross Sectional Properties and Material Constants

The properties of the structural elements are considered as specified in below table 2

Table 2 Properties considered for the study

Property	**Value**
Grade of Concrete	M25
Grade of Steel	Fe415
Characteristic Strength of Concrete, f_{ck}	25 MPa
Density of Concrete	25 kN/m^3
Modulus of Elasticity of Concrete, E_{fe}	25,000 MPa (25,000 x 10^3 kN/m^2)
Poisson's Ratio of Concrete	0.2
Density of Brick Masonry	19.2 kN/m^3
Modulus of Elasticity of Brick Masonry, E_{me} [41]	1.8 x 10^6 kN/m^2
Poisson's Ratio of Brick Masonry	0.20

2.4 Size of Equivalent Diagonal Strut

In this study, the behavior of infilled frames is modeled using a diagonal compression strut, which simplifies the complex interactions between the infill walls and the surrounding frame. The width of the equivalent strut, denoted as *a*, is calculated using

Where

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

H S Vishwanatha, Sreekeshava K S **(2024). *Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads.*** *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*

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

$$\theta = \tan^{-1}\left(\frac{h_{\inf}}{L_{\inf}} \right)$$

The column height, denoted as h_{col}(m), represents the distance between the centerlines of the beams. The height of the infill panel, h_{inf}. The expected modulus of elasticity for the frame material is indicated as E_{fe} in kN/m², while the expected modulus of elasticity for the infill material is denoted as E_{me} in kN/m². The moment of inertia of the column is represented as I_{col} in m⁴. Additionally, the length of the infill panel is referred to as L_{inf} and the diagonal length of the infill panel is indicated as r_{inf}. The thickness of both the infill panel and the equivalent strut is represented by t_{inf}. Furthermore, the angle related to the infill height-to-length aspect ratio is denoted in radians, along with a coefficient used to determine the equivalent width of the infill strut. Lastly, the cross-sectional area of the diagonal strut is indicated as A in m².

Calculated value of diagonal strut as shown in Table 3:

Table 3 : Calculated Size of Diagoanal Strut

Column size	**I_{col} (m⁴)**	**h_{col} (m)**	**r_{inf} (m)**	θ	λ_1	***a***	**A=*a* x t_{inf} (m²)**	**Size of diagonal strut**
500x500mm	0.0052	2.56	5.617	27.11	0.7082	0.775	0.178	775x230mm
500x500mm	0.0052	3.2	5.936	32.61	0.6895	0.757	0.174	757x230mm
500x500mm	0.0052	4.2	6.530	40	0.6569	0.761	0.175	761x230mm

The seismic analysis of a 3-D framed structure is conducted using the SAP2000 Ver. 15 commercial software package. This analysis encompasses various configurations, including a bare frame (accounting for infill mass effects), a solid infilled frame, an open ground storey (OGS), OGS with stiff columns at the ground floor, and OGS with shear walls located at different positions within the structure.

The results of the fully infilled frame are compared with those of the bare frame to assess the effectiveness of the infill in enhancing structural performance. Additionally, the analysis includes a comparison of the open ground storey (OGS) with the infill effect in the storeys above against the

OGS without any infill effect. To evaluate the impact of structural modifications, the effectiveness of incorporating stiff columns at the ground storey and shear walls at various locations is analyzed by comparing these configurations with the fully infilled structure and the OGS that includes the infill effect in the storeys above.

3.0 RESULTS AND DISCUSSION

i) Infill effect

Compared to Model 1 (Bare Frame), it is observed that S.F. (both average and maximum) G.F. columns in Model 2 (full infill) gets reduced by about 71% due to increase in stiffness in the structure.

ii) Open Ground Storey effect

It is observed that average S.F. in G.F. columns is increased in comparison to Rest floor (all other floor) columns and is about 21% in Model 3 (OGS with mass effect of infill on Storey above) and 83% in Model 4 (OGS with infill effect on Storey above) due to reduction in stiffness at ground Storey due to Open Ground Storey. (G.F./Rest floor ratio of average S.F. for Model 1 to 3 is about 1.3 whereas for Model 4 it is about 5.70).

iii) Systems adopted to offset Open Ground Storey effect

a) Considering G+14 structure

G.F. average S.F. in columns is reduced from 193kN in case of Model 4 up to 54kN in OGS with shear wall Models. The percentage reductions in G.F. average S.F. in all Models with respect to Model 4 & Model 2 are shown in Table 4.

Table 4: Percentage reduction of Average Shear Force in columns

Model	Compared to Model 4 (OGS)	Compared to Model 2 (Full infill)	Remarks
MODEL 6	84%	24%	* No reduction in S.F.
MODEL 7	83.5%	19%	
MODEL 8	76.6%	*	
MODEL 9	77%	*	
MODEL 10	72.2%	*	
MODEL 11	87%	36.7%	
MODEL 12	89%	47.3%	

It is seen that all Models of OGS structure with shear wall considered effectively reduce the S.F.

H S Vishwanatha, Sreekeshava K S **(2024).** ***Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads.*** *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*

that gets increased at G.F. due to OGS effect. Though there is substantial reduction in S.F. in G.F. columns compared to OGS (Model 4), Models 8,9,10 result in S.F. higher than that of full infill (Model 2). Comparing Models 6,7,11 &12, it can be seen that S.F. predicted by 6 & 7 are closer to Model 2 than Model 11 & 12 (which seem to be highly conservative).

Model 5 (stiffer columns in ground storey) results in ground storey drift demands similar to that of Model 2 (completely infilled), but the strength demand on the ground storey columns is very large.

Since there is a large variation in S.F. in G.F. columns observed in the structure due to OGS in Model 4, G.F. /F.F. ratio of S.F (G/F_S) is compared for all Models. To see specific behaviour of G/F_S, columns are classified (Ref. Table 5) as Corner, Peripheral, Inner peripheral & Core columns and G/F_S of classified columns for all Models presented in Table.

Table 5: Ratio of G.F. & F.F. Shear Force in columns

Classification of columns	Model Nos.								
	Full infill	OGS	40m shear wall		20m shear wall			60m shear wall	
	2	4	6	7	8	9	10	11	12
Corner columns	*1.19*	7.28	1.65	1.03	1.31	1.31	5.33	1.34	1.42
Peripheral columns	*0.96*	8.47	1.14	1.45	1.71	1.08	0.91	0.95	1.05
Inner peripheral columns	*0.79*	6.38	0.61	0.63	0.82	0.82	0.89	0.52	0.52
Core columns	*0.88*	6.25	0.60	0.65	0.84	1.71	0.89	1.16	0.76

1. The Model 4 (OGS), the G/F_S is very high. G/F_S for OGS ranges between 6.25 to 8.47 & when shear walls are used it ranges to reduced values between 0.52 to 5.33.

2. Between columns of different classifications peripheral & corner columns are more affected due to OGS than inner peripheral & core columns.

3. All shear walled OGS structure effectively reduces the G/F_S values.

4. Comparing shear walls of different length for a particular shear wall location say Model 10, 6 & 11, increasing the length of shear wall more beneficial in reducing G/F_S bringing it closer to full infill effect.

5. Considering the required infill effect G/F_S ranges between 0.79 to 1.19 (as Model 2), main

object is to bring down G/Fs to this level. Comparing different lengths of shear wall for G+14 structures under consideration 40m shear wall seems to be more appropriate because 60m shear wall seems to be conservative & 20m shear wall insufficient in providing additional lateral resistance.

6. For 40m length of shear wall Model 6 &7 are almost comparable, ratios predicted by Model 7 are closer to full infill.

Varying height of the G.F. with respect to F.F.

The maximum S.F. developed in OGS (Model 4) structure is around 202kN for all ratios considered. It is observed from table 6 that marginal variation of S.F. is observed in G.F. columns with respect to reduction in height of columns.

Table 6: G+14 STRUCTURE- COLUMNS SHEAR FORCE IN GROUND FLOOR (G.F.) AND REST FLOORS (REST) [Zone III]

MODEL	AVERAGE SHEAR FROCE (kN)						MAXIMUM SHEAR FORCE (kN)					
	0.8 Ratio		1.0 Ratio		1.3 Ratio		0.8 Ratio		1.0 Ratio		1.3 Ratio	
	G.F.	REST	G.F.	REST	G.F.	REST	G.F.	REST	G.F.	REST	G.F.	REST
MODEL 1	160	120	160	121	160	123	170	126	169	206	173	207
MODEL 2	38	36	38	36	39.5	36	48	36	43	64	46.3	68
MODEL 3	160	125	160	125	160	125	164	124	169	206	173	207
MODEL 4	200	34	200	34	193	33.9	200	34	202	61	203	68
MODEL 5	170	35	170	34	194	33.9	24	46	135	46	214	67
MODEL 6	23	32	25	32	30	33.6	28	33	166	220	167	226
MODEL 7	30	26	30	26	32	27.9	142	189	145	196	149	197
MODEL 8	24	31	26	31	45	31.6	180	167	185	159	291	240
MODEL 9	20	33	24	31	44.4	30.4	118	162	118	163	244	197
MODEL 10	24	29	28	30	53.6	36	172	133	145	154	144	270
MODEL 11	24	24	24	25	25	25.3	117	145	139	137	146	175
MODEL 12	21	22	21	22	20.8	22.1	116	144	118	136	142	189

Increasing height of G.F. from 2.56m to 4.2m induces maximum S.F. at ground floor columns. G/Fs of 4.97 observed for peripheral columns in case of 2.56m height gets increased to 8.47 for 4.2m height, i.e. about 41% increase is observed for increase in height of 1.64m.

H S Vishwanatha, Sreekeshava K S **(2024)**. ***Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads***. *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*

Different Earthquake Zones

Higher G/Fs developed is in case of Zone V as compared to zone II, III & IV clearly showing that as the Earthquake zone increases, OGS effect also increases considerably. With respect to full infill frames performance of shear walls observed for Models 6,7,11 & 12 is good in all zones as depicted for zone III in table 7.

TABLE 7: RATIO OF G.F. TO F.F. SHEAR FORCE IN COLUMNS FOR ALL STRUCTURES [Zone III]

Classification of columns	Structure	Model Nos.											
		1	2	3	4	5	6	7	8	9	10	11	12
CORNER COLUMNS	G+6	1.41	1.13	1.41	7.01	4.00	1.52	0.93	1.24	1.25	4.79	1.34	0.55
	G+14	1.43	1.19	1.43	7.28	4.44	1.65	1.03	1.31	1.31	5.33	1.34	1.42
	G+18	1.43	1.20	1.43	7.25	6.15	1.57	1.05	1.31	1.32	4.75	1.28	1.41
PERIPHERAL COLUMNS	G+6	1.12	0.95	1.12	8.35	2.30	0.84	0.83	1.25	1.07	0.92	0.73	1.07
	G+14	1.11	0.96	1.11	8.47	4.11	1.14	1.45	1.71	1.08	0.91	0.95	1.05
	G+18	1.11	0.97	1.11	8.44	7.27	1.13	1.49	1.70	1.08	0.91	0.94	1.04
INNER PERIPHERAL COLUMNS	G+6	0.89	0.80	0.89	6.45	2.39	0.64	0.66	0.85	0.86	0.91	0.55	0.52
	G+14	0.88	0.79	0.88	6.38	3.77	0.61	0.63	0.82	0.82	0.89	0.52	0.52
	G+18	0.88	0.79	0.88	6.38	6.05	0.60	0.62	0.82	0.82	0.89	0.51	0.52
CORE COLUMNS	G+6	0.90	0.78	0.90	6.35	2.18	0.66	0.69	0.87	1.34	0.92	0.87	0.29
	G+14	0.88	0.76	0.88	6.25	4.08	0.60	0.65	0.84	1.71	0.89	1.16	0.76
	G+18	0.88	0.77	0.88	6.22	6.29	0.62	0.64	0.83	1.82	0.90	1.14	0.54

H S Vishwanatha, Sreekeshava K S **(2024).** ***Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads.*** *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*

b) Structures of different heights (G+6, G+14 & G+18)

The results indicate that the ground floor to first storey shear force ratio (G/FS) remains nearly constant for Model 2 (fully infilled frame) across all building heights, whereas a significant increase is observed for Model 4 (OGS configuration). For the OGS model, the G/FS ratio varies between 6.22 and 8.47, highlighting the pronounced soft storey effect. However, this ratio can be substantially reduced through the introduction of shear walls. For different building heights, the G/FS ratio decreases to a range of 0.29–1.07 for G+6, 0.52–1.04 for G+14, and 0.51–1.14 for G+18 structures when shear walls are provided.

It is further observed that shear wall lengths of 20 m for G+6, 40 m for G+14, and 60 m for G+18 buildings yield performance comparable to that of fully infilled frames. This suggests that the required shear wall length should be selected in proportion to the building height, with taller structures necessitating longer shear walls to achieve adequate seismic performance.

Figures 14 to 20 present the variation of shear force (expressed as G/FS ratio) along the height of the building for different column categories. Among all models, the highest values are recorded for Model 4 (OGS), while the lowest values are associated with shear wall models (Models 6 to 12). The response of Model 5, which incorporates stiffened ground floor columns, falls between these two extremes.

In Model 5, it is observed that the shear force at the ground floor increases with an increase in building height, indicating a limitation of this approach for taller structures. Consequently, this configuration may not be suitable for high-rise buildings exceeding six storeys. In contrast, models incorporating shear walls demonstrate performance comparable to fully infilled frames across all building heights. Therefore, the use of shear walls is found to be a more effective and reliable solution than relying solely on stiffened columns at the ground storey.

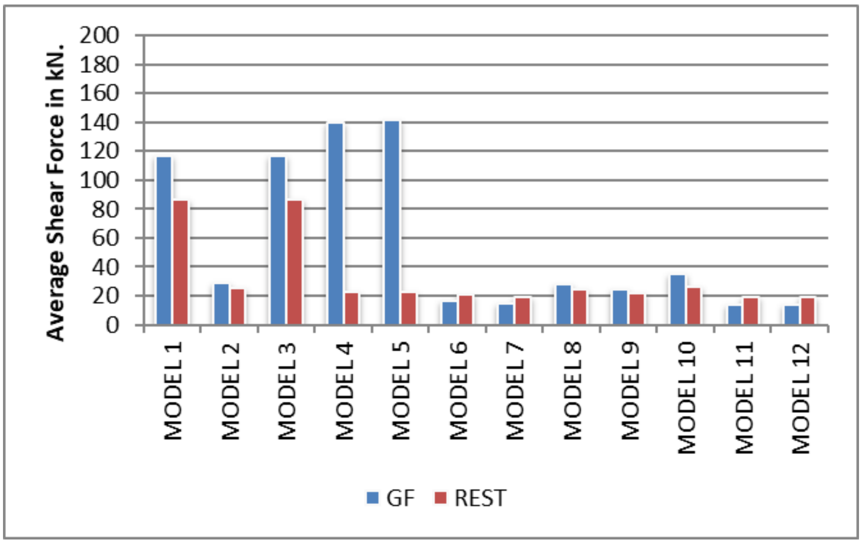

Fig. 14: Average Shear Force in G+6 Structure columns

H S Vishwanatha, Sreekeshava K S **(2024)**. ***Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads***. *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*

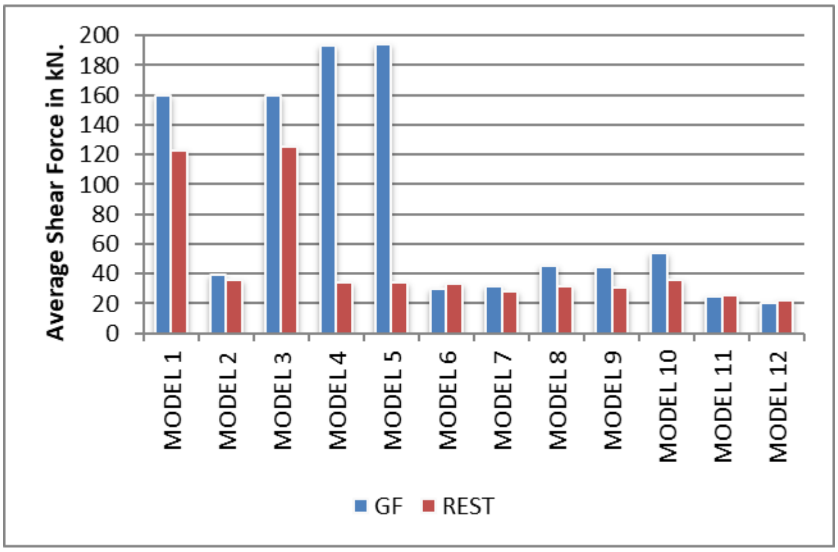

Fig. 15: Average Shear Force in G+14 Structure columns

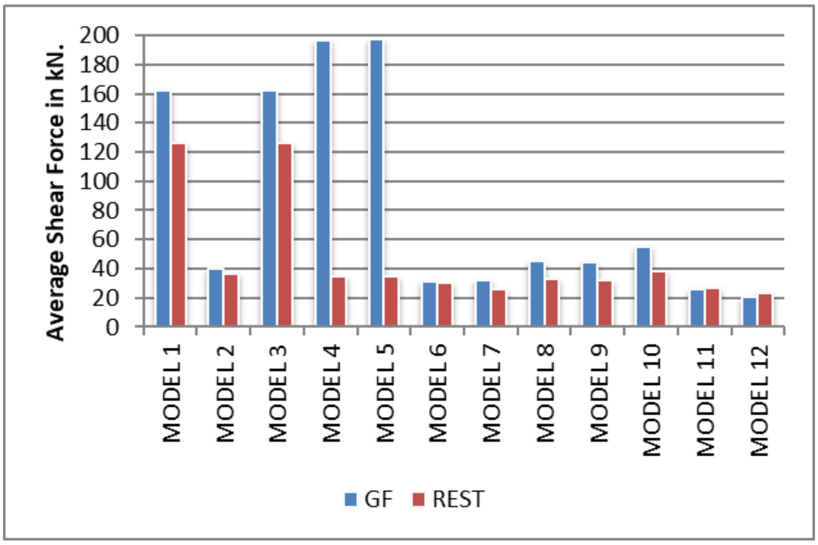

Fig. 16: Average Shear Force in G+18 Structure columns

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H S Vishwanatha, Sreekeshava K S **(2024)**. ***Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads***. *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*

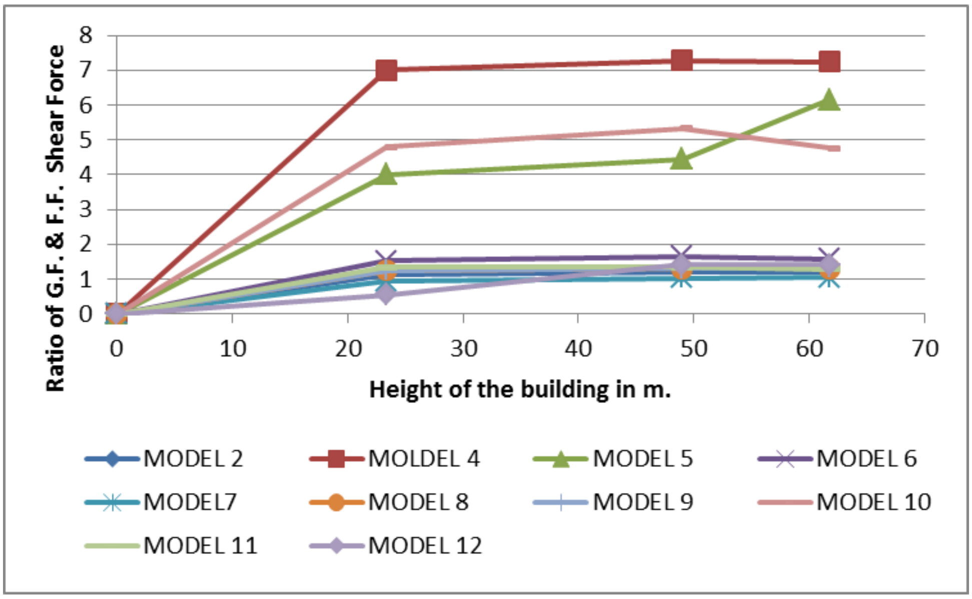

Fig. 17: Ratio of G.F. & F.F. Shear Force developed in Corner columns

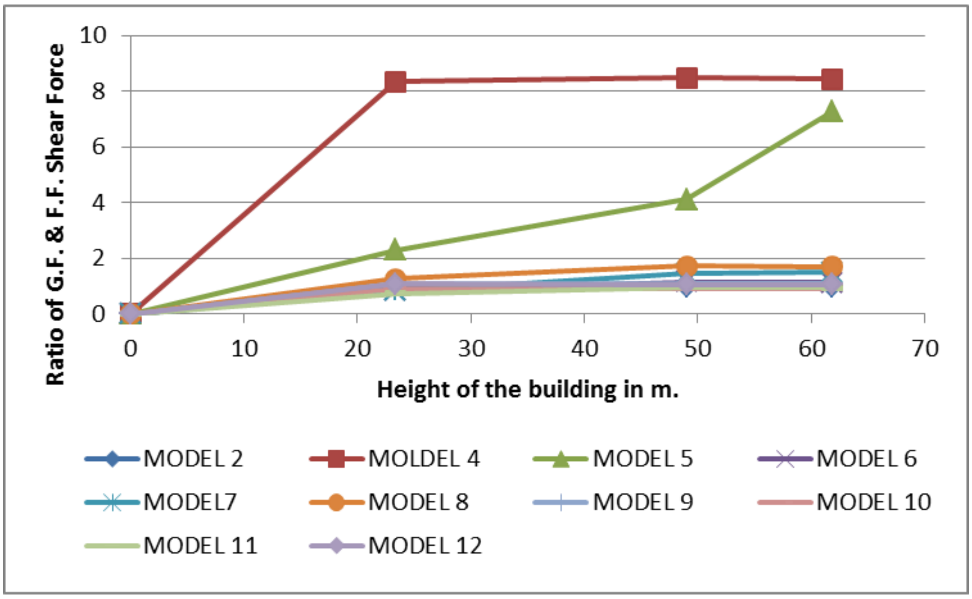

Fig. 18: Ratio of G.F. & F.F. Shear Force developed in Peripheral columns

H S Vishwanatha, Sreekeshava K S **(2024)**. ***Investigation of Column Shear Demand in Open Ground Storey Structures Subjected to Earthquake Loads***. *International Journal of Multidisciplinary Research & Reviews. 3(3). 193-214.*

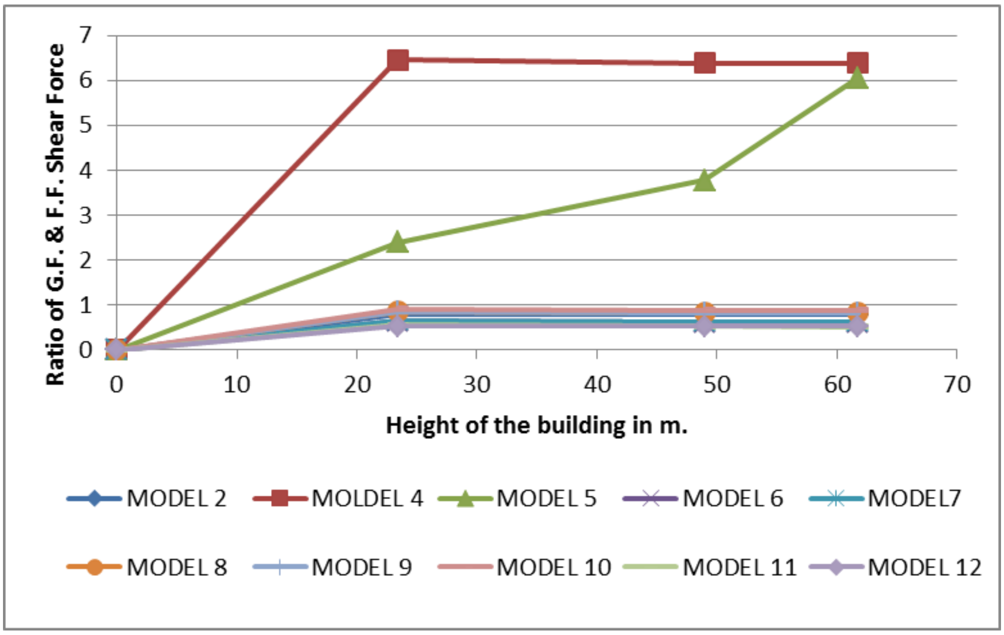

Fig. 19: Ratio of G.F. & F.F. Shear Force developed in Inner Peripheral columns

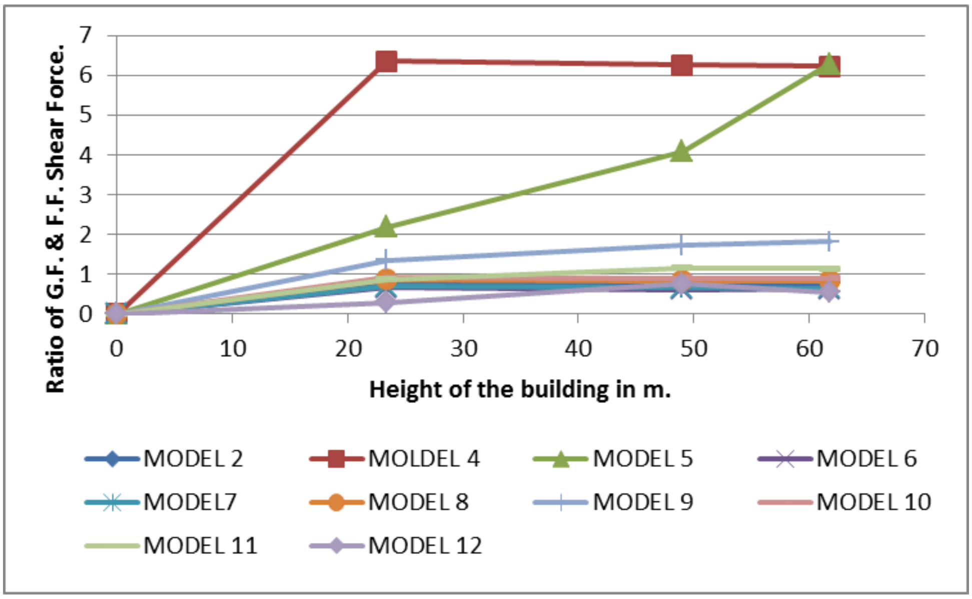

Fig. 20: Ratio of G.F. & F.F. Shear Force developed in Core columns

4.0 CONCLUSIONS

Based on the present study on three-dimensional Open Ground Storey (OGS) reinforced concrete frames subjected to seismic loading using the Equivalent Static Lateral Force Method (ESLM), the following conclusions are drawn:

Influence of Infill on Shear Forces
The presence of masonry infill significantly enhances structural stiffness, leading to a reduction in column shear forces by approximately 70% compared to bare frame structures. This demonstrates the crucial role of infill in improving lateral load distribution.

Effect of Open Ground Storey Configuration
OGS frames exhibit a substantial increase in shear forces at the ground floor, with values rising by nearly 78% compared to fully infilled frames due to stiffness discontinuity. The ground-to-first floor shear force ratio is also considerably higher, indicating pronounced soft storey behaviour.

Effectiveness of Shear Walls as LLRS
The incorporation of shear walls effectively mitigates the increased shear demand in OGS structures, reducing the ground-to-first floor shear force ratio to near acceptable levels. Properly designed shear wall configurations can achieve performance comparable to fully infilled frames.

Influence of Structural Parameters
Shear force demand is higher in peripheral and corner columns (about 10% more than inner columns), and an increase in ground floor height further amplifies shear forces (approximately 25% increase per meter). This highlights the importance of careful geometric and structural design in OGS buildings.

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CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, And/or publication of this article.

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