Comparison of Seismic Performance of RC building with Infill wall of Soft Storey, Bare frame & Infill walls without Soft Storey using Staad-Pro

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Abstract –

In order to accommodate parking needs, open ground-story structures have become a highly popular feature in multistorey projects in urban India. Even though the vulnerability of these structures to earthquake shaking was discovered during previous earthquakes, their construction is still frequently practised. Due to the lack of infills in the open ground floor, these buildings have inconsistent stiffness. Due to the larger stresses being concentrated at the ground story columns as a result of the abrupt loss in stiffness, the structure fails.
The primary goal of this research is to examine the impact of applying a soft tale to a structure. In order to create and examine these three separate G+4 RC building models, Staad Pro software is used.In the analysis, the infill walls' contribution to stiffness is taken into account by modelling them as identical diagonal struts with pins on both ends. In terms of seismic reactions like modal displacement, bending moment, lateral displacement, etc., the behaviour of soft story buildings is contrasted with a fully infilled frame building. The first story columns of fully infilled frame buildings were compared to the first story columns of open soft-storied buildings in terms of axial, shear, bending moment, and torsional moment forces. Additionally, the modification in seismic responses from zone IV is assessed. According to the aforementioned study, soft story introduction during an earthquake shaking is dangerous.

***Key Words*:** Soft storey, Infill walls, Bare frame

1.INTRODUCTION

Open ground stories are now a highly widespread practise in many nations, including India, where most urban multistory buildings are built. Wall panels with brick infill are found in the upper stories. These structures are generally referred to as soft story buildings. Due to the increased population, lack of land, and high cost of land in urban areas, these constructions are frequently carried out to help with the growing need to provide parking space. The soft narrative often resides at the ground level, but depending on the purpose for which it is being developed, it may also exist at any other story level. A soft storey is one whose lateral stiffness is less than 70% of that in the Indian seismic code IS:1893-2002 (Part-1) Open ground stories are now a highly widespread practise in many nations, including India, where most urban multistory buildings are built. Wall panels with brick infill are found in the upper stories. These structures are generally referred to as soft story buildings. Due to the increased population, lack of land, and high cost of land in urban areas, these constructions are frequently carried out to help with the growing need to provide parking space. The soft narrative often resides at the ground level, but depending on the purpose for which it is being developed, it may also exist at any other story level. A soft storey is one whose lateral stiffness is less than 70% of that in the Indian seismic code IS:1893-2002 (Part-1)

AIMS AND OBJECTIVES

This study mainly aims at studying the effect of introducing a soft story in a multistorey building. The objectives include carrying out the seismic analysis of following three models of G+4 RC building in Staad Pro software .

1. bare frame
2. fully infilled
3. open first story and brick infill walls in upper storeys

Various seismic responses such as modal time period, story stiffness, story drifts, and lateral displacements are computed. The column forces of open ground story are also evaluated. Based on these responses, the behavior of soft storied building is compared with a fully infilled frame building.

2. LITERATURE REVIEW

Zubair Ahmed, S; et al. (2014) In this research, G+5 RC building is modelled and analysed in STAAD-Pro software for three different cases i.e. model with no infill wall (bare frame), model with bottom storey open and model with steel bracing in the bottom storey. Dynamic analysis carried out using response spectrum method and performance of building evaluated in terms of storey drifts, lateral displacements, lateral forces, storey stiffness, base shear, time period and torsion.

Arlekar, J.N; et al. (1997) Investigated the behaviour of G+3 RC framed structure by using STAAD-Pro. Nine different models were analysed. Equivalent static analysis and dynamic analysis using response spectrum method were done. Argued for indiscriminate use of open first storey and suggested alternate measures such as column stiffening, provision of core wall, inclusion of soil flexibility for stiffness balance of open first storey.

Hirde, S; Tepugade, G. (2014) Discussed the performance of a G+20 RC building with soft storey at different level along with at GL using nonlinear static pushover analysis. Found that plastic hinges developed in columns of ground level soft storey which is not acceptable criteria for safe design. Displacement reduces when the soft storey is provided at higher level. Hence models retrofitted with shear walls.

Kaushik, H. B; et al. (2009) In this study, several strengthening schemes were evaluated for improving the performance of open ground storey buildings. Non-linear analysis was carried out. Developed a rational method for the calculation of the required increase in strength of open first-story columns. Other strengthening schemes such as providing additional columns, diagonal bracings, and lateral buttresses in the open first story. Code methods increased only lateral strength whereas, some of the alternate schemes studied improved both lateral strength and ductility.

Setia, S; Sharma, V. (2012) Typical six storied RC frame is analysed and modelled in STAAD-Pro software. Equivalent static analysis performed on five different models. Concluded minimum displacement for corner column is observed in the building in which a shear wall is introduced in X-direction as well as in Z-direction. Buildings with increased column stiffness of ground storey perform well in case of storey shear.

3.METHODOLOGY

Structural Modelling

Modelling a building entails assembling all of its many load-bearing components. Idealised models should accurately depict mass distribution, strength, and deformability. The slab is described as a four nodded membrane element with three degrees of freedom at each node, while the beams are modelled as lines with six degrees of freedom at each node. For modelling purposes, the comparable diagonal struts of the infill walls are used to account for their stiffness. It is expected that the strut's end connections are nailed to the containing frame. To ensure the integrated action of all the vertical and lateral load-resisting parts, floor slabs are modelled as a rigid diaphragm.

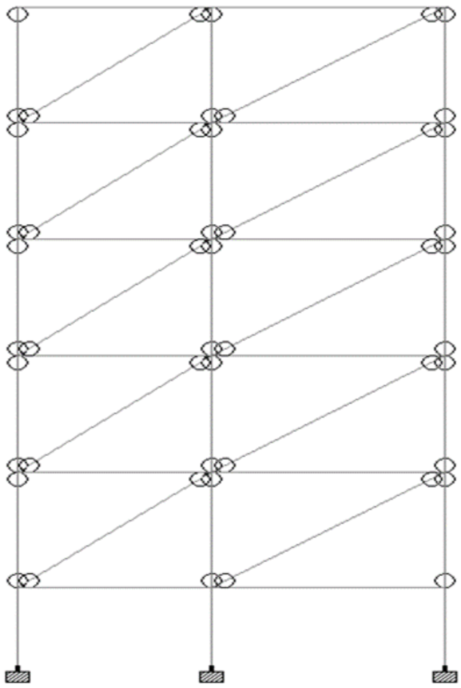


Fig.1: An Infill Building without soft storey

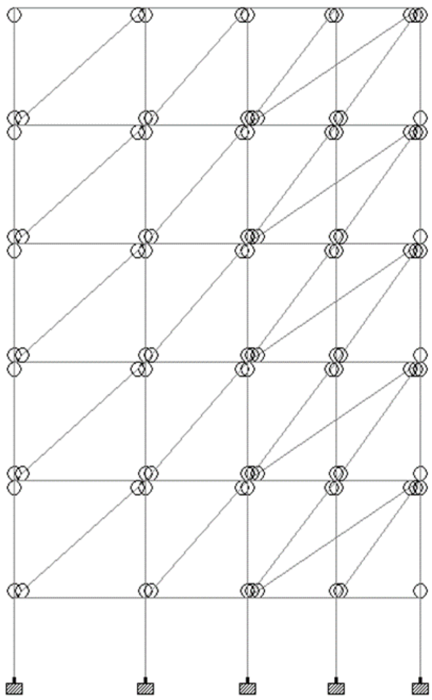


Fig.2: Modelling of infill walls (front view)

Modelling of infill walls

In standard design practise, infills are regarded as non-structural features, however they do affect the structure's general behaviour. Buildings using RC frames have more initial strength and stiffness because to infills. According to research, the infill system functions as a braced frame with compression struts formed by the wall. In order to mimic the infills, similar diagonal struts are used. This strut is modelled so that it won't help with resisting any bending moments, but it will undoubtedly help with the wall's stiffness. Struts have the same material characteristics and thickness as a brick wall. There are several empirical formulae that can be used to determine the strut's effective width.

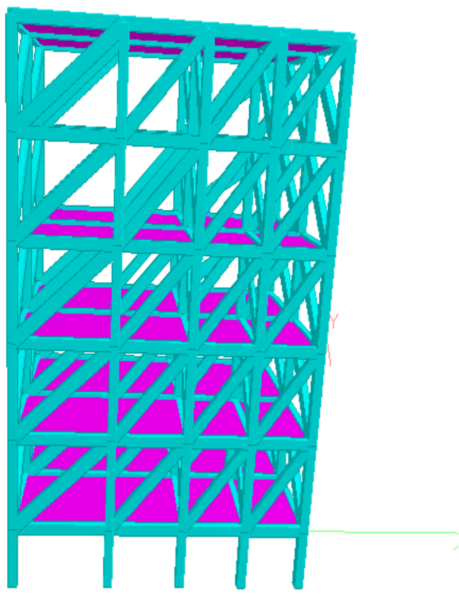
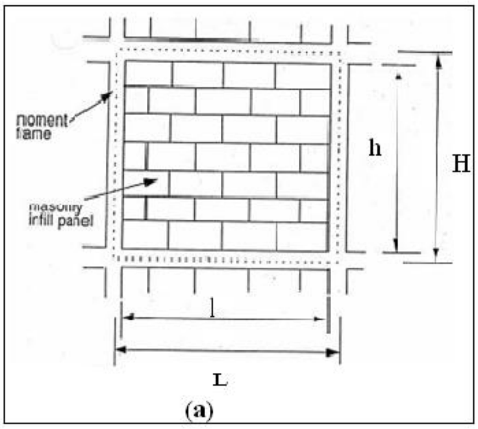


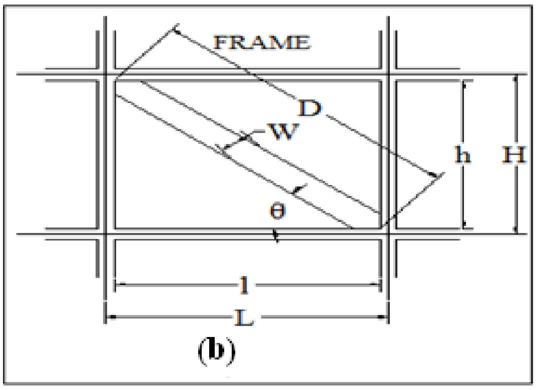
Fig.3: Modelling of infill walls (side view)

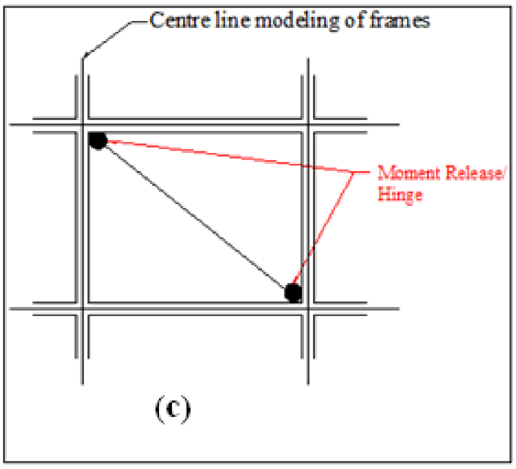
Equivalent Diagonal strut Methods

In this method the analysis is carried out by simulating the action of infills similar to that of diagonal struts bracing the frame. The infills are replaced by an equivalent strut of length D, and width W, and the analysis of the frame-strut system is carried out using usual frame analysis methods. The relationship proposed by Mainstone for computing the width of the equivalent diagonal strut, is widely used in the literature and is given by:

W= 0.175 (λ H)-0.4 D







Idealisation of brick Infill panel as equivalent diagonal strut

$$\lambda = \sqrt[4]{\frac{E_m \; t \, \mathrm{Sin}(2\theta)}{4 \, E_f I_c \, h}}$$

Where,

λ =Stiffness reduction factor

$E_{m=}$ 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.

4. RESULTS

COLUMN NO.75						
TYPE OF BUIDING	HT. OF BUILDING	DEFLECTION	SHEAR (KN)		MOMENT (KN.m))	
	(M)	(MM)	FY	FZ	My	Mz
SOFT STOREY	3	0.75	14.01	-0.98	14.38	164.35
FULL INFILL	3	1.250	-2.44	-0.08	2.82	-51.016
BARE FRME	3	2.250	8.04	-1.03	12.41	123.98

BEAM NO.90						
TYPE OF BUIDING	HT. OF BUILDING	DEFLECTION	SHEAR	(KN)	MOMENT (KN.m)	
	(M)	(MM)	FY	FZ	My	Mz
SOFT STOREY	3	1.163	0.15	0.02	-0.49	3.23
FULL INFILL	3	2.618	0.10	0.04	-1.03	1.56
BARE FRME	3	0.001	0.13	-0.01	0.01	3.27

COLUMN NO. 109						
TYPE OF BUIDING	HT. OF BUILDING	DEFLECTION	SHEAR (KN)		MOMENT (KN.m)	
	(M)	(MM)	FY	FZ	My	Mz
SOFT STOREY	6	1.250	-4.73	0.22	5.55	-98.16
FULL INFILL	6	0.750	0.80	0.08	-1.13	14.87
BARE FRME	6	0.750	7.21	-1.24	16.80	94.03

BEAM NO.124						
TYPE OF BUIDING	HT. OF BUILDING	DEFLECTION	SHEAR	(KN)	MOMENT (KN.m)	
	(M)	(MM)	FY	FZ	My	Mz
SOFT STOREY	6	2.327	0.05	0.04	-0.96	0.47
FULL INFILL	6	0.01	0.09	0.04	-0.91	1.52
BARE FRME	6	1.454	0.07	-0.01	0.03	2.33

COLUMN NO.143						
TYPE OF BUIDING	HT. OF BUILDING	DEFLECTION	SHEAR (KN)		MOMENT (KN.M)	
	(M)	(MM)	FY	FZ	MY	MZ
SOFT STOREY	9	1.0	1.10	0.10	-1.86	20.59
FULL INFILL	9	1.500	0.20	-0.01	0.34	2.04
BARE FRME	9	0.750	6.47	-1.13	15.48	77.98

BEAM NO.158						
TYPE OF BUIDING	HT. OF BUILDING	DEFLECTION	SHEAR	(KN)	MOMENT (KN.m)	
	(M)	(MM)	FY	FZ	My	Mz
SOFT STOREY	9	0.873	0.05	0.03	-0.68	0.89
FULL INFILL	9	0.873	0.05	0.03	-0.76	0.84
BARE FRME	9	1.745	0.02	-0.01	0.03	1.38

COLUMN NO.177						
TYPE OF BUIDING	HT. OF BUILDING	DEFLECTION	SHEAR (KN)		MOMENT (KN.M)	
	(M)	(MM)	FY	FZ	MY	MZ
SOFT STOREY	12	1.250	0.04	-0.04	0.82	-1.19
FULL INFILL	12	1.250	0.20	-0.01	0.19	1.98
BARE FRME	12	0.750	5.10	-0.88	12.76	53.16

BEAM NO.198						
TYPE OF BUIDING	HT. OF BUILDING	DEFLECTION	SHEAR	(KN)	MOMENT (KN.m)	
	(M)	(MM)	FY	FZ	My	Mz
SOFT STOREY	12	2.618	0.02	0.02	-0.47	0.32
FULL INFILL	12	2.618	0.03	0.03	-0.52	0.46
BARE FRME	12	2.036	-0.05	-0.01	0.05	-0.09

COLUMN NO.211						
TYPE OF BUIDING	HT. OF BUILDING	DEFLECTIO N	SHEAR(KN)		MOMENT (kn.M)	
	(M)	(MM)	Fy	Fz	My	Mz
SOFT STOREY	15	2.250	0.01	0.02	-0.18	-0.18
FULL INFILL	15	2.00	-0.02	0.02	-0.14	-0.83
BARE FRME	15	0.750	2.42	-0.70	9.39	17.21

BEAM NO.226						
TYPE OF BUIDING	HT.OF BUILDING	DEFLECTION	SHEAR	(KN)	MOMENT (KN.m)	
	(M)	(MM)	FY	FZ	My	Mz
SOFT STOREY	15	2.618	0.01	0.01	-0.24	0.20
FULL INFILL	15	2.618	0.02	0.01	-0.26	0.23
BARE FRME	15	2.036	-0.05	-0.01	-0.01	-0.25

5. CONCLUSION

- RC frame buildings with open first storeys are known to perform poorly during in strong earthquake shaking. In this paper, the seismic vulnerability of buildings with soft first storey is shown through an example building. The drift and the strength demand in the first storey columns are large for buildings with soft ground storeys and hence necessary measures should take to improve capacities of the columns in the soft first storey.
- From the analysis it is seen that, deflection is more in case of bare frame as compare to that of infill frame, because presence of infill contributes to the stiffness of building.
- When the position of soft storey moved to higher level then parameters tends to reduced.
- Results shows that Moments & Shear forces are always maximum at soft storey level in soft storey Models.
- These results will help design engineers in fast & reliable assessment of effects of soft storey.
- Thus, proper care, expert design, detailing and execution are needed in soft storey buildings.
- A soft storey will have 17% to 20% more roof displacement as compared to a building without soft storey.

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