SEISMIC PERFORMANCE OF A RC FRAME WITH SOFT STOREY CRITERIA

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Abstract

Soft first storey is a typical feature in the modern multi-storey constructions in urban India. Social and functional need to provide parking space at ground level leads seismic vulnerability of such a building. The computer software usage in civil engineering has greatly reduced the complexities of different aspects in the analysis and design of projects. In the present study an attempt has been made to investigate the seismic behaviour of a multi-storey building with soft first storey. When subjected to seismic loads, it was observed that soft storey frames are less resistant when compared to infill frames.

Keywords: *Masonry Infill (MI), Soft storey, relative stiffness, Diagonal strut, Base shear, response spectrum analysis, Time history analysis.*

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1. INTRODUCTION

Increasing population since the past few years has made car parking space for residential apartments in populated cities is a matter of major problem. So that constructions of multi-storeyed buildings with open first storey is a common practice all over THE world. Hence the trend has been to utilize the ground storey of the building itself for parking or reception lobbies in the first storey. These types of buildings having no infill masonry walls in ground storey, but all upper storeys infilled in masonry walls are called "soft first storey or open ground storey building."

This soft storey creates a major weak point in an earthquake, and since whole building down with them, causing serious structural damage soft stories are classically associated with reception lobbies retail spaces and parking garages on the lower stories of a building, which means that when they collapse, they can take the which may render the structure totally unusable.

2. MATERIALS & METHODS

- A study is undertaken which involves seismic analysis of RC frame buildings with different models that include bare frame, infilled frame and open first storey frame. The parameters such as base shear, time period, natural frequency, storey drift and bending moments are studied. The software SAP2000 is used for the analysis of the entire frame models.
- 2D RC frames with three bays having one to five storeys are considered with different configuration of MI for the dynamic analysis using SAP 2000 software. The model specifications are kept same as that for CPRI models.
- Equivalent strut method is used for modelling the MI assuming the thickness of strut to be equal to the thickness of MI and the width of diagonal strut is carried out.
- Modal analysis was carried out to obtain natural frequencies and mode shapes and the results are compared with available experimental results obtained from shake table tests results conducted at CPRI, Bangalore and the models are validated. By increasing bays and storeys, dynamic analysis is continued with modal analysis to obtain natural frequencies followed by equivalent static and response spectrum analysis are carried out to obtain base shear and displacement for all the zones (II- V) as per IS 1893 (Part 1):2002, time history analysis are carried out using Bhuj earthquake data to obtain displacement.

3. RESULTS & DISCUSSIONS

Table-1: Analysis Results Modal

Models	Natural Frequency Freq (Hz)
3B2S	21.51
3B2SF	47.9
3B2SS	15.52
3B3S	14.07
3B3SF	31.5
3B3SS	12.7
3B4S	10.39
3B4SF	20.81
3B4SS	7.89
3B5S	8.21
3B5SF	14.88
3B5SS	6.77

Note:3B2S-3 Bay 2 Storey bare frame
3B2SF- 3Bay 2 Storey infilled Frame
3B2SS- 3 Bay 2 Storey with Soft first storey

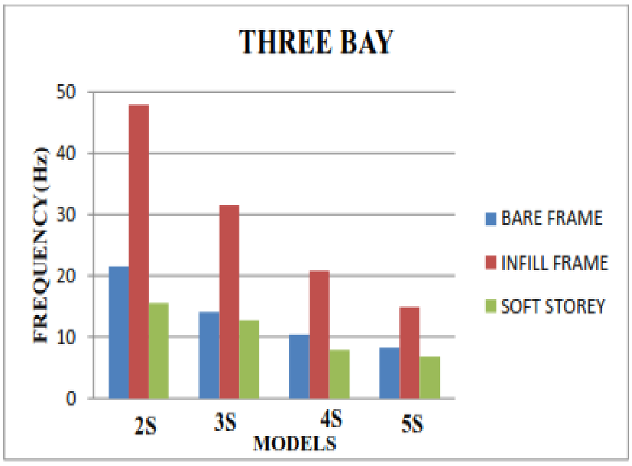

Chart-1: Comparison of Natural Frequency (Hz) for Three Bay

Modal analysis was carried out for three bays with one to five storeys. Chart-1. shows the comparison of natural frequencies (Hz) for bare frame, MI and soft storey conditions. It is observed that the natural frequency of soft storey decreases compare to bare frame and infill frame, whereas the natural frequency of infill frame are also double the frequency of the bare frames. The natural frequency of soft storey decreases by 60% compare to MI.

Table-2: Equivalent Static and Response Spectrum Analyses Results

Models	Base shear (N)
3B2S	243
3B2SF	1537
3B2SS	879
3B3S	365
3B3SF	2533
3B3SS	1810
3B4S	486
3B4SF	3377
3B4SS	2654
3B5S	607
3B5SF	4221
3B5SS	3499

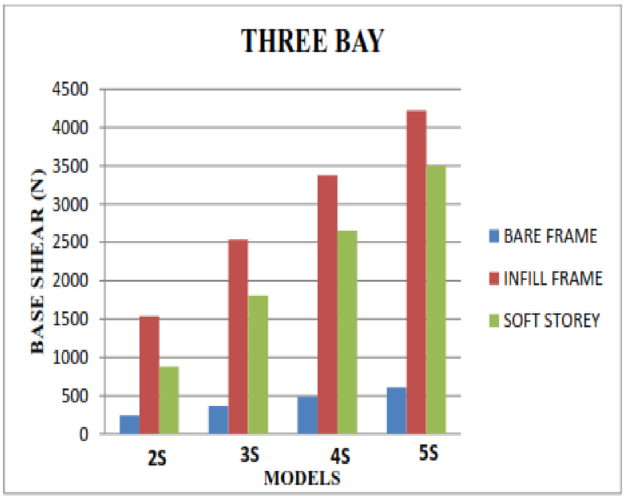

Chart-2: Comparison of Base Shear (N) for Three Bay

Chart-2 shows the comparison of base shear (N) for bare frame, infill frame, and soft storey for three bays upto five storeys. It is observed that base shear is least for bare frames and highest for MI frames. Base shear of soft storey decreases by about 20% when compare to MI frame.

Table-3: Response Spectrum Analysis Results

STOREY LEVEL	*Displacement (mm)*		
	Bare	*Infill*	*Soft*
2	0.08	0.01	0.11
3	0.2	0.03	0.25
4	0.38	0.07	0.39
5	0.61	0.13	0.55

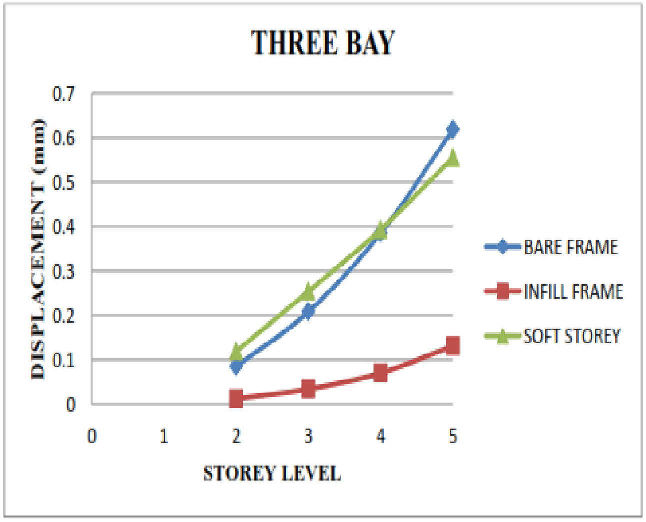

Chart-3: Comparison of Displacement (mm) for Three Bay

Chart-3 shows the comparison of displacement (mm) for bare frame, MI, and soft storey conditions with three bays upto five storeys. It is observed that the displacement in the soft storey is maximum in the lower storeys as compared to the other two conditions which show its criticality in the earthquake resistant design. Whereas in the upper floors, the displacement is higher in bare frame as compared to soft storey condition. Displacements in the MI frames are least due to the presence of infill.

Table-4: Equivalent Static Analysis Results

STOREY LEVEL	*Inter - storey drift (mm)*		
	Bare	*Infill*	*Soft*
1	0.68	0.14	0.56
2	0.56	0.11	0.1
3	0.38	0.08	0.07
4	0.21	0.05	0.04
5	0.08	0.02	0.02

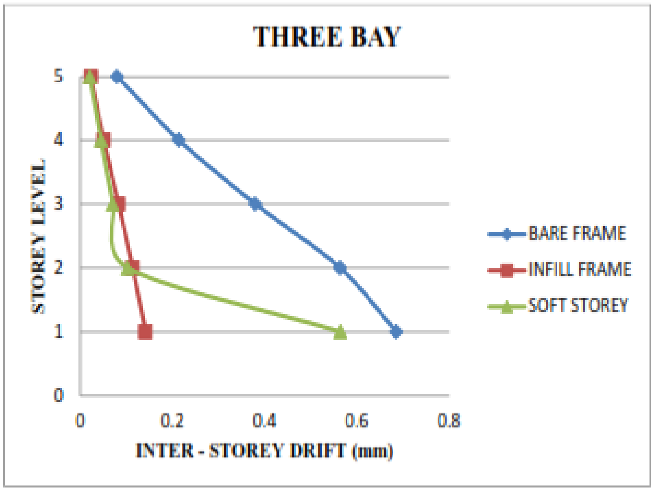

Chart-4: Comparison of Inter-Storey Drift (mm) for Three Bay

Chart-4 shows the comparison of Inter-storey drift (mm) for bare frame, MI, and soft storey conditions with three bays upto five storeys. The inter-storey drift in the first storey are large for soft storey compared to bare frame and infill frame which shows the sudden change in slope of drift, this is due to the abrupt change in storey stiffness, whereas the bare frame and infill frame shows a smooth profile. For soft storey, the inter-storey drift in the first storey increases by 53% of the second storey compared to bare frame and infill frame.

Table-5: Time History Analysis Results

STOREY LEVEL	*Displacement (mm)*		
	Bare	*Infill*	*Soft*
2	0.12	0.01	0.25
3	0.29	0.03	0.54
4	0.59	0.06	0.8
5	0.92	0.14	1.43

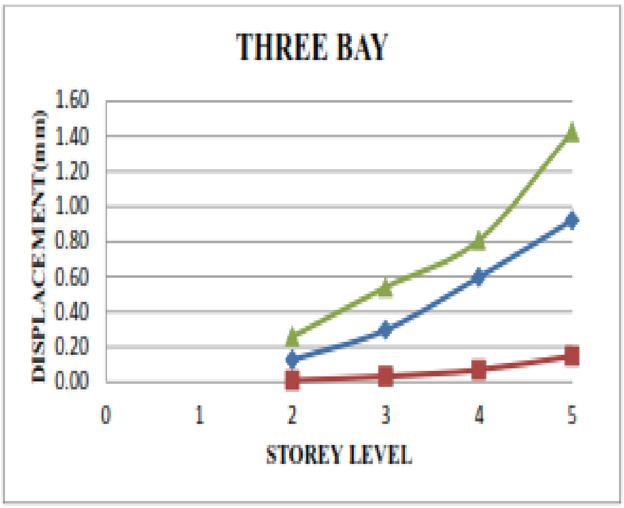

Chart- 5: Comparison of Displacement (mm) For Three Bay

Chart-5 shows the comparison of displacement (mm) for bare frame, infill frame, and soft storey of three bays with respect to the time history analysis using Bhuj earthquake data. It is observed that the large displacement occurs in soft storey compare to bare frame and infill frame. Displacements of soft storey is increased by 75% compare to infill frame.

4. CONCLUSION

Infilled frames should be preferred in seismic regions than the open first storey frame, because the storey drift of first storey of open first storey frame is very large than the upper storeys, this may probably cause the collapse of structure.

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