Behavior of Soft Storey Building

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ABSTRACT :

Soft storey buildings are now a days are common feature in modern multistory constructions in urban India. The main requirement of such type of construction is for parking purpose. But on the other hand they are inherently vulnerable to collapse due to earthquake load.

This paper aims to show the importance of the presence of the open storey in the construction of the building and the error involved in modeling such buildings is studied by using different models with different properties. This paper suggest the immediate measures to prevent the indiscriminate use of soft storeys in buildings, which are designed without regard to the increased displacement, ductility and force demands in the storey columns.

KEYWORDS: - concrete, earthquake, infill, multistory, soft story.

1. INTRODUCTION:

Many urban multistorey buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storeys. The upper storeys have brick infilled wall panels.

The draft Indian seismic code classifies a soft storey as one whose lateral stiffness is less than *50%* of the storey above or below [Draft IS:1893, 1997]. Interestingly, this classification renders most Indian buildings, with no masonry infill walls in the first storey, to be “buildings with soft first storey.” Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height. In buildings with soft first storey, the upper storeys being stiff, undergo smaller inter-storey drifts. However, the inter-storey drift in the soft first storey is large. The strength demands on the columns in the first storey are also large, as the shear in the first storey is maximum. This has adverse effect on the performance of buildings during ground shaking. Such buildings are required to be analyzed by the dynamic analysis and designed carefully.

Figure 1 :: Damage to columns

Figure 2 :: Damage to columns in the soft storey

2. BUILDING UNDER STUDY:

The plan layout of the reinforced concrete moment resisting frame building with one open storey and un-reinforced brick infill walls in the other storeys, chosen for this study is shown in Fig. 3. The building is deliberately kept symmetric in both orthogonal directions in plan to avoid tensional response under pure lateral forces. The building is considered to be located in seismic zone III and intended for commercial use. The building is founded on medium strength soil through isolated footings. The other building parameters are as follows.

- G+7 & G+15 Buildings
- Symmetrical
- Medium strength soil
- Isolated footings

- M20 and Fe415
- Column size: 300 mm X 600mm
- Beam size: 600mm X 300mm
- Office Building (Commercial)
- Floor finish: 1 KN/m^2
- Dead load: 25KN/m^3
- Live load 2 KN/m^2

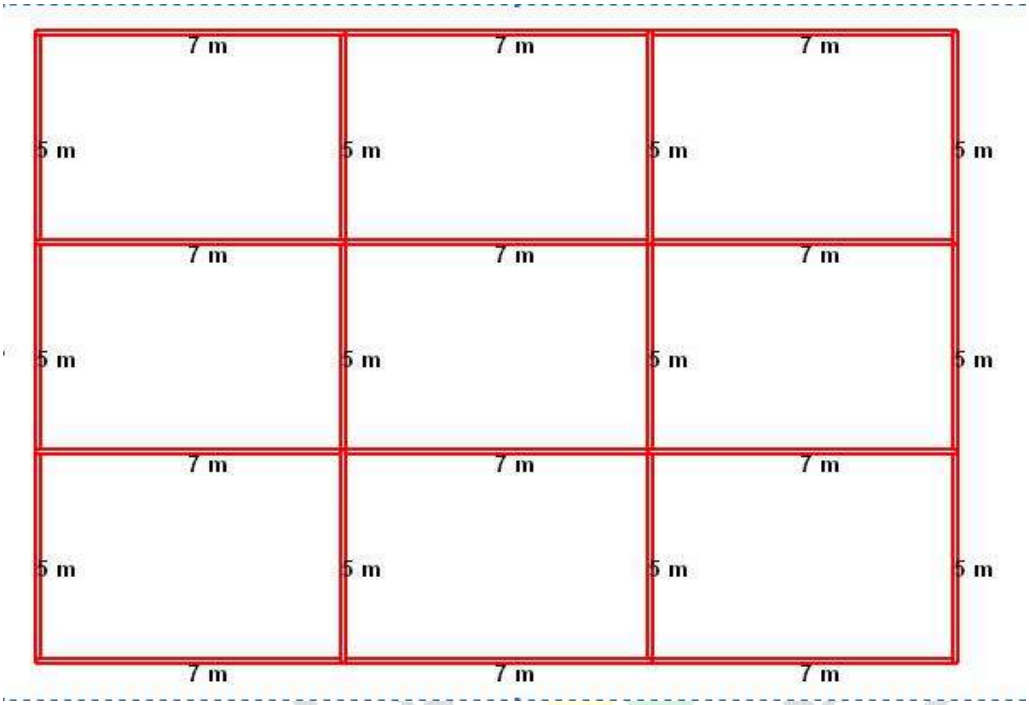
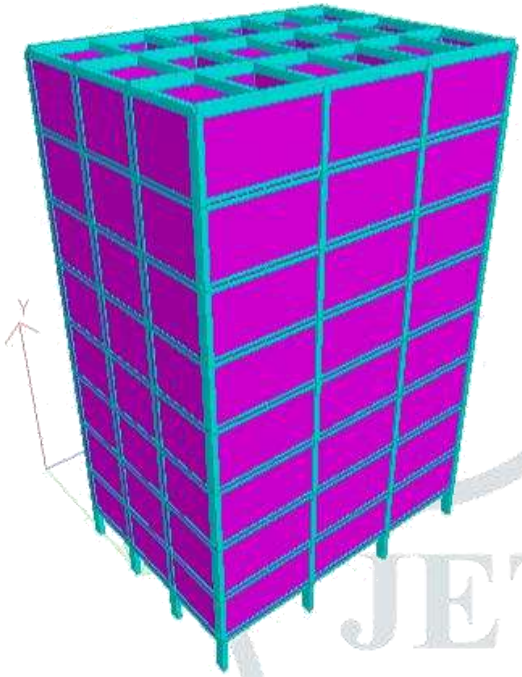
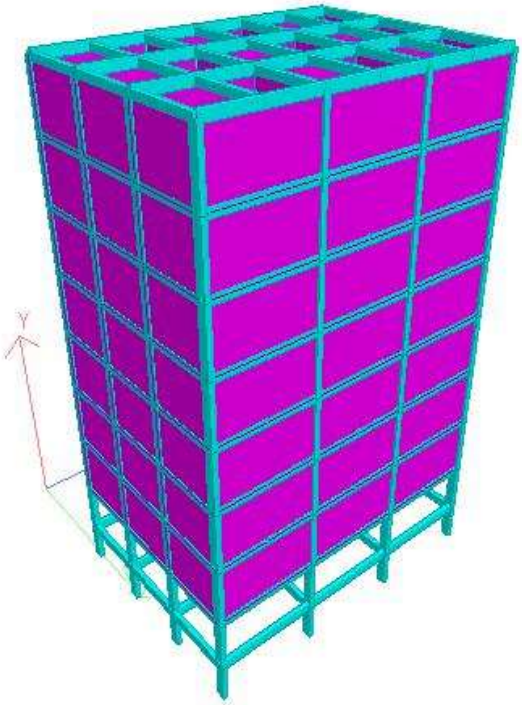


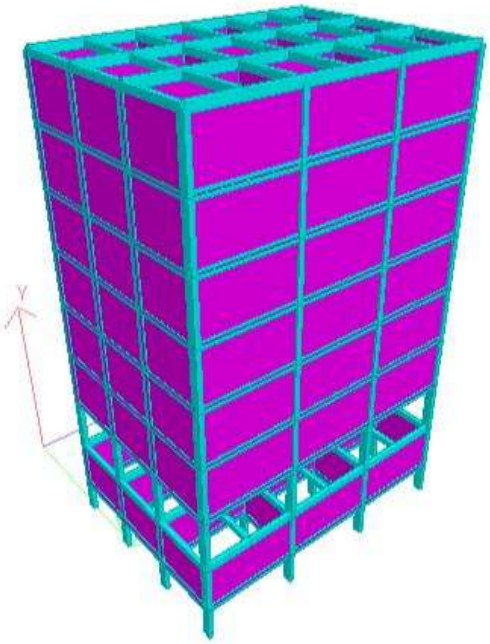
FIGURE 3 :: PLAN AT A GROUND FLOOR OF THE EXAMPLE BUILDING CONSIDERED IN THE STUDY



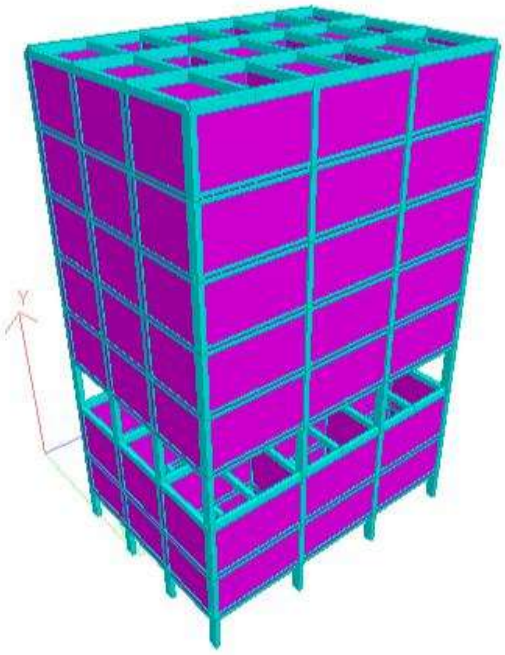
Elevation 1: Building with No Soft Storey



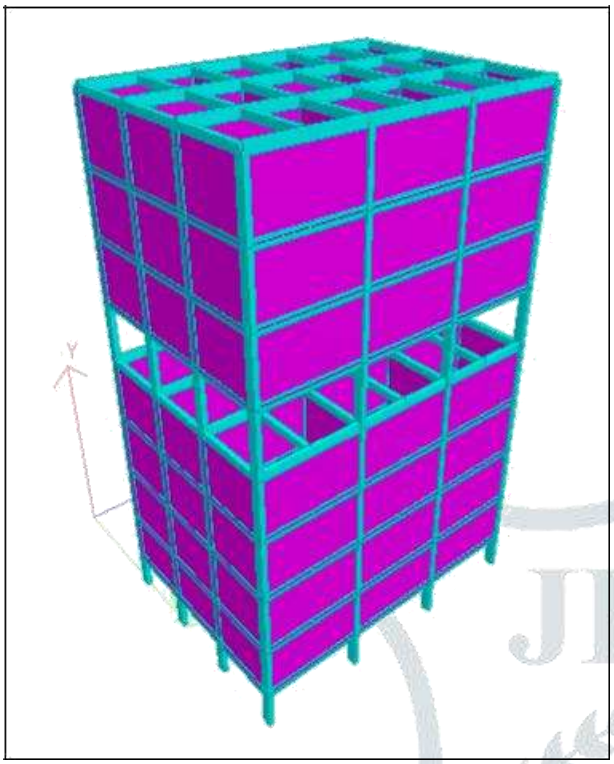
Elevation 2: Building with Ground Floor as Soft Storey



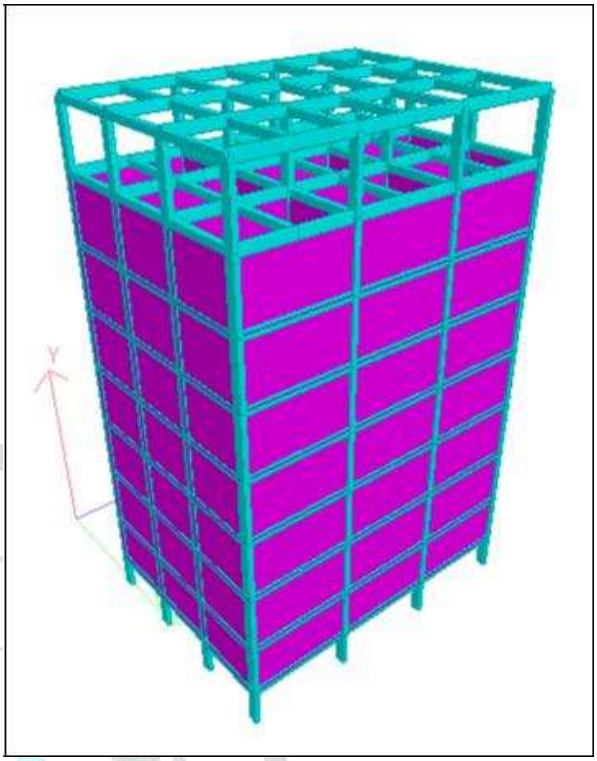
Elevation 3: Building with First Floor as Soft Storey



Elevation 4: Building with Second Floor as Soft Storey



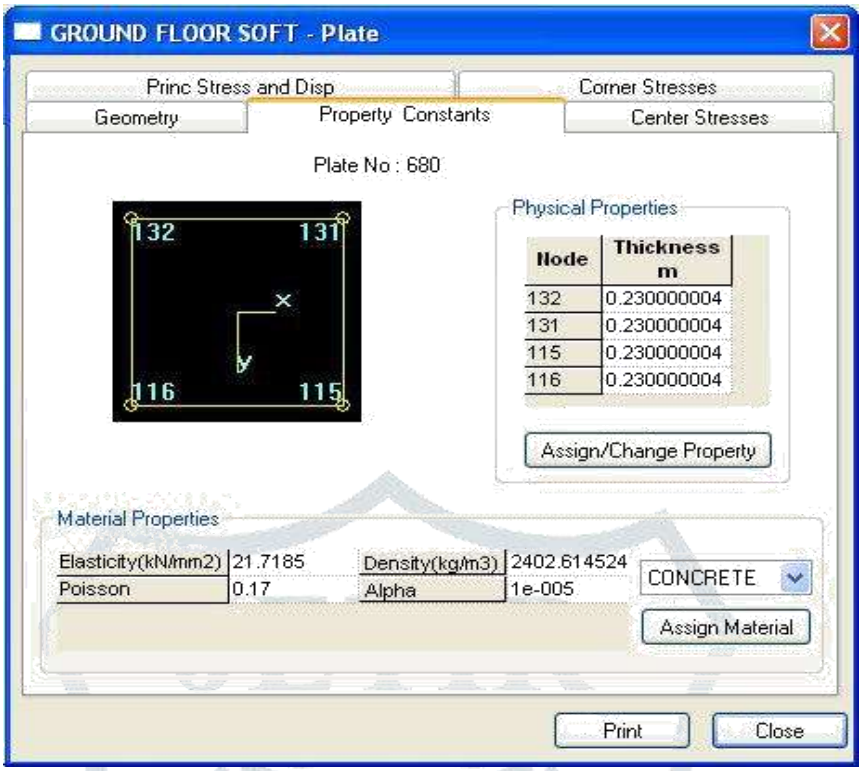
Elevation 5: Building with Fourth Floor as Soft Storey



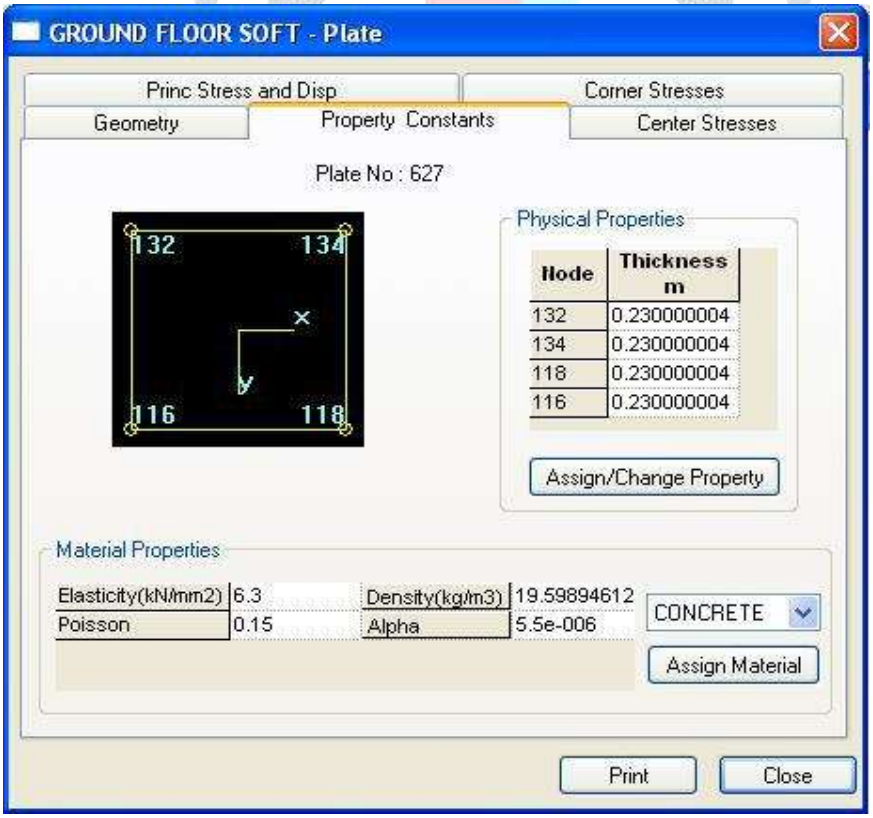
Elevation 6: Building with Top Floor as Soft Storey

3. EQUIVALENT STATIC ANALYSIS:

The natural period of the building is calculated by the expression, $T=0.09H/\sqrt{D}$ given in IS: 1893-2002, wherein *H* is the height and *D* is the base dimension of the building in the considered direction of vibration. Thus, the natural periods for all the models in this method is the same. The lateral load calculation and its distribution along the height is done as per IS: 1893-1984.



:Properties of Concrete 4-noded Plate Element:



: Properties of Brick 4-noded Plate Element:

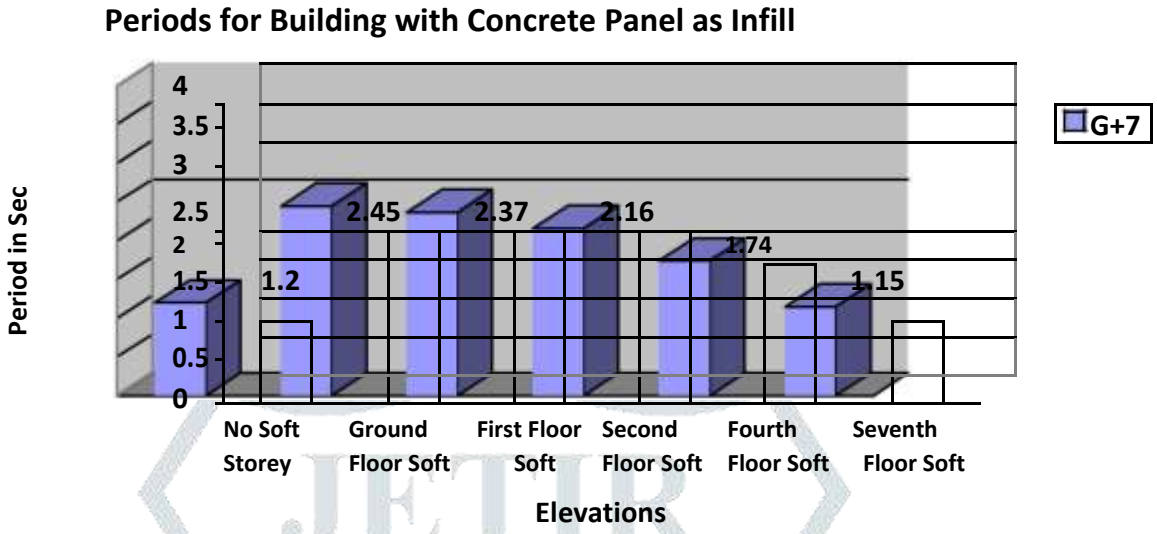
4. RESULTS AND DISCUSSIONS:

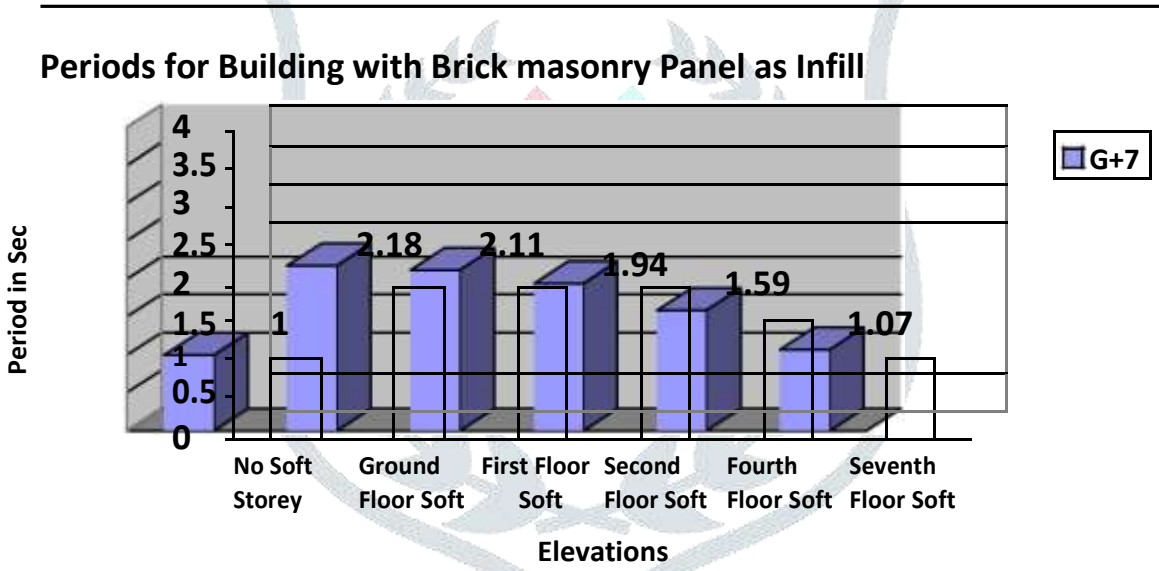
Comparison of Period:

Sr. No.	*ELEVATION*	*Building with Concrete Panels*	*Building with Brick Masonry Panels*
		G+7	G+7
1	Building with No Soft Storey	1.20	1.05
2	Building with Ground Floor as Soft Storey	2.45	2.18
3	Building with First Floor as Soft Storey	2.37	2.11
4	Building with Second Floor as Soft Storey	2.16	1.94
5	Building with Fourth Floor as Soft Storey	1.74	1.59
6	Building with Seventh Floor as Soft Storey	1.15	1.07

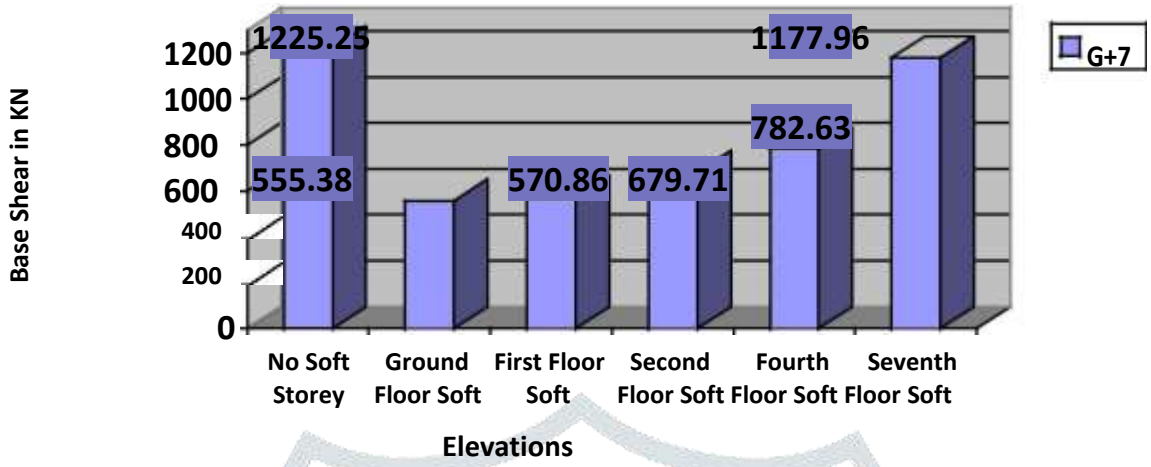
Comparison of Base Shear:

Sr. No.	*ELEVATION*	*Building with Concrete Panels*	*Building with Brick Masonry Panels*
		Base Shear Along X Direction in KN	
1	Building with No Soft Storey	1225.25	304.51
2	Building with Ground Floor as Soft Storey	555.38	143.68
3	Building with First Floor as Soft Storey	570.86	192.51
4	Building with Second Floor as Soft Storey	679.71	236.85
5	Building with Fourth Floor as Soft Storey	782.63	283.41
6	Building with Seventh Floor as Soft Storey	1177.96	304.29
Sr. No.	*ELEVATION*	*Building with Concrete Panels*	*Building with Brick Masonry Panels*
		Base Shear Along Z Direction in KN	
1	Building with No Soft Storey	1706.98	413.30
2	Building with Ground Floor as Soft Storey	857.34	221.00
3	Building with First Floor as Soft Storey	861.17	220.11
4	Building with Second Floor as Soft Storey	940.22	221.53
5	Building with Fourth Floor as Soft Storey	1113.06	233.72
6	Building with Seventh Floor as Soft Storey	1668.79	375.88

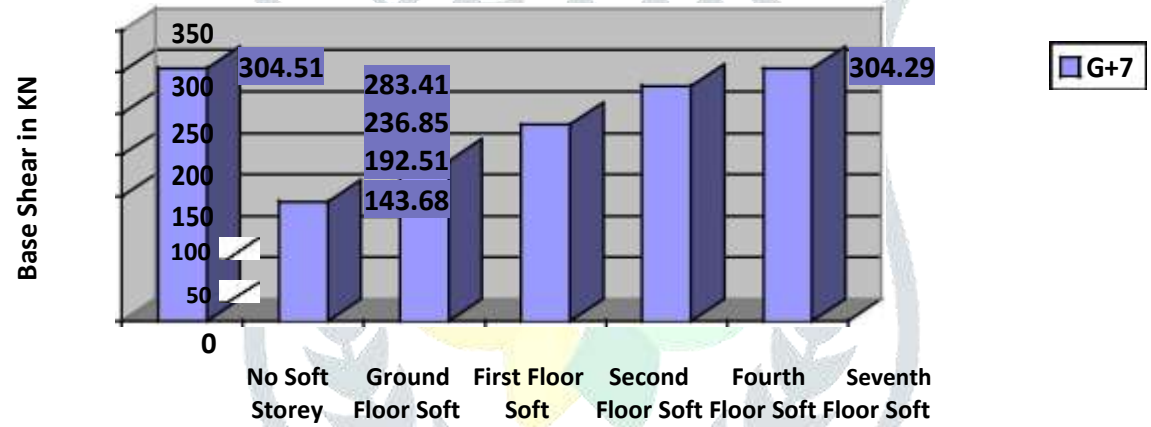

Periods for Building with Concrete Panel as Infill
Period in Sec
4
3.5
3
2.5
2
1.5
1
0.5
0
1.2
2.45
2.37
2.16
1.74
1.15
G+7
No Soft Storey
Ground Floor Soft
First Floor Soft
Second Floor Soft
Fourth Floor Soft
Seventh Floor Soft
Elevations

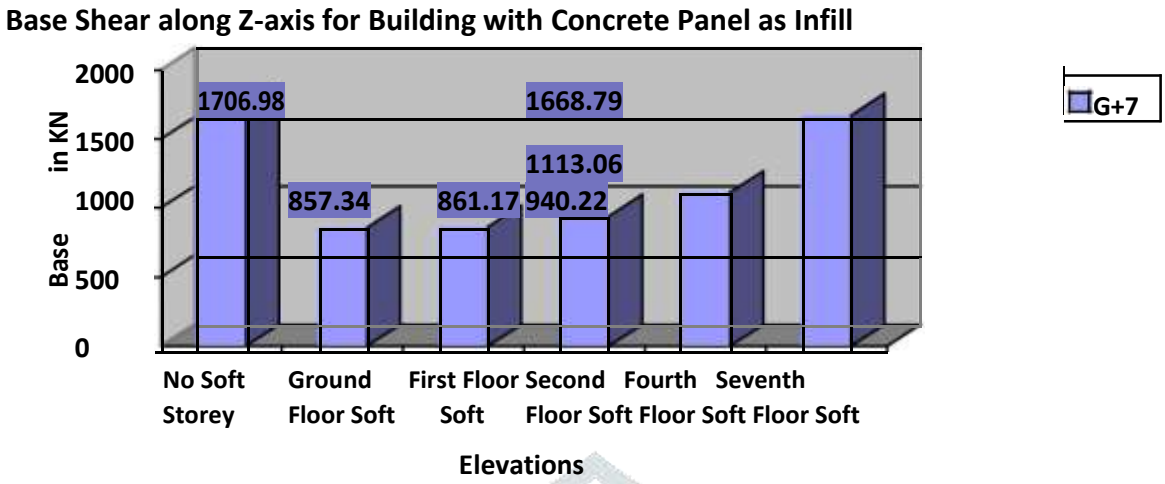

Periods for Building with Brick masonry Panel as Infill
Period in Sec
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2.18
2.11
1.94
1.59
1.07
G+7
No Soft Storey
Ground Floor Soft
First Floor Soft
Second Floor Soft
Fourth Floor Soft
Seventh Floor Soft
Elevations

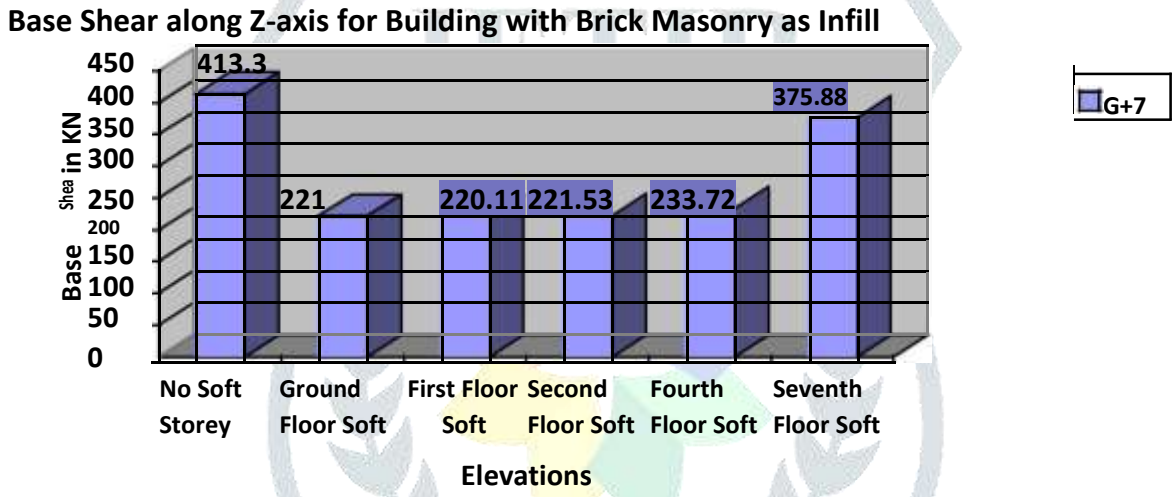
Base Shear along X-axis for Building with Concrete Panel as Infill



Base Shear along X-axis for Building with Brick Masonry as Infill




Base Shear along Z-axis for Building with Concrete Panel as Infill
Base in KN
2000
1500
1000
500
0
1706.98
857.34
861.17
1668.79
1113.06
940.22
G+7
No Soft Storey
Ground Floor Soft
First Floor Soft
Second Floor Soft
Fourth Floor Soft
Seventh Floor Soft
Elevations


Base Shear along Z-axis for Building with Brick Masonry as Infill
Base Shea in KN
450
400
350
300
250
200
150
100
50
0
413.3
221
220.11
221.53
233.72
375.88
G+7
No Soft Storey
Ground Floor Soft
First Floor Soft
Second Floor Soft
Fourth Floor Soft
Seventh Floor Soft
Elevations

5. CONCLUSIONS:

RC frame buildings with open first storeys are known to perform poorly during in strong earthquake shaking. The seismic vulnerability of buildings with soft first storey is shown through an example building. The drift and the strength demands in the first storey columns are very large for buildings with soft ground storeys. It is not very easy to provide such capacities in the columns of the first storey. Thus, it is clear that such buildings will exhibit poor performance during a strong shaking. This hazardous feature of Indian RC frame buildings needs to be recognized immediately and necessary measures are neede to improve the performance of these buildings. More importantly, the performance of buildings those are having top (i.e. 7^{th} floor) storey as soft storey is better than the other. In fact the base shear value is almost same as that of building with no soft storey.

6. FUTURE SCOPE

The open first storey is an important functional requirement of almost all the urban multi-storey buildings, and hence, cannot be eliminated. Alternative measures needed to be adopted for this specific situation. The under-lying principle of any solution to this problem is in (a) increasing the stiffnesses of the first storey such that the first storey is at least *50%* as stiff as the second storey, *i.e.*, soft first storeys are to be avoided, and (b) providing adequate lateral strength in the first storey.

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