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ANALYSIS OF (G+10) MULTISTOREY BUILDING WITH THE EFFECT OF SOFT STORY BY TIME HISTORY METHOD

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Abstract: In the recent trend the multi-storey buildings is the most common word in the construction source, in these buildings the concept of open ground building (OGS) has taken its place in the urban environment due to the fact that it provides the parking facility in the ground storey of the building, as the cost of construction of this type of building is much less than that of a building with basement parking for retail or commercial use. These open ground buildings which possess storey that are significantly weaker or more flexible than adjacent storey are known as soft storey buildings. Soft story's are subjected to larger lateral loads during earthquakes and under lateral loads their lateral deformations are greater than those of other floors so the design of structural members of soft stories is critical and it should be different from the upper floors.In the present study the structural behavior of building is investigated under different cases such as open ground compared bare frame, partial infill walls. Analyzing the structure (using the Program SAP-2000 V16) for various earthquake intensities and checking for multiple criteria at each level has become an essential practice. The linear method of Equivalent static and Time History analysis is carried over to find out the structural behavior.

Keywords: Soft Storey, open ground storey, infill walls, non-structural elements, bare frame, Equivalent static analysis, Time History analysis, SAP-2000 V16.

I. Introduction

A soft story building is a multi-story building with one or more floors which are "soft" due to structural design, generally this buildings are characterized by having a story which has a lot of open space such as parking garages, or large retail spaces or floors with a lot of windows. Since soft stories are classically associated with retail spaces and parking garages, they are often in the lower stories of a building, and the upper floors of most buildings are more rigid than their base floors, as a result the seismic behaviors of the base and the upper floors are significantly different from each other. While the unobstructed space of the soft story might be aesthetically or commercially desirable, it also means that there are fewer opportunities to install shear walls, specialized walls, which are designed to distribute lateral forces so that a building can be able to resists to the swaying characteristic of an earthquake. Soft story impact is also exists at intermediate floors (such as wide balconies, partial rise walls etc.,).

Fig 1: Soft Storey Buildings

Source of the Study:

Soft Stories are usually present in modern frame buildings, as the structural elements are homogenously distributed throughout the building but the apartments are located on the upper floors with many masonry walls, while the ground floor is left totally or partially free of partitions for parking vehicles and for social areas that require wide spaces. In the case of double height ground soft stories, columns are very flexible not only due to the total or partial absence of walls, but as a result of their significantly greater height in relation with those from the upper floors. This configuration is one of the character models of modern design for office buildings, hotels and hospitals, in which the access for the general public has a great importance.

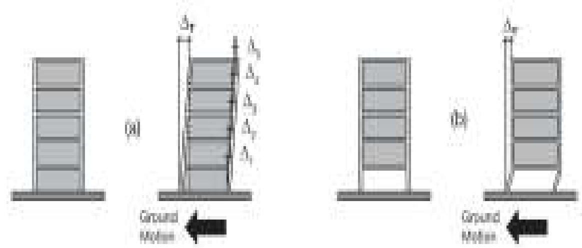

Fig.2. Response of the building due to ground motion (a) a regular building, (b) an building with soft story irregularity.

Methodology:

Three Dimensional analysis of the building is done using standard software program SAP 2000 -V16, which is stimulated into two phase, in the first phase the obtained building is modeled to G+10 storied structure for three different models – Bare framed building model, Open

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ground story building model and partial infill walls building model, these building are analyzed to the gravity loads and seismic loads and finding out the response of the structure (i.e., mode shapes, shear force and other various output of the building) and second phase is that linear time history method is analyzed. Broadly, we can say that the linear analysis of structures to compute the earthquake forces is commonly based on one of the following three approaches.

- An Equivalent Lateral procedure in which dynamic effects are approximated by horizontal static forces applied to the structure. This method is quasi-dynamic in nature and is termed as the Seismic Coefficient Method in the IS code.
- The Response Spectrum Approach in which the effects on the structure are related to the response of simple, single degree of freedom of the time history of varying natural periods to earthquake shaking.
- Response History Method or Time History Method, in which direct input of the time history of a designed earthquake into a mathematical model of the structure using computer analyses.

Considered Models:

Model 1: Bare frame building.

Model 2: Open ground store Building

(Having soft storey at ground floor)

Model 3: Building with Partial Infill Walls in Ground floor.

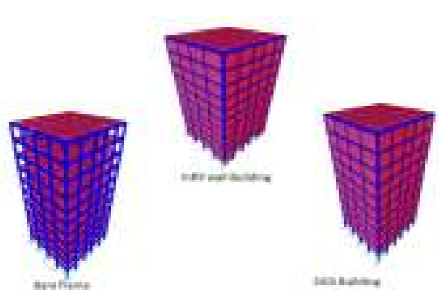


Fig.3 Different building frames

Fig 4 Building Plan

Structural Details of the building:

Length of the building (along X Direction)	17 m
Width of the building (along Y Direction)	16 m
Height of the building (G+10)	33 m
Column Dimension	0.45 m*0.45 m
Beam Dimension	0.3 m*0.45 m
Slab thickness	0.12 m
External wall thickness	0.23 m
Internal wall thickness	0.1 m
Concrete Grade	M 30
Steel Grade	Fe 415

Loading Conditions:

Dead Loads:

a) Self weight of slab = 3 KN/m^2

b) Floor Finish load = 1 KN/m^2

c) Masonry Wall Load (outer) = 13.8 KN/m

d) Masonry Wall Load (inner) = 6 KN/m

Live Load

a) Typical floors = 3 KN/m^2

b) Top floor = 1.5 KN/m^2

Earthquake Loads

As per IS 1893-2002

a) Earthquake Zone-II

b) Response Reduction Factor: 3

c) Importance Factor: 1.5

d) Soil Type: Medium Soil

Considered Ground motions

Linear Time History Analysis is carried out for three ground motions

- Loma Prieta earthquake ground motion

In 1989 Loma Prieta earthquake ground motion which occurred at two rock sites in San Francisco having a movement magnitude of 7.0 and duration of strong motion at the rock sites and usually short source duration for an earthquake of this size, the records in Oakland show strong amplification effects due to the site geology.

- EI Centro earthquake ground motion

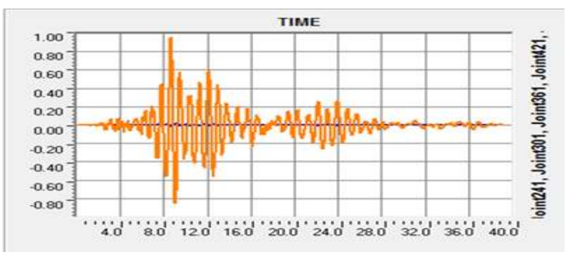
  In 1940 EI Centro earthquake ground motion which occurred in the imperial valley having a movement magnitude of 6.9 and maximum perceived intensity of X on the intensity scale and first major earthquake recorded by a strong motion seismograph.

- Bhuj earthquake ground motion

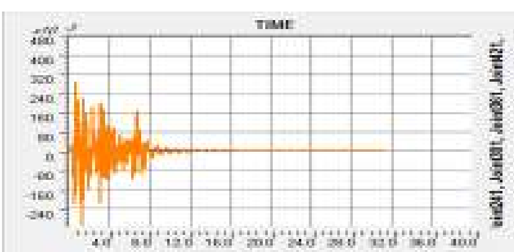
  Third ground motion is of 26th January 2001 kachchh region of Gujarat state Bhuj earthquake of movement magnitude 7.7 occurred along the kachchh main land fault.

Results & Discussion:

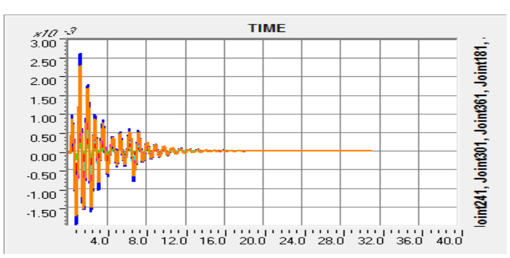
Model – I Bare Frame Building



Graphs-1 Response of the Bare Framedstructure for Loma Prieta earthquake ground data.



Graphs-2 Response of the Bare Framedstructure for BHUJ earthquake ground data



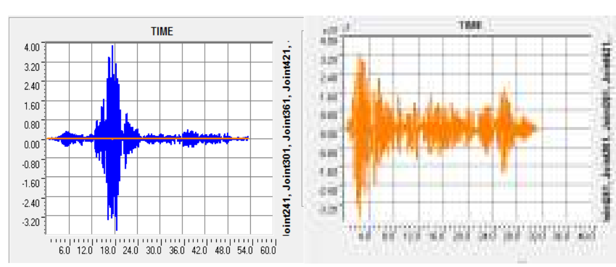
Graphs-3 Response of the Bare Framedstructure for El Centro earthquake ground data.

Table-1 Bare frame building response for various joints for different ground motions

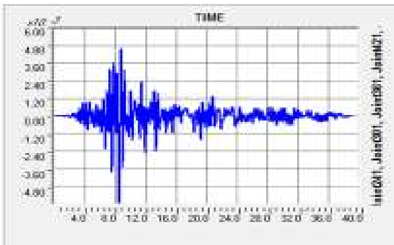
Type of Building	Earthquake Ground data	Bare frame-X Direction (deflection in mm)		Bare frame-Y Direction (deflection in mm)	
		Positive Direction	Negative Direction	Positive Direction	Negative Direction
Joint 2	LOMA PIRETA	1.497	-1.622	1.435	-1.582
	BHUJ	1.352	-1.360	1.540	-1.588
	EL CENTRO	2.090	-2.320	2.333	-2.191
Joint 241	LOMA PIRETA	5.571	-6.034	5.454	-6.056
	BHUJ	4.527	-4.854	5.200	-5.715
	EL CENTRO	7.633	-7.627	7.991	-7.470
Joint 301	LOMA PIRETA	9.425	-1.022	9.264	-1.037
	BHUJ	7.627	-8.098	8.345	-8.827
	EL CENTRO	1.279	-1.135	1.328	-1.131
Joint 361	LOMA PIRETA	1.263	-1.371	1.243	-1.398
	BHUJ	1.048	-1.092	1.199	-1.178
	EL CENTRO	1.795	-1.430	1.811	-1.417
Joint 421	LOMA PIRETA	1.491	-1.622	1.468	-1.654
	BHUJ	1.304	-1.300	1.478	-1.426
	EL CENTRO	2.284	-1.745	2.275	-1.759
Joint 181	LOMA PIRETA	9.550	-8.552	9.102	-7.806
	BHUJ	1.616	-1.889	1.678	-2.098
	EL CENTRO	2.643	-1.982	2.889	-3.131

In the bare frame building we can observe that maximum deflection occurred for lomo earthquake the response of the structure is predominantly very high were as in bhuj is constantly to the path. Similarly for elcentro data the response is huge in initial later on gradually deceased.

Model –II Open Ground story Building



(a) (b)



(c)

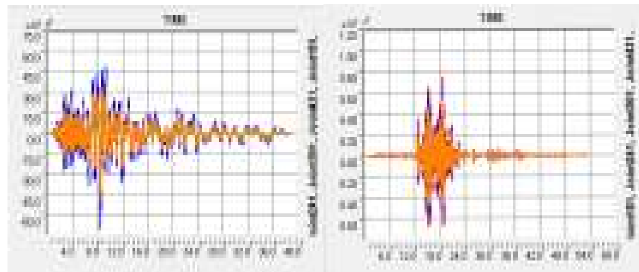
Graphs-4 Response of the Open Groundstructure for Loma Prieta,Bhuj and El Centro earthquake ground data.

Table-2 Open Groundbuilding response for various joints for different ground motions

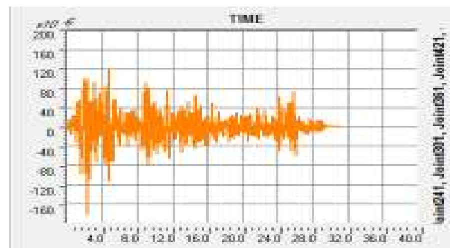
Type of Building	Earthquake Ground data	OGS-X Direction (deflection in mm)		OGS-Y Direction (deflection in mm)	
		Positive Direction	Negative Direction	Positive Direction	Negative Direction
Joint 2	LOMA PIRETA	1.584	-2.139	3.495	-4.557
	BHUJ	6.043	-6.333	1.269	-1.339
	EL CENTRO	2.526	-2.969	5.197	-6.158
Joint 241	LOMA PIRETA	1.676	-2.264	3.703	-4.829
	BHUJ	6.404	-6.723	1.351	-1.423
	EL CENTRO	2.675	-3.146	5.511	-6.533
Joint 301	LOMA PIRETA	1.770	-2.391	3.915	-5.106
	BHUJ	6.769	-7.120	1.434	-1.510
	EL CENTRO	2.827	-3.325	5.832	-6.916
Joint 361	LOMA PIRETA	1.864	-2.518	4.130	-5.386
	BHUJ	7.138	-7.519	1.519	-1.597
	EL CENTRO	2.979	-3.505	6.155	-7.303
Joint 421	LOMA PIRETA	1.957	-2.645	4.343	-5.665
	BHUJ	7.504	-7.917	3.903	-3.823
	EL CENTRO	3.130	-3.685	6.478	-7.688
Joint 181	LOMA PIRETA	2.050	-2.769	4.555	-5.940
	BHUJ	7.865	-8.309	1.687	-1.771
	EL CENTRO	3.279	-3.861	6.796	-8.070

As in the comparison of bare frame to that of open structure building the deflection profile is completely different, where the deflection is maximum for the bhuj ground data which is quite opposite to that of loma.

5.3 Model –IIIPartially Infill wall in Ground Floor



(a) (b)



(c)

Graphs-3 Response of the Partially Infill wall structure for Response of the Open Groundstructure for Loma Prieta,Bhuj and El Centro earthquake ground data.

Table-3Partially Infill wall building response for various joints for different ground motions

Type of Building	Earthquake Ground Data	Partially infill wall-X Direction (deflection in mm)		Partially infill wall-Y Direction (deflection in mm)	
		Positive Direction	Negative Direction	Positive Direction	Negative Direction
Joint 2	LOMA PIRETA	9.171	-1.361	7.840	-1.127
	BHUJ	1.294	-1.203	1.113	-1.212
	EL CENTRO	1.910	-3.025	1.594	-2.468
Joint 241	LOMA PIRETA	1.985	-2.924	1.903	-2.707
	BHUJ	2.843	-2.613	2.750	-2.970
	EL CENTRO	4.176	-6.605	3.913	-6.048
Joint 301	LOMA PIRETA	2.786	-4.061	2.867	-4.026
	BHUJ	4.083	-3.687	4.255	-4.530
	EL CENTRO	5.947	-9.389	5.980	-9.222
Joint 361	LOMA PIRETA	3.573	-5.161	3.831	-5.326
	BHUJ	5.344	-4.761	5.801	-6.109
	EL CENTRO	5.947	-9.389	8.079	-1.244
Joint 421	LOMA PIRETA	4.300	-6.169	4.739	-6.536
	BHUJ	6.535	-5.806	7.282	-7.609
	EL CENTRO	9.370	-1.476	1.007	-1.549
Joint 181	LOMA PIRETA	4.955	-7.072	5.571	-7.640

	BHUJ	7.616	-6.754	8.652	-8.989
	EL CENTRO	1.087	-1.710	1.191	-1.830

II. Conclusion

After having a complete and thought-out investigation of the present work on soft story and their effects on the multistory buildings, right from the starting with the discussion of analytical setup to the stating of results, the following were observed.

- The three models were analyzed in the present work as already discussedabove. It is found that the Open Ground Story Model II has poor performance than the Partial Infill wall Model –III, in which model as a brick masonry confined to a corner frame by strong mortar bonds between walls and frames.
- The constant support provided by the partial infill wall provided at corners in the ground story result in increased the stiffness of the structure as compared to the Bare frame building (Model I) and Open ground story (Model III), and hence has better load bearing capacity then the entire open ground story building.
- It is also noticed that due to strong ground motion data which is indulged to the different model of buildings the maximum displacement is occurring in the open ground story buildings when compared to bare frame and partial infill walls at ground story models.
- So it clearly states that open ground stories are most vulnerable to the seismic, it's better to build the structure with special stiffness parametric source or by implementing the partial infill walls at the corners so that the minimum stiffness is incorporated into the structure by which the failure criteria will be minimized.

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