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Earthquake Resistant Analysis and Design of G+7 Soft Storey Building

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ABSTRACT:Structural designing requires structural analysis and earthquake or seismic analysis of any structure prior to construction. Earthquake or seismic analysis is the calculation of the response of a structure subjected to earthquake excitation. Various seismic data are necessary to carry out the seismic analysis of the structures in this study the seismic response of the structures is investigated under earthquake excitation expressed in the form of member forces, joint displacement, support reaction and story drift. The response is investigated for G+7 Soft Storey building structure by using STAAD PRO designing software. Soft Storey Building or Open Ground storey (OGS) has taken its place in the Indian urban environment due to the fact that it provides much needed parking facility in the ground storey of the building. Surveys of buildings failed in past earthquakes show that this types of buildings are found to be one of the most vulnerable. Presence of infill walls in the frame alters the behaviour of the building under lateral loads. The paper offers study of the soft storey building, its design and seismic analysis with the layout & seismic evaluation of G+7 building using STAAD.pro which is compared between manual & software program calculation. It also involves the comparison of manual & software program calculation of load & total Seismic weight of building from that the base shear is calculated.

KEYWORDS:Soft Storey, Open ground storey, Seismic analysis and Comparison, Staad Pro, Base Shear

I. INTRODUCTION

Open ground storey (also known as soft storey) buildings are commonly used in the urban environment nowadays since they provide parking area which is most required. This type of building shows comparatively a higher tendency to collapse during earthquake because of the soft storey effect. Large lateral displacements get induced at the first floor level of such buildings yielding large curvatures in the ground storey columns. The bending moments and shear forces in these columns are also magnified accordingly as compared to a bare frame building (without a soft storey). The energy developed during earthquake loading is dissipated by the vertical resisting elements of the ground storey resulting the occurrence of plastic deformations which transforms the ground storey into a mechanism, in which the collapse is Unavoidable. The construction of open ground storey is very dangerous if not designed suitably and with proper care. This paper is an attempt towards the study of the OGS buildings and its seismic analysis compared to manual and software calculations. A common Open Ground building are revealed is Figure 1.1.



Fig 1.1 Open Ground storey Building

II. EMBLEMATIC DAMAGED BUILDING EXMPLES

1) The 2001 Bhuj earthquake (Magnitude M7.9 and PGA 0.11g) was among the most devastating a person to witness the collapse of several open ground storey RC buildings. A typical open ground storey residential building at Ahmadabad. The soil storey columns are badly harmed as found in Figure 2.1. Displays the failure of the very first storey columns as a result of shear in Earthquake.



Fig 2.1 Failure of soft storey Building in Bhuj earthquake

2) Figure 1.3 stand for the soft storey ground floor with soft storey ground floor at China Earthquake of a 6 storey developing because of the plastic hinge formation at the soil storey column which is likely to increase the inter storey drift at Ground Floor.



Fig 2.2 Plastic Hinge Formation at Column ends of the soft storey building

III. BEHAVIOUR OF OGS BUILDING

Due to the lack of the infill walls in the ground storey which of existing at the storey above, the stiffness is abrupt decreases that are called as stiffness irregularity. The base shear is registered through the ground storey columns. Due to the increased the shear pressure will cause the increased bending moment and thereby greater curvature which may possibly will higher inter storey drift formation at the ground storey which enhance by the $P\Delta$ effect the plastic hinges are formed. Top of the shop will go as one block. This kind of collapse is called as smooth storey collapse. Due to the reduction in the stiffness at ground storey this particular kind of buildings are viewed as probably the most susceptible sort through the seismic point of view. The fig reveals the soft storey collapse of typical OGS structures.

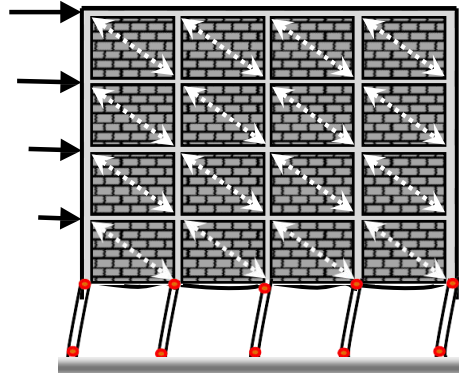


Fig 3.1 Behaviour of OGS Building

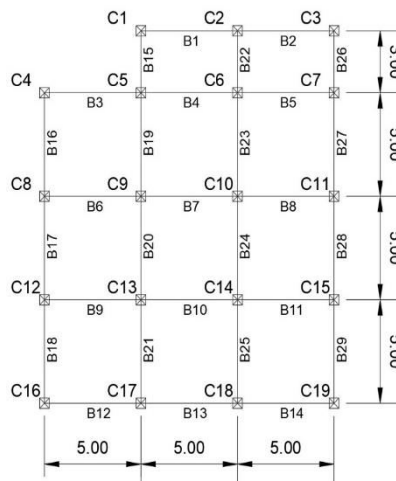
IV. OBJECTIVE OF THE WORK

- To examine a G+7 storey residential building for distinctive loads combinations using STAAD.pro software with connect edition.
- Study of shear forces, Reactions and bending Moments.
- Compare the manual & software calculation for seismic weight.
- Compare the manual & software calculation for base shear.
- To analyse the building using IS code 1893 (part 1): 2002 for seismic analysis.
- To develop, design and analysis model of the High rise structure in STAAD-Pro.
- To verify deflection obtained by STAAD-Pro with IS codal Limit.
- To study the effect of infill strength and stiffness (with infill Opening) in the seismic analysis of Soft ground storey building.
- Modelling of 7-storey building and application of different loads on STAAD-Pro, load calculations due to different loading combinations, analysis and design of structure on STAAD-Pro.
- To study the behaviour of Open Ground Storey buildings designed considering the magnification factor (M.F.)

V. SCOPE AND LIMITATION OF THE WORK

The RC framed Buildings are considered for the analysis by assuming regular in plan. The Out of plane action of walls is neglected in the analysis. The asymmetric arrangement of walls is ignored of the buildings. The Soil structure interaction effects are not considered in the analysis. The Flexibility of floor diaphragms are neglected and considered as rigid diaphragm. The base of the column is assumed to be fixed in the analysis.

VI. CALCULATIONS





Live load	: 3.0 kN/m ² at typical floor : 3.0 kN/m ² on terrace
Floor finish	: 1.0 kN/m ²
Water proofing	: 1.5 kN/m ²
Location	: Mumbai city
Wind load	: As per IS: 875-Not designed for wind load, since earthquake loads exceed wind loads.
Earthquake load	: As per IS-1893 (Part 1) - 2002
Depth of foundation	: 2.5 m below ground
Type of soil	: Type II, Medium as per IS:1893
Allowable bearing pressure	: 200 kN/m ²
Average thickness of footing	: 1.0 m, assume isolated footings
Storey height	: Typical floor: 3.45m
Floors	: G.F. + 7 upper floors.
Ground beams	: To be provided at 100 mm below G.L.
Plinth level	: 0.6 m
Walls	: 230 mm thick brick masonry walls

6.1 Calculation of Dead load:

1) Weight of typical slab (Floor)

Self-weight of slab = 3.75 kN/m²

Floor finish = 1 kN/m²

Total Load = 4.75 kN/m²

Weight = 4.75 X 15 X 15 = 1068.75 KN

= 4.75 X 10 X 3 = 142.5 KN

Total Weight = 1068.75 + 142.5 = 1211.25 KN

2) Weight of Roof (Terrace)

Self-weight of slab = 3.75 kN/m²

Floor finish = 1 kN/m²

Water proofing = 1.5 KN/m²

Total Load = 6.25 kN/m²

Weight = 6.25 X 15 X 15 = 1406.25 KN

= 6.25 X 10 X 3 = 187.5 KN

Total Weight = 1406.25 + 187.5 = 1593.75 KN

3) Weight of longitudinal Beam

Longitudinal beam

Self-weight of beam = 25 X 0.60 X 0.30 = 4.5 kN/m

Weight of beams = 14 X (5-0.375-0.375) X 4.5

= 267.75 KN

4) Weight of Transverse Beam

Self-weight of beam = 25 X 0.60 X 0.30 = 4.5 kN/m

Total load 12 X (5-0.375-0.375) X 4.5 = 229.5 KN

2 X (3-0.375-0.375) X 4.5 = 20.25 KN

Total load = 229.5+20.25 = 249.75 KN



5) Weight of Parapet wall per m height
 = 67 X 0.23 X 20
 = 308.2 kN/m

6) Weight of wall/m height
 Wall of 230mm thick
 Floor height = 3450 mm
 Beam depth = 0.70 m
 Total Load = (26 X (5-0.375-0.375)) + (3 X (3-0.375-0.375)) X 0.23 X 20
 = 539.35 KN/m per height

7) Weight of Columns per m Load
 Self-weight of Column = 19 X 25 X 0.75 X 0.75
 Total Load = 267.1875 kN/m

6.2 Calculation of Live Load (Imposed Load)

The imposed load on roof need not to be considered. (Clause 7.3.2)

Live load is 50 % of Total Live Load =
 Therefore Live Load = 0.50 X 3 KN/m²
 = 1.5 kN/m²

So Total Live Load on each floor = ((15 X 15) + (10 X 3)) X 1.5
 = 382.5 KN

Lumped Mass of Roof Terrace = DL+ LL
 = (1593.75 + 267.75 + 249.75 + 308.2 X 1) + (539.35 (3.45-0.6)/2)+ (267.1875 X 3.45/2) + 0 LL
 = 2419.45 + 768.57 + 460.9
 = 3648.91 KN

Lumped Mass of Typical floor = DL+ LL
 = (1211.25 + 267.75 + 249.75 + (2 X 539.35)) + (2 X 26.1875) + 382.5
 = 1728.75 + 1078.7 + 52.375 + 382.5
 = 3242.325 KN

Total Seismic Weight = (3648.91 + 6 X 3242.325)
 = 23102.86 KN

$$A_h = \frac{Z I S_a}{2 R g} = (0.16 \times 1 \times 1.5) / (2 \times 5) = 0.0241$$

So, Calculated Base Shear is Vb
 = Ah X W
 = 0.0241 X 23102.86
 = 556.77 KN

6.3 Staad-Pro calculations

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*****
* UNITS - KN   METE                               *
* TIME PERIOD FOR Z 1893 LOADING =   0.90312 SEC  *
* SA/G PER 1893=   1.506, LOAD FACTOR= 1.000    *
* VB PER 1893=   0.0241 X   30208.31=   727.85 KN *
*
*****
```

Fig 6.2 Output from Staad-Pro



VII. RESULTS AND DISCUSSION

Description	Manual Calculation	Staad-Pro Software
Time Period	0.9055 sec	0.9031 sec
Sa/g	1.5	1.506
Seismic Weight	23102.86 KN	30208.3 KN
Base Shear	556.77 KN	727.85 KN

Table 7.1 Comparison of Base Shear Results

	Node	L/C	Horizontal	Vertical	Horizontal	Resultant	Rotational		
			X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	69	12 ULC, 1.5 D	21.218	-2.301	-0.887	21.361	0.000	0.000	-0.000
Min X	72	14 ULC, 1.5 D	-21.185	-2.302	-0.907	21.329	-0.000	-0.000	0.000
Max Y	69	1 E X	14.101	0.204	-0.231	14.105	-0.000	0.000	-0.000
Min Y	107	5 ULC, 1.5 DE	0.051	-4.354	-1.294	4.542	-0.000	-0.000	0.000
Max Z	34	17 ULC, 0.9 D	-0.324	-1.301	18.394	18.442	0.000	0.000	-0.000
Min Z	221	15 ULC, 1.5 D	-0.094	-1.388	-19.968	20.017	-0.000	-0.000	-0.000
Max rX	14	13 ULC, 1.5 D	-0.143	-1.404	7.246	7.383	0.001	0.000	0.000
Min rX	121	15 ULC, 1.5 D	-0.018	-1.043	-7.423	7.495	-0.001	0.000	-0.000
Max rY	144	18 ULC, 0.9 D	-19.834	-1.071	-0.671	19.874	-0.000	0.000	0.000
Min rY	144	12 ULC, 1.5 D	19.959	-2.551	-0.619	20.131	-0.000	-0.000	-0.000
Max rZ	52	14 ULC, 1.5 D	-8.225	-1.373	-0.235	8.343	-0.000	-0.000	0.001
Min rZ	49	12 ULC, 1.5 D	8.235	-1.373	-0.289	8.353	-0.000	0.000	-0.001
Max Rst	70	12 ULC, 1.5 D	21.178	-3.231	-1.266	21.460	-0.000	0.000	-0.000

Fig 7.2 Fig showing Deflection

VIII. CONCLUSION

1. Design Base Shear (Manually)

= 556.77 KN

2. Design Base Shear (STAAD Pro)

= 727.85 KN

- The G+7 residential building has been analysed and deigned using STADD. Pro.
- Seismic forces have been considered and the structure is designed as an earthquake resistant structure.
- To conclude, STADD. Pro is versatile software having the ability to determine the reinforcement required for any concrete section based on its loading and determine the nodal deflection against lateral forces.
- It experiences static as well as dynamic analysis of the structure and gives accurate results which are required. The following points have been obtained at the end of the design.
- The values of bending moment and shear force for every individual member have been studied.
- The short-term deflection for all horizontal members is within safe limits.
- Always better to know two or more than a single software so that a counter check can be made especially for a large and mega projects to avoid suspicious results and to continue his design with peace of mind.



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