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Abstract:- Nowadays, tall structures have turned out to be a great engineering wonder. From past earthquakes information, it is demonstrated that a significant number of structures are harmed or destroyed due to earthquakes, therefore, it becomes necessary to decide and analyze seismic reactions over the structure. Earthquake can cause huge destructive to the structure. There is a need of seismic study and planning to protect the structure from earthquake. The analysis of the structures is to determine the deformations and forces induced by applied load or because of ground movements so as to resist earthquakes while designing the buildings. Depending on the intent of the study, a variety of methods are available. In this, seismic response of residential G+7 reinforced cement concrete frame building is analyzed by equivalent static method and by using STAAD.PRO software as per IS 1893(Part1): 2016.

Keywords: Analysis, design, loadings, seismic forces, tall structure.

1. Introduction

Earthquakes are thought to be the leading cause of building structural collapse. Because of the instability of the local building stock, earthquakes have the potential to cause significant damage and financial losses. The building gets damaged due to inertia force, which acts in the opposite direction to the earthquake's acceleration. Seismic loads are inertial forces that are normally dealt with by assuming forces external to the building.[13] As a result, in addition to gravity loads, the foundation would be subjected to a significant lateral force during ground shaking caused by an earthquake. The main objective of this paper is to modify the manually designed multistoried building with seismic effect by analyzing it through STAAD.PRO.[9] The demand for such models is often driven by the need to analyses a vast number of systems in a short period of time. STAAD.PRO software solves typical problem and do seismic analysis of various load combinations.[11] There are two methods for analysis of earthquake or seismic load acting on the building namely; equivalent static method and dynamics analysis method.[12,15]

The main objective of seismic analysis of tall Structures include:

- Assess the structure according to IS 1893(Part1): 2002 for earthquake resistance.
- Static load process analysis of the structure.
- STAAD.PRO software was used to perform a dynamic study of the building.
- Using a variety of lateral stiffness schemes.
- To address energy and environmental issues.

Recently, there are many numbers of tall buildings newly constructed, both residential and commercial as the modern trend is more preferable to the tall structures. As a result, lateral loads such as dead loads, live loads, wind loads, and earthquake forces are becoming increasingly important, posing a challenge in providing adequate strength and stability against lateral loadings.

2. Methodology

In our project, comparative analysis of multistorey building G+7 building is done on STAAD. PRO applications and the Equivalent Static Load process (manually). To analyze the multistorey building and to calculate its various stresses and loads is very difficult and time consuming, therefore, in such case, STAAD.PRO software makes it quick and easy. It takes into account the basic values as per IS 456:2000 for RCC structures and IS 1893(Part1):2002 for earthquake resistant structures.

Table 1. Structural Parameter

Sr. No.	Description	Values
1	Zone Factor Z for zone III	0.16
2	Importance Factor I	1.2
3	Height of Storey	3 m
4	For SMRF Response Reduction Factor	5

Table 2. Material Properties [8]

Description	Symbols	Values as per IS Standards
Seismic zone	-	II (Table 2 Pg.16 of IS 1893:2002)
Seismic intensity	Z	0.1
Importance factor	I	1.5 (Table 6 Pg.18 of IS 1893:2002)
Response reduction factor	R	3 (Table 7 Pg.23 of IS 1893:2002)
Lateral dimension	D	65.6 meters
Height	H	50.4 meters
Fundamental natural period	Ta	0.560
Type of soil	-	Medium
Spectral acceleration coefficient	Sa/g	2.428
Seismic weight	W	680034 kN
Seismic base shear	Vb	41284.632 kN

With reference to the values and properties of material given in table 2, we can analyze manually the load and forces acting on G+7 building.

Dead load calculation:

There are 17 internal columns and 18 external columns in total.

Particulars	Dimensions	
Size of internal column	$= 300 \times 450$ mm.	
Size of external column	$= 300 \times 300$ mm.	
Self − weight of internal column	$= 0.300 \times 0.450 \times 25 \times 1 = 3.375$ kN/m	(1)
Self − weight of external column	$= 0.300 \times 0.300 \times 25 \times 1 = 2.25$ kN/m	(2)
Unit weight of reinforced cement concrete	$= 25$ kN/m^3	
Total self weight of internal column for ground floor	$= 3.375 * 3 * 17 = 172.125$ kN	(3)
Total self weight of external column for ground floor	$= 2.25 * 3 * 18 = 121.5$ kN	(4)

Total weight of column on ground floor	=	$172.125 + 121.5 = 293.625$ kN.	(5)
Size of beams	=	$300 * 450$ mm.	
Self − weight of beam/meter length	=	$0.300 * 0.450 * 25 * 1 = 3.375$ kN/m	(6)
Unit-weight of reinforced cement concrete	=	25 kN/m^3	
Total length of beams.	=	174m	
Total self − weight of beam on one floor	=	$3.375 * 174 = 587.25$ kN.	(7)
Assume a wall thickness of	=	230mm.	
Self − weight of wall	=	$0.23 * 3 * 1 * 20 = 13.8$kN/m	(8)
Density of plastered wall	=	20 kN/m^3 , and height of storey is 3m.	
For parapet wall, height of parapet wall	=	1m. and thickness of wall is 230mm.	
Self − weight of parapet wall	=	$0.230 * 1 * 20 * 1 = 4.6$ kN/m	(9)

*The calculation for the remaining seven floors of column, beam and wall is same as calculate above (from equation 1 to equation 9). [2,3,9]

Assume floor finish **as**	=	0.5 kN/m^2	
Live load is considered 50% if the value of live load is equal to or more than	=	4 kN/m^2.	
Live load per meter length(10)	=	$2 * 1 = 2$kN/m	(10)

*Roof live load will be null. [4]

Seismic weight of building is defined as the total dead load and the appropriate amount of live load as per IS 1893 (part 1):2016

W1 = seismic weight of ground storey = dead load + live load	=	$587.25 + 293.625 + (2 * 174) + (0.5 * 174) = 1315.875$ kN.	(11)
W2 = Dead Load + Live Load	=	$587.25 + 293.625 + (13.8 * 174) + (0.5 * 174) + (2 * 174) = 3717.075$ kN	(!2)
As from W2 to W1 seismic weight will be same as there is symmetry. Therefore,	=	W3= W4=W5=W6=W7= **3717.075 kN**	
W8 = seismic weight of roof	=	$(2 * 174) + (4.6 * 65) + (0.5 * 174) = 734$kN	(13)
Weight = W1 + W2 + W3 + W4 + W5 + W6 + W7 + W8	=	$1315.875 + (3717.075 * 6) + 734 = 24352.325$ kN. [5]	(14)

Lateral load resistance is provided by moment resisting frames filled with brick masonry panels. Hence, approximate fundamental period is given by	-	$Time\ period = 0.09 * h/sqrt(d)$ [9]	(15)
Where, h= total height of building; d= width of building in the direction of axis.			
Earthquake load in X − direction	=	$0.09 * 24/$sqrt (17) = 0.52 sec.	(16)
Earthquake load in Z − direction	=	$0.09 * 24/$sqrt (15.5) = 0.54 sec.	(17)
The building is located on medium soil.			
From figure.1 IS 1893(Part1):2016; for earthquake load in X= 0.52 sec. and Z= 0.54 sec.	=	Spectral acceleration coefficient= 2.5 (As per IS 1893-2016, from graph) Area = $9 * 24/$sqrt (15.5) = $0.16 * 1.2 * 2.5/2 * 5 = 0.048$	(18)

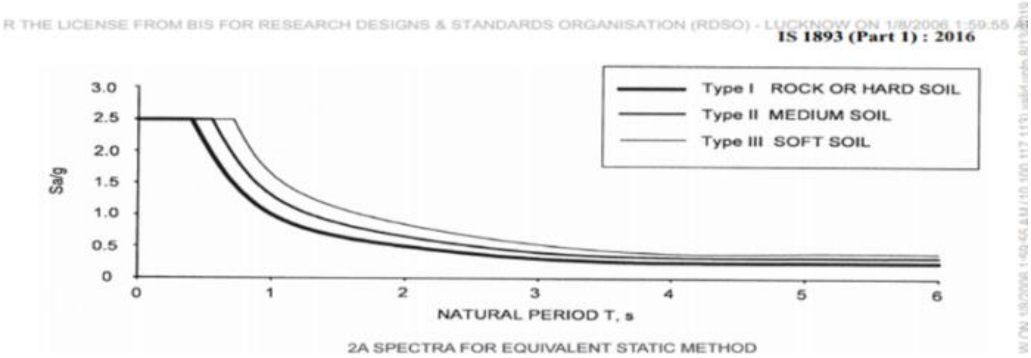

Figure 1. Design spectral acceleration coefficient

The above figure gives the values of Sa/g for different types of soil at a given natural time period (Ta). [1]

Design base shear:

$$\text{Base shear} = \text{Area} * W = 0.048 * 24352.325 = 1168.91 \text{ kN} \quad (19)$$

where W= seismic weight of building. [6,9,12]

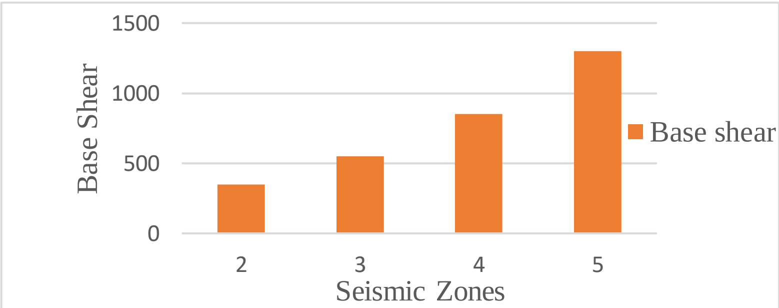

Figure 2. Values of Base shear with different earthquake zones [10,13]

Above figure shows the variation of base shear in different earthquake zones. Zone 5, being the dangerous zone, had a highest base shear force.

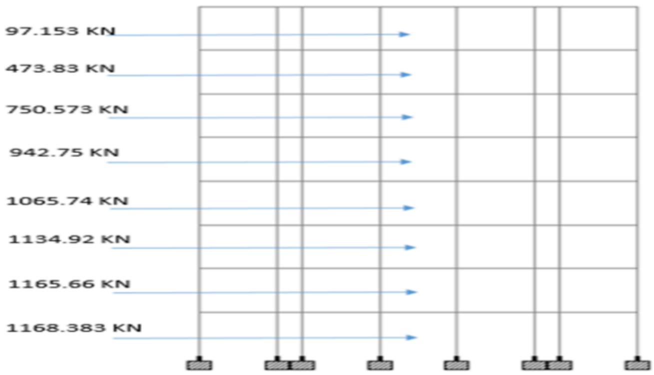

Figure 3. Different base shear values for different floors

The above figure shows the different base shear values calculated manually for different storeys.

3. Analysis through STAAD.PRO:

STAAD.PRO is a fully integrated finite element analysis and design solution with a cutting-edge user interface, visualization capabilities, and international design codes. It can evaluate any structure that is subjected to static, dynamic, wind, earthquake, thermal, or moving loads. STAAD.PRO can help with structural analysis and design for any project, including towers, buildings, culverts, plants, bridges, stadiums, and marine structures. Plan is framed in AutoCAD and STAAD.PRO software in order to analyze the respective structure.

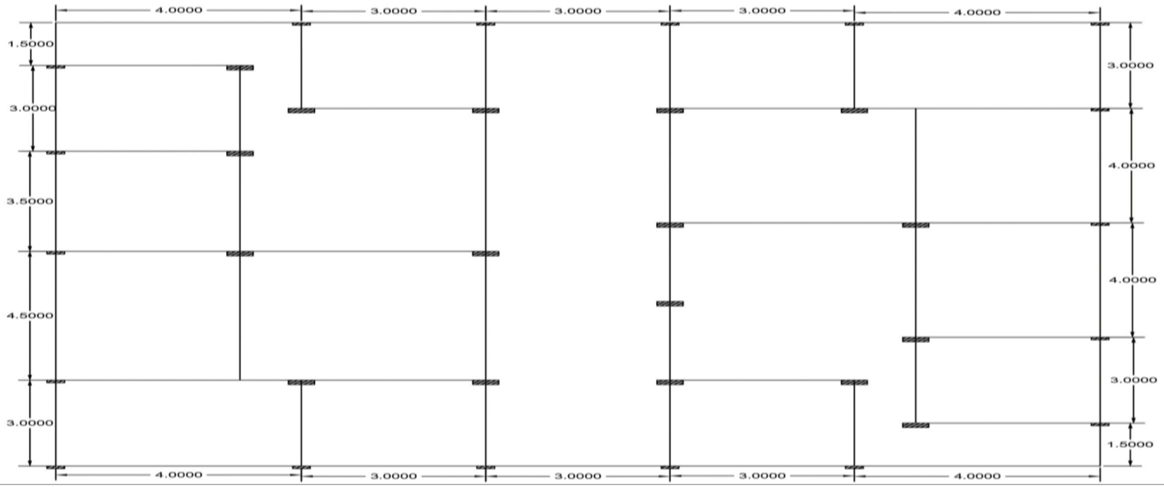

Figure 4. STAAD.PRO plan of a G+7 building.

The figure 4 shows the STAAD.PRO plan of a building which is to be analyzed. [9,14]

- f_y main: Primary Yield Strength of Shear Reinforcement = Fe500- 500000 N/mm^2.
- f_y sec: Secondary Yield Strength of Shear Reinforcement = Fe250- 250000 N/mm^2.
- Maximum main: Maximum Size of Main Reinforcement = 16mm.
- Minimum main: Minimum Size of Secondary Reinforcement = 12mm.
- Minimum main: Minimum Size of Main Reinforcement = 10mm.
- Minimum sec: Minimum Size of Secondary Reinforcement = 8mm.
- Compressive Strength of Concrete = f_c = Grade of Concrete = M25- 25000 N/mm^2.

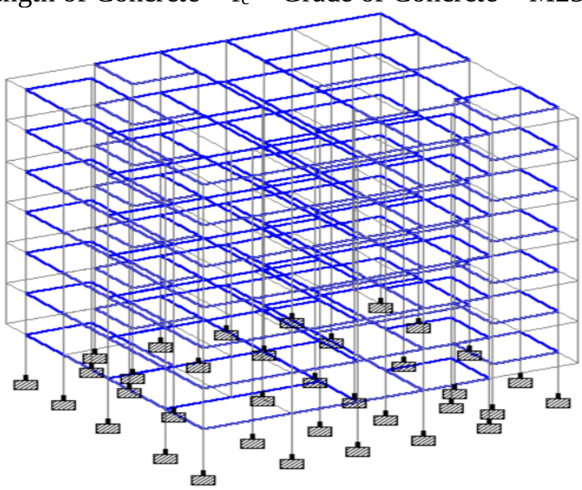

Figure 5. Load applied to structure

Figure 5. shows the various load applied to the structure such as dead load, live load, wind load, earthquake load. [7]

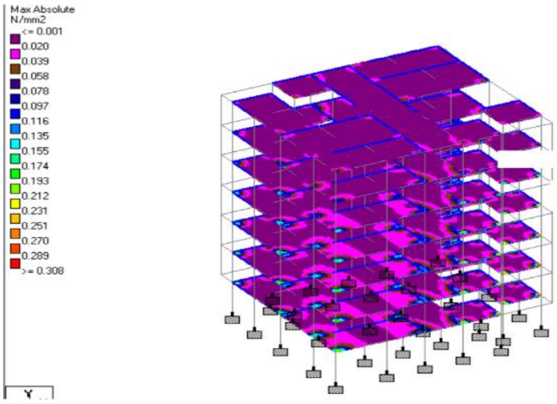

Figure 6. Surface detailing on maximum absolute load

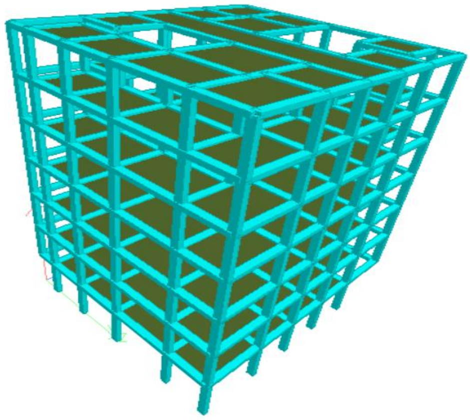

Figure 7. Elevation of G+7 building[14]

Figure 6. Shows the flooring details obtained in STAAD.PRO and figure 7. Shows the elevation view of the building. [7]

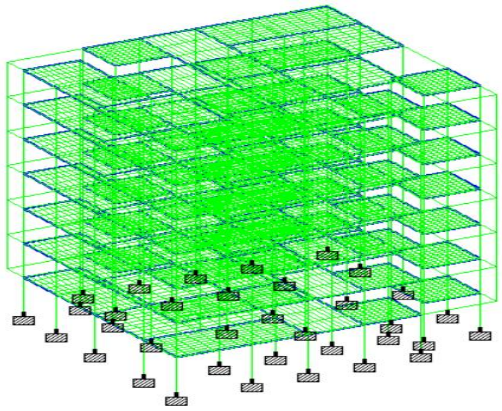

Figure 8. Deflection due to earthquake load

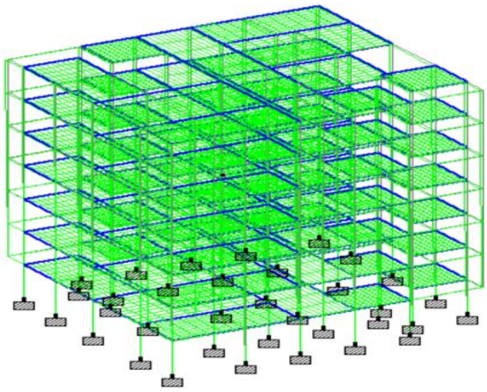

Figure 9. Deflection due to wind load

Figure 8 shows the deflection caused due to earthquake load in x and z- direction which then causes the instability to the structure and figure 9 shows the deflection caused due to wind load acting on the structure. [7]

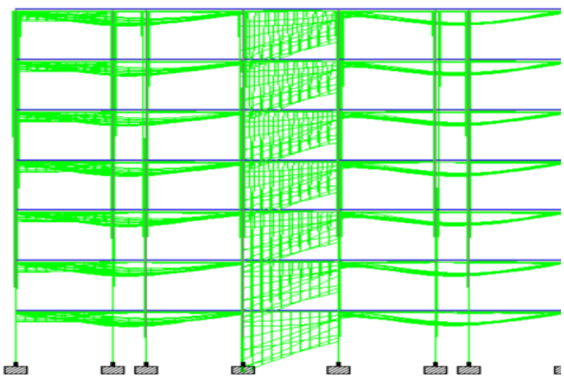

Figure 10. Deflection due to dead load

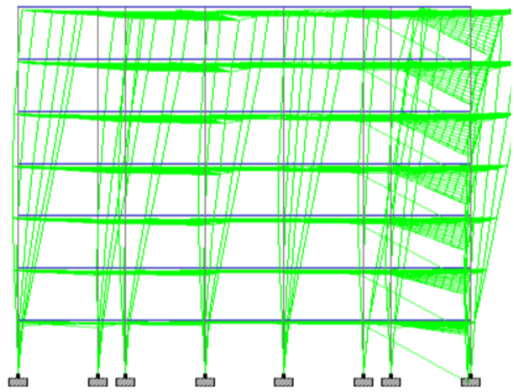

Figure 11. Deflection due to live load

Figure 10 and 11 shows the deflection caused due to dead load and live load acting on the building.[7]

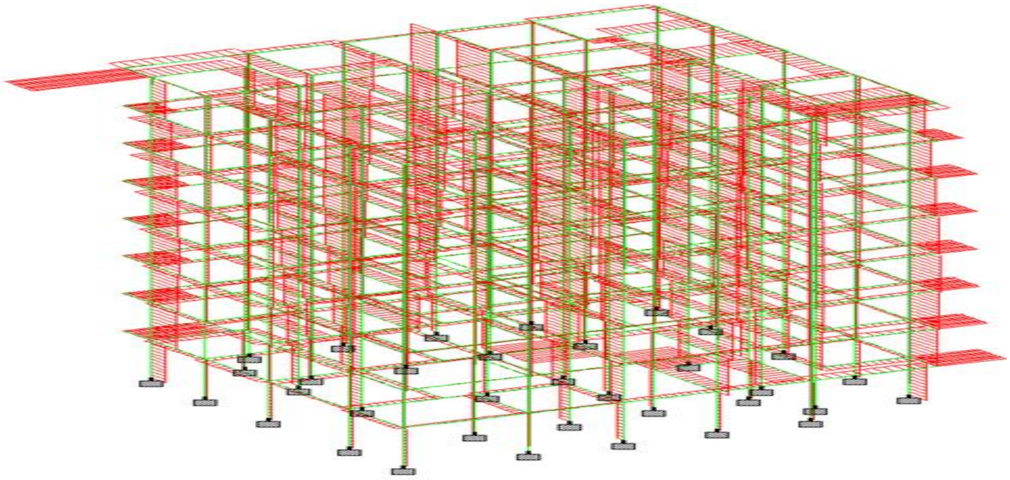

Figure 12. Base shear values obtained after analysis through STAAD.PRO.

Figure 12 shows the different base shear values of different floors and is then tabulated below with their beam numbers. [7,12]

4. Results

After doing manual analysis of seismic loads on G+7 building and further analyzed it by using STAAD.PRO software, results are obtained in tabular form and shear force and bending moment diagram is obtained accordingly.

Table 3. Base shear values for different beams

Sr. No	Beam No.	Base Shear (kN)	Sr. No	Beam No.	Base Shear (kN)
1	57	19.892	19	76	49.748
2	58	23.594	20	78	50.462
3	59	22.518	21	79	44.794
4	60	23.629	22	80	50.433
5	61	19.812	23	81	54.062
6	62	19.315	24	82	37.109
7	63	18.931	25	83	19.232
8	64	18.847	26	84	42.679
9	65	17.939	27	85	53.978
10	67	18.159	28	86	22.638
11	68	18.59	29	87	57.723
12	69	19.15	30	88	54.997
13	70	19.016	31	89	48.968
14	71	19.168	32	90	21.771
15	72	43.749	33	91	51.988
16	73	56.228	34	92	44.225
17	74	37.293	35	94	23.065
18	75	49.506		**Total**	**1193.208 kN**

Table no.3 shows the base shear values calculated for different beams through STAAD.PRO software and is then compared with the base shear values calculated manually.

Table 4. Distribution of total Horizontal Load to Different floor levels [8,9]

Storey	Wi	Hi	WiHi *10-3	$Q_i = W_iH_i^2/(\sum W_iH_i^2) * V_B$	Vi (KN)
8	734	24	422.784	97.153	97.153
7	3717.075	21	1639.23	376.68	473.83
6	3717.075	18	1204.33	276.74	750.573
5	3717.075	15	836.34	192.18	942.75
4	3717.075	12	535.25	122.99	1065.74
3	3717.075	9	301.08	69.18	1134.92
2	3717.075	6	133.81	30.74	1165.66
1	1315.875	3	11.84	2.72	1168.383
Total			5084.16	1168.383	

From table no.4, the distribution of total horizontal loads to different floors can be easily understood. It can be clearly seen that the load increases with the increase of floors from ground level and maximum load acts on the top floor of the building.

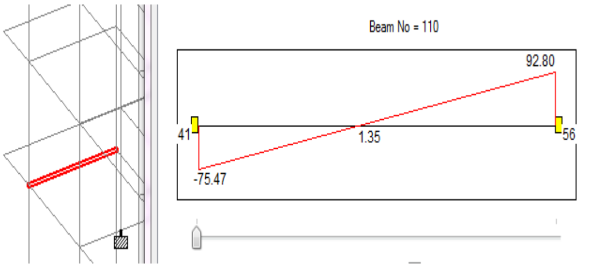

Figure 13. Bending Moment Diagram of beam (First Storey)[12]

In figure 13, a point load of 1.35kn is applied which causes a continuous bending moment in a beam and maximum bending moment for beam 110 is 92.80 kn.m.

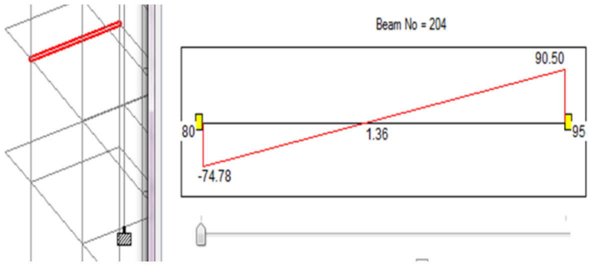

Figure 14. Bending Moment Diagram of beam (Second Storey)[12]

In figure 14, a point load of 1.36kn is applied which causes a continuous bending moment in a beam and maximum bending moment for beam 204 is 90.50kn.m.

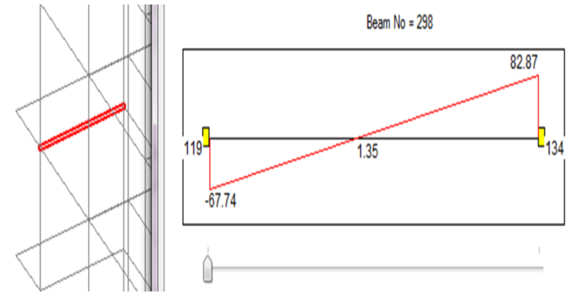

Figure 15. Bending Moment Diagram of beam (Third Storey)

In figure 15, a point load of 1.35kn is applied which causes a continuous bending moment in a beam and maximum bending moment for beam 298 is 82.87kn.m.

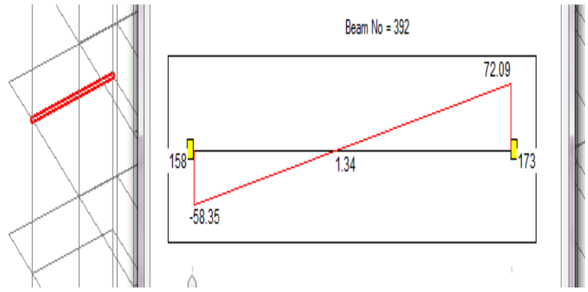

Figure 16. Bending Moment Diagram of beam (Fourth Storey)

In figure 16, a point load of 1.34kn is applied which causes a continuous bending moment in a beam and maximum bending moment for beam 392 is 72.09kn.m.

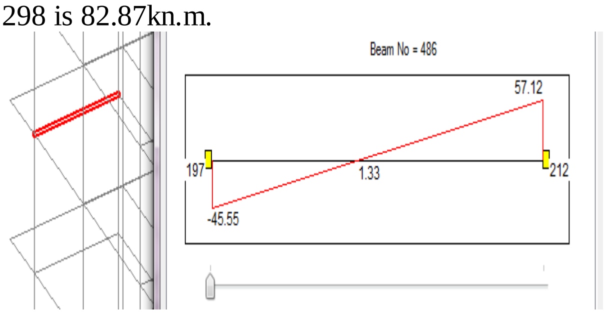

Figure 17. Bending Moment Diagram of beam (Fifth Storey)

In figure 17, a point load of 1.33kn is applied at center which causes a continuous bending moment in a beam and maximum bending moment for beam 486 is 57.12kn.m.

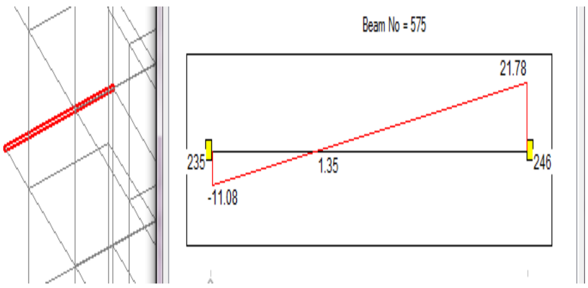

Figure 18. Bending Moment Diagram of beam (Sixth Storey)

In figure 18, a point load of 1.35kn is applied which causes a continuous bending moment in a beam and maximum bending moment for beam 575 is 21.78 kn.m.

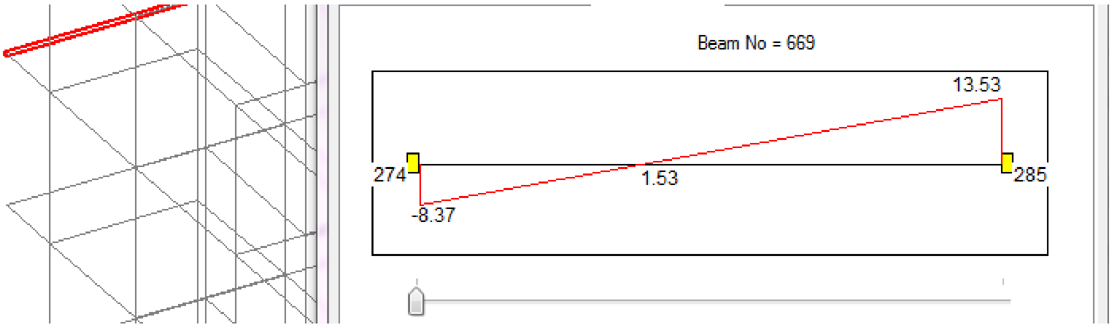

Figure 19. Bending Moment Diagram of beam (Seventh Storey)

In figure 19, a point load of 1.53kn is applied which causes a continuous bending moment in a beam and maximum bending moment for beam 669 is 13.53 kn.m.

Table No.5 shows the compared values of base shear calculated manually and through STAAD.PRO software.

STOREY	MANUALLY CALCULATED WEIGHT	FROM STAAD.PRO SOFTWARE
8	97.153 KN	145.37 KN
7	473.83 KN	511.161 KN
6	750.573 KN	782.942 KN
5	942.75 KN	975.678 KN
4	1065.74 KN	1092.46 KN
3	1134.92 KN	1111.06 KN
2	1165.66 KN	1190.366 KN
1	1168.383 KN	1193.20 KN

Table 6. Displacement by Earthquake Load in X-Direction

NODE	L/C	X	Y	Z	Mm	Rx	Ry	Rz
40	2 EQZ	-0.071	1.375	4.344	4.557	0.001	0	0
44	2 EQZ	-0.016	0.063	4.351	4.351	0	0	0
47	2 EQZ	0.02	-0.342	3.948	3.963	0.001	0	0
49	2 EQZ	0.016	-0.342	3.771	3.787	0.001	0	0
52	2 EQZ	-0.066	0.301	3.942	3.954	0.001	0	0
55	2 EQZ	-0.062	0.259	4.211	4.220	0.001	0	0
59	2 EQZ	0.027	-0.181	3.825	3.829	0.001	0	0
60	2 EQZ	0.007	-0.009	3.942	3.942	0.001	0	0
63	2 EQZ	-0.016	0.112	3.984	3.986	0.001	0	0
70	2 EQZ	0.031	0.069	4.209	4.210	0	0	0
73	2 EQZ	-0.048	0.082	3.944	3.945	0.001	0	0
75	2 EQZ	-0.061	-0.014	3.965	3.966	0.001	0	0
78	2 EQZ	-0.062	-0.038	4.213	4.213	0	0	0

Table no.6 shows the displacement caused due to earthquake load when it is applied horizontally in x-direction

Table 7. Minimum and Maximum displacement of Earthquake Load in Z-Direction

NODE	L/C	X	Y	Z	Mm	Rx	Ry	Rz
40	1 EQX	6.252	0.956	-0.05	6.325	0	0	0
44	1 EQX	6.195	0.326	-0.04	6.204	0	0	-0.001
47	1 EQX	6.284	-0.01	0.023	6.284	0	0	-0.001
49	1 EQX	6.276	-0.25	-0.06	6.281	0	0	-0.001
52	1 EQX	6.263	-0.01	0.016	6.263	0	0	-0.001
55	1 EQX	6.260	-0.29	-0.08	6.267	0	0	-0.001
59	1 EQX	5.903	0.337	-0.007	5.912	0	0	-0.001
60	1 EQX	6.040	-0.26	0.09	6.045	0	0	-0.002
63	1 EQX	6.196	0.094	0.01	6.197	0	0	-0.001
70	1 EQX	5.882	-0.45	-0.08	5.900	0	0	-0.001
73	1 EQX	5.938	0.028	0.005	5.938	0	0	-0.001
75	1 EQX	6.161	0.269	0.015	6.167	0	0	-0.001
78	1 EQX	6.162	-0.33	-0.08	6.171	0	0	-0.001

Table no.7 shows the maximum and minimum displacement caused due to earthquake load when it is applied in z-direction. The max. Base shear was found to be **1168.91 KN** and **1198.23 KN** calculated manually and from STAAD.PRO software respectively.

Conclusion:

This research paper aimed to analyze the seismic load acting on G+7 building. The analysis is done manually using equivalent static load method and is then compared with STAAD.PRO software so as to get better results. STAAD.PRO software evaluates any structure subjected to dynamic loading and gives an accurate result. Some researchers said that the values of base shear calculated manually for different earthquake zones is different as that of the accurate values obtained in the software which, when designed, causes an instability to the structure and thus, the structure gets damaged when subjected to earthquake load form x or z- direction. Therefore, to avoid such situation, it is better to compare the values beforehand and then design the structure accordingly.

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