Seismic Analysis of Multi-Storey Building Using STAAD.Pro & Comparison between Manual and software Calculation

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Abstract - *The paper offers with the layout & seismic evaluation of G+10 building using STAAD.pro & Comparison between manual & software program calculation. In this the seismic responses of a residential G+10 RCC building is analyses by the Equivalent static method & STAAD.pro Software as per IS code 1893 (Part 1): 2016. This analysis is carried out by considering seismic Zone III, & medium soil type & special moment resisting frame. Different responses like lateral force, base shear, displacement, storey drift, moment are plotted in order to compare results. It also involves the comparison of manual & software program calculation of load & total Seismic weight of building from that the base shear is calculated. The frame used for study is 11 (G+10) storey, RCC structure. The typical peak of the floor is 3.0 m in total peak of the structure is 33 m, in the plan of 17 m by 15.5 m.*

***Key Words*: Analysis of high rise structure, Seismic Analysis & Comparison, STAAD.pro, Base shear, Equivalent static method**

1. Introduction

Civil Engineering structures are created to serve some specific features like human habilitation, transportation, bridges, storage etc. in a safe & low-budget way. Structural engineering is worried with planning, designing & the construction of structures. Structural analysis involves the evaluation of the forces & displacement of the components or the structure, so the design process comprises the selection & detailing of components.

Base shear is the calculation of the maximum lateral force that occurs due to the seismic movement of ground at the base of the structure, which creates its effect till the peak of the structure.

Earthquake resistant structures are designed to endure the earthquakes which happen because of seismic forces induced in the ground. No structure can absolutely resist the damage caused by earthquake. The primary purpose of creation of earthquake resistant structure is that it could face up to the sudden ground shaking i.e. Earthquake, thus reducing the structural damage, human death & injuries. The principal goal of earthquake engineering is:

- To design such structures the ones are greater earthquake resistant.
- To design, construct & maintain the structures that are more earthquake resistant, by way of applying the design codes, so that that it causes less damage to structure and life of human.

2. Aim & Objective of Work

The important aim of this project work is to:

- To examine a 10 storey residential building for distinctive loads combinations using STAAD.pro software.
- Study of shear forces
- Study of reactions
- Study of bending moment
- Compare the manual & software calculation for seismic weight
- Compare the manual & software calculation for base shear
- To analyze the building using IS code 1893 (part 1): 2016 for seismic analysis

3. Methodology

The seismic forces can be calculated by following methods for seismic analysis namely:

- Equivalent Static Method
- Dynamic Analysis Method

Equivalent Static Method, different partial safety factors are applied to dead loads, live load, wind load & seismic forces to achieve the ultimate design loads, as per IS 456-2000 & also keeping in mind about earthquake & wind effects.

Dynamic Analysis Method, this method involves the rigorous analysis of the structures by studying the dynamic responses of the structure, where the entire response is considered in terms of component modal responses.

4. Load Calculation

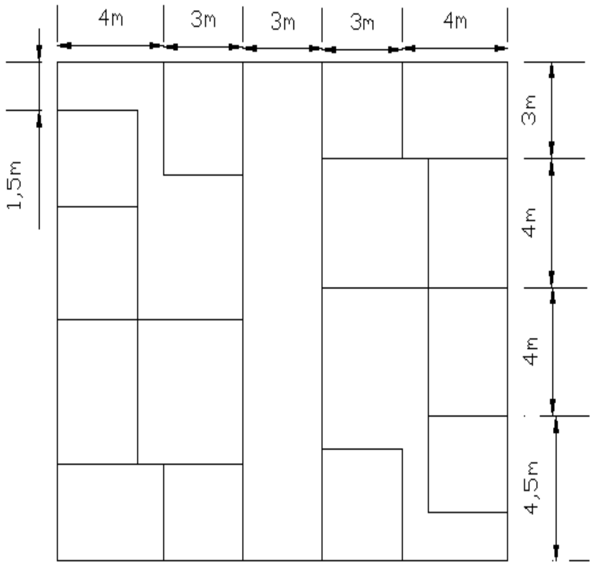

Fig -1: AutoCAD Plan

1) Dead load

Dead Load of Column:

Size of Internal Column = 450 X 400 MM
Size of External Column =450 X 400 MM
No of Internal Column= 17
No of External Column=18
Self-Weight of Internal Column
= 0.45 X 0.40 X 25 X 1
= 4.5 KN/M
Self-Weight of External Column
= 0.45 X 0.40 X 25 X 1
= 4.5 KN/N
Where,
Unit weight of RCC = 25 KN/M^3
Total Self-weight of Internal Column for 1 Floor=229.5 KN/M
Total Self-weight of External Column for 1 Floor=243 KN/M
Total Self-weight of Column for 1 Floor =472.5 KN/M

Dead Load of Beams:

Size of Beams =350 X 350 MM
Self-Weight of Beams/meter length
= 0.35 X 0.35 X 25 X 1
= 3.06 KN/M
Where,
Unit Weight of RCC = 25 KN/M^3
Total length of Beams = 174 M
Total Self-Weight of Beam on One Floor = 3.06 X 174
= 532.44 KN/M

Dead Load for Walls:

Assume Thickness of wall = 230 MM
Therefore,
Self-Weight of Wall = 0.23 X 3 X 1 X20
= 13.8 KN/M
Where,
Density of plastered Wall = 20 KN/M^3
Height of Storey = 3 M

For Parapet Wall:

Height of Parapet Wall = 1 M
Thickness of Parapet Wall = 230 MM
Self-Weight of Parapet Wall
= 0.230 X 1 X 20 X 1
=4.6 KN/M

Floor Finish

Floor Finish = 0.5 KN/M^2 _____(Assumed)

2) Live Load

As per Table 10 Clause 7.3.2 of IS 1893 (part 1): 2016 Live Load is considered 50 % if the value of live load is equal to or more than 4 KN/M^2
Hence,
Live Load per meter length is,
= 2 X 1
= 2 KN/M

3) Seismic Weight

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

W_1 = seismic Weight of Ground Storey
= DL + LL
= 472.5 + 532.44 + (2 X 174) + (0.5 X 174)
= 1440.375 KN

W_2 = DL + LL
= 472.5 + 532.44 + (13.8 X 174) + (2 X 174) + (0.5 X 174)
=3841.575 KN

As from W_2 to W_{10} seismic weight will be same as there is symmetry.
Therefore,
$W_2 = W_3 = W_4 = W_5 = W_6 = W_7 = W_8 = W_9 = W_{10}$ = 3841.575 KN

W_{11} = Seismic Weight of roof (As shown in figure 2 Plan of the building)
= (2X174) + (4.6 X 6.5) + (0.5X174)
= 734 KN

Therefore,
$W = W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7 + W_8 + W_9 + W_{10} + W_{11}$
= 1440.375 + (3841.575 X 9) + 734
= 36784.55 KN

4) Fundamental Period

$T = 0.09 * h / \sqrt{(d)}$

Where,

h = Total height of building

d = width of building in direction of axis

Therefore,

EL in X – Direction

$T_x = 0.09 * 33 / \sqrt{(17)}$

= 0.72 Sec

EL in Z – Direction

$T_z = 0.09 * 33 / \sqrt{(15.5)}$

= 0.75 Sec

The building is located on soft soil from IS 1893 (Part 1) 2016

For T_x = 0.72 Sec

T_z = 0.75 Sec

Ah = 0.16 * 1.5 * 2.33 / 2 * 5

= 0.05592

5) Design Base Shear

V_b = Ah * W

= 0.05592 * 36784.75

=2057 KN

Where,

W = Seismic Weight of Building

Table -1: Manual Base Shear Calculation

MANAUAL BASE SHEAR CALCULATION		
L	17	M
B	15.5	M
H	33	M
(Z)Zone Factor Zone III	0.16	
I	1.5	
R	5	
W	36784.55	KN
T_z= 0.09 * h / $\sqrt{(d)}$	0.754380754	sec
S/G = 1.67/ T	2.33	Z-direction
Ah = (Z * I * T_z) / 2 * R	0.05592	Z-direction
V_b (Z) = Ah * W	2070.07452	Z-direction

5. Building modeling in STAAD.pro

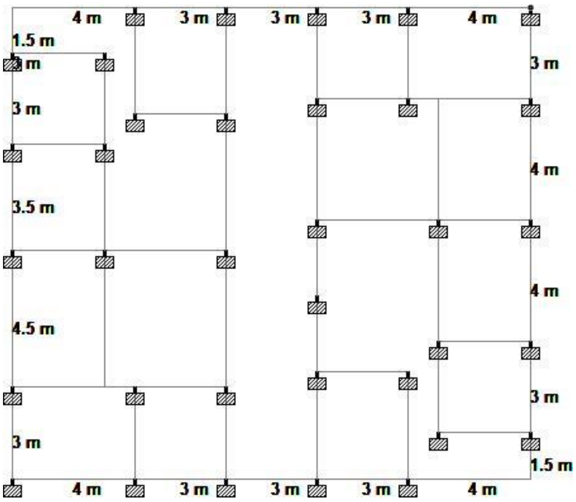

Fig -2: STAAD Plan

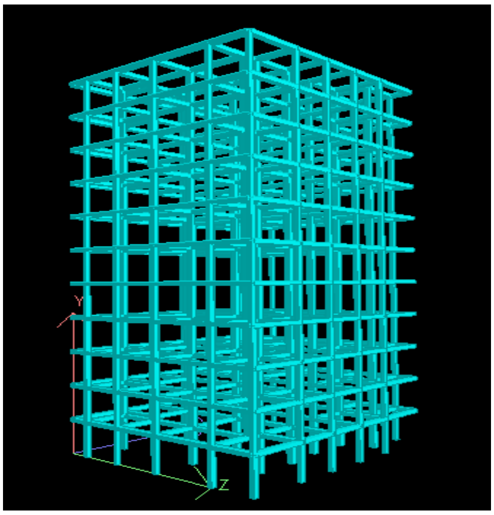

Fig -3: 3-D Rendering

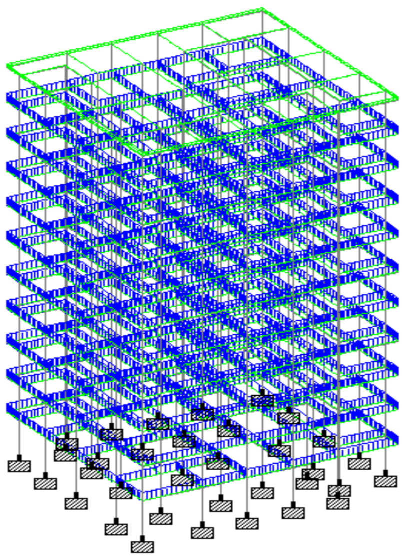

Fig -4: Dead Load on walls

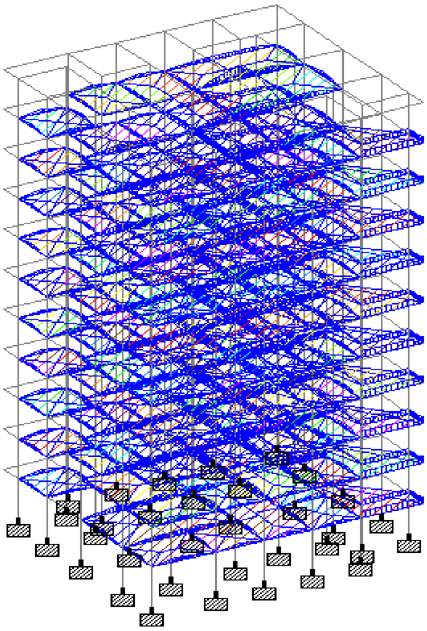

Fig -5: Live Load on walls

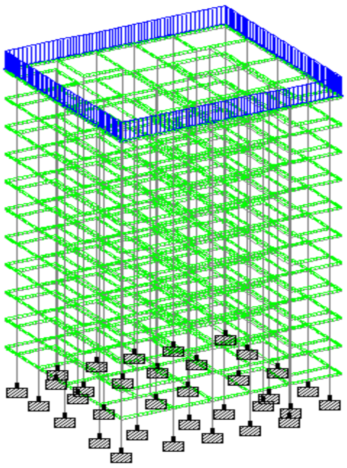

Fig -6: Load on Parapet walls

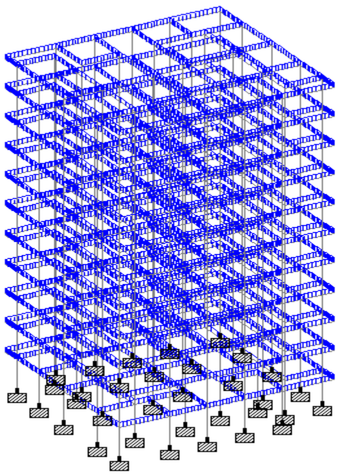

Fig -7: Floor Finish

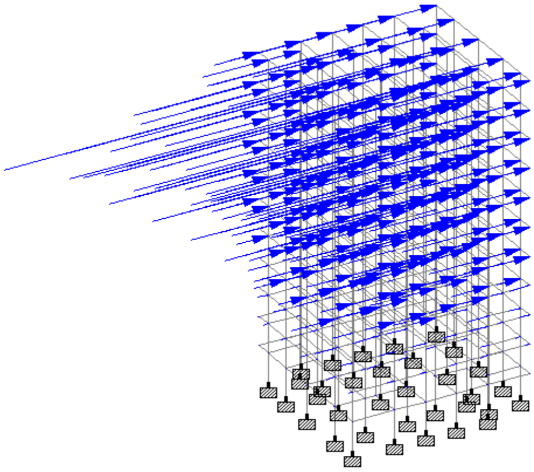

Fig -8: Seismic Load in X-direction

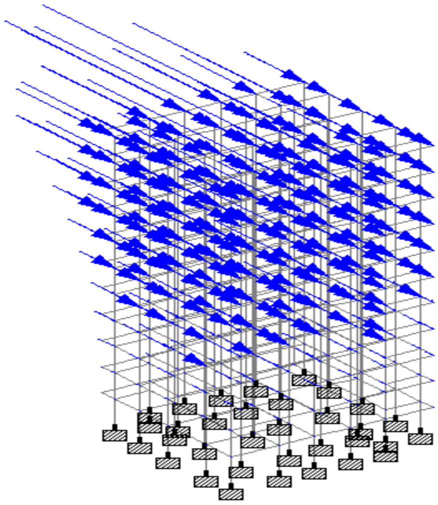

Fig -9: Seismic Load in Z- direction

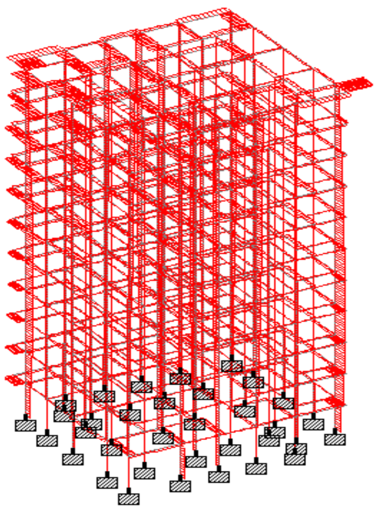

Fig -10: Base Shear

6. Results

Table -2: Manual Base Shear Calculation

DIFFERENT FLOOR LEVELS					
Storey	**Wi**	**Hi**	**Wi*Hi^2/10^-3**	$Q_i = \frac{(Wi*Hi^2/10^{-3})}{\Sigma (Wi*\frac{Hi^2}{10^{-3}})} * V_b$	**Vi**
11	734	33	799.326	116.7038202	116.7038202
10	3841.575	30	3457.4175	504.7925758	621.496396
9	3841.575	27	2800.508175	408.8819864	1030.378382
8	3841.575	24	2212.7472	323.0672485	1353.445631
7	3841.575	21	1694.134575	247.3483621	1600.793993
6	3841.575	18	1244.6703	181.7253273	1782.51932
5	3841.575	15	864.354375	126.1981439	1908.717464
4	3841.575	12	553.1868	80.76681212	1989.484276
3	3841.575	9	311.167575	45.43133182	2034.915608
2	3841.575	6	138.2967	20.19170303	2055.107311
1	1440.375	3	12.963375	1.892688822	2057
Total			**14088.77258**	**2057**	

Table -3: Comparison between Manual Base Shear & Software Calculation Floor Wise

Storey	Manual	Staad Calculation
1	2057	2196.4646
2	2055.107311	2194.443587
3	2034.915608	2172.882886
4	1989.484276	2124.37131
5	1908.717464	2038.128508
6	1782.51932	1903.37413
7	1600.793993	1709.327826
8	1353.445631	1445.209245
9	1030.378382	1100.238037
10	621.496396	663.6338517
11	116.7038202	124.6163393

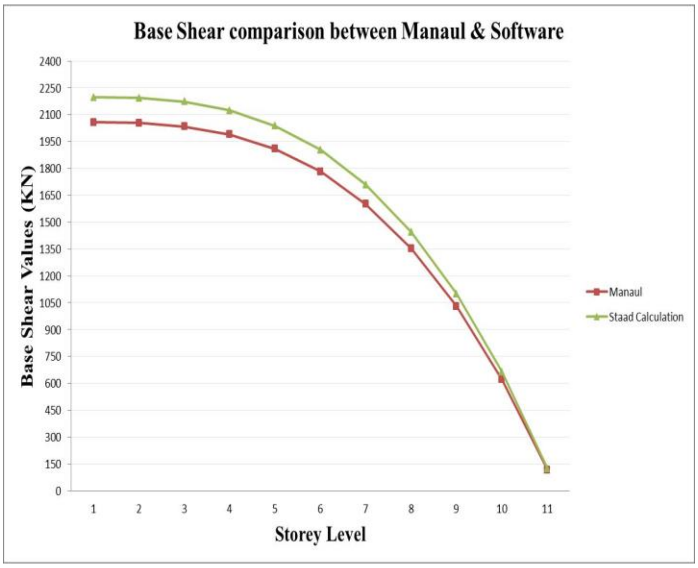

Chart 1: Graph Base Shear comparison between manual and software

7. Conclusions

The aim of the project was planning, designing & analyzing a multi-storey, earthquake resistant structure. We were able to complete the project in a successful & efficient way by considering all the factors.

- Designing using software's like STAAD.pro reduces the man power and saves time in design work.
- Details of each and every member and component can obtained from STAAD.pro
- Software analysis provides more accuracy within the calculations.
- Design base shear calculated Manually = **2057 KN**
- Design base shear (STAAD.pro) = **2196.495 KN**
- The G+10 residential building is designed and analyzed using STAAD.pro.
- Seismic forces were considered while designing and the structure is aimed as Earthquake resistant structure.
- The value of base shear obtained from STAAD.pro is quite more than the manual calculations.

8. References

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