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"Analysis of 23-Floor Tall Building by using Approximate Analysis Method"

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Abstract: Rapid progress in population calls for the increase in necessity of structures for living. Under the changed circumstances, the vertical growth of buildings i.e. constructions of multi-storeyed buildings has become inevitable both for residential and as well as office purposes. In order to compete in the ever growing competent market it is very important for a structural engineer to save time. As a sequel to this an attempt is made to analyze and design a Multi-storeyed building by using a software package such as STAAD-PRO, ETABS are very costly. In this study approximate analysis is presented for multistory building structures. The building is stiffened by an arbitrary combination of lateral load-resisting subsystems (shear walls, frames). The analysis is based on the approximate method (Vertical Load method, Portal Frame method, Cantilever Method, Substitute Frame Method). Approximate methods are useful in preliminary design, and also provide the analyst and the designer with a rapid means of rough checking "exact" solutions. The approximate analysis of building frames for vertical loads is covered in several papers. The intent of this paper is to review an approximate analysis of building frames for vertical loads.

***Key Words*:** Vertical load method, Portal Frame Method, Cantilever Method, Spilt Frame Method, KBS, Storey wise Summation.

1. **INTRODUCTION:** Approximate methods are useful in preliminary design and also provide the analyst and the designers with a rapid means of rough checking "exact" solutions. The approximate analysis of building frames for vertical loads is covered in several papers. The current trend towards taller buildings and lighter forms of construction has brought to light a number of difficulties in the design of tall structures. Architectural and other requirements lead to a form of construction with a spine or core and with perimeter columns, or structural mullions, and a floor slab spanning between. In contrast to vertical loading, lateral load effects on a building increase exponentially with increase in its height. During the last four decades engineers have developed several new framing schemes for tall buildings in order to minimize the material used. In general, frame tube structures are widely accepted as an economical system in high rise buildings over a wide range of building heights.

2. **METHODOLOGY:**
   1. **Introduction:** A residential G+23 storey building has been used for the study. The same plan is used for the analysis by approximate method and by STAAD-Pro. The structural system is taken as Rigid Frame system, with the following parameter as shown in Table no. 1 below.

      The approximate analysis and Staad-Pro analysis are compare with respect to various parameter. The structure were subjected to static earthquake excitation. The different parameters upon seismic loading are compared below.
   2. **Seismic weight:** The seismic weight of building is the sum of seismic weight of all the floors. The seismic weight of each floor is its full dead load plus appropriate amount of imposed load, the latter being that part of the imposed loads which may reasonably be expected to be attached to the structure at the time of earthquake shaking. It includes the weight of permanent and movable partitions, permanent equipment, a part of the live load, etc.

Table No.1 Parameters and design data for G+23 Floor Tall Building

Parameter Consideration	Value
Live Load	4 KN/Sq.M
Live Load at Terrace	1.5 KN/Sq.M
Floor Finish Load / Water proofing load	1.5 KN/Sq.M
Thickness of Shear Wall External	230 mm
Thickness of Shear wall Internal	150 mm
Thickness of Brick wall External	230 mm
Parameter Consideration	Value
Thickness of Brick wall Internal	115 mm
Slab thickness	200 mm
Zone No	II
Soil Type	Medium soil
Floor Height	3 m
Importance Factor	1.0
Response Reduction Factor	5.0
Grade of Steel	FE500
Grade of Concrete	M35
R.C.C. Design Code	IS 456:2000
Live Load Code	IS875: Part II
Dead Load Code	IS875: Part I
Earthquake design code	IS1893: 2016

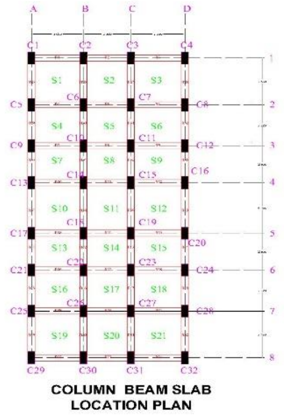


Figure No.1: Column beam plan

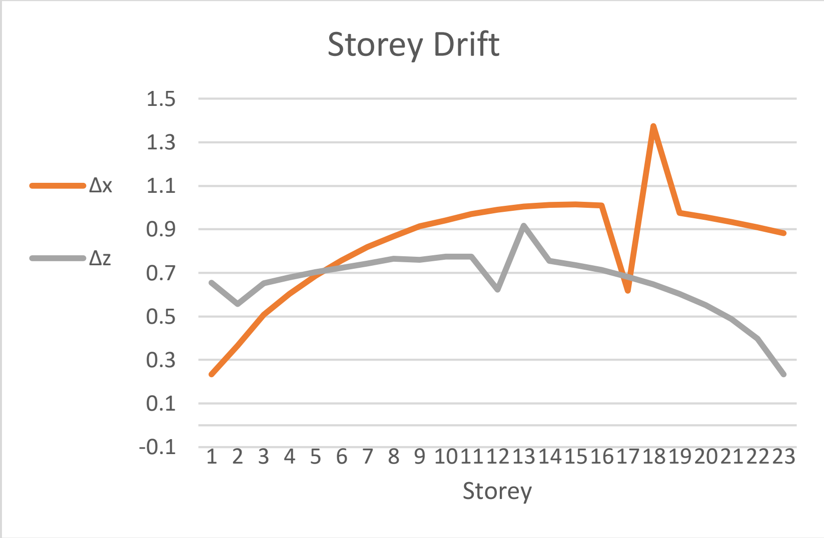
Figure No.2: 3D Model

3. **Story drift (Δ) :** Storey drift is define as the displacement of the storey with respect to the other storey. As per Clause no. 7.11.1 of IS1893 (Part 1) the Store stiffness is not exceeds than $= 0.004\ X\ Heigth\ of\ Storey$

Table No. 2: Drift (Δ) Calculations in X-direction & Y-direction

Storey	Δx	Δz
1	0.233	0.656
2	0.365	0.556
3	0.508	0.652
4	0.604	0.679
5	0.686	0.703
6	0.758	0.724
7	0.818	0.742
8	0.869	0.764
9	0.914	0.76
10	0.941	0.774
11	0.972	0.776
12	0.991	0.623

Storey	Δx	Δz
13	1.005	0.918
14	1.012	0.755
15	1.014	0.736
16	1.011	0.714
17	0.619	0.683
18	1.376	0.647
19	0.975	0.604
20	0.956	0.553
21	0.934	0.488
22	0.909	0.398
23	0.883	0.233



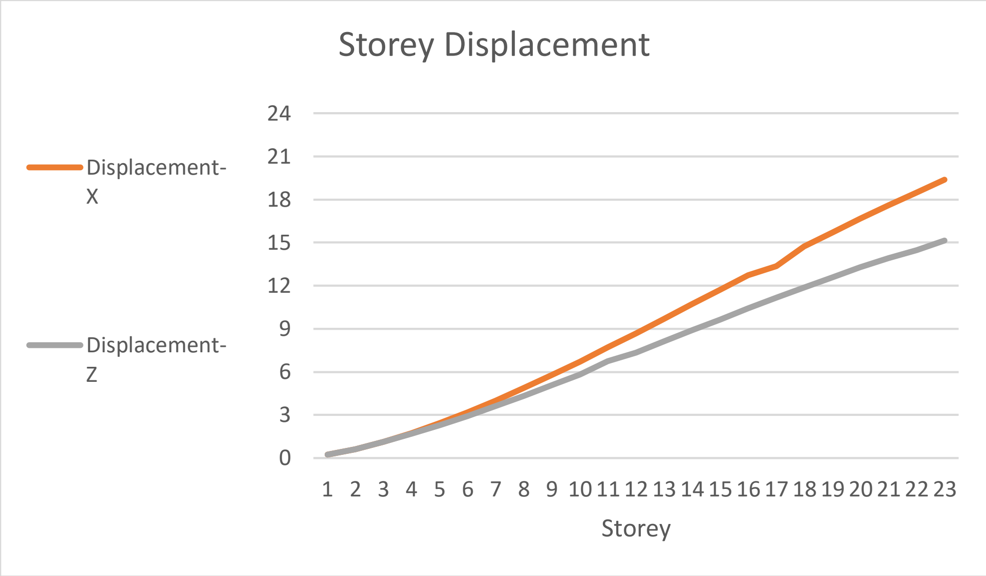
Graph No.1: Drift (Δ) in X-direction & Y-direction

4. **Lateral displacement (Storey displacement):** It's Define as the displacement of the structure with respect to the base of the structures.

$$Displacement = \left\{{}^{Total\ Heigth\ of\ building}/_{500}\right\}$$

Table No.3: Displacement Calculations in X-direction & Z-direction

Storey	Displ.-X in mm	Displ.-Z in mm
1	0.233	0.233
2	0.628	0.631
3	1.136	1.119
4	1.740	1.672
5	2.426	2.276
6	3.184	2.923
7	4.002	3.606
8	4.871	4.32
9	5.785	5.056
10	6.726	5.811
11	7.698	6.729
12	8.689	7.352
13	9.694	8.128
14	10.706	8.902
15	11.720	9.662
16	12.731	10.426
17	13.35	11.168
18	14.726	11.892
19	15.702	12.595
20	16.658	13.274
21	17.592	13.926
22	18.501	14.482
23	19.384	15.138



Graph No.2: Displacement in X-direction & Y-direction

5. **Time period (T):** It's the time period of structure being the important factor affecting seismic performance of the building frames

Where, $T = \frac{0.09}{\sqrt{d}}$ ....As per IS 1893 Table No. 2

Table No. 4: Manual (a) and Software (b) calculation of Time Period

Direction	X dir.	Z dir.
Ta	1.426	2.129

Direction	X dir.	Z dir.
Ta	1.530	2.129

6. **Base shear (V_B):** It's an estimation of the maximum expected lateral forces on the base of the structure due to seismic activity it's calculated using the seismic zone. Soil material properties and building code lateral forces equation.

Total Base Shear (V_B) = $\left\{\frac{CvI}{RT}\right\} w = Ah * W$

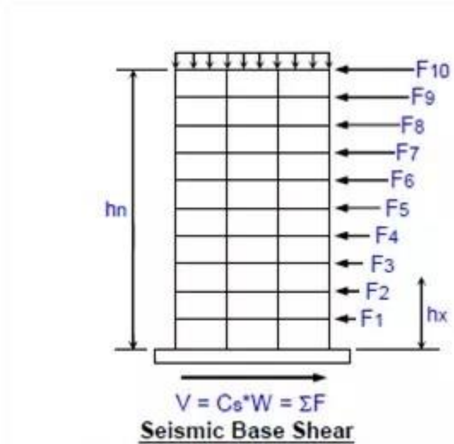


Figure No.1: Base Shear Distribution

Table No.5: Calculation of Base shear by manually (a) and by Software (b)

(a)

Direction	X dir.	Z dir.
Vb	1124.413	753.275

(b)

Direction	X dir.	Z dir.
Vb	1049.74	754.39

7. **Lateral Shear (Q_i):** It's the forces that act's in the direction parallel to ground and perpendicular to the direction of gravitational pull of earth is known as lateral forces. The lateral forces are distributed vertically, it was a distribution of the base shear to different floor levels. As pre IS 1893 Cl no. 7.7.1.

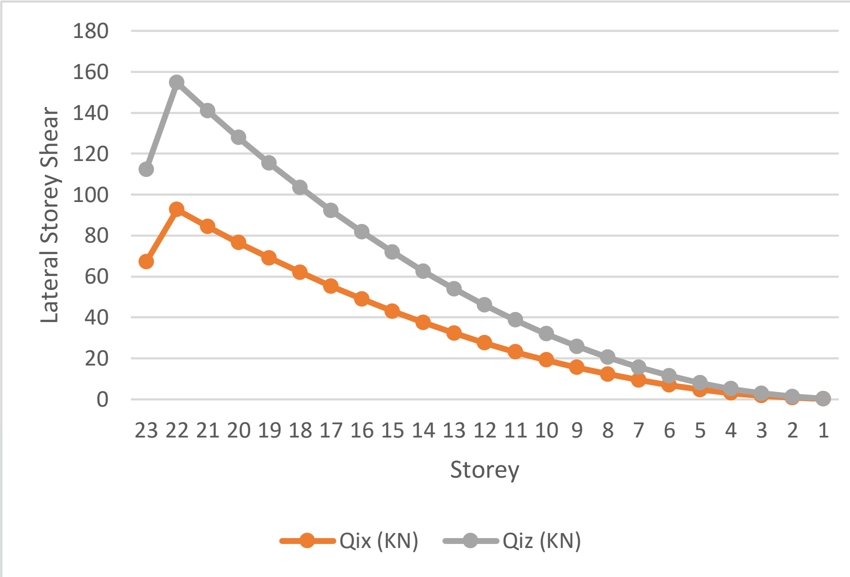
$$Q_i = V_B \frac{W_{i\,hi^2}}{\sum_{j=1}^{n} Wi\,hi^2}$$

Where, $Q_i = Design\ Lateral\ force\ at\ floor, Wi = Seismic\ weight\ of\ floor\ i$

$hi = Height\ of\ floor\ i\ measured\ from\ base$

$n = Number\ of\ storey\ in\ the\ building\ is\ the\ number\ of\ levels\ at$

$which\ the\ masses\ are\ located$



3. **RESULTS AND DISCUSSION:** Linear Static analysis carried by STAAD-Pro software (V8i) under serviceability combination loads (gravity and seismic loads) on all the structures. All the structures are applied with same kind of loading and study is done on standard combinations of loads, but the results are produced for the critical combinations of loads.
   a. All the storey drift are within the limit as per IS 1893:2002 (Storey Drift = 0.004*storey height).
   b. The displacement is increase with height is increase of the building. In X-direction the displacement is more as compare to the Z-direction with respect to the gravity and seismic loading conditions.
   c. In this study we calculate the time period results in STAAD-Pro and also manually but it has some changed in X-direction about 0.104 seconds more time period in X-direction in Software calculations. And in Z-direction it's same in both direction X & Z.
   d. There is some variation in X-direction, in manual calculation base shear value is 1124.413 KN and in Software it's 1049.74 KN. And in Z-direction the base shear value is similar in manual calculation value is 753.275 KN and in software value is 754.39 KN.
   e. The lateral force in top storey is maximum and to base storey is minimum.

4. **Conclusion:**
   a. The storey drift calculated by the software for different loading combination is within the limit as per IS:1893.
   b. The displacement of the structure is calculated by software for different loading condition and in different direction is within the limit as per IS1893.
   c. The time period calculated by the software and by manual calculation is very close
   d. In this study it's found that the base shear is nearby similar to each other (by manual calculated & by software calculated) and it's observe carefully at the time of analysis.
   e. Lateral forces are calculated by the manual method for both X & Z-direction.

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