

## Design of Multi Story Building and Comparison of Base Shear Using Staad pro and Manual Process

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### Abstract

Seismic tremor happened in multistoried building demonstrates that if the structures are not well outlined and developed with and satisfactory quality it prompts the entire crumple of the structures. To guarantee security against seismic powers of multi-storied building subsequently, there is having to investigation of seismic examination to plan tremor resistance structures. The conduct of G+ 6 multi-stories working of consistent design under earth shake is complex and it differs of wind loads are accepted to act at the same time with earth shake loads.

In this paper a private of G+6multi-story building is considered for earth shake at specific zones i.e. ZONE III utilizing Staad PRO V8i, MANUAL .Assuming that material property is straight static and dynamic examination are performed. The aggregate structure was broke down by PC with utilizing STAAD.PRO programming.

We watched the reaction diminishment of cases normal minute opposing casing and uncommon minute opposing casing esteems with diversion charts in static and dynamic investigation

**Keywords:** G+6 Multi-Story Building, Staad PRO V8i, Steam.

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### 1. Introduction

#### STAAD PRO

This chapter reviews about some of the fundamental concepts of structural design and present them in a manner relevant to the design of light frame residential structures. The concepts from the basis for understanding the design procedures and overall design approach addressed in the remaining chapter of the guide. With this conceptual background, it is hoped that the designer will gain a greater appreciation for creative and efficient design of home, particularly the many assumptions that must be made.

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- Specifying Supports.
- Specifying Loads.
- Specifying the Analysis type.
- Specifying Post-Analysis Print Commands.
- Specifying Steel Design Parameters.
- Performing Analysis and Design
- Viewing the Output File
- Verifying results on screen both graphically and numerically.

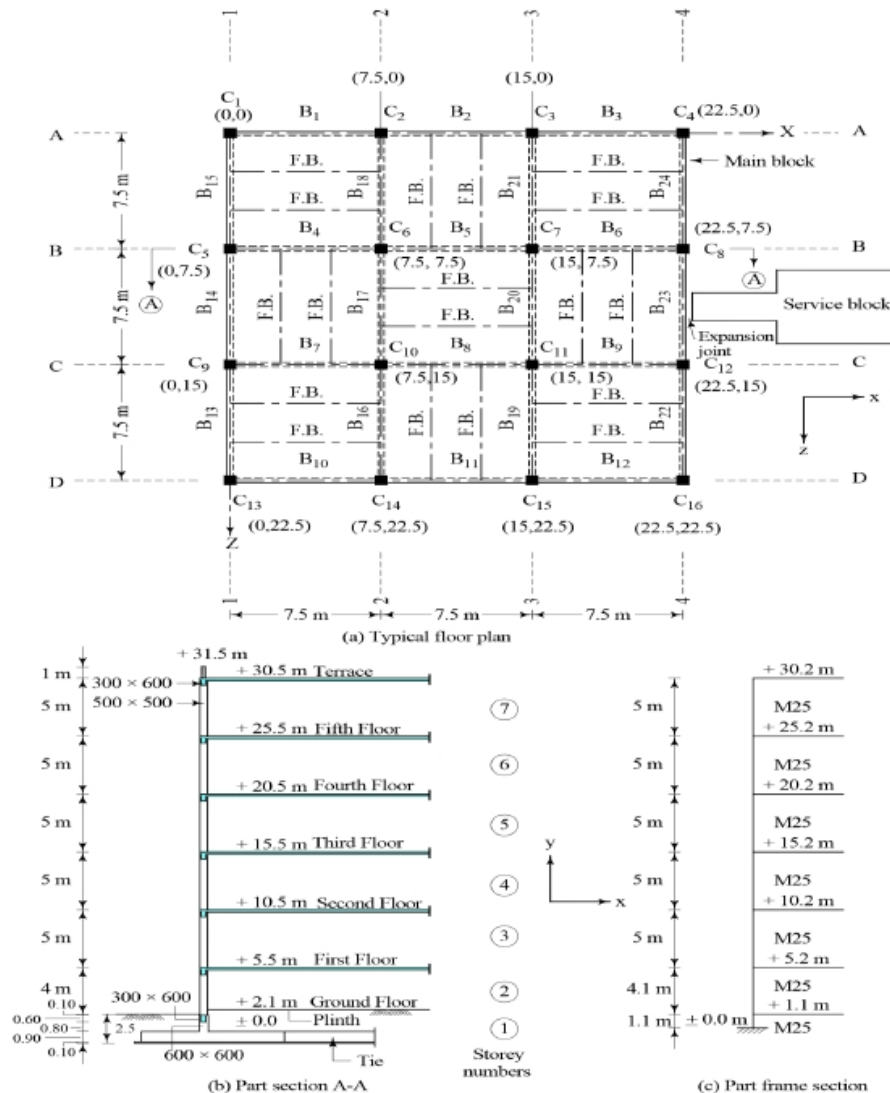


Figure 1: Architecture/ Structural Plan

#### INPUT PARAMETERS:

The design data shall be as follows:

|                                  |                                                                                            |
|----------------------------------|--------------------------------------------------------------------------------------------|
| Live load                        | : 4.0 kN/m <sup>2</sup> at typical floor                                                   |
|                                  | : 1.5 kN/m <sup>2</sup> on terrace                                                         |
|                                  | : 1.0 kN/m <sup>2</sup>                                                                    |
|                                  | : 2.0 kN/m <sup>2</sup>                                                                    |
| Floor finish                     | : 1.0 kN/m <sup>2</sup>                                                                    |
| Water proofing                   | : Vadodara city                                                                            |
| Terrace finish                   | : As per IS: 875-Not designed for wind load, since earthquake loads exceed the wind loads. |
| Location                         | : As per IS-1893 (Part 1) - 2002                                                           |
|                                  | : 2.5 m                                                                                    |
| Wind load                        | : Type II, Medium as per IS:1893                                                           |
|                                  | : 200 kN/m <sup>2</sup>                                                                    |
| Earthquake load                  |                                                                                            |
| Depth of foundation below ground | : 0.9 m, assume isolated footings                                                          |
| Type of soil                     |                                                                                            |
| Allowable bearing pressure       |                                                                                            |
| Average thickness of footing     |                                                                                            |
| Storey height                    | : Typical floor: 5 m, GF: 3.4 m Floors : G.F. + 5 upper floors.                            |
| Ground beams                     | : To be provided at 100 mm below G.L.                                                      |
| Plinth level                     | : 0.6 m                                                                                    |
| Walls                            | : 230 mm thick brick masonry wall                                                          |
| Only at periphery.               |                                                                                            |

## Material Properties

### Concrete

All components unless specified in design: M25 grade all

$$E_c = 5\,000 \quad f_{ck} \text{ N/mm}^2 = 5\,000 \quad f_{ck} \text{ MN/m}^2 \\ = 25\,000 \text{ N/mm}^2 = 25\,000 \text{ MN/m}^2.$$

For central columns up to plinth, ground floor and first floor: M30 grade

$$E_c = 5\,000 \quad f_{ck} \text{ N/mm}^2 = 5\,000 \quad f_{ck} \text{ MN/m}^2 \\ = 27\,386 \text{ N/mm}^2 = 27\,386 \text{ MN/m}^2.$$

### Steel

HYSD reinforcement of grade Fe 415 confirming to IS: 1786 is used throughout.

**1.2. Geometry of the Building** not provided, since the floor directly rests on ground (earth filling and 1:4:8 c.c. at plinth level) The general layout of the building is shown in and no slab is provided. The ground beams are Figure 1. At ground level, the floor beams FB are provided at 100 mm below ground level. The numbering of the members is explained as below. **1.2.1.**

### Storey number

Storey numbers are given to the portion of the building between two successive grids of beams. For the example building, the storey numbers are defined as follows:

| Portion of the building       | Storey no. |
|-------------------------------|------------|
| Foundation top – Ground floor | 1          |
| Ground beams – First floor    | 2          |
| First Floor – Second floor    | 3          |
| Second floor – Third floor    | 4          |
| Third floor – Fourth floor    | 5          |
| Fourth floor – Fifth floor    | 6          |
| Fifth floor - Terrace         | 7          |

### 1.2.2. Column number

General In the plan of Figure 1, the columns from C1 to C16 are numbered in a convenient way from left to right and from upper to the lower part of the plan. Column C5 is known as column C5 from top of the footing to the terrace level. However, to differentiate the column lengths in different stories, the column lengths are known as 105, 205, 305, 405, 505, 605 and 705 [Refer to Figure 2(b)]. The first digit indicates the storey number while the last two digits indicate column

number. Thus, column length 605 means column length in sixth storey for column numbered C5. The columns may also be specified by using grid lines.

### 1.2.3. Floor beams (Secondary beams)

All floor beams that are capable of free rotation at supports are designated as FB in Figure 1. The reactions of the floor beams are calculated manually, which act as point loads on the main beams. Thus, the floor beams are not considered as the part of the space frame modelling.

### 1.2.4. Main beams number

Beams, which are passing through columns, are termed as main beams and these together with the columns form the space frame. The general layout of Figure 1 numbers the main beams as beam B 1 to B12 in a convenient way from left to right and from upper to the lower part of the plan. Giving 90 o clockwise rotation to the plan similarly marks the beams in the perpendicular direction. To floor-wise differentiate beams similar in plan (say beam B5 connecting columns C6 and C7) in various floors, beams are numbered as 1005, 2005, 3005, and so on. The first digit indicates the storey top of the beam grid and the last three digits indicate the beam number as shown in general layout of Figure 1. Thus, beam 4007 is the beam located at the top of 4thstorey whose number is B7 as per the general layout.

## 1.3. Gravity Load calculations

### 1.3.1. Unit load calculations

Assumed sizes of beam and column sections are:

Columns: 500 x 500 at all typical floors

Area,  $A = 0.25 \text{ m}^2$ ,  $I = 0.005208 \text{ m}^4$

Columns: 600 x 600 below ground level

Area,  $A = 0.36 \text{ m}^2$ ,  $I = 0.0108 \text{ m}^4$

Main beams: 300 x 600 at all floors

Area,  $A = 0.18 \text{ m}^2$ ,  $I = 0.0054 \text{ m}^4$

Ground beams: 300 x 600

Area,  $A = 0.18 \text{ m}^2$ ,  $I = 0.0054 \text{ m}^4$

Secondary beams: 200 x 600

### Member self- weights:

Columns (500 x 500)

$0.50 \times 0.50 \times 25 = 6.3 \text{ kN/m}$

Columns (600 x 600)

$0.60 \times 0.60 \times 25 = 9.0 \text{ kN/m}$  Ground beam (300 x 600)

$0.30 \times 0.60 \times 25 = 4.5 \text{ kN/m}$  Secondary beams rib (200 x 500)

OUT PUT:

CENTER OF MASS AND CENTER OF RIGIDITY:

| Story   | Diaphragm | MassX    | MassY    | XCM   | YCM   | CumMassX  | CumMassY  | XCCM   | YCCM  | XCR    | YCR  | XCM-XCR | YCM-YCR |
|---------|-----------|----------|----------|-------|-------|-----------|-----------|--------|-------|--------|------|---------|---------|
| 1       | D1        | 433.628  | 433.628  | 11.98 | 12.11 | 3896.8984 | 3896.8984 | 11.314 | 11.25 | 12.112 | 12.8 | -0.132  | -0.69   |
| 2       | D1        | 764.4547 | 764.4547 | 11.98 | 12.11 | 3463.2704 | 3463.2704 | 11.322 | 11.25 | 12.112 | 12.8 | -0.132  | -0.69   |
| 3       | D1        | 764.4547 | 764.4547 | 11.98 | 12.11 | 2698.8157 | 2698.8157 | 11.319 | 11.25 | 12.112 | 12.8 | -0.132  | -0.69   |
| 4       | D1        | 764.4547 | 764.4547 | 11.98 | 12.11 | 1934.361  | 1934.361  | 11.314 | 11.25 | 12.112 | 12.8 | -0.132  | -0.69   |
| 5       | D1        | 764.4547 | 764.4547 | 11.98 | 12.11 | 1169.9064 | 1169.9064 | 11.303 | 11.25 | 12.112 | 12.8 | -0.132  | -0.69   |
| TERRACE | D1        | 405.4517 | 405.4517 | 11.98 | 12.11 | 405.4517  | 405.4517  | 11.25  | 11.25 | 12.112 | 12.8 | -0.132  | -0.69   |

Story Shear:

| Story   | Load  | Loc    | P | VX | VY       | T | MX        | MY |          |
|---------|-------|--------|---|----|----------|---|-----------|----|----------|
| TERRACE | EQX   | Bottom |   | 0  | -339.36  | 0 | 3682.986  | 0  | -1636.88 |
|         | 5 EQX | Top    |   | 0  | -798.48  | 0 | 8603.402  | 0  | -1636.88 |
|         | 4 EQX | Top    |   | 0  | -1137.84 | 0 | 11847.889 | 0  | -5450.62 |
|         | 3 EQX | Top    |   | 0  | -1221.48 | 0 | 13764.15  | 0  | -10726.3 |
|         | 2 EQX | Top    |   | 0  | -1308.65 | 0 | 14699.889 | 0  | -16843.7 |
|         | 1 EQX | Top    |   | 0  | -1318.64 | 0 | 14871.716 | 0  | -23377   |
| G       | EQX   | Top    |   | 0  | -1338.75 | 0 | 14878.014 | 0  | -28796.9 |

Figure 2 (a) Gravity Loads: Frame AA

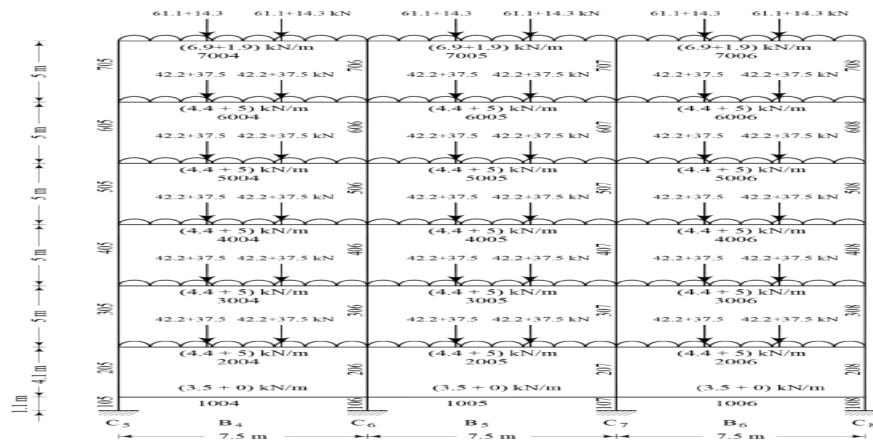


Figure 2(b) Gravity Loads: Frame BB

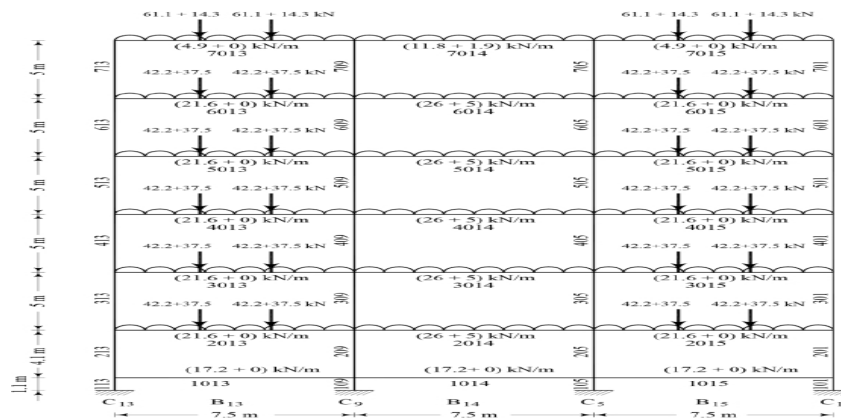


Figure 2(c) Gravity Loads: Frame 1-1

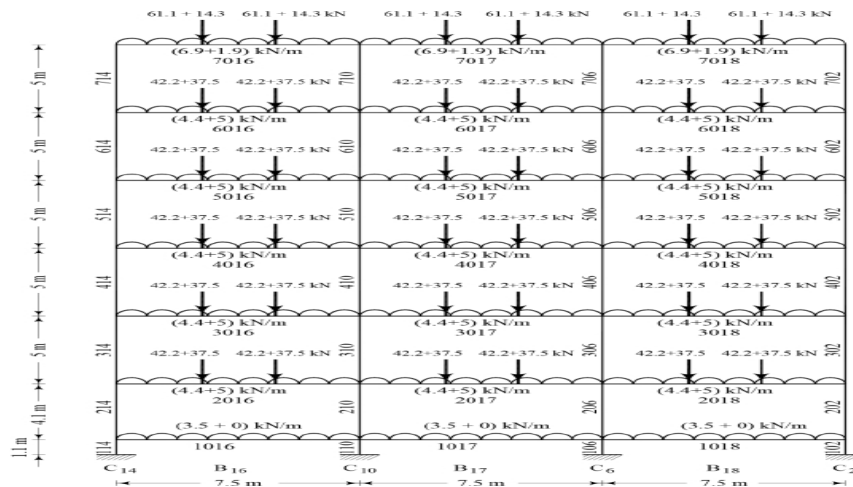


Figure 2(d) Gravity Loads: Frame 2-2

### Seismic Weight Calculations

The seismic weights are calculated in a manner similar to gravity loads. The weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey. Following reduced live loads are used for analysis: Zero on terrace, and 50% on other floors [IS: 1893 (Part 1): 2002, Clause 7.4]

#### (1) Storey 7 (Terrace):

DL + LL

|           |                             |            |
|-----------|-----------------------------|------------|
| From slab | 22.5 x 22.5 (5.5+0)         | 2 784 + 0  |
| Parapet   | 4 x 22.5 (4.9 + 0)          | 441 + 0    |
| Walls     | 0.5 x 4 x 22.5 x (21.6 + 0) | 972 + 0    |
| Secondary | 18 x 7.5 x (2.5 + 0)        | 338 + 0    |
| Beams     |                             |            |
| Main      | 8 x 22.5 x (4.5 + 0)        | 810 + 0    |
| Columns   | 0.5 x 5 x 16 x (6.3 + 0)    | 252 + 0    |
| Total     |                             | 5 597 + 0  |
|           |                             | = 5 597 kN |

#### (2) Storey 6, 5, 4, 3:

DL + LL

|                  |                                  |               |
|------------------|----------------------------------|---------------|
| From slab        | 22.5 x 22.5 x<br>(3.5 + 0.5 x 4) | 1 772 + 1 013 |
| Walls            | 4 x 22.5 x (21.6<br>+ 0)         | 1 944 + 0     |
| Secondary        | 18 x 7.5 x                       | 338 + 0       |
| Beams            | (2.5 + 0)                        |               |
| Main             | 8 x 22.5 x                       | 810 + 0       |
| Beams            | (4.5 + 0)                        |               |
|                  | 16 x 5 x                         | 504+0         |
|                  | (6.3 + 0)                        |               |
| Columns          |                                  | 5 368 +1 01   |
| Total = 6 381 kN |                                  |               |

(4) Storey 1 (plinth):

DL + LL

|        |                               |           |
|--------|-------------------------------|-----------|
| Walls  | 0.5 x 4 x 22.5 (17.2<br>+ 0)  | 774 + 0   |
|        | 0.5 x 4 x 22.5 x              | 158 + 0   |
| Walls  | (3.5 + 0)                     |           |
|        | 8 x 22.5 x                    | 810 + 0   |
| Main   | (4.5 + 0)                     |           |
| Beams  | 16 x 0.5 x 4.1 x (6.3<br>+ 0) | 206 + 0   |
| Column | 16 x 0.5 x 1.1 x<br>(9.0 + 0) | 79 + 0    |
| Total  |                               |           |
|        |                               | 2 027 + 0 |

= 2 027 KN

Seismic weight of the entire building

= 5 597 + 4 x 6 381 + 6 138 + 2 027

= 39 286 KN

The seismic weight of the floor is the lumped weight, which acts at the respective floor level at the centre of mass of the floor.

### Determination of base shear:

The total design lateral force or design base shear along any principal direction shall be determined by the following expression, Clause 7.5 of IS 1893(Part I): 2002.

$$V_B = A_h W$$

Where,

$A_h$  = Design horizontal seismic coefficient for a structure

$W$  = Seismic weight of the building

$A_h$  shall be determined by the following expression:

$$A_h = (Z/2)(I/R)(S_a/g)$$

Note: The value of  $A_h$  will not be taken less than  $Z/2$  whatever the value of  $(I/R)$ .

### 1.5. Design Seismic Load

The infill walls in upper floors may contain large openings, although the solid walls are considered in load calculations.

Therefore, fundamental time period  $T$  is obtained by using the following formula:

$$T_a = 0.075 h^{0.75}$$

[IS 1893 (Part 1):2002, Clause 7.6.1]

$$0.75$$

$$= 0.075 \times (30.5)^{0.75} = 0.97 \text{ sec. Zone factor, } Z = 0.16 \text{ for Zone III IS:}$$

1893 (Part 1):2002, Table 2

Importance factor,  $I = 1.5$  (public building)

Medium soil site and 5% damping

$$S_g 1.36$$

$$g = 1.402$$

IS: 1893 (Part 1): 2002, Figure 2.

**Table1. Distribution of Total Horizontal Load to Different Floor Levels**

| Storey | $W_i$<br>(kN) | $h_i$<br>(m) | $W_i h_i^2$<br>$\times 10^3$ | $Q_i$<br>$\frac{W_i h_i^2}{\sum W_i h_i^2}$ | $V_i$<br>(kN) |
|--------|---------------|--------------|------------------------------|---------------------------------------------|---------------|
| 7      | 5 597         | 30.2         | 5 105                        | 480                                         | 480           |
| 6      | 6 381         | 25.2         | 4 052                        | 380                                         | 860           |
| 5      | 6 381         | 20.2         | 2 604                        | 244                                         | 1 104         |
| 4      | 6 381         | 15.2         | 1 474                        | 138                                         | 1 242         |
| 3      | 6 381         | 10.2         | 664                          | 62                                          | 1 304         |
| 2      | 6 138         | 5.2          | 166                          | 16                                          | 1 320         |
| 1      | 2 027         | 1.1          | 3                            | 0                                           | 1 320         |
| Total  |               |              | 14068                        | 1320                                        |               |

$$S_g = 1.36$$

$$g = 0.97 \quad = 1.402$$

IS: 1893 (Part 1): 2002, Figure 2

Ductile detailing is assumed for the structure. Hence, Response Reduction Factor,  $R$ , is taken equal to 5.0. It may be noted however, that ductile detailing is mandatory in Zones III, IV and V.

Hence,

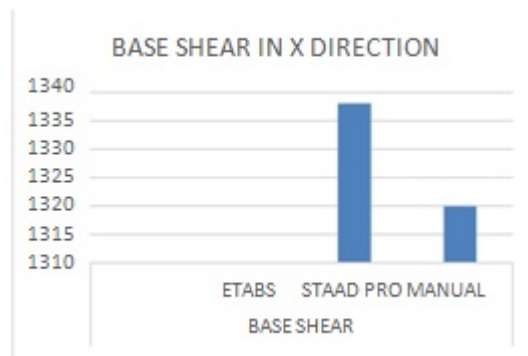
$$A_h = \frac{0.16}{1.402} = 0.0336$$

Base shear,  $V_B = A_h W$

$$= 0.0336 \times 39\,286 = 1320\text{KN}$$

The total horizontal load of 1 320 kN is now distributed along the height of the building as per clause 7.7.1 of IS1893 (Part 1): 2002. This distribution is shown in Table 1

**GRAPH:**



## Conclusion

In the present thesis a comparison of a g+6 building using STAAD.Pro and manual has been compared. It is observed that software has its own integrity of analysis. The moments, shear forces are comparatively higher in STAAD.Pro and manual as the stresses considered from the center of the support. It is observed that the base shear obtained in STAAD.Pro is much higher when compared to values obtained in manual calculations. Comparison is done based on the seismic performance of the structure using nonlinear static and nonlinear dynamic (push over analysis & time history analysis) as ETABS and SAP 2000 are meant for nonlinear analysis by which accuracy of the results can be obtained. STAAD.Pro is not feasible for nonlinear analysis as it is good for steel and finite element analysis only.

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