Study Report on High Rise Steel Buildings In India By STAAD Pro

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Abstract- *Some of the common types of accommodation found in India were bungalows, apartments or flats, pent houses and so on. The sector of apartments and group houses are recently initiated with the concept of tall-buildings in India. As a result of growing population and urbanization, the concept of high-rise buildings has its importance in modern infrastructure facilities. They save space and accommodate more residents than that of smaller buildings. These high-rise buildings are primarily subjected to lateral loads (seismic, wind etc) which contributes to the instability of the structure. These factors are to be considered at the initial stages which otherwise contributes to the breaking down of the structure. In the current thesis, the steel structure is analyzed in STAAD Pro for structural behaviour under various loading conditions. Factors like geometry, bending movement and deflection are studied under the action of loads. steel production has grown strongly in recent decades and India is now the world's fourth-largest steel producer. Nevertheless, India's consumption of steel relative to the size of its economy is very low by international standards. As the economy develops further, steel consumption is likely to increase. Indeed, Indian steelmakers have plans to expand capacity substantially in order to meet the anticipated increase in demand. While India has relatively large reserves of iron ore, its steelmakers import most of the coking coal they require.*

Keywords- Acting Loads, Wind, Tilt, Seismic Forces, Natural Frequency, Stabilization, Buckling, P-Delta, Column Shortening, Designing Steel Columns and Design of a Steel Beam.

I. INTRODUCTION

Tall buildings throughout the world are becoming popular day by day. With the advent of modern day construction technology and computers, the basic aim has been to construct safer buildings keeping in view the overall economics of the project. A high-rise building, apartment tower, office tower, apartment block, or block of flats, is a tall building or structure used as a residential and or office use. Benefits include they act as landmarks, create unique skyline and efficient land use. Although there is no particular definition, various bodies have tried to define what 'high-rise' means "a building having many stories" or "any structure where the height can have a serious impact on evacuation".

The Mumbai Municipal Corporation (BMC) proposed that any building with a height of 30m (nine floors) be categorized as a high rise. But from the structural point of view it can be defined as the a building that its height will be affected by lateral forces resulting from earthquakes and wind forces to extent that such forces will play a major role in the process of design. Based on the distribution of the components of the primary lateral load-resisting system over the building, the structural system of high-rise buildings can be broadly classified as Interior Structures and Exterior Structures. In interior structural system, the major part of the lateral load-resisting system is located within the interior of the building. Whereas in exterior structural system, the lateral loads resisting system, is located along the building perimeter.

II. OUTLINE OF THESIS

In the current thesis, the Steel Structural prototype is analyzed in STAAD Pro for structural behaviour under various loading conditions. Factors like geometry, bending movement and deflection are studied under the action of loads

III. BEHAVIOUR OF HIGH RISE BUILDINGS

A lot of inventions helped make the high-rise buildings functional, such as the telephone and the elevator. Earlier it had been difficult to rent out space above the fifth floor because of the tiresome walk up and down staircases. When Elisha Otis invented a self-braking elevator vertical transportation was possible. However, this transportation was very slow until improved by Werner von Siemens in 1880 with his electrically powered elevator.

ACTING LOADS

A building is exposed to a large number of different loads. They can be static or dynamic, come from outside or inside of the building.

Wind is air in motion relative to the surface of the earth. The primary cause of wind is traced to earth's rotation and differences in terrestrial radiation. **Tilt**, as mentioned earlier, is one of the lateral loads acting on a building. Its origin comes from the fact that in a column-system structure the columns have certain geometric imperfections.**Seismic loads** -Plate movement in the earth's crust causes earthquakes that occur as vibrations. These vibrations move as waves with force components in every direction, the ones that are most dangerous for buildings are the horizontal components. **Natural frequency** -, *f*0, is the number of oscillations per second of a structure that may swing freely. An oscillating structure has a tendency to develop greater amplitude of a swing at the natural frequency than at other frequencies.

STABILIZATION

The stabilization of a high-rise building can be divided into different subsystems:

- Floor systems
- Vertical load resisting systems
- Dampening systems
- Lateral load resisting systems

➢ **Floor systems**

The floor systems primary task is to resist the gravitational loads on them but they should also provide fire resistance, sound dampening, housing for ventilation and more.

➢ **Vertical load resisting systems**

To resist the vertical load a building uses columns, bearing walls, beams, hangers and cables. In high-rise buildings these are made up from structural steel, reinforced concrete and composite materials.

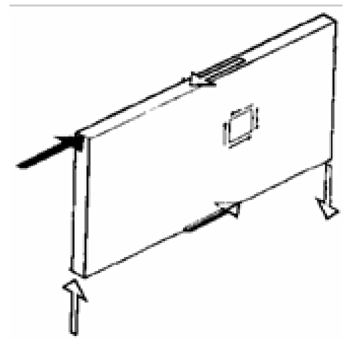
➢ **Dampening systems**

Damping is a measure of the rate at which the energy of the motion is dissipated. Higher damping means the motion is better reduced; making the building feel more stable to its occupants.

➢ **Lateral load resisting systems**

Lateral load resisting systems are structural elements which resist seismic, wind and eccentric gravity loads. There are a lot of different systems but they can be broken down to three fundamental ones which all other systems are a combination of. They are:

- Shear walls
- Moment resisting frames
- Braced frames



➢ **Shear walls**

Shear walls, Figure 3.4, are often defined as vertical elements of the horizontal load resisting system. Walls of steel or timber frames with a board fastened to it are included in the definition. Masonry shear walls are also used, with solid walls and grouted cavity masonry with reinforcements encased. However, considering high-rise building shear walls are more associated with reinforced concrete walls.

Shear walls generally start at foundation and are continuous throughout the building height. The walls provide large strength and stiffness to buildings in the direction of their orientation, mostly due to its large cross-section area that provide great moment of inertia, which significantly reduces lateral sway of the building. The reason to make big elements of reinforced concrete instead of other materials, e.g. steel which would give even more stiffness, is its much cheaper cost.

➢ **Moment resisting frame**

Moment resisting frame, also called moment frame or rigid frame, is made by rigid connections between horizontal and vertical members. Steel, reinforced concrete and steel-concrete composite rigid frames are used. In earlier high-rise buildings, while concrete were under development, steel frames were predominated. The combination of steel and concrete has evolved in recent times which offer the ability to quickly build the framework of steel and then incasing concrete into the frame to increase its stiffness and weight. The higher weight and stiffness improves the damping and the axial strength.

The lateral deformation of rigid frame depends mostly on shear sway but also on column shortening. Its resisting of lateral loads includes primarily by the flexural stiffness and strength of members and joints. Number of stories, story height and column spacing has proportional influence on the frame's strength and stiffness. Larger bending moments appears in the lower levels with its maximum in the connections, shown in Figure 3.5. As building stories increase so does the bending moment both in beams and columns. Columns usually get bigger from top to bottom with respect to increasing gravity load. They can therefore withstand the increased moment while the beams are subjected to the same gravitational loads but needs to be resized to manage the increased moment.

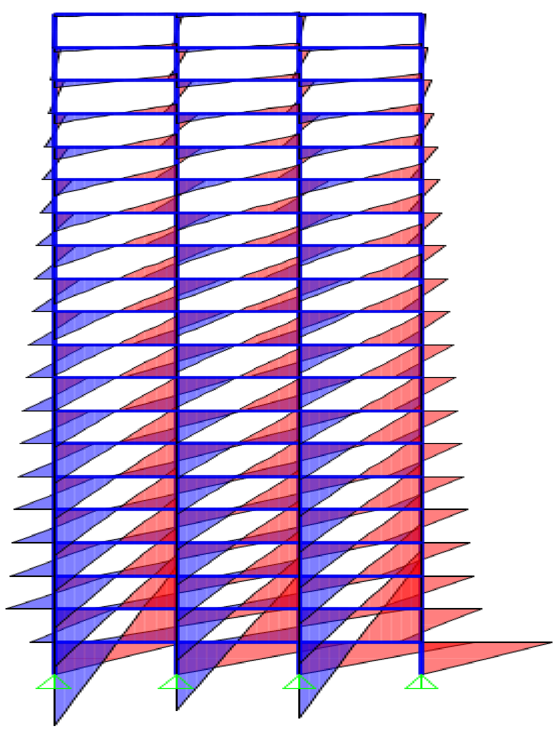


Figure 3.5
Bending moments for a rigid frame

Why the bending moment increases in columns with increasing number of stories is easy to understand while moment increasing in beams is a little bit harder. By applying only one wind-load on the top of the building it is simpler to understand the principle of the developed force and the transmission through the buildings elements. As the force is applied at a distance from the ground there will be a moment that by the equation of equilibrium results as vertical reaction forces in the supports, as tension and compression. There will also be horizontal reaction forces that prevent the lateral movement of the building.

- **Braced frame**

Bracing is another way to take care of horizontal loads. The simplest method is to place a diagonal brace, nodes are designed as leads. The transfer of horizontal loads down to one of the supports takes place in the braces direction in the form of either axial tension or compression depending on the direction of the horizontal load. This means that the axial stiffness of the frame members is what is resisting lateral loads. When subjected to a horizontal load, in an X-brace, one of the diagonals will be subjected to compression while the other is in tension, shown in Figure 3.7.

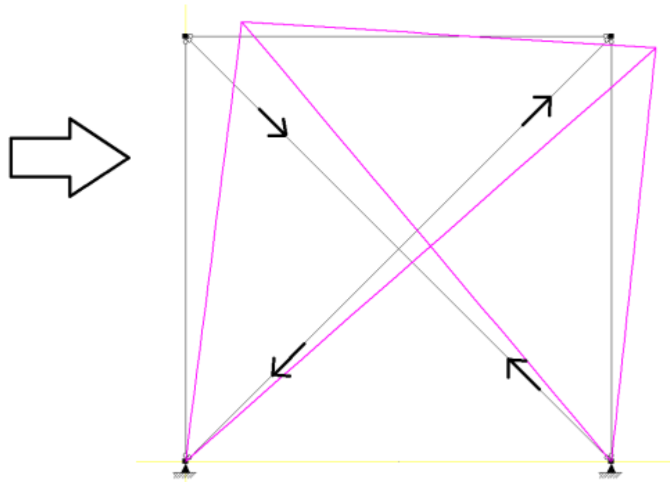


Figure 3.7 Forces in the diagonal braces
when subjected to lateral load

There are many different types of bracing. While the most common and one of the most effective is the X-bracing, this takes a lot of space in the structure which makes little room left for openings. V,K, diagonal- and knee bracing are other types that is often used, these provide better room for openings but are less effective against horizontal loads. There are also eccentrically braced systems that provides different shapes and openings, they have good ductility for resisting seismic forces but provide less stiffness than the concentric braced frame. A few regular shapes are shown in Figure 3.8.

- **Braced rigid frame**

If the braced frame, or shear walls, and a rigid frame are combined, it produces a greater amount of lateral stiffness. This is because of the way the two systems react to the horizontal loads. With the moment frames shear deformation and the bracing's bending deformation the combined deformation is more efficient, as shown in Figure 3.10. Instead of continuing to bend at the top the rigid frame keeps the shear wall or braced frame in place, while at the bottom the bracing, or wall, is restraining the shear deformation of the moment frame. This results in a deflection with an "S" shape.

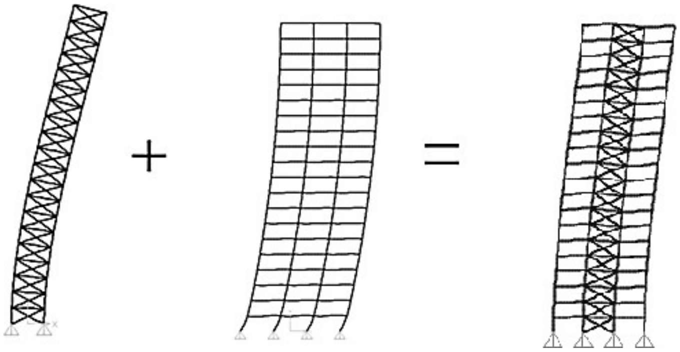


Figure 3.10 A braced frame combined with a rigid frame will decrease a buildings deflection

IV. DESIGN OF HIGH RISE COMPONENTS

Designing the primary building elements; beams, columns, walls, doesn't differ much from a low-rise building. Design for buckling, tilt and P-delta effects is done in the same way. However, since the loads are much greater their effects must be considered on a larger scale than for a low-rise. Column shortening that is often negligible in low-rise buildings must be taken into account when designing tall buildings.

During construction the structural behavior of the building can change from the ideal finished stage. Therefore a construction sequence analysis should be made, this is especially important for tall buildings.

BUCKLING

The buckling instability is a phenomenon of elongate columns which are loaded with compression forces in their longitudinal direction. The phenomenon means that at a certain critical load, the so-called buckling load, a columns shape is substantially changed in terms of deflection which results in that the column fail. Quite often the buckling of a column leads to sudden and dramatic failure and occurs before the normal stress reaches the strength of the columns material. As long as the acting load is less than the buckling load there is a slight deformation of the column, elastic shortening that can be calculated with the modulus of the elasticity.

P-DELTA

P-delta is second order effects. Second order effects can arise in every structure where elements are subject to axial load. When a model is loaded, it deflects. The deflection may give rise of an additional moment – a second order moment. It is of notable importance to consider this as additional moment may incur additional deflections which in turn again can incur additional moment, a third order, and so on until the loads can eventually exceed the capacity. Therefore in the design of members the total moment, summary of moments caused of the first order,, and second order, , should be included or proportionately "decreased" capacity should be used.

COLUMN SHORTENING

When a vertical load is applied to a column it shortens. Shortening takes place in all structures but when reaching great heights its effect has significant importance. As the columns shortening are added together the overall shortening of a high- rise building becomes big enough to have real consequences. Floor slabs starts to tilt because of differential column shortening which in turn affects the cladding, partitions, mechanical equipment and more, a possible result is shown in Figure4.3.

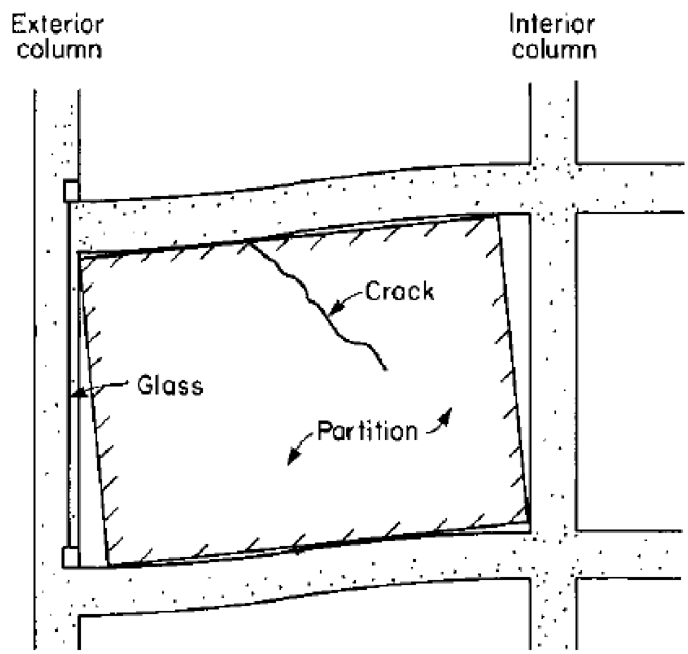


Figure 4.1 Effects of differential column shortening

CONSTRUCTION SEQUENCE

In conventional design the strength, stability and deflection are based on the structure when it's completely erected. This can be compared to constructing a structure in space without any gravitational loads and then adding all loads instantaneously when the structure is finished. In some cases this will create a false image of stress distribution because when the building is being erected components may have a different behavior than when the building is completed, making the building fail during construction. When designing a structure, especially high-rise structures, an analysis of the building during the construction process should therefore be made. Construction sequence allows each story to be added progressively which can change the designed load to better fit the real structure.

DESIGNING STEEL COLUMNS

The design of the steel columns is simpler than of the concrete because the steel has same material properties in tension and compression, no cracking, shrinkage and negligible creep effects are developed over time.

ISWB 350 @ 569N/M

1.Axial load = 600KN

Design Load = 600*1.5

= 900KN

2.Assume f_{cd}= 130N/mm^2

3.Appropriate area required = p/f_{cd}

= 900*10^3/130

= 6923.07mm^2≃ 7250mm^2

4.Choose ISWB 350 @ 569N/M

A = 7250mm^2

n = D = 350mm

b_f = 200mm

t_f = 11.4mm

r_{22} = 146.3

r_{44} = 40.3

5. Buckling class h/b_f = 350/200 = 1.75 > 1.20

t_f = 11.4mm < 40mm

The section falls under bucling class of 'a' about z-z axis and 'b' about y-y axis.

6. Effective length (k_l) = (0.8)*l (Refer table-11 of IS:800-2007)

= 0.8*3 = 2.4m

= 2400mm

7. Effective slenderness ratio = k_l/r_{min}

= 2400/40.3

= 59.55 ≃ 60

8. Design comp. stress (f_{cd})

From table 9(6) of IS÷ 800 ÷ 2007

For k_l/r_{min} = 60 ,f_y = 200, f_{cd}= 152

9. Design comp. strength P_d = A_c * f_{cd}

= 7250*152

= 1102000N ⇒ 1102KN ≥ 900KN

Important pages in code book :

- Page no : 10 – Sectional classification
- Page no : 53, 54 or 70 – Design beam strength
- Page no : 59 – Design shear strength
- Page no : 67 – Check for web bearing
- Page no: 55, 56 & 57

DESIGN OF A STEEL BEAM

The design of beams deals with proportioning of members, the determination of effective section modulus, maximum deflection and the shear stress. In general, the rolled steel sections have webs of sufficient thickness such that the criterion for design is seldom governed by shear.

f_u= 410N/mm^2 ; f_y = 250N/mm^2

Factored dead load = 1.5*4 = 6KN/m^2

Factored live load = 1.5*4.5 = 6.75KN/m^2

Therefore, UDL on the beam = (6+6.75)*2.8

= 35.7KN/m

L effective = 2.8 + 0.2/2 + 0.2/2

= 3m

- Factored B.M = (M) = $wl_e^2/8$ = 35.7*3*3/8
  = 40.16KN.m
- Factored shear force = $wl_e/8$ = 35.7*3/2
  = 53.55KN.m
- $Z_{p:(REQ)}$ = M.r_{m0} / f_y
  = 40.16*10^6*1.10/250 = 1767.04 * 10^3 mm^3

Depth is restricted to 350mm

Therefore, Consider ISWB 350 @ 569 N/m with Z_p = 887*10^3 mm3

Therefore, Provide a cover plate to balance Z_p

Z_a = $Z_{p:(REQ)}$- Z_p of selected section

= 1767.04*10^3 – 887*10^3

= 880*10^3 mm^3

Area of cover plate A = Z/h = 880*10^3/350

= 2514.4 mm^2

So let width of cover plate = width of flange of I-section

b_f = 200mm

Therefore, thickness of cover plate = A/b_f = 2514.4/200

= 12mm

Therefore, provide cover plate of thickness 12mm

Therefore, plastic section modules provided

$Z_{p(prov)}$ = 1767.04*10^3 + (200+6)(350+6)

= 1840*10^3>$Z_{p(req)}$

Therefore, depth of section = 350+(12+12)

= 374 < 400mm

Properties of ISWB 350 @ 569 N/m :

Depth of section h = 350mm

Flange of section b_f = 200mm

Flange thickness t_f = 11.4mm

Web thickness t_w = 8mm

Radius of root = 12mm

Moment of Inertia = I_z = 15521.7*10^4mm^4
I_y = 1175.9* 10^4mm^4
Elastic section modules = 887*10^3mm^3
Web depth = d = h-2(t_f+R_l)
= 350 – 2(11.4+12)
= 303.2mm

1. b/t_f = 17.54 > 15.7 ε where ε = √(250/250) =1
2. d/t_w = 43.75 < 84ε

Therefore b_f = 26
b = b_f = 200/2 = 100

1. b/t_f = 100/11.4=8.77 < 9.4ε
2. d/t_w = 43.75 < 84ε

- Shear capacity of section : (Page no : 59)

$V_a = A_v.f_y/\sqrt{3}\ r_{mo}$
$= (h*t_w)*f_y/\sqrt{3}\ r_{mo}$
= (350*8)*250/√3*1.10
= 368.421KN
0.6V_d = 0.6*368.421 = 221.05 > 205.74KW

- Moment capacity of section : (Page no : 53)

$M_d = P_b*Z_p*f_y/r_{mo}$
= 1*1767.04*10^3*250/1.10
= 401.6KN.m> 326.61

- Check for deflection :

Therefore, Factored UDL = 35.7 KN/m
Therefore, Service UDL = 35.7/1.5 = 23.8KN/m
Therefore, Max.Deflection, $\delta_{max} = (w_l^4/EI_2)*5/384$ where E = 2*10^5

$I_2 = 15521.7*10^4 + 2((200*12^3/12)+(200*12)((350+12)/2)^2$
= 16916.5*10^4mm^4
δ_{max}= ((23.8*3000^4)/(2*10^{5*}16916.5*10^4))*5/384
= 0.74mm
$\delta_{allowable}$= l/300 = 3000/300 = 10mm

Therefore, $\delta_{allowable} > \delta_{max}$

- Check for web bearing :

$F_w = A_e * f_{yw}/r_{mo}$
= ((b_1 + n_1) f_{yw}* t_w)/r_{mo} where b_1 = length of stiff bearing
n_1 = 2.5(t_f + R_1)
= 2.5(11.4+12)
= (100+58.5)*8*250/1.10 = 58.5mm
= 288.81KN > 205.74KN

Therefore, Section is safe in bearing

V. ANALYSIS

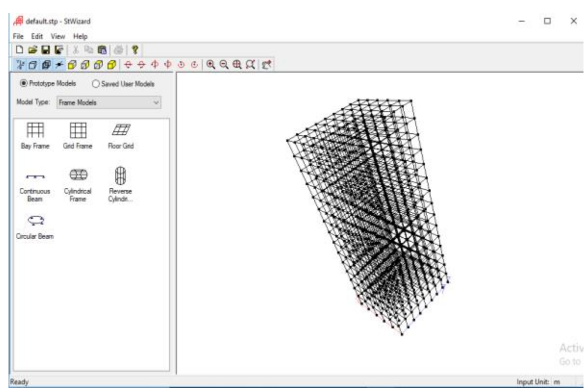
For greater understanding of the structural systems different analysis are made. Performance of the framed structure upon the action of loads(wind primarily) is the primary subject looked upon but other things are measured as well.

The first analysis is of systems in 3D using STAAD with a 30 stories structure. A simplification is made when converting 3D systems to 2D system. Comparison is made from the deflection from wind. Other compared subjects are weight, utilization and connection (as pieces).

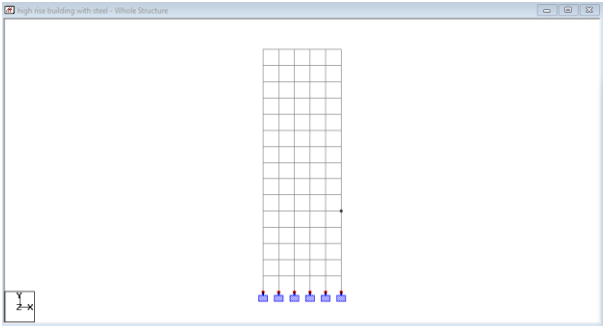
The second analysis is made using STAAD PRO in 3D primary with 30 stories building. In this analysis the stabilization is compared from both deflection because of wind and the stiffness calculated from the natural frequency.

5.1 3D ANALYSIS USING STAAD PRO

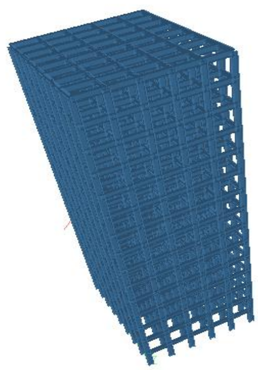
The design is based on the limit state method with Indian codes available in the design tool. A bay-framed structural prototype of 15 storeys (each 3 metre height) is considered.



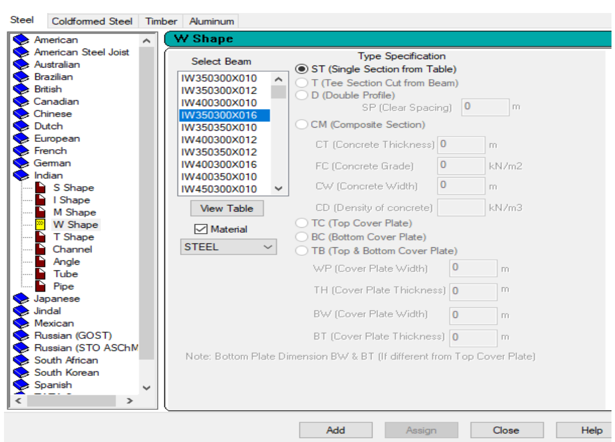
In the section profile tables steel section (W-shape) IW 350X300 is assigned for beams and columns. The supports are assumed to be fixed.



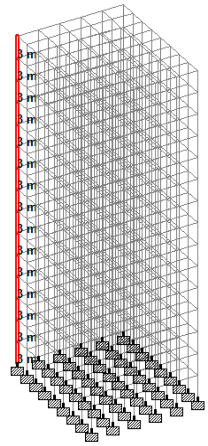
The prototype can be viewed in a rendering mode. In load case details under the dead load, self weight of the each structural member and floor loads with height ranging from 0-45 metres are considered.



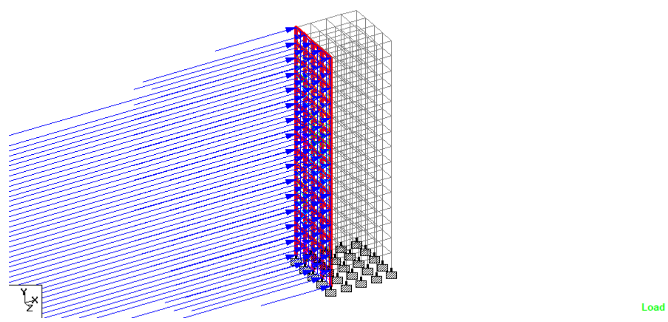
A factor of -1 is considered for the self weight. The member load is assumed to be -3KN per m^2 with height ranging from 0-45 metres is assigned.



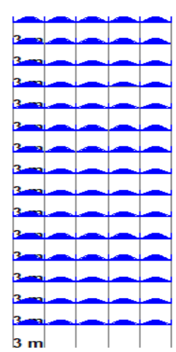
In the live load section a floor load of magnitude -4.5KN per m^2 is assumed with the same altitude.



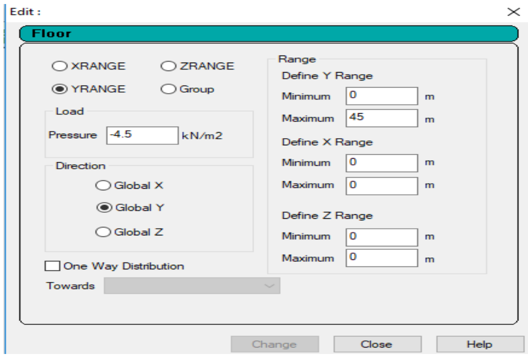
The lateral windward force is assumed to be 1.5kN/m^2 for an altitude of 45metre. For the considered 3D model the wind is assumed to be acting both in negative and positive directions of x and z axis.



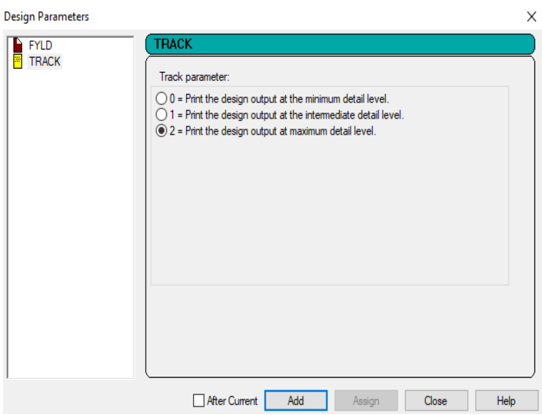
In the auto load combinations, loads are generated according to Indian code. The steel design is done using IS 800:2007 LSD (Limit State Design).



From the available parameter section, desired parameters such as FYLD (yield strength of steel) and track parameter are selected.

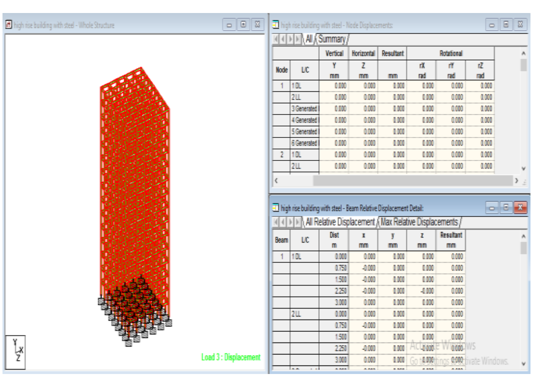


Under the design parameters the yield strength of steel is considered to be 250000KN per m^2. The check code number take off and take off are assigned.

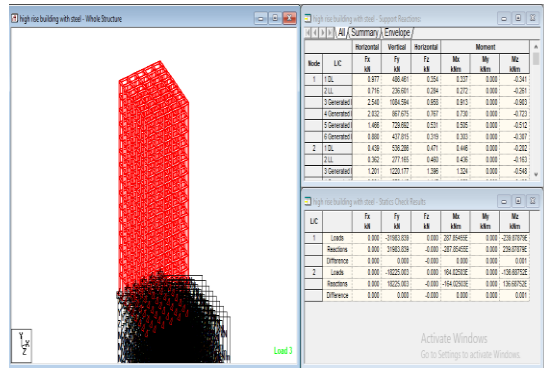


VI. REPORTS AND DISCUSSIONS

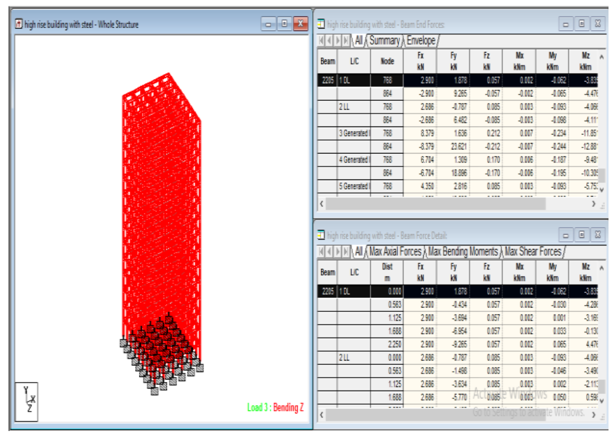
In the post-processing session the nodal displacements can be checked.



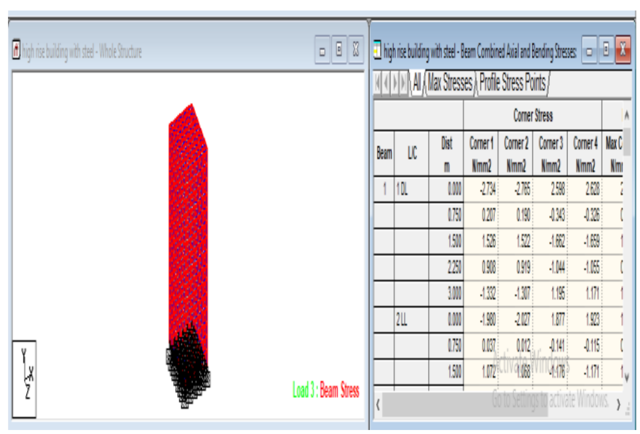
The displacement of the members can be observed in a three dimension (x, y and z in mm). The reactions at the supports (F_x, F_y and F_z) and moments (M_x, M_y and M_z) can be viewed.



The beams can be analyzed for unity check, stresses and forces.



For the unity check the actual ratio should not exceed allowable ratio (1.00) and failed members are to be considered.



Under the animate section, the prototype can be viewed for tilt or sway.

Total Applied and Reaction Load-1 :

```
 ***TOTAL APPLIED LOAD ( KN   METE ) SUMMARY (LOADING     1 )
     SUMMATION FORCE-X =          0.00
     SUMMATION FORCE-Y =     -15470.79
     SUMMATION FORCE-Z =          0.00
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   STAAD SPACE                                              -- PAGE NO.   572


    SUMMATION OF MOMENTS AROUND THE ORIGIN-
    MX=       92824.73  MY=          0.00  MZ=      -92824.73


 ***TOTAL REACTION LOAD( KN   METE ) SUMMARY (LOADING     1 )
     SUMMATION FORCE-X =         -0.00
     SUMMATION FORCE-Y =      15470.79
     SUMMATION FORCE-Z =         -0.00

    SUMMATION OF MOMENTS AROUND THE ORIGIN-
    MX=      -92824.73  MY=         -0.00  MZ=       92824.73


 MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      1)
           MAXIMUMS    AT NODE
    X = -1.18080E-03     240
    Y = -2.89359E-01     238
    Z = -8.65167E-04     398
    RX=  1.55173E-04      78
    RY=  3.97864E-07     320
    RZ= -9.04585E-05     236
```

Total Applied and Reaction Load-2 :

```
 ***TOTAL APPLIED LOAD ( KN   METE ) SUMMARY (LOADING     1 )
     SUMMATION FORCE-X =          0.00
     SUMMATION FORCE-Y =     -15470.79
     SUMMATION FORCE-Z =          0.00
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    SUMMATION OF MOMENTS AROUND THE ORIGIN-
    MX=       92824.73  MY=          0.00  MZ=      -92824.73


 ***TOTAL REACTION LOAD( KN   METE ) SUMMARY (LOADING     1 )
     SUMMATION FORCE-X =         -0.00
     SUMMATION FORCE-Y =      15470.79
     SUMMATION FORCE-Z =         -0.00

    SUMMATION OF MOMENTS AROUND THE ORIGIN-
    MX=      -92824.73  MY=         -0.00  MZ=       92824.73


 MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      1)
           MAXIMUMS    AT NODE
    X = -1.18080E-03     240
    Y = -2.89359E-01     238
    Z = -8.65167E-04     398
    RX=  1.55173E-04      78
    RY=  3.97864E-07     320
    RZ= -9.04585E-05     236
```

Steel Design for IW350x300 (Indian Sections):

```
 STAAD SPACE                                              -- PAGE NO.  598


                    STAAD.PRO CODE CHECKING - IS-800-2007-LSD (V2.0)
                   ***************************************************

|-----------------------------------------------------------------------------|
| Member Number:      1                                                       |
| Member Section:  ST   IW350350X2040   (INDIAN SECTIONS)                     |
| Status: PASS  Ratio:   0.080  Critical Load Case:    23  Location:    0.00  |
| Critical Condition: Sec. 8.4                                                |
| Critical Design Forces:  (Unit: KN    METE)                                 |
|     FX:    -475.076E-03 T     FY:    -35.316E+00      FZ:   -143.534E-03    |
|     MX:      -4.240E-03      MY:   -243.691E-03      MZ:     45.027E+00     |
|-----------------------------------------------------------------------------|
| Section Properties:    (Unit:  CM  )                                        |
| AXX:     304.000E+00        IZZ:      97.828E+03        RZZ:      17.939E+00|
| AYY:      33.440E+00        IYY:      24.711E+03        RYY:       9.016E+00|
| AZZ:      44.000E+00        IXX:     796.000E+00         CW:     607.380E+03|
| ZEZ:       4.681E+03        ZPZ:       5.045E+03                            |
| ZEY:       2.471E+03        ZPY:       1.836E+03                            |
|-----------------------------------------------------------------------------|
| Slenderness Check:    (Unit:  KN    METE)                                   |
| Actual Length:        3.000E+00                                             |
| Parameters:     LZ:        3.000E+00  LY:        3.000E+00                  |
|                 KZ:            1.000  KY:            1.000                  |
| Actual Ratio:  33.27 Allowable Ratio: 400.00  LOAD:    26 FX:  -924.825E-03 T |
|-----------------------------------------------------------------------------|
| Section Class:      Plastic; Flange Class:      Plastic; Web Class:    Plastic|
```

Steel Take Off for IW350x300 (Indian Sections):

```
 STEEL TAKE-OFF
 --------------

    PROFILE                  LENGTH(METE)     WEIGHT(KN  )

 ST   IW350350X2040             2924.98          6830.791
                                             ----------------
                                  TOTAL =        6830.791


 MEMBER        PROFILE                   LENGTH        WEIGHT
                                         (METE)        (KN  )

     1      ST   IW350350X2040              3.00          7.006
     2      ST   IW350350X2040              3.00          7.006
     3      ST   IW350350X2040              3.00          7.006
     4      ST   IW350350X2040              3.00          7.006
     5      ST   IW350350X2040              3.00          7.006
     6      ST   IW350350X2040              3.00          7.006
     7      ST   IW350350X2040              3.00          7.006
     8      ST   IW350350X2040              3.00          7.006
     9      ST   IW350350X2040              3.00          7.006
    10      ST   IW350350X2040              3.00          7.006
    11      ST   IW350350X2040              3.00          7.006
    12      ST   IW350350X2040              3.00          7.006
    13      ST   IW350350X2040              3.00          7.006
    14      ST   IW350350X2040              3.00          7.006
    15      ST   IW350350X2040              3.00          7.006
    16      ST   IW350350X2040              3.00          7.006
```

VII. CONCLUSIONS AND FURTHER STUDIES

CONCLUSIONS

Based On The Limited Study Carried Out, The Following Conclusions Are Made:

1. Efficiency and stability are the main factors which make steel structures more preferable

2. Less bending moment, drift and tilt are other important parameters which are effectively treated using steel structures
3. It is quite affordable just like R.C.C but life span is much better than that of R.C.C
4. Under the effect of wind loads, as the height of the structure increases, the lateral deflection and the overturning moment at the base increase. Tall buildings almost always require additional structural material, in order to limit the lateral deflection and resist the overturning moment, over and above that required for gravity loads only.
5. The key idea in limiting the wind drift in a tall building by changing the structural form of the building in something more rigid and stable to confine the deformation and increase stability
6. The stiffness (rigidity) and stability requirements become more important as the height of the structure increases, and they are often the dominant factors in the design
7. As the building height increases time period has increased i.e., 45% to 50% increase can be observed from the graphs or every addition of 15 stories.
8. Maximum base shear at the base of the building increase with the increase in number of stories. Hence it can be conclude that base shear depends mainly on seismic weight of the building.
9. The reduction in the displacement of rigid frame with shear wall framed structure is 50 % with respect to R.C.C. frame.

FURTHER STUDIES

The main conclusions of this comparative study, concerning the efficiency of the presented five structural systems and the ability of each system in limiting the wind drift for a certain building height, can be summarized in the following:

Rigid frame system The relatively high lateral flexibility calls for uneconomically large members .It is not possible to accommodate the required depth of beams within the normal ceiling space in tall rigid frame. Not stiff as other three systems and considered more ductile and more susceptible to wind failures. Rigid frame with shear wall The benefits of this system depend on the horizontal interaction, which is governed by the relative stiffness of walls and frames and the height of the structure. As the structure height and the stiffness of the frames increase, the interaction between walls and frames increases. The major factor in determining the influence of the frames on the lateral stiffness of this system is the height. As the structure height increases, the sharing of walls from the base shear decreases with respect to frames and more interaction induced between both of them**.**

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[7] **7. Design of Steel structures Text book by S K Duggal** :Design of steel structures by S K Duggal is an important book for Civil engineers to learn and analyze the different types of loads on the structure and various methods on how to design a safe steel structure. this book covers all topics of Steel structure design.