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A Comparative Study between RCC and Steel Design for Industrial and Commercial Structures

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Abstract: **The main objective of this project is to give a brief comparison between RCC (Reinforced Cement Concrete) and Steel Designs for Industrial & Commercial Structures. Generally we use RCC (or) Structural Steel for most of the Structures. The material selected (or) the design procedure opted will depend on various factors like Functional aspects, Compatibility, Load cases, Span, Economical aspects and other local conditions. In this Article, design and analysis aspects like Bending Moment, Axial Load etc., related to Industrial & Commercial Structures in RCC and Steel are presented. A comparison is made between these two cases and the most economical and safe one for the Industrial Structures as well as Commercial Structures is suggested here. In this Article, Industrial Structures having Ground floor with working Space 30.45m x 16.64m subjected to Crane Load and for Commercial Structures, Shopping Complex having Ground + 2 Upper Floors, 2 – Storied Office Building are analyzed in detail**

Keywords: **Industrial Structures, Commercial Structures, Moments, Axial Load, RCC, Steel.**

I. INTRODUCTION

Most of the Structures in India are made with Reinforced Cement Concrete irrespective of category or purpose of the Building or Structures. But in case of Industrial and Commercial Building the scenario is different and they are constructed both with Reinforced Cement Concrete and Structural Steel. Now a day's Commercial Buildings having more working space (Shopping Malls) are designed for Structural Wall System having Flat Slab Floor System with Moment Frame or Structural Wall System having Post Tensioned Slab with Moment Frame. In Flat Slabs, reinforced slab is monolithically connected with Columns without any provision of beams. RCC Moment Frame with Structural Wall System is normally used for Commercial Structures requiring moderate (or) low work space (Wholesale shops & Retail Shops).

In Case of Industrial Structures, they are mostly low rise structures and supporting roof system is chosen based upon the purpose or by considering Structural Behaviour of Building. Commonly in India, Industrial Buildings are Steel Structures having truss with roof covering. Roof Trusses together with supporting columns and it depends on the purpose it may subject to crane load in order to shift (or) to lift load from one point to another point within working space like ceramics factory etc

Industrial Structures:

A Structure designed to serve a specific function in industry (or) to support manufacturing process (or) to store raw materials.

The following are some features required for industrial structures:

(a) Working space have to be more i.e. more column free space.

(b) The Floor Height required is high when compared to normal buildings.

(c) High Span Structure.

Commercial Structures:

A Structure designed to fulfil a specific use in an area (or) to support the exchange and storage of raw materials, goods etc..,

The following are some of the considerations for Commercial Buildings:

(a) In case of wholesale shops and Retail shops, Dead weight of the material is high.

(b) Live load is more comparing to Residential Building.

2. INDUSTRIAL STRUCTURES

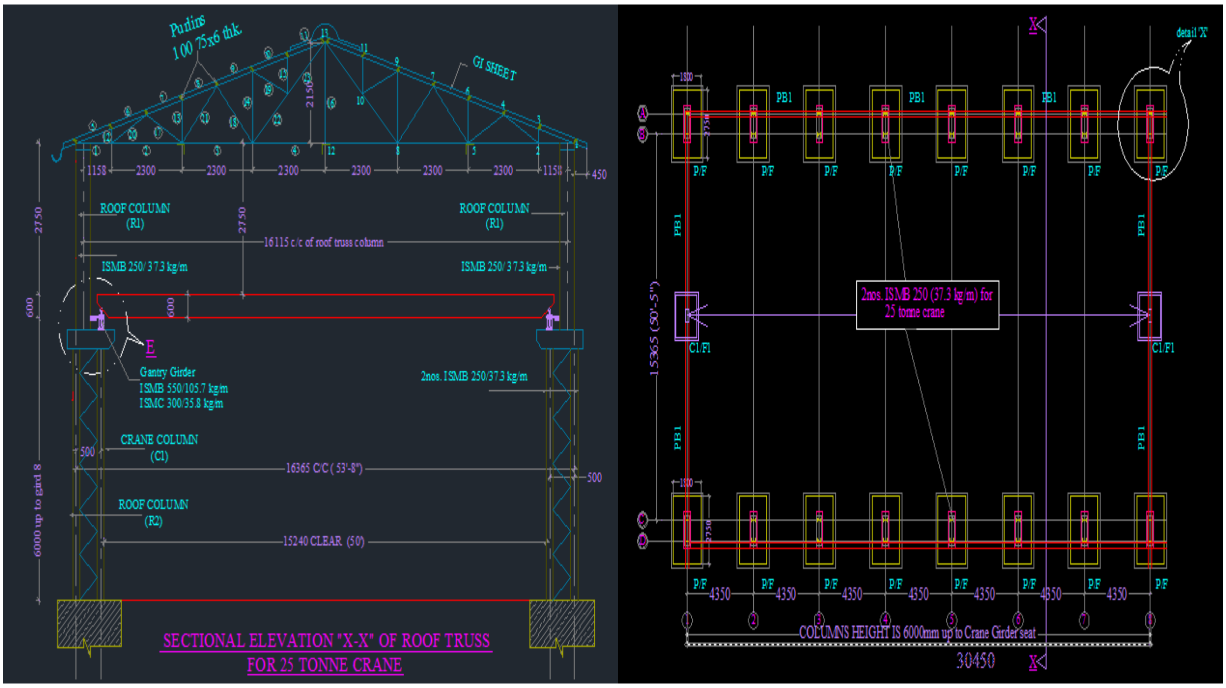
Here design is done using Staad Pro Software and Manual Process as well. Designs for Two Industrial models with different materials are performed.

1. Industrial Structure with Structural Steel

2. Industrial Structure with RCC

2.1 Description and data of Steel Industrial Structure:

Clear Span of Truss	:	17.016 m
Spacing of Purlin	:	1.254 m
Central Rise of Truss	:	2.150 m
Location	:	Hyderabad
Life Span	:	50 Years
Permeability	:	Normal
Height of Truss @ Eaves Level	:	9.350 m
Roof Sheeting	:	GI Sheets
Span of Purlin	:	4.350 m



a) Sectional View **b) Plan**

Fig .2.1: Description of Steel Industrial Structure

2.1.1 Materials Used :

a) Structural Steel:

- Yield Strength : 250 N/mm^2
- Modules of Elasticity : 2 x 10^5 MPa
- Poisons Ratio , Elastic Range : 0.3
- Plastic Range : 0.5

b) Concrete:

- Characteristic Compressive Strength (f_{ck}) : 20 N/mm^2
- Poisons Ratio : 0.17
- Density : 25 k N/m^3

c) Reinforcing Steel :

- Yield Strength : 415 N/mm^2
- Modules of Elasticity : 2 x 10^5 MPa

2.1.2 Load Calculations:

1. Dead Load: (as per IS 875 Part-1 i.e. GI Sheet Unit weight 131 N/m)

Weight of Roof Sheeting : 131 x 1.254 = 164.274 N/m

Self Weight of Purlin : 100 N/m

Total Dead Load @ Purlin : 264.274 N/m

2. Live Load : (as per IS 875 Part-2)

Live Load on Sloping Roof : 750-20(14.19-10) N/m^2

: 666.2 N/m^2

Live Load on Purlin per metre : 666.2x 1.254 x cos (14.19)

: 810 N/m

3. Wind Load : (as per IS 875 Part-3)

Basic Wind Speed @ Hyderabad : 44 m/s

Risk Coefficient (k1) (50 Years) : 1

Terrain (or) Size Factor (k2) : 1

Topography Factor (k3) (level) : 1

Design Wind Speed : 44 m/s

Basic Wind Pressure : 0.6 x 44 x 44

: 1161.6 N/m2

Internal Wind Pressure Cpi : ± 0.2 p

External Wind Pressure Coefficient (Cpe) :

w=17.016 h = 9.350 =➔ h/w === 0.55

Range of h/w is 1.5 > 0.55 > 0.5

Table 2.1: External Wind Pressure Coefficients

Roof Angle (α)	θ = 0^0 Wind normal to ridge		θ = 90^0 Wind parallel to ridge	
	EF	GH	EG	FH
100	-1.1	-0.6	-0.8	-0.6
14.190	-0.93	-0.56	-0.8	-0.6
200	-0.7	-0.5	-0.8	-0.6

Wind normal to ridge θ=0^0

Case 1: External + Internal Suction:

Wind on windward rafter : -0.93+0.2 = -0.73

Wind on leeward rafter : -0.56+0.2 = -0.36

Case 2: External + Internal Pressure:

Wind on windward rafter : -0.93-0.2 = -1.13

Wind on leeward rafter : -0.56-0.2 = -0.76

Wind parallel to ridge θ=90^0

Case 3: External + Internal Suction: : -0.8+0.2 = -0.6

Case 4: External + Internal Pressure: : -0.8-0.2 = -1.0

Among 4 Cases, Case 2 gives the most severe effect.

Wpe = (Cpe – Cpi) x Design Wind Pressure

= -1.13 x 1161.6

= 1312.6 N/m2 (away from rafter)

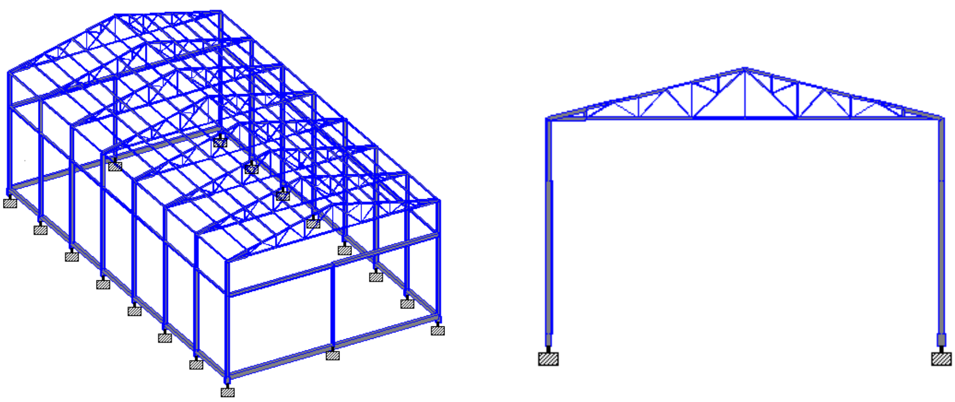
Wind Load On Purlin = 1312.6 x 1.254 = 1646 N/m

4. Crane Load :

Moving Load on both sides = 125k N

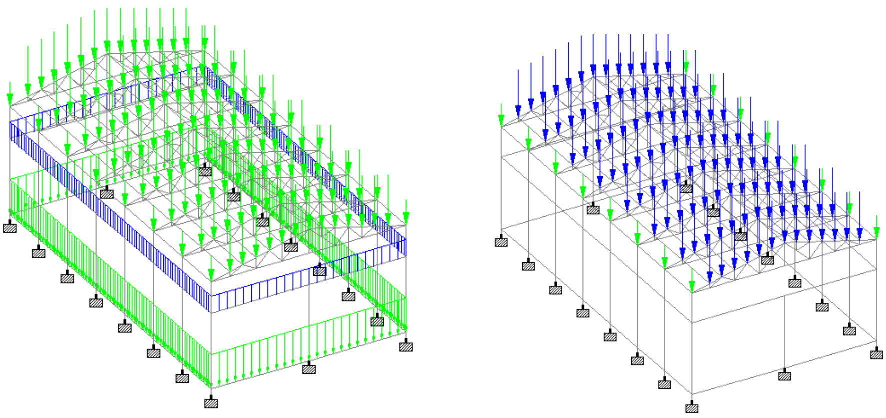
5. Load Combinations:

1. 1.5 x Dead Load + 1.5 x Live Load + Moving Load
2. 1.5x Dead Load + 1.5 x(Wind Load +Z) + Moving Load
3. 1.5x Dead Load + 1.5 x(Wind Load -Z) + Moving Load
4. 1.2 x Dead Load +1.2 x Live Load + 1.2 x (Wind Load +Z)+ Moving Load
5. 1.2 x Dead Load +1.2 x Live Load + 1.2 x (Wind Load -Z)+ Moving Load

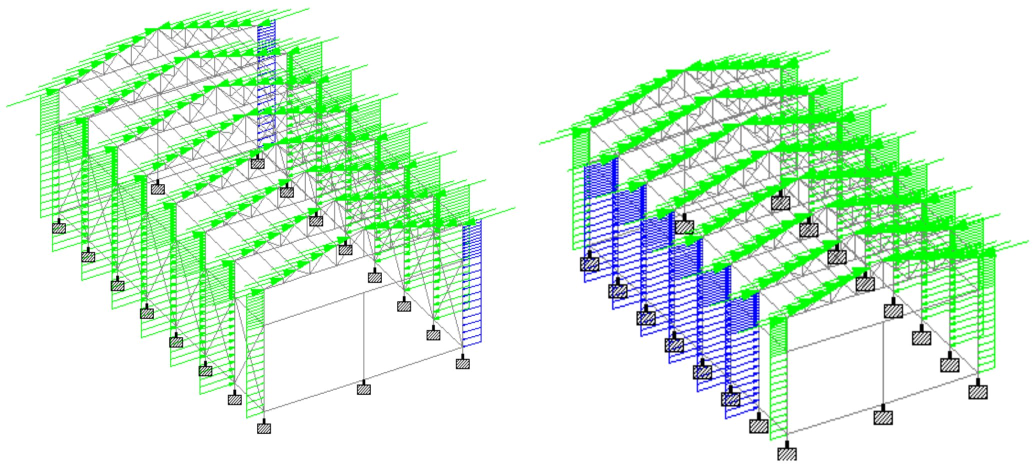


a) 3D View of Steel Industrial Structure **b) Sectional View**

Fig 2.2 Description of Steel Industrial Structure in Staad Pro

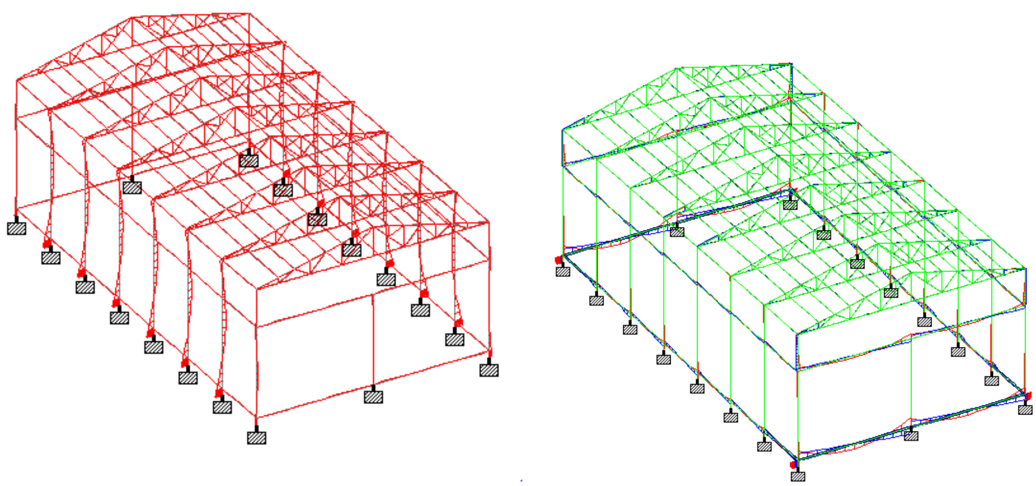


a) Dead Load b) Live Load



C) Wind Load in +Z Direction d) Wind Load in –Z Direction

Fig 2.3 : Load Case models in Staad Pro

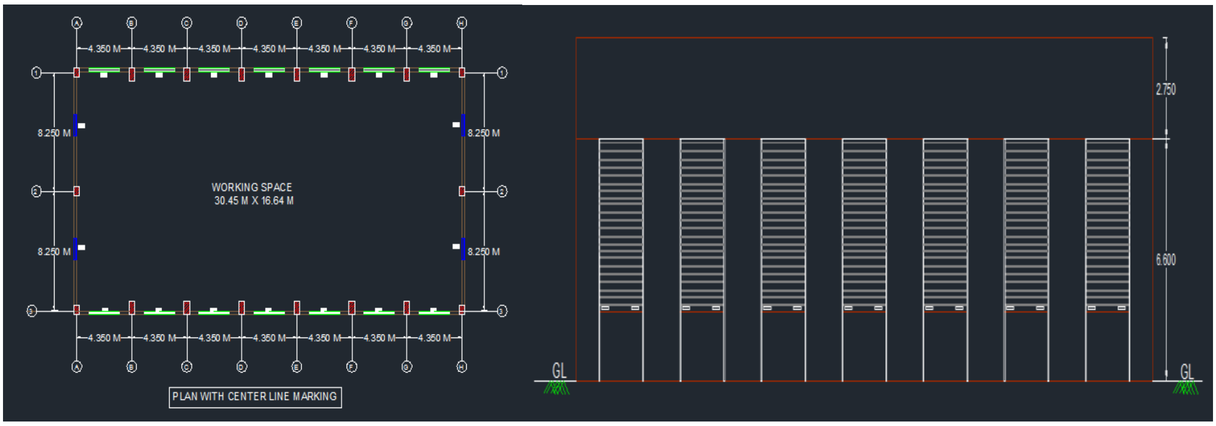


a) Axial Loading b) Bending

Fig 2.4 : Analysis of Steel Industrial Structure in Staad Pro

2.2 Description and Date of RCC Industrial Structure :

The Industrial Structure shown below is a RCC Framed Structure with Ground Floor. The Height of the Industrial Building is +9.350m from the Finished Ground Level where +6.600m from the Finished Ground Level is Tie Beam Level and +9.350m from Ground is Roof level. The Structure is having 230 mm Thick Brick wall and with 2.4m wide Rolling Shutters.



a) Plan b)Elevation

Fig 2.5 : Description of RCC Industrial Structure

2.2.1 Materials Used :

a) Concrete:

- Characteristic Compressive Strength (f_{ck}) : 25 N/mm^2
- Poisons Ratio : 0.17
- Density : 25 k N/m^3

b) Reinforcing Steel :

- Yield Strength : 415 N/mm^2
- Modules of Elasticity : 2 x 10^5 MPa

2.1.2 Load Calculations:

a).Dead Load (+7.6m Roof Level):

On Roof Slab (25x 0.15) = 3.75 k N/m2

Wall Load on Plinth Beam = 9.80 k N/m

Wall Load on Tie Beam @ Crane Girder = 4.80 k N/m

b).Live Load (+7.6 m Roof Level) :

On Roof Slab (As Per IS 875 Part-2) = 0.75 k N/m2

c) Moving Load :

Crane Load (or) Trolley Load (One side) = 123 kN

d) Wind Load (As Per IS 875 Part-3)

Basic Wind Speed @ Hyderabad = 44 m/s

Risk Coefficient (k1) (50 Years) = 1

Terrain (or) Size Factor (k2) = 1

Topography Factor (k3) (level) = 1

Design Wind Speed = 44 m/s

Basic Wind Pressure = 0.6 x 44 x 44

= 1161.6 N/m2

= 1.162 kN/m2

Wind Load on Column along + Z Direction

Corner Columns = 1.162 x 4.35 /2

= 2.5 k N/m

Middle Columns = 1.162 x 4.35

= 5.0 k N/m

Wind Load on Column along - Z Direction

Corner Columns = -1.162 x 4.35 /2

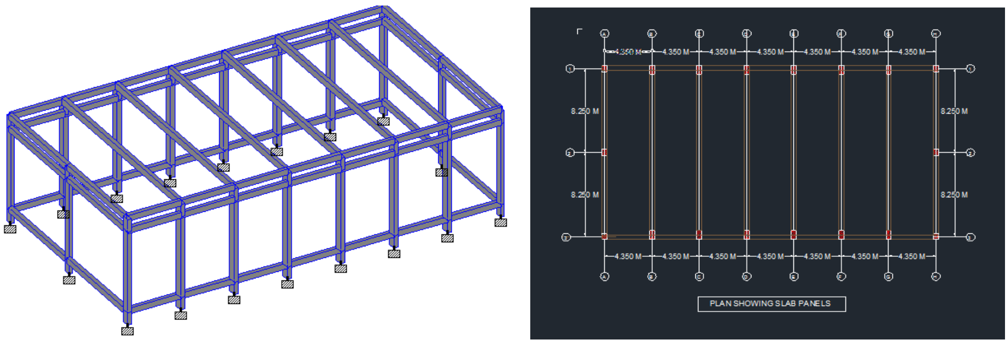
= -2.5 k N/m

Middle Columns = -1.162 x 4.35

= -5.0 k N/m

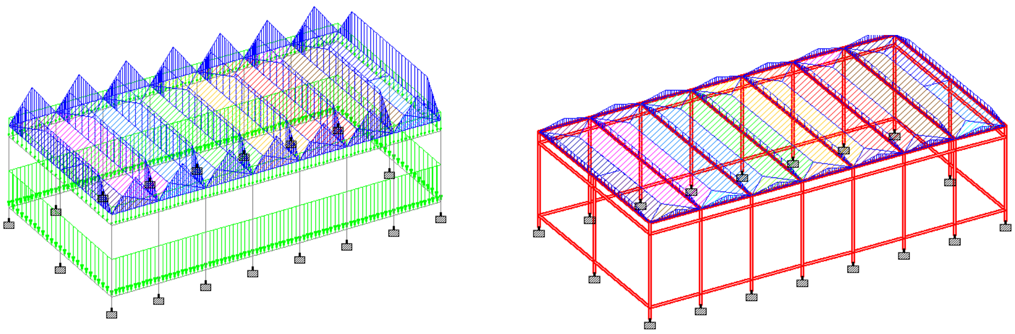
e).Load Combinations:

1. 1.5 x Dead Load + 1.5 x Live Load + Moving Load
2. 1.5x Dead Load + 1.5 x(Wind Load +Z) + Moving Load
3. 1.5x Dead Load + 1.5 x(Wind Load -Z) + Moving Load
4. 1.2 x Dead Load +1.2 x Live Load + 1.2 x (Wind Load +Z)+ Moving Load
5. 1.2 x Dead Load +1.2 x Live Load + 1.2 x (Wind Load -Z)+ Moving Load

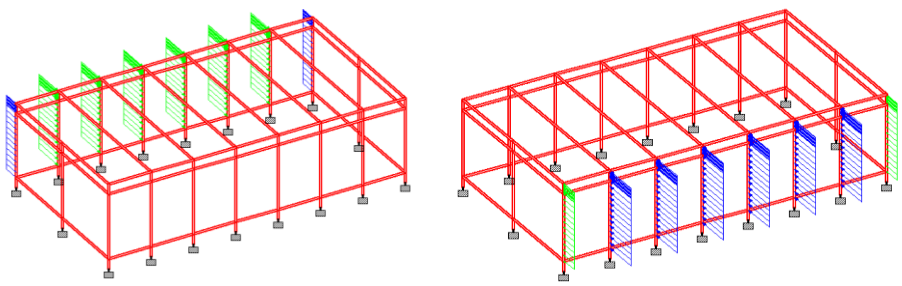


a) 3D Staad Model **b) Slab Panels**

Fig 2.6 : Staad Model and Slab Panels



a) Dead Load **b) Live Load**



c) Wind Load in +Z Direction **d) Wind Load in –Z Direction**

Fig 2.7 : Load Case models in Staad Pro

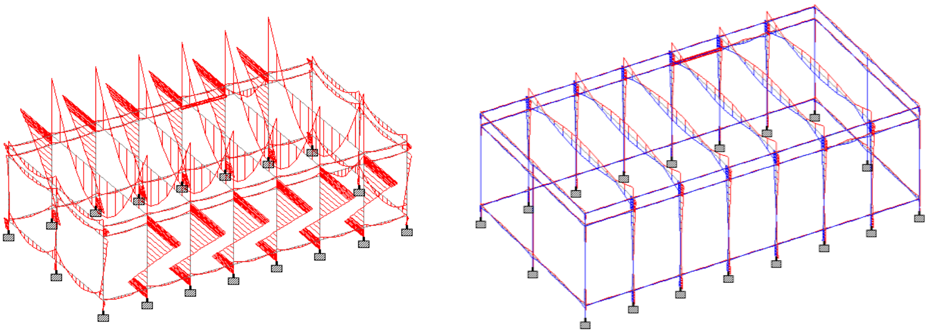


Fig 2.4 : Analysis of RCC Industrial Structure in Staad Pro

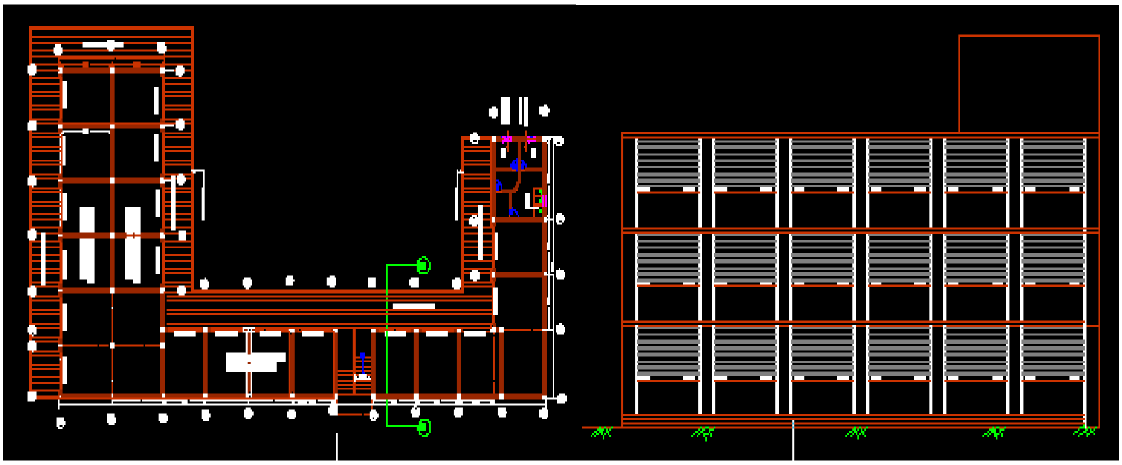
3. COMMERCIAL BUILDINGS

Here design is done using Staad Pro Software and Manual Process as well. Designs for Two Commercial models with different materials are performed.

1. Shopping Complex
2. Office Building
3. Petrol Bunk

3.1 Description and Data of RCC Shopping Complex:

The proposed Municipal Shopping Complex is a RCC framed structure (G+2). The height of building is 3.000m from the Finished Floor Level (+0.60m). The FGL(+0.0m) is 0.6m below the FFL. The Roof level (+3.725m TOC) is 3.125m above the Plinth beam top level. The building is an RCC framed structure. The Brick wall thickness is 230mm . Shopping complex comprising of Shopping Rooms (No's 19 for each floor) , ladies and gents toilets and stair case.



a) Plan **b) Elevation**

Fig 3.1 : Description of RCC Shopping Complex

3.1.1 Materials Used :

a) Concrete:

- Characteristic Compressive Strength (f_{ck}) : 25 N/mm^2
- Poisons Ratio : 0.17
- Density : 25 k N/m^3

b) Reinforcing Steel :

- Yield Strength : 415 N/mm^2
- Modules of Elasticity : 2 x 10^5 MPa

3.1.2 Load Calculations:

a) Dead Load:

1).Loads at + 3.725m level

On Roof slab (Floor load + Floor finish load)

= 0.125x 25 + 0.05x24 =4.325k N/m2

2).Loads at Plinth level

Parapet (Brick Wall) load on Roof Beam

= 0.115x0.6x20 = 1.38 k N/m

3).230 mm thick brick wall load on beams

= 0.230x2.925 x 20.00 = 13.455 kN/m

4)115 mm thick brick wall load on beams

= 0.115 x 2.925 x 20.00 = 6.728k N/m

5) 230 mm thick brick wall load on beams

= 0.23x 2.5x20 = 11.5 k N /m

6) 115 mm thick balcony downward projections on beams

= 0.115 x 0.8 x 25 = 2.3 k N/m

b) Live Load

1)Loads at Roof level

On Roof slab (Accessible roof) = 4 k N/m^2

2)Loads at Roof level

On Balcony (Accessible roof) = 2 k N/ m^2

c)Wind Load:

Wind loads are considered in accordance with IS 875 (Part 3) - 1987

Basic wind Speed considered (Vb) = 50 m/sec

Design Wind Speed is given by Vz = k1 k2 k3 Vb

Design Wind Pressure = 0.6x V_Z^2

Risk Coefficient (K1) =1.08

Terrain, Height and structure size Coefficient (K2) = 0.98

(for Terrain Category = 2, Class-A and Height = 10m)

Topography Factor (K3) = 1

Design Wind Speed is given by Vz = 50 x 1.08 x 0.98 x 1 = 52.92 m/sec

Design Wind Pressure = 0.6 x 52.92 x 52.92 = 1.68 k N/m^2

Table 3.1 :Wind load on columns along + X direction

Along grid 13	=	1 * 1.68 * 3.65 /2	=	3.07 k N/m
Along grid 12	=	1 * 1.68 * (3.65 + 3.64)/2	=	6.12 k N/m
Along grid 11	=	1 * 1.68 * 3.64 /2	=	3.06 k N/m
Along grid 10	=	1 * 1.68 *(3.04+3.04) /2	=	5.11 k N/m
Along grid 9	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid 8	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid 7	=	1 * 1.68 * (3.04 + 2.74)/2	=	4.86 k N/m
Along grid 6	=	1 * 1.68 * (2.74 + 3.04)/2	=	4.86 k N/m
Along grid 5	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid 4	=	1 * 1.68 * (3.04 + 2.43)/2	=	4.59 k N/m
Along grid 3	=	1 * 1.68 * 2.43 /2	=	2.04 k N/m
Along grid 2	=	1 * 1.68 * 3.65 /2	=	3.07 k N/m
Along grid 1	=	1 * 1.68 * 3.65 /2	=	3.07 k N/m

Table 3.2: Wind load on columns along - X direction

Along grid 13	=	1 * 1.68 * 3.65 /2	=	3.07 k N/m
Along grid 12	=	1 * 1.68 * (3.65 + 3.64)/2	=	6.12 k N/m
Along grid 11	=	1 * 1.68 * (3.64+3.04) /2	=	5.61 k N/m
Along grid 10	=	1 * 1.68 *(3.04+3.04) /2	=	5.11 k N/m
Along grid 9	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid 8	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid 7	=	1 * 1.68 * (3.04 + 2.74)/2	=	4.86 k N/m
Along grid 6	=	1 * 1.68 * (2.74 + 3.04)/2	=	4.86 k N/m
Along grid 5	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid 4	=	1 * 1.68 * (3.04 + 2.43)/2	=	4.59 k N/m
Along grid 2	=	1 * 1.68 * (3.65+2.43) /2	=	5.11 k N/m
Along grid 1	=	1 * 1.68 * 3.65 /2	=	3.07 k N/m

Table 3.3 :Wind load on columns along + Z direction

Along grid A	=	1 * 1.68 * 3.04 /2	=	2.55 k N/m
Along grid B	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid C	=	1 * 1.68 * (3.04+3.04) /2	=	5.11 k N/m
Along grid D	=	1 * 1.68 *(3.04+3.04) /2	=	5.11 k N/m
Along grid E	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid G	=	1 * 1.68 * (3.04 + 2.77)/2	=	4.88 k N/m
Along grid H	=	1 * 1.68 * (2.77)/2	=	2.33 k N/m
Along grid I	=	1 * 1.68 * (4.38)/2	=	3.68 k N/m
Along grid J	=	1 * 1.68 * (4.38 + 3.04)/2	=	6.23 k N/m
Along grid K	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m

Table 3.4 :Wind load on columns along - Z direction

Along grid A	=	1 * 1.68 * 3.04 /2	=	2.55 k N/m
Along grid B	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid C	=	1 * 1.68 * (3.04+3.04) /2	=	5.11 k N/m
Along grid D	=	1 * 1.68 *(3.04+3.04) /2	=	5.11 k N/m
Along grid E	=	1 * 1.68 * (3.04 + 3.04)/2	=	5.11 k N/m
Along grid I	=	1 * 1.68 * (4.38)/2	=	3.68 k N/m
Along grid J	=	1 * 1.68 * (4.38+3.04)/2	=	6.23 k N/m
Along grid K	=	1 * 1.68 * (3.04+3.04)/2	=	5.11 k N/m
Along grid F	=	1 * 1.68 * (3.65 + 3.04)/2	=	5.62 k N/m
Along grid H	=	1 * 1.68 * (3.65)/2	=	3.07 k N/m

d) Seismic Load :

The seismic load on the structure is calculated as per IS 1893 - 2002.

X direction: Zone Considered = II

Zone Factor = (Z) = 0.16

Importance Factor = (I) =1

Response reduction Factor , R = 5

Horizontal Seismic Coefficient (Ah) = 0.16 x 1 x 2.5 /(2 x 5) = 0.04

Z direction: Zone Considered = II

Zone Factor = (Z) = 0.16

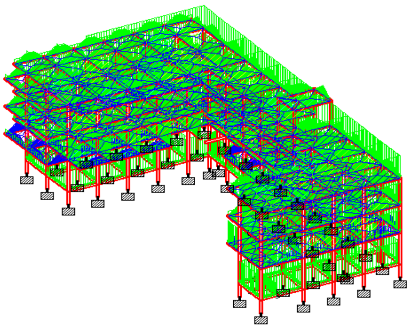
Importance Factor = (I) =1

Response reduction Factor , R = 5

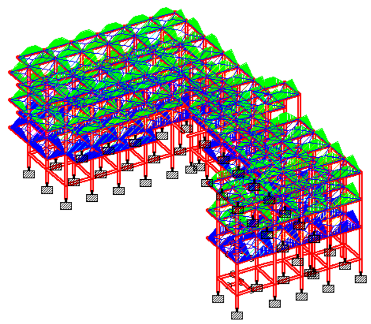
Horizontal Seismic Coefficient (Ah) = 0.16 x 1 x 2.5 /(2 x 5) = 0.04

e) Load Combinations :

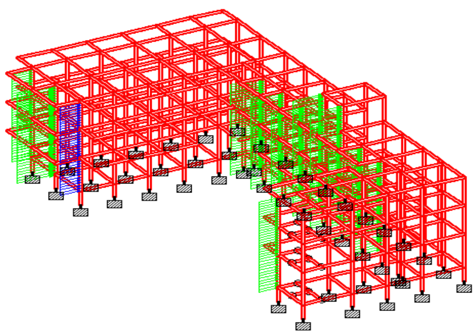
1. 1.5(DL+LL)
2. 1.5(DL+WL(+ X))
3. 1.5(DL+WL(+ Z))
4. 1.5(DL+WL(- X))
5. 1.5(DL+WL(- Z))
6. 1.5(DL+EQ(+X))
7. 1.5(DL+EQ(+Z))
8. 1.5(DL+EQ(-X))
9. 1.5(DL+EQ(-Z))
10. 1.2(DL+LL+WL(+ X))
11. 1.2(DL+LL+WL(+ Z))
12. 1.2(DL+LL+WL(- X))
13 1.2(DL+LL+WL(- Z))
14 1.2(DL+0.25LL+EQ (+ X))
15. 1.2(DL+0.25LL+EQ (+ Z))
16. 1.2(DL+0.25LL+EQ (+ Z))
17. 1.2(DL+0.25LL+EQ (- Z))



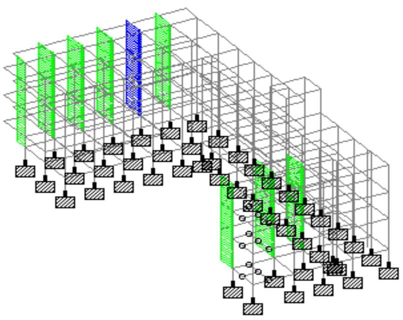
a) Dead Load



b) Live Load

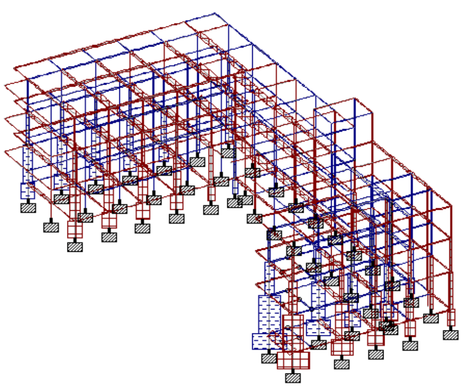


c) Wind Load in Z direction



d) Wind Load in X direction

Fig 3.2 : Load Case Models in Staad Pro



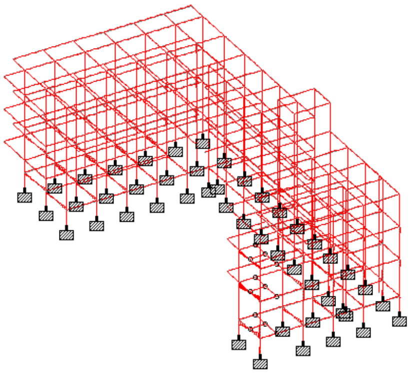
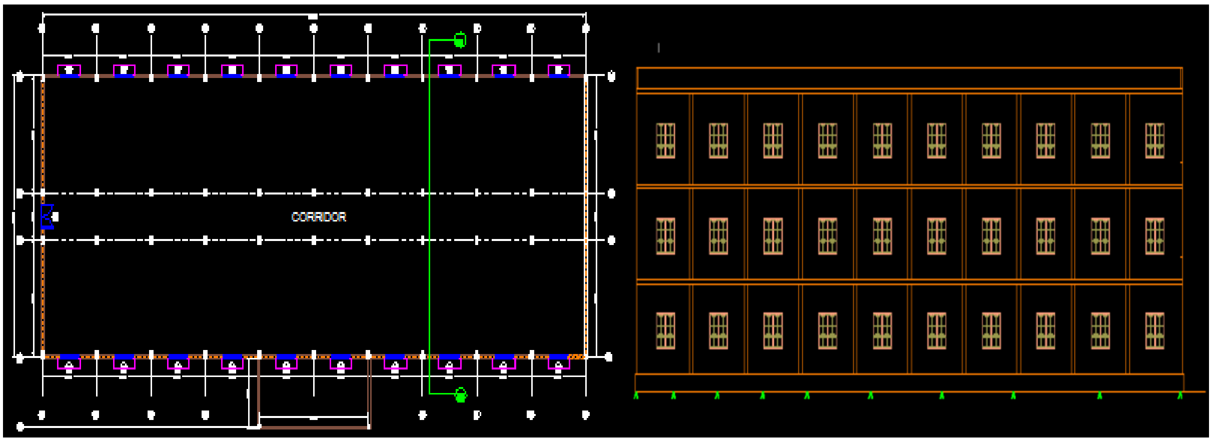


Fig 3.3 : Analysis of RCC Shopping Complex in Staad Pro

3.2 Description and Data of RCC OFFICE BUILDING:

The proposed Municipal Office Building is a RCC framed structure with Ground + 2 Upper Floors. The height of building is 3.125m from the Finished Floor Level (+0.60m). The FGL(+0.0m) is 0.6m below the FFL. The Roof level (+3.725m TOC) is 3.125m above the Ground level. The building is an RCC framed structure. The Brick wall thickness is 230mm . Muncipal Office comprising of Rooms with Aluminium Sheet Partitions .



a) Plan **b) Elevation**

Fig 3.4: Description of an Office Building

3.2.1 Materials Used :

a) Concrete:

- Characteristic Compressive Strength (f_{ck}) : 25 N/mm^2
- Poisons Ratio : 0.17
- Density : 25 k N/m^3

b) Reinforcing Steel :

- Yield Strength : 415 N/mm^2
- Modules of Elasticity : 2 x 10^5 MPa

3.1.2 Load Calculations:

a) Dead Load :

Loads at + 3.725m level

1) On Roof slab (Floor load + Floor finish load)

=0.150x 25 + 0.05x24 =4.955k N/m2

2)Loads at Plinth level

230 mm thick brick wall load on Plinth beams

=0.230x2.100 x 20.00 = 9.660 kN/m

3)230 mm thick brick wall load on Tie beams

= 0.230 x 0.795 x 20.00 = 3.657 k N/m

4) 230 mm thick brick wall load on beams

=0.23x 2.775 x20 = 12.765 k N /m

b) Live Load

Loads at Roof level

On Roof slab (Accessible roof) = 4 k N/m^2

c)Wind Load:

Wind loads are considered in accordance with IS 875 (Part 3) - 1987

Basic wind Speed considered (Vb) = 50 m/sec

Design Wind Speed is given by Vz = k1 k2 k3 Vb

Design Wind Pressure = 0.6x V_Z^2

Risk Coefficient (K1) =1.08

Terrain, Height and structure size Coefficient (K2) = 0.98

(for Terrain Category = 2, Class-A and Height = 10m)

Topography Factor (K3) = 1

Design Wind Speed is given by Vz = 50 x 1.08 x 0.98 x 1 = 52.92 m/sec

Design Wind Pressure = 0.6 x 52.92 x 52.92 = 1.68 k N/m^2

Table 3.5 :Wind load on columns along + Z direction

Along grid 11	=	1 * 1.68 *(4.50) /2	=	3.78 k N/m
Along grid 10	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 9	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 8	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 7	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 6	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 5	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 4	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 3	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 2	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 1	=	1 * 1.68 * 4.5 /2	=	3.78 k N/m

Table 3.6 :Wind load on columns along - Z direction

Along grid 11	=	1 * 1.68 *(4.50) /2	=	3.78 k N/m
Along grid 10	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 9	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 8	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 7	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 6	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 5	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 4	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 3	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 2	=	1 * 1.68 * (4.5 + 4.5)/2	=	7.56 k N/m
Along grid 1	=	1 * 1.68 * 4.5 /2	=	3.78 k N/m

Table 3.7 :Wind load on columns along + X direction

Along grid A	=	1 * 1.68 * 7.5 /2	=	6.30 k N/m
Along grid B	=	1 * 1.68 * (7.5 + 3.0)/2	=	8.82 k N/m
Along grid C	=	1 * 1.68 * (3.0+ 7.5) /2	=	8.82 k N/m
Along grid D	=	1 * 1.68 *(7.5) /2	=	6.30 k N/m

Table 3.8 :Wind load on columns along - X direction

Along grid A	=	1 * 1.68 * 7.5 /2	=	6.30 k N/m
Along grid B	=	1 * 1.68 * (7.5 + 3.0)/2	=	8.82 k N/m
Along grid C	=	1 * 1.68 * (3.0+7.5) /2	=	8.82 k N/m
Along grid D	=	1 * 1.68 *(7.5) /2	=	6.30 k N/m

d).Seismic Load :

The seismic load on the structure is calculated as per IS 1893 - 2002.

X direction: Zone Considered = II

Zone Factor = (Z) = 0.16

Importance Factor = (I) =1

Response reduction Factor , R = 5

Horizontal Seismic Coefficient (Ah) = 0.16 x 1 x 2.5 /(2 x 5) = 0.04

Z direction: Zone Considered = II

Zone Factor = (Z) = 0.16

Importance Factor = (I) =1

Response reduction Factor , R = 5

Horizontal Seismic Coefficient (Ah) = 0.16 x 1 x 2.5 /(2 x 5) = 0.04

e) Load Combinations :

1. 1.5(DL+LL)
2. 1.5(DL+WL(+ X))
3. 1.5(DL+WL(+ Z))
4. 1.5(DL+WL(- X))
5. 1.5(DL+WL(- Z))
6. 1.5(DL+EQ(+X))
7. 1.5(DL+EQ(+Z))
8. 1.5(DL+EQ(-X))
9. 1.5(DL+EQ(-Z))
10. 1.2(DL+LL+WL(+ X))
11. 1.2(DL+LL+WL(+ Z))
12. 1.2(DL+LL+WL(- X))

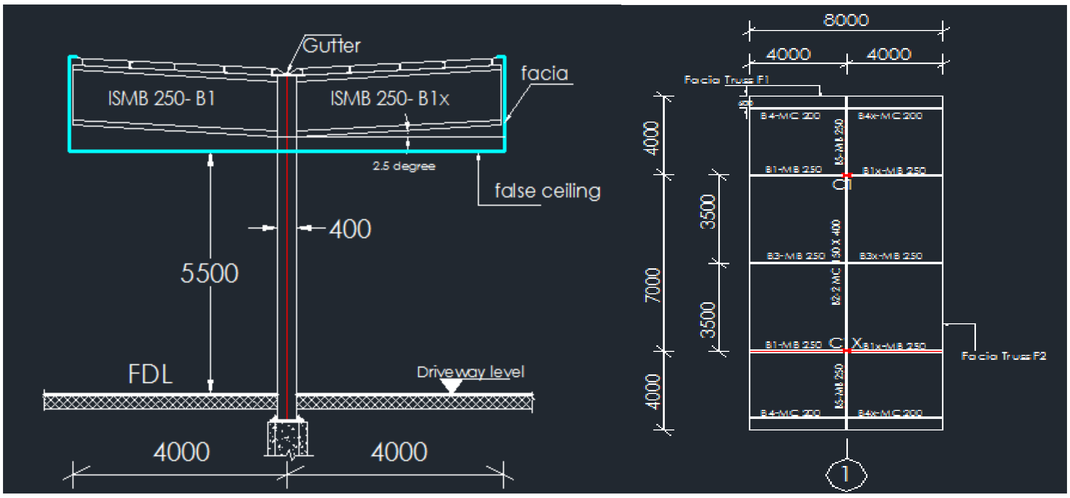
13 1.2(DL+LL+WL(- Z))

14 1.2(DL+0.25LL+EQ (+ X))

15. 1.2(DL+0.25LL+EQ (+ Z))
16. 1.2(DL+0.25LL+EQ (+ Z))
17. 1.2(DL+0.25LL+EQ (- Z))

3.3 Description and Data of PETROL BUNK:

Petrol Bunk comprising of Canopy with Sizes: 15.00 mt X 8.00 mt. The structural arrangements and dimensions of MS Sections used in the erection of the canopy i.e that the columns sections (2 Nos) are of ISMC 200 Box : 200 X 400, Main beams are of ISMC 150 Box :150 X 400 and cross beams ISMB:200 & ISMC 150/ Purlins ISMC:75 and facia frame 50x50x6 have been placed.



a) Sectional View **b) Plan**

Fig 3.5 : Description of Petrol Bunk

3.3.1 Materials Used :

a) Structural Steel:

- Yield Strength : 250 N/mm^2
- Modules of Elasticity : 2 x 10^5 MPa
- Poisons Ratio , Elastic Range : 0.3

  Plastic Range : 0.5

b) Concrete:

- Characteristic Compressive Strength (f_{ck}) : 20 N/mm^2
- Poisons Ratio : 0.17
- Density : 25 k N/m^3

c) Reinforcing Steel :

- Yield Strength : 415 N/mm^2
- Modules of Elasticity : 2 x 10^5 MPa

3.2.2 Load Calculations:

a).Dead Load: (as per IS 875 Part-1 i.e. GI Sheet Unit weight 131 N/m)

Weight of Roof Sheeting : 131 x 1.200 = 157.2 N/m

Self Weight of Purlin : 100 N/m

Total Dead Load @ Purlin : 257.2 N/m

b).Live Load : (as per IS 875 Part-2)

Live Load on Roo : 750 N/m^2

c)Wind Load : (as per IS 875 Part-3)

Basic Wind Speed @ Hyderabad	:	44 m/s
Risk Coefficient (k1) (50 Years)	:	1
Terrain (or) Size Factor (k2)	:	1
Topography Factor (k3) (level)	:	1
Design Wind Speed	:	44 m/s
Basic Wind Pressure	:	0.6 x 44 x 44
	:	1161.6 N/m2

d).Load Combinations:

1. 1.5 x Dead Load + 1.5 x Live Load
2. 1.5x Dead Load + 1.5 x(Wind Load +Z)
3. 1.5x Dead Load + 1.5 x(Wind Load -Z)
4. 1.2 x Dead Load +1.2 x Live Load + 1.2 x (Wind Load +Z)
5. 1.2 x Dead Load +1.2 x Live Load + 1.2 x (Wind Load -Z)

4. RESULTS AND DISCUSSIONS

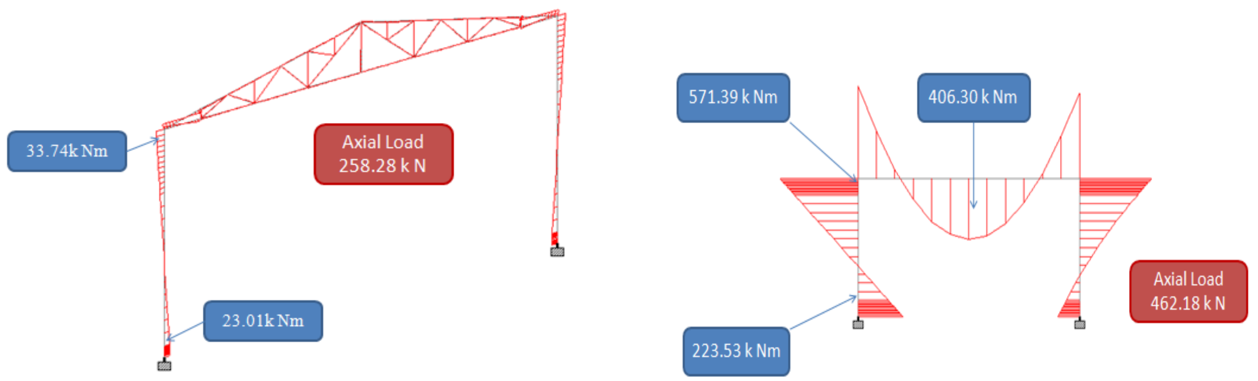
4.1 Industrial Structures:

Table 4.1 : End Reaction for Different Load Combination in case of Steel Industrial Structures

S.No	Load Combination	F_x (k N)	F_y (k N)	F_z (k N)	M_x (k Nm)	M_y (k Nm)	M_z (k Nm)
1	1 DEAD LOAD	0.789	92.472	-0.943	-0.255	0	-3.356
2	2 LIVE LOAD	1.42	25.217	0	0	0	-6.018
3	3 WIND -Y	2.754	52.382	0	0	0	-11.668
4	4 WIND LOAD -Z	-25.634	0.094	0.038	0.025	0	52.31
5	5 1.5 DL+1.5 LL	3.313	176.533	-1.415	-0.383	0	-14.06
6	6 1.5 DL+ 1.5 WL Z	-37.268	138.848	-1.358	-0.345	0	73.432
7	7 1.5 DL + 1.5WL Y	5.314	217.281	-1.415	-0.383	0	-22.536
8	8 1.2 DL + 1.2 LL +1.2 WL+Z	-28.11	141.339	-1.086	-0.276	0	51.524
9	9 1.2 DL +1.2 LL+1.2WL Y	5.955	204.084	-1.132	-0.306	0	-25.25
10	17 LOAD GENERATION, LOAD #17, (8 of 15)	3.31	282.756	-4.058	-0.645	0	-14.045
11	32 LOAD GENERATION, LOAD #32, (8 of 15)	-37.272	245.071	-4.001	-0.608	0	73.448
12	47 LOAD GENERATION, LOAD #47, (8 of 15)	5.31	323.503	-4.058	-0.646	0	-22.52
13	62 LOAD GENERATION, LOAD #62, (8 of 15)	-28.114	247.561	-3.729	-0.539	0	51.54
14	77 LOAD GENERATION, LOAD #77, (8 of 15)	5.951	310.307	-3.775	-0.569	0	-25.234

Table 4.2 : End Reaction for Different Load Combination in case of RCC Industrial Structures

S.No	Load Combination	F_x (k N)	F_y (k N)	F_z (k N)	M_x (k Nm)	M_y (k Nm)	M_z (k Nm)
1	1 DEAD LOAD	0.525	326.734	-68.007	-0.308	-0.062	-192.63
2	2 LIVE LOAD	-0.002	26.954	-10.721	0.003	-0.009	-30.366
3	3 WIND -Y	-0.001	2.374	-8.417	0.001	-0.097	-49.932
4	4 WIND LOAD -Z	0.001	-2.375	29.625	-0.001	0.105	92.024
5	5 1.5 DL+1.5 LL	0.785	530.533	-118.09	-0.458	-0.108	-334.49
6	6 1.5 DL+ 1.5 WL Z	0.787	493.663	-114.64	-0.461	-0.239	-363.84
7	7 1.5 DL + 1.5WL Y	0.79	486.538	-57.527	-0.464	0.064	-150.9
8	8 1.2 DL + 1.2 LL +1.2 WL+Z	0.627	427.275	-104.57	-0.365	-0.202	-327.51
9	9 1.2 DL +1.2 LL+1.2WL Y	0.629	421.576	-58.922	-0.367	0.039	-157.16
10	17 LOAD GENERATION, LOAD #17, (8 of 15)	2.825	555.685	-118.09	-0.769	-0.108	-334.49
11	32 LOAD GENERATION, LOAD #32, (8 of 15)	2.827	518.815	-114.64	-0.772	-0.239	-363.84
12	47 LOAD GENERATION, LOAD #47, (8 of 15)	2.83	511.691	-57.572	-0.775	0.064	-150.9
13	62 LOAD GENERATION, LOAD #62, (8 of 15)	2.667	452.427	-104.57	-0.676	-0.202	-327.51
14	77 LOAD GENERATION, LOAD #77, (8 of 15)	2.669	446.728	-58.922	-0.678	0.04	-157.16



a) Industrial Steel Truss **b) RCC Industrial Structure**

Fig 4.1 : Moments & Axial Loads for Typical Columns

Table 4.3: Comparision Between RCC Industrial Structures and Steel Industrial Structures :

S.No	DESCRIPTION	SELF WEIGHT (k N)	MOMENTS (kNm)	AXIAL LOAD (kN)	COST OF STRUCTURE
1	Steel Industrial Structure	92.472 k N	73.448 k N m	323.503 k N	26,54,485.00
2	RCC Industrial Structure	326.734 k N	363.84 k N m	555.685 k N	37,93,705.00
3	Difference Between RCC & Steel	234.262 k N	290.39 k N m	232.182 k N	11,39,220.00
4	No of times RCC over Steel	3.53	4.95	1.72	1.43
5	% Difference	253%	395%	71.77%	43 %

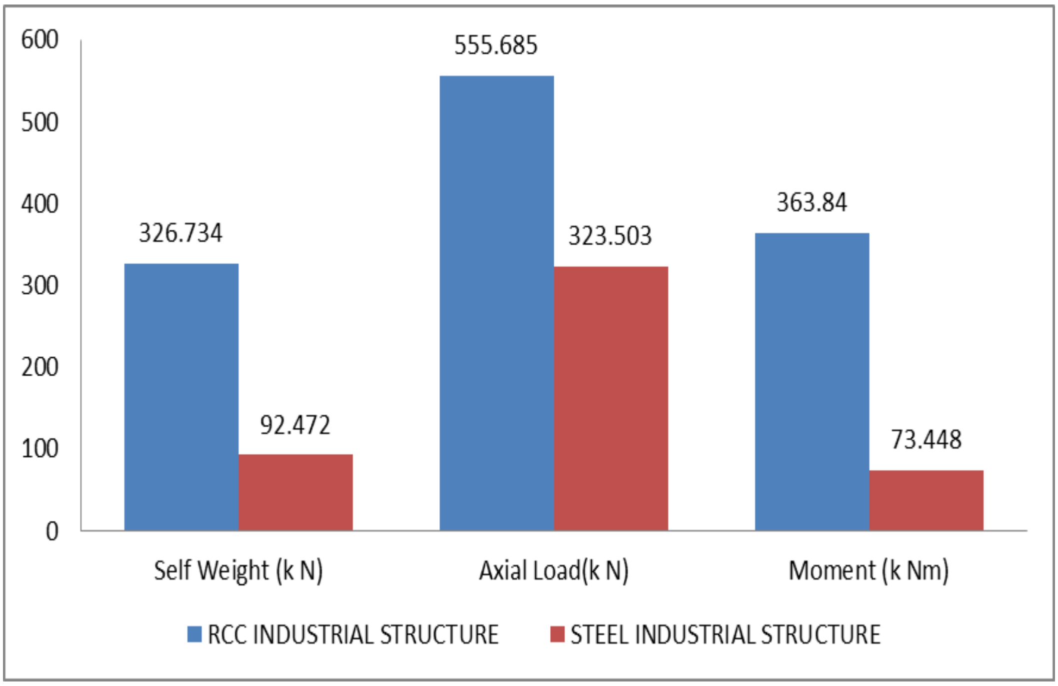


Fig 4.2 : Showing Structural Parameters Comparision Between RCC and Steel Industrial Structures

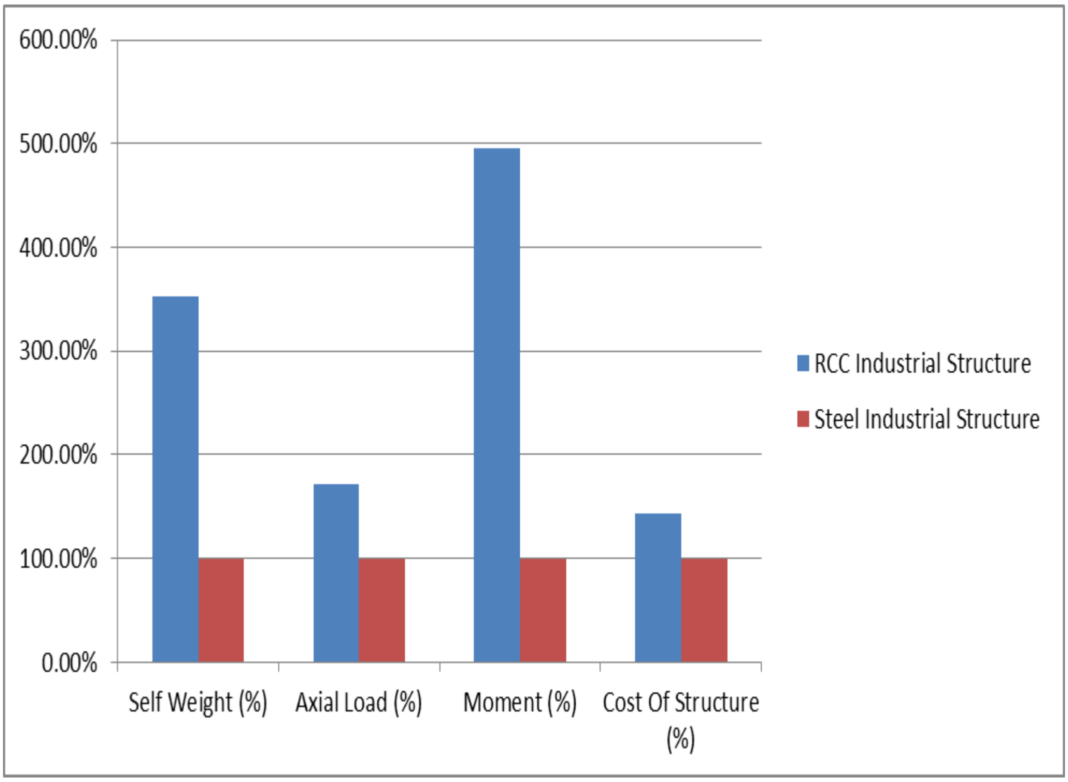


Fig 4.3 : Showing Overall Comparison Between RCC and Steel Industrial Structures

From the above results in case of Industrial Structures , Structural Steel is more preferable because Steel is ductile in nature and so it is capable of resisting tensile forces . Due to more working space requirement, the span has to be more and due to this more bending moments are development as well as Crane Load is also one of the cause for high loading and moments .

Column in the Industrial Structure are Slender Columns due to operational concern in Industrial Structures height is normally high and it leads to Slender Column and in such cases Steel Columns are more economical .

4.2 Commercial Structures:

Table 4.4 : End Reaction for Different Load Combination in case of RCC Commercial Structures

S.No	Load Combination	F_x (k N)	F_y (k N)	F_z (k N)	M_x (k Nm)	M_y (k Nm)	M_z (k Nm)
1	1.5DL + 1.5LL	9.719	922.966	15.177	7.276	-0.03	-4.866
2	1.5DL + 1.5WL+X	3.781	689.697	12.801	4.596	-0.286	3.517
3	1.5DL + 1.5WL+Z	15.688	752.818	16.55	9.434	0.211	-12.877
4	1.5DL + 1.5WL-X	10.367	679.247	0.152	-13.044	-0.106	-6.248
5	1.5DL + 1.5WL-Z	7.589	760.297	30.395	27.182	0.067	-2.526
6	1.5DL + 1.5EQ+X	4.38	694.219	14.481	6.79	-0.041	-1.691
7	1.5DL + 1.5EQ+Z	9.336	695.293	8.672	-1.115	0.088	-4.874
8	1.5DL + 1.5EQ-X	13.571	744.751	14.503	6.765	-0.006	-10.462
9	1.5DL + 1.5EQ-Z	8.615	743.677	20.312	14.67	0.041	-3.897
10	1.2(DL + LL + WL+X)	3.62	714.542	10.789	4.076	-0.234	2.429
11	1.2(DL + LL + WL+Z)	13.146	765.039	13.788	7.947	0.164	-10.686
12	1.2(DL + LL + WL-X)	8.888	706.182	0.67	-10.036	-0.09	-5.383
13	1.2(DL + LL + WL-Z)	6.666	771.023	24.864	22.145	0.048	-2.405
14	1.2(DL + 0.25LL + EQ+X)	3.652	596.071	11.722	5.532	-0.034	1.257
15	1.2(DL + 0.25LL + EQ+Z)	7.618	636.497	7.074	-0.792	-0.071	-3.995
16	1.2(DL + 0.25LL + EQ-X)	11.006	635.497	11.74	5.511	-0.006	-8.466
17	1.2(DL + 0.25LL + EQ-Z)	7.04	635.637	16.387	11.836	0.031	-3.214

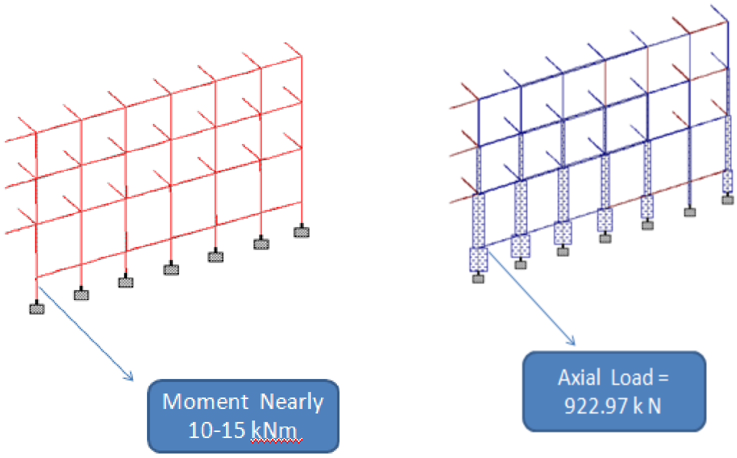


Fig 4.4 : Moments & Axial Loads for Typical Columns

In Case of Low Rise (or) Middle Rise Structures , the Moments are low i.e as in the case of above Commercial Structures (Shopping Complex and Office Building) the moments developed are around 10-20 kNm and in such case RCC is highly enough in order to meet the required moments . Here Axial Load is 927.97 k N , even though it is high ,Concrete is strong in compression and it can resist.

For Tall Structures (or) High Rise Structures, the moments developed are high due to wind load and the slenderness in the column increases. As per the Draft Indian Standard, Criteria for Structural Safety of Tall Buildings CED 38 (10639) gave some guidelines regarding the usage of RCC in Tall Buildings.

- In case of large Working Space like as in Shopping Malls, Flat Slabs are used. But as per this code in case of Seismic Zone V & IV, Structural Wall System + Flat Slab Floor System with perimeter moment frame are not allowed.
- For Zone III – 70m, Zone II – 100m is the limit for the height of the structure.

So in case of High Rise Structures, it is better to opt Structural Steel instead of RCC for Safety Concern

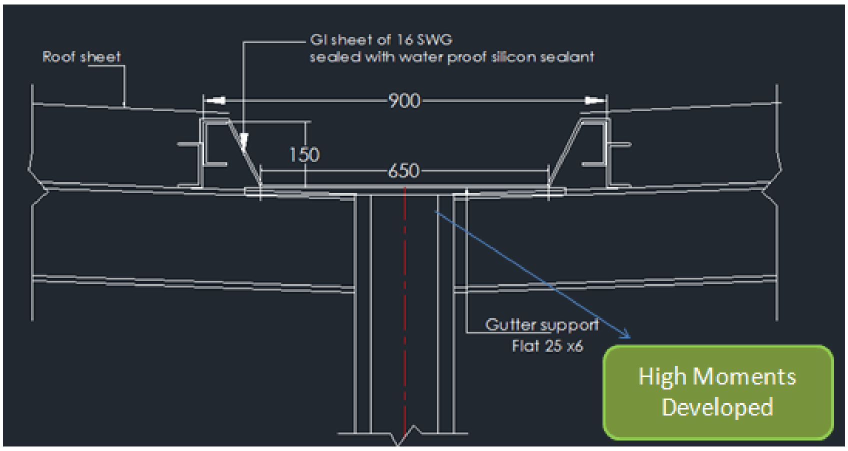


Fig.4.5 : Canopy Structure Subjected to High Loads

For Petrol Bunk (or) Canopy Structures , Structural Steel is more preferable when compared to RCC due to huge development of moments . Canopy Structure is having Cantilever portion and due to this High moments are developed and RCC is not preferable one in such cases..

5. CONCLUSION

Structural Steel is advanced over RCC construction in case of Strength, Ductility, Durability, Light Weight and fast construction. Steel structures having some advantage compared to Reinforced Cement Concrete and they are Corrosive in case of exposed conditions (Sea Shore Area, River Bed Area), Heat conductor and requires proper maintenance. In this case Steel Industrial Structures are more efficient in comparison with RCC Industrial Structure (i.e. RCC Structures having Self Weight 3.53 times , Axial Load 1.72 times , Moment 4.95 times , Cost of Structure 1.43 times more compared to Steel Industrial Structures)

In case of Industrial Structures, Structural Steel is preferred in view of high Strength and Ductile nature which leads resistance to unexpected wind loads and more utilization of space.

- In case of commercial structures (Low rise structures), RCC is preferred for a moderate length.
- In case of High rise commercial structures, Structural steel is preferred due to high wind loads and Tensile loads

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