International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 05 | May 2021 www.irjet.net p-ISSN: 2395-0072

Design of a 6-storeyed steel structure using StaadPro Software

Atika Pathan[1], Nidhi Sonavane[2], Praduman Singh[3]

[1]*Student, B. Tech Civil Engineering, GSFC University, Vadodara, Gujarat, India*
[2]*Student, B. Tech Civil Engineering, GSFC University, Vadodara, Gujarat, India*
[3]*Student, B. Tech Civil Engineering, GSFC University, Vadodara, Gujarat, India*

---***---

Abstract - *This research paper aims to design a 6-storey steel structure of an industrial building and find the approximate cost for its construction. At first, we assumed the basic data close to a real-life scenario. Using this data, we designed the Steel elements of this structure using StaadPro software and also referred to various IS codes, books, research papers, etc. This structure to designed to sustain various loadings, i.e., Dead Load, Live Load, Wind Load, and Earthquake loads. Various load combinations are taken into consideration to make this structure resistant to all the above loads.*

Key Words: Steel sections, Loads, StaadPro, Industrial building, IS codes

1.INTRODUCTION

Nowadays, large-span, super-high, over-weight, vibration, airtight, high-rise, and light-weight engineering structures are generally steel structures. One of these segments is industrial buildings where steel structures are widely witnessed. The reason being their added advantages over the concrete structures. Steel structures can take heavy loads despite of being light weight. Also, steel structures can be fabricated easily, hence consumes less time in construction and also has higher scrap value.

1.1 Structure Geometry

The details of the geometry of structure are as follows:

- Type of structure: Industrial building
- Location: Vadodara, Gujarat
- Superstructure: Structural Steel
- Substructure: Reinforced Concrete
- Number of storey: 6
- Height of each floor: 3.6 meters
- Number of bays in longitudinal direction: 3 (7.5m, 7.5m, 4m)
- Number of bays in lateral direction: 1 (7.5m)
- Roof: Gable frame with 1.5 meters rise
- Purlin spacing: 1.2 meter
- Roofing sheet: Asbestos cement sheet
- Flooring: 6mm Steel grating
- Foundation level: 3m

1.2 Preliminary Drawings

The elevation and section of structure is shown in fig-1. The arrangement of members at different levels where the equipment rest is shown in the fig 2, fig-3, fig4 & fig-5.

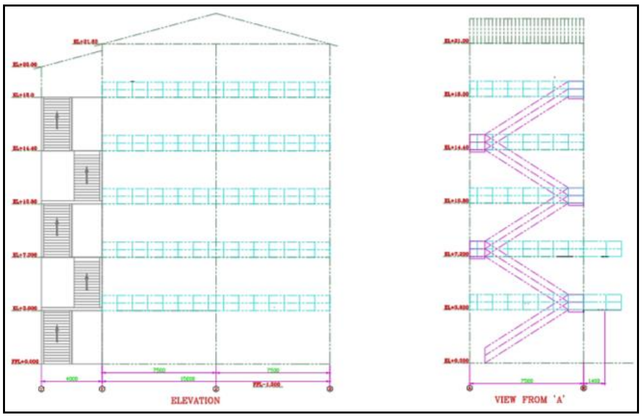

Fig -1: Elevation & Section view

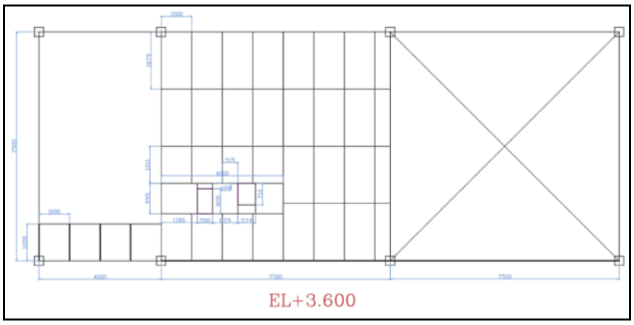

Fig -2: Member arrangement at EL +3.6m

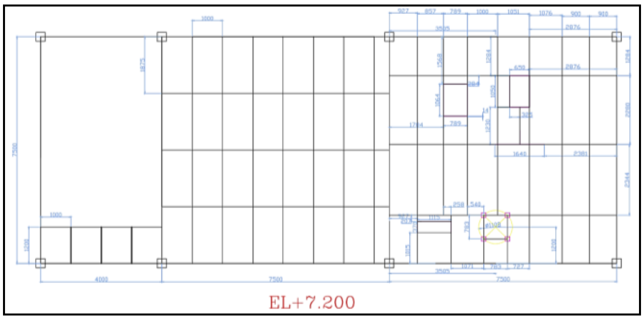

Fig -3: Member arrangement at EL +7.2m

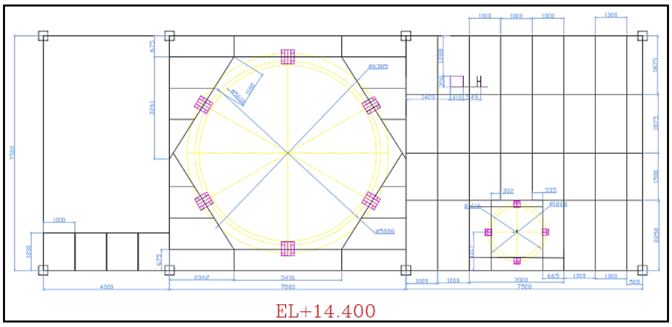

Fig -4: Member arrangement at EL +14.4m

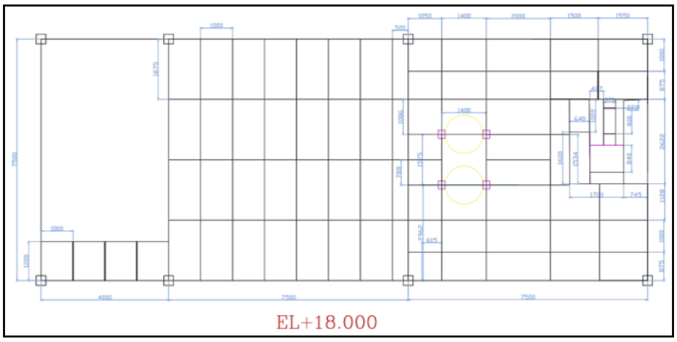

Fig -5: Member arrangement at EL +18.0m

2. STAADPRO MODELLING

This structure was modelled using StaadPro software [1]. In this whole structure, the beam to column connection are moment connection and other connections are shear connections. There are a few exceptions, mainly where the equipment rests, which are moment connections. The model created in StaadPro software is as shown in the fig-6. Also, the bays where there is no equipment is provided with tie members in the center.

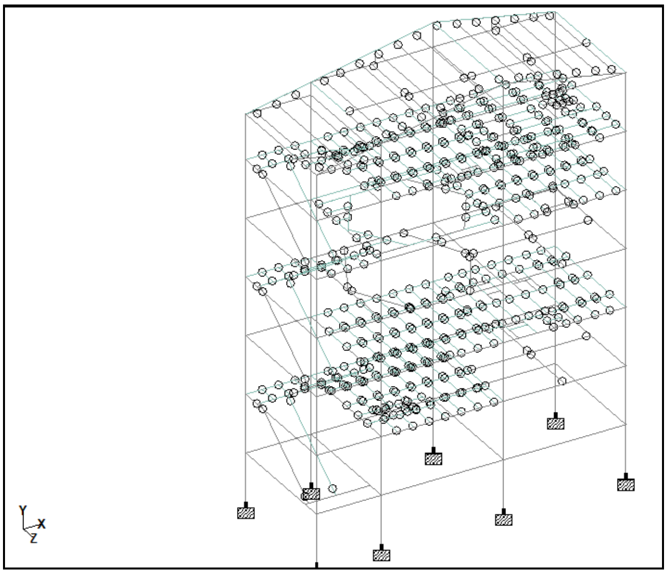

Fig -6: Analytical model

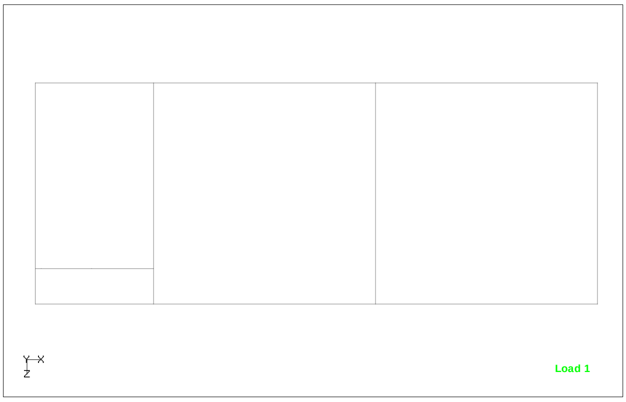

Fig -7: Section at EL +0.0m (Concrete ground beams)

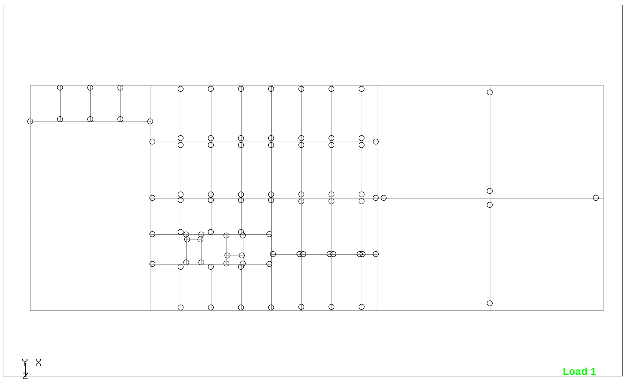

Fig -8: Section at EL +3.6m

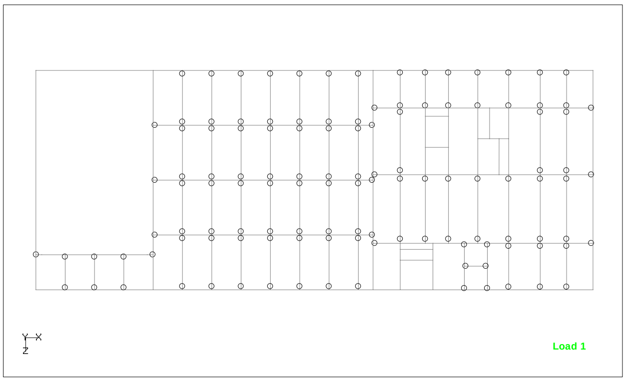

Fig -9: Section at EL +7.2m

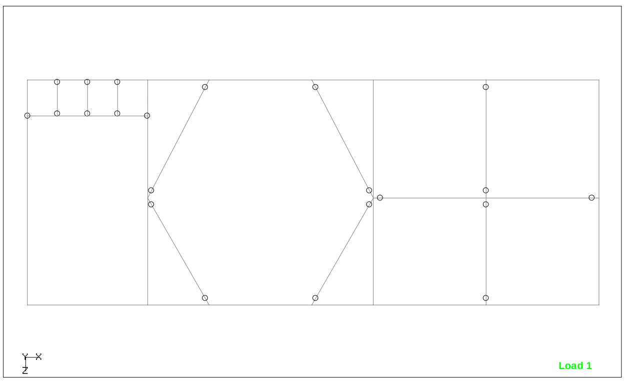

Fig -10: Section at EL +10.8m

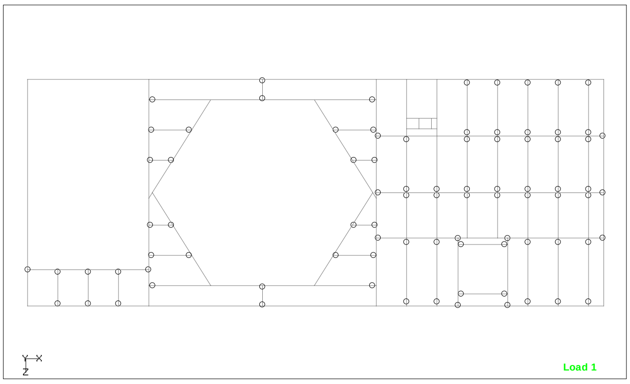

Fig -11: Section at EL +14.4m

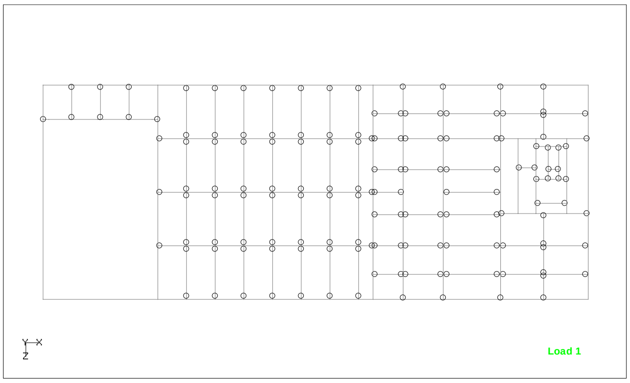

Fig -12: Section at EL +18.0m

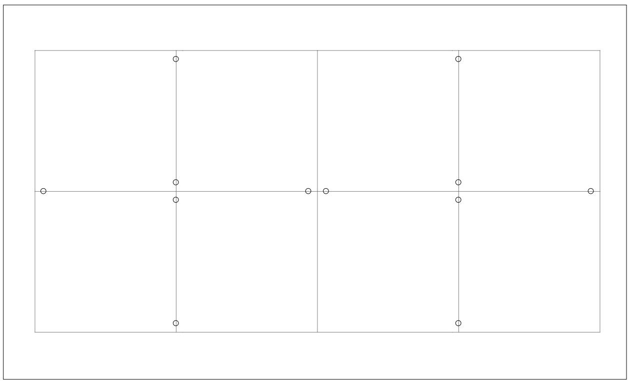

Fig -13: Section at EL +21.6m

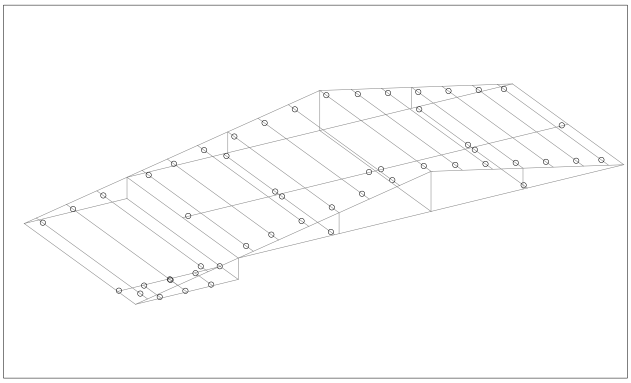

Fig -14: Structure Roof

3. ANALYSIS & DESIGN

For analysis of the structure, various loads like Dead load, live load, wind load & earthquake loads (EQ) and load combinations are considered as shown in the table-1. The earthquake analysis is done by joint weight method. All the loads are considered complying to IS 875 part 1[4], part 2[5], part 3[6] & IS1893(part1): 2002[7].

	Dead Load	Live Load	Wind Load	EQ Load
1	1.5	1.5	-	-
2	1.2	1.2	1.2	-
3	1.2	1.2	-	1.2
4	0.9	-	1.5	-
5	0.9	-	-	1.5
6	1	1	-	-
7	1	-	1	-
8	1	-	-	1
9	1	0.8	0.8	-
10	1	0.8	-	0.8

Dead Load (DL)	**Live Load (LL)**
Self-weight of structure	On Floor = 7 KN/m2
Steel grating = 0.5 KN/m2 on each floor	On staircase: 4 KN/m2
Machine Load in form of Point load and Uniformly Distributed load as required	
Asbestos cement sheet on roof = 0.13 KN/m2	
6mm Steel plate for stairs: 0.462 KN/m2	

Wind Load (WL)	**Earthquake Load (EQ)**
Basic wind speed for Vadodara (Vb) = 44 m/s	IS 1893 – 2002/2005
Probability factor (k1) for 50 years = 1	Include 1893 part 4 for industrial structure
Terrain, height and structure size factor (k2) = 0.985	In zone just select your city – Vadodara - Z value = 0.16
Topography factor (k3) = 1	Response reduction factor – 5
Design wind speed (Vz) = 43.34 m/s	Importance Factor (F) = 1
	Soil type – Medium Soil
	Structure type – Steel Frame Building
	Damping Ratio – 5 %
	Foundation Depth – 3m

Table -1: Loads & load combinations

The various loads applied are shown in the below figures.

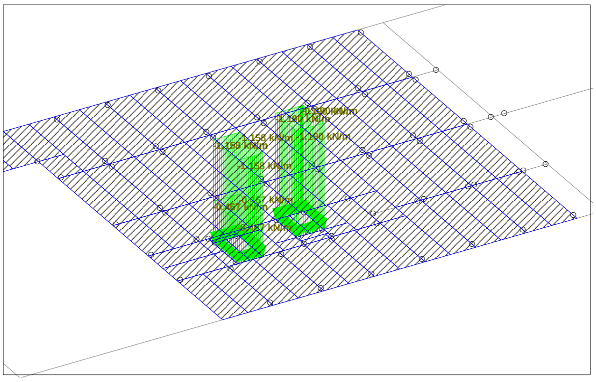

Fig -15: Equipment load on EL +3.6m

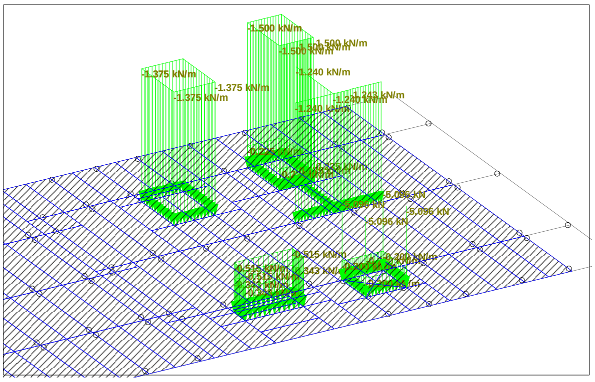

Fig -16: Equipment load on EL +7.2m

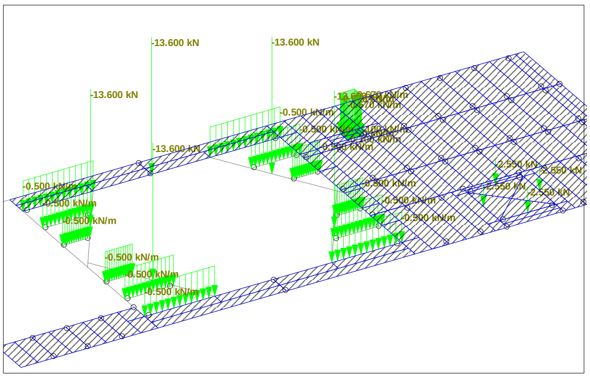

Fig -17: Equipment load on EL +14.4m

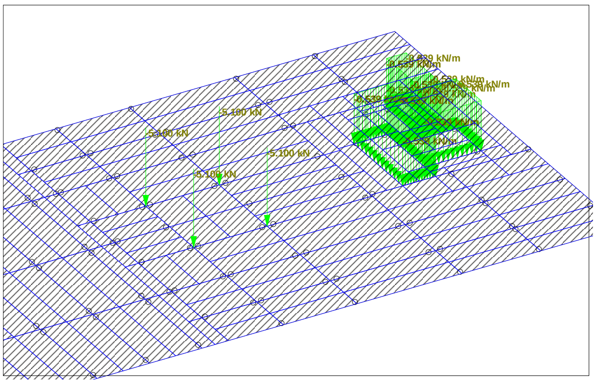

Fig -18: Equipment load on EL +18.0m

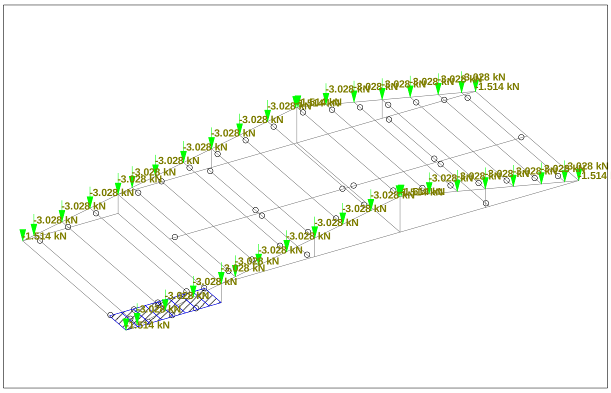

Fig -19: Dead load on purlin panel points

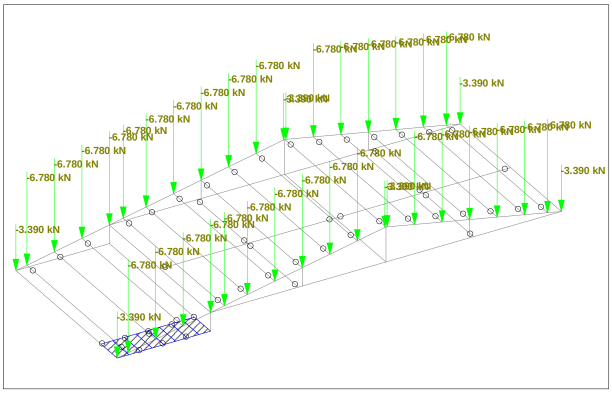

Fig -20: Live load on purlin panel points

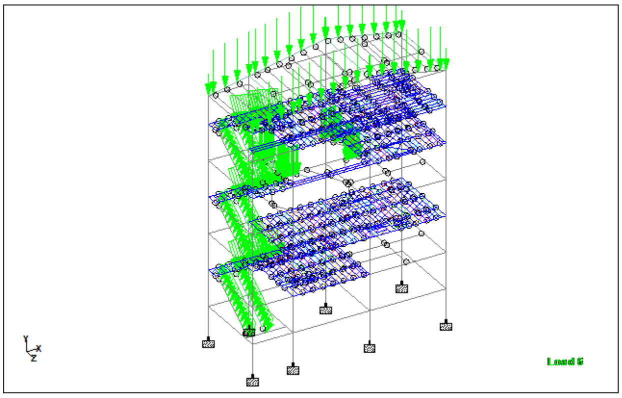

Fig -21: Live load on structure

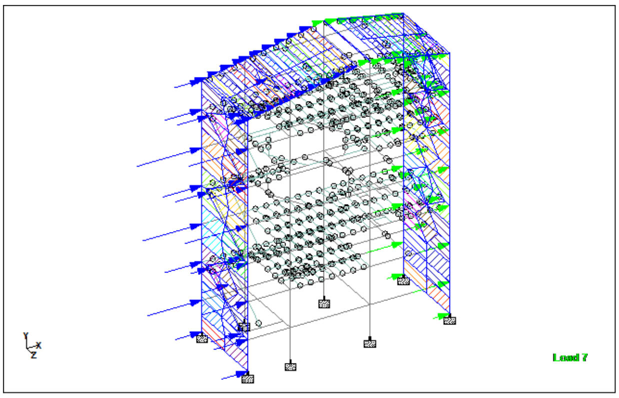

Fig -22: Wind load in X+ direction

3.1 Design of Steel members

The steel design is done in StaadPro software with reference to IS800: 2000[3]. The availability of various steel sections in the Indian market is considered for designing this structure. For the same, a small survey was carried out on various sites in and near the Vadodara district. In the structure, the primary beams are allotted as ISMB 500, the secondary beams as ISMB 350, tertiary beams as ISMC 125, staircase beams as ISMB 225, rafters as ISMC 300 box, purlins as ISMC 175, 5 columns as ISMC 400 box, and 3 columns as ISMC 400 front to front, 150mm apart. Also, in these 3 columns a 6mm plate is provided throughout till EL +7.2m and afterward battens of 6mm as only connecting members i.e., they do not transfer any loads. The members allotted are demonstrated in the fig-23, fig-24, fig-25, fig-26, fig-27, fig-28 and fig-29. Also, a reaction summary is shown in table-2.

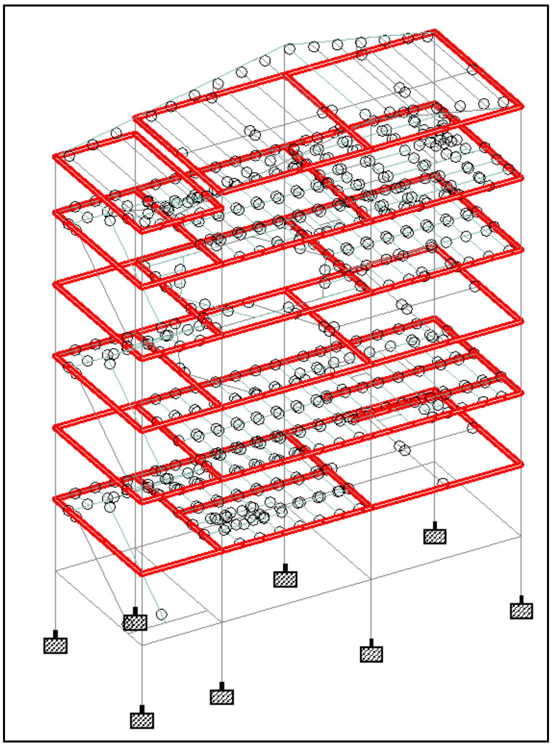

Fig -23: ISMB 500

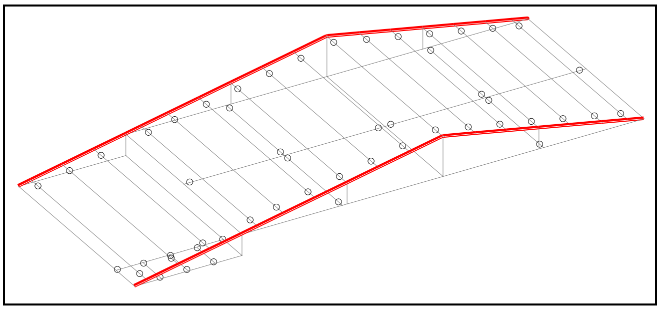

Fig -24: ISMC 300 box

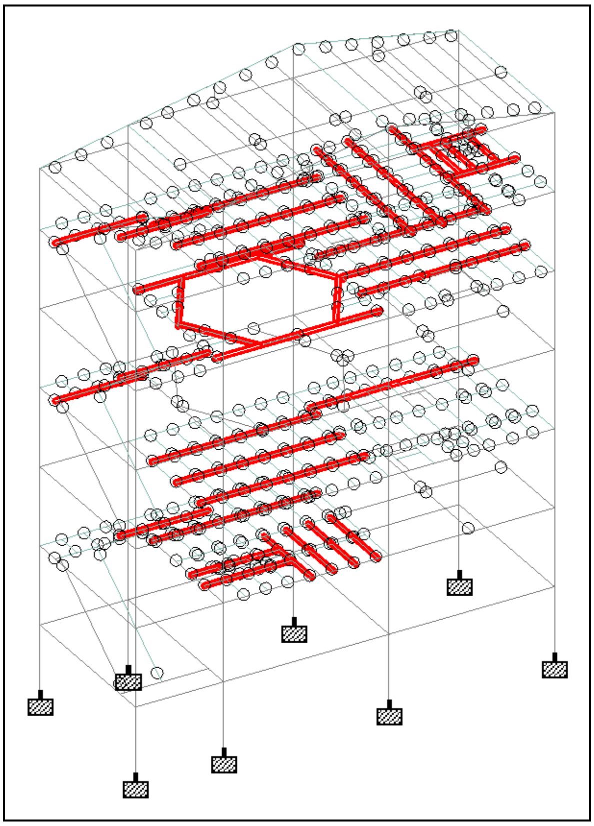

Fig -25: ISMB 350

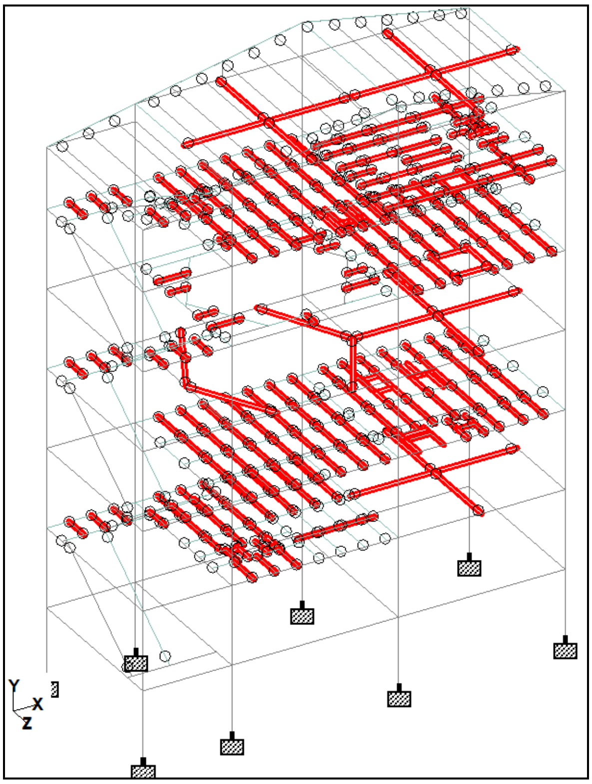

Fig -26: ISMC 125

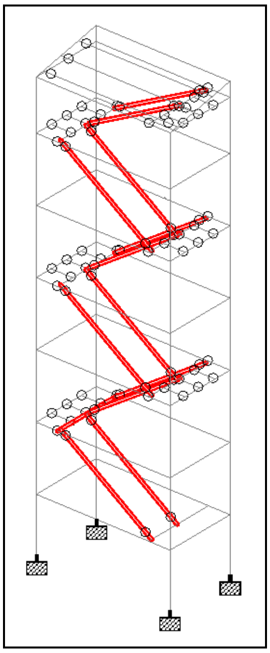

Fig -27: ISMB 225

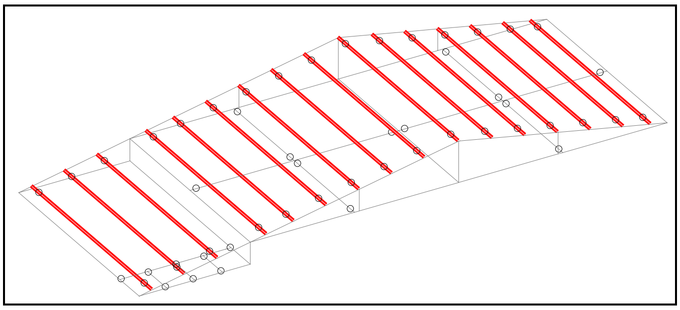

Fig -28: ISMC 175

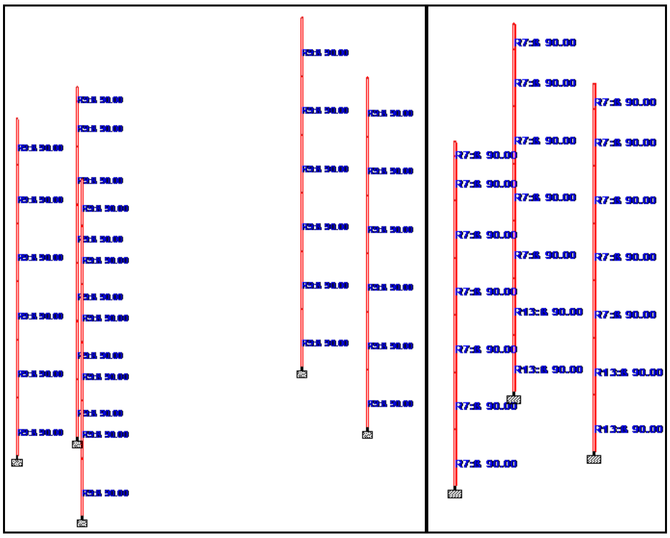

Fig -29: Steel columns

Reaction Summary

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	FX (kN)	FY (kN)	FZ (kN)	MX (kN·m)	MY (kN·m)	MZ (kN·m)
Max FX	9	25:0.9DL+1.5W	**76.993**	232.716	2.325	3.283	-0.007	-189.160
Min FX	9	24:0.9DL+1.5W	**-78.940**	213.618	1.310	0.387	0.005	192.753
Max FY	10	11:1.5*(DL+LL)	-11.821	**1.26E+3**	-19.987	-36.461	0.001	5.365
Min FY	9	9:WL Z+	-1.306	**-184.108**	-89.214	-226.952	0.005	3.215
Max FZ	10	27:0.9DL+1.5W	-0.680	-30.893	**126.703**	321.802	-0.007	-0.211
Min FZ	9	26:0.9DL+1.5W	-2.973	-52.685	**-132.030**	-338.658	0.007	6.720
Max MX	9	27:0.9DL+1.5W	-0.859	485.225	124.942	**326.395**	-0.001	1.587
Min MX	10	26:0.9DL+1.5W	0.016	505.690	-130.228	**-343.205**	0.003	-2.347
Max MY	3	23:1.2(DL+LL+	-2.645	108.950	57.219	143.916	**1.291**	0.509
Min MY	8	11:1.5*(DL+LL)	24.231	837.977	-29.131	-17.759	**-3.617**	-26.952
Max MZ	9	24:0.9DL+1.5W	-78.940	213.618	1.310	0.387	0.005	**192.753**
Min MZ	9	25:0.9DL+1.5W	76.993	232.716	2.325	3.283	-0.007	**-189.160**

Table -2: Reaction summary

3.2 3D view of structure

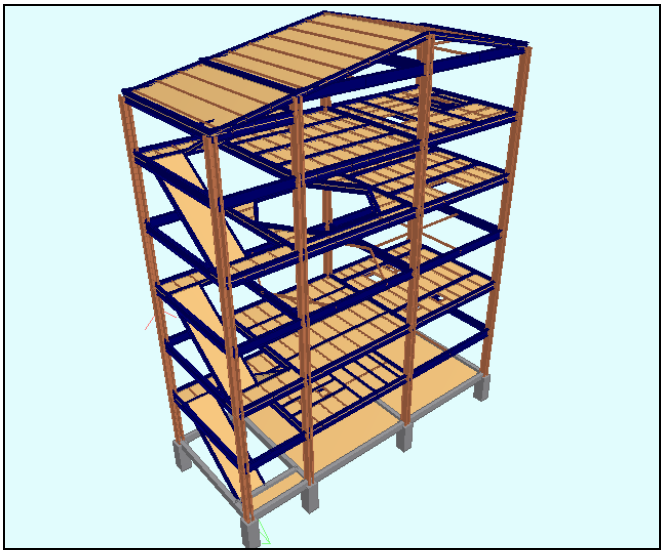

Fig -30: 3D view 1

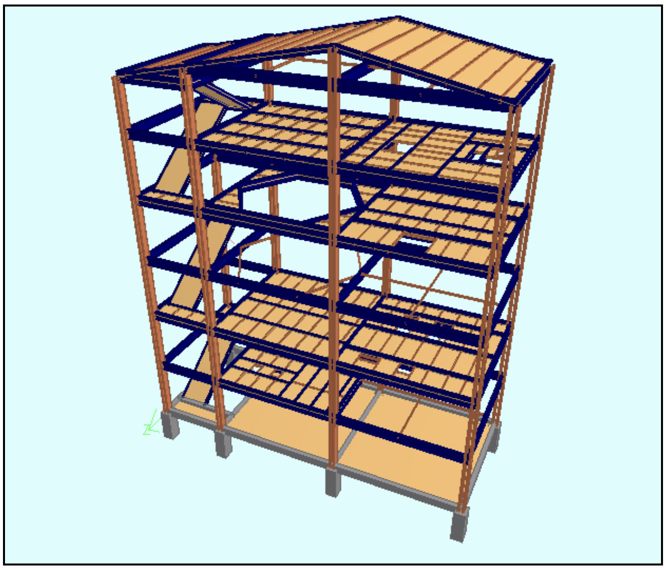

Fig -31: 3D view 2

4. COST ESTIMATION

As mentioned earlier, a small market survey was carried out on various sites. In this survey, the average market rate of structural steel was also found out. Through calculations, it was estimated that total 81 tons (approx.) of steel would be consumed and the total cost comes out to be ₹ 92,38,545.

BOQ: Steel						
No:	**Material**	**Unit**	**Quantity**	**Rate ₹**	**Cost ₹**	
1.	Structural Steel	Kg	81,039.8507	65	52,67,591	
2.	Steel Fabrication	Kg	81,039.8507	30	24,31,196	
			Total			76,98,787
3.	Connections, base plate, bolts, cleat, etc	Kg	20% of cost		15,39,758	
	Total					***92,38,545***

Table -3: BOQ of structural steel

5. CONCLUSIONS

An industrial steel building design was performed using StaadPro software. The building comprises structural steel for the superstructure and concrete for substructure. The structure comprises 2 bay frames, 7.5m each. There are a total 6 number of floors spaced at 3.6m, on which different equipment rests. Also, a stair is provided in a 4m bay i.e., besides the main bay for accessing the floors. A gable frame supports the top roof of the building. The foundation is at 3m below the ground level. Various IS codes are referred for this design. Finally, this design was safe and can be implemented. Also, a market survey was undertaken for the market rates of various materials and activities on different construction sites.

REFERENCES

[1] Book "Steel Structures: Design and Practice" by N. Subramanian

[2] Research paper "Consideration of Seismic Design of Multi-storeyed Steel Structure using STAAD-Pro" by 1) Sarang Dhawade, Department of Civil Engineering1, Prof. Ram Meghe College of Engineering, Amravati, Maharashtra, India. 2) Shrikant Harle Department of Civil Engineering2 Prof. Ram Meghe College of Engineering, Amravati, Maharashtra, India, Vol. 3 Issue 2, February – 2014, IJERT.

[3] IS800: 2000 - Code of Practice for general construction in Steel

[4] IS 875(Part 1) :1987 – Code of practice for design loads (Other than Earthquake) for buildings and structures: Part 1 Dead loads-Unit Weights of building material and stored material.

[5] IS 875(Part 2) :1987 - Code of practice for design loads (Other than Earthquake) for buildings and structures: Part 2 Imposed loads

[6] IS 875(Part 3) :2015 - Code of practice for design loads (Other than Earthquake) for buildings and structures: Part 3 Wind loads

[7] IS 1893(Part 1): 2002 – Criteria for earthquake Resilient Design

[8] SP 6-1 (1964): ISI Handbook for Structural Engineers - Part1 Structural Steel Sections [CED 7: Structural Engineering and structural sections]