

Planning and Analysis of Steel Industrial Warehouse

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Abstract - An industrial warehouse is a structure which provides a proper environment to store goods such as raw materials, manufactured products and heavy machineries. In India, due to the rapid growth of industrialization, need for a well-planned and economical industrial warehouse has been increased. From the critical review of literature, the objective of this study is decided as to plan and analyse a two-storey industrial warehouse with conventional angular and tubular sections and pre-engineered sections. The plan and elevation of an industrial warehouse were drafted using AUTOCAD software. Analysis and design of an industrial warehouse was carried out using STAAD-Pro software according to Indian standards. From the analysis and design, the amount of steel required and maximum axial force, shear force, relative displacement and bending moment were obtained for the proposed warehouse with conventional angular and tubular sections and pre-engineered sections. From the results, it is concluded that the industrial warehouse with pre-engineered sections is found to be the most economical when compared to an industrial warehouse with conventional angular, tubular sections based on the total steel take-off evolved. From the comparative study, it is also observed that the forces, moments and displacements developed in critical elements of an industrial warehouse are found to be very less with pre-engineered sections compared to conventional angular and tubular sections.

Keywords: Industrial warehouse, Two-storey, angular sections, tubular sections, Pre-engineered sections, analysis, design.

I. INTRODUCTION

Warehouses must be designed to accommodate the loads of the materials to be stored, the associated handling equipment, the receiving and shipping operations and associated trucking, and the needs of the operating personnel. Warehouses allow controlling the differences between the incoming flow of goods (received from suppliers, production centers, etc.) and the outgoing flow of goods (goods being sent to production, sales, etc.). Warehouse can be constructed by using conventional steel materials or pre-fabricated steel elements which are also called pre-engineered construction. Conventional steel warehouse is a low rise steel structure with roofing systems of truss with coverings.

The roof truss is fabricated using angular, tubular, solid circular sections etc. Pre-engineered steel buildings are constructed using steel built up sections which are designed and fabricated in the factory and assembled at the site of construction using bolted connections. Pre-engineered steel buildings can be fitted with different structural accessories and the building can be made waterproof by use of special mastic beads, filler strips and trims. This is very versatile buildings systems and can be finished internally to serve any functions and accessorized externally to achieve attractive and unique designing styles. The main advantages of pre engineered buildings are less construction time, less cost, flexibility for expansion, low maintenance, architectural versatility etc.

Shankaranand et. al [9], Shivani et.al [10] analysed and designed an industrial warehouse for different load effects using STAAD-Pro. C.M Meera [8], Ashok et. al [7], Anisha and Tushar [1] carried out a comparative study by designing a typical frame of an industrial warehouse shed using Pre-Engineered Building (PEB) concept and Conventional Steel Building (CSB) concept. The authors concluded that the steel quantity depends on primary members and purlins, PEB concept seems to be more economical compared to CSB concept.

However, more displacements are observed in PEB concept compared to CSB concept. The critical review of literature indicated that most of the warehouses considered are single storey. Analysis and designs were not available for multi storey warehouses using various types of steel sections. Comparative studies are also not available for the same which necessitated this project. The main objective of this project is to plan and analyse a two storey industrial warehouse using conventional steel building and Pre-engineered building concepts.

II. ANALYSIS OF AN INDUSTRIAL WAREHOUSE

2.1 Planning of warehouse

The industrial warehouse considered for the analysis is of two-storeys and the specifications adopted are given in Table 1. The plan and elevation of the warehouse is drafted using AUTOCAD software and are shown in Fig. 1 and Fig. 2 respectively.

2.2 Loads

Different types of loads such as dead load, live load, wind load and snow load are considered for the analysis. The dead load (DL) comprises of self-weight of the structure, weight of roofing, G.I sheets, purlins, sag rods, bracings and other accessories which is considered according to IS:875 (part 1) -1987. The total dead load for warehouse with conventional sections and pre-engineered sections are obtained as 4.95 kN/m and 2.46 kN/m respectively.

Table 1: Specifications of an Industrial Warehouse

Particulars	Specifications
Location	Jammu and Kashmir, India
Type of building	Two-storeyed industrial warehouse
Total bay length	90 m
Total span width	60 m
Number of bays	15
Each bay length	6 m
Number of spans	4
Each span width	15 m
Eave height	6m
Ridge height	2m
Purlin spacing	3m
Roof angle	3.81 degrees

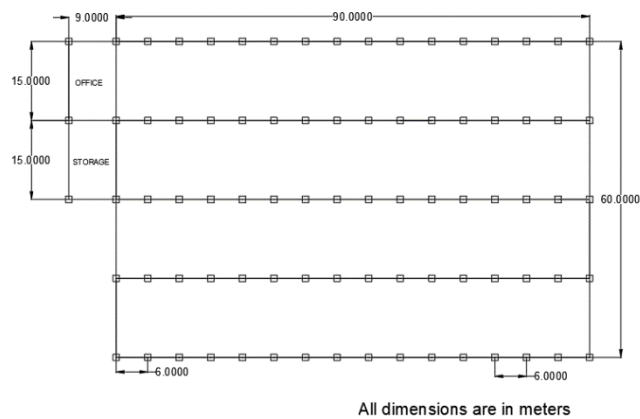


Figure 1: Plan of the proposed industrial warehouse

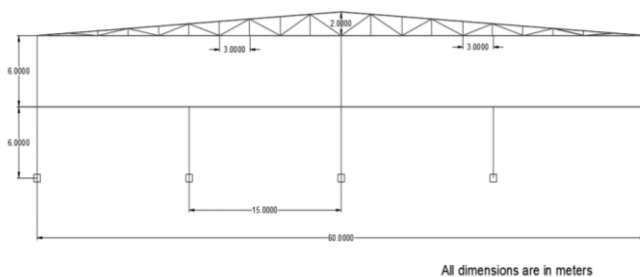


Figure 2: Elevation of the proposed industrial warehouse

Live loads (LL) for roof with no access provided the live load is taken as 0.75 kN/m² with a reduction of 0.02 kN/m² for every one degree above 10 degrees of roof slope according to IS:875 (part 2) -1987.

Wind loads (WL) on the structure were calculated according to IS:875 (part 3)-2015 (revised). The basic wind speed for selected location of Jammu and Kashmir was obtained as 39 m/s. The wind loads on the warehouse from left to right and from right to left are given in Table 2.

Table 2: Wind loads on warehouse

Load case	Left (kN/m)	Right (kN/m)
$\theta = 0+$	0.992	-1.116
$\theta = 90+$	0.264	-0.264
$\theta = 0-$	3.632	3.765
$\theta = 90-$	2.90	2.904

Snow loads (SL) on the roof were obtained according to IS:875 (part 4) -1987. The shape coefficient and ground snow load are considered as 0.8 and 4.08 kN/m² respectively.

The most possible load combinations were considered for analysis of the proposed industrial warehouse according to IS:875 (part 5) -1987 and are listed below.

1. 1.5(DL+LL)
2. 1.2(DL+LL+WLLR)
3. 1.2(DL+LL+WLRL)
4. 1.2DL+0.5SL
5. 1.2(DL+LL-WLLR)
6. 1.2(DL+LL-WLRL)
7. 1.2DL+1.0WLLR+1.0WLRL+0.5SL
8. 0.9DL+1.0WLLR+1.0WLRL
9. 0.9DL+1.0SL

2.3 Analysis

The analysis and design of an industrial warehouse is carried out with conventional building concept and pre-engineered building concept using STAAD-Pro software. The analysis of columns, rafters, purlins and bracings are done by adopting tapered I, angular and tubular sections.

The proposed industrial warehouse was first analysed with conventional angular sections and tubular sections and then with pre-engineered sections separately. The 3D view of industrial warehouse with angular sections is shown in Fig. 3.

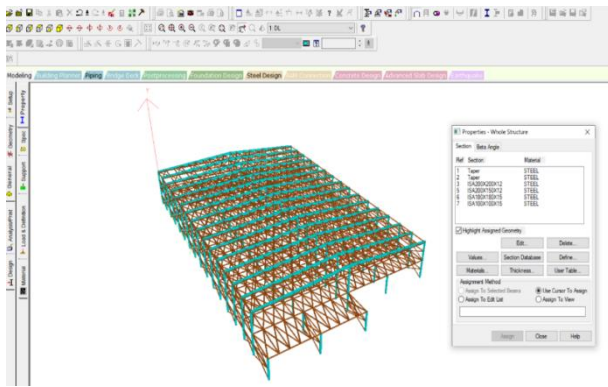


Figure 3: 3D view of warehouse with angular sections

The profiles of axial force, shear forces and deflection of beams and profile of bending moment of beams and columns for a critical frame of warehouse with conventional sections and pre-engineered sections are shown in Fig.4 to Fig. 11 respectively.

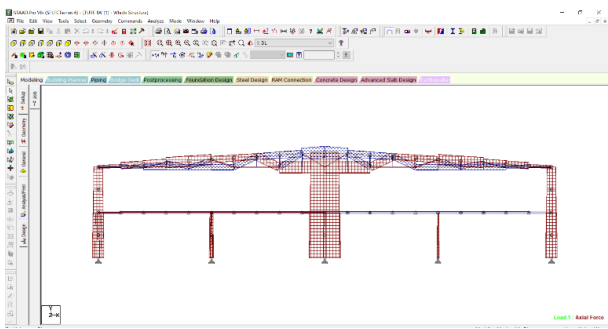


Figure 4: Axial force profile of warehouse with conventional sections

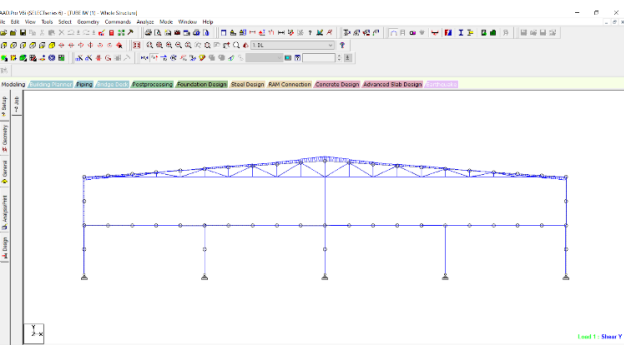


Figure 5: Shear force profile of warehouse with conventional sections

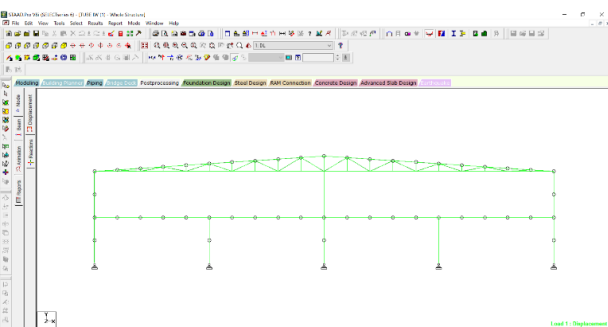


Figure 6: Deflection profile of a warehouse with conventional sections

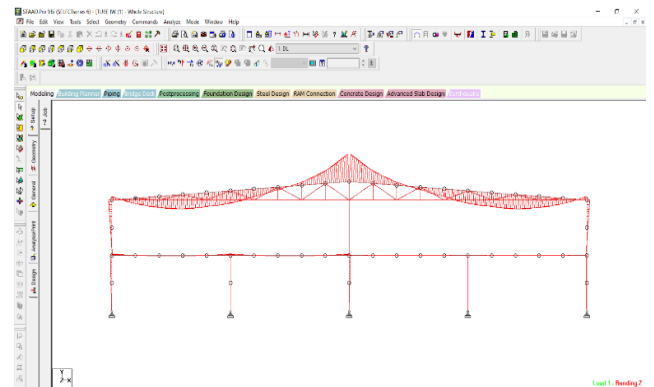


Figure 7: Bending moment profile of a warehouse with conventional sections

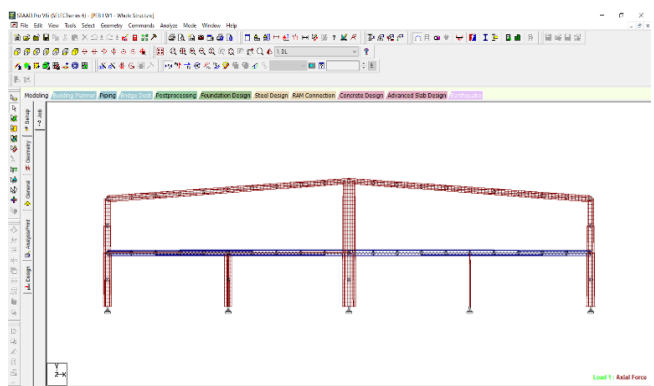


Figure 8: Axial force profile of warehouse with pre-engineered sections

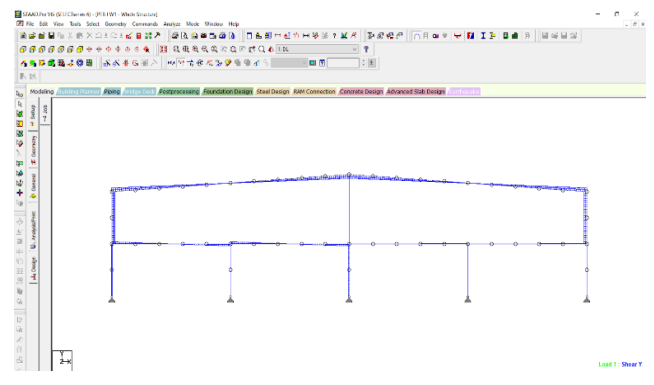


Figure 9: Shear force profile of warehouse with pre-engineered sections

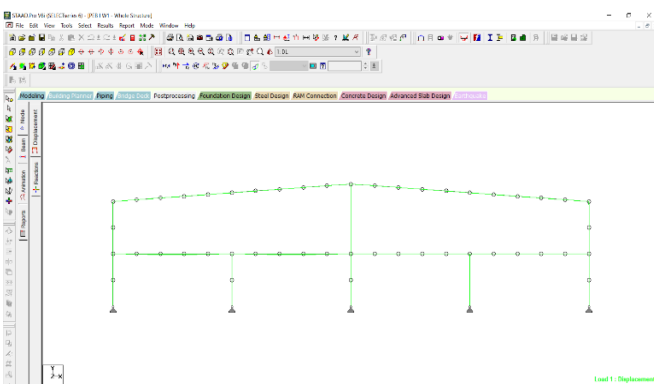


Figure 10: Deflection profile of a warehouse with pre-engineered sections

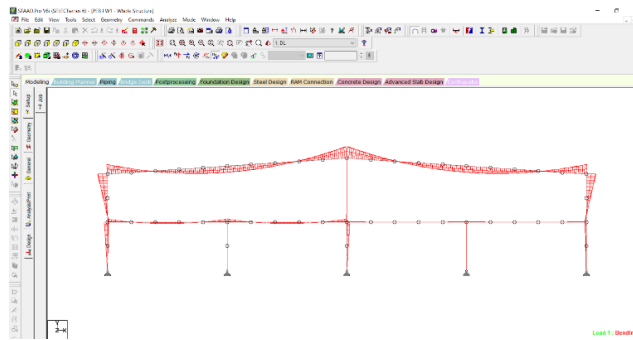


Figure 11: Bending moment profile of a warehouse with pre-engineered sections

III. RESULTS AND DISCUSSIONS

The maximum axial forces, shear forces, deflections and bending moments developed in the critical elements of the industrial warehouse with conventional angular, tubular and pre-engineered sections are obtained from the analysis for different load combinations and given in table 3 to 6 respectively.

Table 3: Maximum axial forces

Load case	Maximum Axial force (F_x) (kN)		
	Conventional Angular sections	Conventional Tubular sections	Pre-engineered sections
DL	824.24	701.25	338.91
LL	162.56	166.84	147.41
WLLR	-55.59	-121.55	-107.250
WLRL	-120.91	-121.86	-109.339
SL	706.62	725.20	640.74
1.5(DL+LL)	1.48E+3	1.3E+3	729.48
1.2(DL+LL+WLLR)	1.12E+3	895.85	454.89
1.2(DL+LL+WLRL)	1.04E+3	895.47	452.38
1.2DL+0.5SL	1.34E+3	1.2E+3	727.06
1.2(DL+LL-WLLR)	1.25E+3	1.19E+3	712.29
1.2(DL+LL-WLRL)	1.33E+3	1.19E+3	714.79
1.2DL+1.0(WLLR+WLRL)+0.5SL	1.17E+3	960.69	510.48
0.9DL+1.0(WLLR+WLRL)	565.31	387.71	88.43
0.9DL+1.0SL	1.45E+3	1.36E+3	945.76

Table 4: Maximum shear forces

Load case	Maximum shear force (kN)		
	Conventional Angular sections	Conventional Tubular sections	Pre-engineered sections
	F_y	F_y	F_y
DL	323.01	296.77	-130.09
LL	75.26	78.88	-76.58
WLLR	-8.58	-58.95	51.27
WLRL	-53.81	-55.60	61.91
SL	327.15	342.90	-332.90
1.5(DL+LL)	597.42	563.49	-310.01
1.2(DL+LL+WLLR)	467.64	380.04	-186.48

1.2(DL+LL+WLRL)	413.36	384.07	-173.71
1.2DL+0.5SL	551.20	527.58	-322.56
1.2(DL+LL-WLLR)	488.24	521.54	-309.54
1.2(DL+LL-WLRL)	542.51	517.51	-322.31
1.2DL+1.0(WLLR+WLRL)+0.5SL	488.80	413.02	-209.37
0.9DL+1.0(WLLR+WLRL)	228.321	152.535	-3.891
0.9DL+1.0SL	617.87	610.00	-449.98

Table 5: Maximum relative of displacements

Load case	Maximum relative displacement (mm)		
	Conventional Angular sections	Conventional Tubular sections	Pre-engineered sections
DL	2.185	0.635	12.588
LL	0.019	0.620	0.008
WLLR	5.202	0.710	0.007
WLRL	4.718	0.202	0.006
SL	0.075	2.693	0.031
1.5(DL+LL)	3.302	1.881	18.884
1.2(DL+LL+WLLR)	3.601	0.654	15.105
1.2(DL+LL+WLRL)	3.020	1.263	15.107
1.2DL+0.5SL	2.658	2.108	15.108
1.2(DL+LL-WLLR)	8.884	2.356	15.109
1.2(DL+LL-WLRL)	8.303	1.748	15.107
1.2DL+1.0(WLLR+WLRL)+0.5SL	7.263	1.197	15.107
0.9DL+1.0(WLLR+WLRL)	7.954	0.340	11.328
0.9DL+1.0SL	2.038	3.625	11.334

Table 6: Maximum bending moments

Load case	Maximum bending moment (kNm)		
	Conventional Angular sections	Conventional Tubular sections	Pre-engineered Sections
	M_y	M_y	M_y
DL	1.48E+3	1.43E+3	435.17
LL	394.57	321.057	301.14
WLLR	-104.92	-69.166	-60.17
WLRL	-298.52	-248.144	-221.78
SL	1.72E+3	1.44E+3	1.31E+3
1.5(DL+LL)	2.82E+3	2.64E+3	1.11E+3
1.2(DL+LL+WLLR)	2.13E+3	2.02E+3	619.67
1.2(DL+LL+WLRL)	1.9E+3	1.81E+3	621.15
1.2DL+0.5SL	2.64E+3	2.43E+3	1.18E+3
1.2(DL+LL-WLLR)	2.38E+3	2.19E+3	1.15E+3
1.2(DL+LL-WLRL)	2.61E+3	2.41E+3	1.16E+3
1.2DL+1.0(WLLR+WLRL)+0.5SL	2.24E+3	2.11E+3	738.71
0.9DL+1.0(WLLR+WLRL)	932.78	960.35	-45.07
0.9DL+1.0SL	3.05E+3	2.72E+3	1.71E+3

The summary of the results of analysis of industrial warehouse with conventional angular and tubular sections and pre-engineered sections is given in Table 7.

Table 7: Analysis results summary

Description	Conventional Angular sections	Conventional Tubular sections	Pre-engineered sections
Steel Take-off (tonnes)	2217.43	1688.56	931.3
Maximum Axial force (kN)	1.48E+3	1.36E+3	945.764
Maximum Shear force (kN)	617.875	610.002	449.984
Maximum Displacement (mm)	8.875	3.625	18.884
Maximum bending Moment (kNm)	3.05E+3	2.72E+3	1.71E+3

From Table 7, it can be observed that the warehouse with pre-engineered sections found to be more economical in-terms of amount of steel required for construction and development of maximum forces and moments even though the displacements are higher compared to the other sections. The higher displacements were observed in warehouse with pre-engineered sections due to the larger beam lengths.

VI. CONCLUDING REMARKS

The following are the major conclusions drawn from the comparative study of analysis of an industrial warehouse with conventional angular and tubular sections and pre-engineered sections.

- i. The warehouse with pre-engineered sections found to be more economical compared to conventional angular and tubular sections.
- ii. The warehouse with pre-engineered sections found to be more lighter compared to the other sections. The total steel take-off evolved for an industrial warehouse with pre-engineered sections is found to be 58% and 44.84% lesser compared to the industrial warehouse with angular and tubular sections respectively.
- iii. The time for analysis and design is less for warehouse with pre-engineered sections compared to the other sections due to the optimization of materials and also process requires only basic design steps.
- iv. The magnitude of maximum axial force for an industrial warehouse with pre-engineered sections is found to be 36.09% and 30.45% lesser compared to the industrial warehouse with angular and tubular sections respectively.
- v. The total magnitude of maximum shear force for an industrial warehouse with pre-engineered sections is found to be 27.17% and 26.22% lesser compared to the industrial warehouse with angular and tubular sections respectively.
- vi. The total magnitude of maximum bending moment for an industrial warehouse with pre-engineered sections is found to be 43.93% and 37.13% lesser compared to the

industrial warehouse with angular and tubular sections respectively.

REFERENCES

- [1] Anisha Goswami., and Tushar Shende. “Pre-Engineered Building Design of an Industrial Warehouse”, *International Research Journal of Engineering and Technology (IRJET)*, Vol. 5, No. 6, 2018, pp. 1484-1488.
- [2] BIS 875 (PART - 1), 1987. “Indian Standard code of practice for design loads (other than earthquake) for buildings and structures part 1 dead loads – unit weights of building materials and stored materials.” *Bureau of Indian Standards*, New Delhi, India.
- [3] BIS 875 (PART-2), 1987. “Indian Standard code of practice for design loads (other than earthquake) for buildings and structures part-2 imposed loads.” *Bureau of Indian Standards*, New Delhi, India.
- [4] BIS 875 (PART-3), 2015(Revised). “Indian Standard code of practice for design loads (other than earthquake) for buildings and structures part-3 wind loads” *Bureau of Indian Standards*, New Delhi, India.
- [5] BIS 875 (PART-4), 1987. “Indian Standard code of practice for design loads (other than earthquake) for buildings and structures part-4 snow loads.” *Bureau of Indian Standards*, New Delhi, India.
- [6] BIS 875 (PART-5), 1987. “Indian Standard code of practice for design loads (other than earthquake) for buildings and structures part-4 Special loads and combinations.” *Bureau of Indian Standards*, New Delhi, India.

- [7] Kankuntla Ashok. Y., Nirantar Shalaka R., and Rajgiri Dinesh. N. "Optimum Design of an Industrial Warehouse", *International Journal of Science and Research (IJSR)*, Vol. 6, No. 6, 2017, pp.2562-2566.
- [8] Meera. C. M. "Pre-Engineered Building Design of an Industrial Warehouse", *International Journal of Engineering Sciences & Emerging Technologies*, Vol. 5, No. 2, 2013, pp.75-82.
- [9] Shankaranand, S. H., Rahul Patange., Megha, S. P, Deepa, C. K, Renuka, G. M. "Design and analysis of industrial warehouse using STAAD Pro". *International Journal of Futures Research and Development (IJFRD)*, Vol. 1, No. 1, 2020, pp. 1-14.
- [10] Shivani Meher., Ruchita Nar., Sadichha Jagadale., and Gaitami Kalal. "Design of an Industrial Warehouse", *International journal of Engineering Research & Technology (IJERT)*, Vol. 7, No. 2, 2018, pp.302-306.

Citation of this Article:

Dr. Sreelatha Vuggumudi, G. Venkateswarlu, "Planning and Analysis of Steel Industrial Warehouse" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 6, pp 95-101, June 2023. Article DOI <https://doi.org/10.47001/IRJIET/2023.706015>
