International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VI **Month of publication:** June 2022

DOI: https://doi.org/10.22214/ijraset.2022.43932

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VI June 2022- Available at www.ijraset.com

A Comparative Study of Conventional Steel Building and Pre-Engineered Building Structure using Staad Pro

Neeraj Kumar[1], Dr. K.S. Grover[2]
[1]M. Tech in Structural Engineering, [2]Professor, Department of Civil Engineering
[2]Department of Civil Engineering, Rajasthan Technical University, Kota, Rajasthan, India

Abstract: Steel is generally used in all the industrial structures. The design of Pre-Engineered Building structures using tapered sections as the primary frames has saved quantity of steel substantially when comparing to the steel used on Conventional Steel Building structures. In this study, industrial building of different spans (10m, 15m, 20m, 25m, 30m, 40m & 50m) is analysed and designed according to the Indian Standards, IS 800-2007 using conventional hot rolled sections and PEB tapered sections. In this study, a relation is being made among the parameters of building to get the flow of pattern of steel reduction in the primary frames of different spans of structures. This study is carried out using STAAD PRO Connect edition.
Keywords: Pre-Engineered Building, Conventional Steel Building, STAAD Pro, IS 800-2007, Tapered Section

I. INTRODUCTION

Industrial buildings are generally used as factories, mills, shops, processing plants, warehouses, cold storage, assembly plant, etc. These buildings typically require a long span without/or fewer columns' obstructions. Steel as a construction material is commonly used in the construction of industrial buildings. For small (up to 15m) and medium span (up to 30m) buildings, steel hot rolled sections (conventional sections) are used, but for larger span structures (more than 30m span), even the largest available hot rolled steel section is not suitable to use and therefore, built-up sections/truss girders/plate girders are used.

Pre-Engineered Building are the buildings that are predesigned and prefabricated. These are factory-made products and are shipped to the construction site in completely dismantled condition, and then all the components are assembled and erected at the site. Therefore, it reduces the completion time and results in a steel structure of good quality and precision. PEB uses hot rolled tapered sections for primary members (rafters and columns) and cold-formed sections for secondary members (purlins, etc.), thereby reducing steel wastage.

As Indian industries are developing at a significantly faster rate due to globalization, more space is required rapidly, and Pre-Engineered Buildings can be the solution for that. PEBs have lots of scope in our country. It can fill the critical shortage of housing, educational and healthcare facilities, airports, railways, etc.

The concept of PEB involves the pre-engineering of structural elements like columns and rafters using a predesigned registry of buildings for different geometry. The design concept of PEB is developed to reduce the cost of steel buildings and make them aesthetically pleasing.

In PEBs, the tapered sections are generally used in the primary frames and this concept of using tapered sections was first adopted in the U.S.A. considering the bending moment diagram. In the locations where the higher bending moment is present, greater depth is used, whereas in the locations of less bending moment value, less depth is being emphasized. Furthermore, unlike the conventional steel sections where the Moment of Inertia (I) remains constant due to the constant depth, it is not the case for PEB tapered sections due to varying depths.

As per the formula,

$I = b \times d^3/12$ (where d = depth, b = width of section)

The depth of sections highly affects the moment of inertia (to the exponential power of 3) and hence, for increasing or decreasing the strength by simply changing the depth is quite an obvious approach in PEB sections and therefore, leading to economic structures.

In conventional steel buildings where the hot rolled steel sections are used, the size of each structural element is selected based on the maximum internal stress caused due to external loads. As we know that hot rolled steel sections have a uniform depth, many parts of the steel sections which are low in stress are in excess of design requirements.

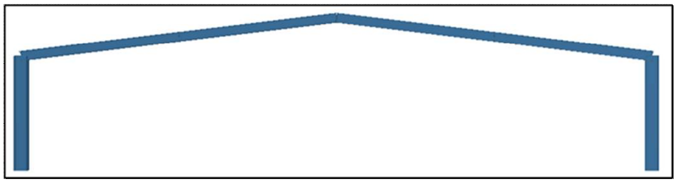


Figure 1: Conventional Steel Building frame

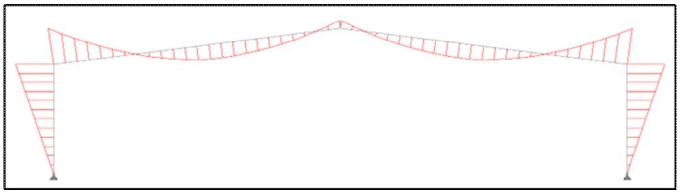


Figure 2: Diagram showing Bending moment variation in the frame

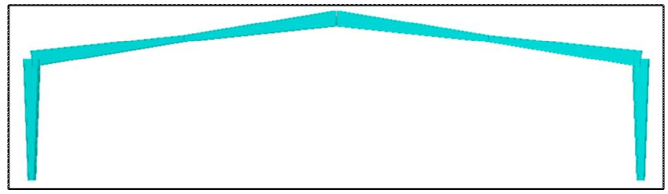


Figure 3: Pre-Engineered Building frame

In the case of PEB frames, they are manufactured from the standard plates using the extensive inventory of the PEB manufacturer. The frames are generally of the shape matching the bending moment diagram, hence optimizing and reducing the total weight of the structure.

II. LITERATURE SURVEY

The literature review of the work done previously by various authors on PEB gives an insight into the importance of these building systems over the conventional building system. The work done by the authors previously on PEB is being presented below.

Milind Darade and Milind Bhojkar (2014) did a comparative study and design of the conventional frame with concrete columns, steel columns and PEB sections. Their work has considered the industrial building of length 44m and width 20m to carry out the analysis and design work using the STAAD Pro V8i version. Researchers have studied that the cost of building can be minimized by utilizing optimum cross-section of steel. Their studies have concluded that CSB is 26% heavier than PEB and PEB is 30% economical.

Neha R. Kolate and Shilpa Kewate (2015) have studied the importance of having long spans and structures with column-free areas in the industrial structures and pre-engineered buildings are the ones that can fulfill that requirement. They have considered steel frames having triangular Pratt truss as roofing system of 60m length and 30m span with varying bay spacing 4m, 5m, and 6m respectively. The eave level for all cases is 10m, and the EOT crane is supported at the height of 8m from the ground level. The analysis and design are carried out using STAAD Pro V8i. Authors have compared the analysis and design of pre-engineered and conventional steel buildings. Their research has concluded that conventional steel building is 23% heavier than pre-engineered building and the steel wastage of pre-engineered building is less. Also, the PEB is 18% more economical than conventional steel buildings.

N.C. Dubey and Swati Wakachaure (2016) have shown that pre-engineered buildings have lots of advantages when compared to conventional ones. PEB tapered sections reduce the quantity of steel used in the building. They have analyzed and designed the structure as per IS 800-1984 & IS 800-2007. They have considered a building with a length of 80m and a span of 60m, with a clear height of 11.4m with a 5.76-degree slope for PEB and 18 degrees for Conventional Steel building (CSB) to carry out the analysis and design for 2D frames. They compared the PEB with CSB in terms of the steel quantity and deflection separately for IS 800-2007 & IS 800-2007. Authors concluded that the PEB structure is 30 percent lighter than the conventional steel building. Also, the deflection limits are higher in IS 800-1984 as compared to IS 800-2007. The weight of the PEB structure is less as compared to the CSB structure resulting in reduced foundation size.

Vivek Thakre and Mr. Laxmikant Vairagade (2016) have shown the advantages of pre-engineered buildings having singly storey in terms of economy and ease of fabrication. Their work analysed and designed a warehouse using IS 800-1984, IS 800-2007, and by referring MBMA-96 and AISC-89. They have compared the economy of structure in terms of weight comparison, between Indian codes and American codes. Their research has depicted that the design of pre-engineered buildings can be done by simple procedure with respect to IS codes.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VI June 2022- Available at www.ijraset.com

III.METHODOLOGY

In the present study, the work involves analyzing and designing industrial buildings with conventional and pre-engineered buildings with spans of 10m, 15m, 20m, 25m, 30m, 40m & 50m. The length of structures for the mentioned spans is taken by maintaining an aspect ratio of 1.5. Similarly, the eave height of the building is also correlated with span as the ratio of ⅕, which means that, for spans in multiple of 5, eave height increases by 1m. The height of the building above the eave is also co-related such that the roof angle is also constant for all spans of the building and, therefore, a ratio of ⅓ is maintained with eave height (for e.g., if the eave height is 1m, the height of building above eave is 1 x ⅓ = 0.33m). The mentioned spans are chosen to generate a flow of comparison such that the indicative results of intermediate spans can be generated simply with the help of interpolation.

The buildings shall be analyzed and designed for each span using conventional as well as pre-engineered tapered sections. The following standards are used in the design of CSB as well as PEB buildings:

IS 800 - 2007
IS 875 - 1987 (part 1)
IS 875 - 1987 (part 2)
IS 875 - 2015 (part 3)

All the parameters considered in the design of industrial buildings with different spans are given in the Table 1 & 2.

TABLE 1 - BUILDING PARAMETERS

Type of building	Industrial Building						
Location	Delhi						
Width/Span (in m)	10	15	20	25	30	40	50
Length (in m)	15	22.5	30	37.5	45	60	75
Eave height (in m)	2	3	4	5	6	8	10
Apex height (in m)	2.67	4	5.33	6.67	8	10.67	13
Roof slope (in deg)	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Bay spacing (in m)	5	4.5	5	4.69	4.5	6	7.5

TABLE 2 – LOAD ON STRUCTURES

Load type	**Value**
1. Seismic Load	Seismic load generally not govern the design of industrial building, hence, not considered
2. Dead Load a) Self-weight b) Roof sheeting c) Fixtures d) Services e) Purlins (cold form Z purlin)	 Program calculated as per model information 60 N/m^2 25 N/m^2 100 N/m^2 60 N/m^2

3. Live Load	750 N/m^2 (Considering the building roof is partially accessible, hence the live load will be the taken as half of minimum prescribed value)
4. Wind Load	Wind load coefficients are calculated as per IS 875 (Part III)
5. Load combinations	The load combinations are considered as per IS 800:2007

A. Design Considerations

- In the design of industrial buildings, the following points are considered in the design:
- The crane load is not considered.
- In the mainframes, the rafters and columns are rigidly connected to each other (Moment connection).
- The column base is considered as pinned support.
- The building is designed as a closed building.
- The lateral stability of the building is ensured by providing bracings in the end bay and middle bay in a longitudinal direction, continuing up to the roof and in the gable end in the transverse direction.
- Moment along Y-axis and Z-axis (My and Mz) are released from all the tie members to avoid heavy connections between the mainframe and tie members.
- The moment at the end joint with the rafter is released for the middle columns in the end frame.
- The orientation of middle columns in the end frame is changed by 90 degrees to utilize the strength along the longer span.
- The bracings and tie members used in conventional and PEB structures will be kept the same to determine the quantity of steel for primary frames.
- All the analysis and design are carried out using STAAD Pro Connect edition

IV. RESULTS

A. The results of displacement for 10m, 15m, 20m, 25m, 30m, 40m, and 50m span buildings have been obtained, as shown in Table 3.

TABLE 3 – LATERAL DISPLACEMENT FOR EACH BUILDING

Span (meter)	Permissible Displacement (mm)	Conventional Building (mm)	PEB Building (mm)
10	55.56	22.77	27.65
15	83.33	64.85	80.75
20	111.11	84.13	86.55
25	138.89	92.41	96.04
30	166.67	113.79	155.08
40	222.22	191.97	219.84
50	277.78	231.82	233.58

B. The results of steel quantity for 10m, 15m, 20m, 25m, 30m, 40m, and 50m span building have been obtained, as shown in Table 4.

TABLE 4 – STEEL QUANTITY FOR EACH BUILDING

Span (meter)	Conventional Building		PEB Building	
	Tons	Kg/m^2	Tons	Kg/m^2
10	3.14	20.96	2.74	18.25
15	9.35	27.69	8.9	26.30
20	21.47	35.78	18.54	30.90
25	40.14	42.81	34.92	37.25
30	70.8	52.44	55.44	41.07
40	199.96	83.31	193.58	80.65
50	304.10	81.09	294.56	78.55

C. The comparison of lateral displacement and steel quantity for 10m, 15m, 20m, 25m, 30m, 40m, and 50m span building have been drawn, as shown in Figure 4 & 5.

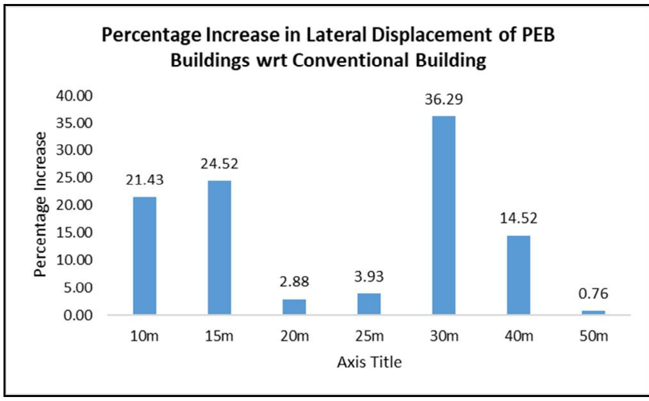


Figure 4: Comparison of lateral displacement for each building

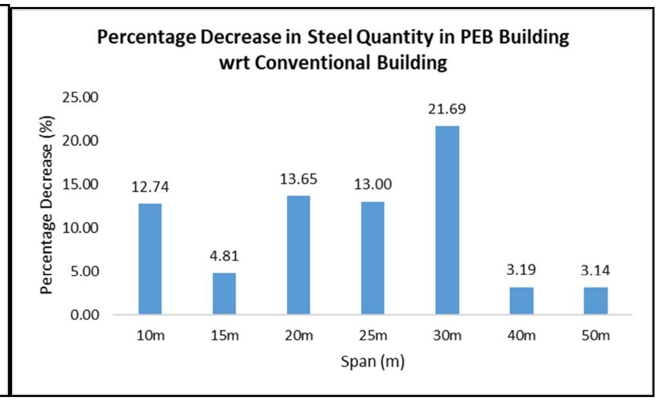


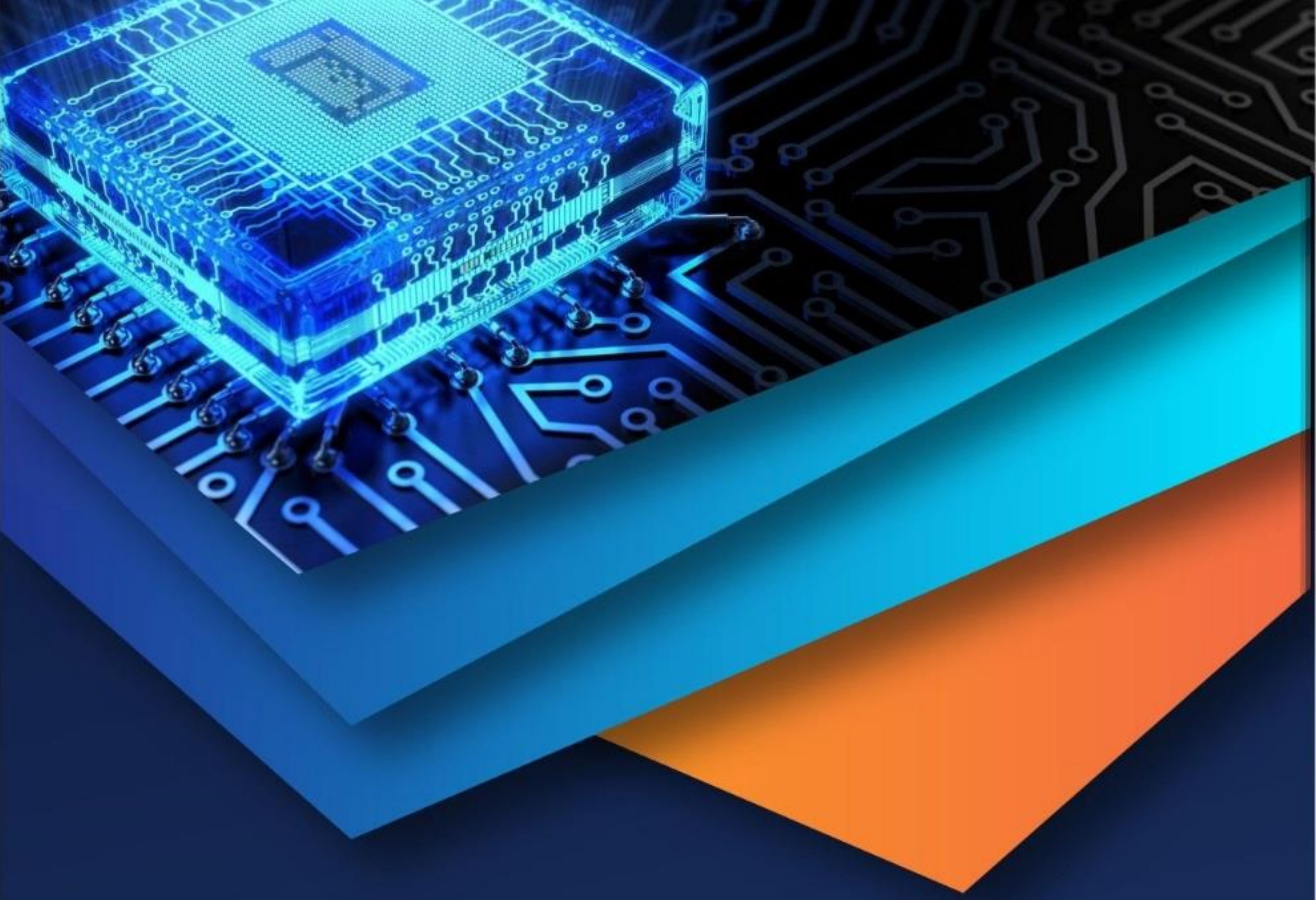
Figure 5: Comparison of steel quantity for each building

V. CONCLUSIONS

A. For all span of structures, the PEB structures are lighter than the Conventional Steel Building structures.
B. The displacement in Pre-Engineered Building structures is on the higher side simply because of light weight and varying depth. Also, it has been observed that for long span structures, the difference in displacement is not significant, simply because of usage of plate girder, which can be customized as per requirement (same as in the case of PEB).
C. The concrete foundation of PEB tapered primary frame will be small compared to conventional steel building foundation because the overall dead load will be reduced and the concrete quantity will be reduced.
D. PEB tapered section buildings looks aesthetically pleasing and hence can be used in the design of façade of buildings.

REFERENCES

[1] IS 875 (Part I) – 1987 Code of practice for design loads (other than EQ load) for buildings and structures (Dead Load)
[2] IS 875 (Part II) – 1987 Code of practice for design loads (other than EQ load) for buildings and structures (Imposed Load)
[3] IS 875 (Part I) – 1987 Code of practice for design loads (other than EQ load) for buildings and structures (Wind Load)
[4] IS 800:2007 – Indian Standard general construction in steel – code of practice
[5] N. Subramanian, "Steel Structures Design and Practice" Oxford University Press
[6] S.K. Duggal, "Limit State Design of Steel Structures" The McGraw-Hill Companies
[7] Technical Handbook, "Kirby Building Systems India Ltd."
[8] Technical Manual, August 2016, Pre-Engineered Steel Buildings Co., Ltd
[9] PEB Technical Manual, Vol. I, Edition A, 2015, Everest Industries Ltd.
[10] T D Mythili "Analysis and Comparative Study of Conventional Steel Structure with PEB Structure" International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064
[11] M. Suneetha, "Design and Analysis of Industrial Building with Gabled Roof by using STAAD.Pro" International Journal of Advanced Technology in Engineering and Science, Vol. No. 4, Issue No. 10, October 2016
[12] Swati Wakchuare, "Design and Comparative Study of Pre-Engineered Building" 2016 IJEDR, Vol. 4, Issue 2, ISSN: 2321-9939
[13] Neha R. Kolate, "Comparative Study of Pre-Engineered and Conventional Steel Frames for different Wind Zones" International Referred Journal of Engineering and Science (IRJES), Vol. – 4, Issue 7, July 2015
[14] Vivek Thakre, "Analysis and Cost Comparative study of Conventional Industrial building with PEB structure" Journal of Information, Knowledge and Research in Civil Engineering, ISSN 0975 – 6744



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY