ANALYSIS AND DESIGN OF PRE-ENGINEERED BUILDING OF AN INDUSTRIAL WAREHOUSE

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Abstract
Long Span, Column free structures are the most essential in any type of industrial structures and Pre Engineered Buildings (PEB) fulfills this requirement along with reduced time and cost as compared to conventional structures. The present work involves the comparative study and design of Pre Engineered Buildings (PEB) and Conventional steel frames. Design of the structure is being done in Staad Pro software and the same is then compared with conventional type, in terms of weight which in turn reduces the cost. Three examples have been taken for the study. Comparison of Pre Engineered Buildings (PEB) and Conventional steel frames is done in two examples and in the third example, Pre Engineered Building structure with increased bay space is taken for the study. In the present work, Pre Engineered Buildings (PEB) and Conventional steel frames structure is designed for wind forces. Wind analysis has been done manually as per IS 875 (Part III) – 1987.

Keywords: Pre Engineered Building, conventional structure, staad pro software, reduce the cost.

I. INTRODUCTION

Steel industry is growing rapidly in almost all the parts of the world. The use of steel structures is not only economical but also ecofriendly at the time when there is a threat of global warming. Here, "economical "word is stated considering time and cost. Time being the most important aspect, steel structures (Pre-fabricated) is built in very short period and one such example is Pre Engineered Buildings (PEB). Pre-engineered buildings are nothing but steel buildings in which excess steel is avoided by tapering the sections as per the bending moment's requirement. One may think about its possibility, but it's a fact many people are not aware about Pre Engineered Buildings. If we go for regular steel structures, time frame will be more, and also cost will be more, and both together i.e. time and cost, makes it uneconomical. Thus in pre-engineered buildings, the total design is done in the factory, and as per the design, members are pre-fabricated and then transported to the site where they are erected in a time less than 6 to 8 weeks. The structural performance of these buildings is well understood and, for the most part, adequate code provisions are currently in place to ensure satisfactory behavior in high winds. Steel structures also have much better

Strength-to-weight ratios than RCC and they also can be easily dismantled. Pre Engineered Buildings have bolted connections and hence can also be reused after dismantling. Thus, pre-engineered buildings can be shifted and/or expanded as per the requirements in future. In this paper we will discuss the various advantages of pre-engineered buildings and also, with the help of three examples, a comparison will be made between pre-engineered buildings and conventional steel structures.

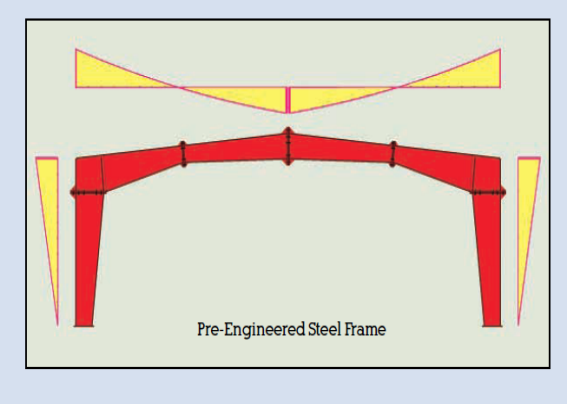

Fig. 1 Pre-Engineered steel frame.

II. LITERATURE REVIEW

Paper 1:-

Comparative Studyof Analysis and Design of Pre-Engineered-Buildings and Conventional Frames.

By Aijaz Ahmad Zende, Prof. A. V. Kulkarni, Aslam Hutagia

In this present work, Staad Pro software has been used in order to analyze and design Pre-engineered building structures and conventional structures. They have considered 3 examples.

I. In the first example, a 3D model of a Hostel building has been designed and compared with conventional structure using conventional steel. It is seen that the weight of tapered PEB sections are 369.24kN whereas for conventional building, it is found to be 491.64 KN Pre-Engineered Building weighs 25% less than that of conventional building.

II. In the second example, a 2D plane frame of width 44m for both PEB and conventional has been designed and comparison has been made in terms of weight of steel. PEB structure is designed for a clear span of 44m without any column in between, as not in case of conventional frame, where it is not possible to provide a clear span truss and hence an interior column is provided. It is noticed that, even though PEB structures provides clear span, it weighs 10% lesser than that of conventional buildings.

III. In the third example, a 2D plane frame of width 80m has been designed with tapered sections for PEB. This frame has been designed for different bay spacing to choose the most economical.

Table No. I

Spacing (m)	No. Of Frames	Weight/ Frame (KN)	Total (KN)
8	11	782	8602
8.88	10	805	8050
10	9	948	8537
10.425	8	1046	8374
13.33	7	1218	8528

Paper 2:-

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This paper is a comparative study of PEB concept and CSB concept. The study is achieved by designing a typical frame of a proposed Industrial Warehouse building using both the concepts and analyzing the designed frames using the structural analysis and design software Staad.Pro.

Table No. II

SR. NO.	Description	PEB	CSB
1	Support reaction(KN)	355.47	375.58
2	Max deflection(mm)	1.86	8.61
3	Max shear force(KN)	340.94	453.98
4	Max moment(KN)	888.97	908.57

III. OBJECTIVES

A. Pre Engineered Buildings

Presently, large column free area is the utmost requirement for any type of industry and with the advent of computer software's it is now easily possible. With the improvement in technology, computer software's have contributed immensely to the enhancement of quality of life through new researches. Pre-engineered building (PEB) is one of such revolution. "Pre-engineered buildings" are fully fabricated in the factory after designing, then

transported to the site in completely knocked down (CKD) condition and all components are assembled and erected with nut-bolts, thereby reducing the time of completion.

B. *Advantages of PEB*

Following are some of the advantages Pre-engineered building structures

a. Construction Time: Buildings are generally constructed in just 6 to 8 weeks after approval of drawings. PEB will thus reduce total construction time of the project by at least 40%. This allows faster occupancy and earlier realization of revenue. This is one of the main advantages of using Pre-engineered building.
b. Lower Cost: Because of systems approach, considerable saving is achieved in design, manufacturing and erection cost.
c. Flexibility of Expansion: As discussed earlier, these can be easily expanded in length by adding additional bays. Also expansion in width and height is possible by pre designing for future expansion.
d. Large Clear Spans: Buildings can be supplied to around 90m clear spans. This is one of the most important advantages of PEB giving column free space.
e. Quality Control: Buildings are manufactured completely in the factory under controlled conditions, and hence the quality can be assured.
f. Low Maintenance: PEB Buildings have high quality paint systems for cladding and steel to suit ambient conditions at the site, which in turn gives long durability and low maintenance coats.
g. Energy Efficient Roofing: Buildings are supplied with polyurethane insulated panels or fiberglass blankets insulation to achieve required "U" values (overall heat transfer coefficient).
h. Erection: Steel members are brought to site in CKD conditions, thereby avoiding cutting and welding at site. As PEB sections are lighter in weight, the small members can be very easily assembled, bolted and raised with the help of cranes. This allows very fast construction and reduces wastage and labor requirement. From the numerous advantages of Pre-engineered building, in the present study, the point b is considered for the study, i.e. to save the steel and reducing cost, while all the other points are self-explanatory.

APPLICATIONS

Pre-Engineered Building concept have wide applications including warehouses, factories, offices, workshops, gas stations, showrooms, vehicle parking sheds, aircraft hangars, metro stations, schools, recreational buildings, indoor stadium roofs, outdoor stadium canopies, railway platform shelters, bridges, auditoriums, etc.

PEB structures can also be designed as re-locatable structures.

PERFORMANCE

All components of the PEB system are specially designed to act together as a system for highest efficiency. PEB designs are revised regularly with respect to the actual field conditions and in accordance with various country codes, which resulted in improved standardized designs leading to high performance of the structure. CSB system components are conventionally designed for a specific project and the performance depends on how the individual project is designed.

IV. METHODOLOGY

I. ANALYSIS AND DESIGN OF PEB

In this present work, Staad Pro software has been used in order to analyze and design Pre-engineered building structures and conventional structures. In the first example, a 2D plane frame of length 80 m, width 30m and bay spacing 6 m for both PEB and Conventional has been designed and comparison has been made in terms of weight of steel. In the second example, a 2D plane frame of length 80 m, width 30m and bay spacing 8 m has been designed with tapered sections for PEB, this example is not solved with conventional sections as it is neither possible by using only conventional steel sections nor it is economical. This frame has been designed for different bay spacing to choose the most economical.

a. Structural Analysis and Design

STAAD Pro software can be used for analyzing and designing of the pre-engineered buildings. It gives the Bending Moment, Axial Forces, Shear Forces, Torsion, Beam Stresses of a steel

structure so that the design can be done using tapered sections and check for the safety.

b. Static Analysis

In the present work, using the Staad Pro software, 2D analysis has been done using Stiffness Matrix Method. All the components of Pre-engineered building are tapered using the in-built option of the Software. The software provides options for hinged, fixed, and spring supports with releases so as to analyze as per our requirement. Herein this work, fixed supports are assigned to the structures. It also facilitates Linear, P-Delta Analysis, and Non-Linear Analysis with automatic load and stiffness correction. Multiple Analyses can also be done simultaneously which reduces the time. It also has an option of assigning members as tension only members and compression-only members for truss structures.

Dynamic Analysis

Dynamic analysis has been done in the present work taking wind loads into consideration. The software provides automatic load generation for wind forces, however, the wind loads are calculated manually for the present work as per IS codes. The software also provides Loading for Joints; Members/Elements including concentrated, Uniform, Linear, Trapezoidal, Temperature, Strain, Support Displacement, Prestressed and Fixed end Loads. It also provides the facility of Combination of Dynamic forces with Static loading for subsequent design.

II. EXAMPLE 1- INDUSTRIAL SHED

a. Statement of the Problem

In this Example a comparison of 2D Plane Frame is made for both pre-engineered building and conventional type. The plane frame is having width 30 m and bay spacing 6 m and eave height 6 m, subjected to wind load. A 5-Ton Crane System is considered.

Main Frame-
Frame Type - Clear Span, Rigid Frame.
Support- Pinned
Building Width (W) – 30 m (O/O Steel Columns)
Building Length (L) –80 m (O/O Steel Columns)
Bay Spacing- 11 @ 6 m
Eaves height- 6 m
Roof Slope- 1 in10
Grits Type-
Sidewall grits- Continuous
End wall grits- Continuous
Purlin Type-
Roof Purlin- Continuous
Spacing- 1.5m c/c
Panel Type-
Roof- Galvanized sheet.

V. DISCUSSION

Pre-Engineered Buildings have vast advantages over the Conventional Steel Buildings. The results of the software analysis and literature studies conducted for both the concepts suggest the same. The various inferences made from the studies are described below.

a. Material Take off

PEB structures are lighter than CSB structures.

b. Design

PEB design is rapid and efficient compared CSB design. Basic design steps are followed and optimization of materials while software analysis is possible for PEB, increasing the quality of design. CSB design is done with fewer design aids and each project needs to develop the designs which require more time. Connection design is also lesser for PEB when measured up to CSB.

c. Foundation

Support reaction for PEB is much lesser than CSB as per the analysis. Hence, light weight foundation can be adopted for PEB which leads to simplicity in design and reduction is cost of construction of foundation. Heavy foundation will be required for CSB structure.

d. Erection

Steel members are brought to site in CKD conditions, thereby avoiding cutting and welding at site. As PEB sections are lighter in weight, the small members can be very easily assembled, bolted and raised with the help of cranes. This allows very fast construction and reduces wastage and labor requirement. From the numerous advantages of Pre-engineered building, in the present study, the point b is considered for the study, i.e. to save the steel and reducing cost, while all the other points are self-explanatory.

e. Lower Cost

Because of systems approach, considerable saving is achieved in design, manufacturing and erection cost.

VI. CONCLUSION

This paper tells us about Design of PEB structure by simple method using IS codes. It also tell us the benefits of PEB structures than other structure

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