A STUDY AND DESIGN OF PRE-ENGINEERED BUILDING STRUCTURE FOR INDUSTRIAL WAREHOUSE BY USING STAAD.Pro

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Abstract : In structural engineering, a pre-engineered building (PEB) is designed by a manufacturer to be fabricated using a pre-determined inventory of raw materials and manufacturing methods that can efficiently satisfy a wide range of structural and aesthetic design requirements. Pre- engineered steel buildings can be fitted with different structural accessories including mezzanine floors, canopies, fascia's, interior partitions etc. The building is made water proof by use of special mastic beads, filler strips and trims. Pre-engineered building is an assembly of I-shaped members, often referred as I-beams. In pre- engineered buildings, the I beams used are usually formed by welding plates steel together to form the I section. The I beams are then field-assembled (e.g. bolted connections) to form the entire frame of the pre-engineered building. Some manufacturers taper the framing members (varying in web depth) according to the local loading effects. Larger plate dimensions are used in areas of higher load effects. The Industrial Warehouse is a closed structure to store the goods and raw materials in protective storage. These are used for protection from weather, protection from direct sunlight. This type of warehouse need special structures to be built, thus enables the Heavy vehicles to enter for loading and unloading purpose. Hence Pre-Engineered buildings are specially designed. In this project, An Industrial ware house is taken modeled in Staad.Pro Axial Forces, Axial stresses, Shear Force, Bending Moment, Maximum displacement, Torsion are calculated for all Columns, Bracing, Purlins and Bracing

Keywords – Pre Engineered Building, Industrial Warehouse, Tapered Section.

I. INTRODUCTION

1.1 Pre-Engineered Building:

"Pre Engineered Steel Buildings" are manufactured or Produced in the plant itself. The manufacturing of structural members is done on customer requirements. The detailed structural members are designed for their respective location and are numbered, which cannot be altered; because members are manufactured with respect to design features. These components are made in modular or completely knocked condition for transportation. These materials are transported to the customer site and are erected. Welding and cutting process are not performed at the customer site. No manufacturing process takes place at the customer site. In this all the sections is only Tapered Sections. Buildings & houses are one of the oldest construction activities of human beings. The construction technology has advanced since the beginning from primitive construction technology to the present concept of modern house buildings. The present construction methodology for buildings calls for the best aesthetic look, high quality & fast construction, cost effective & innovative touch.

1.2 Concept of Pre-Engineered Building:

India being a developed country massive house building construction is taking place in various parts of the country. Since 30% of Indian population lives in towns and cities; hence construction is more in the urban places. The requirement of housing is tremendous but there will always be a shortage of house availability as the present masonry construction technology cannot meet the rising demand every year. Hence one has to think for alternative construction system for steel or timber buildings, but timber is anyway not suitable to tropical countries like India.

In structural engineering, a pre-engineered building (PEB) is designed by a manufacturer to be fabricated using a pre-determined inventory of raw materials and manufacturing methods that can efficiently satisfy a wide range of structural and aesthetic design requirements. Within some geographic industrial sectors these buildings are also called Pre-Engineered Metal Buildings. Historically, the primary framing structure of a pre-engineered building is an assembly of Tapered Section. In PEB, Tapered Section beams used are usually formed by welding steel plates together to form of I section. I section beams are then field-assembled (e.g. bolted connections) to form the entire frame of the pre-engineered building.

1.3 Material used for Pre-Engineered Building:

A typical assembly of a simple metal building system is shown below to illustrate the Synergy between the various building components as described below:

- Primary components
- Secondary components
- Sheeting (or) cladding

1.3.1 Primary Components:

Main framing basically includes the rigid steel frames of the building. The PEB rigid frame comprises of tapered columns and tapered rafters (the fabricated tapered sections are referred to as built-up members). The tapered sections are fabricated using the state of art technology wherein the flanges are welded to the web. Splice plates are welded to the ends of the tapered sections. The frame is erected by bolting the splice plates of connecting sections together.. All rigid frames shall be welded built-up "I" sections or hot-rolled sections. The columns and the rafters may be either uniform depth or tapered. Flanges shall be connected to webs by means of a continuous fillet weld on one side. All end wall roof beams and end wall columns shall becold-formed "C" sections, mill-rolled sections, or built-up "I" sections depending on design requirements. Plates, Stiffeners, etc. All base plates splice plates, cap plates, and stiffeners shall be factory welded into place on the structural members.

1.3.2 Secondary Components:

Purlins, Grits and Eave struts are secondary structural members used as support to walls and roof panels. Purlins are used on the roof; Grits are used on the walls and Eave struts are used at the intersection of the sidewall and the roof. They are supplied with minimum yield strength of 34.5 KN/m. Secondary members act as struts that help in resisting part of the longitudinal loads that are applied on the building such as wind and earthquake loads and provide lateral bracing to the compression flanges of the main frame members for increasing frame capacity. Purlins, Grits and Eave struts are available in high grade steel conforming to ASTM 607 Grade 50 or equivalent, available in 1.5 mm, 1.75 mm. 2.0 mm, 2.25 mm, 2.5 mm and 3.0 mm thickness. They come with a pre-galvanized finish, or factory painted with a minimum of 35 microns (DFT) of corrosion protection primer.

1.3.3 Sheeting or Cladding:

The sheets used in the construction of pre- engineered buildings are composed of the fallowing: Base metal of either Galvanized coated steel conforming to ASTM A 792 M grade 345B or aluminum conforming to ASTM B 209M. Galvanized coating contains 55% Aluminum and about 45% Zinc by weight. An exterior surface coating is done on painted sheets of 25 microns of epoxy primer with a highly durable polyester finish. An interior surface coating on painted sheets of 12 microns of epoxy primer and modified polyester or foam. The sheeting material is cold-rolled steel, with hot dip metallic coating of Galvanized sheet.

1.4 Advantages of PEB:

- Easy future expansion/modification.
- Weather proof and resist fire hazards.
- Optimized design of steel reducing weight of steel.
- International Quality Standards
- Seismic & Wind pressure resistant.
- Quality design, manufacturing and erection, saving around 30-40% of project time
- Quick delivery and Quick turn-key construction.
- Pre-painted and has low maintenance requirement.
- Erection of the building is fast.
- Future extensions can be easily accommodated without much hassle.
- Energy efficient roof and wall system using insulations.
- Suitability for Hilly regions and other geographically difficult areas
- Unlimited architectural possibilities.

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1.5 Comparison of Conventional Steel Building and Pre Engineered Building

Table-1: Comparison of CSB & PEB

Factor	Pre-Engineered Building	Conventional Steel Building
Structure Weight	Pre-engineered buildings are on the average 30% lighter because of the efficient use of steel. Primary framing members are tapered built up section. With the large depths in areas of higher stress	Primary steel members are selected hot rolled -T-sections. Which are, in many segments of the members heavier than actually required by design.
Delivery	Average 6 to 8 weeks	Average 20 to 26 weeks
Erection cost and Time	Both costs and time of erection are accurately known based upon extensive experience with similar buildings.	Typically, conventional steel buildings are 20% more expensive than PEB in most of the cases
Future Expansion	Future expansion is very easy and simple.	Future expansion is most tedious and more costly

2. Literature Review

Syed Firoz, (2012): The pre-engineered steel building system construction has great advantages to the single storey building, practical and efficient alternative to conventional buildings, the system representing one central model within multiple disciplines. Pre-engineered building creates and maintain in real time support is currently being implemented by Staad Pro Choosing steel to design a Pre-engineered steel structures building is to choose a material which offers low cost, Strength, durability, design flexibility, adaptability and recyclability. Steel is the basic material that is used in the materials that are used for Pre- engineered steel building.

C.M. Meera (2013) : has carried out a comparative study of PEB and CSB concept. The achieved by designing a typical frame of a proposed Industrial Warehouse building using both the concept and analyzing the designed frames using the structural analysis and design software Staad Pro. The designing of industrial warehouse includes designing of the structural element including principal rafter or roof truss, column and column base, purlins, sag rods, tie rods, gantry girder, bracing, etc. A combination of standard hot-rolled sections, cold-framed Industrial building can be categorized as Pre-Engineered Building (PEB) and Conventional Steel Building (CSB), according to the design concepts. The paper starts with the discussion of methods adopted in the study. Loads and the load combination adopted for carrying out the analysis of the structure is well defined in the further portions. A section depicting the importance of the software used and the software procedure followed is included. Final portion explains the results obtained from the software analysis of the case study and the inferences from the literature studies. The paper aims at developing a perception of the design concept of PEB structures and its advantages over CBS structure.

S.D. Charkha and Latesh (June 2014): observes that, Using of PEB instead of CSB may be reducing the steel quantity. Reduction in the steel quantity definitely reducing the dead load. Reduction in the dead load reducing the size of Foundation. Using of PEB increase the Aesthetic view of structure.

3. INDUSTRIAL WAREHOUSE:

A WAREHOUSE is a closed structure to store Goods and Industrial raw material storage. Most of the Industrial warehouse is constructed by using pre-engineered buildings. The main specialty of this warehouse is they consist of long spans without any supports or columns. Warehouse is used manufactures, importers, exporters, transport businesses, customs etc. They are usually large plain buildings industrial parks on the outskirts of cities, towns or villages. Prefab steel warehouse provides the greatest possible storage space to accommodate one.

3.1 Design Process For Industrial Warehouse:

Loads on Structure:

The determination of the loads acting on a structure is a complex problem. The nature of the loads varies essentially with the architectural design, the materials, and the location of the structure. Loading conditions on the same structure may change from time to time, or may change rapidly with time.

Dead Load:

Dead loads shall cover unit weight/mass of materials, and parts or components in a building that apply to the determination of the dead loads in the design of buildings and shall be considered as per IS: 875 (Part 1) - 1987 according to the densities of the possible components. This includes main frames, purlins, girt, cladding, bracing and connections etc.

Live Load:

Imposed loads shall be considered as per IS: 875 (Part 2) – 1987. Live load shall be considered as 0.75 KN/sum for the analysis and design.

Wind Load:

The basic wind speed and design velocity which shall be modified shall be taken As per IS: 875 (Part 3) – 1987. The basic wind speed at Rajahmundry shall be considered as 44m/sec as per IS: 875 (Part III). This shall be considered for calculating the wind loads. Analysis shall be carried out by considering future expansions if any which has been indicated in the building descriptions and critical forces shall be taken for design.

3.2 Design Criteria:

The parameters considered for Industrial Warehouse Design :
Width = 30 m
Length = 42.5m
Eave Height = 8 m
Bay Spacing = 6 m
Roof Slope = 5.78 degrees

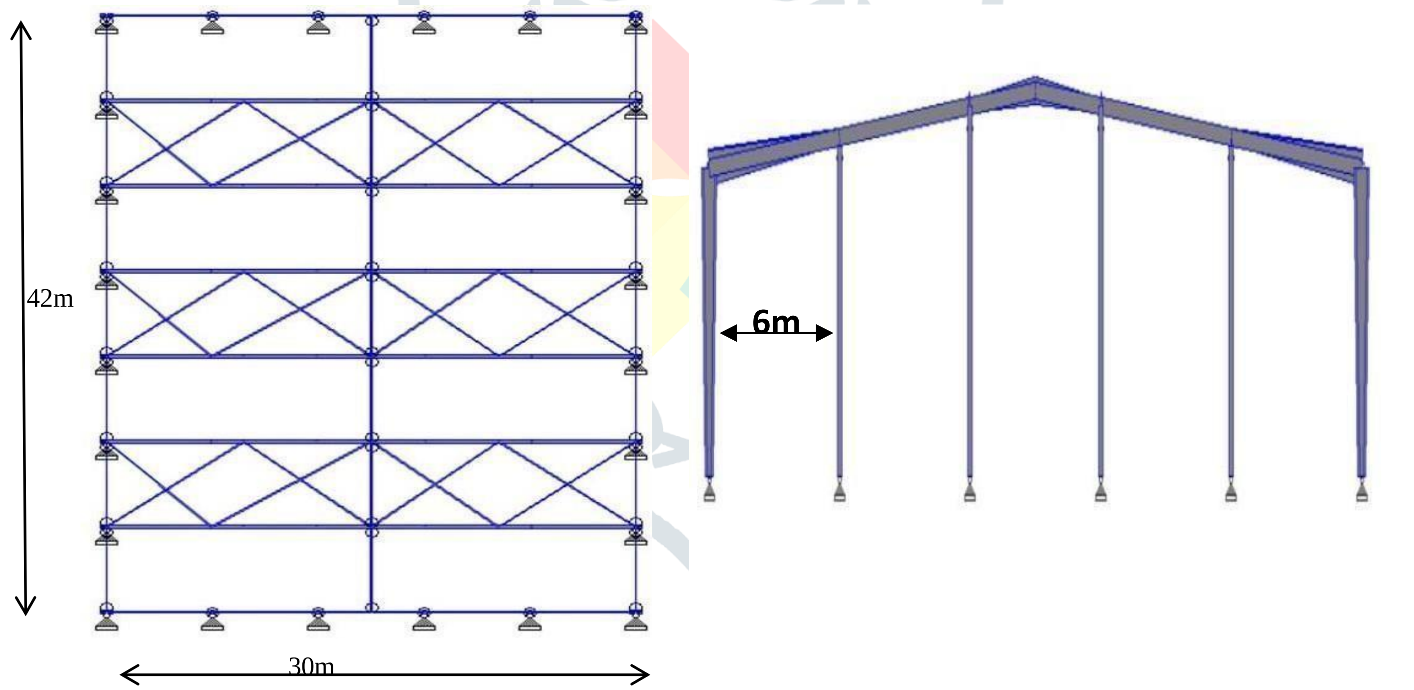

Fig-1 : Pre Engineered Plan & Sections

A) Dead Load Calculation:

Purlins = 5 kg

Bracing = 9.5 kg
The total load transferring from these components are 1.0 KN/m^2
Total Dead load = 1.0*6(Bay Spacing) = 6 KN/m^2

B) Live Load Calculation:

Live Load is considered from the crane loading and manual loading during erection and is 0.57KN/m according to MBMA code of chapter 4,

Live Load = 0.57x 6= 3.42 KN/m^2

C) Wind Load Calculations:

Wind Speed Vb = 44 m/sec Risk coefficient, k_1 = 1
Terrain, Ht & size factor k_2 = 1.05
Topography Factor, K_3 = 1.0
Design Wind Speed, $V_Z = Vb*k_1*k_2*k_3$
= 44*1*1.05*1.0
= 46.2m/sec

Design wind pressure, $P_Z = 0.6*(V_Z)^2$
$= 0.6*(46.2)^2$
= 1280.664 KN

=1.28 N/mm^2

4. STAAD PRO GENERATED LOADS:

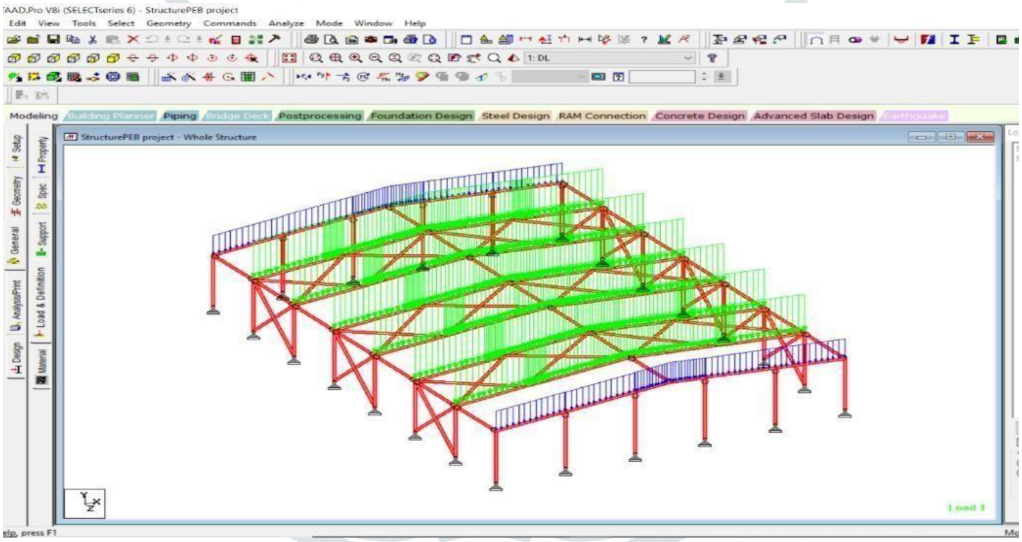

Figure-2: Dead Load View in STAAD.Pro

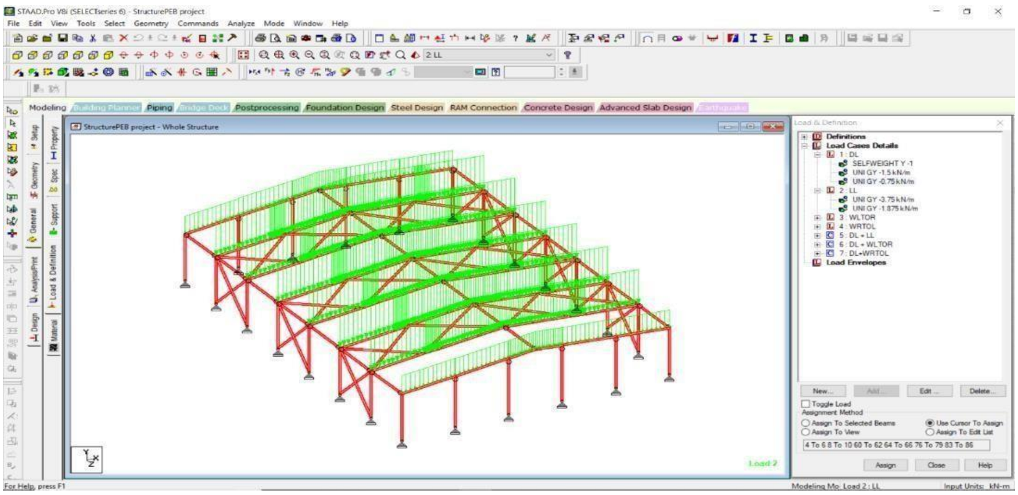

Figure-3: Live Load View in STAAD.Pro

4.1 Industrial Warehouse Design by using STAAD.Pro :

STAAD pro features state of the art user interface, visualization tools, powerful analysis and design engines with advanced finite element (FEM) and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification STAAD pro is the professional first choice. STAAD Pro was developed by practicing engineers around the globe. It has evolved over 20 years and meets the requirements of ISO 9001 certification.

5. RESULT AND DISCUSSION:

By using Staad.Pro we had done the design, In this design mainly designed Four elements i.e**., COLUMNS, RAFTERS, PURLINS & BRACINGS.** These four elements Results are as followed

- Shear Force
- Torsion
- Maximum Displacement
- Bending Moment

Table- 2 Design Results

Components	**Bending Moment**	**Shear Force**	**Torsion**	**Max displacement**
Column	8.167N/mm^2	150.77KN	0.00KN.m	52.72mm
Purlins	-3.71N/mm^2	178.7KN	12.4KN.m	12.89mm
Rafter	-8.85N/mm^2	25.62KN	0.08KN.m	75.275mm
Bracing	-2.07N/mm^2	164.53KN	0.02KN.m	11.527mm

6. CONCLUSION:

Pre-engineered Metal building concept forms an unique position in the construction industry in view of their being ideally suited to the needs of modern Engineering Industry. It would be the only solution for large industrial enclosures having thermal and acoustical features. The major advantage of metal building is the high speed of design and construction for buildings of various categories.

- PEB‘s can be constructed within a less time.
- High speed construction is possible with PEB‘s.
- It is economical.
- As Pre Engineered Building Contains Tapered Section, all Bending Moment will be balanced.

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