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Structural Analysis and Design of Pre-Engineered Buildings for Different Geometrics and Bracings

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ABSTRACT

The steel industry is expanding quickly in practically every region of the world. With the threat of global warming, using steel constructions is not only practical but also environmentally friendly. Here, the word "economical" is used in the context of time and money. Pre-engineered buildings are one example of a steel structure that is constructed quickly because time is the most essential factor (PEB). Pre-engineered structures are simply steel structures with surplus steel avoided by tapering the sections to the required bending moment. It's possible, although few people are aware of pre-engineered buildings, despite the possibilities. Regular steel constructions will take longer to build and will cost more money, which when added together, time and money, makes it unprofitable. As a result, in pre-engineered buildings, the entire design process is completed in the factory. Then, in accordance with the design, members are pre-fabricated and transported to the site, where they are quickly put into place within 6 to 8 weeks.

Large column free areas are currently the most important demand for any form of industry, and with the development of computer software, it is now quite simple to achieve. Computer software has made a significant contribution to the improvement of quality of life through fresh studies thanks to technological advancements. One such revolution is the pre-engineered building (PEB) industry. "Pre-engineered buildings" are designed, fully constructed in the factory, and then delivered to the site in a completely knocked-down (CKD) condition. All components are then assembled and erected with nut-bolts, shortening the construction period..

This article uses ETABS software to analyse and design a pre-engineered building that is 120 metres long, 35 metres wide, and 24 metres high at the eaves. In this thesis, I took into account different bay spacing like 5m, 7.5m, and 10m in order to understand the behaviour of pre-engineered structures and to comprehend the geometric effect on pre-engineered buildings. Pre-Engineered Buildings, which take less time and money to construct than traditional structures, meet the criterion for long Span, Column Free Structures, which is the most important in any sort of Industrial Structures. . All loads and load combinations are manually computed in accordance with IS 875 (Part I–IV) – 1987, and the ETABS programme assigns an earthquake load automatically. The ETABS 2019 modelling and analysis software is used for all models. Additionally, for different bay spacings, the studied performance based on analysis results such as bending moments, shear forces, and results of all centre and gable rafters and centre and gable columns are compared.

Keywords: TABS, PEB, Equivalent Static analysi

1. Introduction

1.1: PRE-ENGINEERED STEEL BUILDINGS or (PEB):

Being a developed nation, India is seeing a tremendous housing construction boom across the nation. Construction is more prevalent in urban areas because 30% of the population of India lives in towns and cities. Although there is a great need for housing, there will never be enough homes available since the current masonry construction technique cannot keep up with the demand, which is increasing every year. Therefore, one must consider alternate steel or timber building construction methods; nevertheless, lumber is inherently unsuitable for tropical nations like India.

Pre-engineered buildings (PEBs) are structures that have been pre-engineered by a manufacturer to be constructed using a predetermined inventory of raw materials and manufacturing techniques that can effectively satisfy a variety of structural and aesthetic design requirements. These structures are also known as pre-engineered metal buildings in some geographically specific industry sectors.

Pre-engineered buildings are constructed entirely in a factory, and the building materials are transported to the construction site in CKD (Completely knock down condition). Cranes are then used to hoist these components after they have been fastened or joined on the job site. The pre-engineered building requires buildings to be constructed quickly, with high-quality materials, and with pleasing aesthetics. Construction of residential and commercial buildings can make substantial use of pre-engineered constructions. The structures may have multiple stories (4-6 floors). These structures can withstand a variety of environmental risks.Pre-engineered buildings can be modified to fit a wide range of structural purposes; however, using standard details will result in the largest economic savings. Pre-engineered structures with effective designs can be up to 30% lighter than traditional steel structures. Less steel is required for lighter weight, which could result in cost savings for the structural framework.

1.2: FEATURES AND ADVANTAGES:

Features: For the basic steel frame of pre-engineered steel buildings, a combination of built-up sections, hot rolled sections, and cold formed elements is used. For the roofing and wall cladding, either single skin sheeting with additional insulation or insulated sandwich panels are used. The idea is to offer a full building envelope system that is airtight, energy-efficient, lightest in weight and cost, and, most all, made to perfectly match the needs of the user.

Mezzanine floors, canopies, fascias, interior partitions, and other structural accessories can be added to pre-engineered steel buildings. Special mastic beads, filler strips, and trimmings are used to make the building waterproof. This is a very adaptable construction system that may be furnished on the inside to fulfil any purposes and decorated on the outside to create appealing and distinctive creating styles. It has many advantages over traditional structures and is especially useful in the construction of lowrise buildings..

Although pre-engineered structures tend to be low rise, the maximum eave height might reach 25 to 30 metres. For offices, homes, showrooms, storefronts, and other applications, low rise buildings are perfect. It is highly affordable and quick to apply the pre-engineered buildings concept to low rise buildings. When combined with other engineered subsystems, buildings can be constructed in less than half the usual time.

The most typical and affordable low rise building form has a ground level, two intermediary floors, and a roof. Low rise buildings can have slanted or flat roofs. Mezzanine systems are used to construct the intermediate levels of low-rise buildings. Construction of single-story residential buildings takes the shortest amount of time and is possible in any type of geographic area, including plain land, hills with an extremely cold climate, and climate zones that are also quite hot..

Advantages:

Reduction in Construction Time: Buildings are typically delivered in just a few weeks after approval of drawings. Foundation and anchor bolts are cast parallel with finished, ready for the site bolting. In India the use of PEB will reduce total construction time of the project by at least 50%. This also allows faster occupancy and earlier realization of revenue.

Lower Cost: Due to the systems approach, there is a significant saving in design, manufacturing and on site erection cost. The secondary members and cladding nest together reducing transportation cost.

Flexibility of Expansion: Buildings can be easily expanded in length by adding additional bays. Also expansion in width and height is possible by pre designing for future expansion.

Larger Spans: Buildings can be supplied to around 80M clear spans.

Quality Control: As buildings are manufactured completely in the factory under controlled conditions the quality is assured.

Low Maintenance: Buildings are supplied with high quality paint systems for cladding and steel to suit ambient conditions at the site, which results in long durability and low maintenance costs.

Energy Efficient Roofing and Wall Systems: Buildings can be supplied with polyurethane insulated panels or fiberglass blankets insulation to achieve required “U” values.

Architectural Versatility: Building can be supplied with various types of fascias, canopies, and curved eaves and are designed to receive pre cast concrete wall panels, curtain walls, block walls and other wall systems.

Single Source Availability: As the complete building package is supplied by a single vendor, compatibility of all the building components and accessories is assured. This is one of the major benefits of the pre-engineered building systems.

1.3: BENEFITS OF PEB:

In nutshell, the benefits may be summarized as under

- Easy future expansion/modification.
- Weather proof and fire hazards.
- Optimized design of steel reducing weight.
- 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.

● The building can be dismantled and relocated easily.

● Future extensions can be easily accommodated without much hassle.

● Increased Life cycle performance and cost competitiveness

● Environment – friendly structures

● Better rainwater harvesting through gutters and down-take arrangements

● Lighter weight; savings in foundation cost of 10-20 percent

● The building can be dismantled and relocated easily

● Easy integration of all construction materials

● Energy efficient roof and wall system using insulations.

● Suitability for Hilly regions and other geographically difficult areas

● Unlimited architectural possibilities

1.4: APPLICATIONS OF PEB:

Applications of Pre-Engineered steel buildings include

● Houses & Living Shelters

● Factories

● Warehouses

● Sport Halls (Indoor and Outdoor)

● Aircraft Hangers

● Supermarkets

● Workshops

● Office Buildings

● Labor Camps

● Petrol Pumps/Service Buildings

● Schools

● Community centers

● Railway Stations Equipment housing/shelters.

There is a great possibility of improving the aesthetic quality with a choice of roofing elements, exterior finishes, weather-sheds, color system and variations in planning as well as massing.

1.5: PROFILE OF PEB:

All over the world, pre-engineered building system or PEB system is becoming an eminent segment in pre-engineered construction industry. It has become possible because pre- engineered building system encompasses all the characteristics that are compatible to modern demands viz. speed, quality and value for money. Pre-engineered buildings find many pre-engineered construction applications, which could be intrinsic and high-end.

1.5.1: PEB prospect in the world:

Technological improvement over the year has contributed immensely to the enhancement of quality of life through various new products and services. One such revolution was the pre- engineered buildings. Through its origin can be traced back to 1960's its potential has been felt only during the recent years. This was mainly due to the development in technology, which helped in computerizing the design.

PEB concept has been very successful and well established in North America, Australia and is presently expanding in U.K and European countries. PEB construction is 30 to 40% faster than masonry construction. PEB buildings provide good insulation effect and would be highly suitable for a tropical country like India. PEB is ideal for construction in remote &hilly areas. A recent survey by the Metal Building Associations (MBMA) shows that about 60% of the non-residential low rises building in USA are pre-engineered buildings.

1.5.2: PEB Prospects in India:

Although PEB systems are extensively used in industrial and many other non residential constructions worldwide, it is relatively a new concept in India. These concepts were introduced to the Indian markets lately in the late 1990's with the opening up of the economy and a number of multi nationals setting up their projects. India has an installed steel capacity of 35 to 40 million tones & apparent steel consumption is around 27 to 30 million tones.

The current pre-engineered steel building manufacturing capacity is 0.35 million tonnes per annum. The industry is growing at the compound rate of 25 to 30 %.

1.6: TECHNICAL PARAMETERS OF PEB:

Pre-Engineered Buildings are custom designed to meet client's requirements. PEB's are defined for definite measurements. The produced members fit to the designed dimensions. Measurements are taken accurately for the requirements. The basic parameters that can define a PEB are

Width Or Span Of Building: The centre to centre length from one end wall column to the other end wall column of a frame is considered breadth or span of the building. The width between two columns can be measured as span. The span length for different buildings varies. The design is done on span length given by customer. The basic span length starts from 10 to 150 meters or above with intermediate columns. Aircraft hangars, manufacturing industries, Stadiums posses major span width. No modifications or extending span be done.

Length Of Building: The length of PEB is the total length extending from one front end to the rear end of the building. The length of PEB can be extendable in future.

Building Height: Building height is the eave height which usually is the distance from the bottom of the main frame column base plate to the top outer point of the eave strut. When columns are recessed or elevated from finished floor, eave height is the distance from finished floor level to top of eave strut.

Roof Slope: This is the angle of the roof with respect to the horizontal. The most common

roof slopes are 1/10 and 1/20 for tropical countries like India. The roof slope in snow fall locations can go up to 1/30 to 1/60. Any practical roof slope is possible as per customer's requirement.

Bay Spacing: The distance between the two adjacent frames of a building is called as a Bay spacing. The spacing between two frames is a bay. End Bay length is the distance from outside of the outer flange of end wall columns of centre line of the first interior frame columns. Interior bay length is the distance between the centre lines of two adjacent interior main frames Columns. The most economical bay spacing is 7.5m to 8.0m. However bay length up to 10m is possible.

1.7: COMPONENTS OF PEB:

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
- Accessories

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 endwall roof beams and endwall columns shall be cold- 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.

Built- up “I” section to build primary structural framing members (Columns and Rafters)

Columns:

The main purpose of the columns is to transfer the vertical loads to the foundations. However a part of the horizontal actions (wind action) is also transferred through the columns.

Basically in pre-engineered buildings columns are made up of I sections which are most economical than others. The width and breadth will go on increasing from bottom to top of the column. I section consists of flanges and web which are made from plates by welding Rafter.

A rafter is one of a series of sloped structural members (beams) that extend from the ridge or hip to the wall-plate, down slope perimeter or eave, and that are designed to support the roof deck and its associated loads.

Secondary Components:

Purlins, Grits and Eave struts are secondary structural members used as support to walls and roof panels. Purloins 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. Purloins, 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.

Purlins and girts shall be cold-formed "Z" sections with stiffened flanges. Flange stiffeners shall be sized to comply with the requirements of the latest edition of AISI.

Purlins and Girts:

Purlins and girts shall be roll formed Z sections, 200 mm deep with 64 mm flanges shall have a 16 mm stiffening lip formed at 45˚ to the flange. Purlins and girts shall be cold- formed "Z" sections with stiffened flanges. Flange stiffeners shall be sized to comply with the requirements of the latest edition of AISC .Purlin and girt flanges shall be unequal in width to allow for easier nesting during erection. They shall be pre punched at the factory to provide for field bolting to the rigid frames. They shall be simple or continuous span as required by design. Connection bolts will install through the webs, not flanges

Eave Struts:

Eave Struts shall be unequal flange cold-formed "C" sections. Eave struts are 200 mm deep with a 104 mm wide top flange, a 118 mm wide bottom flange, both are formed parallel to the roof slope. Each flange has a 24 mm stiffener lip.

Bracings:

The Cable bracing is a primary member that ensures the stability of the building against forces in the longitudinal direction such as wind, cranes, and earthquakes.

Diagonal bracing in the roof and sidewalls shall be used to remove longitudinal loads (wind, crane, etc.) from the structure. This bracing will be furnished to length and equipped with bevel washers and nuts at each end. It may consist of rods threaded each end or galvanized cable with suitable threaded end anchors.

Sheeting Or Cladding:

The sheets used in the construction of pre- engineered buildings are composed of the following: Base metal of either Galvalume coated steel conforming to ASTM A 792 M grade 345B or aluminium conforming to ASTM B 209M. Galvalume coating is 55% Aluminium and about 45% Zinc by weight. An exterior surface coating 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, high tensile 550 MPA yield stress, with hot dip metallic coating of Galvalume sheet.

1.8. OBJECTIVES:

In the present study, Pre-Engineered buildings concept is relatively new technique that are used to design from low rise to high rise multilevel parking and Industrial buildings for manufacturing plants and Aircraft Hangars. The main objectives in this thesis is

●To know how to analyse PEB building using ETABS software.

●To know the performance of PEB subjected to linear static analysis.

●To study the behaviour of the PEB for various geometric conditions

●To study the behaviour of the PEB for various load conditions as per Indian standards.

2.1: GENERAL: LITERATURE REVIEW

1.Comparative Study of Analysis and Design of Pre-Engineered Buildings and Conventional Frames, by G. Durga Rama Naidu.

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 60 m, width 25m 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 60 m, width 25m 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.

2.Analysis of Pre –Engineered Buildings,by Jinsha M S

In this paper Pre-Engineered Building of 25m width & 6m Eave Height has been analyzed and designed by using STAAD Pro.2007 to understand the behavior of Pre –Engineered structure & to check in which case it achieves the economy in steel quantity by varying bay spacing as 6m, 8m, 10m, & 12m. Long Span, Column free structures are the most essential in any type of industrial structure and Pre Engineered Buildings fulfills this requirement along with reduced time and cost as compared to conventional structures. In the present work, Pre Engineered Buildings (PEB) is designed for wind forces. Wind analysis has been done manually as per IS 875 (Part III) – 1987.

3.A Comparative Study on Analysis & Design of Pre-Engineered & Conventional Industrial Building, by Hemant Sharma.

In this case study, I have analyzed, Designed, and compared the pre-engineered industrial building with the conventional building by mainly comparing the bending moments in different sections. Also, I have considered different components of the pre-engineered steel building. To design and analyze the PEB and CSB I have used Staad pro v.8 as well as Indian standard codes. And finally, I have compared these two structures in terms of Economy and Time saving of construction. In the analysis, I have analyzed and designed the Purlins, Girts, Eave Struts, and Bracings, etc. For the design, I have considered Dead Load, Live Load, and Wind Load for the location of Vadodara, Gujarat as per IS Code consideration.

4.A Study on the Structural Analysis and Design of Pre-Engineered Buildings for Different Geometries Santosh S. Patil.

In this study, three models of industrial structures of PEBs are analyzed and designed according to the Indian standards. The models are considered having different geometries and a parametric study is carried out to access the performance of the models in terms of self-weight, cost of construction, and time of construction. Three PEB models were created using STAAD.Pro software and analyzed for gravity loads and wind loads.

5.Design and Analysis of Conventional and PreEngineered Building (R.C.C and Steel) , D.Rakesh.

In this study comparison of displacement and steel quantity is done in a conventional type of truss and pre-engineered structure. In this study, the pre-engineered structure shows fewer displacements in columns and less consumption of steel. Pre-engineered steel structures building offers low cost, strength, durability, design flexibility.

6.A Review On Pre-Engineered Building Design Of An Industrial Warehouse Anisha T.

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

7.Pre-Engineered Building Design Of An Industrial Warehouse, C. M. Meera

The present study is included in the design of an Industrial Warehouse structure located at Ernakulam. The structure is a container warehouse of Vallarpadam Container Terminal. The actual structure is proposed as a Pre-Engineered Building with four spans each of 30 meters width, 16 bays each of 12 meters length and an eave height of 12 meters. In this study, a typical PEB frame of 30 meter span is taken into account and the design is carried out by considering wind load as the critical load for thestructure. CSB frame is also designed for the same span considering an economical roof truss configuration. Both the designs are then compared to find out the economical output. The designs are carried out in accordance with the Indian Standards and by the help of the structural analysis and design software Staad.Pro.

8.Aircraft Hanger Design Pre-Engineered Building Ashwini.M.Kadam

The present study is included in the design of an Aircraft Hanger structure located at Mumbai. The structure is proposed as a Pre-Engineered Building of 79.3 meters width, 10 bays each of 8.48 meters length and an eave height of 22meters. In this study, a PEB frame of 22 meter width is taken into account and the design is carried out by considering wind load as the critical load for the structure. The designs are carried out in accordance with the Indian Standards and by the help of the structural Analysis and design by software SAP2000, ANSYS.

9.Progressive Analysis of Pre-Engineered Steel Building Md. Sumon Reza

In order to carry out the research, certain approaches and methodologies are required to be followed. The research was based on both exploratory and descriptive method. A random set of sample had chosen and a questionnaire was given. This study was mainly based on primary data and a questionnaire was developed that consisted mainly close-ended questions. For accomplishing this project, following points will be considered Collection of the information regarding conventional methods of building technologies and the limitations associated with it. Study various concepts of pre-engineered building and its various applications. Recent innovations and substitute techniques that are implemented for pre-engineered building will be highlighted . The designs are carried out in accordance with the Standards and by the help of the structural analysis and design software STAAD pro.

10.Comparative Study of an Industrial Pre – Engineered Building with Conventional Steel Building Deepti D. Katkar

The present work presents the comparative study and design of conventional steel frames with concrete columns and steel columns and Pre Engineered Buildings (PEB). In this work, an industrial building of length 44m and width 20m with roofing system as conventional steel truss and pre-engineered steel truss is analyzed and designed by using STAAD Pro V8i.

11.Comparative Analysis of Industrial Structure in Pre-Engineered Building with Conventional Steel Building, Shubham D. Kothawade.

In this research, an industrial structure warehouse is analyzed and designed according to the Indian standards (IS 800-2007) and additionally through referring American Standard (AISC LRFD). The various loads like dead, live, wind, seismic and snow loads according as per IS codes are considered for the present work for relative study of Pre-Engineered Buildings (PEB) and Conventional Steel Building (CSB). To compare the consequences of the numerous parametric study to perform the variations in terms of shear force, support reaction, weight correlation and cost evaluation.

12.Comparative Study of Seismic Analysis and Design of Pre-Engineering Building with Conventional Industrial Building on different bay spacing Muthu Meena M

This paper comprises about the comparative study of total steel take off for both the frames along different bay spacing of about 4m, 6m, 8m and 12m for the same area this is achieved by using STAAD Pro V8i software for analysis and design. The structure is designed for static and dynamic forces which include wind load and earthquake load according to IS codes. The deflection is controlled by providing cross bracings.

13.Comparative Study of Pre-Engineered and Conventional Industrial Building Pradeep V

The present work presents the comparative study and design of conventional steel frames with concrete columns and steel columns and Pre-Engineered Buildings (PEB). In this work, an industrial building of length 44m and width 20m with roofing system as conventional steel truss and pre-engineered steel truss is analyzed and designed by using STAAD Pro V8i.

14.Analysis And Design Of Pre-Engineered Building Of An Industrial Warehouse Subodh.S.Patil

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.

15.Analysis And Design Of Pre-engineered Building E.Ramy

The present study is included in the design of an Industrial workshop structure located at Chennai. The actual structure is proposed as a Pre-Engineered Building with length 234m and width 120m it has four spans each of 30 meters width, 30 bays each of 7.4 meters length and an eave height of 19 meters. In this study, a typical PEB frame of 30 meter span is taken into account and the design is carried out by considering dead load, live load and wind load.

16.Comparative Study of Analysis and Design of Pre-Engineered Buildings and Conventional Frames Aijaz Ahmad Zende.

The present work involves the comparative study of static and dynamic analysis 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, longer span Pre-Engineered Building structure is taken for the study. In the present work, Pre-Engineered Buildings (PEB) and Conventional steel frame's structure is designed for dynamic forces, which includes wind forces and seismic forces. Wind analysis has been done manually as per IS 875 (Part III) – 1987 and seismic analysis has been carried out as per IS 1893 (2002).

17.Pre-Engineered Building Design of an Industrial Warehouse Anisha Goswami. The Present work involves the comparative study and design of PreEngineering Buildings (PEB) and Conventional steel Building (CSB). Conventional Steel Building is old concept which take lots of time, quality and typical erection factor to modified that issues Pre- Engineering concept is developed. It introduced to the Indian market in 1990's.PEB concept is totally versatile not only due to its quality, prefabrication, light weight and economical construction. The study is achieved by designing a typical frame of Industrial warehouse shed using both the concept and analyzing the designed frame using the structural analysis and design software STAAD Pro.

18.Analysis and Design of Pre-Engineered Building Using IS800:2007 and International Standards Pratik R. Atwal

In this report, comparison is made between IS800:2007 & International standards. The entire range of preengineered building is studied while doing this comparison. A school building is designed using IS800:2007 & International standards by keeping the loading parameters similar, all the loads are applied accordance with Indian codes. An attempt is made to study the variation in tonnage as per IS800:2007 & International standards & possible reasons for variation in respective results. Analysis and design of these building frames was carried out using Staad-Pro software & manually also. As per market study it observed that more than 70% pre-engineered buildings are designed according to American codes. As per the design result obtained during this dissertation work it is noted that the weight of structure is reduced by 23.97% as compared to IS800:2007. Even though most of the pre-engineered buildings are designed accordance to American code it is noted that by using Euro-03 weight of structure is reduced by 27.2% and by using BS5950-2000 weight of structure is reduced by 9.04% respectively as per obtained design results as compared to IS800:2007.

19.Design Concept of Pre-Engineered Building, Syed Firoz.

The pre-engineered steel building system construction has great advantages to the single storey buildings, practical and efficient alternative to conventional buildings, the System representing one central model within multiple disciplines. Preengineered building creates and maintains in real time multidimensional, data rich views through a project support is currently being implemented by Staad pro software packages for design and engineering.

20.Design And Analysis of Pre-Engineered Steel Frame D V Swathi

In this present work, a comparison of 2D Plane Frame is made for both pre-engineered building and conventional type. Staad Pro software has been used in order to analyze and design a Pre-engineered building structure. In the below example, a 2D plane frame of length 50 m, width 38.1m and bay spacing 6.25 m has been designed.

21.Comparative Study of an Industrial Pre-Engineered Building with Conventional Steel Building Pradip S. Lande

In this study, an industrial structure (Ware House) is analyzed and designed according to the Indian standard, IS 800-2007 and American code, MBMA-96 by using the structural analysis and design software STAAD-pro. The economy of the structure is discussed in terms of its weight comparison, between Indian code (IS800-2007) & American code (MBMA-96). A comparative study has also been carried out between cold formed sections as purlins with traditional used hot rolled sections for industrial structures.

3. LOADS AND LOAD COMBINATIONS

3.1: LOADS ON STRUCTURE:

Structural loads in pre-engineered buildings are an important consideration in the design of buildings. Building codes require that structures be designed and built to safely resist all actions that they are likely to face during their service life, while remaining fit for use. Minimum loads or actions are specified in these building codes for types of structures, geographic locations, usage and building materials. Structural loads or actions are forces, deformations, or accelerations applied to structure components. Loads cause stresses, deformations, and displacements in structures. Assessment of their effects is carried out by the methods of structural analysis. Excess load or overloading may cause structural failure, and hence such possibility should be either considered in the design or strictly controlled.

Forces that act vertically are gravity loads like dead load, collateral load, live load. Forces that act horizontally, such as stability, wind and seismic events require lateral load resisting systems to be built into structures. As lateral loads are applied to a structure, horizontal diaphragms transfer the load to the lateral load resisting system. The loads combinations include different combinations according to standard codes (IS 800 – 2007 and AISC -89/ MBMA – 2002) by considering both serviceability and strength criteria. Given below are different types of structural load in pre-engineered buildings.

3.1.1. Different Types Structural Loads in Pre-Engineered Buildings:

S. No.	Material	Unit Weight kN/m3
1	Plain Cement Concrete	24
2	Reinforced Cement Concrete Steel	25
3	Steel	78.5
4	Brick Masonry (Cement Plaster)	20
5	Stone Masonry Granite	24
6	Asbestos Cement Sheets	0.13

7	Cement (i) Ordinary Portland (ii) Rapid Hardening	 14.10 12.55
8	Lime Concrete	19.2
9	Mortar (i) Cement (ii) Lime	 20.4 16
10	Marble	26.7
11	Glass	27
12	Timber (i) Chir (ii) Deoder (iii) Teak (iv) Sal	 5.65 5.35 6.28 8.5
13	Bitumen	0.102
14	Surkhi (Brick dust)	9.9
15	Sand Stone	22.0-23.5

Dead load: Dead loads, also known as permanent or static loads, are those that remain relatively constant over time and comprise, for example, the weight of a building's structural elements, such as beams, walls, roof and structural flooring components. Dead loads may also include permanent non-structural partitions, immovable fixtures and even built-in cupboards.

Dead load on a PEB structure is the result of the weight of the permanent components such as beams, floor slabs, columns and walls. These components will produce the same constant 'dead' load during the lifespan of the building. Dead loads are exerted in the vertical plane. Dead load is calculated According to IS: 875 (Part 1) –1987. Dead load = volume of member x unit weight of materials. By calculating the volume of each member and multiplying by the unit weight of the materials from which it is composed, an accurate dead load can be determined for each component. The different components can then be added together to determine the dead load for the entire structure.

In this case WD=0.15 kN/m2 Spacing (S1) =5m

Spacing (S2) =7.5m Spacing (S3) =10m DL= WD x Spacing

Live load: Live loads refer to the dynamic forces from occupancy and intended use. They represent the transient forces that can be moved through the building or act on any particular structural element. Also measured in psf, these loads include the anticipated weight of people, furniture, appliances, automobiles, moveable equipment and the like. Because live loads depend on structural strength, knowledge of the exact planned use of the building is critical. The might of the dead load, or lack thereof, often defines how much live load it can handle. Reinforced concrete creates the heaviest dead loads but also supports the most weight with its tremendous compressive strength. Structural steel offers much less of a dead load and provides superior support for live loads in multi-story buildings. Natural and engineered wood rest relatively lightly on the foundation but support less live loads than steel and concrete. Live load acting on structural members is due to the moveable equipment and stuff. For pre-engineered buildings, live load is generated on the roof during construction and maintenance work. The corresponding code used for calculating life load is ASCE/SEI 7-10.

In this case WL=0.75 kN/m2 Spacing (S1) =5m

Spacing (S2) =7.5m Spacing (S3) =10m LL= WL x Spacing

Wind load: Wind load is the load, in pounds per square foot, placed on the exterior of a structure by wind. This will depend on the angle at which the wind strikes the structure and the shape of the structure.

Preventing wind damage involves strengthening areas where buildings could come apart. The walls, roof and foundation must be strong, and the attachments between them must be strong and secure. For a structure to wind loads, it must have a continuous load path from the roof to the foundation — connections that tie all structural parts together and can resist types of wind loads that could push and pull on the building in a storm. Wind loads are governed by wind speed, roof slope, eave height, exposure category and open wall conditions of the building. Usually, steel buildings are not designed for a wind speed less than 110 km/h. Wind exerts three types of forces on a structure namely Uplift load [Wind flow pressures that create a strong lifting effect, much like the effect on airplane wings], Shear load [Horizontal wind pressure that could cause racking of walls, making a building tilt] and Lateral load. Horizontal pushing and pulling pressure on walls that could make a structure slide off the foundation or overturn.

Table 3.3. Wind Load Parameters

Basic wind speed Vb=	50 m/s
Risk coefficient K1=	1
Terrain coefficient K2=	1.09
Topography coefficient K3=	1
Importance factor K4=	1

Design wind speed Vz=	54.5
Wind pressure Pz=	1782.15N
Combination factor Kc=	1
Directional factor Kd=	0.9
Area avg factor Ka=	0.8
Design pressure Pd=	1.283148
Area of openings A=	4200

Seismic load: Seismic loads are produced by the structure's resistance to motion (or inertia), when the ground accelerates during an earthquake. The magnitude of seismic loads depends on many factors, some of which are functions of the location of the building and nature of the site. Furthermore, many of these factors vary greatly from site to site in the same general area. s. PEB manufacturers can help to achieve this by combining steel structures with concrete for optimal protection from the earthquake. They know from experience how much of concrete should be replaced with metal frames and what type of steel to use in a specific earthquake prone zone. More importantly, metal sections, the mainstay of PEB engineering have higher resistance to earth-quake damages than an only-concrete building.

3.2: ANALYSIS BY USING ETABS SOFTWARE AS PER INDIAN STANDARDS:

The step-by-step procedure for P-Delta analysis is given in follow:

1) First, we select new model option in the software. And then we need to select the codes.

2) After the selection of default settings then we need to define grid in the ETABS software. Then define length and width of bays and number of bays in X and Y direction and number of Story and storey height and then base storey height.

3) After defining the grid, then we need to define the material properties.

4) After defining material properties, then we need to define the sectional properties like rafter tapered sections, gables rafters, column tapered sections.

5) After selection of sectional properties, then draw the structural plan of the structure.

6) After completion of modelling, then we need to define load pattern, and load cases.

7) Then assign DL, LL, WL and EQ loads as per Indian standard calculation.

8) Then auto define load combinations as per Indian standard.

9) Check model and analyse the structure.

4. ANALYSIS OF THE STRUCTURE BY USING ETABS

4.1: GENERAL:

To observe the effects of P-delta, three different cases are taken. PEB 1: PEB with bay spacing of 5m

PEB 2: PEB with bay spacing of 7.5m PEB 3: PEB with bay spacing of 10m

4.2: PRIMARY DATA:

Table-4.1 Details for Building Models

Details for Building Models	
Plan Size	120m x 35m
Height	24m
Type of soil	II
Zone	II
Dead load	0.15 kN/m2
Live Load	0.75 kN/m2
Earthquake Load	As Per IS:1893(Part-I)-2002
Zone Factor	0.10
Response Reduction Factor	5
Wind Load	As Per IS: 875:1987(Part-3)
Wind Speed	50m/s
Terrain Category	3

4.3: ANALYSIS AND RESULTS OF PEB BUILDING BY USING ETABS:

The step-by-step procedure for analysis of the structure is given in follow:

1) First, we select new model option in the software. And then we need to select the codes.

2) After the selection of default settings then we need to define grid in the ETABS software. Then define length and width of bays and number of bays in X and Y direction and number of Story and storey height and then base storey height.

3) After defining the grid, then select the flat slab grid model. Then we need to define the material properties.

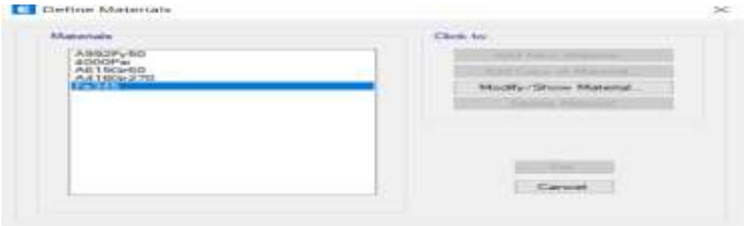


Fig.4.1. Material Properties of The Structure

4) After defining material properties, then we need to define the sectional properties like column and rafters

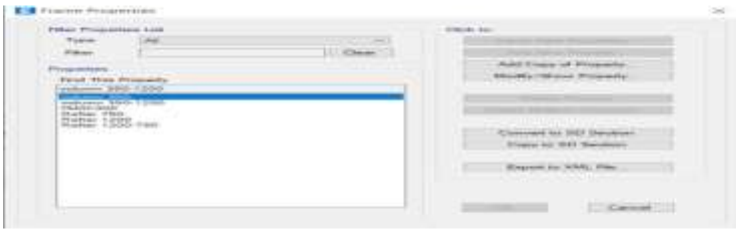


Fig.4.2. Sectional Properties of Structure

5) After selection of sectional properties, then draw the structural plan of the structure.

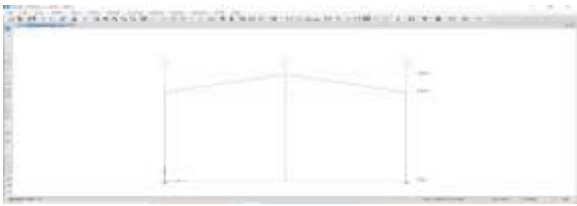


Fig.4.3. Structural Elevation of The Structure

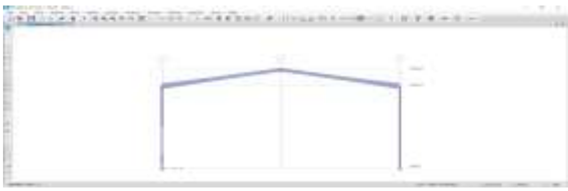


Fig.4.4. 3D View of the Structure

Fig.4.5. Structure Plan With 5m Bay Spacing

Fig.4.6. Structure Plan With 7.5m Bay Spacing

Fig.4.7. Structure Plan With 10m Bay Spacing

Fig.4.8. Elevation and 3D View of Structure

6) After completion of modelling, then we need to define load pattern.

Fig.4.9. Load Patterns Consider for the Analysis

7) Then define load cases and load combinations.

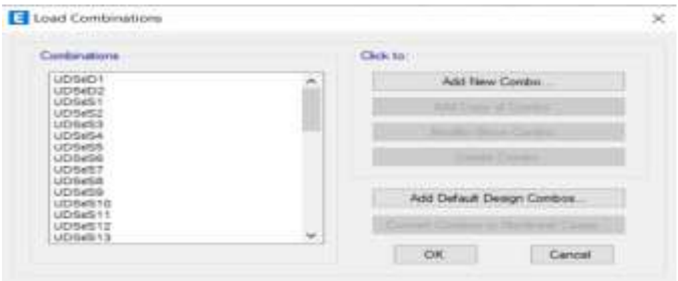


Fig.4.10. Load Cases

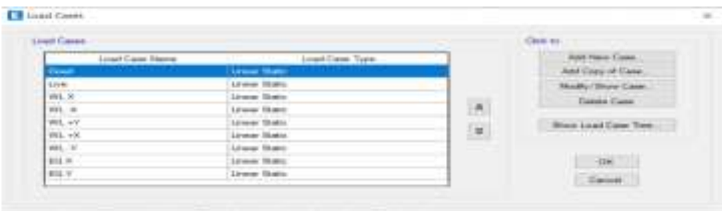


Fig.4.11. Load Combinations

8) Check model and analyse the structure.

Fig.4.12. Deformed Shape of the Structure

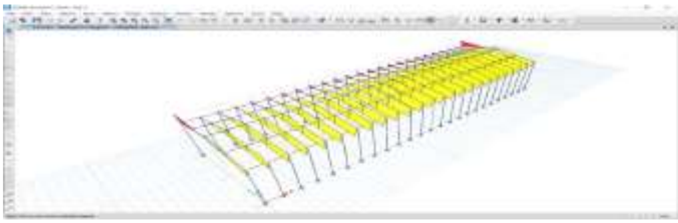


Fig.4.13. Analysis Results

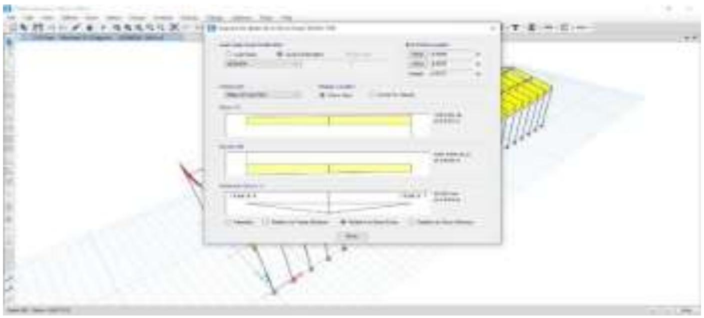


Fig.4.14. Response Plot of the Structure

RESULTS AND DISCUSSION

ANALYSIS RESULTS:

Table 5.1. Bending Moment Results of Gable Rafter -1

Gable Rafter -1	
Model	**Bending Moment**
PEB-1	2289.53
PEB-2	3191.8
PEB-3	3497.76

Table 5.1. Bending Moment Results of Gable Rafter -1

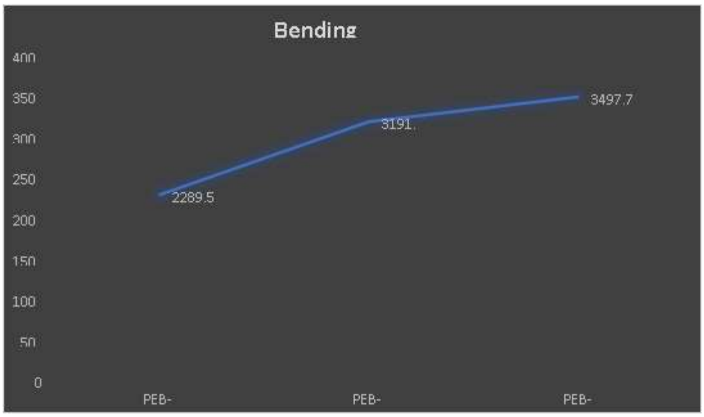


Fig- 5.1. Bending Moment Results of Gable Rafter -1

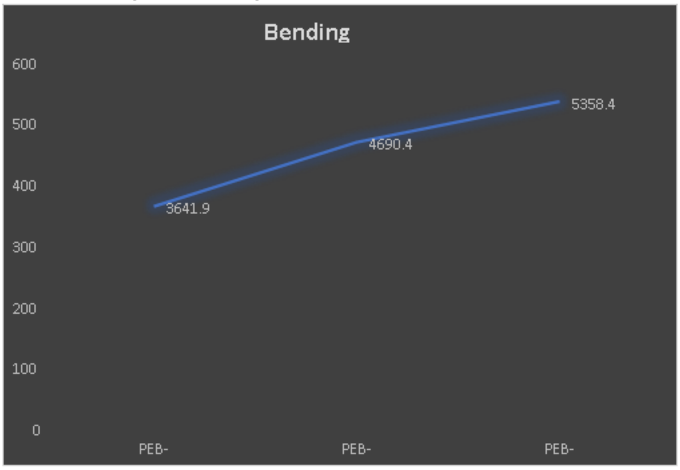
Table 5.2. Shear force Results of Gable Rafter -1

Gable Rafter -1	
Model	**Shear force**
PEB-1	195.14
PEB-2	238.01
PEB-3	296.36

Table 5.3. Bending Moment Results of Gable Rafter -2

Gable Rafter -2	
Model	**Bending Moment**
PEB-1	3641.91
PEB-2	4690.45
PEB-3	5358.48

Fig- 5.3. Bending Moment Results of Gable Rafter -2



Gable Rafter -2	
Model	**Shear force**
PEB-1	158.28
PEB-2	183.39
PEB-3	256.26

Table 5.4. Shear force Results of Gable Rafter -2

Centre Rafter -1	
Model	**Bending Moment**
PEB-1	2839.38
PEB-2	4065.82
PEB-3	5281.09

Table 5.5. Bending Moment Results of Centre Rafter -1

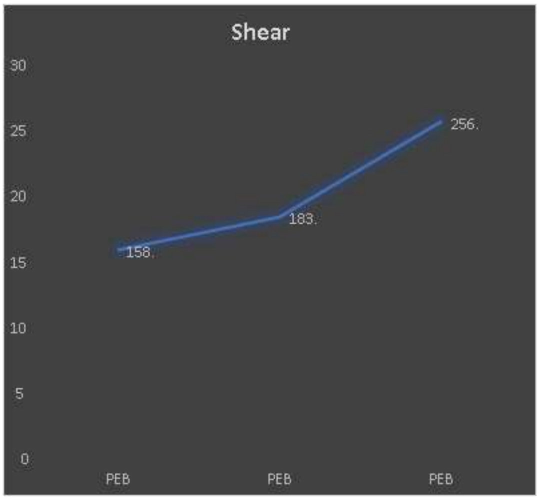


Fig 5.5 Bending Moment Results of Center Rafter -1

CONCLUSION

Steel is such a versatile material that every object we see in our daily life has used steel directly or indirectly. There is no viable substitute to steel in construction activities. Steel remains and will continue to remain logical and wide choice for construction purpose, environmentally also, as much of the steel used is recycled.

Steel building offers more design and architectural flexibility for unique or conventional styling. Its strength and large clear spans mean the design is not constrained by the need for intermediate support walls. As your requirements changes over the years, you can reuse, relocate, & modify the structure.

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.

- Bending Moment and shear force results of Gable rafter 1 are 28.26%,8.74% and 18.01%,19.68% respectively.
- Bending Moment and shear force results of Gable rafter 2are 22.35%,12.47% and 3.12%,36.24% respectively.
- Bending Moment and shear force results of centre rafter 1 are 30.16%,23.01% and 16.63%,22.37% respectively.
- Bending Moment and shear force results of centre rafter 2 are 35.75%,7.01% and 6.92%,9.71% respectively.

- Bending Moment and shear force and axial force results of Gable column are 18.30%,8.30% and 14.82%,11.24% and 18.27%, 38.10% respectively.
- Bending Moment and shear force and axial force results of centre column are 17.58%,24.12% and 11.60%,29.23% and10.99 %,31.06 % respectively.
- Storey displacement results are 31.74%, 21.92% respectively.

REFERENCES:

1.A explanatory handbook on proposed IS 875 (part3) Wind Loads on Buildings and structures by Department of Civil Engineering IIT Roorkee

2.Design of Steel Structures by R.Sathish Kumar and A.R. Santhakumar

3.Design Concept of Pre Engineered Building by Syed Firoz, Sarath Chandra kumar,

S. kanakamba rao International Journal of Engineering Research and Applications, vol2 pp 267- 272.

4.Design Flexibility of steel by Rajesh Maheshwari, Head Technical Marketing (Coated Steel) at Tata BlueScope Steel Limited.

5.Pre Engineered Steel Buildings a promising Future by Dr. Abhay Gupta, Vice President (Engineering) Era Building Systems Ltd.

6.Unicon Pre Engineered Buildings brochure

7.PEB a boon for Building Industry by Steel building systems India.

8.Fiberglass Wool Insulation for PEB's and Metal Roofs.

9.Design of Long span structures and Hangars by Amit Bharana ERA buildings ltd.

10.Pre Engineered for Success: Tracking Growth of PEB Steel buildings in India.

11.Pre Engineered Metal Buildings < The Latest Trend in Building Construction. By K.K. Mitra Llyods Insulations Limited.12.

12.Contour the world of steel Buildings Brochure

13.PEB VS Conventional the Zamil Steel Limited.

14.CMAA A Pre Engineered Building Process Updated.

15.Kit Buildings Manufacturers, Big Country Buildings Pvt ltd Brouchure.

16.Pre Engineered Metal Buildings Section 13121, Bloomington

17.PEB Steel Buildings Solutions Product Brochures.

18.MetcoRoof Pvt ltd.brochure on Peb.

19.Standard Specifications for Mesco Metal Buildings, Mesco Building Solutions.

20.Frontier Steel Buildings, Pre Engineered steel Buildings.

21.Pre Engineered Buildings selection of Framing System Roofing & wall Matreials.by N. Subramanian

22.Unified facilities Guide Specification, Division 13 Pre Engineered Metal Buildings. Standard Product Specification by Zamil Steel Buildings.