DESIGN AND ANALYSIS OF PRE ENGINEER FRAME WITH IS800:2007

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ABSTRACT

Steel is the material of choice for design because it is inherently ductile and flexible. Fast construction lowers overhead expenses for construction management services. Steel is extensively used in the construction of industrial buildings of large spans with or without cranes (medium and heavy buildings), where the concrete construction is not feasible.

In steel structural buildings there are 2 types. They are Conventional Steel Buildings, Pre Engineered Buildings.

In Conventional Steel buildings, mill-produced hot rolled sections (Beams and columns) are used. The Size of each member is selected on the basis of the maximum internal stress in the member. Since a hot rolled section has a constant depth, many parts of the member, in areas than the actual requirement. Extra Materials can mean extra cost and added weight.

Frames of Pre- Engineered Buildings are made from an extensive inventory of standard plates stocked by the PEB manufacturer. PEB frames are normally tapered and often have flanges and webs of variable thickness along the individual members. The frame geometry matches the shape of the internal stress diagram thus minimizing material waste and reducing the total weight of the structure. The methodology opted is PEB.

Early 1900s-Concept of metal buildings originates in USA. Simple industrial structures using truss rafters, straight columns, sectional roofs and wall were created.

Late 1950s and Early 1960s- Computerized design allowed buildings to be tailored to individual customer requirements. Roll forming lines allowed continuous span cold rolled z-purlins. Colour coated panels and factory insulated panel improved architectural appearance. Major increase in design possibilities contributed to the boom in metal buildings. The term PEB comes into existence.

1990s- PEB start dominating the low rise building market. Precision roll forming lines for the cladding and section members introduced. Automatic production lines for structural sections introduced. High quality paint systems for steel and cladding introduced. Statistics shows, about 60 % of low rise industrial and commercial buildings in USA use PEB system.

INTRODUCTION

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. Modern day requirement of structures is that these should be lighter yet not compromising on functionality.

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.

Though initially only off the shelf products were available in these configurations aided by the technological development tailor made solutions are also made using this technology in very short durations. 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.

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. The market potential of PEB's is 1.2 million tons per annum. The current pre-engineered steel building manufacturing capacity is 35 million tons per annum. The industry is growing at the compound rate of 25 to 30 %.

With respect to design of the structure and aesthetic appearance India is way behind. Indian manufacturers are trying to catch up; comparatively PEB's is a new concept in India. Beside, in fabrication and other areas of PEB India is very good. As compared to other countries Indian codes for building design are stringent but safer. IS standards are upgraded continuously. In India, American codes are also followed.

Figure: Pre Engineered Building

Pre-engineered steel buildings can be fitted with different structural accessories including mezzanine floors, canopies, fascia's, interior partitions etc. and the building is made water proof by use of special mastic beads, filler strips and trims. This is very versatile buildings systems and can be finished internally to serve any functions and accessorized externally to achieve attractive and unique designing styles. It is very advantageous over the conventional buildings and is really helpful in the low rise building design.

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

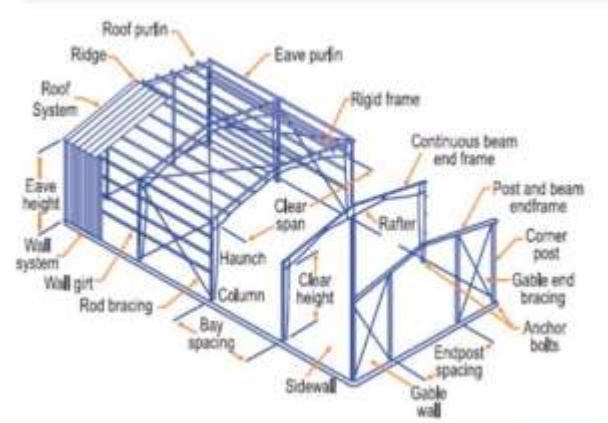
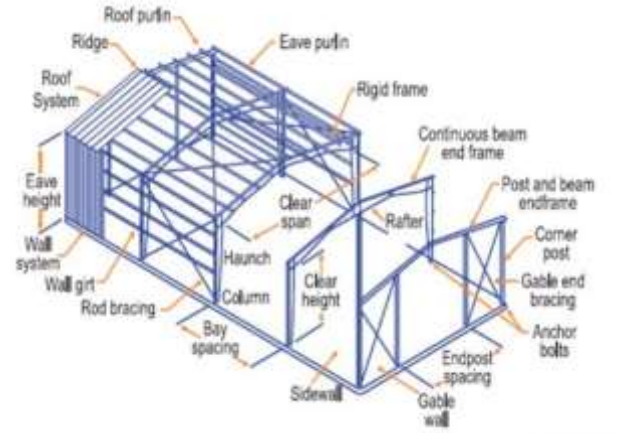


Figure Components of PEB



PRIMARY COMPONENTS

Main framing

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 apart 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.

LATERALLY SUPPORTED BEAM

A Beam may be assumed to be adequately supported at the supports, provided the compression flange has full restraint and nominal restrain at supports as follows

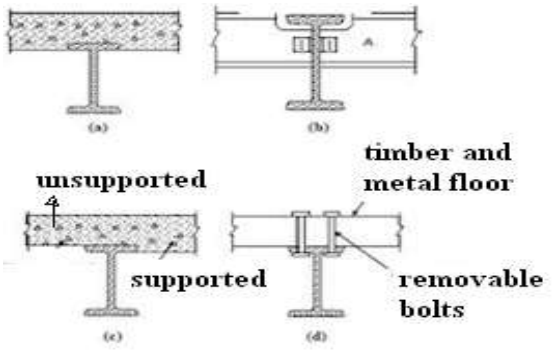


Figure: Laterally supported and unsupported

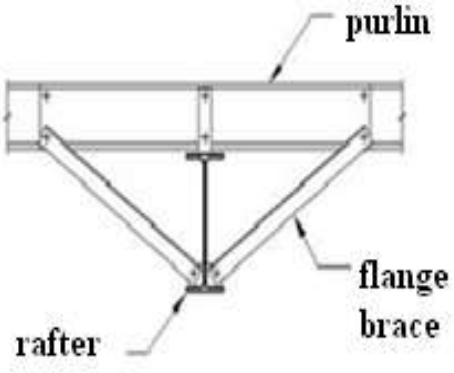


Figure: Laterally and Torsional beams restrained

There are 2 shapes that are most important in every member of steel structures.

- Deflection shape
- Buckling shape.

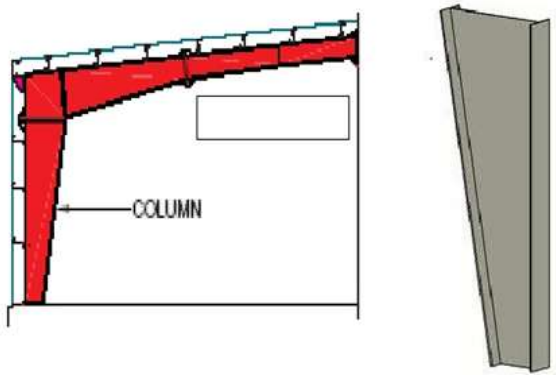


Figure Column and Rafter of PEB

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.

τ_b vs c/d ratio (aspect ratio) (shear stress vs aspect ratio)

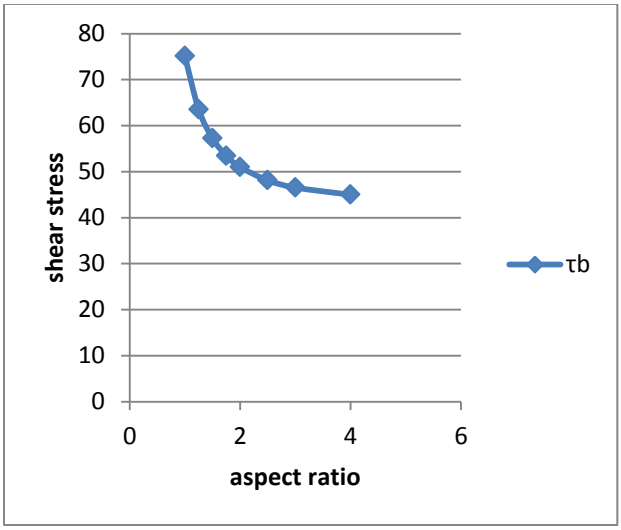


Figure: Shear stress vs aspect ratio

POSSIBLE FAILURES

Local buckling: Failures occurs by buckling of one or more individual plate elements (either flange or web). It can be prevented by selecting suitable width-to-thickness ratio of component plates.

Squashing: When the length is relatively small (stocky columns) and its component plates elements are prevented from local buckling it attains full strength or squash load.

Overall flexural bending: This mode of failure normally controls the design of most compression members. This type of failure of the member occurs by excessive

deflections in the plane of the weaker principal axis of the section.

Torsional and flexural -Torsional buckling: This type of failure occurs by twisting about the shear center in the longitudinal axis. A combination of flexure and twisting called as flexural torsional buckling. In open sections that are doubly symmetric are not subjected to the flexural torsional buckling as the, since shear center combines with the centroid of the section.

BOLTED CONNECTIONS

Bolted connections are connections whose components are fastened together primarily by bolts (fasteners). Depending on the direction and line of action of the loads relative to the orientation and location of the bolts, the bolts may be loaded in tension, shear, or a combination of tension and shear. For bolts subjected to shear forces, the design shear strength of the bolts also depends on whether or not the threads of the bolts are excluded from the shear planes. Because of the reduced shear areas for bolts whose threads are not excluded from the shear planes; these bolts have lower design shear strengths than their counterparts whose threads are excluded from shear plane.

FORCES TRANSMISSION IN BOLTS

First is called the nominal slip critical capacity. Second is called the nominal bearing capacity. In snug tight connection slip occurs at smaller loads. So nominal capacity is negligible. The only capacity available for snug tight is nominal bearing capacity. The loads plates each bear on a separate side of bolt with the force distribution considered as uniformly distributed load along the bolt. The maximum shear occurs at the contacted surface of the plates. The strength capacity of bolt then, is the shear capacity of the bolt. If the shear capacity exceeds the strength then the shear failure occurs.

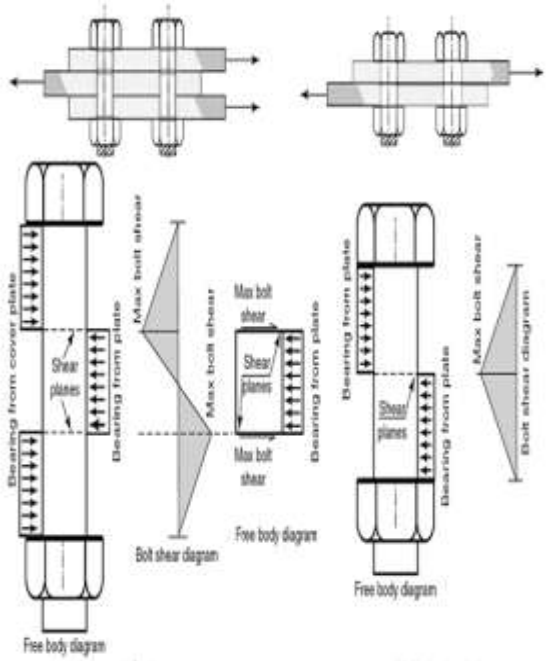


Figure: Shear and tensile stress distribution in bolt

ANALYZING USING STAAD.ProV8i

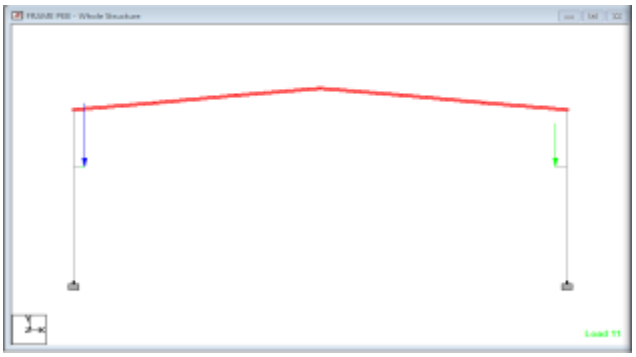


Figure: PEB Frame with Crane Load

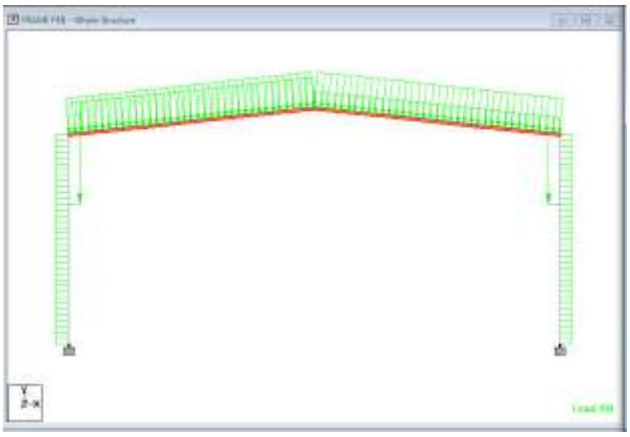


Figure PEB Frame with Load Combination

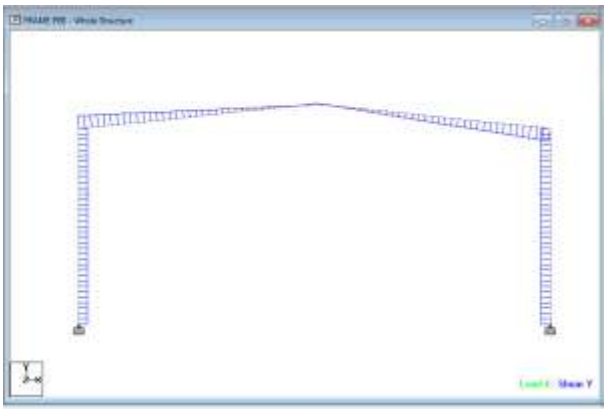


Figure: Shear Force Diagram with Live Load

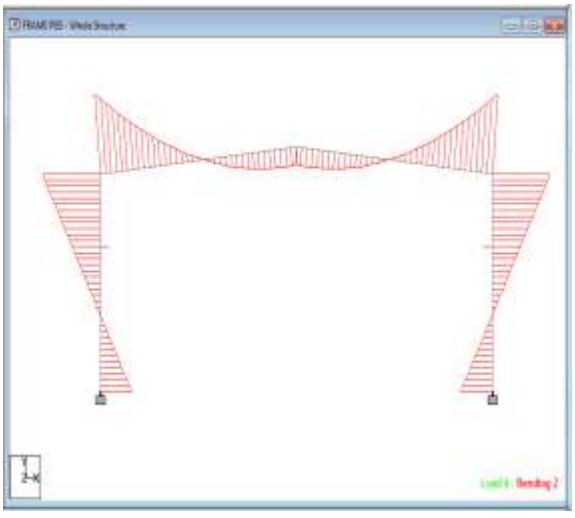


Figure: Bending Moment Diagram with Live Load

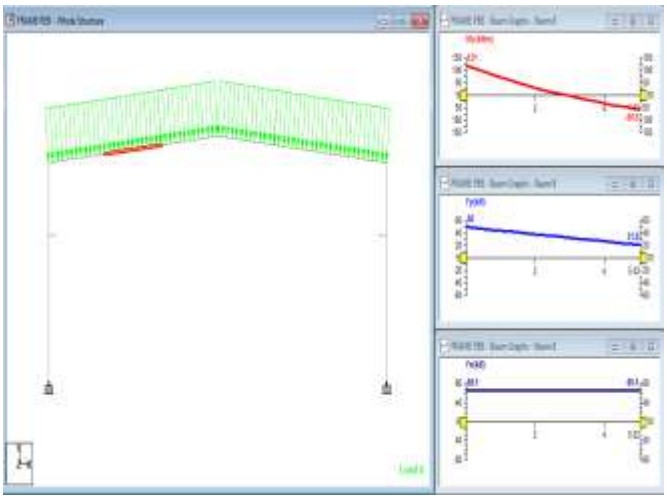


Figure: Rafter Graphs

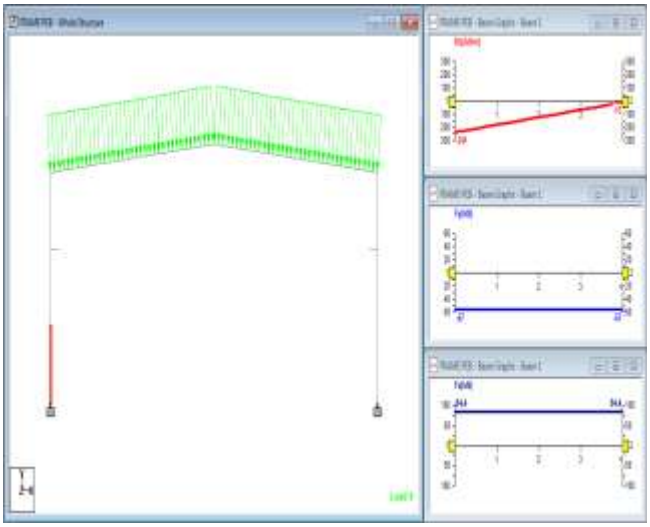


Figure: Column Graphs

CONCLUSIONS

- 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 is a preferred material for construction, due to its various advantages like quality, aesthetics, economy and environmental conditions.
- This concept can have lot of scope in India, which can actually fill up the critical shortage of housing, educational and health care institutions, airports, railway stations, industrial buildings & cold storages etc.
- 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.
- In Semi- compact section in flexural strength calculations entire section is considered i,e. 126ε.
- In slender section only flanges are considered in flexural strength calculations.
- Shear strength up to $d/t \leq 67\varepsilon$ the member has full strength capacity i,e. $\frac{f_y}{\sqrt{3}}$, once if member exceeds this value the strength decreases.
- In compression strength calculations up to 42ε the section can be considered as a effective section beyond this section is ineffective in strength calculation
- $A_e = A_g - (d/t_w - 42\varepsilon)*t_w^2$.

REFERENCES

- IS: 800-2007, Indian Standard Code for General Construction in Steel, 3rd revision, Indian Standards Institution, New Delhi, 2008.
- IS 875 - Bureau of Indian Standards. Part I to Part III
- IS 1893-2002 - Bureau of Indian Standards
- Subramanian, N., Design of Steel Structures, Oxford University Press, New Delhi, 2008.
- Fundamentals of structural engineering, Gambhir.
- Design of steel structures Duggal S.K.
- A explanatory handbook on proposed IS 875 (part3) Wind Loads on Buildings and structures by Department of Civil Engineering IIT Roorkee.
- Design of Steel Structures by R.Sathish Kumar and A.R. Santhakumar.
- 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.

- Design Flexibility of steel by Rajesh Maheshwari, Head Technical Marketing (Coated Steel) at Tata BlueScope Steel Limited.
- Pre Engineered Steel Buildings a promising Future by Dr. Abhay Gupta, Vice President (Engineering) Era Building Systems Ltd.
- Unicon Pre Engineered Buildings brochure.
- PEB a boon for Building Industry by Steel building systems India.
- Fiberglass Wool Insulation for PEBs and Metal Roofs.
- Design of Long span structures and Hangars by Amit Bharana ERA buildings ltd.
- Pre Engineered for Success: Tracking Growth of PEB Steel buildings in India.
- Pre Engineered Metal Buildings < The Latest Trend in Building Construction. By K.K. Mitra Llyods Insulations Limited.12.
- Contour the world of steel Buildings Brochure.
- PEB VS Conventional the Zamil Steel Limited.
- CMAA A Pre Engineered Building Process Updated.
- Kit Buildings Manufacturers, Big Country Buildings Pvt ltd Brouchure.
- Pre Engineered Metal Buildings Section 13121, Bloomington.
- PEB Steel Buildings Solutions Product Brochures.