

A Study On Pre-Engineered Building – A Construction Technique

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ABSTRACT

Steel industry is growing rapidly in almost all the parts of the world. The use of steel structures is not only economical but also eco friendly at the time when there is a threat of global warming. 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). This review from the past experiences presents the results of experimental and analytical studies done on Pre Engineered Building. Results show that these structures are economic, reduces construction cost and time, energy efficient and flexibility of expansion.

Keywords : Pre-Engineered Building.

I. INTRODUCTION

The scientific-sounding term pre-engineered buildings came into being in the 1960s. Typically, a pre-engineered building is a metal building that consists of light gauge metal standing seam roof panels on steel purlins spanning between rigid frames with light gauge metal wall cladding. In other words, it has a much greater vertical and horizontal deflection. Pre engineered buildings are generally low rise buildings which are ideal for offices, houses, showrooms, shop fronts etc. 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 first rigid-frame buildings introduced in the late 1940s could span only 40 ft. In a few years, 50-, 60-, and 70-ft buildings became possible. By the late 1950s, rigid frames with 100-ft spans were made, ribbed metal panels became available, allowing the buildings to look different from the old tired corrugated appearance. Third, collared panels were introduced by Strand-Steel Corp. in the early 1960s, permitting some design individuality.

At about the same time, continuous span cold-formed Z purlins were invented (also by Strand- Steel), the first factory-insulated panels were developed by Butler, and the first UL-approved metal roof appeared

on the market. 1st And last, but not least, the first computer-designed metal buildings also made their debut in the early 1960s. With the advent of computerization, the design possibilities became almost limitless. All these factors combined to produce a new metal-building boom in the late 1950s and early 1960s. As long as the purchaser could be restricted to standard designs, the buildings could be properly called pre-engineered.

II. REVIEW OF LITERATURE

2.1 Syed Firoz, Sarath, Chandra Kumar et.al (2012) observed that, 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. Pre-engineered 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. 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. It negates from regional sources. It also means choosing reliable industrial products which come in a huge range of shapes and colours; it means rapid site installation and less energy consumption. It means choosing to commit to the principles of sustainability. Infinitely recyclable, steel is the material that reflects the imperatives of sustainable development.

A tall steel building is not more in the total number of tall steel structures that are built around the world. A large steel structures being built are only single storey buildings for industrial purpose. Secondary structural members span the distance between the primary building frames of metal building systems. They play a complex role that extends beyond supporting roof and wall covering and carrying exterior loads to main frames. Secondary structurals, as these members are sometimes called, may serve as flange bracing for primary framing and may function as a part of the building's lateral load-resisting system. Roof secondary members, known as purlins, often form an essential part of horizontal roof diaphragms; wall secondary members, known as girts, are frequently found in wall bracing assemblies. The majority of steel structures being built are only low-rise buildings, which are generally of one storey only. Industrial buildings, a sub- set of low-rise buildings are normally used for steel plants, automobile industries, light, utility and process industries, thermal power stations, warehouses, assembly plants, storage, garages, small scale industries, etc. These buildings require large column free areas. Hence interior columns, walls and partitions are often eliminated or kept to a minimum. Most of these buildings may require adequate headroom for use of an overhead traveling crane. A third type of secondary framing, known by the names of eave strut, eave purlin, or eave girt, acts as part purlin and part girt—its top flange supports roof panels, its web, wall siding. Girts, purlins, and eave struts exhibit similar structural behaviour. Since most secondary members normally encountered in metal building systems are made of cold- formed steel, our discussion starts with some relevant issues in design of cold-formed steel structures.

2.2 Aijaz Ahmad Zende 1, Prof. A. V. Kulkarni , et.al (Jan. - Feb. 2013) observes that even though PEB structures provides clear span, it weighs lesser than that of Conventional Buildings. Infinitely recyclable, steel is the material that reflects the imperatives of sustainable development. For longer span structures, Conventional buildings are not suitable with clear spans. Pre-engineered building are the best solution for longer span structures without any interior column in between as seen in this present work, an industrial structure has been designed for 88m. With the advent of computerization, the design possibilities became almost limitless. Saving of material on low stress area of the primary framing members makes Pre- engineered buildings more economical than Conventional steel buildings especially for low rise buildings spanning up to 90.0 meters with eave heights up to 30.0 meters. PEB structures are found to be costly as compared to Conventional structures in case of smaller span

structures. To Conclude “Pre-Engineered Building Construction gives the end users a much more economical and better solution for long span structures where large column free areas are needed”.

2.3 C. M. Meera (June 2013) observes that Pre-Engineered Building (PEB) concept is a new conception of single storey industrial building construction. This methodology is versatile not only due to its quality pre-designing and prefabrication, but also due to its light weight and economical construction. The concept includes the technique of providing the best possible section according to the optimum requirement. This concept has many advantages over the Conventional Steel Building (CSB) concept of buildings with roof truss. This paper is a comparative study of PEB concept and CSB concept. 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, explicitly as in. PEB structures can also be designed as re-locatable structures. Steel is a material which has high strength per unit mass. Hence it is used in construction of structures with large column-free space. Most of the Industrial Structures require this criterion. An Industrial Warehouse is a storage building and is usually characterized as single storey steel structures with or without mezzanine floors. The enclosures of these structures may be brick masonry, concrete walls or GI sheet coverings. The walls are generally non-bearing but sufficiently strong enough to withstand lateral forces caused by wind or earthquake. The designing of industrial warehouse includes designing of the structural elements including principal rater or roof truss, column and column base, purlins, sag rods, tierods, gantry girder, bracings, etc. A combination of standard hot-rolled sections, cold-formed sections, profiled sheets, steel rods, etc. are used for the construction of industrial steel structures. Industrial buildings can be categorized as Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB), according to the design concepts. The paper starts with the discussion of methods adopted in the study. Introduction to PEB systems and CSB systems are then described followed by the details of case study. Loads and the load combinations 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 concepts of PEB structures and its advantages over CSB structures.

2.4 Jatin D. Thakar, 2 Prof. P.G. Patel observes that Pre-engineered building are steel building wherein the framing members and other components are fully fabricated in the factory after designing and brought to the site for assembly, mainly by nut-bolts, thereby resulting into a steel structure of high quality and precision. In conventional steel construction, we have site welding involved, which is not the case in P.E.B using nut-bolt mechanism. These structures use hot rolled tapered sections for primary framing and cold rolled sections (generally “Z” and “C” sections) for secondary framing as per the internal stress requirements, thus reducing wastage of steel and the self-weight of the structure and hence lighter foundations. International codes are referred in their design as per the MBMA (Metal Building Manufacturers Association) standards which are more flexible allowing the use of built-up sections of minimum 3.5 mm thickness against 6 mm as minimum criteria in conventional steel sections. There is use of steel of high strength (345MPa) which prominently speaks about greater strength with judicious use of steel as a result of tapered profile. The tapered section concept was first adopted in U.S.A keeping in mind the bending moment diagram. At locations of high bending moment values, greater depth is used while less moment encouraged the use of lesser depths. Further unlike the conventional steel sections, where Moment of inertia (I) remains constant, it is not so in case of P.E.B due to varying depths.

2.5 G. Sai Kiran, A. Kailasa Rao, R. Pradeep Kumar (Aug 2014) observes that, In recent years, the introduction of Pre Engineered Building (PEB) concept in the design of structures has helped in optimizing design. The adoptability of PEB in the place of Conventional Steel Building (CSB) design concept resulted in many advantages, including economy and easier fabrication. In this study, an industrial structure (Ware House) is analyzed and designed according to the Indian standards, IS 800-1984, IS 800-2007 and also by referring MBMA-96 and AISC-89. In this study, a structure with length 187m, width 40m, with clear height 8m and having R-Slope 1:10, is considered to carry out analysis & design for 2D frames (End frame, frame without crane and frame with 3 module cranes). The economy of the structure is discussed in terms of its weight comparison, between Indian codes (IS800-1984, IS800-2007) & American code (MBMA-96), & between Indian codes (IS800-1984, IS800-2007).

2.6 S.D. Charkha and Latesh S (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.

2.7 U. D. Dabhade¹, N.A.Hedao², Dr. L. M. Gupta³ and Dr. G. N(2009) observes that, the time savings of 55.3% is achieved due to use of steel framed composite floor construction rather than precast framed with precast concrete floor and 14.3% time than that of steel framed with precast concrete slab. The construction of steel framed composite floor building saves time, which leads to an overall savings in net cost. The direct cost required for steel framed with composite floor is 23.10%, higher than precast frame with precast concrete floor and only 0.52% higher than steel framed with precast concrete floor. Considering time related savings, the net cost required for steel framed with composite floor is 12.99%, more than precast frame with precast concrete floor and 2.32% less than steel frame with precast floor. The steel framed with precast concrete floor saves 35.83% construction time than precast frame with precast concrete floor, which required extra 22.70% of direct cost and 14.96% of net cost. However, study is restricted to structural frame only. If other items are also considered in the study like excavation work, finishing items, services, cladding etc

III. PRE ENGINEERED BUILDING (PEB)

It is a combination of “precast” & “prefabricated” structures. Pre engineered buildings are generally low rise buildings which are ideal for offices, houses, showrooms, shop fronts etc. The application of pre engineered buildings concept to low rise buildings is very economical and speedy. Buildings can be constructed in less than half the normal time. Although PEB systems are extensively used in industrial and many other non residential constructions worldwide, it is relatively a new concept in India.

IV. ADVANTAGES OF PEB

PEB is a suitable Construction technique for developing countries for the following reasons:

4.1 Reduced 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. PEB will reduce total construction time of the project by at least 50%. This also allows faster occupancy and earlier realization of revenue.

4.2 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. Steel buildings that are properly insulated save natural resources, energy and money.

4.3 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.

4.4 Large clear spans

Buildings can be supplied to around 80M clear spans.

4.5 Quality control

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

4.6 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 coats.

4.7 Energy efficient roofing and wall system

Buildings can be supplied with polyurethane insulated panels or fiberglass blankets insulation to achieve required "U" values.

4.8 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. All the components are available in different colours also.

4.9 Single source responsibility

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.

4.10 Sustainability

Steel is 100% recyclable and is the most recycled material in the world. Thus, each ton of recycled steel saves 2,500 pounds of iron ore and approximately 1,000 pounds of coal.

V. APPLICATIONS OF PEB

In the USA, where the PEB concept was originally conceived during the early years of this century, nearly 70% of all single storey non-residential construction now utilizes pre-engineered buildings. Applications range from small car parking sheds to 90 m (+), wide clear span aircraft hangars to low- rise multi-storey buildings.

The most common applications of pre-engineered buildings are:

5.1 Industrial

Factories, Workshops, Warehouses, Cold stores, Car parking sheds, Slaughter houses, Bulk product storage.

5.2 Commercial

Showrooms, Distribution centers, Supermarkets, Fast food restaurants, Offices, Labor camps, Service station, Shopping centers. Schools, Exhibition halls, Hospitals, Theatres/auditoriums, Sports halls.

5.3 Institutional

Schools, Exhibition halls, Hospitals, Theatres, Sport halls.

5.4 Recreational

Gymnasiums, swimming pool enclosures, Indoor tennis courts.

5.5 Aviation & Military

Aircraft hangars, Administration buildings, Residential barracks.

5.6 Agricultural

Poultry buildings, Dairy farms, Greenhouses, Grain storage, Animal confinement.

VI. MAIN COMPONENTS

6.1 Main Frame

Rigid steel frames of the building are mainly considered as the Main Frames of PEB. 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.

6.2 Purlins, Girts and Eave Struts

Purlins, Girts and Eave Struts are secondary structural members used to support the wall and roof panels. Purlins are used on the roof; Girts are used on the walls and Eave Struts are used at the intersection of the sidewall and the roof. Secondary members have two functions: they 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 they provide lateral bracing to the compression flanges of the main frame members thereby increasing frame capacity.

6.3 Sheetings and Insulation

Panels used for sheeting purpose are generally of ribbed steel sheets used as roof and wall sheeting, roof and wall liners, partition and soffit sheeting. The steel sheets are generally produced from steel coils having thickness 0.5 mm to 0.7 mm high tensile stress.

6.4 Paints and Finishes

Normally the primary and secondary steel are coated with one coat (35 microns) of red oxide paint without any special treatment to steel. However, if some special paint has to be applied to steel in order to give better anti – corrosion properties, then the steel members have to be shot – blasted and then coated with the special paints. For houses; inside and outside painting on walls and falseceiling is to be provided.

6.5 Doors and Windows

Steel or aluminium framed doors and windows are fixed to the purlins or the supporting profiled steel either by welding or bolted to the flanges already fixed to the purlins. Proper flashings are applied wherever necessary.

6.6 False Ceiling

False ceiling is usually required for residential buildings or offices. A metal frame work is hung from the ceiling and false ceiling of rigid boards are either bolted or placed over the frame work.

6.7 Partition Walls

Partition walls are usually required for residential building or offices. Partition wall comprises of two rigid boards having insulation sandwiched in between and fixed to the steel columns or supporting profiled steel and purlins. Alternatively prefab sandwich panels can also be fixed to the columns and purlins.

6.8 Flooring

Flooring is usually of conventional nature consisting of cement concrete. For intermediate floors; metal decking sheet is fixed to purlins and concrete poured over it.

VII. CONCLUSION

From the past advancement, the use of PEB is implemented and continuously increasing, but its usage is not throughout the construction industry. It is reviewed that PEB structures can be easily designed by simple design procedures in accordance with country standards, it is energy efficient, speedy in construction, saves cost, sustainable and most important its reliable as compared to conventional buildings. Thus PEB methodology must be implemented and researched for more outputs.

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