Overview of Pre-Engineered Buildings

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Abstract: Buildings & houses are the basic requirements of any human being. There are several changes in construction technology since the beginning. The basic requirements of construction nowadays are best aesthetic look, fast, economical & high quality. Pre- engineered building is best option for these all requirements. Pre-engineered buildings are cost effective, time consuming as compared to other conventional buildings. Generally pre-engineered buildings are faster than conventional buildings, 25 % less time consuming & 30% lighter than conventional buildings. The plan & load on the building are calculated at the beginning, & the members are manufactured in factory & they are just assembled on actual site at time of construction.

1. Introduction

The scientific-sounding term pre-engineered buildings came into being in the 1960s. The buildings were pre-engineered because, like their ancestors, they relied upon standard engineering designs for a limited number of off-the-shelf configurations. Several factors made this period significant for the history of metal buildings. First, the improving technology was constantly expanding the maximum clear-span capabilities of metal buildings. 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, 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. Once the industry started to offer custom-designed metal buildings to fill the particular needs of each client, the name pre-engineered building became somewhat of a misnomer. In addition, this term was uncomfortably close to, and easily confused with, the unsophisticated prefabricated buildings, with which the new industry did not want to be associated. Despite the fact that the term pre-engineered buildings is still widely used, and will be often found even in this book, the industry now prefers to call its product metal building systems.

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. Here, “economical” word is stated considering time and cost. Time being the most important aspect, steel structures (Pre-fabricated) is built in very short period and one such example is Pre Engineered Buildings (PEB). Pre-engineered buildings are nothing but steel buildings in which excess steel is avoided by tapering the sections as per the bending moment’s requirement. One may think about its possibility, but it’s a fact many people are not aware about Pre Engineered Buildings. If we go for regular steel structures, time frame will be more, and also cost will be more, and both together i.e. time and cost, makes it uneconomical. Thus in pre-engineered buildings, the total design is done in the factory, and as per the design, members are pre-fabricated and then transported to the site where they are erected in a time less than 6 to 8 weeks.

The structural performance of these buildings is well understood and, for the most part, adequate code provisions are currently in place to ensure satisfactory behavior in high winds. Steel structures also have much better strength-to-weight ratios than RCC and they also can be easily dismantled. Pre Engineered Buildings have bolted connections and hence can also be reused after dismantling. Thus, pre-engineered buildings can be shifted and/or expanded as per the requirements in future. In this paper we will discuss the various advantages of pre-engineered buildings and also, with the help of three
examples, a comparison will be made between pre-engineered buildings and conventional steel structures.

Presently, large column free area is the utmost requirement for any type of industry and with the advent of computer software’s it is now easily possible. With the improvement in technology, computer software’s have contributed immensely to the enhancement of quality of life through new researches. Pre-engineered building (PEB) is one of such revolution. "Pre-engineered buildings” are fully fabricated in the factory after designing, then transported to the site in completely knocked down (CKD) condition and all components are assembled and erected with nut-bolts, thereby reducing the time of completion.

2. Advantages of Pre-Engineered Buildings

a) Construction Time: Buildings are generally constructed in just 6 to 8 weeks after approval of drawings. PEB will thus reduce total construction time of the project by at least 40%. This allows faster occupancy and earlier realization of revenue. This is one of the main advantages of using Pre-engineered building.

b) Lower Cost: Because of systems approach, considerable saving is achieved in design, manufacturing and erection cost.

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

d) Large Clear Spans: Buildings can be supplied to around 90m clear spans. This is one of the most important advantages of PEB giving column free space.

e) Quality Control: Buildings are manufactured completely in the factory under controlled conditions, and hence the quality can be assured.

f) Low Maintenance: PEB Buildings have high quality paint systems for cladding and steel to suit ambient conditions at the site, which in turn gives long durability and low maintenance coats.

g) Energy Efficient Roofing: Buildings are supplied with polyurethane insulated panels or fiberglass blankets insulation to achieve required “U” values (overall heat transfer coefficient).

3. Various systems in PEB

3.1 Primary System

Primary system consists of tapered or parallel columns and tapered beams which are called as rafters. The base of the columns can be either pinned or fixed based on the load requirements. Lengths of these members are generally restricted to 12m for ease of transports. Joints are connected with high tensile bolts.
3.3 Wind Bracing System

There are two types of wind bracing systems. The first one is Rod bracing system and the second one is portal system. Each type of system is chosen based on the design and functional requirement of the structure.

Figure 6: typical wind bracing across rafters

3.4 Roofing & Cladding System

Roofing and cladding system can be with single skin zinc and aluminum coated steel sheets, GI sheets, both of which could be bare or color coated; It could with double skin sheets with or without insulation material in between; It could be sandwich panels with steel sheets outside and PUF/PIR/Mineral Wool/Glass wool core inside. Roofing and cladding could have skylights with Poly Carbonate/ PVC or FRP sheets.

Figure 8: turbo ventilator, gutter with down pipe

3.5 Accessories

Accessories include, Turbo Ventilators, Ridge vents, Flashings, trims, Gutters, Down pipes, ladders, Louvers etc.

3.6 Finishing

Primary structural members are generally finished with shot peening, Sand blasting, two coats of anti corrosive primers, followed by two coats of paints to specifications. Secondary members or either painted after sand blasting or Galvanized to 275 gsm or above based on the requirement.

4. Technical Parameters of PEB

Pre Engineered Buildings are custom designed to meet clients requirements. PEBs 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

1. 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.

2. Length of Building

The length of PEB is the total length extending from one frontend to the rear end of the building. The length of PEB can be extendable in future.

3. 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.

4. 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 snowfall locations can go up to 1/30 to 1/60. Any practical roof slope is possible as per customers’ requirement.

5. Design Loads

Unless otherwise specified per-engineered buildings are designed for the following minimum loads. The designed loads play a crucial role in case of PEB. The failure of the structures occurs if not properly designed for loads. 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. Loads are usually classified into two broad groups as dead loads and live loads. Dead loads (DL) are essentially constant during the life of the structure and normally consist of the weight of the structural elements. On the other hand, live loads (LL) usually vary greatly. The weight of occupants, snow and vehicles, and the forces induced by wind or earthquakes are examples of live loads. The magnitudes of these loads are not known with great accuracy and the design values must depend on the intended use of the structure.

5.1 Dead Load

The structure first of all carries the dead load, which includes its own weight, the weight of any permanent non-structural partitions, built-in cupboards, floor surfacing materials and other finishes. It can be worked out precisely from the known weights of the materials and the dimensions on the working drawings.

5.2 Live Load

All the movable objects in a building such as people, desks, cupboards and filing cabinets produce an imposed load on the structure. This
loading may come and go with the result that its intensity will vary considerably. At one moment a room may be empty, yet at another packed with people. Imagine the ‘extra’ live load at a lively party.

5.3 Wind Loads

Wind has become a very important load in recent years due to the extensive use of lighter materials and more efficient building techniques. A building built with heavy masonry, timber tiled roof may not be affected by the wind load, but on the other hand the structural design of a modern light gauge steel framed building is dominated by the wind load, which will affect its strength, stability and serviceability. The wind acts both on the main structure and on the individual cladding units. The structure has to be braced to resist the horizontal load and anchored to the ground to prevent the whole building from being blown away, if the dead weight of the building is not sufficient to hold it down. The cladding has to be securely fixed to prevent the wind from ripping it away from the structure.

5.4 Roof Load

Live loads produced by maintenance activities, rain, erection activities, and other movable or moving loads by not including wind, snow, seismic, crane, or dead loads.

5.5 Roof Snow Load

Gravity load induced by the forces of wind blowing from any horizontal direction.

5.6 Auxiliary Loads

Dynamic loads induced by cranes, conveyers, or other material handling systems.

5.7 Seismic Loads

They are the Horizontal loads acting in any direction structural systems due to action of an earthquake.

5.8 Floor Live Loads

Loads induced on a floor system by occupants of a building and their furniture, equipment, etc

6 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.

7 Types of Frame

A frame is a combination of Columns and inclined beams (rafters). There are various type of frames.

7.1 Clear Span (Cs)

It’s the span length between two columns without any obstruction. It has split Beams with ridge line at the peak or centre of the building. The maximum practical width or span is up to 90 meters, but it can also be extended up to 150 meters in case of Aircraft Hangars.

7.2 Arched Clear Span

The column is an RF column while the Rafter is curved. It has no ridge line and peak. The curved roof rafter is used in for aesthetic look. The maximum practical is up to 90 meters, but can be extended to 120 meters.

7.3 Multi Span (Ms1)

The Multi spans (MS1) are those which have more than 1 span. The intermediate column is used for the clear span in which width of each span is called width module.

7.3.1 Arched Multi Span (Ams1)

Arched multi span has RF column and a curved Rafter with one intermediate column. It has width module for the entire span. The multi spans can be extended up to AMS1, AMS2 and AMS3 etc.

7.3.2 Multi Span 2 (Ms2)

The Multi Span (MS2) has more than one intermediate span. It has three width modules with one ridge line.

7.4 Single Slope

It has two columns with different heights having Roof sloping on both the column.

7.5 Multi Gable

Multi gable has two or more spans where no intermediate columns are used. The columns are added to the extended width and columns are not placed at the ridge lines.

7.6 Roof Systems

It has straight columns with Roof having supports are not by TPCA.

7.7 Lean To

Lean to slopes is used extremely for an extending to a building on either side with short span. The rafters rest on column designed for lean to on one side and rests on the main column of the building.

7.8 Canopy

Canopies are used in case of open ends where there is an easy access. There are columns in straight path having roof extended to a large length.

5. Applications of PEB

- warehouses
- factories
- workshops
- offices
- gas stations
- vehicle parking sheds
- showrooms
- aircraft hangars
- metro stations
- schools
- recreational
- indoor stadium roofs
• outdoor stadium canopies
• bridges
• railway platform shelters

6. Conclusion
This paper effectively conveys that PEB structures can be easily designed by simple design procedure. PEB structures are more advantageous than conventional structures in economy, speed of construction & simple erection. Hence it is concluded that PEB has wide scope in India but they are still not preferred.

7. References


