Study on Advantages and Design Aspects of Pre-Engineered Steel Building over Conventional Steel Building

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***Abstract*—This paper focused to "Study on Advantages and Design Aspects of Pre-Engineered Steel Building over Conventional Steel Building". Pre-Engineered Building (PEB) technology is one of pioneering concept in construction industry for effective utilization of material and also for easier construction process. In this paper, advantages, load combinations and design aspects of PEB over conventional steel building is studied.**

Keywords—Pre-Engineered Steel Building, Conventional Steel Building, Load Combination, Advantages, etc.,

INTRODUCTION

Steel is a very important material in construction field due to its properties and structural behaviour. Because of huge availability and easier fabrication, it is utilized in high quantity in construction industries.

PEB structures are low cost and effective steel structure when compared with conventional steel buildings.

PEB system is a building enclosure system that always includes a structural system and often includes roof and wall cladding.

PEB system use a combination of built-up sections, hot rolled sections and cold formed elements which provide the basic steel frame work with a choice of single skin sheeting with added insulation or insulated sandwich panels for roofing and wall cladding. The concept is designed to provide a complete building envelope system which is air tight, energy efficient, optimum in weight and cost and, above all, designed to fit user requirement like a well fitted glove.

The structural system consists of rigid frames that are fabricated from Plate steel to "Tapered I-Section". This rigid frame consists of roof beams and columns that are bolted together in site. The "cold formed" steel members are commonly used as a secondary structural system. The secondary structural member often referred to as purlins and girts.

In fact, PEB buildings are custom-engineered to specific dimensions, structural criteria and materials in accordance with building codes. Each part of the system is designed to precisely fit together which transforms into buildings that can be built with greater speed and accuracy than in using conventional methods.

In Conventional steel building, hot rolled steel sections are used. The size of each member is selected on the basis of the maximum internal stress in the members. Since hot rolled steel section has a constant depth, many parts of the member, in areas of low internal stresses are in excess of design requirements.

Additionally, PEB system offer significant cost performance advantages over conventional building system including lower life cycle costs for greater return on investment, unlimited design flexibility and sustainability.

Advantages of Pre-Engineered Steel Building

Construction Time

PEB structure will reduce total construction time of the project by at least 40%.

This will allow faster occupancy and earlier realization of revenue.

Lower Cost

Up to 30% of project cost is saved in PEB structures when compared with conventional building.

Because of optimization in section leads to considerable saving in material.

Large Clear Span

PEB structures can be built up to 90m clear span.

The most important advantage of Pre-Engineered Steel building is large clear span without intermediate supports.

Flexibility of Expansion

PEB structures can be expanded easily in length by adding bays. Also expansion in width and height is possible by pre designing for future expansion.

Quality Control

PEB systems are manufactured completely in the factory under controlled conditions, and hence the quality can be assured.

Low Maintenance

PEB have high quality paint systems for cladding and steel to suit ambient conditions at site, which in turn gives longer durability and low maintenance cost.

Erection

As PEB system sections are lighter in weight, the small members can be very easily assembled, bolted and raised with the help of cranes. This allows very fast construction and reduces wastage and labour requirement.

Energy Efficient Roofing

Buildings are supplied with polyurethane insulated panels or fiberglass blankets insulation to achieve required "U" values (overall heat transfer coefficient).

APPLICATIONS OF PRE-ENGINEERED STEEL BUILDING

The most common applications of PEB system are

1) Industrial: Factories, Workshops, Warehouses, Cold stores, Car parking sheds, Slaughter houses, Bulk product storage.

2) Commercial: Showrooms, Distribution centers, Supermarkets, Fast food restaurants, Offices, Labour camps, Service station, Shopping centers.

3) Institutional: Schools, Exhibition halls, Hospitals, Theatres / auditoriums, Sports halls.

4) Recreational: Gymnasiums, swimming pool enclosures, Indoor tennis courts.

5) Aviation & Military: Aircraft hangars, Administration buildings, Residential barracks.

6) Agricultural: Poultry buildings, Dairy farms, Greenhouses, Grain storage, Animal confinement

COMPONENTS OF PRE-ENGINEERED STEEL BUILDING

Primary Members

The most important parts of the Pre Engineered Building are Columns and Rafters which are otherwise called as Primary Structure. The major load of the building is being borne these members. Assembled Columns and Rafters make the frame of the buildings on which all other parts of the buildings are fixed.

Secondary Members

Z – Purlin, Girts, Eave struts etc are secondary members of structural framing. Z-Purlins are cold formed steel member fabricated from steel sheets. Purlins are used in all Pre Engineered building as a secondary load member. Zee or Cee girts are used to hold wall panels.

Panels 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.

LOADS AND LOAD COMBINATIONS

Dead and Collateral Loads

Dead load is the weight of all permanent construction materials, such as roofing, framing, and other structural elements. Being well defined and known in advance, dead load is assigned a relatively low factor of safety in the ultimate (load factor) design. Collateral or superimposed dead load is a specific type of dead load that includes the weight of any materials other than the permanent construction. It may account for the weight of mechanical ducts, pipes, sprinklers, electrical work, future ceilings, and re-roofing.

The IS: 875 (Part 1) – 1987 Code of Practice for design loads (other than earthquake) for buildings and structures for dead load calculation.

Live Load

Live load refers to the weight of building occupants, furniture, storage items, portable equipment, and partitions Owing to the fact that live load is relatively short-term, not easily predictable or quantifiable, it carries large factors of safety (uncertainty, really) in the ultimate design methods.

As per IS : 875 (Part 2) – 1987 Code of Practice for design loads (other than earthquake) for buildings and structures, which provides the actual weight of all the people and furniture in a structure probably does not exceed this load.

Wind Load

As per IS : 875 (Part 3) – 1987 Code of Practice for design loads (other than earthquake) for buildings and structures gives basic wind speed map of India, which is applicable to 10 m height above mean ground level for different zones of the country.

Earthquake Load

Factors affecting the magnitude of earthquake forces on the building include the type of soil, since certain soils tend to amplify seismic waves or even turn to a liquid like consistency (the liquefaction phenomenon). The degree of the building's rigidity is also important. In general terms, the design seismic force is inversely related to the fundamental period of vibration; the force is also affected by the type of the building's lateral load-resisting system.

The actual formulas for determination of seismic forces are given in IS 1893: 2002 Criteria for earthquake resistant design of structures. In general, these formulas start with the weight of the structure and multiply it by several coefficients accounting for various factors.

Load Combinations

From IS 800-2007, we fine load combinations as

(i) 1.5 (DL + LL)
(ii) 0.9 (DL + LL) + 1.5 WL at 0^o
(iii) 0.9 (DL + LL) + 1.5 WL at 90^o

From IS 800-1984, Load combinations for design purposes shall be the one that produces maximum forces and effects from the following combinations of loads.

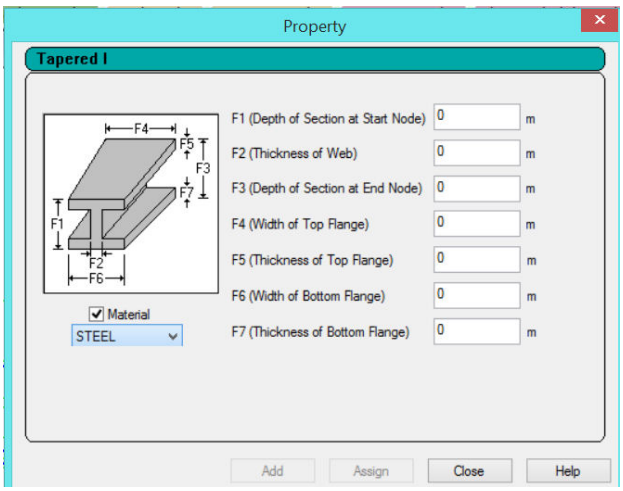
(i) DL + LL
(ii) DL + LL + WL/EL
(iii) DL + WL/EL
(iv) DL + LL + CL
(v) DL + LL + CL + WL/EL
(vi) 0.75*(DL + LL + WL/EL)
(iv) 0.75*(DL + LL + CL + WL/EL)

ANALYSIS OF PRE-ENGINEERED STEEL BUILDING

Software for Analysis

STAAD Pro software can be used for analyzing and designing of the pre-engineered buildings. It gives the Bending Moment, Axial Forces, Shear Forces, Torsion, Beam Stresses of a steel structure so that the design can be done using tapered sections and check for the safety.

The below image shows, how to get tapered I-section in Staad Pro.



Static Analysis

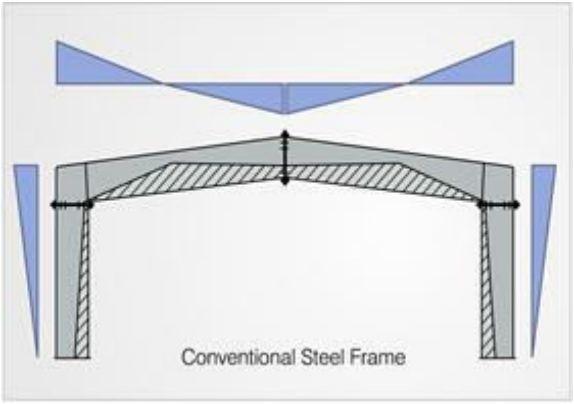
Using the Staad Pro software, 2D/3D analysis has been done using Stiffness Matrix Method. All the components of Pre-engineered building are tapered using the in-built option of the Software. The software provides options for hinged, fixed, and spring supports with releases so as to analyze as per our requirement. It also facilitates Linear, P-Delta Analysis, and Non-Linear Analysis with automatic load and stiffness correction. Multiple Analyses can also be done simultaneously which reduces the time. It also has an option of assigning members as tension-only members and compression-only members for truss structures.

Dynamic Analysis

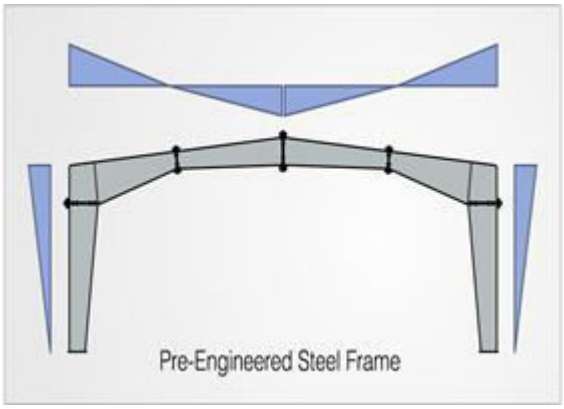
In dynamic analysis, seismic loads and wind loads into consideration. The software provides automatic load generation for seismic and wind forces, however, the seismic loads and wind loads are calculated. The software also provides Loading for Joints, Members/Elements including Concentrated, Uniform, Linear, Trapezoidal, Temperature, Strain, Support Displacement, Prestressed and Fixed-end Loads. It also provides the facility of Combination of Dynamic forces with Static loading for subsequent design.

Design of Pre-Engineered Steel Building

In conventional steel structure, hot rolled steel section of uniform depth is provided which is design for maximum internal stress. So material in hatched portion of below diagram represents wastage of material in conventional steel building frame.



In PEB structure, tapered I-section is provided based on stress distribution along the frame. Multiple trials are preferred to get the optimized steel section for PEB structures. In below diagram, member is designed as per the stress distribution over the span.



Conclusion

Pre-engineered steel structure buildings offer 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. Infinitely recyclable, steel is the material that reflects the imperatives of sustainable development.

For longer span structures, Conventional buildings are not suitable with higher clear spans. Pre-engineered building are the best solution for longer span structures without any intermediate column in between the spans.

Saving of material on low stress area of the primary framing members makes PEB buildings more economical than Conventional steel building. PEB structures are found to be costly as compared to Conventional structures in case of smaller span structures.

References

[1] Gupta Dinesh Kumar, Baig Mirza Aamir, Design of Industrial Steel Building by Limit State Method, International Journal Of Advanced Research, Ideas and Innovations in Technology, 2017. ISSN : 2454-132X, Vol 3, Issue 4, Pp : 414-424.

[2] Shrunkhal V Bhagatkar, Farman Iqbal Shaikh, Bhanu Prakash Gupta and Deepak Kharta, A Study On Pre-Engineered Building – A Construction Technique, International Journal of Engineering Research and Applications, Mar-2015. ISSN : 2248-9622, Vol. 5, Issue 3, pp.05-09.

[3] J.Jayavelmurugan, J.R.Thirumal, Padmanabhan haridas, A Study on Pre Engineered Steel Building Structures, International Journal of Innovative Research in Science, Engineering and Technology, Jan-2015. ISSN : 2319 – 8753, Vol. 4, Issue 1, Pp : 18622-18629.