

Review Paper on Comparison of Conventional Steel Building & Pre-Engineering Building

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Abstract-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. 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.

Index Terms- Industrial steel building, Pre-Engineering Building, IS 875:1987 (LSM)

1. INTRODUCTION

An industrial building is any structure that is used to store raw materials, house a manufacturing process, or store the furnished goods from a manufacturing process. Industrial buildings can range from the simplest warehouse type structure to highly sophisticated structures integrated with a manufacturing system. These buildings are low rise steel structures characterised by low height, lack of interior floor, walls, and partitions. The roofing system for such a building is a truss with roof covering. Design of basic elements of the structure (Roof deck, Purlins, Girders, Columns and Girts) is not difficult, but combining them into functional and cost effective system is a complex task.

In Industrial building structures, The walls can be formed of steel columns with cladding which may be of profiled or plain sheets, GI sheets, precast concrete, or masonry. The wall must be adequately strong to resist the lateral force due to wind or earthquake.

COMPONENT OF AN INDUSTRIAL BUILDING:-

The elements of industrial buildings are listed below.

- 1) Purlins
- 2) Sag rods
- 3) Principal Rafters
- 4) Roof Truss
- 5) Gantry Girders
- 6) Bracket
- 7) Column and Column base
- 8) Girt Rods
- 9) Bracings

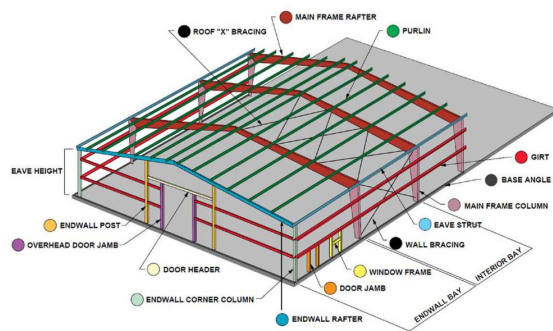


Fig 1: Various component of Industrial building

The previous elements are briefly explained below.

Purlins

Purlins are beams which are provided over trusses to support roof coverings. Purlins spans between top chord of two adjacent roof trusses. When purlin supports the sheeting and rests on rafter then the purlins are placed over panel point of trusses. Purlins can be designed as simple, continuous, or cantilever beams. Purlins are often designed for normal component of forces. the various sections of purlins are as follows.

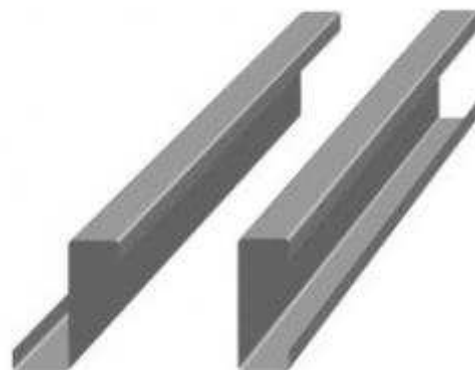


Fig2: Sections of Purlins

Sag Rod

These are round sections rods and are fastened to the web or purlin. The roof covering in industrial

buildings are not rigid and do not provide proper support. Therefore, sag rods provided between adjacent purlins to extend lateral support for purlins in their weaker direction. A sag rod is designed as a tension member to resist the tangential component of the resultant of the roof load and purlin dead load. The tangential component of the roof load is considered to be acting on the top flange of purlins, whereas the normal component and purlin dead load is assumed to act at its centroid. Therefore the sag rod should be placed at a point where the resultant of these forces act.

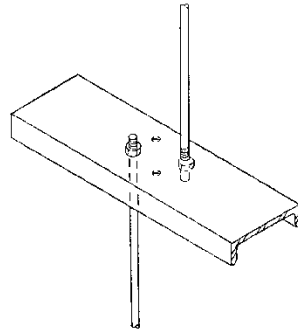


Fig 3: Sag rod

Principal rafter

The top chord member of a roof truss is called as principal rafter. They mainly carry compression but they may be subjected to bending if purlins are not provided at panel points.

Roof Trusses

Roof trusses are elements of the structure. The members are subjected to direct stresses. Truss members are subjected to direct tension and direct compression.

Gantry Girder

Gantry girders are designed as laterally unsupported beams. Overhead travelling cranes are used in industrial buildings to lift and transport heavy jobs, machines, and so on, from one place to another. They may be manually operated or electrically operated overhead travelling crane. A crane consists of a bridge made up of two truss girders which moves in the longitudinal direction. To facilitate movement, wheels are attached to the ends of crane girders. These wheels move over rails placed centrally over the girders which are called gantry girders.

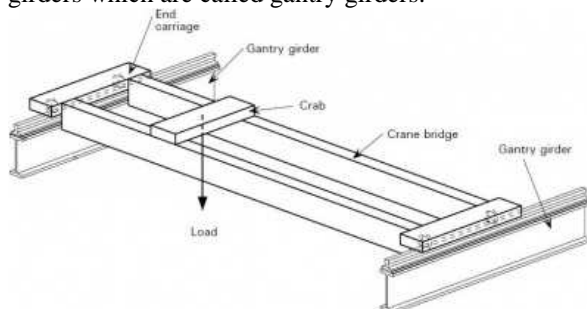


Fig 4: Gantry Girder

Brackets

Brackets types of connections are made whenever two members to be secured together do not intersect.



Fig 5: Brackets

Column and Column Base

A column is a structural member which is straight to two equal and opposite compressive forces applied at the ends. Stability plays an important role in the design of compression member because in columns buckling is involved. The problem of determining the column load distribution in an industrial building column is statically indeterminate. To simplify the analysis the column is isolated from the space frame and is analyzed as a column subjected to axial load and bending.

An industrial building column is subjected to following loads in addition to its self weight.

- 1) Dead load from truss
- 2) Live load on roof truss
- 3) Crane load
- 4) Load due to wind

Steel columns are normally supported over concrete blocks. However when the load supported by these columns are large and the bearing pressure of concrete from below is insufficient to resist the loads, they may fail. Therefore it is a normal practice to distribute column loads to steel base plate which are placed over these concrete blocks. In addition to transferring safely the column loads, a base plate also maintains the alignment of the column in plane, verticality of the column and controls column and frame deflection.

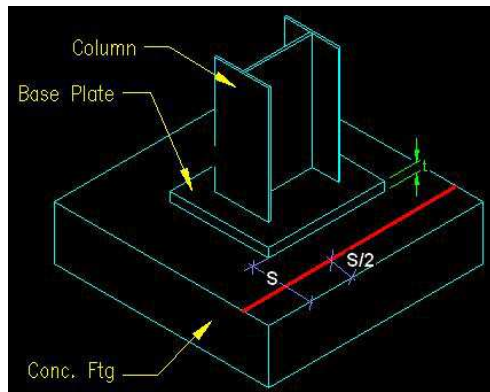


Fig 6: Column and column base

Girt

These are beams subjected to unsymmetrical bending. These support vertical dead load from the sliding and horizontal wind loads. Usually these are unequal angle sections connected with the longer leg to withstand the effect of wind. Girts are assumed to be continuous.

Bracing

It is important to trace the longitudinal crane forces through the structure in order to insure proper wall and crane bracing. For lightly loaded cranes, wind bracing in the plane of the wall may be adequate for resisting longitudinal crane forces. While for every large longitudinal forces, the bracing is most likely to be required in the plane of crane rail.

When the wind acts in the direction normal to the plane of industrial building bents, i.e., in the longitudinal direction, then it becomes essential to brace it to another to provide sufficient stability against wind or other longitudinal force. Vertical column bracing transfers the longitudinal force to the foundation.

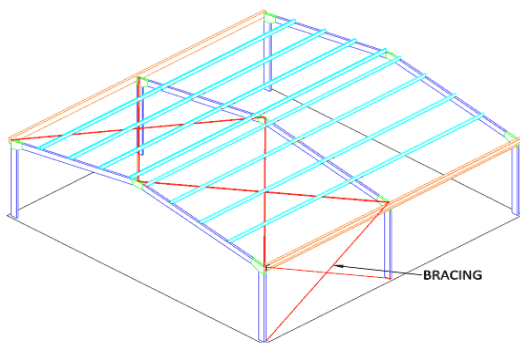


Fig 7: Bracing

2. VARIOUS LOADS ON AN INDUSTRIAL BUILDING

Dead load

The dead load of truss includes the dead load of roofing materials, purlins, trusses and roof bracing systems. The dead weight of the trusses may be assumed to be equal to 10% of the load on the truss. The weight of the bracing may be assumed to be 12-

15 N/m² of the plan area. A simple for the estimation of the approximate dead weight of the roof truss in N/m².

Superimposed loads

The load assumed to be produced by the intended use of occupancy of a building, including the self weight of movable partitions, distributed, concentrated loads, loads due to impact and vibration sand dust load but excluding wind, seismic, snow and other loads due to temperature changes, creep, shrinkage, differential settlement etc IS: 875 (part 2) 1987 specifies live loads to be assumed in the analysis of an industrial building.

Wind load

The most critical load on an industrial building is the wind load. For the roof and walls of an industrial building, consideration must be made for pressure difference between the opposite faces of such elements to accounts for external and internal air pressures exerted by wind blowing against the building. When the negative air pressure is less than the atmospheric pressure is known as suction. IS 875 (part 3) 1987 specifies the following wind load coefficients to be assumed in the analysis of an industrial building.

The wind force F is obtained by an equation

$$F = (C_{pe} - C_{pi}) AP_z$$

Snow load

IS 875 (part 4) 1987 specifies the following snow load to be assumed in the analysis of an Industrial building. If the structure is situated in an area where the roof is subjected to snow, the load considered for design should be the maximum of live or snow load. The load due to snow depends upon the pitch of the roof, shape of the roof and roofing material. Snow load may be assumed to be 2.5 N/m² per mm depth of snow. When the roof slope is greater than 50 degree Snow load may be neglected.

3. AN OVERVIEW OF THE CONCEPT OF PRE-ENGINEERING BUILDINGS

The scientific-sounding term pre-engineered buildings came into being in the 1960s. The buildings were pre-engineered because they rely upon standard engineering designs for limited number configurations. These buildings are mostly custom designed metal building to fill the particular needs of customer.

Basically, a PEB is a rigid jointed plane frame from hot-rolled or cold – rolled sections, supporting the roofing and side cladding via hot-rolled or cold-formed purlins and sheeting rails. Pre Engineered Buildings offers many advantage such as more effective use of steel than in simple beams, easy extension at any time in the future and ability to

support heavy concentrated loads. PEB frames have a roof slope of from 6 to 12 degree, mainly chosen because of the smaller volume of air involved in heating and cooling the building. Usually, the portal frames are composed of tapered stanchions and rafters. Most often, the beam is tapered by providing a slope to the flange for water runoff and keeping the bottom flange horizontal for ceiling applications.

The main reason for the popularity of the gabled rigid- frame system lies in its cost efficiency. It requires less metal than most other structural systems of the same span and eave height.

A typical single-storey metal building system is supported by main frames forming a number of bays. Bay size is the space between frame centerlines measured along the sidewall. Frame clear span is the clear distance between frame columns. Metal building system can have a variety of wall materials, the original and still the most popular being metal siding, supported by sidewall or end wall girts.

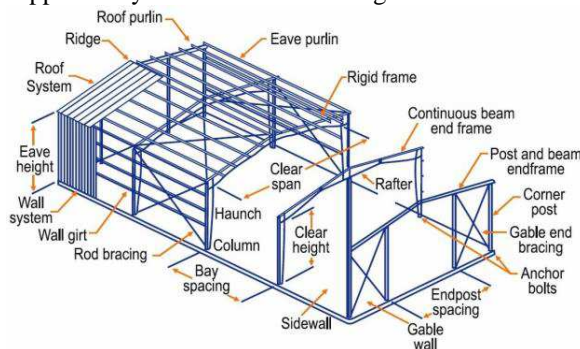


Fig 8: Various component of PEB

4. COMPONENT OF A PRE-ENGINEERED BUILDING

The component of a PEB may be broadly divided into following four parts, namely

- 1) Main Frame
- 2) Secondary Frame
- 3) Wind Bracing
- 4) Exterior cladding

Main Frame

Moment resisting frames provides lateral stability and transfer the roof and wall load to the foundation through anchor bolts. Main frames are built up tapered or constant depth column and rafters. The tapered profile is based on the moment diagram of the structure, which results in greater economy compare to any other structure. This is the main difference with respect to other structural steel frame building where in straight columns and beams are used. The tapered sections are welded using automatic welding machine to ensure high quality and rapid construction. Flanges are welded to the web by a continuous single side fillet weld. Splices using flange plate are usually provided at the zones of low moment in the frame.

Secondary Frame

Purlins girts and eaves 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. Purlins and Girts provide lateral bracing to the building columns, rafter and prevents lateral buckling of compression flanges. Purlins and Girts are usually Cold Rolled steel C or Z sections having minimum yield strength of 345 Mpa. Z shaped purlins are usually adopted for PEB since this shape provides greater advantage of being lapped at support points and nested together to increase the stiffness. C section on the other hand lacks this capability.

Wind Bracing

Roof and wall cross bracing provide longitudinal stability to the building. It enables effective transfer of wind load acting on building end walls to the foundation.

Exterior Cladding

Exterior Cladding provides a water tight envelope. It transfers the Structural loads i.e. Wind and Live load to the Secondary Framing. It provides lateral bracing to the Purlin and girt.

5. STABILITY OF A PRE-ENGINEERED BUILDING

A building lacking lateral stability against wind and earthquake loads will not be standing for long. The most popular Pre-Engineered structure, rigid frame, relies on its own moment resisting ability to laterally support the building.

A typical design solution for metal building systems is to provide moment- resisting frames spanning the short direction of the building and braced frames in the exterior walls. The vertical bracing located in the end wall acts primarily in resisting lateral loads acting in the direction parallel to the frames, while the sidewall bracing resists the loads in the perpendicular direction.

6. COMPARISON OF PRE-ENGINEERED STEEL BUILDINGS OVER CONVENTIONAL STEEL BUILDINGS

	PRE-ENGINEERED STEEL BUILDINGS	CONVENTIONAL STEEL BUILDINGS
Structure Weight	Pre-engineered buildings are on an average 30% lighter through efficient use of steel. Primary members are tapered built up sections, with large depths in the areas of highest stress.	Primary steel members are selected from standard hot rolled I section, which are, in many segments of the members, heavier than what is actually required by

		design. Members have constant cross-sections regardless of the varying magnitude of the local stresses along the member length.
Design	Specialized computer analysis and design programs optimize material required. Drafting is also computerized using standard details that minimize use of project custom details.	Substantial engineering and detailing work is required on every project. Generalized computer analysis programs requires extensive input/output and design alterations.
Delivery	Average 6 to 8 weeks.	Average 20 to 26 weeks.
Foundations	Simple design, easy to construct and light weight.	Extensive, heavy foundations required.
Erection Simplicity	Since the connections of the components are standard, the learning curve of erection for each subsequent project is faster.	The connections are normally complicated and differ from project to project, resulting in longer learning curves of erection for new project.
Erection Cost & Time	Both costs and time of erection are accurately known based upon extensive experience with similar buildings.	Typically conventional steel buildings are 20% more expensive than PEB. In most of the cases the erection cost and time are not estimated accurately.
Seismic Resistance	The low-weight flexible frames offer higher resistance to seismic force.	Rigid heavy weight structures do not perform well in seismic zones.

Overall price	Price per square meter may be as much as 30% lower than conventional building.	Higher price per square meter.
Architecture	Outstanding architectural design can be achieved at low cost using standard architectural features and interface details	Special architectural design and features must be developed for each project, which often require research and results in higher cost.
Future Expansion	All project records are safely and orderly kept in electronic format indefinitely, making it easier for owner or designer to obtain a copy of his building records at any time.	It would be difficult to obtain records, after a long period of time. It is required to contact more than one party, involved in project, to obtain accurate information.
Safety and responsibilities	Single source of supply results in total responsibility by one supplier, including design liability.	Multiple responsibilities can result in question of who is responsible when components do not fit properly, insufficient material is supplied, or materials fail to perform.
Performance	All components have been specified and designed specifically to act together as a system for maximum efficiency, precise fit and peak performance in the field.	Components are custom designed for specific application on a specific job. Design and detailing errors are possible when assembling the diverse components in unique building.

7. ADVANTAGES OF STEEL CONSTRUCTION

1. High quality, aesthetic
2. Lower maintenance costs

3. Non combustible to fire
4. Steel is environmentally friendly
5. Components can be used again and again
6. Steel components are frequently functional
7. Steel construction is strong, durable and stable
8. Steel Construction promotes good design and safety
9. Construction with Steel is sustainable to Temperature effects
10. Steel frame construction is rigid in structure and dimensionally stable
11. Steel can be re-used without effecting the environment
12. Construction with Steel components is very fast compared to other materials
13. Steel construction of buildings with steel components is resistant to termites and other destructive insects.
14. Steel constructions are cheaper than any other construction methods
15. Steel construction is a fast method of construction

8. APPLICATION OF PEB

The most common applications of Pre-Engineered Buildings are:

- 1) Factories
- 2) Steel Mills
- 3) Sports Stadiums
- 4) Shipyards
- 5) Logistic Centres
- 6) Waste Treatment Factories



Fig 9: Logistic centre



Fig 10: Shipyards

CONCLUSION

This paper effectively conveys that PEB structures can be easily designed by simple design procedures in accordance with country standards. In light of the study, it can be concluded that PEB structures are more advantageous than CSB structures in terms of cost effectiveness, quality control speed in construction and simplicity in erection. The paper also imparts simple and economical ideas on preliminary design concepts of PEBs. The concept depicted is helpful in understanding the design procedure of PEB concept.

REFERENCES

- [1] International Journal of Engineering Sciences & Emerging Technologies, June 2013. ISSN: 2231 – 6604 Volume 5, Issue 2, pp: 75-82
- [2] Syed Firoz, Sarath Chandra Kumar B, S.Kanakambara Rao, Design Concept Of Pre Engineered Building, International Journal of Engineering Research and Applications (IJERA) Vol. 2, Issue 2, Mar-Apr 2012, pp.267-272.
- [3] Dr. N. Subramanian Computer Design Consultants Gaithersburg, MD 20878, USA Pre-Engineered Buildings Selection of Framing System, Roofing & Wall Materials
- [4] Dr. V. L. Shah & Prof. Mrs Vina Gore, Limit state Design of Steel Structure
- [5] S. K. Duggal, Limit State Design of Steel Structure.