A REVIEW ON VARIOUS TYPES OF INDUSTRIAL BUILDING

Swapnil D. Bokade[1], Laxmikant Vairagade[2]
[1]Department of Civil Engineering, Nagpur University, Nagpur, India
Swapnilbokade99@gmail.com
[2]Department of Civil Engineering, Nagpur University, Nagpur, India
lvairagade@gmail.com

ABSTRACT

Industrial building is the design and construction of buildings serving industry. Such buildings rose in importance with the industrial revolution, and were some of the pioneering structures of modern architecture. Paper covered two types of industrial building such as conventional and pre-engineered building. 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.

KEYWORDS

Industrial Building, Staad Pro, Steel Building, Roof Deck, Purlins, Girders, Columns.

I. 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 characterized 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.

II. TYPES OF INDUSTRIAL BUILDING

2.1. Conventional Industrial Building

It is any structure that is used to store raw materials and etc. Buildings are low rise steel structures characterized by low height, lack of interior floor, walls, and partitions. Design of basic elements of the structure (Roof deck, Purlins, Girders, Columns and Girts).

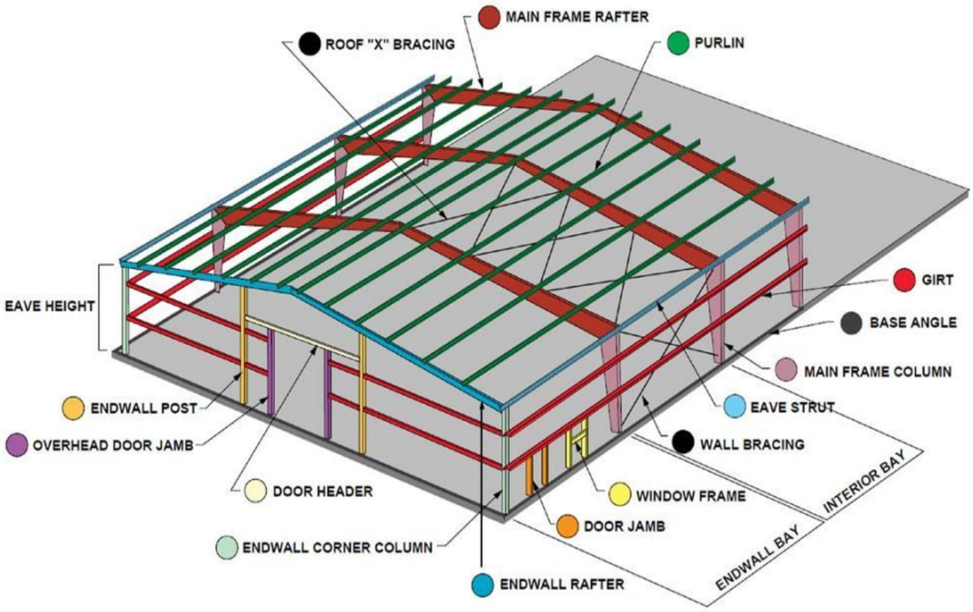

Figure. 1 Various elements of industrial building

- **Component of an industrial building:-**

The elements of industrial buildings are given below:

2.1.1. Purlins

Purlins are beams which are provided over trusses to support roof coverings. Purlins spans between top chords 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. Purlins are of various sections such as Z purlin, channel purlin, I section Purlin, Truss purlin etc. some sections of purlins are shown below.

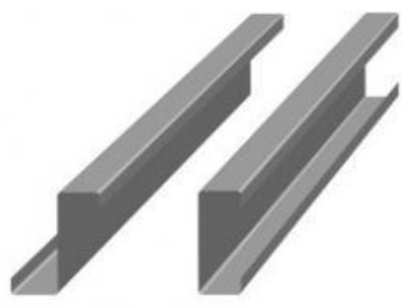

Figure. 2 Various sections of purlin

2.1.2. Sag Rods

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.

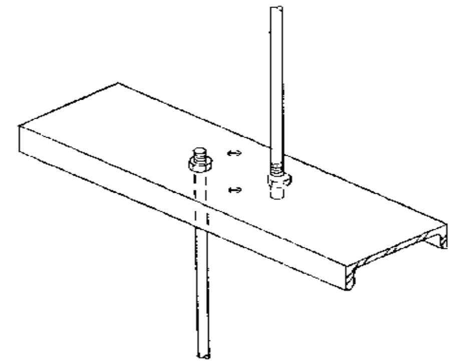

Figure. 3 Sag rod

2.1.3. Principle 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.

2.1.4. Roof Truss

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

2.1.5. Gantry Girders

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.

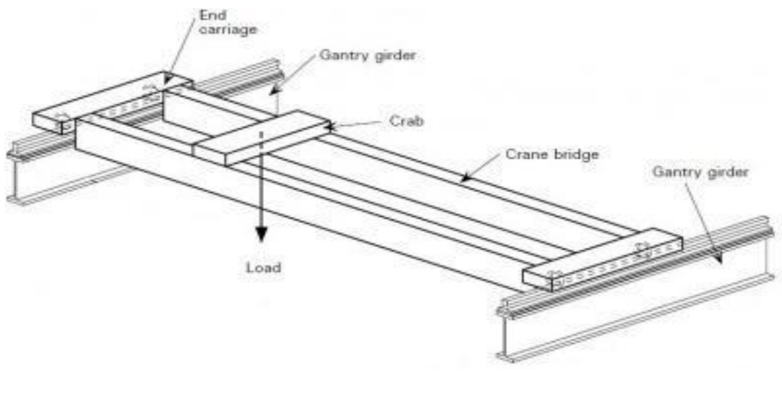

Figure. 4 Gantry girders

2.1.6. 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.

- Dead load from truss
- Live load on roof truss
- Crane load
- 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.

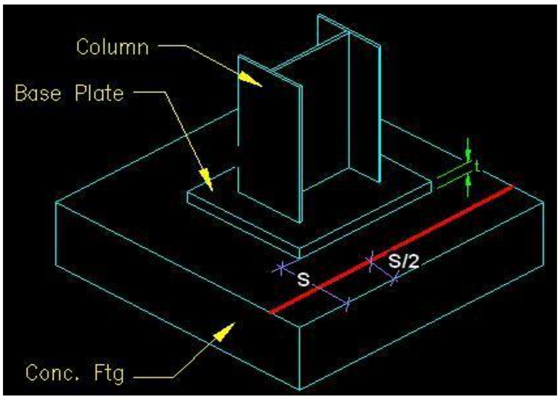

Figure. 5 Column and column base

2.1.7. Girt Rods

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.

2.1.8. Bracings

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.

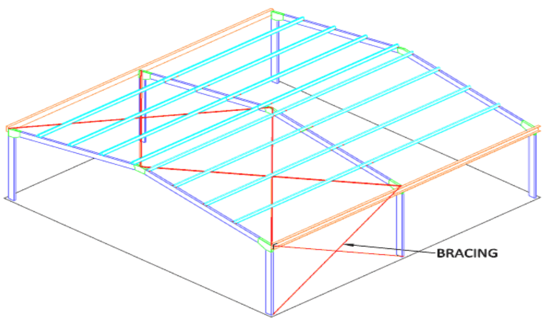

Figure. 6 Bracing

2.2. Pre-Engineering Buildings

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 much 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.

- **Component of A Pre-engineered Building**

Broadly divided into following four parts

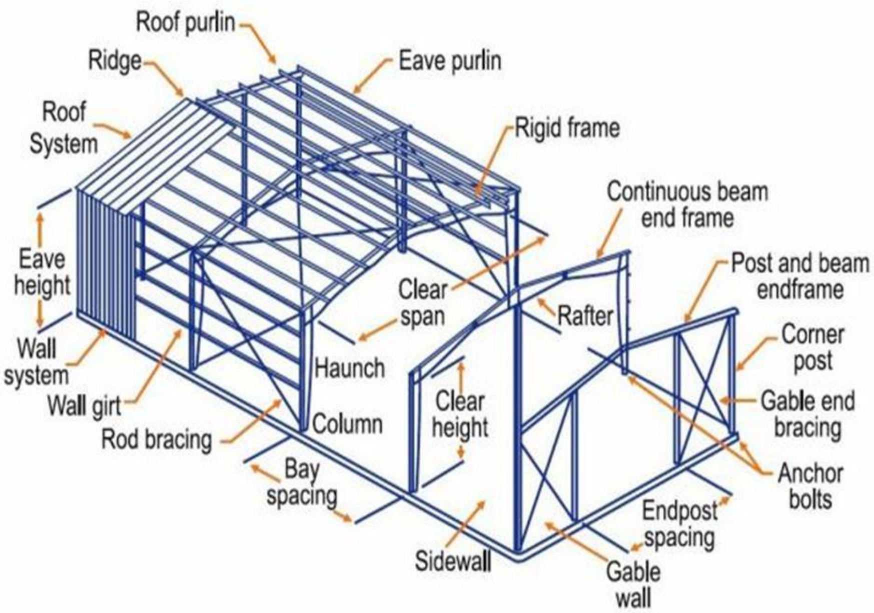

Figure. 6 Various component of PEB

2.2.1. 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.

2.2.2. Secondary Frame

Purlins, girts and eves 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.

2.2.3. Girt Rods

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.

2.2.4. 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

III. LITERATURE REVIEW

Paper [1] stated that in long spans, column free structures are the most essential in any type of industrial structures and Pre Engineered Buildings (PEB) fulfills required cost as compared to conventional structures. His work involves the comparative study of static and dynamic analysis and design of Pre Engineered Building (PEB) and conventional steel frames by using STADD PRO software. For his work comparison of Pre Engineered Building and Conventional steel frames is done in two examples and in third example, longer span Pre Engineered Building structure is taken for the study. From the analysis and design he found that weight of Pre Engineered Building is reduced to 27% providing lesser dead load which in turns offers higher resistance to seismic forces also Pre Engineered Building are found to be costly as compared to conventional structures in case of smaller span structures and also weight of PEB depends upon the Bay spacing to certain limit.

In [2] they designed Pre Engineered building (PEB) and compared with conventional steel building (CSB). Author modeled a frame subjected to a Dead Load, Live Load, Wind load and crane Load and she compared results of PEB with CSB and founded that PEB structures are lighter than CSB structures and it was found that PEB structures are 30% lighter than CSB. Delivery of material to the site is 6 to 8 weeks whereas for CSB it is 20 to 26 weeks. Also Erection time is much lesser for PEB than CSB. Since PEB are lighter than CSB so they provide higher resistance to earthquake loads. And due to tapered section involved and less load in PEB it is very economical as compared to CSB.

Author [3] designed Pre-engineered ware house of various span of 25m, 30m, and 40m and of various Bay length of 4.5m, 5.5m 6.5m and 7.7m having Eave height of 6m and the structure is analyzed and designed based on IS 800 taking Dead Load, Live Load, Wind Load and Seismic Load considering load combination from IS. He analyzed results for Base Reaction, Column Moment, rafter Moment Displacement at ridge, and Displacement a mid-span and is compared for each bay spacing and from the results it was found that there is decrement in increase of load for bay spacing of 5.5m to 6.5m and increment of load for bay spacing 6.5m to 7.5 m. Also he mentioned that Steel quantity is primarily depending on primary members and purlins. As the spacing of frame increased steel consumption is decreased for primary members and increased for secondary members (purlin runner, girt etc.)

Paper [4] designed and compared between Hot Rolled steel structure and cold formed steel structure. Also by using cold formed system economy is achieved with completion of project in minimized time. He designed cement go down with cold formed section and hot rolled sections by using STADD PRO software and conclusion is made with the results that by using cold formed section cost and material is saves about 25%.

Author [5] provide a designer of Industrial Building with guidelines and design criteria for the design of building without cranes or building with light to medium cranes. It would seem a simple task to design a good industrial building. However combining the element like roof, purlin girt rod, girders and column into a most functional and cost efficient system is a complex task. For this designer has to be provided with the information like site information, soil condition, plan layout and work flow, preferred bay sizes, future expansion plan, floor slab, wall material preferences, roofing preferences, and budget.

IV. CONCLUSIONS

The paper is focused on various types of industrial building. From the design it is clear that using angle section for Truss and channel section for purlins, Steel Truss Building using pipe section and PEB is found to be economical compared to Steel Truss Building using angle section. By using proper selection of material the Industrial Steel truss Building is economical compared to PEB. In the future, Design of Industrial Building and PEB for multistoried can be studied. Design of Industrial Building and PEB considering crane load can be studied.

ACKNOWLEDGEMENTS

We would like to thank the researchers as well as publishers for making their resources available and teachers for their guidance. We are also thankful to reviewer for their valuable suggestions and also thank the college authorities for providing the required infrastructure and support.

REFERENCES

[1]. Aijaz Ahmad Zende "Comparative Study of Analysis and Design of Pre-Engineered Buildings and Conventional frames" IOSR Journal of Mechanical and Civil Engineering 2278-1684, 2013.
[2]. C. m. Meera "Pre-Engineered Building Design of an Industrial warehouse" International Journal of engineering sciences & Emerging Technologies 2231-6604, 2013.
[3]. Jatin D. Thakar "Comparative Study of Pre-Engineered Steel Structure by Varying Width of structure" International Journal of Advanced Engineering Technology 0976-3945, 2013.
[4]. Mr. Roshan S. Satpute "Building design Using Cold Formed Steel Structure" International Journal of Engineering and Science 2319-183X,2012.
[5]. S.K. Duggal "Limit State Design Of Steel Structures" Tata McGraw Hill Publishing Company Limited. New Delhi, 2010.
[6]. Prof. Dr. V. L. Shah and Prof. Mrs. Veena Gore "Limit State Design Of Steel Structures" Structures Publishing. Third Edition. Pune, 2013.
[7]. N. Subramanian "Design of Steel Structures" Oxford University Press. New Delhi, 2010.
[8]. Dr. N. M. Bhandari, Dr. Prem Krishna and Dr. Krishan Kumar "An Explanatory Handbook on Proposed IS 875 (Part 3) wind Loads on Buildings and Structures" Department of Civil Engineering Indian Institute of Technology, Roorkee.
[9]. Is 800:2007 "Indian standard Code of Practice for General Construction in Steel Bureau of Indian Standards" Third Revision, New Delhi, India.
[10]. IS: 801-1975 (Reaffirmed 1995) "Indian standard Code of practice for use of Cold-Formed light gauge Steel Structure Member in General Building Construction" Bureau of Indian standard, First Revision, New Delhi, India.

AUTHORS

Swapnil D. Bokade received Diploma in Civil Engineering in year 2010 and Bachelor of Engineering degree in Civil Engineering in 2013 and now pursuing Post Graduation (M. Tech.) in the department of Civil Engineering from G. H. Raisoni Academy of Engineering & Technology, in the current academic year 2016-17. He is now studying for the domain Structural Engineering as research purpose on Design and Comparison of various types of industrial building during his academic year.

Prof. Laxmikant Vairagade. He is presently working as an Assistant. Professor, Department of Civil Engineering, G. H. Raisoni Academy Of Engineering and Technology, Nagpur, Maharashtra, India. His research area is Structural Engineering.