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Comaprative Study of Pre-Engineered Buildingd and Conventional Steel Structures

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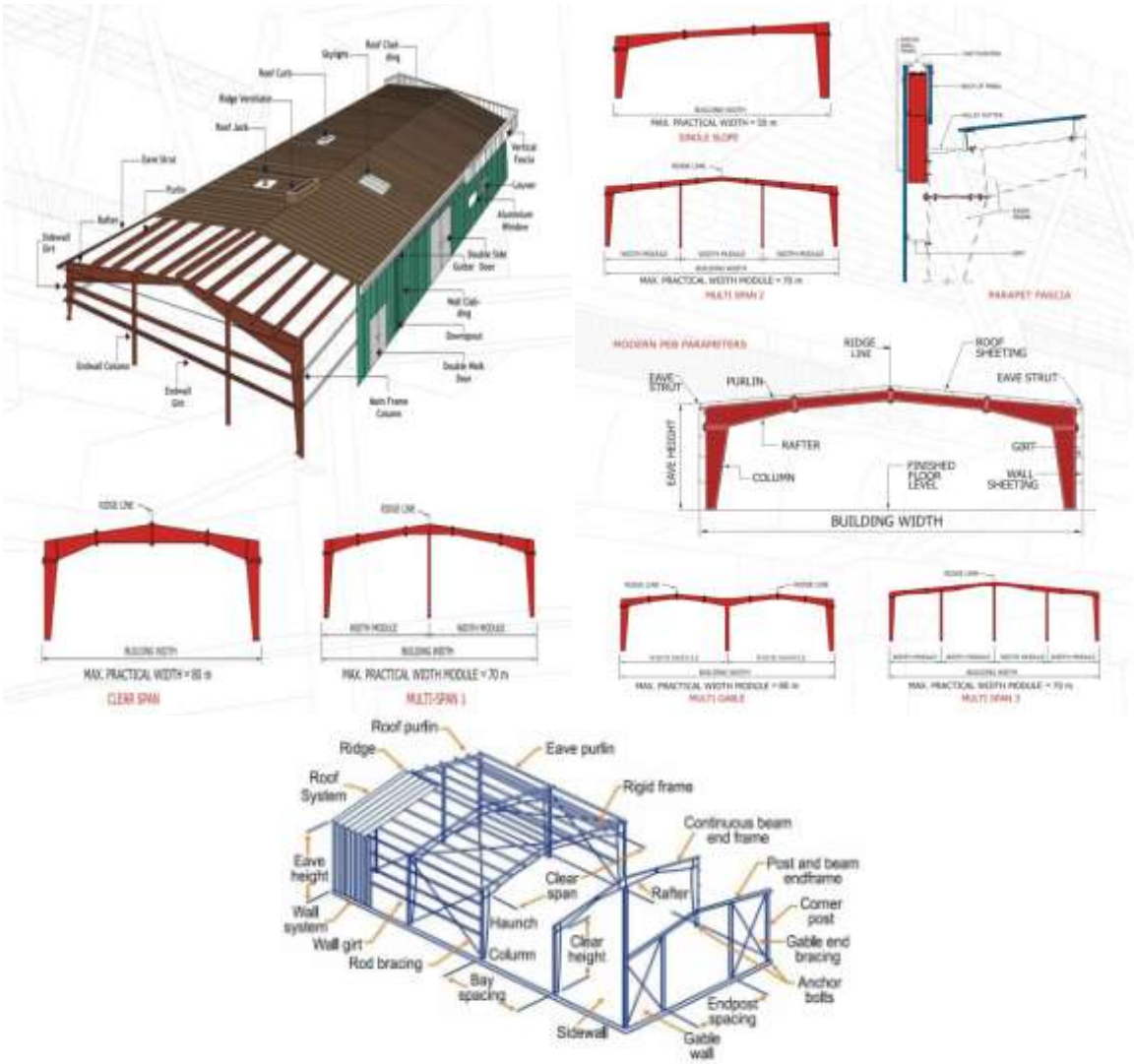
***Abstract**: Steel industry is growing rapidly in almost all the parts of the world. The use of steel structures is not only economical but also Eco-friendly at the time when there is a threat of global warming. Here, "economical" word is stated considering time and cost. Time being the most important 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.*
The pre-engineered building calls for very fast construction of buildings and with good aesthetic look sand quality construction. Pre-engineered Buildings can be used extensively for construction of industrial and residential buildings. The buildings can be multi storied (4-6 floors). These buildings are suitable to various environmental hazards.
Dynamic analysis has been done taking seismic loads and wind loads into consideration. Pre-engineered buildings are most economical option and after a specific span steel quantity in PEB are almost same as that of conventional steel structure. PEB frames are light and more flexible than conventional steel frames and provide higher resistance to seismic forces.
This paper is a comparative study of PEB concept and CSB concept. The study is achieved by designing a typical frame of a proposed Industrial Warehouse building and analyzing the designed frames using the structural analysis and design software.
***Keywords**: Conventional Steel Structures, Pre-Engineered Building, Pre-fabricated, Economical, Loads, Dynamic Analysis*

I. Introduction:

On the basis of type of roof truss and the pre-engineered structure i.e. Pre-engineered Building, the industrial buildings are analyzed. Industrial building is generally classified as braced and unbraced framed structures. In the braced type of buildings, the trusses rest on column with hinges and stability is provided by bracings in three mutually perpendicular planes. Transferring horizontal loads from frames i.e. loads categorized as wind load and earth quake load or horizontal surge due to acceleration and breaking of travelling cranes over gantry girders to the foundation is the basic function of bracing. Stability to the structure in longitudinal direction is provided by the longitudinal bracing whereas stability in the lateral direction is provided by the gabble bracing. The lateral loads on the structure due to wind or earthquake is transferred by the tie bracing at the bottom chord level of the truss to the end gabble bracings likewise, the rafter bracing and the bracing system works at the bottom chord. The design strength of the compression chord of the roof trusses is increased by the action of purlin. Frequently used unbraced frames like portal frames are most used frames in industrial building construction as its construction is simple, economic, and easy and has fast erection. Large utility area with maximum column free space is provided in such frames. In such structures, the inner columns are eliminated and the foundation and its area, the valley gutters and internal drainage is required comparatively less. The portal frame is a rigid jointed plane made from hot rolled or cold rolled sections, supporting roofing and side cladding. Its typical span ranges from 30-40 m and its bay spacing could be 4.5-10 m.

The Pre-engineered Building is the amalgamation of pre-casted and pre-fabricated structures. These are best possible for offices, houses, showrooms, shop fronts etc. One of the important factors for choosing the pre-engineered buildings is the less time consumption of time for its erection and the economic factor. It can be used for around 80m of clear span.



II. Literature Survey:

Neha R. Kolate, Shipa Kewate (July 2015) made a comparative study between pre-engineered building and conventional steel building and observes that PEB has many advantages over CSB such as zero maintenance and superior strength, it is corrosion resistance and features an attractive appearance and it is high level technology innovation and better product over conventional material. PEB system has protection against non-uniform weathering. In this paper, they studied that most of the steel structures are made in a conventional way using conventional sections and this leads to uneconomical and heavy structure and this pushes forward technology to get a better replacement and that is Pre-engineered building having better properties than conventional steel frames.

S.D. Charkha and Latesh S. Sanklecha (June 2014) observes that constantly increasing cost of steel giving rise to an uneconomical construction practice which needs to be altered using new innovative technology. There are many reasons to choose PEB over CSB such as quality design, manufacturing, erection, low maintenance due to pre-painted sections, building can be dismantled and relocated easily and future extension without much hassle is possible due to bolted connection. Along with this PEB proves to be a better system because of its ability to span long distance as many other gable structures are limited to a span of about 100 ft. in cost effective manner. Mainly trusses are provided for longer span but significant design fabrication time is

needed. Based on above parameters they concluded that choosing PEB over CSB reduces steel quantity which reduces dead load and hence size of foundation is reduced.

Shrunkhal V Bhagatkar, Farman Iqbal Shaikh, Bhanu Prakash Gupta and Deepak Kharta (March 2015) on "A Study on Pre- Engineered Building – A Construction Technique". International Journal of Engineering Research and Applications (IJERA), Vol. 5, Issue 3, (Part -2) pp.05-09. They observed that Pre-engineered Building (PEB) is a suitable Construction technique for developing countries. 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. PEB will reduce total construction time of the project by at least 50%. This also allows faster occupancy and earlier realization of revenue. Buildings can be supplied with around 80m clear spans. 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. 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 nonresidential constructions worldwide, it is relatively a new concept in India. They reviewed that PEB structures can be easily designed through simple design procedures in accordance with country standards, which is energy efficient, speedy in construction, saves cost, sustainable and most important it's reliable as compared to conventional buildings.

Milind Bhojkar and Milind Darade (December 2014) on "Comparison of Pre Engineering Building and Steel Building with Cost and Time Effectiveness". International Journal of Innovative Science, Engineering & Technology (IJISET), Vol. 1 Issue 10 They observed that, the Pre-engineered building system is unmatched in its speed and value and that's why they are said to be economical for modern construction. The erection time of the pre-engineered building is 50% of conventional steel building or less than 8 weeks. Clear spans up to 90 meters wide (could be extended up to 150 m in case of Aircraft hangers) and eave heights as high as 30 meters are possible. The cost may be approximate 30% of Conventional steel Building only. The various types of Main frame for the basic supporting component in the PEB systems; main frames provide the vertical support for longitudinal and lateral stability for the building in its direction while lateral stability in the other direction is could be achieved by application of bracing system. The Pre-engineered buildings could be high rise buildings Conventional steel buildings are low rise steel structures with roofing systems of truss with roof coverings. Various types of roof trusses can be used for these structures depending upon the pitch of the truss. For large pitch, Fink type truss can be used; for medium pitch, Pratt type truss can be used and for small pitch, Howe type truss can be used. Skylight can be provided for day lighting and for more day lighting, quadrangular type truss can be used. The selection criterion of roof truss also includes the slope of the roof, fabrication and transportation methods, aesthetics, climatic conditions, etc. Several compound and combination type of economical roof trusses can also be selected depending upon the utility. Standard hot-rolled sections are usually used for the truss elements along with gusset plates.

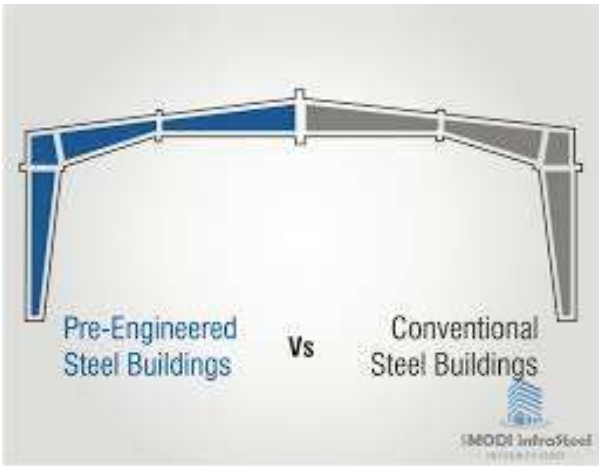
G. Sai Kiran, A. Kailasa Rao, R. Pradeep Kumar (August 2014) on "Comparison of Design Procedures for Pre Engineering Buildings (PEB): A Case Study". International Journal of Civil, Architectural, Structural &Construction Engineering (IJCASCE), Volume 8, No. 4 They observed that in recent years, the introduction 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,isconsidered to carry out analysis& design for 2D frames (End frame, frame without crane and frame with 3 module cranes). The economy of the structure as they discussed is in terms of its weight comparison, between Indian codes (IS800-1984, IS800-2007) & American code (MBMA-96), & between Indian codes (IS800-1984, IS800-2007).

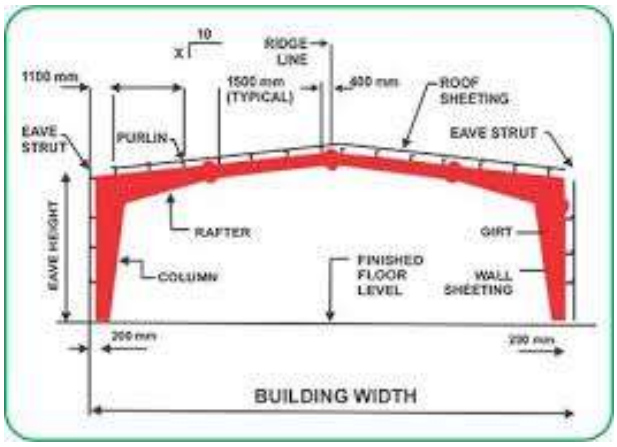
C. M. Meera (June 2013) observes that Pre-Engineered Building (PEB) concept is a new conception of single storey industrial building construction. This methodology is versatile not only due to its quality pre-designing and prefabrication, but also due to its light weight and economical construction. 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, tie rods, 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.

Aijaz Ahmad Zende 1, Prof. A. V. Kulkarni (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.

Jatin D. Thakar, 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.





Objective:

The following are the objective of the present study:

1. To design various system for Different types of Loads (Dead, Live and Dynamic etc.) and evaluate the steel consumption in both the system.
2. Reduce the steel Consumption, hence reducing the Cost of structure.
3. To study comparative costing of various types of system.

III. Methodology:

1. To optimize the sections for Pratt truss chord members.
2. To model most optimized truss section & PEB with different bracings by using any finite element software STAADpro, SAP 2000 and Etabs etc.
3. To analyze Conventional Steel Building (Pratt truss) & PEB structure under wind load.
4. Comparison of Pre Engineered Building and Conventional Steel Building (Pratt Truss).

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