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Comparative Study of an Industrial Pre – Engineered Building with Conventional Steel Building

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Abstract - *In recent years, the introduction of Pre-Engineered Building (PEB) concept in the design of structures has helped in optimizing design. Long span, Column free structures are the most essential in any type of industrial structures and Pre Engineered Buildings (PEB) fulfil this requirement along with reduced time and cost as compared to conventional structures. This methodology is versatile not only due to its quality predesigning and prefabrication, but also due to its light weight and economical construction. The present work presents the comparative study and design of conventional steel frames with concrete columns and steel columns and Pre Engineered Buildings (PEB). In this work, an industrial building of length 44m and width 20m with roofing system as conventional steel truss and pre-engineered steel truss is analyzed and designed by using STAAD Pro V8i.*

Keywords: Pre-Engineered Building, Staad.Pro, Tapered Section.

1. INTRODUCTION

India has the second fastest growing economy in the world and a lot of it, is attributed to its construction industry which figures just next to agriculture in its economic contribution to the nation. In its steadfast development, the construction industry has discovered, invented and developed a number of technologies, systems and products, one of them being the concept of Pre-engineered Buildings (PEBs). As opposed to being on-site fabricated, PEBs are delivered as a complete finished product to the site from a single supplier with a basic structural steel framework with attached factory finished cladding and roofing components. The structure is erected on the site by bolting the various building components together as per specifications. PEBs are developed using potential design software. The onset of technological advancement enabling 3d modelling and detailing of the proposed structure and coordination has revolutionized Conventional building construction. Pre-Engineered Buildings (PEB) is the future for India. Most of the Indian business community is just started to realize the benefits of PEB's. Where you have been building with concrete for as long as anyone can remember, it is difficult to change. However India's most progressive companies are seeing the benefits of PEB's.

1.1. What is Pre-Engineered Building?

PEB are tailor made buildings which are combination of built up section, hot rolled section, cold formed element and profiled sheets based on client's requirement & actual design calculations using tapered sections. Pre-engineered steel buildings can be fitted with different structural accessories including mezzanine floors, canopies, fascias, interior partitions etc. and the building is made water proof by use of special mastic beads, filler strips and trims. This is very versatile buildings systems and can be finished internally to serve any functions and accessorized externally to achieve attractive and unique designing styles. It is very advantageous over the conventional buildings and is really helpful in the low rise building design. From the excavation to occupancy no other building system matches pre-engineered building system when it comes to speed and value.

Pre - Engineered buildings are generally low rise buildings; however the maximum cave heights can go up to 25 to 30 meters. Low rise buildings are ideal for offices, houses, showrooms, shop fronts etc. The application of pre-engineered concept to low rise buildings is very economical and speedy. Buildings can be constructed in less than half the normal time especially when complimented with other engineered sub-systems.

The most common and economical type of low-rise building is a building with ground floor and two intermediate floors plus roof. The roof of a low rise building may be flat or sloped. Intermediate floors of low rise buildings are made of mezzanine systems. Single storied houses for living take minimum time for construction and can be built in any type of geographic location like extreme cold hilly areas, high rain prone areas, plain land, extreme hot climatic zones etc.

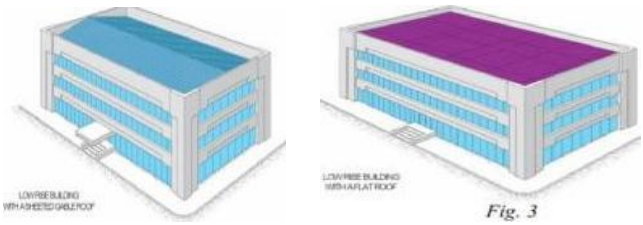

Fig.1.1 Roofing system

1.2 Features

Pre-engineered buildings are known for their ease of construction. An example can very well explain the difference between the traditional method of construction

and the method followed by pre-engineered buildings. The conventional method of constructing a building is to transport bricks, timber, cement, sand, steel and construction aggregate, etc. to the site, and to construct the building on site from these materials. In prefabricated construction, only the foundations are constructed in this way, while sections of walls, floors and roof are assembled in a factory, transported to the site, lifted into place by a crane and bolted together.

Some of the features of Pre Engineered Buildings are as follows:

a. Like it doesn't need any timber for doors and windows it's all steel made, so our environment is intact.

b. The building is made water proof by use of special mastic beads & filler strips.

c. The time and energy involved in the construction of a Pre-engineered Building is much less than the conventional industrial structures.

d. The complete building system is Pre-engineered to facilitate easy production & assembly on site.

e. These buildings can be installed at the client's site, within a limited period of time with less labor hours.

f. As the construction of these building takes lesser time, Pre-engineered buildings saves a great amount of labour cost.

g. Moreover, a Pre-engineered Building can be easily uninstalled and set up again at a different site.

1.3 Components:

There are basically nine major components in a pre-engineered building such as:

a. Main framing or vertical columns

b. End wall framing

c. Purlins, girts and eave struts

d. Sheeting and insulation or prefab panels

e. Crane system

f. Mezzanine system

g. Bracing system

h. Paints and finishes

i. Miscellaneous services

2. Applications

In the USA, where the PEB concept was originally conceived during the early years of this century, nearly 70% of all single storey non-residential construction now utilizes pre-engineered buildings. Applications range from small car parking sheds to 90 m (+), wide clear span aircraft hangars to low-rise multi-storey buildings. Almost every conceivable building use has been achieved using the pre-engineered building approach.

The most common applications of pre-engineered buildings are:

a. Industrial

- Workshops
- Warehouses
- Cold stores
- Car parking sheds
- Slaughter houses
- Bulk product storage
- Factories

Fig.2.1 Ware house

b. Institutional

- Schools
- Exhibition halls
- Hospitals
- Theaters/auditoriums
- Sports halls

c. Agricultural

- Poultry buildings

- Dairy farms
- Green Houses
- Grain storage
- Animal confinement

d. Aviation & Military

- Air crafts hangers
- Administration buildings
- Residential barracks

Fig.2.2 Air crafts hangers

3. Detail specification PEB and conventional steel structures:

Detail specification of hanger shed.

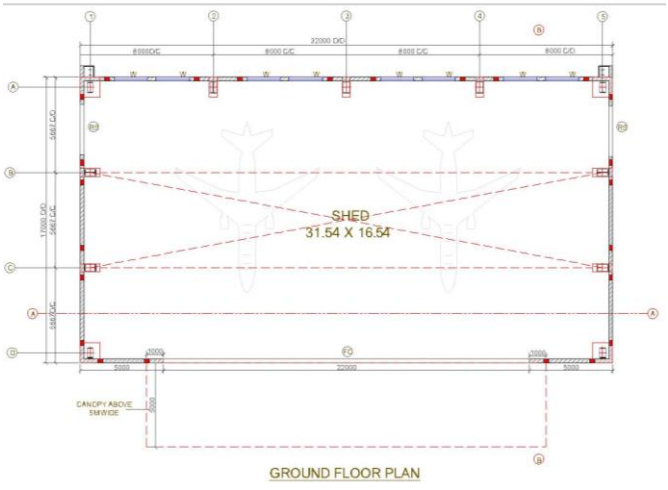

Fig.3.1 Plan of hanger shed

Size of Shed:-30.00 (L) X 17.00 (W) Out to Out

Slope: - 1:10

Height: - 10.0m @ Eaves level

4. Results

In terms of percentage, the steel required for primary frame in pre engineering building is 48.77% less as compared to conventional steel building.

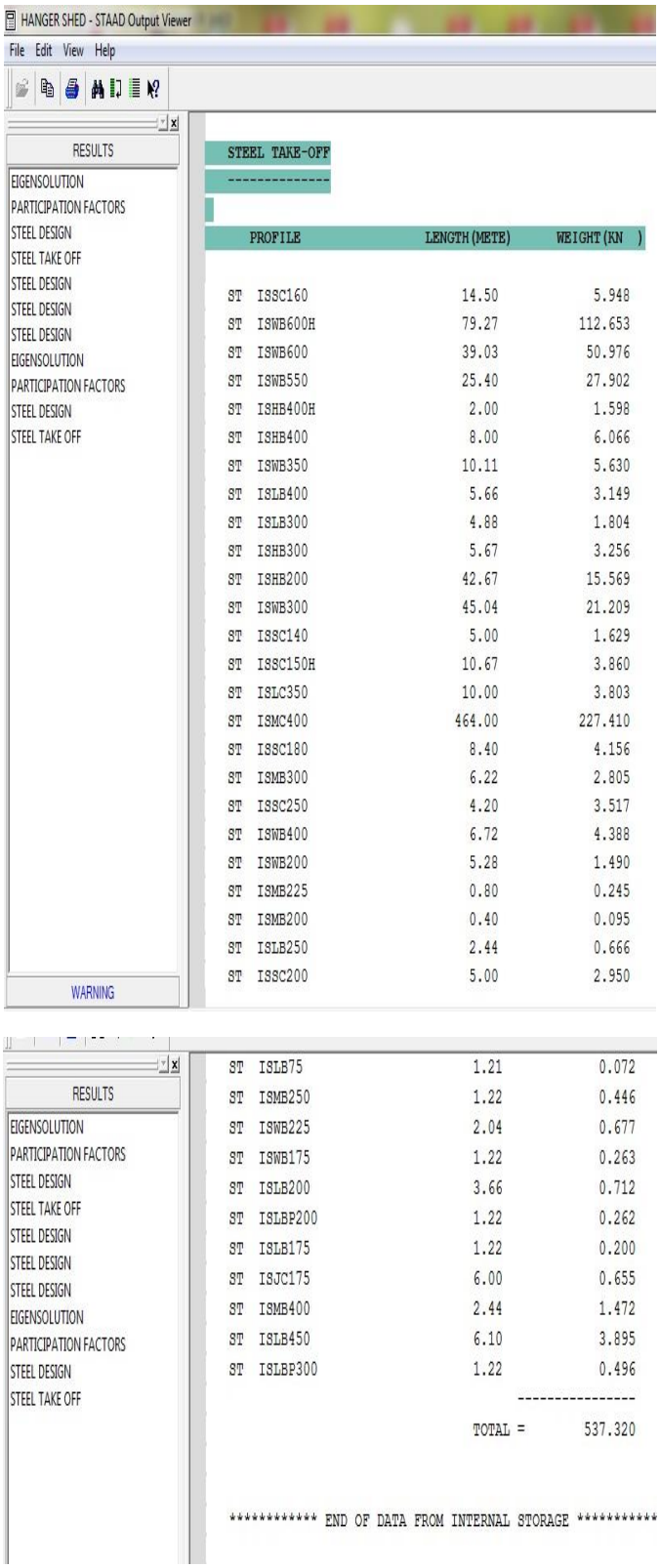

Fig.4.1 Steel take off of conventional hanger shed

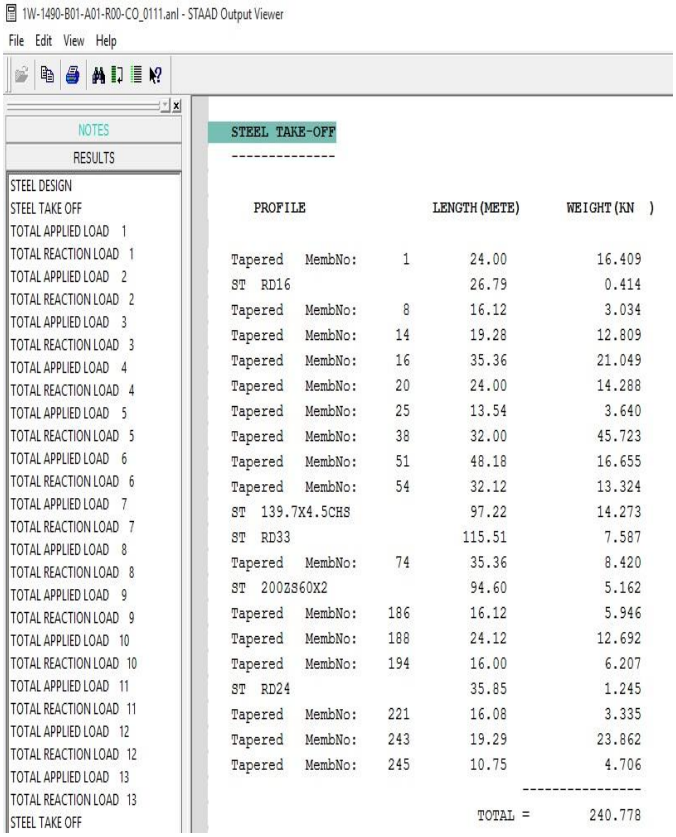

Fig.4.2 Steel take off of PEB hanger shed

5. Comparison on basis of design and analysis of hanger shed considering it as Conventional Steel Building and Pre Engineered

Points of Comparison	Pre-Engineered Steel Buildings	Conventional Steel Building
Structure Weight	Pre-Engineered Buildings are about 30% lighter through the efficient use of steel Primary framing members are tapered (varying depth) built-up plate sections with large depths in the areas of highest stress	Primary steel members arc selected from standard hot rolled "1" sections which are in many segments of the members, heavier than what is actually required by design. Members have constant cross section regardless of varying magnitude of the local stresses along the member length.
	Secondary members are light weight cold formed "Z" or "C" shaped numbers.	Secondary members are selected from standard hot rolled "I" and "C" sections, which are heavier.
Design	Quick and efficient. Since PEB's are mainly formed of standard sections and connections, design time is significantly reduced. Basic designs are used over and over: Specialized computer analysis and design programs optimize material required. Drafting is also computerized using standard details that minimize project custom details. Design, shop details sketches and erection drawings are supplied free of charge by the manufacturer drawings are usually prepared within 2 weeks. PEB engineers design and detail pre-engineered buildings almost every day throughout the year resulting in faster and more efficient designs. Consultant's in house design and drafting time is considerably reduced. Allowing more time for co-ordination and review, and increased margins on design fees	Each conventional steel structure is designed from scratch by the consultant, with fewer design aids available to the engineer. Substantial engineering and detailing is required on every project. Generalized computer analysis program require extensive input/output and design alterations. Extensive consultant time is devoted to design and drafting, as well as co-ordination and review, often at a significant expense. Each project is a special case; engineers need more time to develop the design and details of the unique structure. More complicated design requiring extensive design and drafting time from consultants.
Delivery	Average 6 to 8 weeks.	Average 20 to 26 weeks.
Foundations	Simple design, easy	Extensive, heavy

	to construct and light weight	foundations complicated.
Erection Simplicity	Since the connections of the components are standard, the learning curve of erection for each subsequent project is faster. Periodic free-of-charge erection ' support at the site is usually provided by PEB manufacturers.	The connections are normally complicated and differ from project to project, resulting in longer learning curves of erection for new projects
Erection Cost and time	Both cost & time of erection are accurately known, based upon extensive experience with similar buildings. PEBs are often erected by specialized PEB builders with extensive experience in the erection of similar buildings, offering very competitive rates. PEB builders usually have a stock of standard components, in their camps; enabling them to complete jobs on time should any shortage or site damage occur to materials. The erection process is easy, fast, step by step and with hardly any. Requirement for equipment. Erection is slow and extensive field labour is required. Heavy equipment	Typically, they are 20% more expensive than PEB. In most of the cases, the erection costs and time are not estimated accurately
	is often needed.	
Seismic Resistance	The low weight flexible frames offer higher resistance to seismic forces	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 steel.	Slightly cheaper sue to use of poor quality material.
Architecture	Outstanding architectural design can be achieved at low cost using standard architectural features and interface details. Traditional wall and fascia materials, such as concrete, masonry and wood, can be utilized.	Special architectural design and features must be developed for each project, which Often require research and thus resulting in much higher costs
Sourcing & Co-ordination	Building is supplied complete with cladding and all accessories, including erection (if desired) from one single source.	Many source of supply project management time is required to co-ordinate suppliers and sub-contractors.
Cost of Change Orders	PEB manufacturers often stock a large amount of basic raw materials that can he flexibly used in many types of PEB projects. Change orders are easily accommodated at all stages of the order fulfillment process. Little or no material is wasted even' if a change order is made after fabrication starts.	Substitutions of hot rolled sections that are infrequently rolled by mills is expensive and time consuming. Change orders that are made, after hot rolled sections are shipped for fabrication, often result in redundancies to a lot of hot rolled sections, which ultimately result in more cost to the end-user.
Building	Designed to fit the system, with	Every project requires special

Accessories	standardized, interchangeable parts, including pre-designed flashing and trims. They are mass produced for economy and are available with the building. They have been tried in thousands of existing buildings.	design for accessories and special sourcing for each item. Flashing and trims must be uniquely designed and fabricated
Future Expansions	All project records are kept in electronic format indefinitely, making it easy for the owner or designer to obtain a copy of his building records at any time. Future expansion is simple, easy and cost effective. One supplier can co-ordinate changes.	It will be difficult to obtain project records, after a long period of time. It is required to contact more than one party, involved I the project to obtain accurate information. Future expansion would be more difficult and more likely, costlier
Responsibility	Single source of supply results in total responsibility by one supplier, including design liability PEB manufacturers can be relied upon to service their buildings long after they are supplied to protect their reputation.	Multiple responsibilities can result in questions of who is responsible when components do not fit properly, insufficient material is supplied, or materials fail to perform, particularly at the supplier/contractor interface. The consultant carries total design liability.
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 a special application on a specific job. Design and detailing errors are possible when assembling the diverse components into unique buildings.
	Experience with similar buildings, in actual field Conditions worldwide, has resulted in design improvements over time, which allows dependable prediction of performance	Each building design is unique, so prediction of how components will perform together is uncertain. Materials which have performed well in some climates may not do so in other environments

6. Comment

As per the current case study if the Industrial Steel Building is designed for 70m x 25m x 13m for a particular site as per site requirement and the respective loading conditions as per the IS codes by using either portal frame truss, A-type frame truss, saw-tooth type truss or pre-engineered sections then the saw tooth type truss framed structure is found to be 60% more cost effective than other conventional type of trusses and in comparison to this the pre-engineered building is found to be more 30% lighter in weight, economical, strength full, highly efficient with minimum chances of error etc. and best suiting structure spanning from 20m to 80m for single storey building.

7. Conclusion

Hence the pre-engineered buildings are more advantageous over conventionally designed buildings in terms of cost effectiveness, time saving, future scope, subtleness and economy. This paper of comparative study between conventional and pre-engineered building shows their experimental and analytical studies carried out in this field. The results show that the steel structures are far more economical energy efficient and flexible in design than other type of structures for industrial use.

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