AN OVERVIEW OF PRE-ENGINEERED BUILDING SYSTEMS

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ABSTRACT: Pre-Engineered Building concept involves the steel building systems which are predesigned and prefabricated .The present construction methodology calls for the best aesthetic look, high quality & fast construction, cost effective & innovative touch. One has to think for alternative construction system like pre-engineered steel buildings. 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. This review is focused on the obstructing issues in pre-engineered building technology by the new emerging companies in India and the critical success factors that are involved in these systems. Also, the contribution of pre-engineered building systems in India in the economic growth of country through various applications is stated briefly.

Index terms : Eco-friendly construction, Metal Building systems, Pre-engineered Building; Pre-Engineered Building Systems; Pre-Engineered Technology; Prefabricated Buildings;

1.INTRODUCTION

TECHNOLOGICAL improvement over the year has contributed immensely to the enhancement of quality of life through various new products and services. One such revolution was the pre–engineered buildings. 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. 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. Pre-engineered buildings are those which are fully fabricated in the factory after designing, shipped to site in CKD (completely knocked down) condition; and all components are assembled and erected at site with nut-bolts, thereby reducing the time of completion.

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The designs were ready-made but the building components were either ready-made or manufactured against specific orders. These buildings were pre-designed or 'pre-engineered' into standard sizes, spans, bays and heights, and use standard details for fixing cladding, roofing, gutters, flashing, windows, doors etc. taking advantage of industrial practices of mass production of components economically.

2. CONCEPT

2.1 Pre Engineered Buildings

Pre-Engineered Building concept involves the steel building systems which are predesigned and prefabricated. As the name indicates, this concept involves pre-engineering of structural elements using a predetermined registry of building materials and manufacturing techniques that can be proficiently complied with a wide range of structural and aesthetic design requirements. The basis of the PEB concept lies in providing the section at a location only according to the requirement at that spot. The sections can be varying throughout the length according to the bending moment diagram.

This leads to the utilization of non-prismatic rigid frames with slender elements. Tapered I sections made with built-up thin plates are used to achieve this configuration. Standard hot-rolled sections, cold-formed sections, profiled roofing sheets, etc. is also used along with the tapered sections. The use of optimal least section leads to effective saving of steel and cost reduction. The typical PEB frame of the structure is as shown in the Figure.

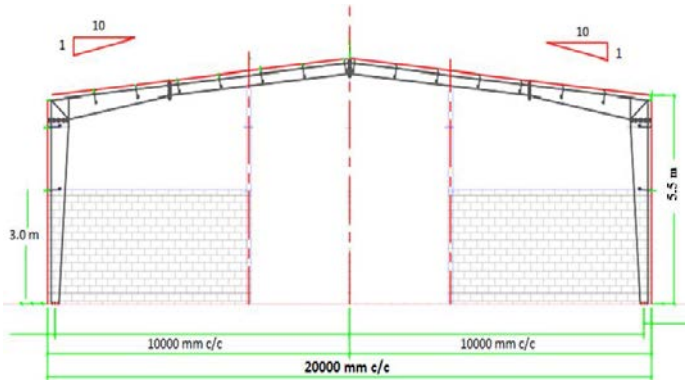

Fig .1 Single Frame of a Pre Engineered Building

2.2 Conventional Steel Buildings

Conventional steel buildings (CSB) 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. The CSB frame of the structure considered in the study is as shown in Figure.

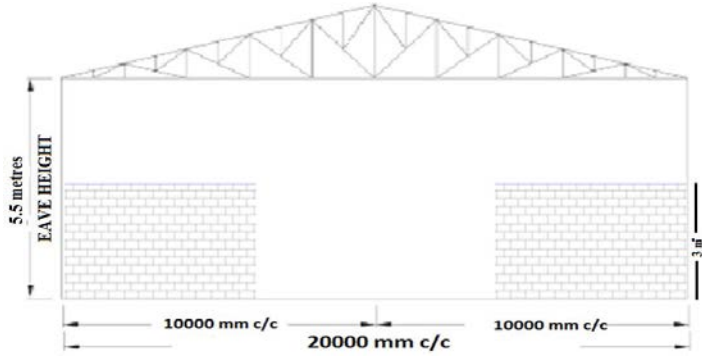

Fig.2 Single Frame of a Conventional Steel Building

3Superiority Over Conventional Buildings

Buildings are generally constructed in just 6 to 8 weeks after approval of drawings. PEB will thus reduce total construction time of the project by at least 30%. This allows faster occupancy and earlier realization of revenue. Because of systems approach, considerable saving is achieved in design, manufacturing and erection cost.These can be easily expanded in length by adding additional bays. Also expansion in width and height is possible by pre designing for future expansion.Buildings can be supplied to around 90m clear spans. This is one of the most important advantages of PEB giving column free space.Buildings are manufactured completely in the factory under controlled conditions, and hence the quality can be assured.PEB Buildings have high quality paint systems for cladding and steel to suit ambient conditions at the site, which in turn gives long durability and low maintenance coats.Buildings are supplied with polyurethane insulated panels or fibre glass blankets insulation to achieve required "U" values (overall heat transfer coefficient). Steel members are brought to site in CKD conditions, thereby avoiding cutting and welding at site. As PEB sections are lighter in weight, the small members can be very easilyassembled, bolted and raised with the help of cranes. This allows very fast construction and reduces wastage and labour requirement.

3.1Most Notable Advantages of modern PEB

- Economical Construction
- Fast construction time
- Low Maintenance cost
- Infinite choice of layouts
- Earth quake resistance
- Ease of Future Expansions
- Unique Aesthetic Appeal
- Larger Clear Spans

3.2 Diversified Applications

Applications of pre-engineered steel buildings include (but are not limited to) the following

- Industrial Buildings & WorkshopsWarehouses
- Commercial Complexes & Supermarkets
- Showrooms
- Corporate Office Buildings
- Schools
- Indoor Stadiums
- Outdoor Stadiums with canopies
- Fuel Stations
- Metro Stations, Bus Terminals, Parking Lots
- High-rise Buildings
- Customized Housing
- Large Exhibition Centres
- Aircraft Hangers
- Labour Camps
- Community Centres
- Railway Stations & Railway Storage yards
- Equipment housing/shelters
- Telecommunication shelters

Fig 3. Application of PEB

Fig. 4. Components of PEB building

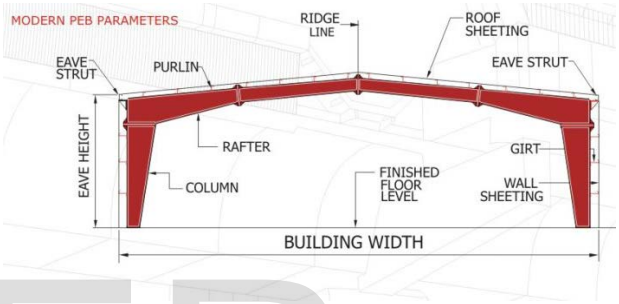

Fig. 5 Modern PEB parameters

4COMPONENTS OF PEB

4.1 Main Components

There are following major components in a pre-engineered building:

- Primary or Main frame
- Gable End framing or Wind columns
- Secondary frame or Purlins, girts etc.
- Roof & Wall Sheeting
- Bracing system
- Crane system
- Mezzanine system
- Insulations
- Attachments like canopies, fascia etc.
- Doors, Windows, Ventilators
- Accessories like Turbo vents, Ridge Vents, Skylights etc.

4.2Main Framing

Main framing basically includes the rigid steel frames of the building. The PEB rigid frame comprises tapered/straight columns and tapered rafters (steel plate fabricated 'I' or 'H' sections are referred to as built-up members). The frame is erected by bolting the end plates of connecting sections together.

4.3 Secondary frame or Purlins, girts etc.

Purlins, girts and eave struts are also known as secondary cold-formed members. There is no welding involved in their preparation. They are prepared by press bending the HR steel coil giving it the desired shape(Z- or C-shape).

4.4Roof & Wall Panels

Metallic plain or colour coated profiled steel sheets are usedas roof and wall sheeting. The steel sheets are generally made from Zincalume or Galvalume coils in thickness range of 0.47mm to 0.55mm. The base steel is either galvanized having a zinc coating varying from a minimum Mass of 120 gsm./m^2 to a maximum of 275 gsm./m^2 (total of both sides) or a base steel coating of zinc – aluminum (zinc 45%, aluminum 55%) of total Mass of 150 gsm./m^2 (total of both sides) are available with permanent colour coating. The colourcoating is also available in various options in polyester paint coating like regular modified polyester, silicon modified polyester andsuper polyester coatings. Special organic coatings like

PVF2 (Poly Vinyl Fluoride) are also made available. These various colourcoatings on the base steel with galvanized or zinc aluminium coating provides suitable resistance for various kinds of environment hazards. Metal roofing and siding profiles can be manufactured to any length – limited only by transportation constraints (usually to 12 meters). To eliminate water ingress, generaloverlap joint considered is 15 cm to 20 cm.It also has a major advantage for the designers as itallows roofing with minimum pitch which is a rarecase in conventional buildings. This happens due tojoint-less run of roofing as it has flexibility in cuttingof lengths. Slopes as shallow as 1:20 are possiblewhich allows sufficient drainage of water therebyimproving long term performance of the panels.These profile steel sheets are conventionallycategorized into two types depending upon the typeof fine-tuning arrangement followed. These two typesare Through Fastened and second one is StandingSeam. Installation of this type of roofing & claddingsystem can provide 30 years or more of trouble-freeaccommodation in most environments.

4.5 Bracing system

Longitudinal cross bracing, used to provide lateral stability to the structureagainst wind, seismic or other forces, comprises of rods, pipes, angles or cables with an eye bolt and an adjusting nut at both ends, located near the outer flange of columns or rafters and attached at the web of the rigid frame.

4.6 Crane systems

These pre–engineered buildings can be equipped with Overhead EOT cranes, Semi-gantry cranes, wall mounted cranes, Mono rails and under slung cranes for various material and equipment handling operations inside. These buildings are being designed for crane capacities ranging from 1MT to 250MT. The crane runway beams (Gantry Girders) are simply supported built-up sections with/without cap channels and with maintenance platforms and ladders. Catwalks for crane maintenance are usually mounted alongside the crane beams, suspended under rigid frame rafters or elevated above the top of the building roof. Cranes at various levels can also be provided. PEB vendors generally do not keep the supply of rail and Crane Bridge with crane in their scope.

4.7Mezzanine systems

Standard mezzanine structure consists of built-up beams that support built-up, hot-rolled or cold-formed mezzanine joists which in-turn support a metal deck. A concrete slab is cast on the metal deck as a finished surface. Steel checkered plates may also be used as top surface. These mezzanines are used for office space, storage or equipment supports in industries. For commercial buildings and high-rise structures several types of light weight panel boards are available as horizontal surface.

4.8 Insulations

These buildings can be properly insulated by providing fibrous insulation slabs/rolls of non-combustible Rockwool, Aluminum foil laminated, placed over a metal mesh bed created between the purlins, and then the roofing steel sheet fixed over it. The siding walls can also be insulated by providing a double skin profile steel sheet wall cladding having Rockwool Insulation slab sandwiched in between and held in position with the help of 'Z' spacers in between the two profile steel sheets. In similar pattern a double skin insulated roofing system can also be erected.

4.9 Sandwich Panels

Sandwich panels are generally adopted for thermallyefficient roof and wall claddings forbuildings whichis especially suited in high altitude areas and coldstorages. It is an alternative to the pre-fabricatedinsulated panels. It generally comprises of two-singleskin panels with polyurethane foam insulation inbetween. It is extensively adopted in non-residentialandresidential buildings which also has goodinsulation properties and noise reduction properties..

4.10 Paints and finishes

Paints and finishes protect the surface deterioration which happens due to the interior environment and exterior environment of the structure. In general, synthetic enamel and epoxy based paints are used for painting and finishing purposes as per therecommendation of architect/client.

4.11 Accessories, Attachments etc.

Accessories and attachments are governed by the functional requirements and architectural aesthetics of the structure. Hence, they are supplied in ready fit condition. Also, the ventilation systems and lighting systems are to be designed and attached by consulting an expert.

4.12 High Strength materials

The ordinary construction utilizes the steel having nominal yield stress of approximately 250 MPa whereas the PEB construction uses steel of yield stress approximate to 340 MPa. This recent change in grade of structural steel is due to the revision ofIS2062:2006. There are reliable manufacturers for these steel manufacturers like TATA, SAIL, etc. who are manufacturing these in India. New materials like Fe 540B gives yield stress of around 410 MPa which has thickness lower than 20 mm and the galvalume or zincalume roofing and wall sheets having strengths in the range of 550MPa.Steel is popular in construction due to the flexibility it provides in design, its material strength, unorthodox geometry and volume

to weight ratio. Also, economical fabrication can be done along with easy erection.

5 CRITICAL SUCCESS FACTORS AND ISSUES OF PEB IN RECENT MARKET SCENARIO

There are some critical success factors analyzed over a period of time which are posing threat to the flourishment of this metal building systems. They are as follows:

Fig. 6. Critical Success factors

6.1 Increased Technical Competence

Technical competence is the critical base and a necessity for surviving in the industrial competition. Mostly, the companies which cannot invest in their own in-house R&D section, they are mostly forming an alliance with reputed companies in order to offer more quality products. Hence, rather than investing in their own R&D, that much amount is utilized in buying of products and rewarding the companies with the profit associated with the members. PEB construction is not recommended for high rise buildings as it is not the ideal choice for the factory buildings to sustain very high dead loads and live loads. Hence, the engineering expertise offer low-rise factory buildings and its aesthetic requirement with large spanning capacity and other operational uses soas to place the company in a better competition to handle competition.

6.2 Standardization and Modularization

All projects have a primary aim to be achieved, i.e., to build a structure fulfilling the customer's specifications. So, to extract the profit out by fulfilling the customer's need, you need to develop some production strategies like standardisation and modularization of the building components. It also enables better transportation planning which adds to the benefits of standardization and modularization.

6.3 Closer alignment between manufacturing arm and other supply chain partners

There is repetitive process of manufacturing and supplying. Hence, the manufacturing arm and supply arm should create a harmonial relationship. Thisarises the need of Supply chain management which will help to strengthen the alliances with subcontractors and raw-material suppliers which would result in reduction of logistics cost for the company. This will bring overall economy to the project.

6.4 Price Competitiveness

Steel fabrication can be done with expensivemachineries as well as low cost machineries too. Thisallows open competition and no barrier like conditionfor new comers. Hence, no single company has aclear brand advantage as the competition on priceranges from Rs.75-95/kg. Hence, major decidingfactor is the delivering charges charged by the companies. So it's a major decisive concern.

6.5 End user needs

End user needs are to be identified well and derive benefits out of it, you need to develop and modify the production and supply chain strategies to stay in forefront of the competition. This can be done collaboratingwith supplychain partners, taking theirregular customer feedback and forging strategic alliances with the large builders to forecast their own product demand.

6.6 Develop suitable marketing strategies

To develop marketing strategies, it is essential to know the market restrained for PEBs. After identifying the market restrainer's, it should be mitigated by educating public about the benefits of PEBs. To appeal the customers with attractive marketing strategy to various residential customers which would open an entirely new dimension for them? This will promote the brand awareness as well as trust over the company which would be a major differentiating factor.

7ISSUES IN PEB

There are few issues in PEB which are discovered over a large period of time thorough examination during erection and under seismic conditions as stated below:

7.1Fire Protection

Fire protection systems are still a major issue of concern for steel structures when compared to concrete or other

construction materials. The smaller members and thermal mass of the steel structures makes it more hazardous. The catastrophic failure of WTC tower in USA due to fire caused by burning of aviation fuel and sudden escalation of temperature lead to devastation of structure which is still a rigid part of memory. Structural cost of building comprises of good share of fire protection systems. Hence, engineers are challenged to reduce the cost of fire protection systems and also to assure adequate resistance to devastating situations caused due to fire.

7.2 Buckling

Buckling and stability are also the major issue of concern in PEB. Due to this, maximum eave height is limited generally to 25m to 30m and also stability iscritical due large clear span.

7.3 Micro Cracks

With progressing time, it is observed that increasing yield stress, operating stress levels, emphasis on plastic and ultimate capacity and the use of welded construction have resulted in increased frequency if initiation of micro-cracks which causes fracture in bridges and other industrial buildings. This micro cracks and its crack growth is more hazardous in seismic areas.

7.4 Corrosion

Steel has great tendency to corrode when exposed to the environment, which leads to deterioration, increased maintenance costs, and increased reconstruction costs. Although Galvanization, paint, and coatings may provide protection against corrosion, yet they increase the overall fabrication costs of the steel structure appreciably. In hot and humid regions and industrially polluted severe environments problem is more pronounced. Therefore, engineers have to continually seek economically viable solutions to aim at reducing these costs.

7.5 Welding

Presently welded constructions are more commonly used, for these provide stiffer, stronger structures with reduced building weight. Increased steel yield strength requires new innovative welding methods, because high strength steels pose more difficulty to weld without affecting adversely the ductility and performance of the structural system. Recently the use of fully automatic and semi-automatic submerged arc welding results in increase in welding speed apart from the good quality. The elimination of any fumes, smoke or any visible arc column gives an ease of operation and efficiency; better quality & thus encourages its application in welding industry.

7.6 Ductility from Seismic Considerations

Seismic design is today a must requirement for almost all civil engineering structures. Although steel is an ideally more suited material from point of view of seismic design because of its property inherent material strength, stiffness, and ductility. Weld ability may affect the seismic performance and it follows that new methods to improve inelastic seismic performance of steel structures need to be investigated.

8 SCOPE IN INDIA

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 progressivecompanies are seeing the benefits of PEB's.

* PEBs needs a huge initial investment.
* Indian education has most of the focus on RCC buildings in course curriculum and hence advancement in steel construction is ignored.
*. IS codes should be modified as the sections selected are found to be heavier mostly.
*Hence, Pre-engineered building has a wide scopefuture in India as they are still not preferred today.

CONCLUSION

- Pre-engineered steel structures building offers 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.
- Most attractive economy in civil engineering construction can be achieved by optimum use of steel of high grade and composite form of construction with improved materials.
- But, there are some aspects that are needed to be addressed in the immediate future:

1. PEBs needs a huge initial investment.
2. Indian education has most of the focus on RCCbuildings in course curriculum and henceadvancement in steel construction is ignored.

3. Fire-fighting protocols in steel buildings haveto improve as per the customer's

concern.

4. IS codes should be modified as the sectionsselected are found to be heavier mostly.

Hence, Pre-engineered building has a wide scopefuture in India as they are still not preferred today.

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