Planning and Design of Pre-Engineered Buildings (PEB)

An Online Continuing Education Course for Engineers

Course Number: BD-3027

Credit: 3 Hours / 3 PDH / 3 CPD

Planning and Design of Pre-Engineered Buildings (PEB)

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1. Introduction:

Over the past several decades, the accelerated adoption of steel in construction has led to its widespread use across a variety of building types. Many of these structures share similar specifications, functions, and architectural requirements. To enhance efficiency within the industry, the concept of pre-engineered buildings (PEBs) was introduced, aiming to reduce the time required for planning, design, detailing, material procurement, fabrication, and erection.

This efficiency is achieved through the provision of standardized design sections (profiles) that accommodate a broad range of building spans and lengths, along with uniform accessory dimensions, including purlin clips, fascia parapets, sliding doors, canopies, and roof extensions.

This course provides a comprehensive examination of key aspects of the PEB industry. It begins with the planning of structural systems for pre-engineered buildings, including the optimal selection of systems to meet functional requirements, followed by the determination of structural loads acting on PEB structures.

The course offers an in-depth analysis of primary structural systems—such as clear span frames, multi-span frames, and multi-gable frames—secondary structural systems—including braced frames, transitions, expansion joints, jacking systems, and end wall systems—and sub-structural elements, such as purlins, girts, and eave struts. Additionally, crane-supporting systems, including crane brackets, separate columns, stepped columns, and trussed columns, are examined.

The structural loads considered include dead, roof live, live, snow, dust, sand, machinery, crane, wind, seismic, temperature, and settlement loads.

Following load determination, the course addresses the analysis and design of these systems. Emphasizing one of the primary advantages of PEBs—cost-effectiveness—the course also presents guidelines for selecting the most economical sections for each structural system.

This course covers the following topics:

1. Concept of pre-engineered buildings (PEB).
2. Dimensioning of PEB.

3. Main structural systems in PEB.
4. Secondary structural systems in PEB.
5. Sub-structural systems in PEB.
6. Crane-supporting systems in PEB
7. Structural loads on PEB: dead, roof live, live, snow, dust, sand, machinery, crane, wind, seismic, temperature, and settlement loads.
8. Analysis and design of structural systems of PEB.

2. Concept of Pre-Engineered Buildings (PEB):

The pre-engineered buildings are steel buildings with selected typical sections, materials, connections, wall and roof panels, architectural components, etc.

They are commonly used in factories, warehouses, cold-stores, car parking garages, showrooms, mega malls, schools, sports halls, aircraft hangars, material storage facilities, barracks, poultry buildings, etc.

The benefits of the pre-engineered buildings are summarized as follows:

- The low cost of materials, especially when using built-up steel sections, as the designer has the choice to select the most economical sizes of the steel section (web depth, web thickness, flange width, flange thickness).
- The low cost of engineering services: since most of the components of the building are pre-engineered or specially designed, but under a narrow range of options, the engineering time becomes less than the ordinary design and detailing services of other steel buildings.
- The resulting scrap from the production process is less than the scrap resulting from the fabrication of hot-rolled members.
- The fabrication quality is guaranteed due to the controlled environment of the fabrication workshops. Materials are purchased in accordance with ASTM specifications, and the welding processes are performed by certified AWS welders.
- Pre-engineered buildings provide large unobstructed spans up to 400 ft, and spacing between columns up to 100 ft.
- The addition of future extensions to the building is easy because of the modular nature of the pre-engineered buildings.
- From an aesthetic point of view, the PEB provides different wall panel colors, sub-secondary steel systems to be integrated with other facade systems, such as GRC, glazing, curtain walls, etc.
- The maintenance of the building is easy, starting from cleaning the panels, washing the eave gutters, and the periodic tight of the connection bolts for crane/machinery supporting structures.

The typical pre-engineered building consists of:

- The main structural system: this system is the main gravity supporting system, which may also resist the lateral loads (wind or seismic) in one orthogonal direction of the building. It is typically a portal frame system or truss system. It has typical sizes to give the flexibility to the designer to cover the required span set by the owner.
- The sub-structural systems: they are other systems provided in the building to provide local supports to gravity loads or lateral loads in certain areas in the building, such as: bracing systems, end wall systems, jacking systems, and expansion joints.
- Secondary framing elements: include roof purlins, side wall girts, end wall girts, and eave struts. These elements are supported by the main structural systems and used to support the roof or wall coverage panels.
- Roof and wall coverage panels: these panels are used to produce an envelope for the building, such as single-skin sheeting, sandwich panels. These panels are provided with some accessories such as trims, beam mastic, foam enclosures, pipe flashing, gutters, and downspouts.
- Flooring systems: such as the mezzanines used to support the heavy live loads, such as administrative floors, machinery supporting floors, etc. The mezzanines are covered by concrete on a metal deck, grating, or checkered plates. They also include roof platforms that are used for maintenance purposes above the building roof, catwalks used for maintenance purposes under the roof level, such as cranes, machinery, pipelines, etc. The flooring systems are provided by some egress means, such as staircases, ladders, etc.
- Crane-supporting systems: bracket system, separate column system, trussed-tower system, and stepped column system.
- Connecting elements: bolts, anchor bolts, sheeting fasteners.
- Building accessories: include personal doors, sliding doors, roll-up doors, windows, framed openings, louvres, roof curbs, ventilators, translucent panels.

Figure (01) shows the components of roof and wall sheeting panels in a typical pre-engineered building.

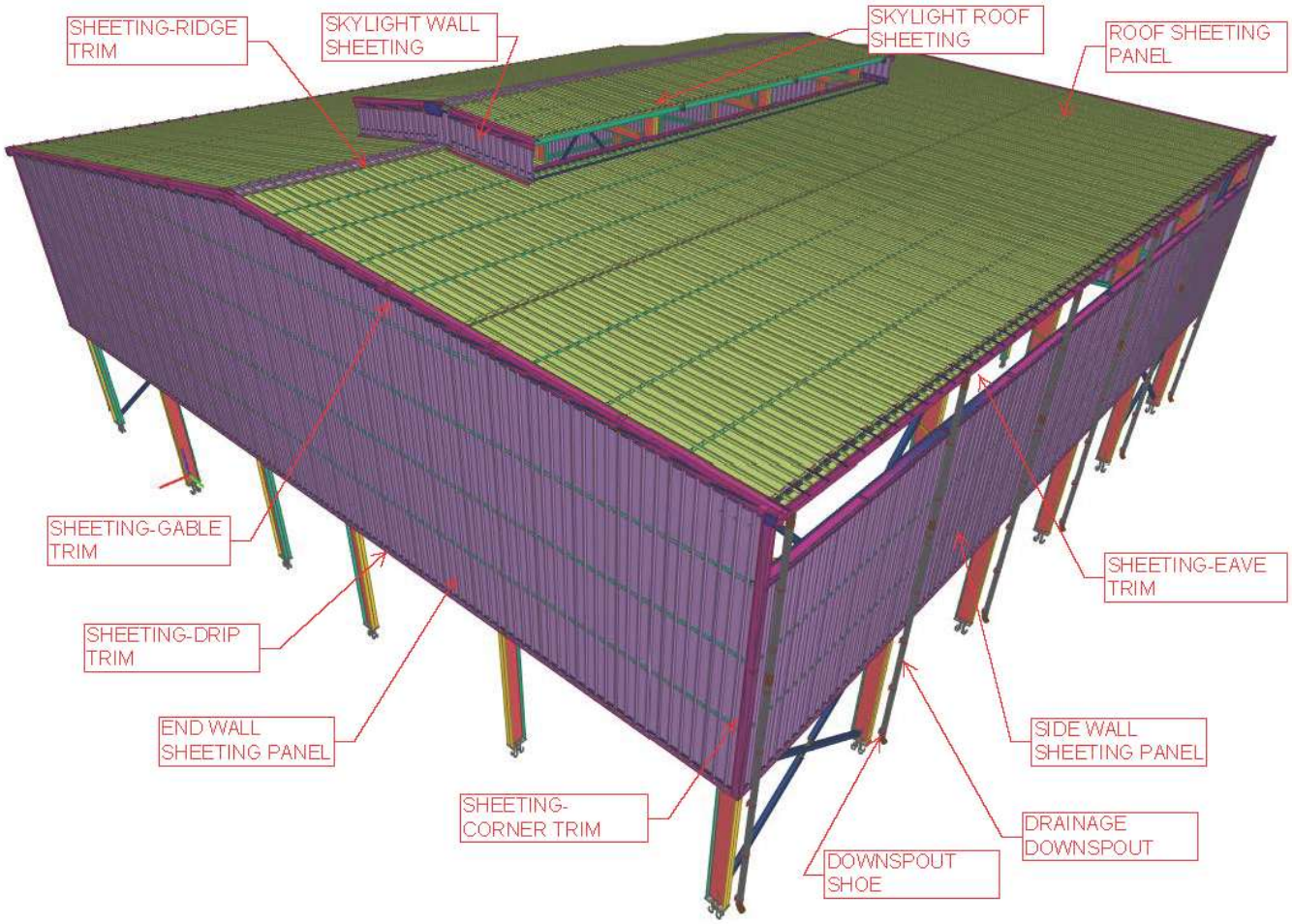


Figure (01). Components of Roof and Wall Sheeting in PEB Building

Most of the PEB companies have typically designed and detailed items for the roof and wall panels. This is achieved by selecting constant critical dimensions of the building, such as distance from the main system column edge to the side wall sheeting steel line, end wall column edge to the end wall sheeting steel line, to get the same sizes of sheeting trims, purlin clips, and girt clips.

Figure (02) shows the components of main, secondary, and sub-structural systems in a typical pre-engineered building.

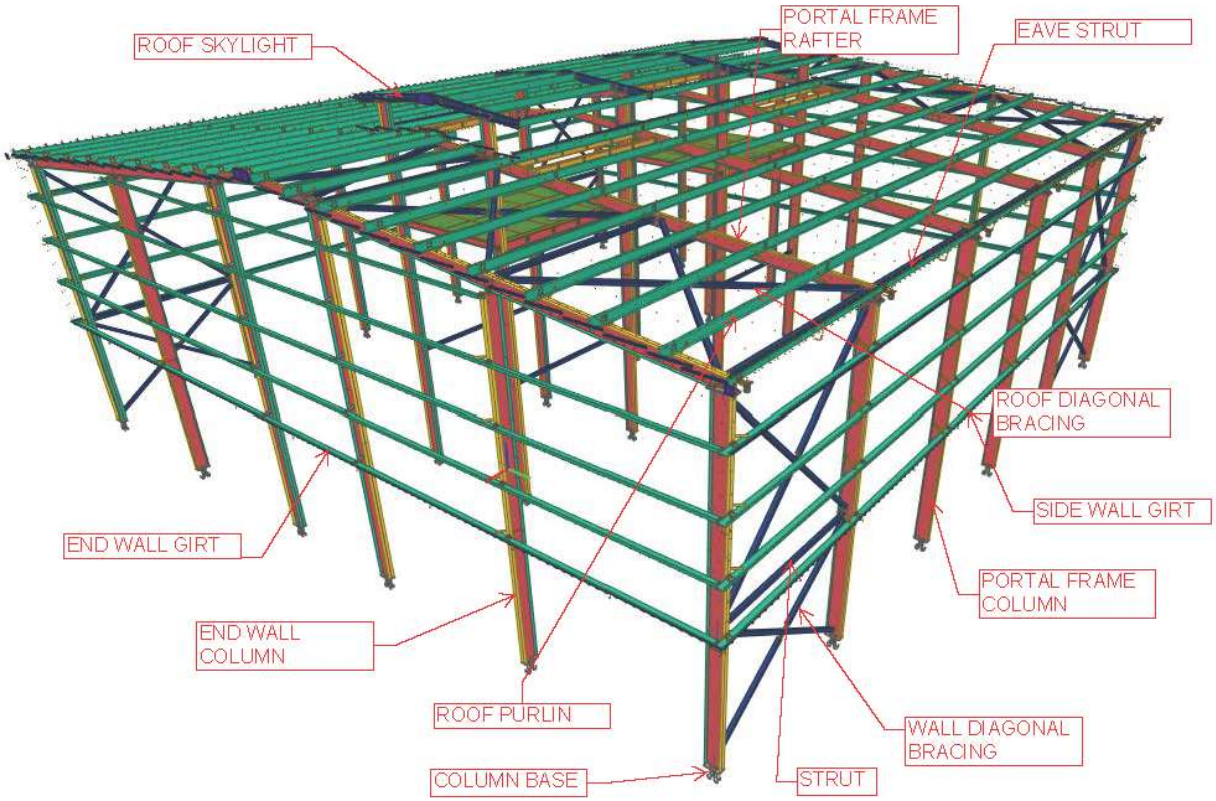
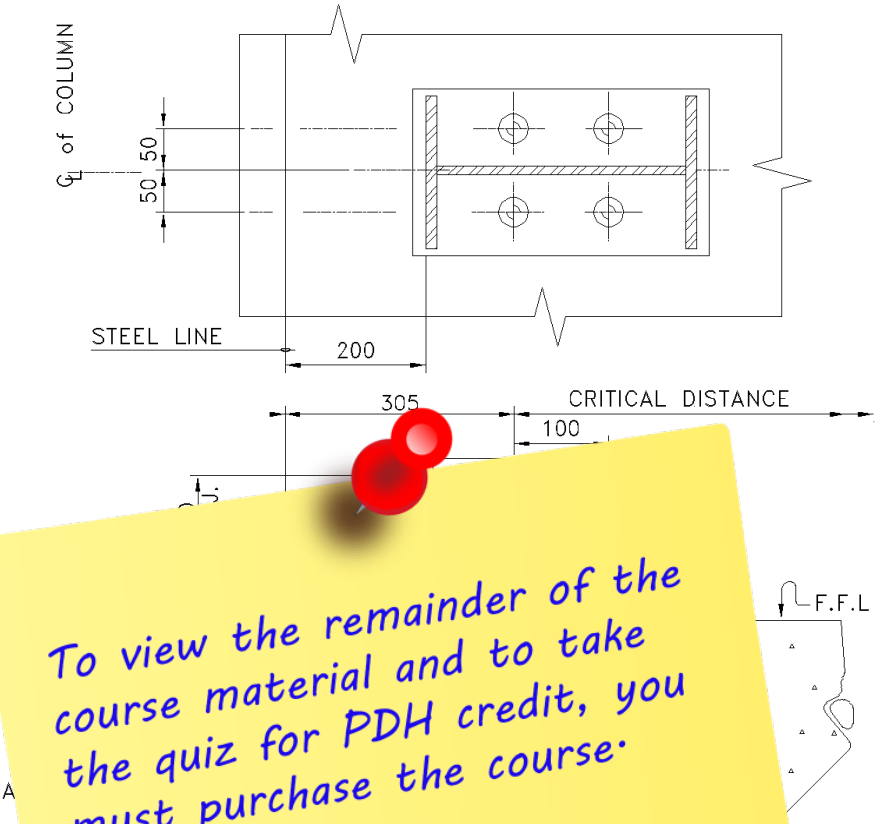


Figure (02). Components of Roof and Wall Sheeting in PEB Building

Figure (03) shows a typical base detail for a main frame column in a PEB building. There are many fixed dimensions in the detail:

- The distance between the steel line (back of wall sheeting panel) to the outer flange of the column is set to be 200 mm. This fixed dimension results in all clips of wall girts and eave struts having the same size.
- The spacing of the anchor bolt is set to be 100 mm in both directions. This makes the configuration of the punching process still the same for all base plate dimensions; therefore, the punching process will be performed faster.
- The distance between the steel line and the first outer anchor bolt is 305 mm, which makes the "critical distance" (the distance between the outermost anchor bolts along the frame span) still the same for all columns, regardless of the depth of the column at base.



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