Design of Steel Domed Structures

An Online Continuing Education Course for Engineers

Course Number: S-2026

Credit: 2 Hours / 2 PDH / 2 CPD

Design of Steel-Domed Structures

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Overview:

Domed structures are widely used in many types of buildings, such as museums, churches, mosques, old historic buildings, and many other similar buildings because they have an amazing view from outside and inside the building.

They are also used in industrial plants, such as cement plants, for the storage and blending of limestone and cement clinker. The advantage of domed structures are listed below:

- They give large spans for these areas up to 500 feet.
- They provide precise, easy, and handy material handling operations under one roof, such as loading, unloading, transportation, storing, and feeding.
- They maximize the space for labor for all operational works.
- They maintain energy efficiency levels.
- They provide additional spaces for future extensions.

This course especially discusses the domed steel structures for industrial use, as they have additional structural requirements differing from historical buildings.

This course covers all structural design processes, starting from choosing of statical system, determination of loads, analysis, and design of structural members. It also covers the erection methods of the domed structure.

This course involves a deep study of the determination of loads on domed structures in accordance with ASCE7-22.

This course covers the following topics:

1. Shapes of domes structures.
2. Statical systems of domed structures. (Roof, walls, secondary members)
3. Loads acting on the domed structure. (Dead, Roof Live, Snow, Wind, Dust, Temperature).
4. Serviceability of domed structures.
5. Erection method.

1. Shapes of Domed Structures:

From a geometry point of view, the domed structures have two basic shapes:

i. Domed structure with columns:

This type is used when it is a required clear height at the edge of the building below the roof beams, as shown in Figure (01).

ii. Domed structure without columns:

This type is used when it is not a required clear height at the edge of the building below the roof beams. Also, it gives a beautiful look from the outside of the dome, as shown in Figure (02).

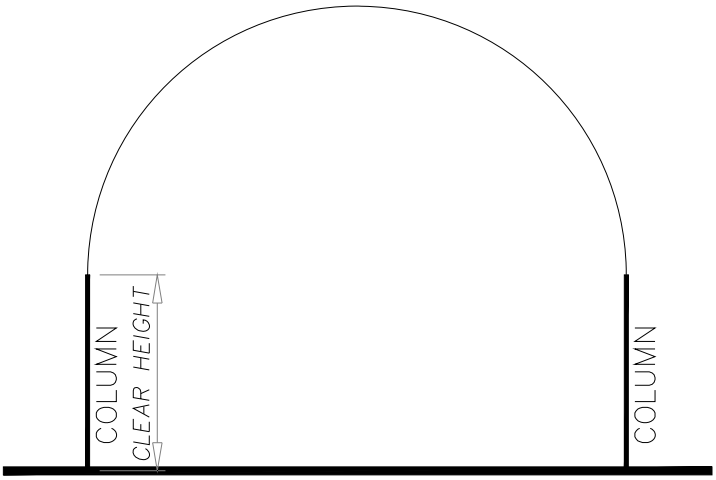

Figure (01). Domed Structure with Columns

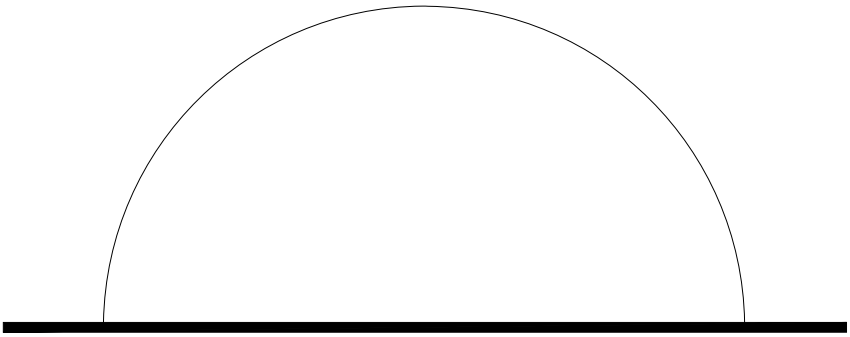

Figure (02). Domed Structure without Columns

2. Statical Systems of Domed Structures:

Domed structures are composed of several structural components. The designer shall choose the proper statical system for each structural component.

The proper statical system shall satisfy the following requirements:

- Economic design of steel sections.
- Ease of fabrication and erection.
- Fulfillment of building functions and serviceability.

Components of domed structure:

- Radial main system.
- Roof system.
- Wall system.
- Roof coverage system.
- Wall coverage system.

i. Radial Main Systems:

Typically, the main radial system is either a moment portal frame or a trussed frame. Choosing one of them depends on the span (or diameter) of the domed structure and the architectural requirements of the building.

Sometimes, the architect requires that the main radial system be a trussed frame for a beautiful architectural view.

It is practical to choose a moment portal frame system for spans less than 500 feet, as it will be cheaper than the truss system, which costs higher fabrication costs.

The number of main radial systems required to cover the building area depends on the required tangential spacing of the main radial system at the edges of the building.

This spacing shall not be large enough to reduce the span of the wall girt because the girts will be simply supported and cannot be continuous because of the domed shape of the wall. The simply supported girt is subject to higher flexure compared to continuous girt; therefore, the span shall be reduced as possible.

Reducing the tangential spacing will lead to a reduced span of roof purlins at the edge, which leads to the economic design of roof purlin.

Radial main systems shall be connected to middle ring beams at the middle of the roof, as shown in Figure (03) in green color. This ring beam assures the stability of all main systems forming the domed structure.

For domed structures with large spans, an intermediate sub-beam shall be provided between any two non-adjacent, as shown in Figure (03) in yellow color. This is to eliminate congestion of main systems at the middle ring beam and to ease the fabrication and erection of the domed structure.

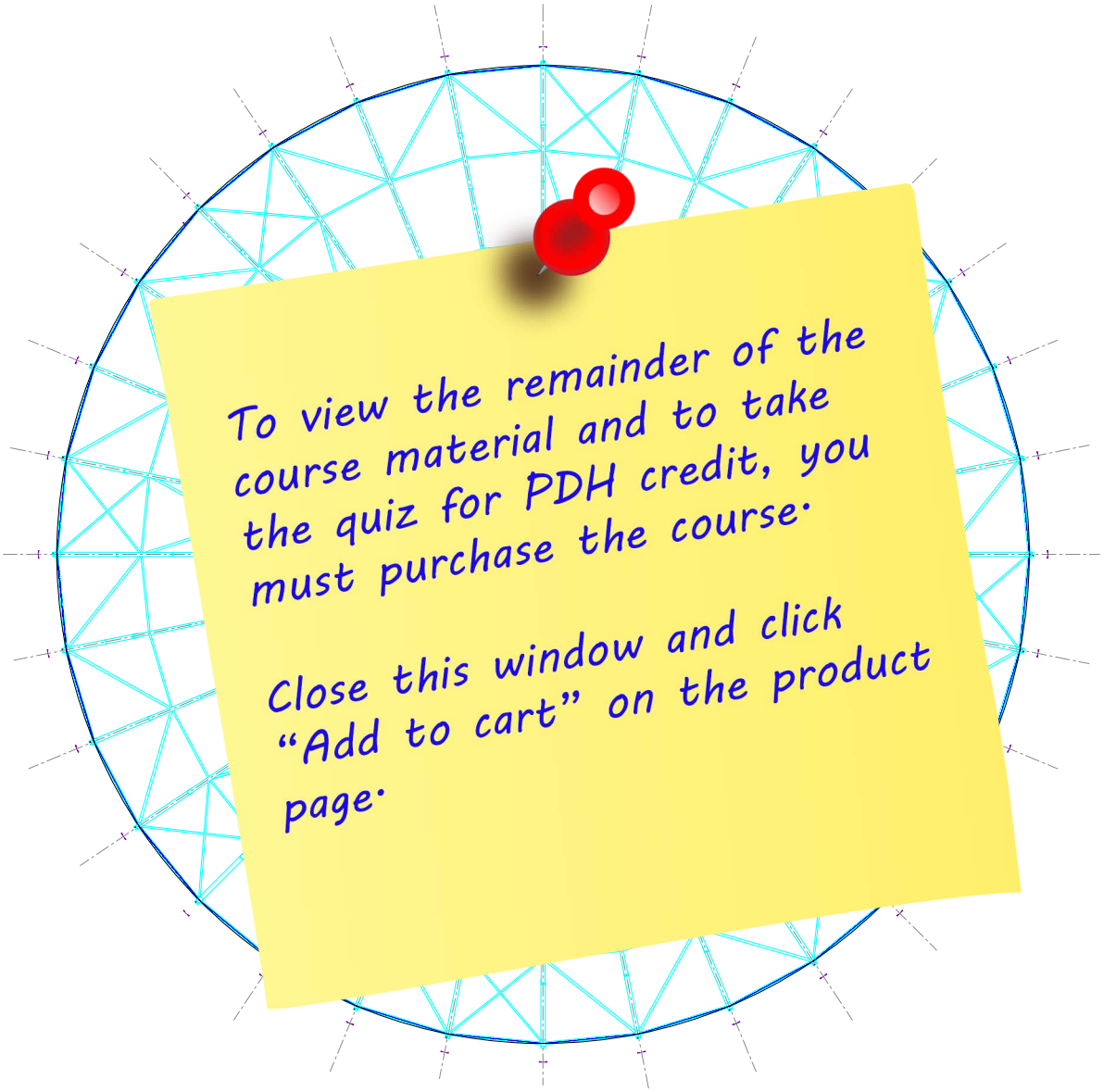

Figure (03). Roof Plan of Domed Structure

The roof beam of the main moment frame may be segmented or domed, as shown in Figure (04); the segmented beam has a fabrication cost less than the domed one.