



Ministry of Higher Education and Scientific Research
University of Salahaddin
College of Engineering
Architectural department



Truss, Portal frame and Space frame AS Roofing System

Prepared by: Assist. Lec. Sakar

26.2.2023

Truss

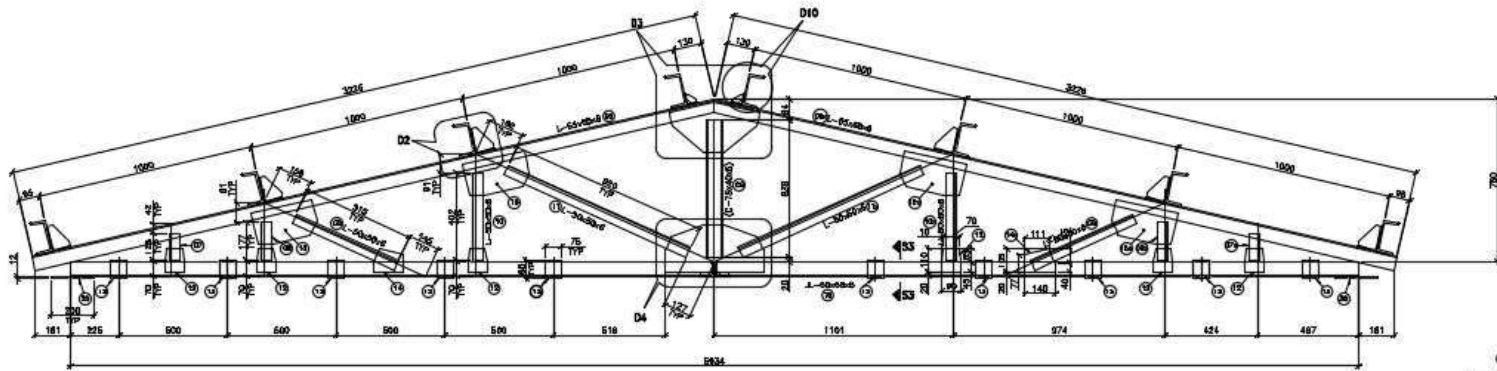
- A **truss** is an assembly of *members* such as beams, connected by *nodes*, that creates a rigid structure.
- In engineering, a truss is a structure that "consists of two-force members only, where the members are organized so that the assemblage as a whole behaves as a single object".
- A "two-force member" is a structural component where force is applied to only two points. Although this rigorous definition allows the members to have any shape connected in any stable configuration, trusses typically comprise five or more triangular units constructed with straight members whose ends are connected at joints referred to as *nodes*.

What is a roof truss?

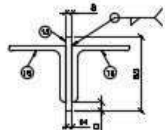
- A roof truss, also known as a trussed rafter, is a prefabricated structural framework which is used to support the roof on a building.
- [Roof trusses](#) are predominantly triangular in shape, and they typically include triangular shapes in various configurations to suit the roof's pitch, size or design.
- Triangles are commonly used in construction due to their practicality and their ability to enable finite control of loads, making them ideal for roof structures.
- Roof trusses are made **off-site**, then lifted into place where they are secured into the roof structure of a building.
- There are two main roof truss types – flat and pitched.
- These truss types can be categorised into more specific truss types, all of which are suitable for a range of different construction applications.

Truss production flow chart at factory

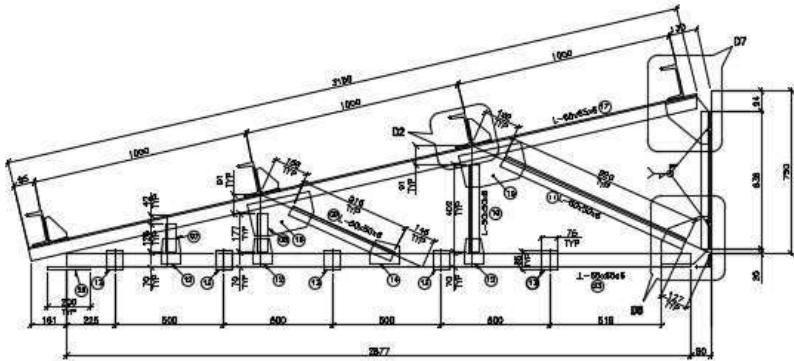




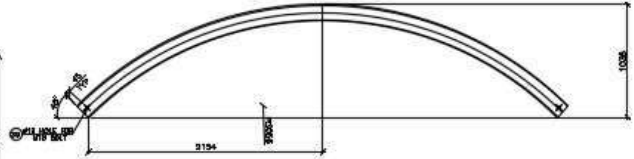
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 (SCALE 1:100)



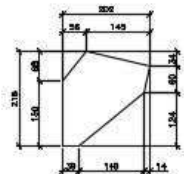
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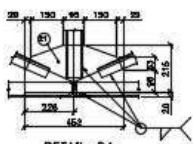
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DETAIL-D8x (drawing)
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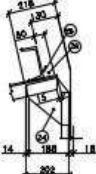
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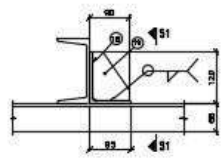
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DETAIL OF ITEM NO: 24x (drawing)
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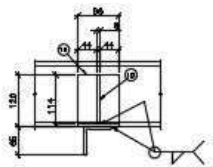
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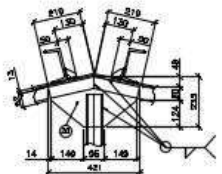
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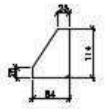
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DETAIL-D2x (drawing)
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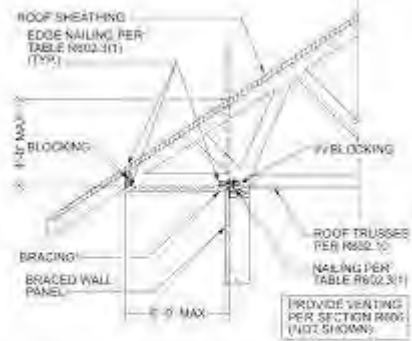
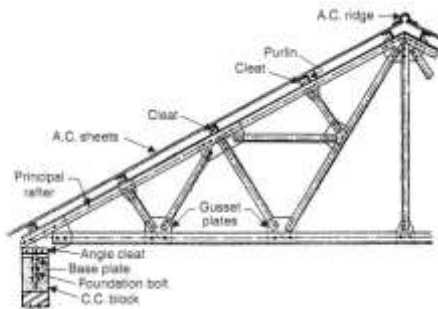
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DETAIL-D3
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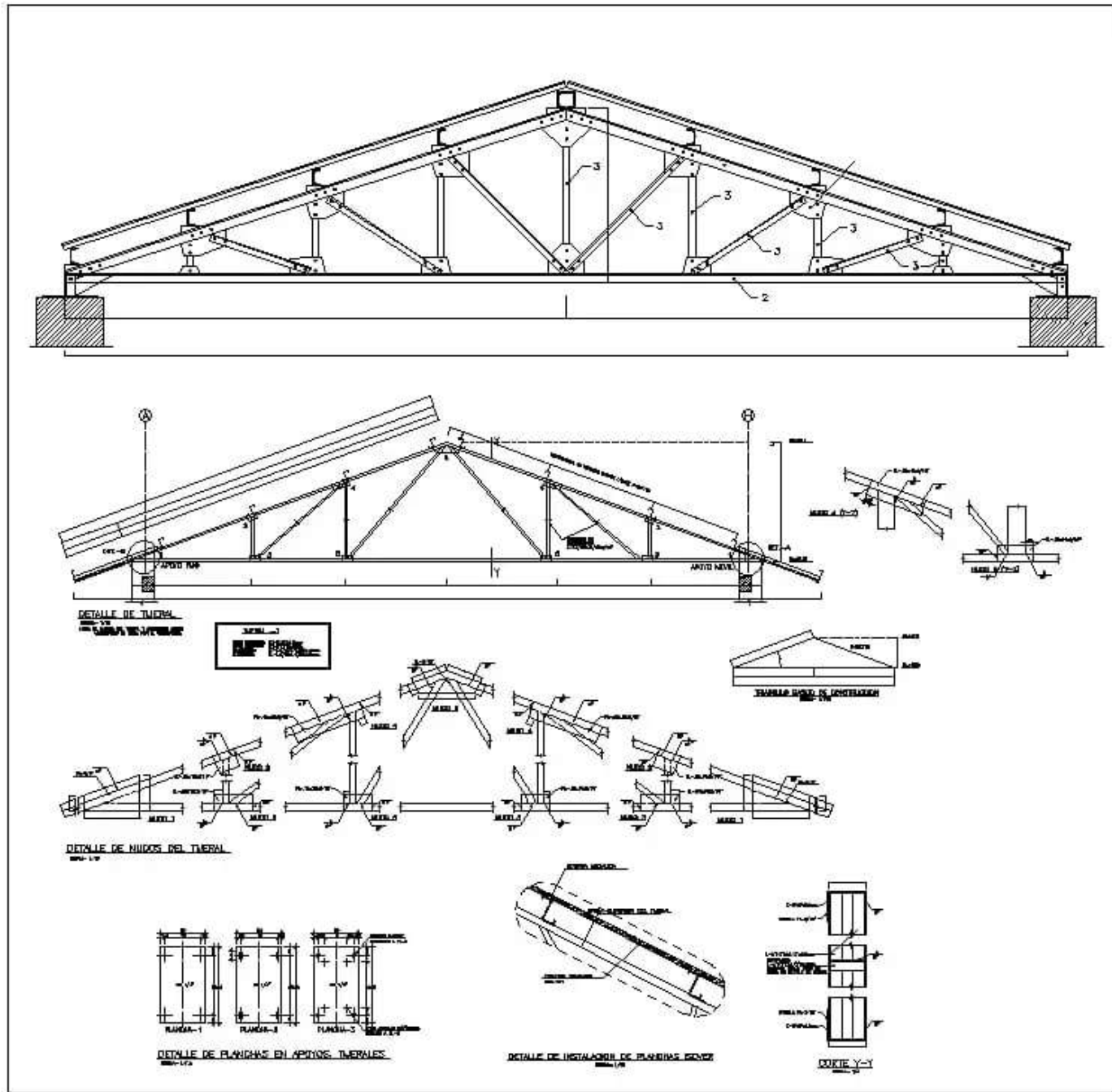


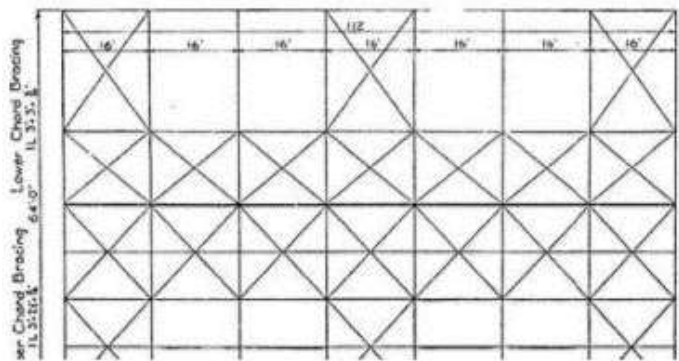
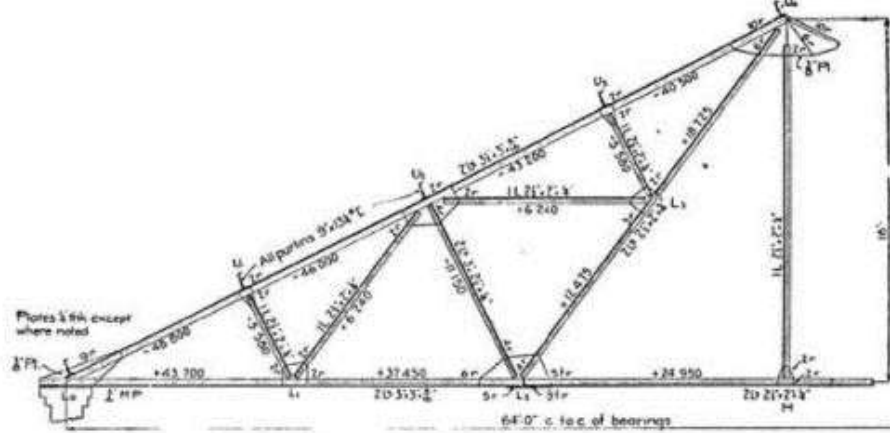
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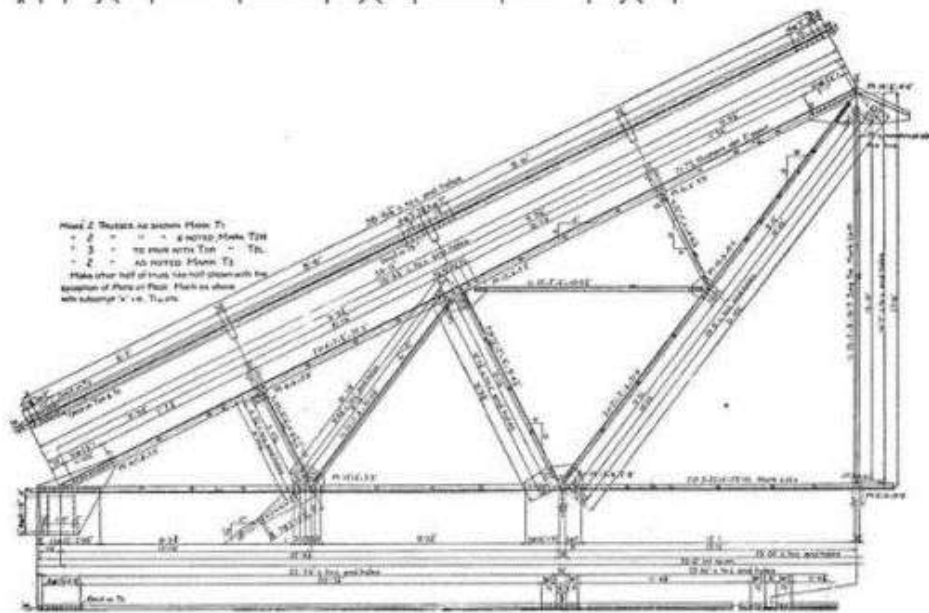
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
Methods of fastening shall be as described in Section R602.10.4.

FIGURE R602.10.6.3(2)
BRACED WALL PANEL CONNECTION OPTION TO
PERPENDICULAR RAFTERS OR ROOF TRUSSES





STRESS SHEET FOR FINK TRUSS ROOF



Portal frame

- Portal frames are generally low-rise structures, comprising columns and horizontal or pitched rafters, connected by moment-resisting connections. Resistance to lateral and vertical actions is provided by the rigidity of the connections and the bending stiffness of the members, which is increased by a suitable haunch or deepening of the rafter sections.
- This form of continuous frame structure is stable in its plane and provides a clear span that is unobstructed by bracing.
- They are very efficient for enclosing large volumes, therefore they are often used for industrial, storage, retail and commercial applications as well as for agricultural purposes.

Portal frame

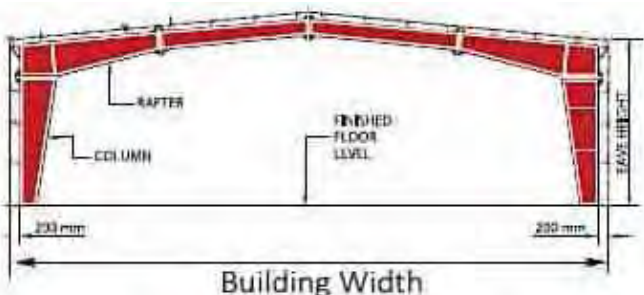
- Portal Frame Steel Buildings use the portal frame as the force carrier, and the enclosure structure is a system of thin-walled C/Z-shaped steel purlins and colored profiled steel plates.
- It is a new type of building structure system widely used.
- It has the advantages of being lightweight, having a high degree of industrialization, having a short construction period, having high comprehensive economic benefits, and having a flexible column network layout.



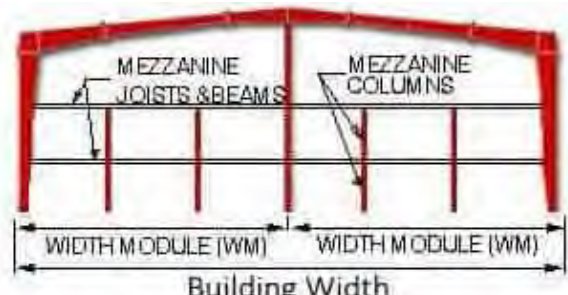
Form of Rigid Frame

- The portal frame structure comes in several shapes, including single-span, double-span, high-low-span, and multi-span, with options such as a single ridge, multiple ridges, single slope, double slope, multiple slopes, and a flat slope.
- **Single-span** rigid frames are commonly used in buildings that don't need much lateral space and have spans ranging from (9) or 18 to 36 meters.
- The beams and columns of these frames are usually made of welded or rolled H-shaped sections and are positioned and adjusted in height based on the span and the bending distance diagram.
- **The multi-span** rigid frame is ideal for large buildings, with a similar cross-section to the single-span rigid frame but with a center column that typically has an equal cross-section. Currently, the maximum span of a portal frame has reached 72 meters.

The portal frame's recommended height ranges from 4.5 to 9.0mm, with a maximum height of 12m if an overhead crane is present.



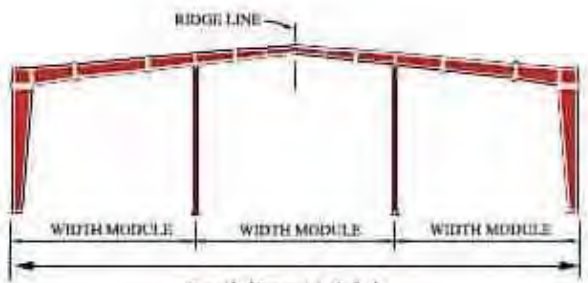
Single Span



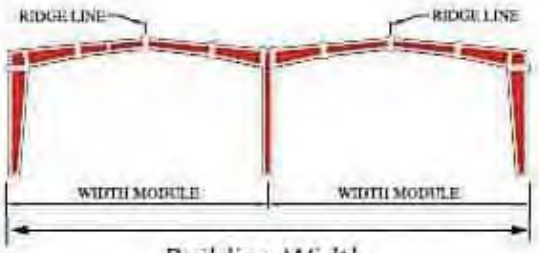
Multi-span with Mezzanine Floor



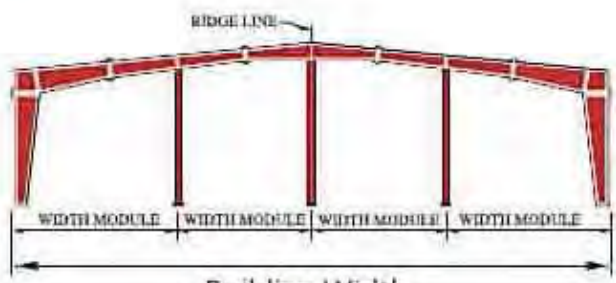
Single Slope



Multi-Span "2"



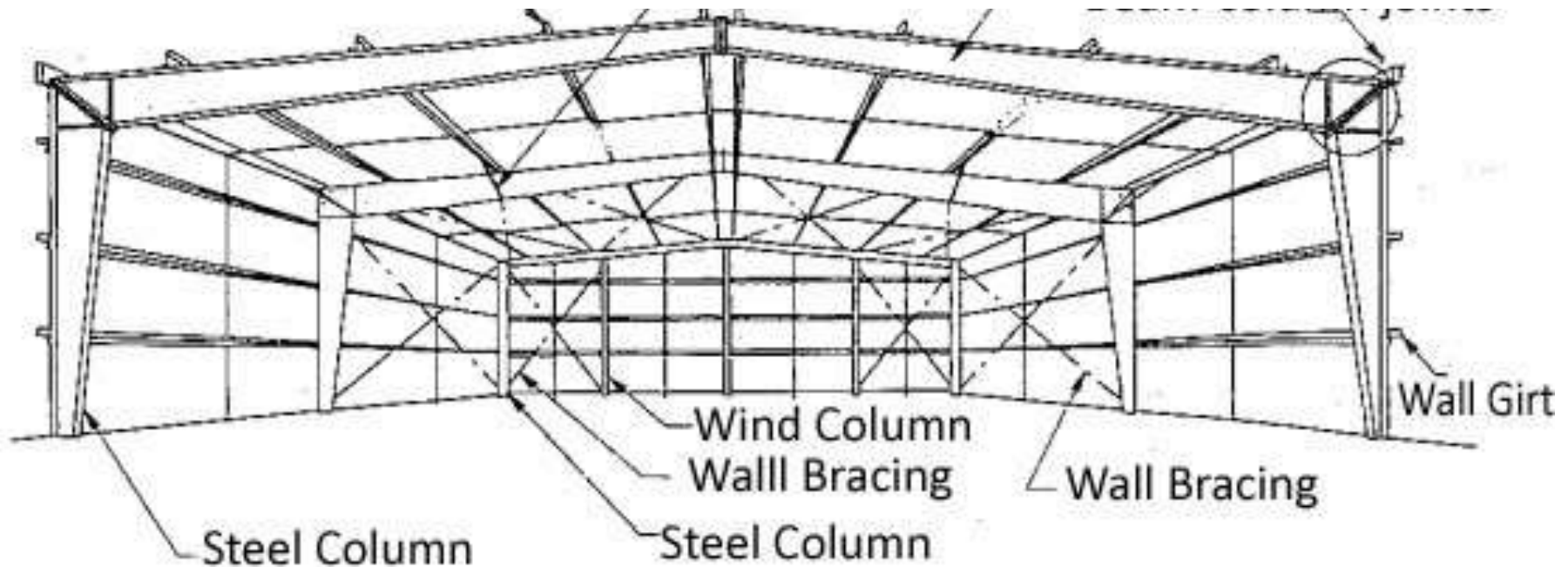
Multi-Gable

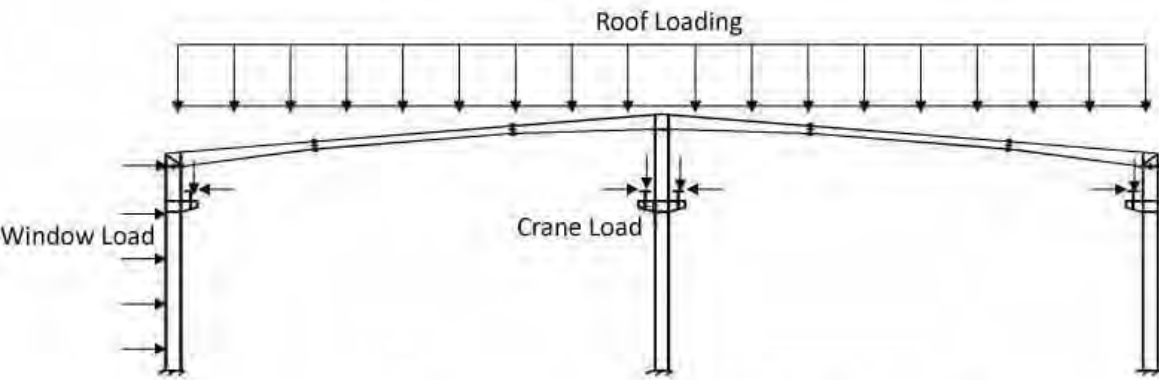


Multi-Span "3"

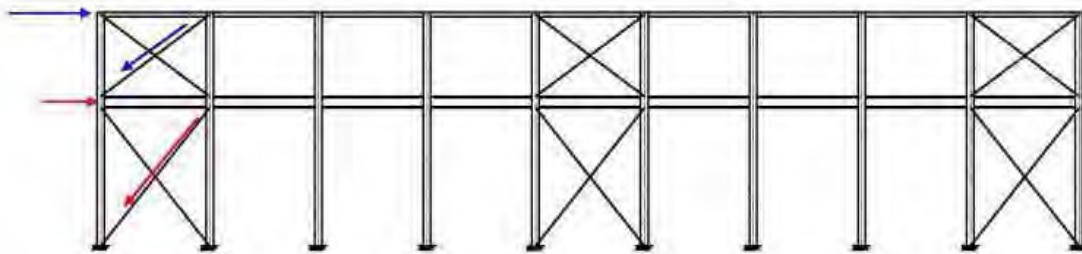
The composition of Portal Steel Frame Buildings

1. Primary framing: transverse rigid frames (including middle and end rigid framing), floor beams, crane beams, support systems, etc.
2. Secondary framing: roof purlin and wall girt, etc.
3. Envelope structure: roof and wall panels;
4. Auxiliary structures: stairs, platforms, handrails, etc .;
5. Foundation.

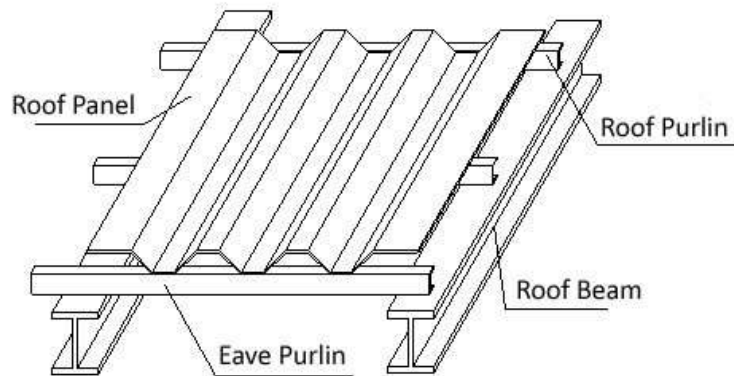




Transverse portal Steel frame



Longitudinal Frame Structure



Bracing

Type: Roof horizontal bracing, wall bracing.

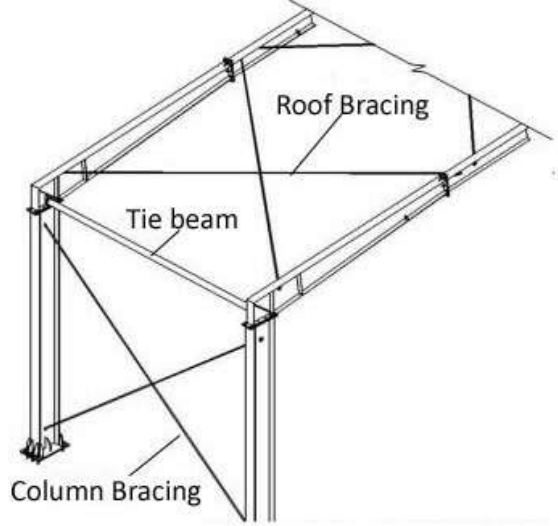
- 1). The roof horizontal bracing comprises roof cross bracing, tie beam, and fly bracing. Its primary function is to increase the overall rigidity of the roof.
- 2). Wall bracing is implemented to enhance the stability of the wall frame structure.

Use:

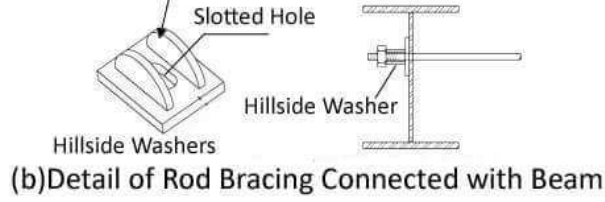
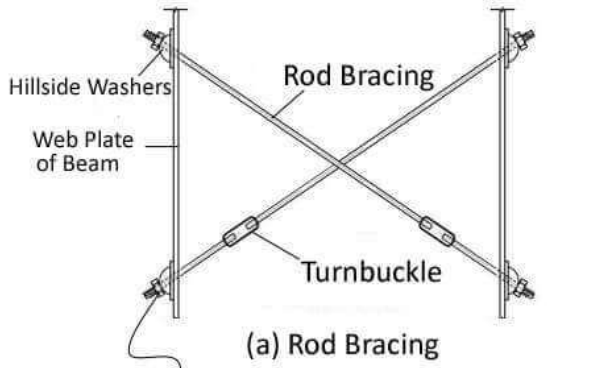
- 1). Improving the structural rigidity of the building's interior space.
- 2). Guaranteed structural stability.
- 3). Transmit wind load, crane brake load, and seismic load to the load-bearing members.

Why Steel Building Need Wall Bracing

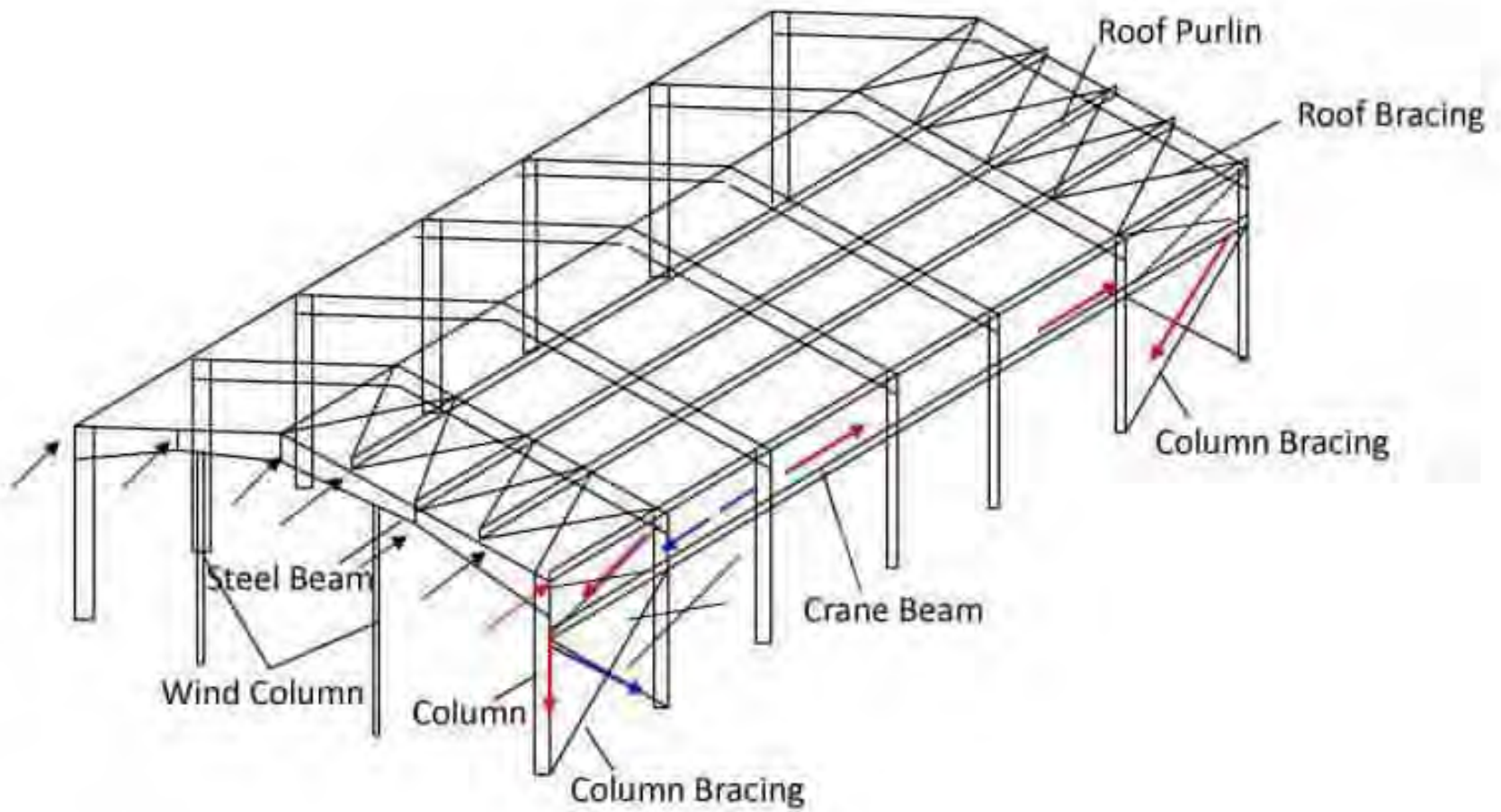
External loads exert their impact on the envelope of the structure. The secondary structure carries the vertical and lateral forces to the lateral portal frame of the primary structure. The portal frame's resistance to external influences is dependent on its stiffness. The roof and wall bracing transmit longitudinal wind loads to the foundation.



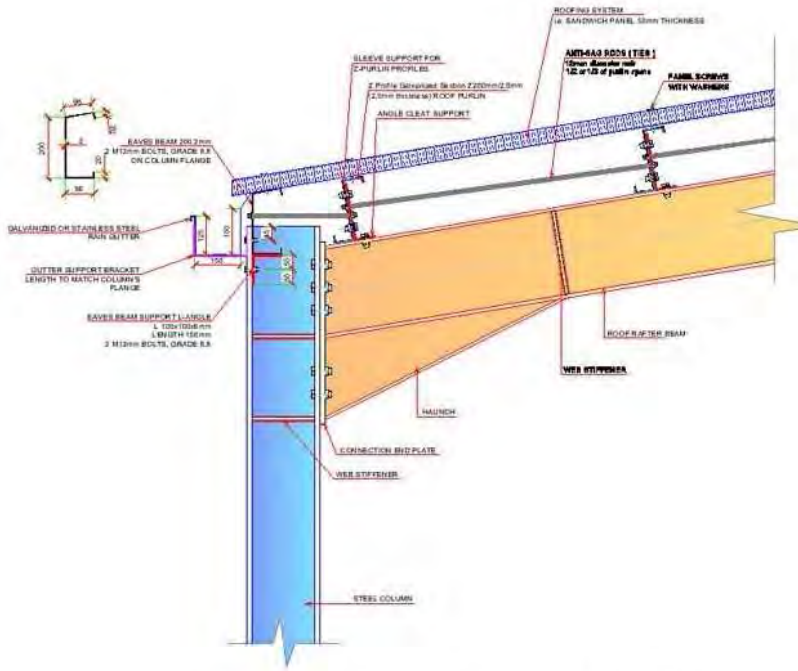
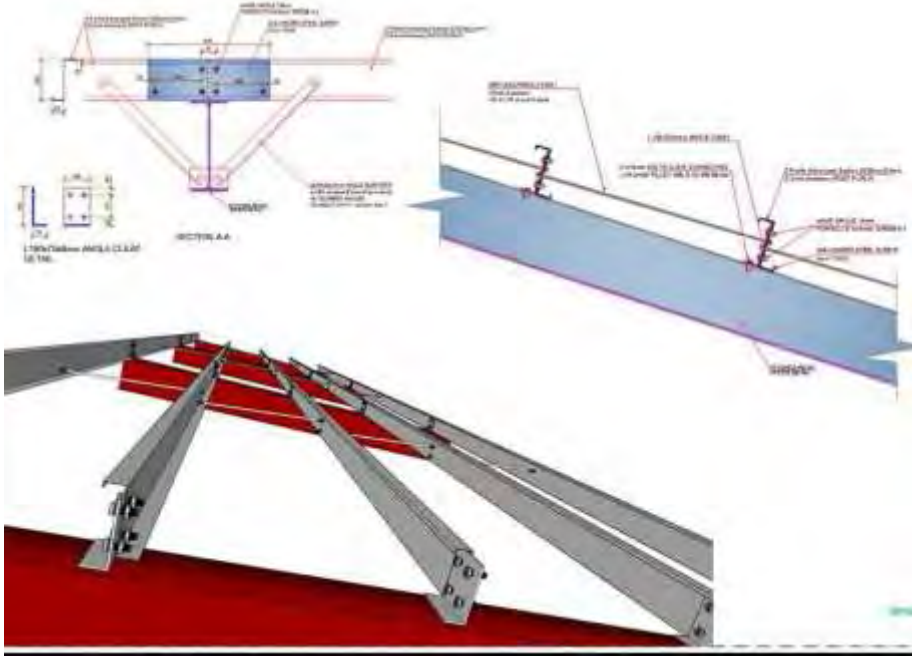
Roof and Wall Bracing



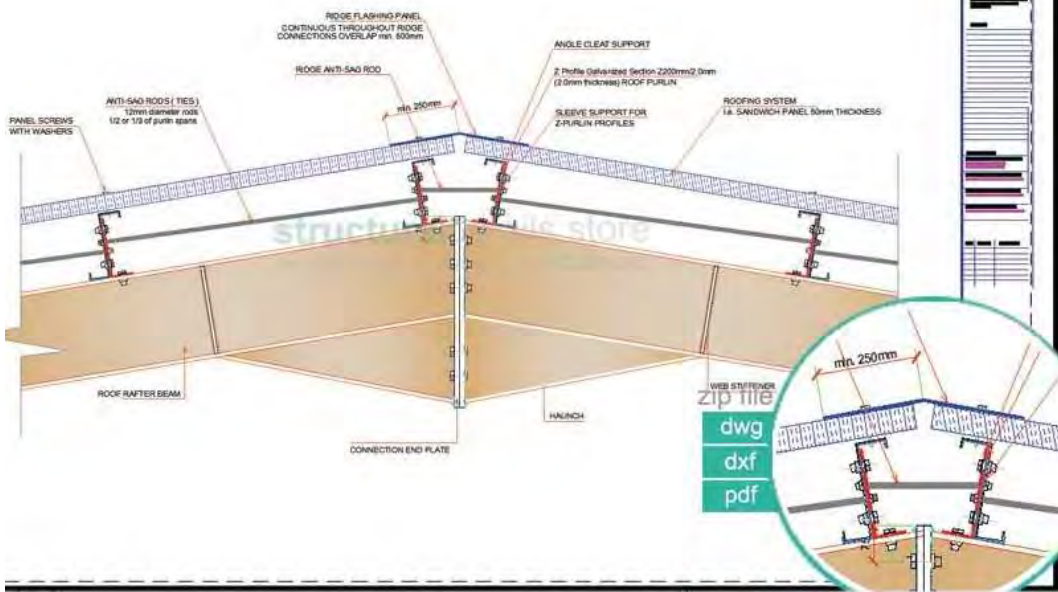
Detail of Rod Bracing



Transfer Path of Horizontal Load



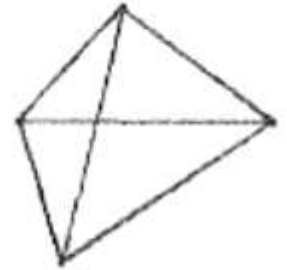
EAVES BEAM DETAIL - STEEL FRAME ROOF EDGE



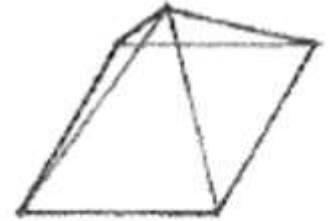
Space frame

A space frame is a truss - like rigid structure constructed from interlocking struts in a geometric pattern. Space frames usually utilize a multidirectional span, and are often used to accomplish long spans with few supports. They derive their strength from the inherent rigidity of the triangular frame - flexing loads (bending moments) are transmitted as tension and compression loads along the length of each strut. The system of the space frame is known as the common space lattice, the octet truss, or the octahedron - tetrahedron complex.

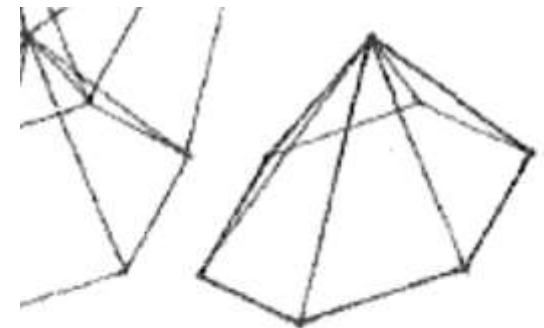
A space frame is a long-spanning three-dimensional plate structure based on the rigidity of the triangle and composed of linear elements subject only to axial tension or compression. The simplest spatial unit of a space frame is a tetrahedron having four joints and six structural members.



Triangular Grid



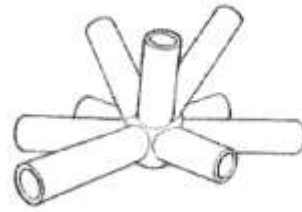
Square Grid



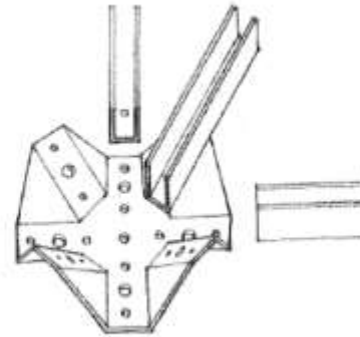
Hexagonal Grid



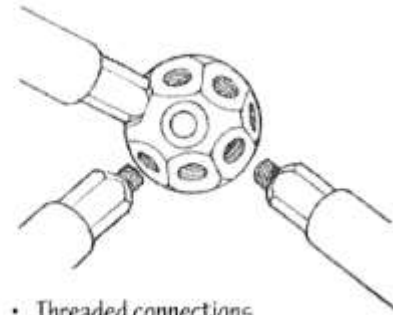
- Space frames may be constructed of structural steel pipe, tubing, channels, tees, or W-shapes.



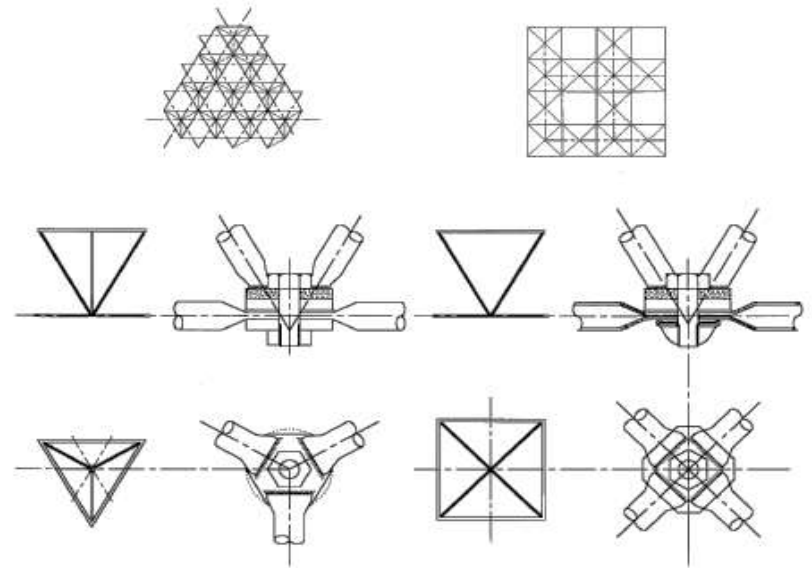
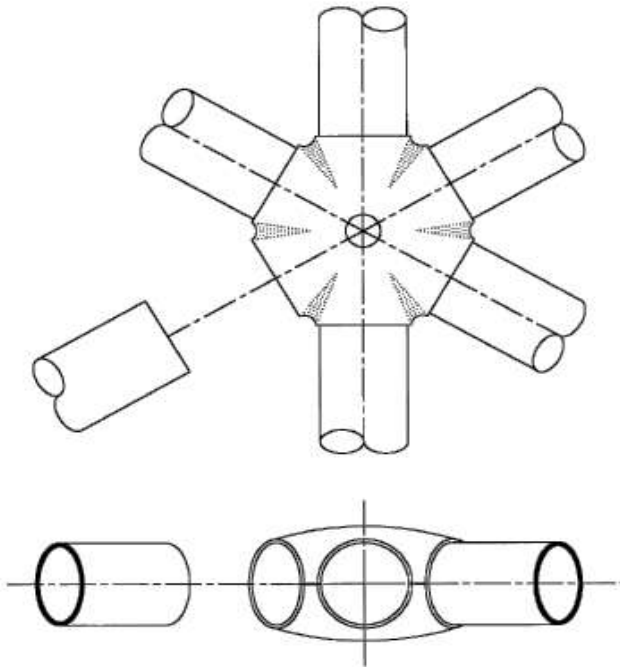
• Welded connection

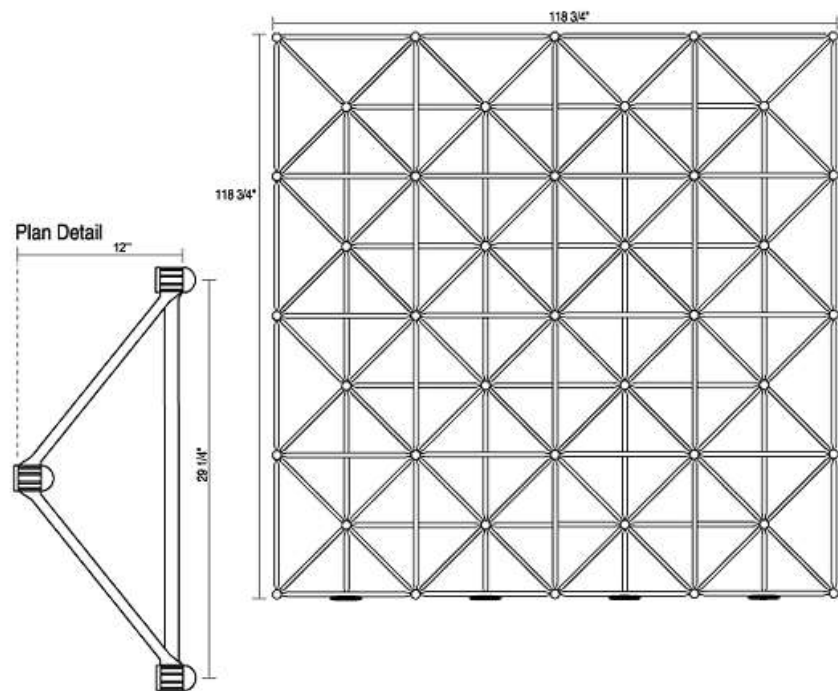
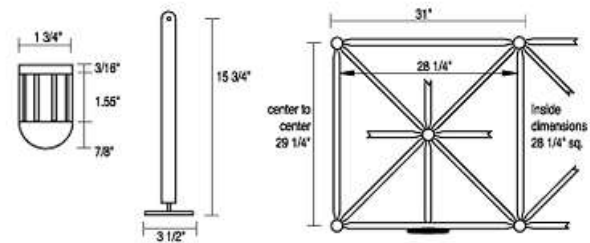
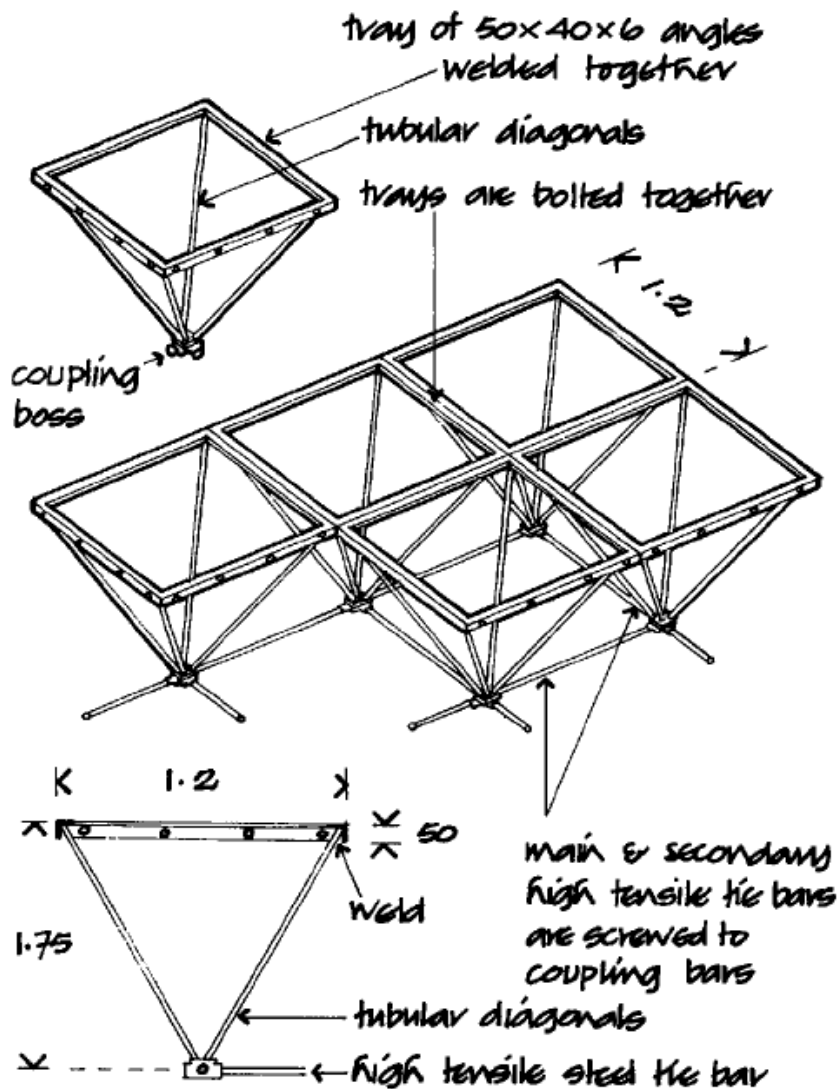


• Bolted connection

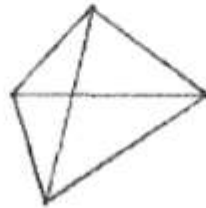
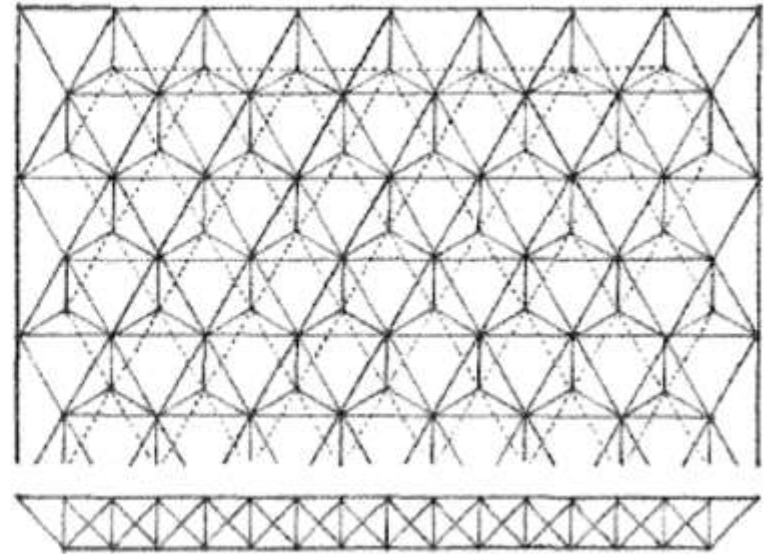
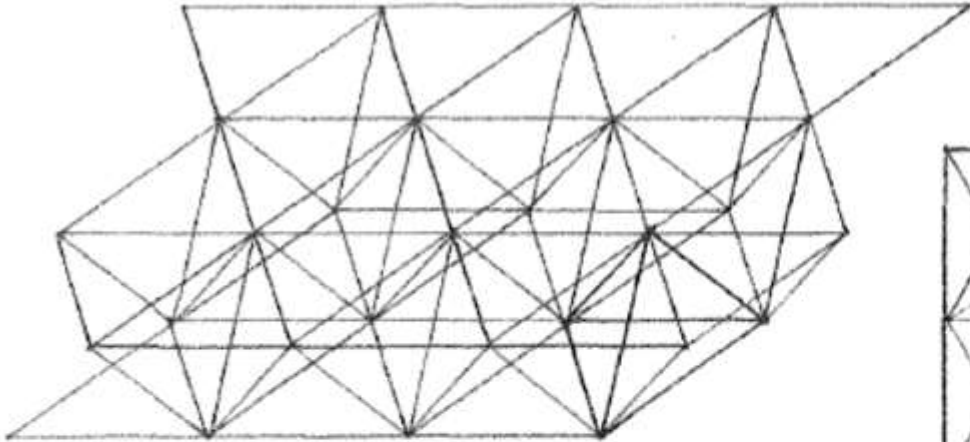


• Threaded connections



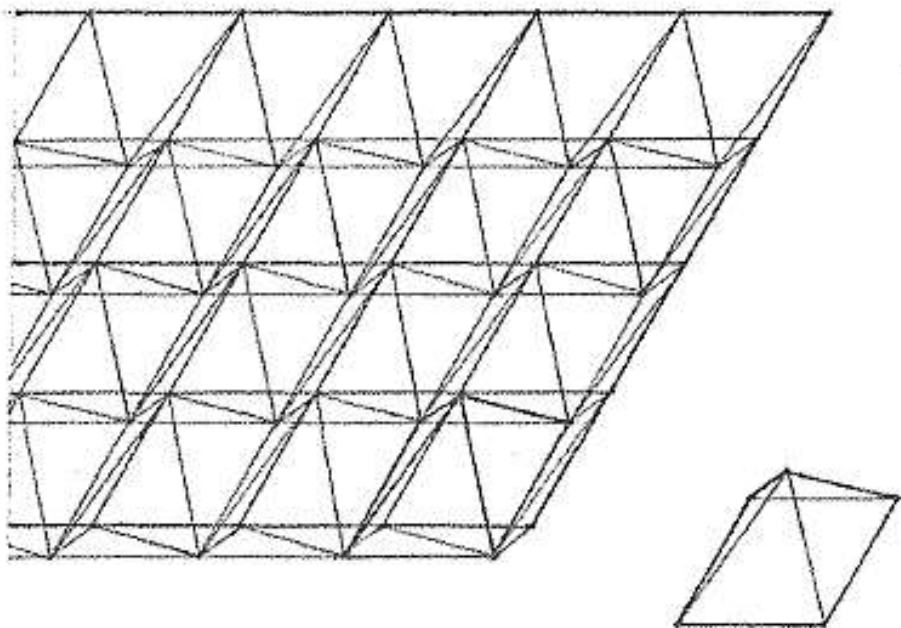


Space frame types

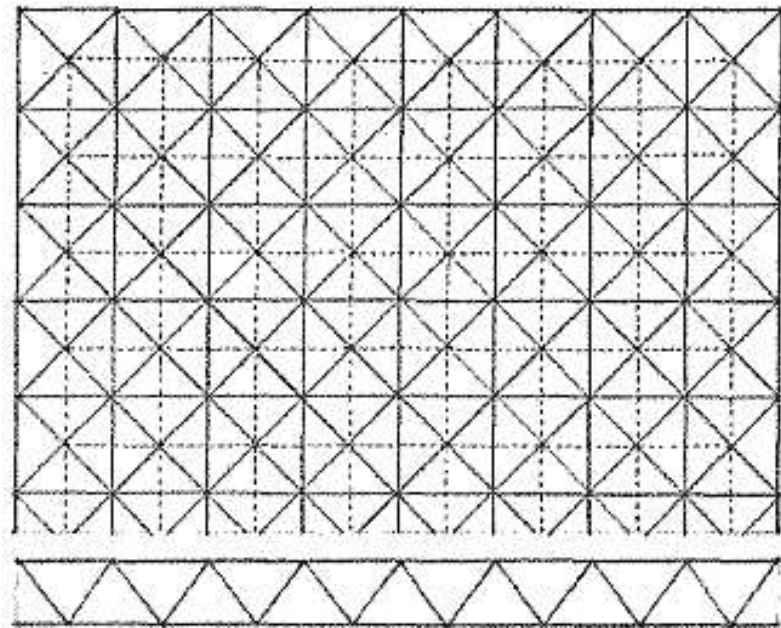


Triangular Grid

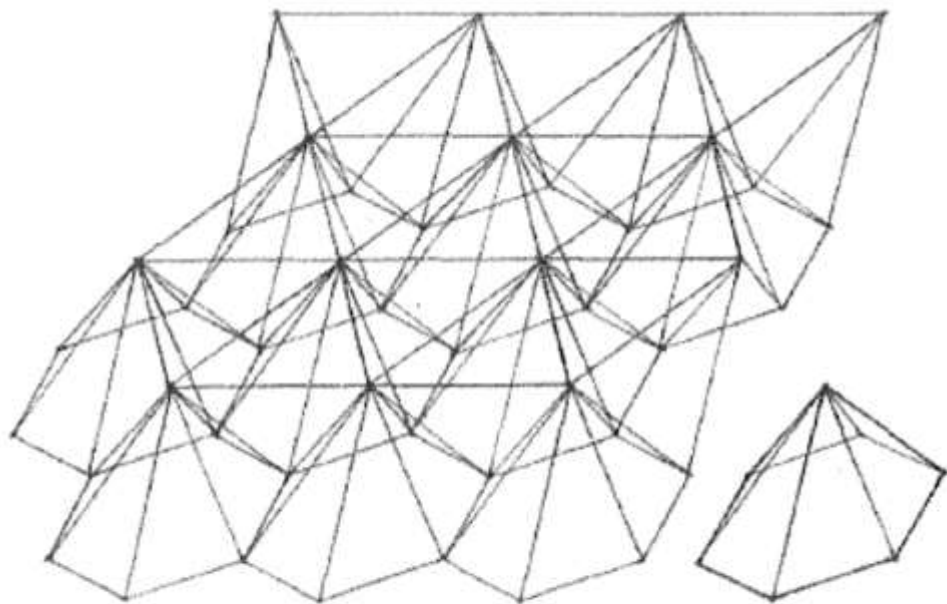
Space frame types



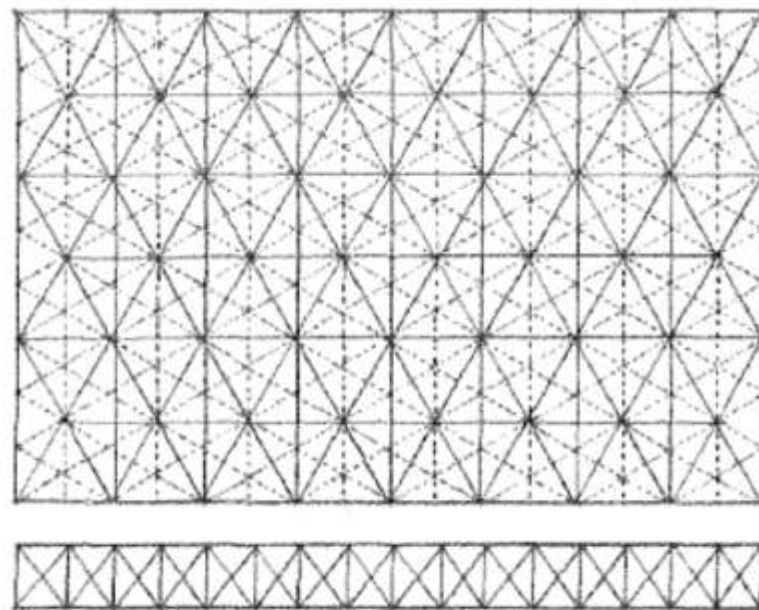
Square Grid

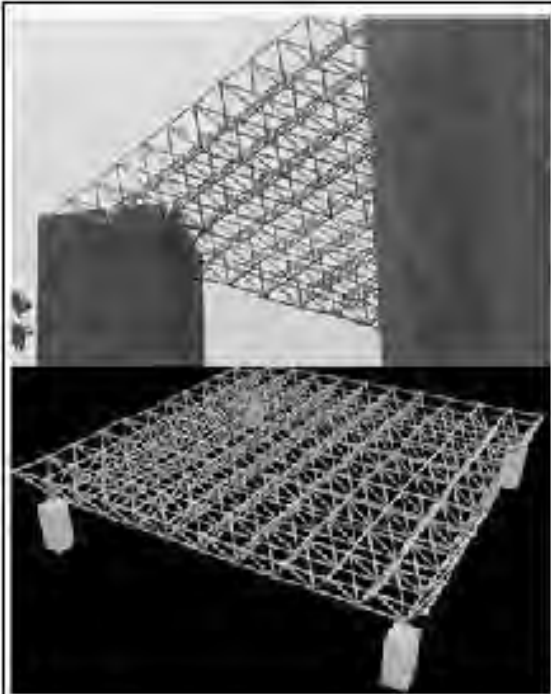


Space frame types



Hexagonal Grid





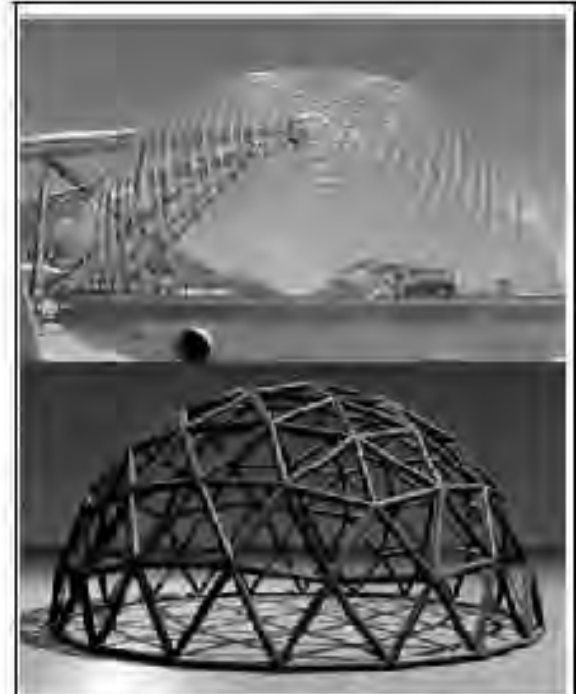
1- Flat covers

These structures are composed of planar substructures. The plane are channeled through the horizontal bars and the shear forces are supported by the diagonals.



2- Barrel vaults

This type of vault has a cross section of a simple arch. Usually this type of space frame does not need to use tetrahedral modules or pyramids as a part of its backing.



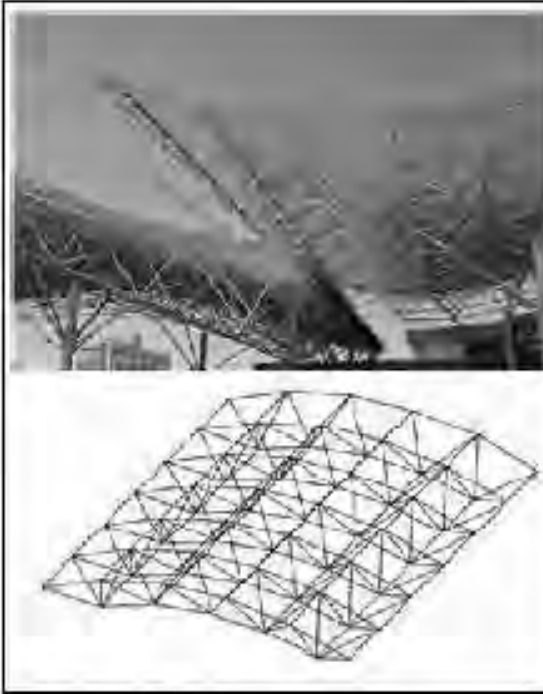
3- Spherical domes

These domes usually require the use of tetrahedral modules or pyramids and additional support from a skin.



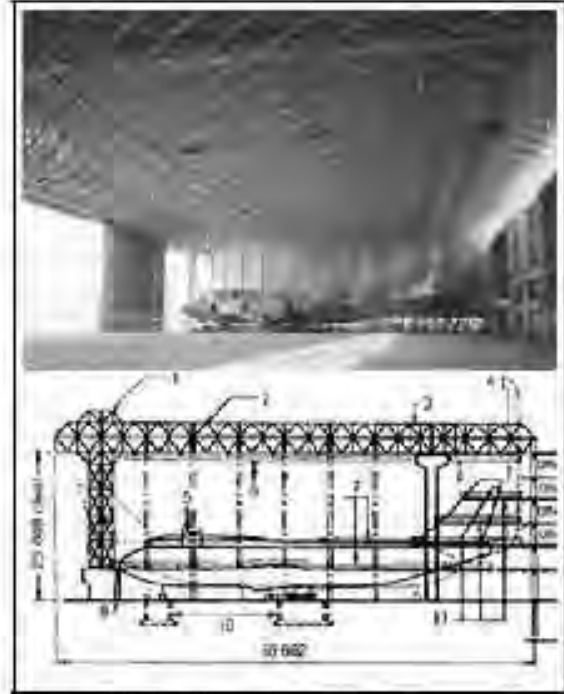
1- Single-Layer

All elements are located on the surface to be approximated.



2- Double-Layer

The elements are organized in two parallel layers with each other at a certain distance apart. The diagonal bars connecting the nodes of both layers in different directions in space.

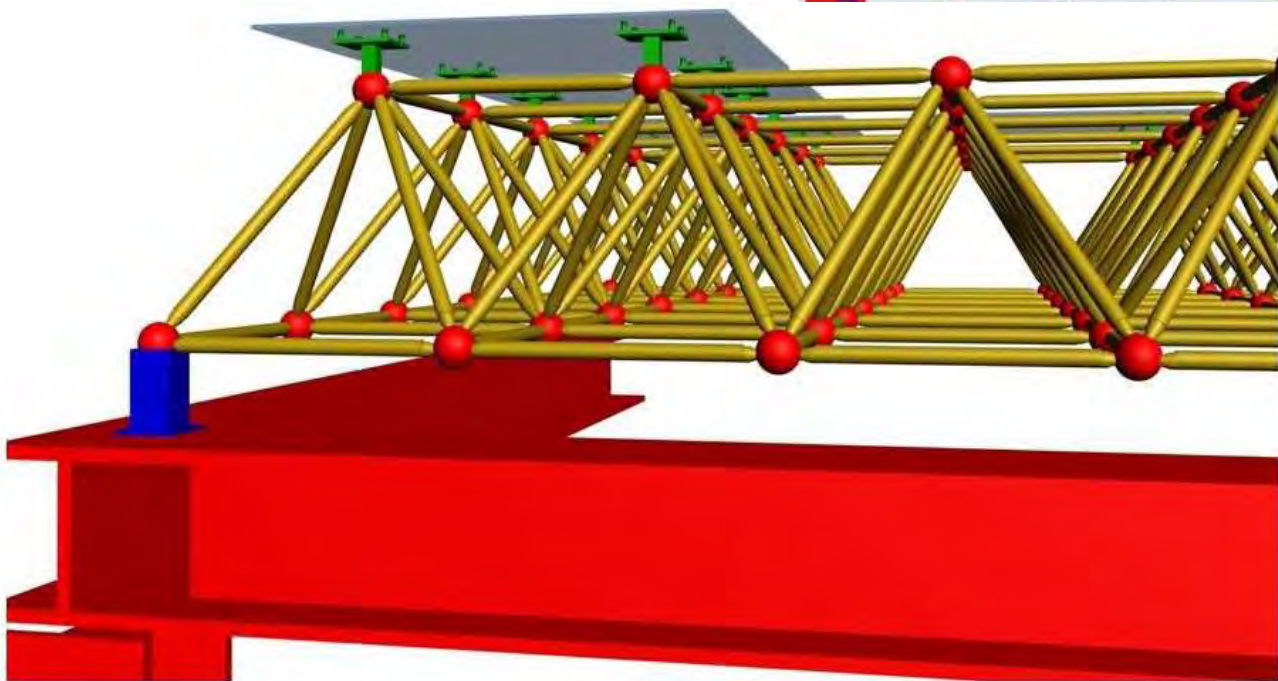
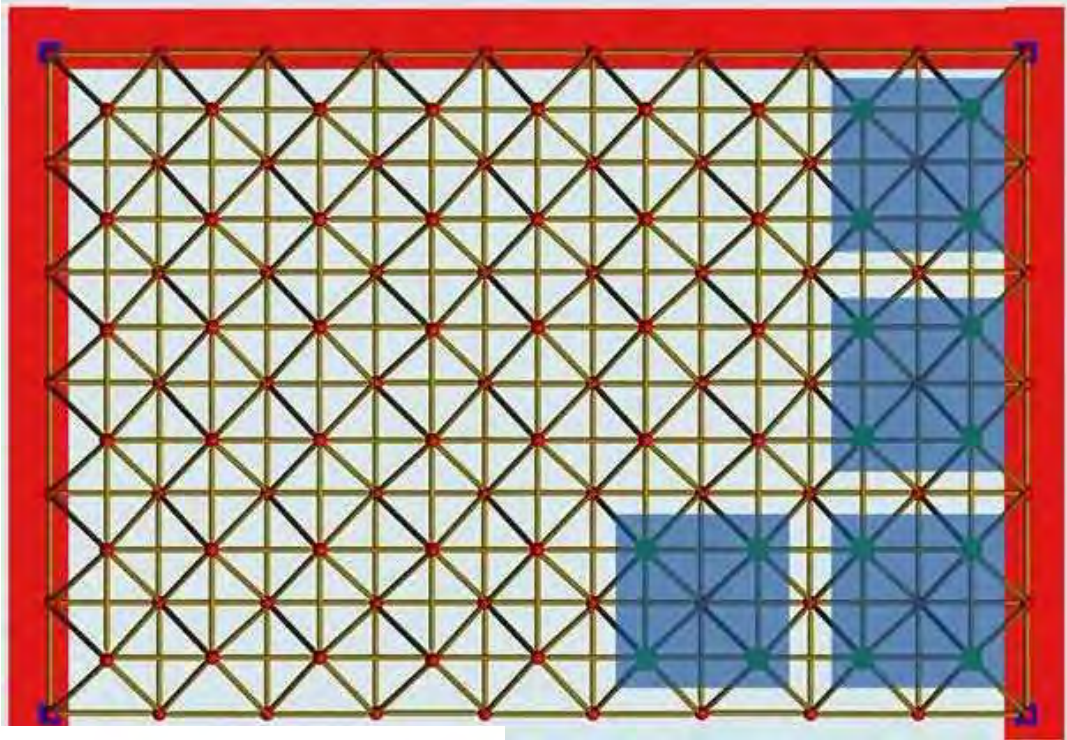


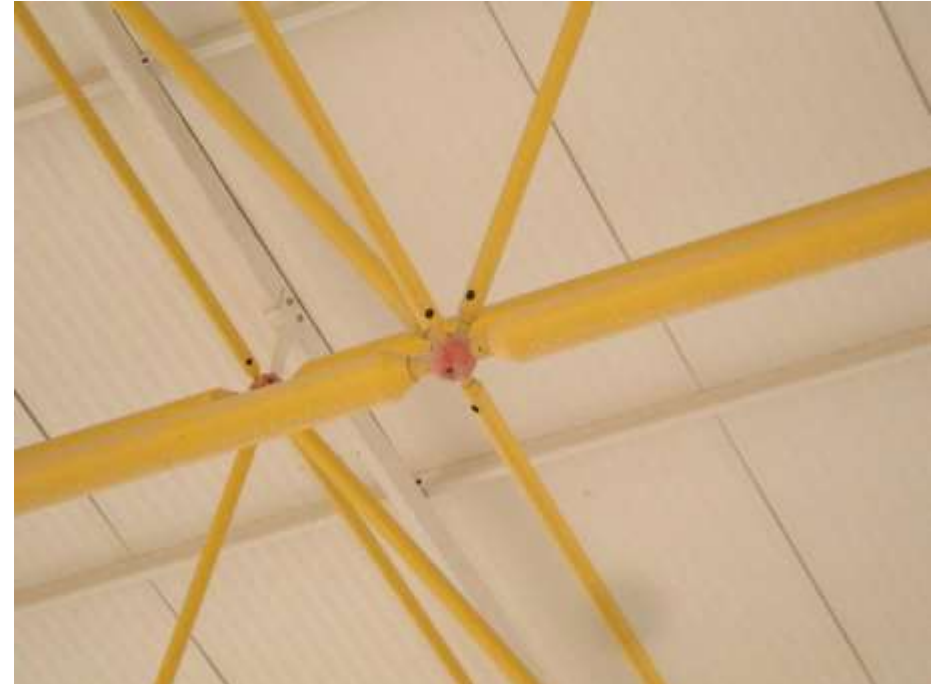
3- Triple-Layer

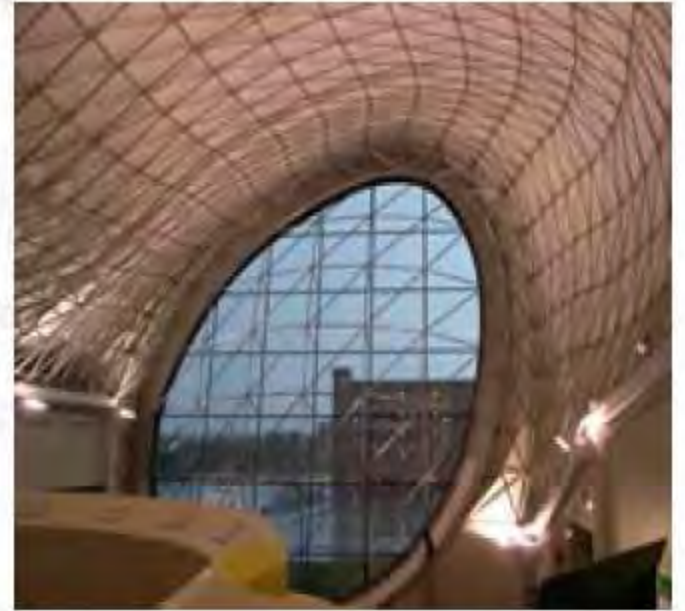
Elements are placed in three parallel layers, linked by the diagonals. They are almost always flat. This solution is to decrease the diagonal members length.

SPACE FRAME DETAILS











Application

The space frame construction can be applied in following constructions:

- **Commercial and industrial buildings**
- **Auditoriums**
- **Airport hangers**
- **Sport stadiums**
- **Sky lights**
- **Mosque**
- **Lighting towers**
- **Petrol pumps**
- **Canopies**
- **Exhibition hall**
- **Scaffoldings**
- **Traffic signs**
- **Malls**
- **Transport terminals**
- **Schools**
- **Pools**
- **Arenas**
- **Entertainment**

Salient features

1. Enormous spanning capability
2. Light weight
3. High aesthetics
4. High resale value
5. Higher safety factor
6. Extension with additional unit
7. Free forms
8. All service lines can run through frame
9. Simple modification or dis - assembly for re - use
10. Suit irregular support or plan geometry
11. Pre - assembly allows project acceleration