

# Lecture 8

## Long Span Coverings – Part 1: Planar and Barrel Vault Space Structures

### **Acknowledgement**

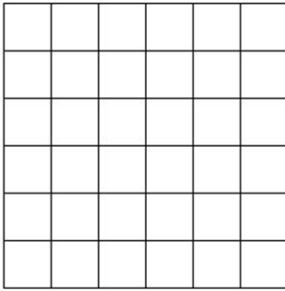
*I express my gratitude to doctor Dawid Mqdry for creating this work and for professor Antoni Biegus for making available to me the materials incorporated in his book "Stalowe budynki halowe" (Steel industrial buildings), which were mainly used at drawing this work up*

## Types of spatial truss systems

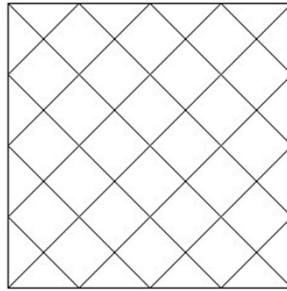
- two dimensional grids
- cylindrical vaults
- domes

## Two dimensional grids

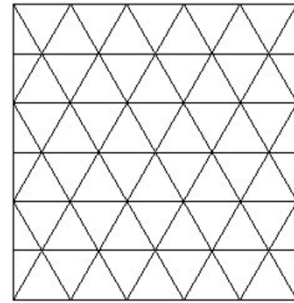
- Simple layer grids



(a) Square : two directions



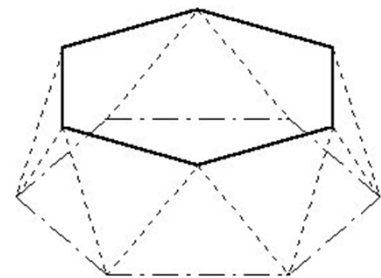
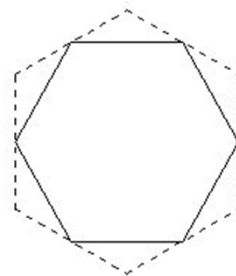
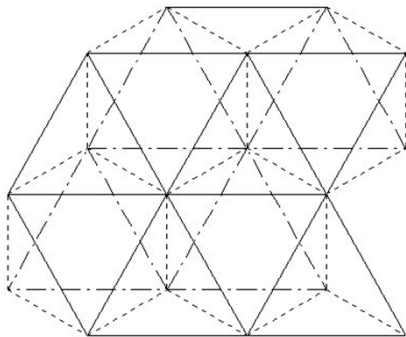
(b) Diagonal : two directions



(c) Three directions

## Two dimensional grids

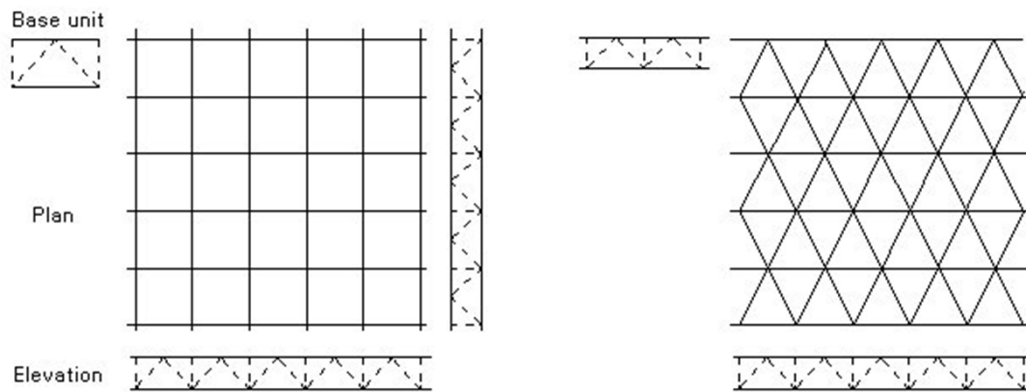
- Double layer grids



— Upper layer  
 - - - Bracing layer  
 - - - Bottom layer

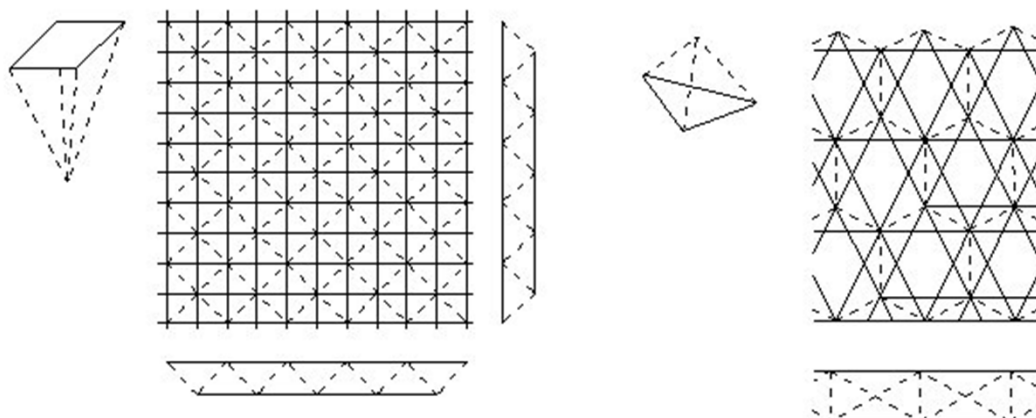
## Types of double layer grids

- lattice grids



## Types of double layer grids

- spatial grids



## Types of double layer grids

- spatial grids

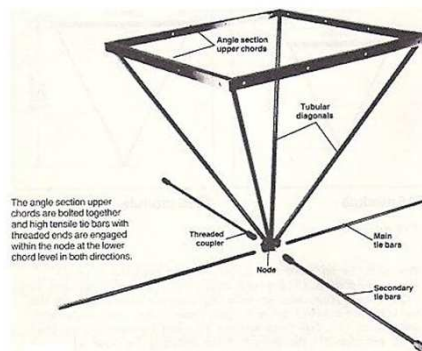
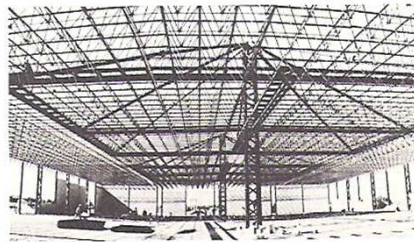
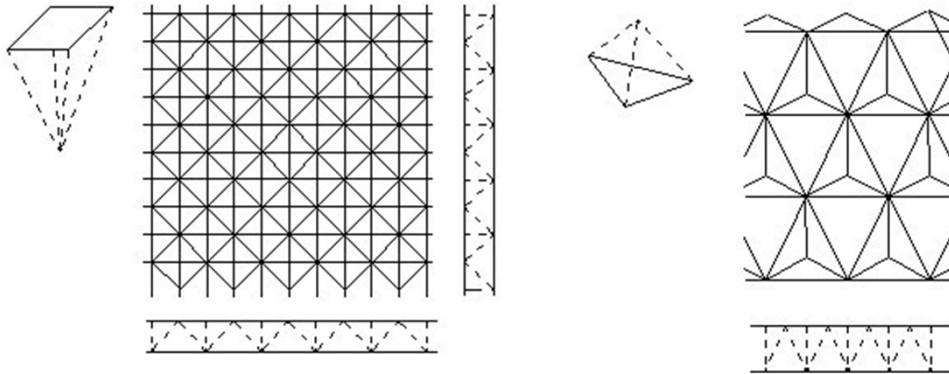


Fig.1.1 Exhibition centre and a pyramidal unit [3]

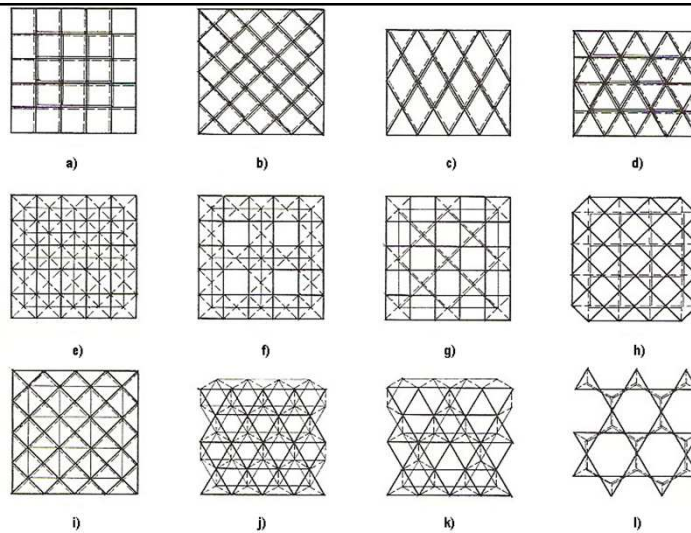


Fig.1.2 Types of commonly used space trusses: 1- composed of lattice trusses, a) two-way orthogonal lattice grids, b) two-way diagonal lattice grids, c) two-way diagonal skew lattice grids, d) three-way lattice grids, 2- composed of square pyramids, e) orthogonal pyramid space grids, f) orthogonal square pyramid space grids with openings, g) diagonal square pyramid space grids with openings h) diagonal square pyramid space grids with star elements, i) square pyramid space grids with star elements, 3- composed of triangular pyramids, j) triangular pyramid space grids, k) triangular pyramid space grids with openings, l) triangular pyramid space grids of honeycomb pattern

## The advantages of double layer grids

- they are three dimensional structures which can withstand loads from any direction.
- they are hyperstatic, and buckling of some compression members does not cause the whole to collapse as has been demonstrated by mathematical models and experiments.
- their rigidity minimises deflections.
- they have a very good fire resistance.
- their composition allows factory pre-fabrication in modular elements, which are easily transported. Fabrication precision ensures ease of assembly and erection.

## The advantages of double layer grids

- they allow a wide choice of support positions owing to modular construction.
- the space between the two layers may be used to install electricity, electrical and thermal piping, etc.
- installation is carried out by bolting and may be done whatever the atmospheric conditions.
- they provide indisputable aesthetic qualities.

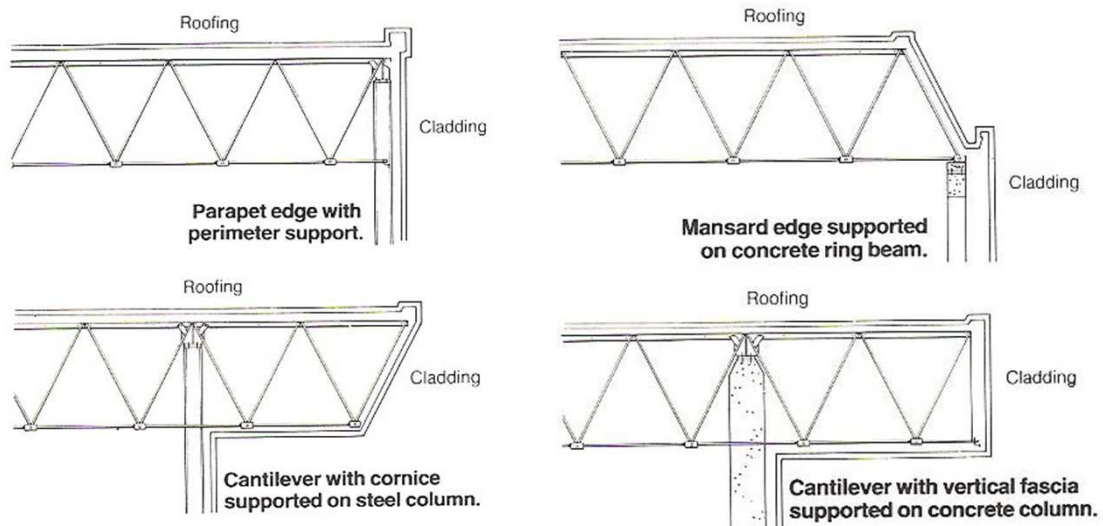


Fig.1.3 Typical support conditions [3]

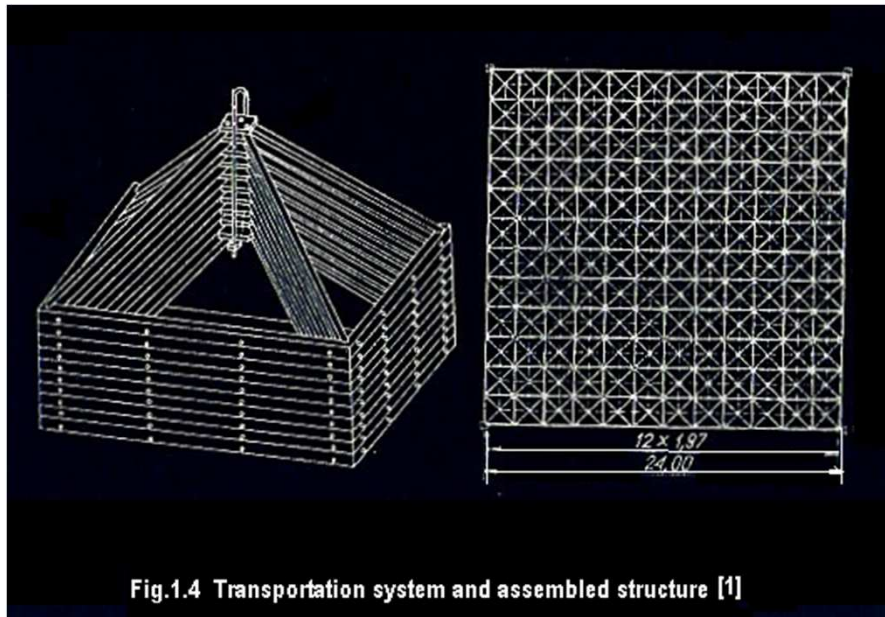


Fig.1.4 Transportation system and assembled structure [1]

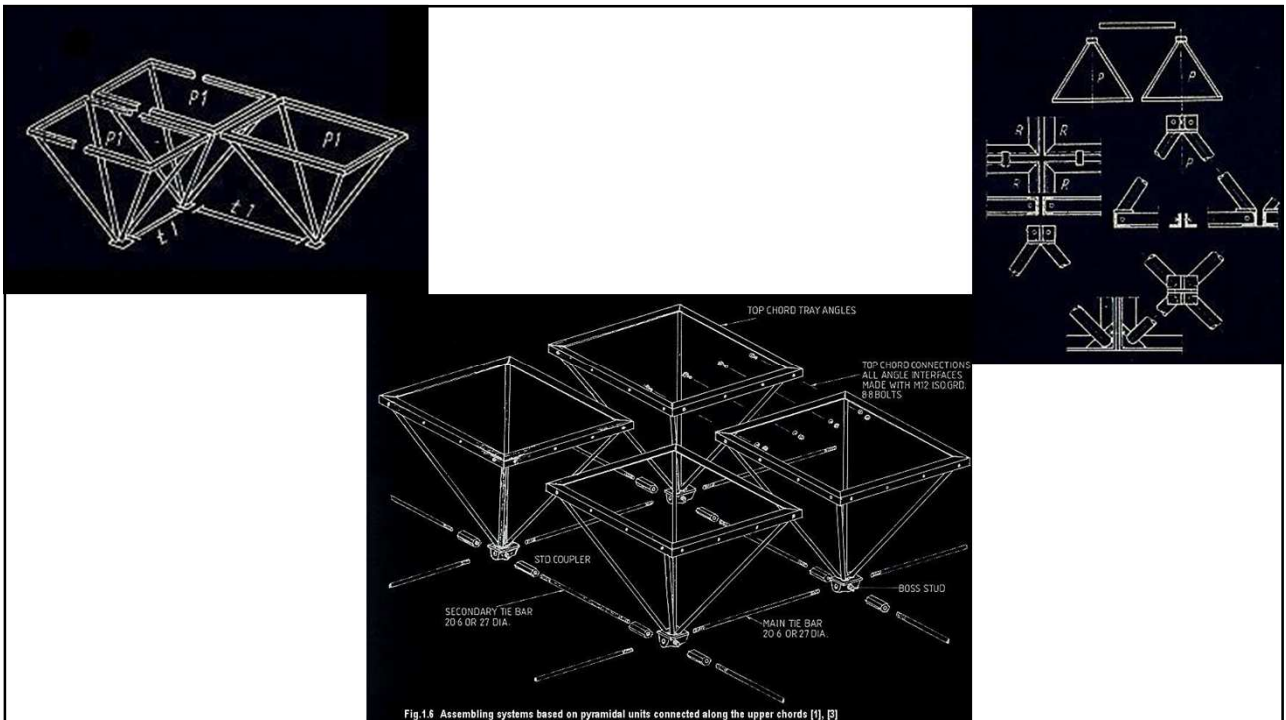


Fig.1.5 Assembling systems based on pyramidal units connected along the upper chords [1], [2]

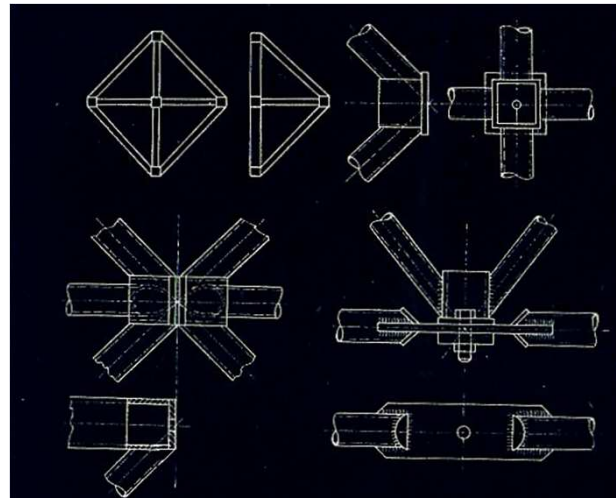
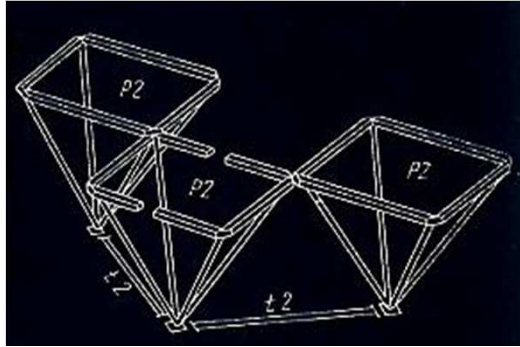


Fig.1.7 Assembling systems based on pyramidal units connected at the corners [1]

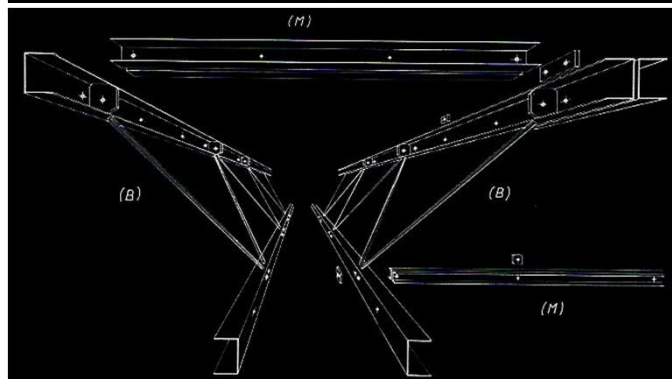
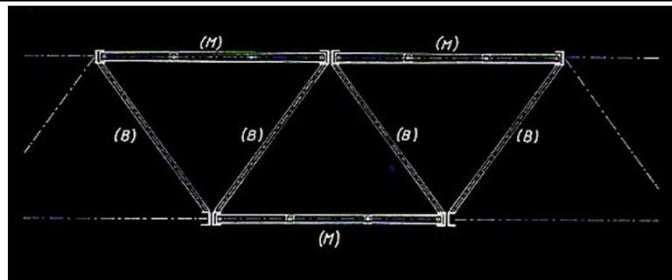


Fig.1.8 Assembling systems based on planar truss to single struts connection [3]



## Cylindrical vaults

- The optimum shape (rise/span ratio) is in the region of 0,15 to 0,20

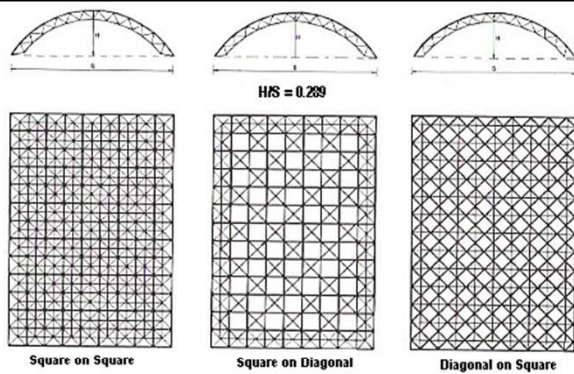
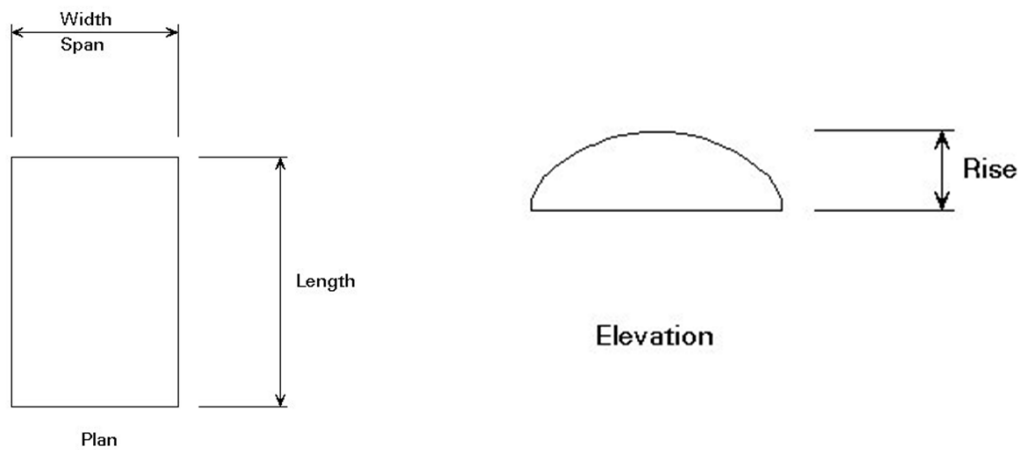


Fig.1.9 Double layer braced barrel vaults [2]

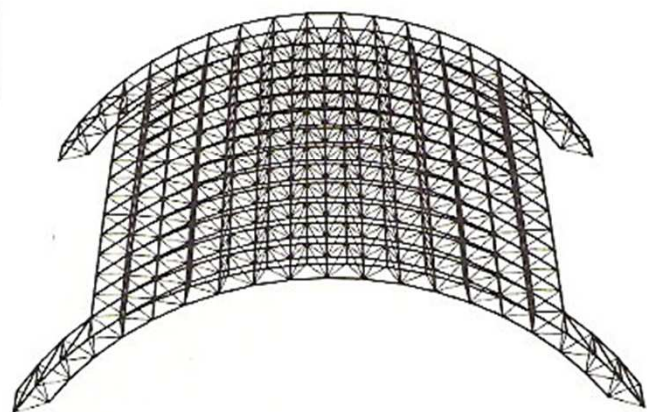
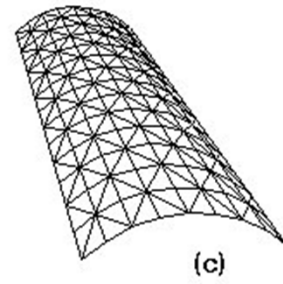
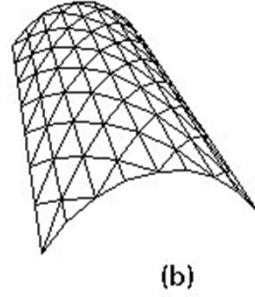
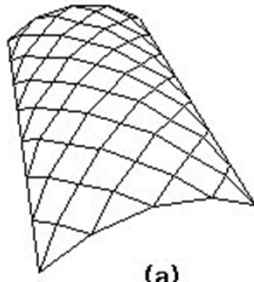
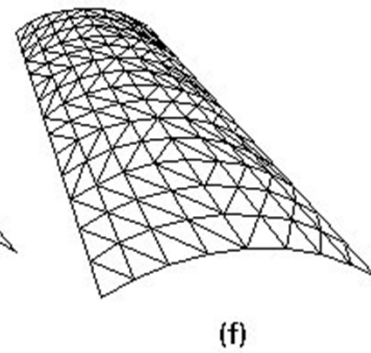
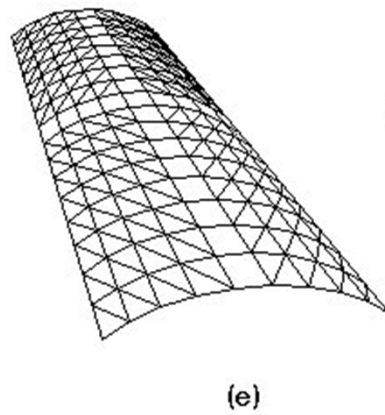
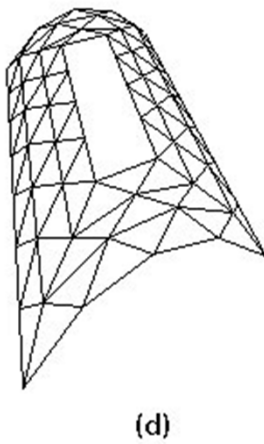


Fig.1.10 Isometric view on barrel space structure [3]

## Cylindrical vaults



## Cylindrical vaults



## Cylindrical vaults

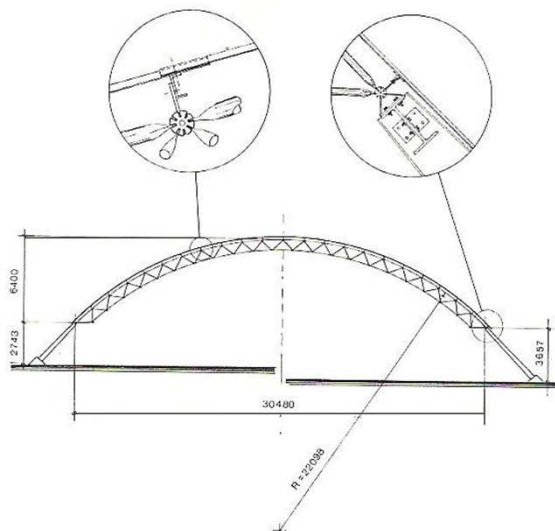
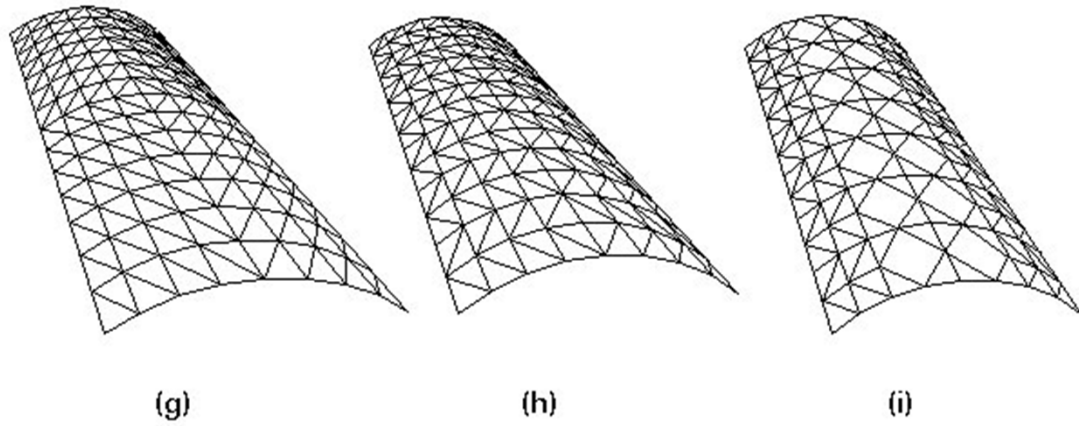


Fig.1.11 Section and details of tridetic steel braced barrel vault [2]

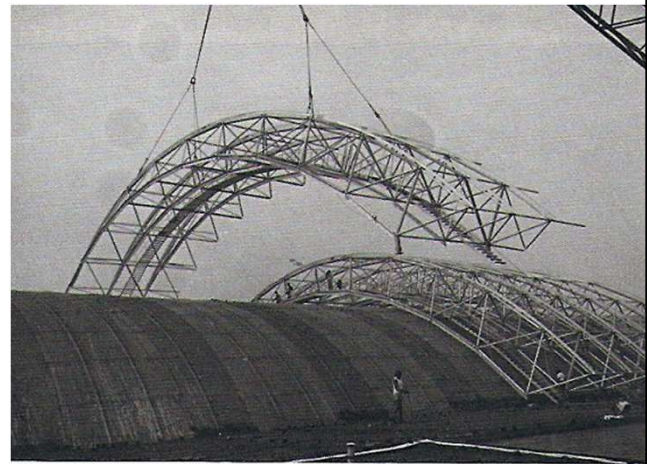
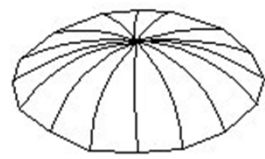
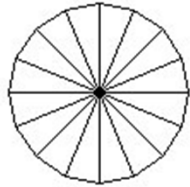
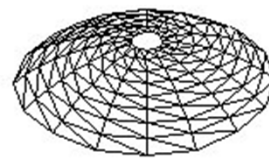
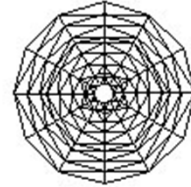


Fig.1.12 Lifting of one preassembled space frame unit [2]

## Domes

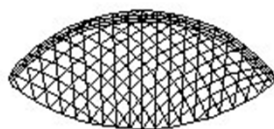
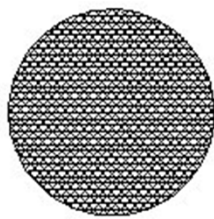


ribbed dome

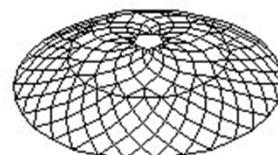
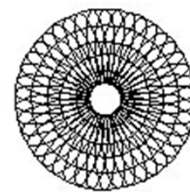


Schwedler dome

## Domes



Three-way grid dome



Lamella dome

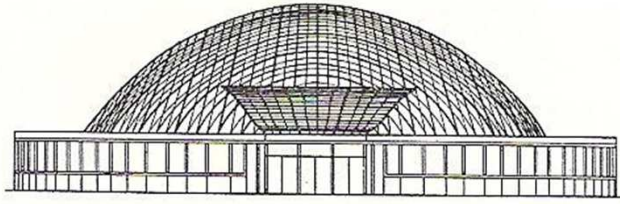


Fig.2.1 View on Krupp's dome pavilion [3]

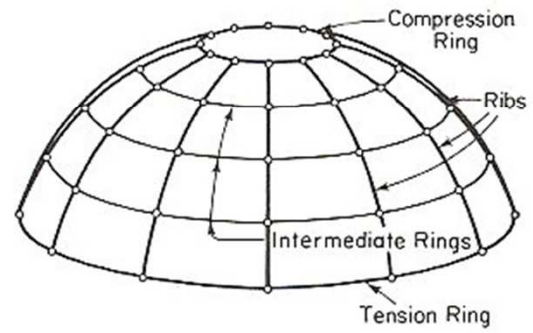
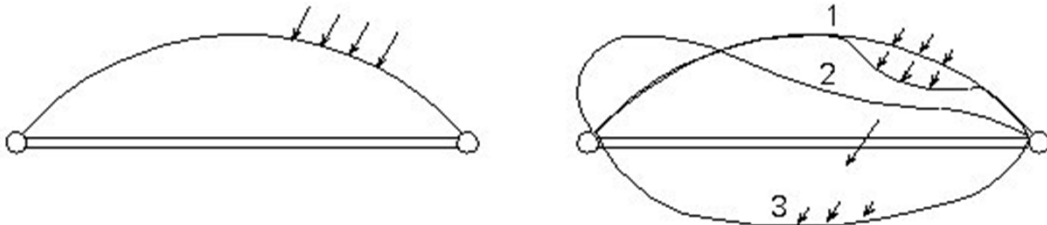


Fig.2.2 Basic dome's elements [2]

Unsymmetrical action



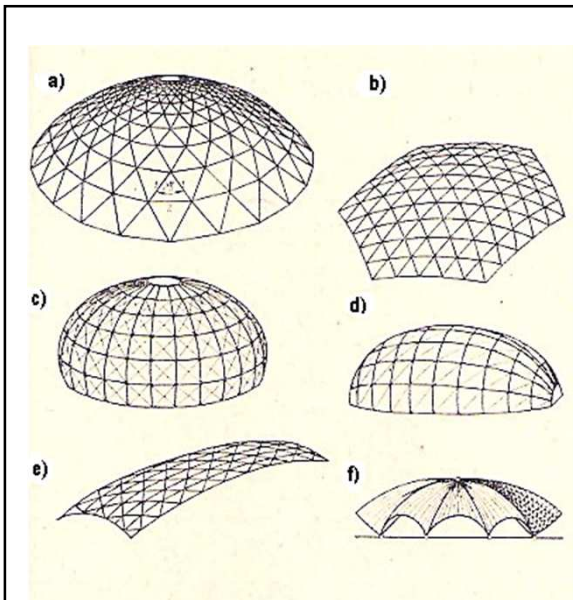
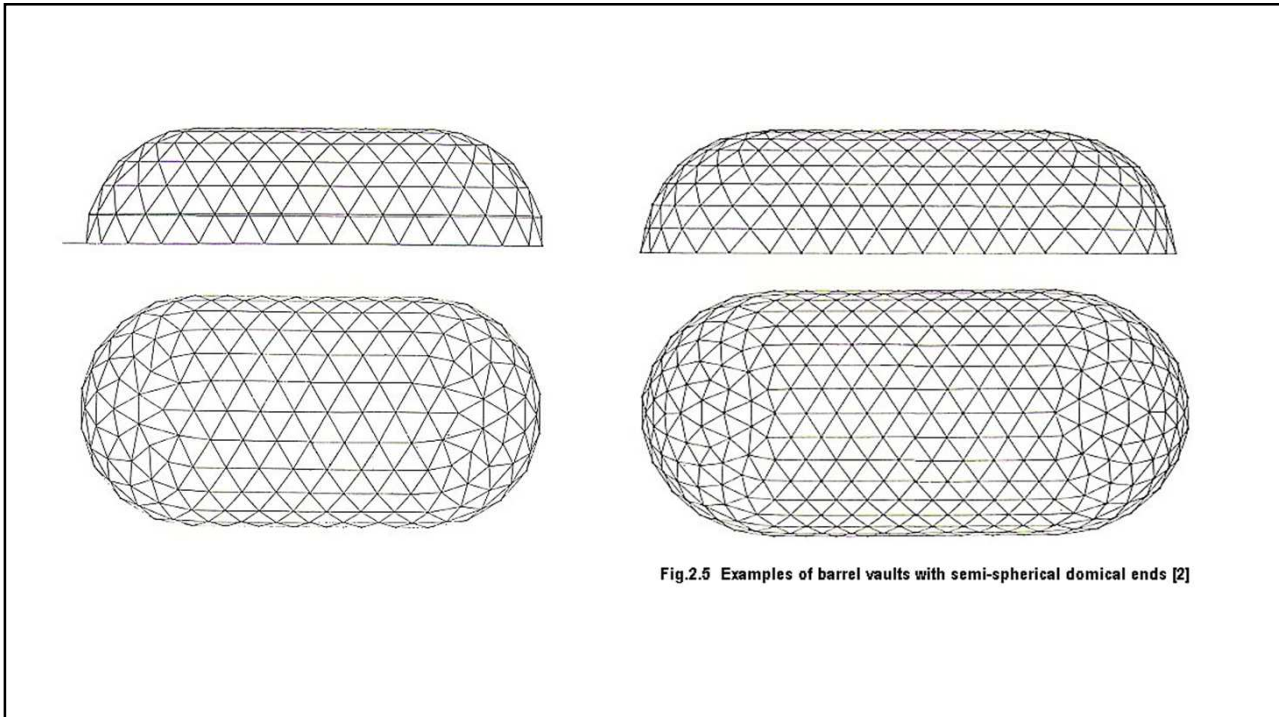


Fig.2.3 Examples of double-curved strut shells [1]

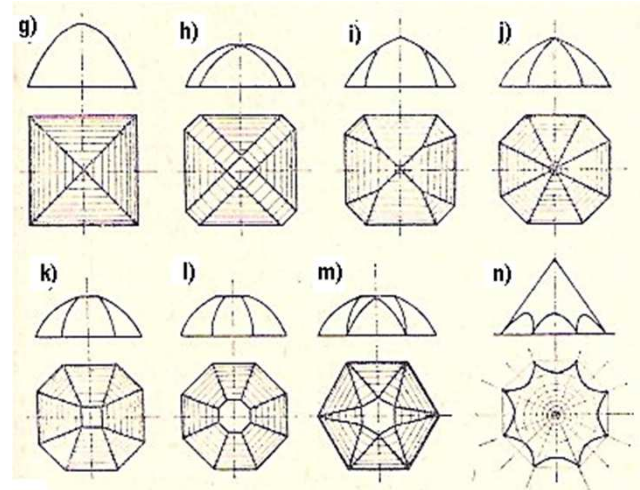


Fig.2.4 Domes on polygonal bases [1]

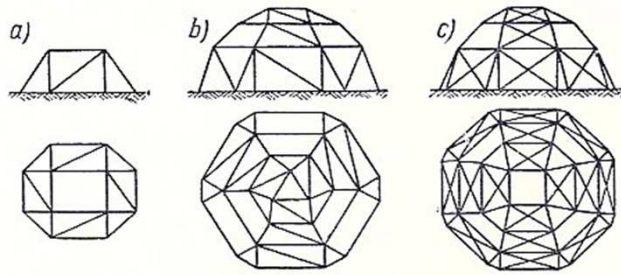


Fig.2.6 Zimmermann's domes [3]

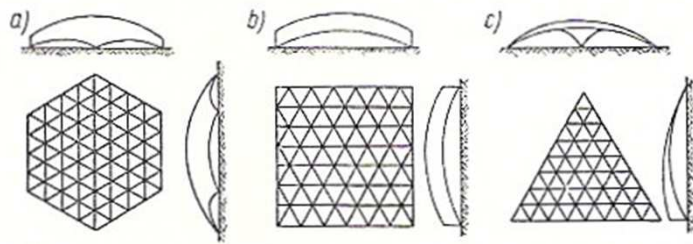
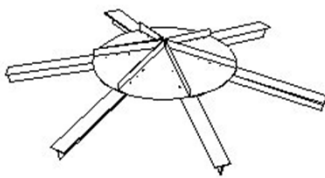
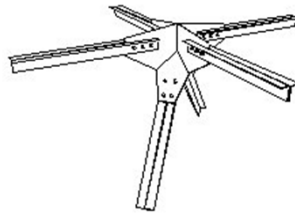


Fig.2.7 Three-way grid domes over the polygonal plan [3]

## Nodes

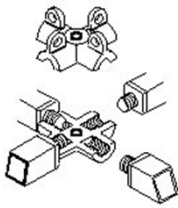


(a) Plate nodes

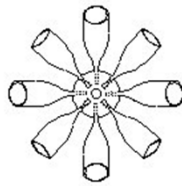


(b) Folded plate nodes

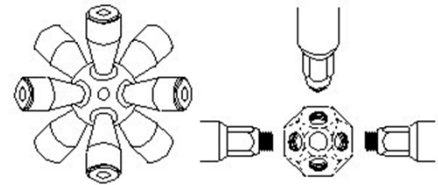
## Nodes



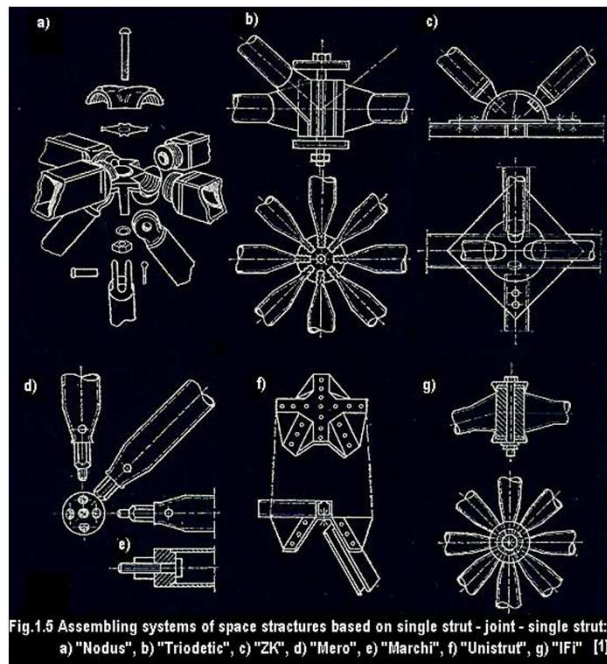
(c) Cast nodes



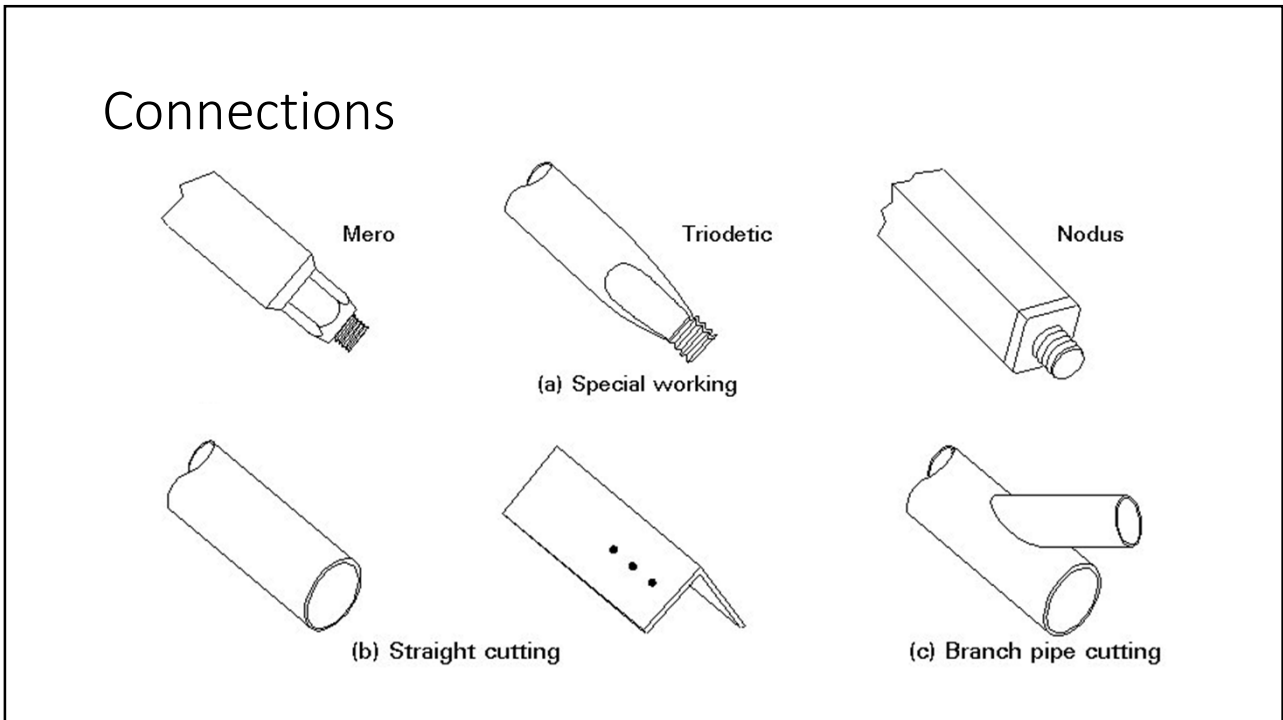
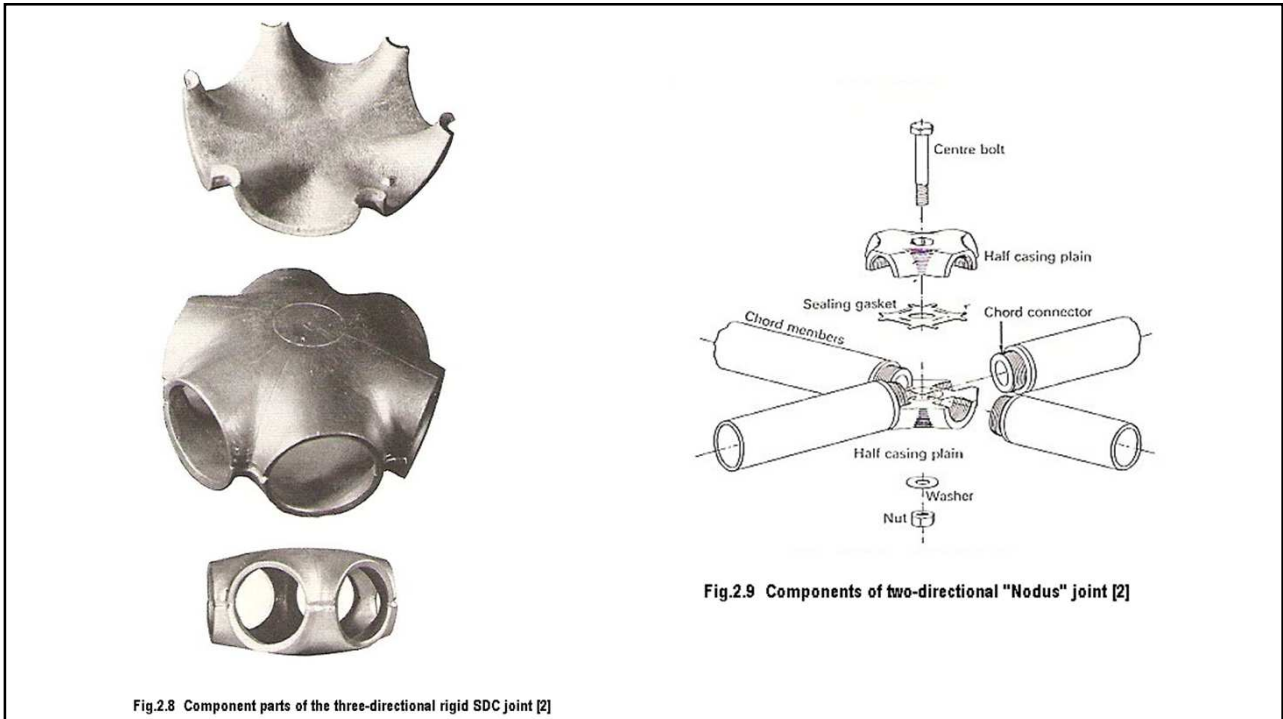
(d) Extruded aluminium



(e) Special working



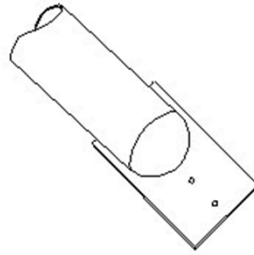




## Connections



(d) Flattening



(e) Plate welding

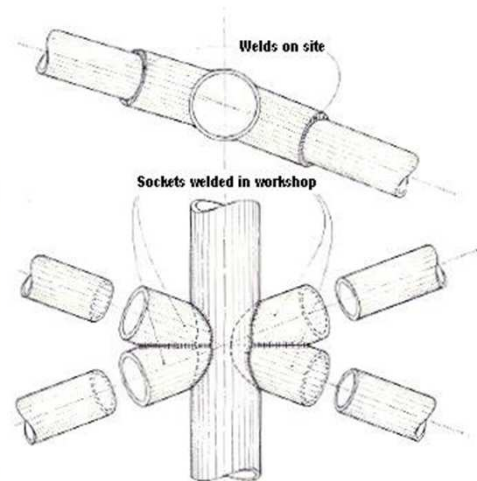
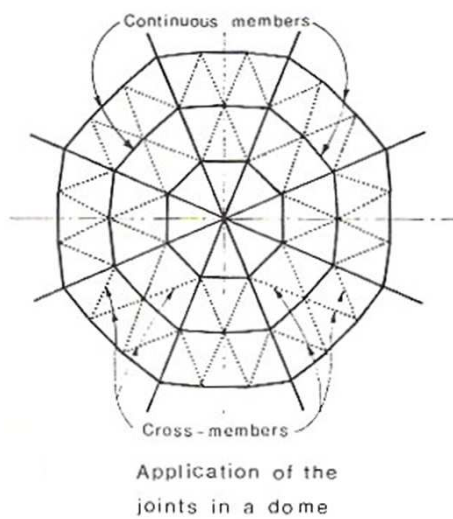
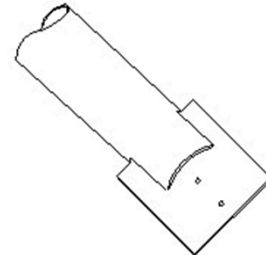


Fig.2.10 Plan and elevation of a typical joint for domes [3]