جامعة أبو بكر بلقايد
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UNIVERSITÉ DE TLEMCEN
Faculté de Technologie

A3 ARCHITECTURE

SUBJECT: STRUCTURE IN ARCHITECTURE 1

CHAPTRE 5 : DOME STRUCTURES

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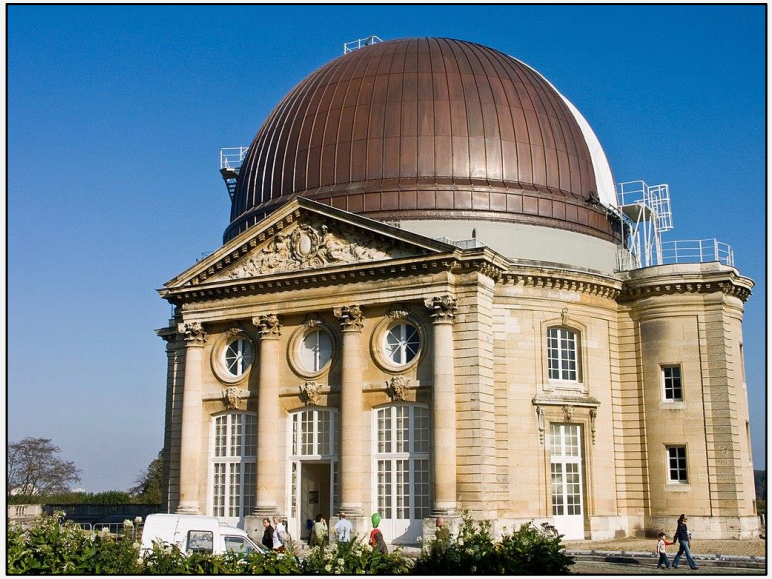
WHAT IS DOMES STRUCTURES ?

Domes are iconic architectural structures used in construction to cover large-span spaces. They are characterized by their curved shape and their ability to distribute loads efficiently.



The Paris Observatory
(Paris, France, 1667)

The Dome of the Rock
(Jerusalem, Palestine, 691)

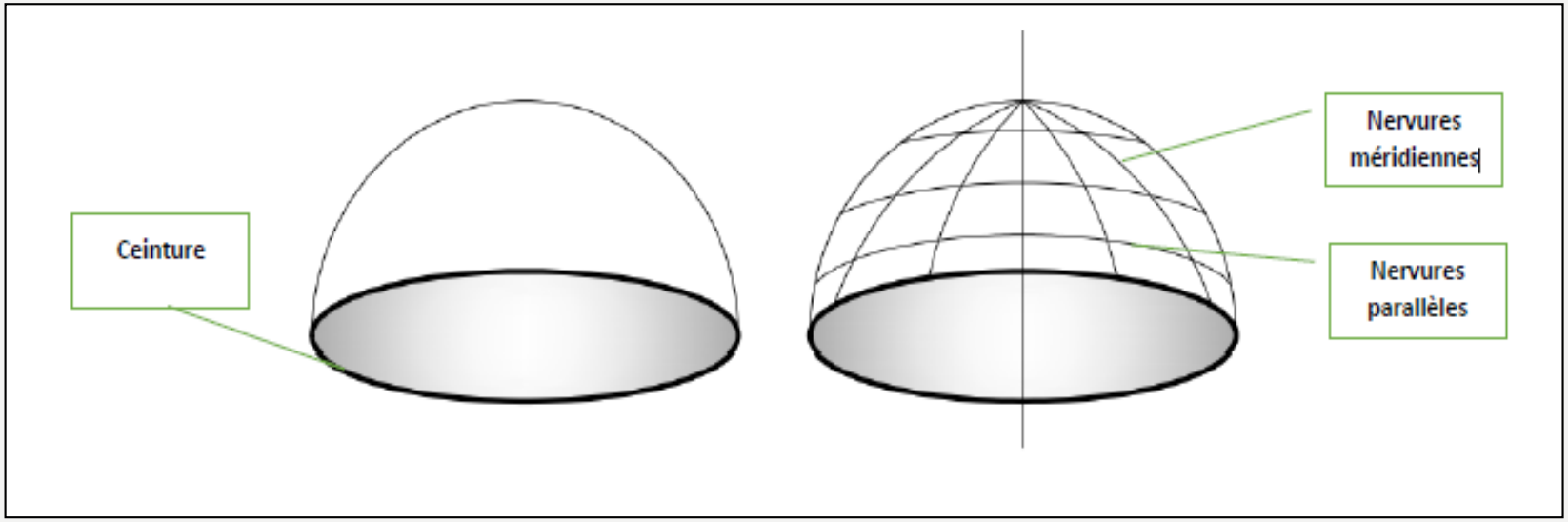
ADVANTAGES OF DOMES

- **Structural efficiency:** Resists compression and lateral forces
- **Large span:** Can cover wide spaces without internal supports
- **Aesthetic:** Creates a sense of grandeur and lightness
- **Insulation:** Domes allow natural light and contribute to energy efficiency

Hagia Sophia Mosque, 32.60 m
(Istanbul, Turkey, 6th century)

COMPONENTS OF A DOME

A dome consists of a thin shell, generally of revolution, stiffened by ribs—either meridional, parallel, or in both directions. It is usually equipped with a base ring resting on supports, which can be continuous or discrete.



MATERIALS USED FOR DOMES

- **Stone and brick:** laid in layers (or "rings") with mortar
- **Glass and steel:** for transparent or semi-transparent structures
- **Reinforced concrete:** for large spans and durability

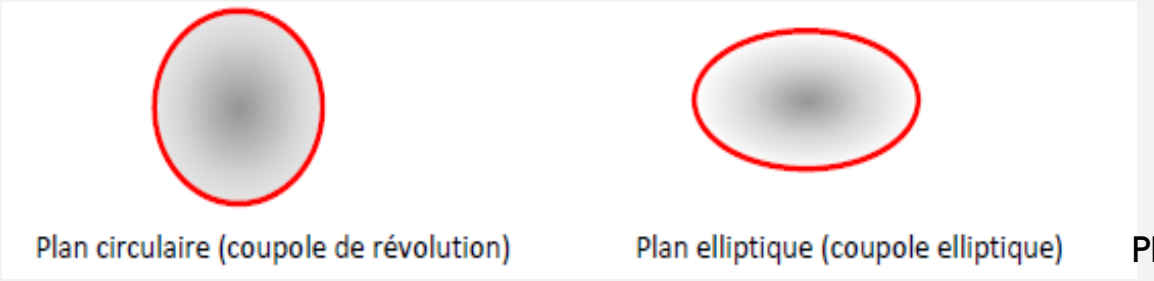
By stone and brick

By glass and steel

By reinforced concrete

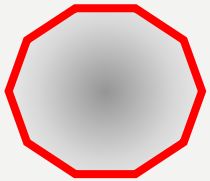
CLASSIFICATION OF DOMES

- **According to the plan shape:** the dome's plan can be circular, elliptical, or polygonal.

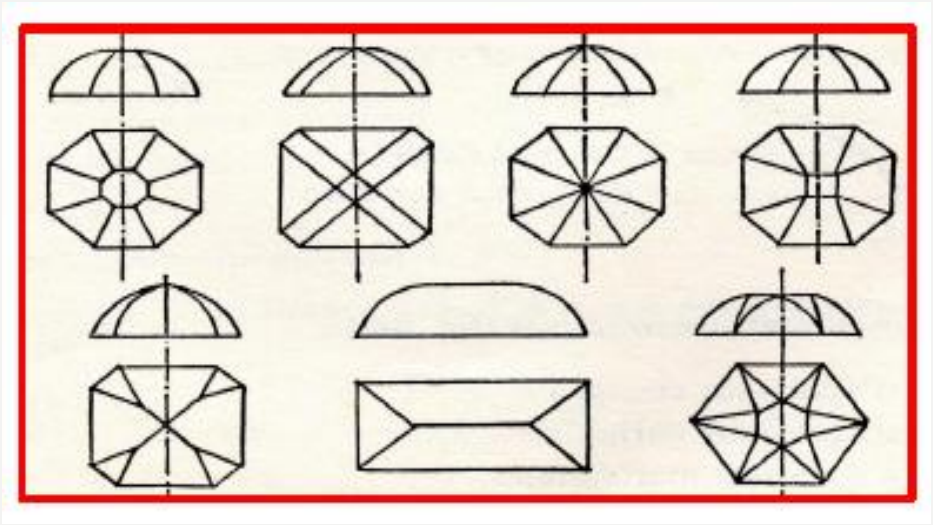


Plan circulaire (coupole de révolution)

Plan elliptique (coupole elliptique)

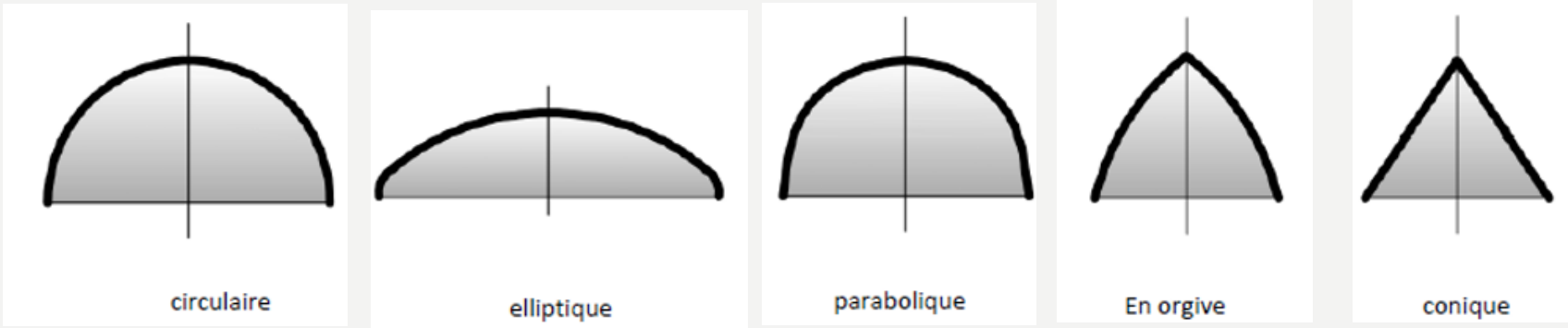


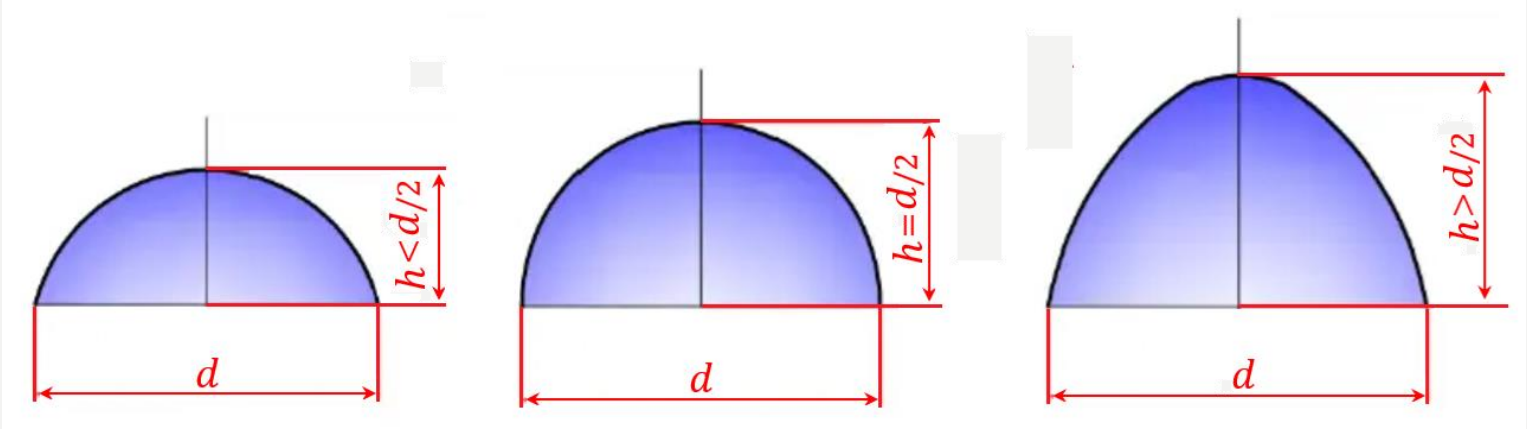
Plan polygonale (Coupole polygonale)



CLASSIFICATION OF DOMES

- **According to the shape of the meridian:** the rise of the dome can vary.

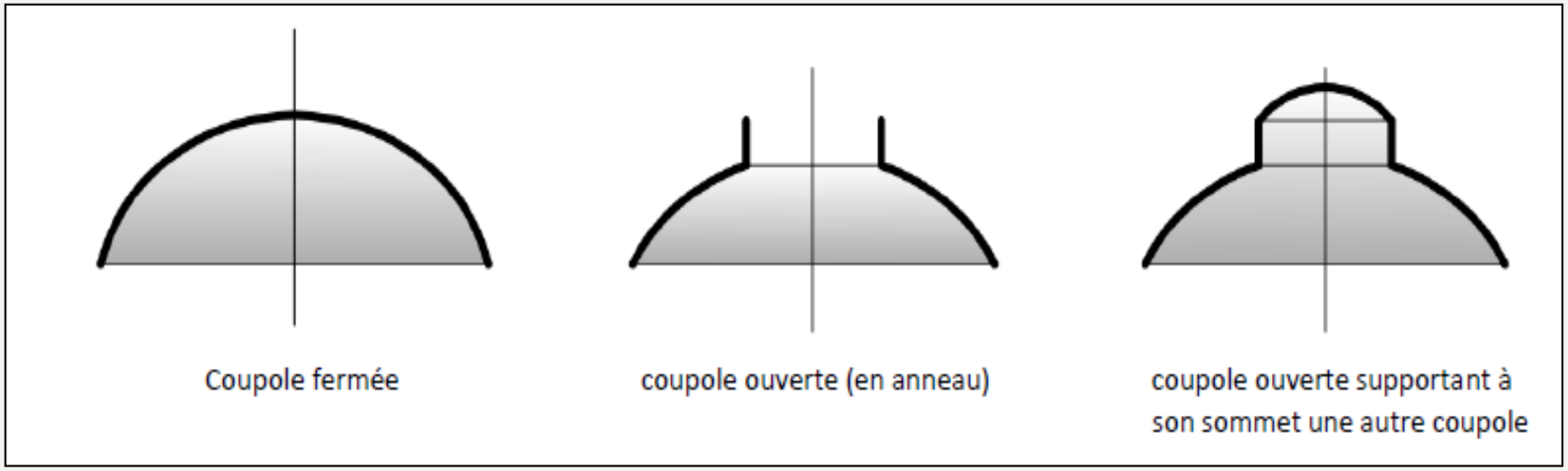




Low-rise domes | **Semicircular domes** | **Hight-rise domes**

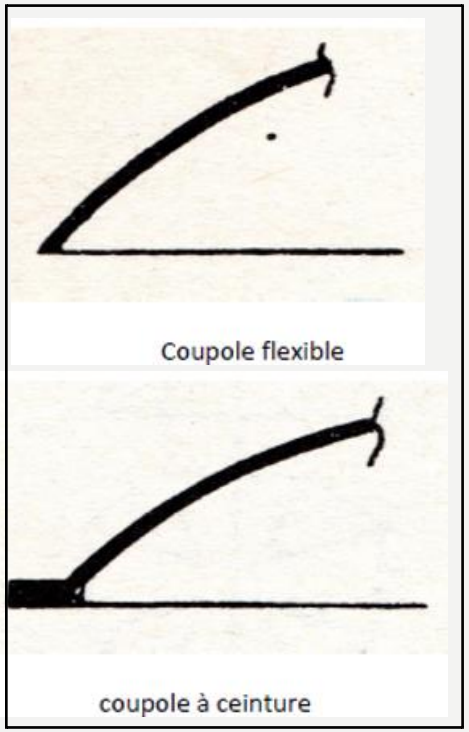
CLASSIFICATION OF DOMES

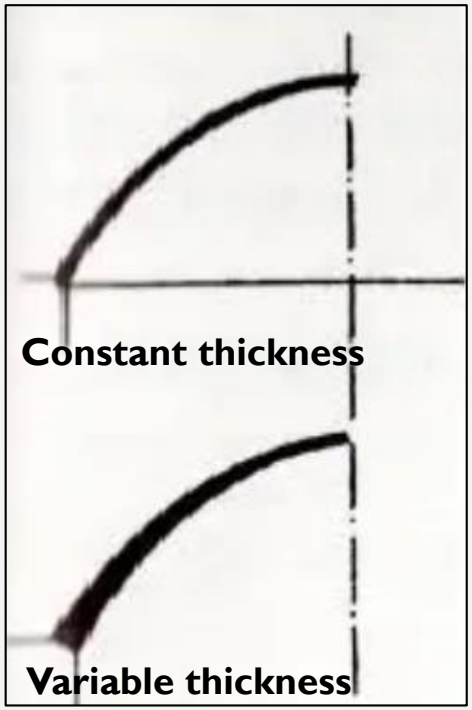
- **According to the shape of the top:** a dome can be closed, open, or elevated by another dome.

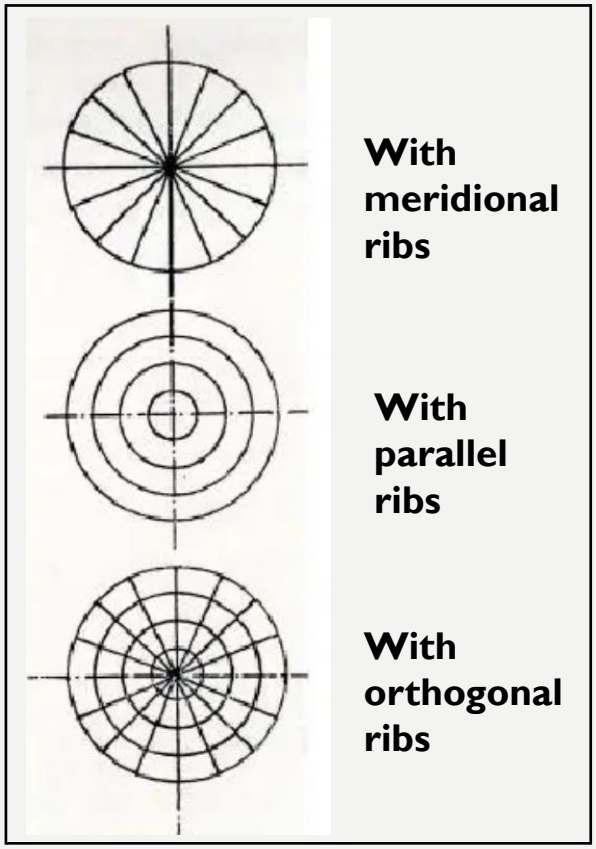


CLASSIFICATION OF DOMES

- **According to the construction method:** the construction of a dome varies depending on its design and intended use.

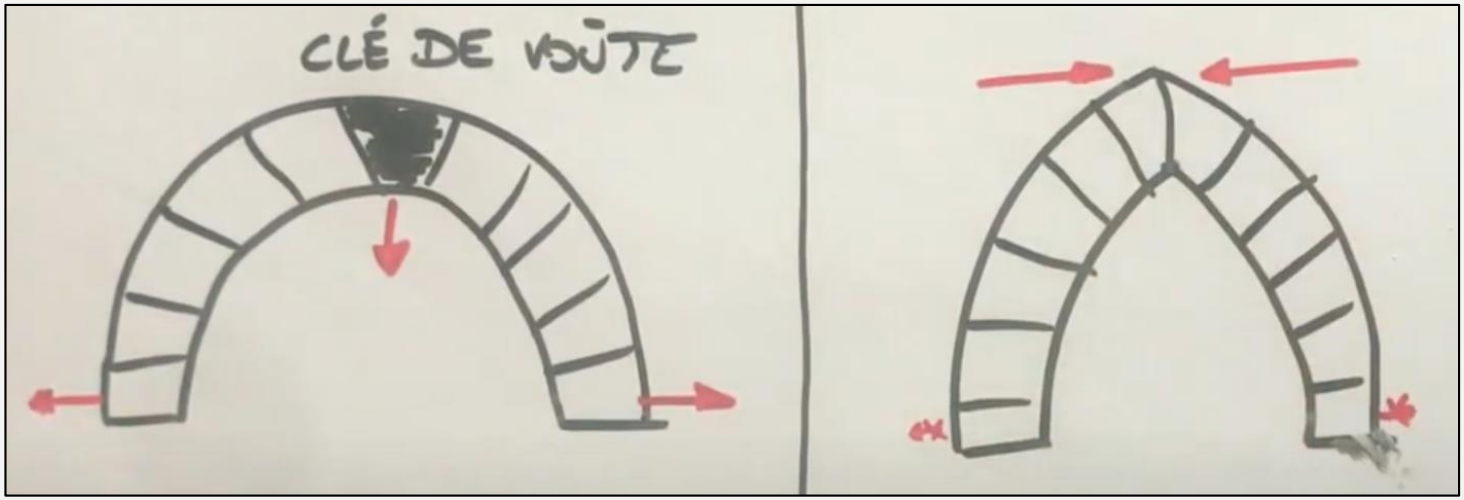






BEHAVIOR OF DOMES AND RIB VAULTS

- The dome distributes loads evenly over its circular base, transmitting significant vertical (weight) and horizontal (thrust) forces. In contrast, the rib vault channels vertical forces while reducing horizontal thrust forces.



Vidéos représentatives :

- https://www.youtube.com/watch?v=xB8IpYLFna8&ab_channel=YoungHeroEngineer
- https://www.youtube.com/watch?v=aRSyZQSUIB8&ab_channel=C%27estpassorcier

CONSTRUCTION OF A REINFORCED CONCRETE DOME

The construction of a reinforced concrete dome represents a major technological advancement in architecture. Thanks to its strength and flexibility, reinforced concrete allows for the design of larger, lighter domes that meet modern standards. Here is a detailed overview of the process, advantages, and examples:

- **Step 1:** Install formwork made of wood, metal, or polystyrene.
- **Step 2:** Place reinforcement bars or steel mesh within the formwork to strengthen the dome.
- **Step 3:** Pour the concrete in sections to ensure even distribution and prevent cracks. After the concrete has hardened, the formwork can be removed.

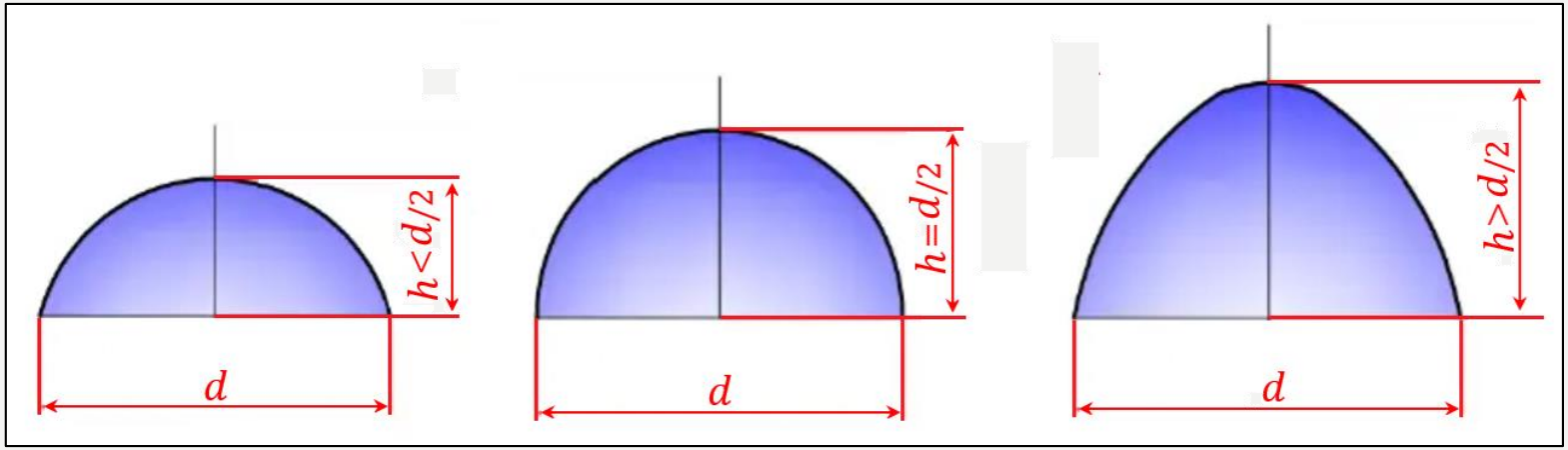
Vidéos représentatives :

- https://www.facebook.com/jkmmarchitects/videos/1439064559525386/
- https://www.youtube.com/watch?v=IaVyHdSwU44&ab_channel=%D9%85%D8%B5%D8%B7%D9%81%D9%89%D8%B5%D8%B7%D9%8A%D9%81%D8%A7%D9%86

CALCULATION METHOD FOR A REINFORCED CONCRETE DOME

In this course, the calculation of domes with different rise heights (the meridian) is addressed using Timoshenko's membrane method.

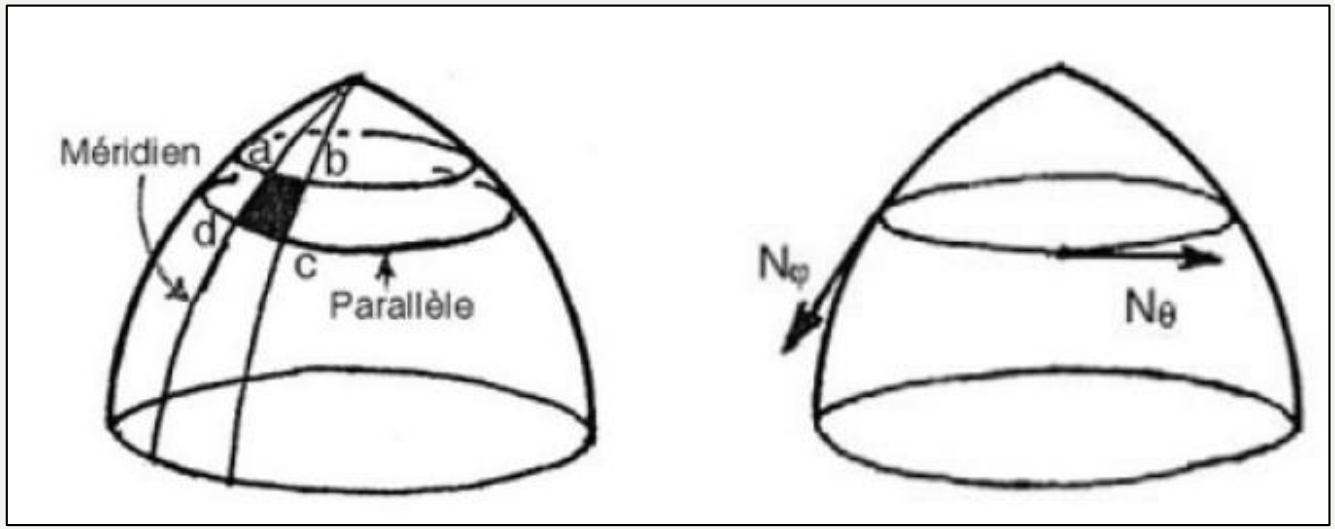
- **Low-rise dome:** the rise is smaller than the radius
- **Semicircular dome:** the rise is equal to the radius
- **Hight-rise dome:** the rise is greater than the radius



Low-rise domes | **Semicircular domes** | **Hight-rise domes**

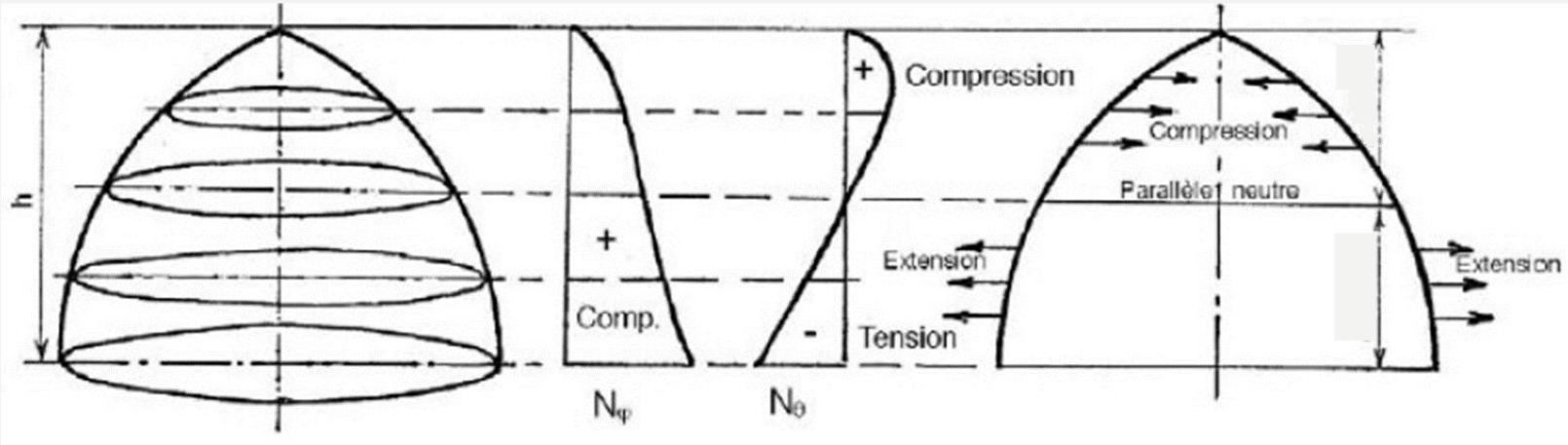
CALCULATION METHOD FOR A REINFORCED CONCRETE DOME

Consider a shell with a circular base. The shell is divided into **meridians and parallel circles** (simply called parallels). The equilibrium of the element (a, b, c, d) is studied using differential calculus, then extended by integration to the entire shell surface. This allows determining the force N_{ϕ} developing along a meridian and the force N_{θ} developing along a parallel under the effect of the shell's self-weight.



CALCULATION METHOD FOR A REINFORCED CONCRETE DOME

- The forces along the meridian $N_{\emptyset}$ are **compressive** forces that increase from the top of the dome to its base.
- The forces along the parallels N_{θ} are considered **compressive** above the neutral axis and become **tensile** below the neutral axis.



CALCULATION METHOD FOR A REINFORCED CONCRETE DOME

❑ **General pre-dimensioning:** Applicable to all types of domes

According to Eurocode 2 (EC2), although no universal formula is provided for thin shells, it is recommended to maintain a minimum thickness given by the following relation:

$$e_{\min} = \max(5\,\text{cm}, \frac{d}{250})$$

d : the diameter of the dome

h : the height of the dome (the rise)

r : the radius of the dome