# Chapter I: Long-Span Structures

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# Objectifs

- Identify the long-span structures, their history, classification, area of use, the materials used
- Identify various basic geometries of long-span buildings such as beams, trusses, arches, cables, plates, membranes, shells, and domes.
- Analysis of beams, trusses, arches, and cables.

# Long-Span buildings

I

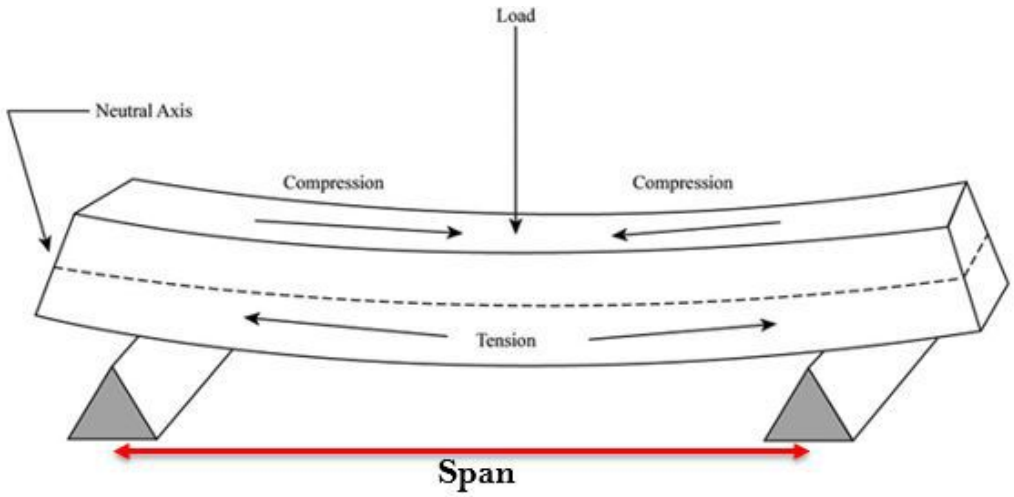
## 1. Introduction

*Définition*

A roof should help in protecting the building against external conditions in order to provide comfort and safety for the building occupants.

*Roof of Barcelona airport*

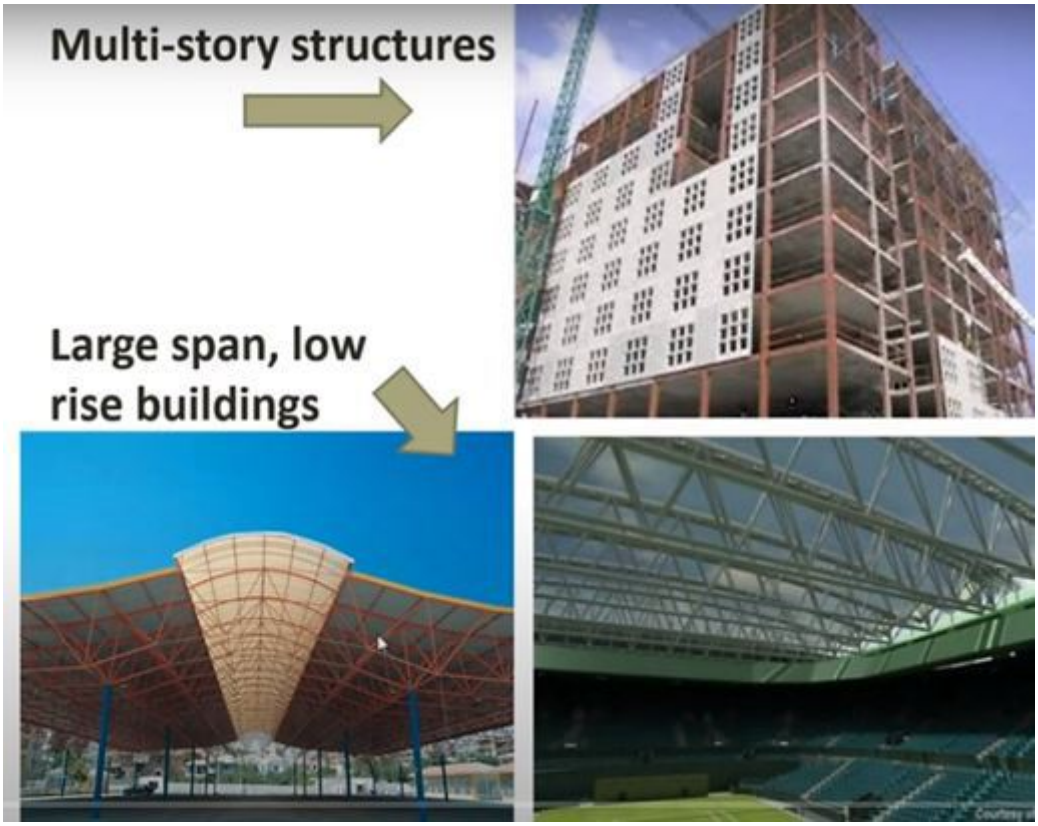
When a beam spans between two simple supports and carriers a uniformly distributed load (such as a roof covering) it tends to bend in the centre.




*A span of a beam*

Long span roof construction:

Categories of buildings




*Fondamental*

Can a simple span roof support be used for distance in excess of ex. 15m ?

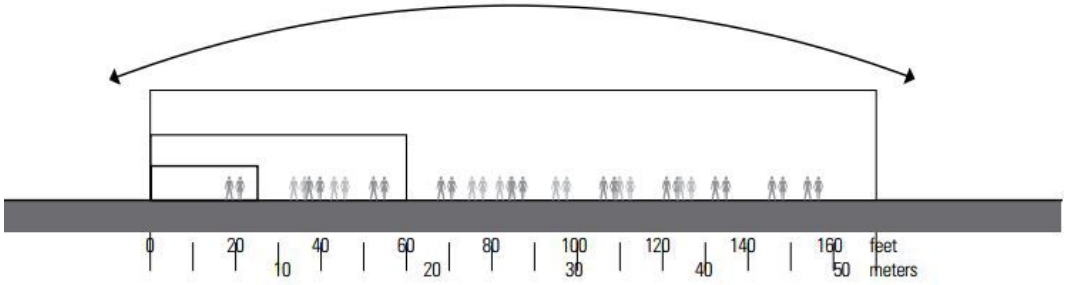
In essence, we want to:

- Increase a beam's resistance to bending
- Whilst minimizing the self weight of structural member
- Maximizing its efficiency both economically and structurally

# 2. Definition

*Définition*

Long-span buildings create unobstructed, column-free spaces greater than 18 meters for a variety of functions/ activities.




*Long-span structure definition*

Examples of relevant activities:

- ...where visibility is important: i.e. auditoriums and covered stadiums
- ...where flexibility is important: i.e. exhibition halls and certain types of manufacturing facilities
- ...where large movable objects are housed: i.e. aircraft hangars

## *Exemple : Spectacular long span structures in late 20th century*

Largest covered stadium > 300 m Span

*Awe-Inspiring stadium (Singapore)*

Cf. "Construction of Awe-Inspiring Stadium (Singapore) by Total Architecture approach – the integration of Arup's architecture"

Largest exhibition hall = 216 m Span

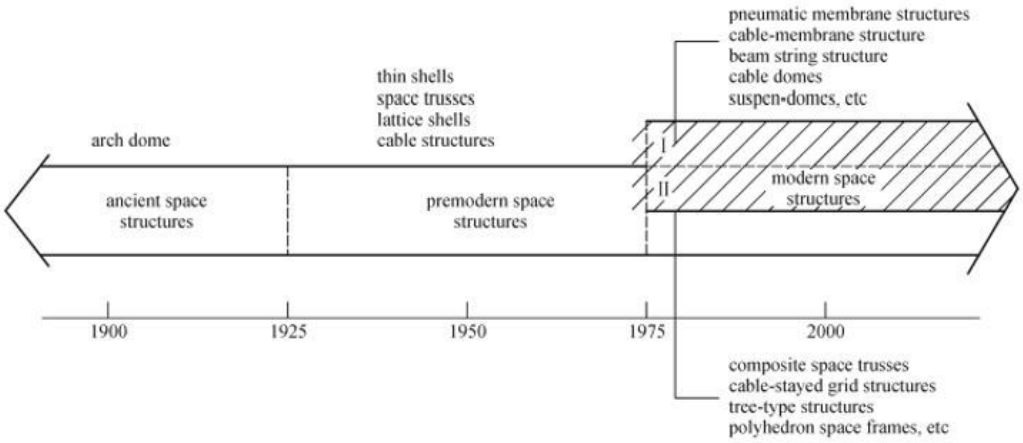
*National exhibition and conventional centre (Shanghai-China)*

Largest hangar = 75-80 m span (to fit largest commercial fixed-wing aircraft with a wingspread of 69,4 m)

*Aerium hangar (Brandenburg-Germany)*

# 3. History

Proposed periods of the history of long-span space structures (by the authors Dong et al, 2012):

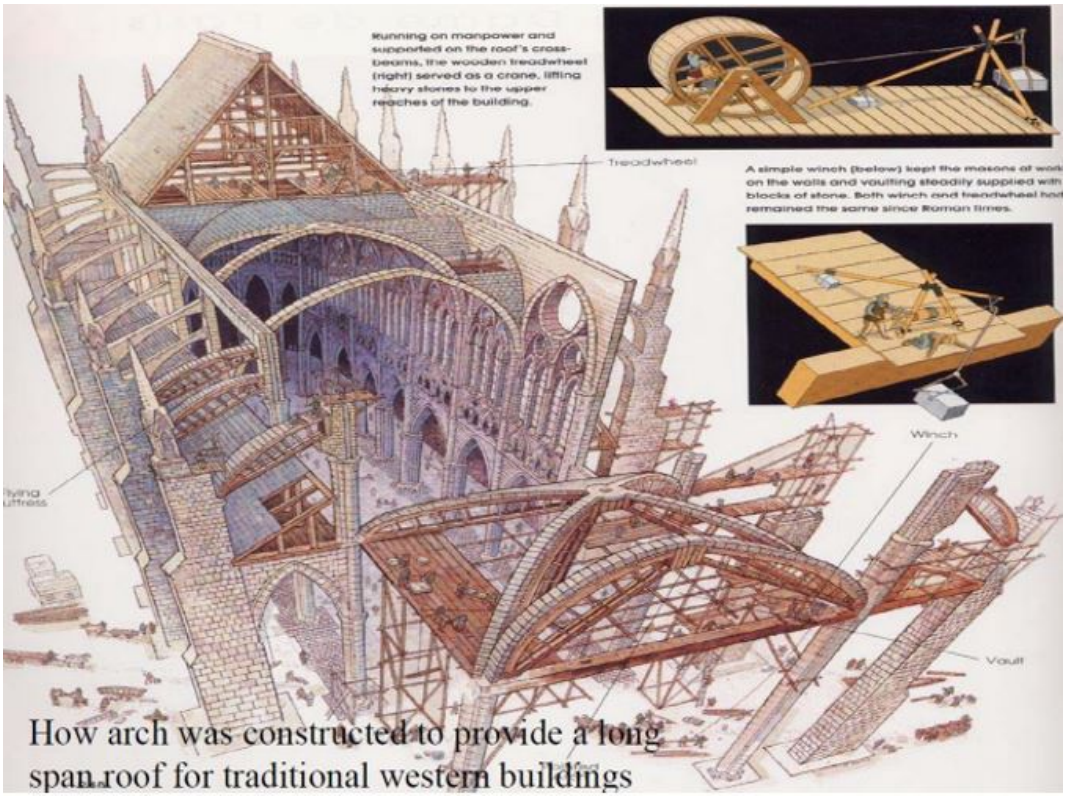



*Age partition of space structures*

## *Ancient long span structures (before 1925):*

The only materials available in ancient times:

- Timber
- Masonry made of stone (vulnerable in tension and bending)
- Masonry of bricks made of clay (also vulnerable in tension and bending)



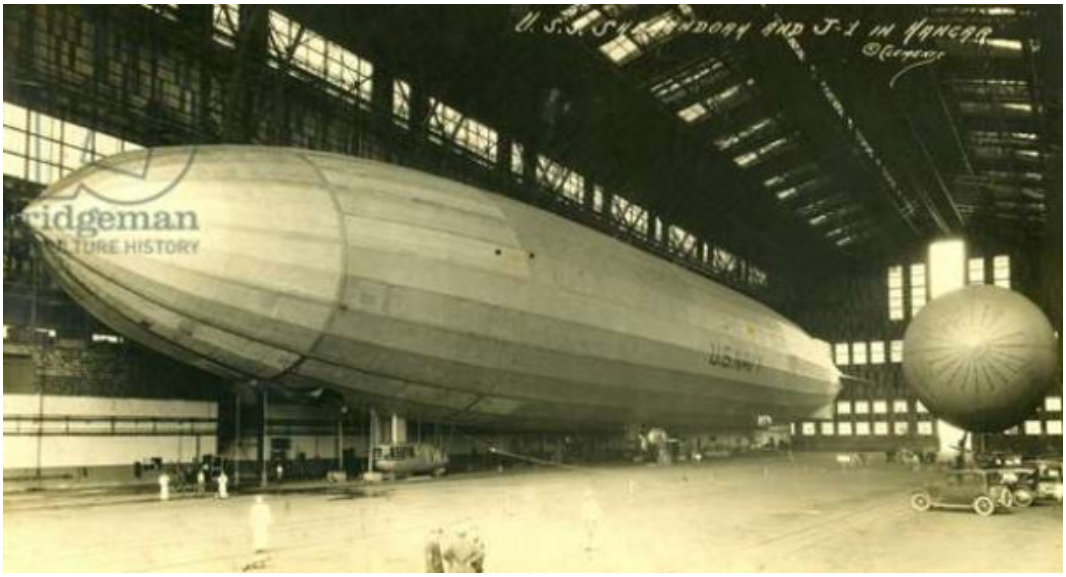

*Construction of an arch system*

### *Remarque*

Reaching long spans in such constructions = EXTREMELY DIFFICULT!

ONLY POSSIBILITY: via the arch-and-vault systems (i.e., palaces) working in compression only

*Later ancient space structures (between 1920 and 1975)*



*Airship hangar US Navy-New Jersey -79 m span in 1922*

*Modern space structures (after 1970)*

*Comprehensive Gymnasium of Seoul Olympic Games = first cable-dome in the world designed by the American engineer Geiger in 1975*

## 4. Material used

Material used for long-span structures:

- All reinforced concrete (RC) including precast
- All metal (e.g. mild-steel, structural steel, stainless steel or alloyed aluminium)
- All timber
- Laminated timber
- Metal + RC (combined)
- Plastic coated textile material (fabric) – for roofing / cladding
- Fiber reinforced plastic – for roofing / cladding

# 5. Classification

Classified into two groups:

- Bending structures :have both tensile and compressive forces such as (plate girder, trusses)
- Funicular structures: work either in pure tension (cable-stayed roof, the bicycle wheel) or in pure compression (parabolic arch, dome)

# 6. Basic Geometries

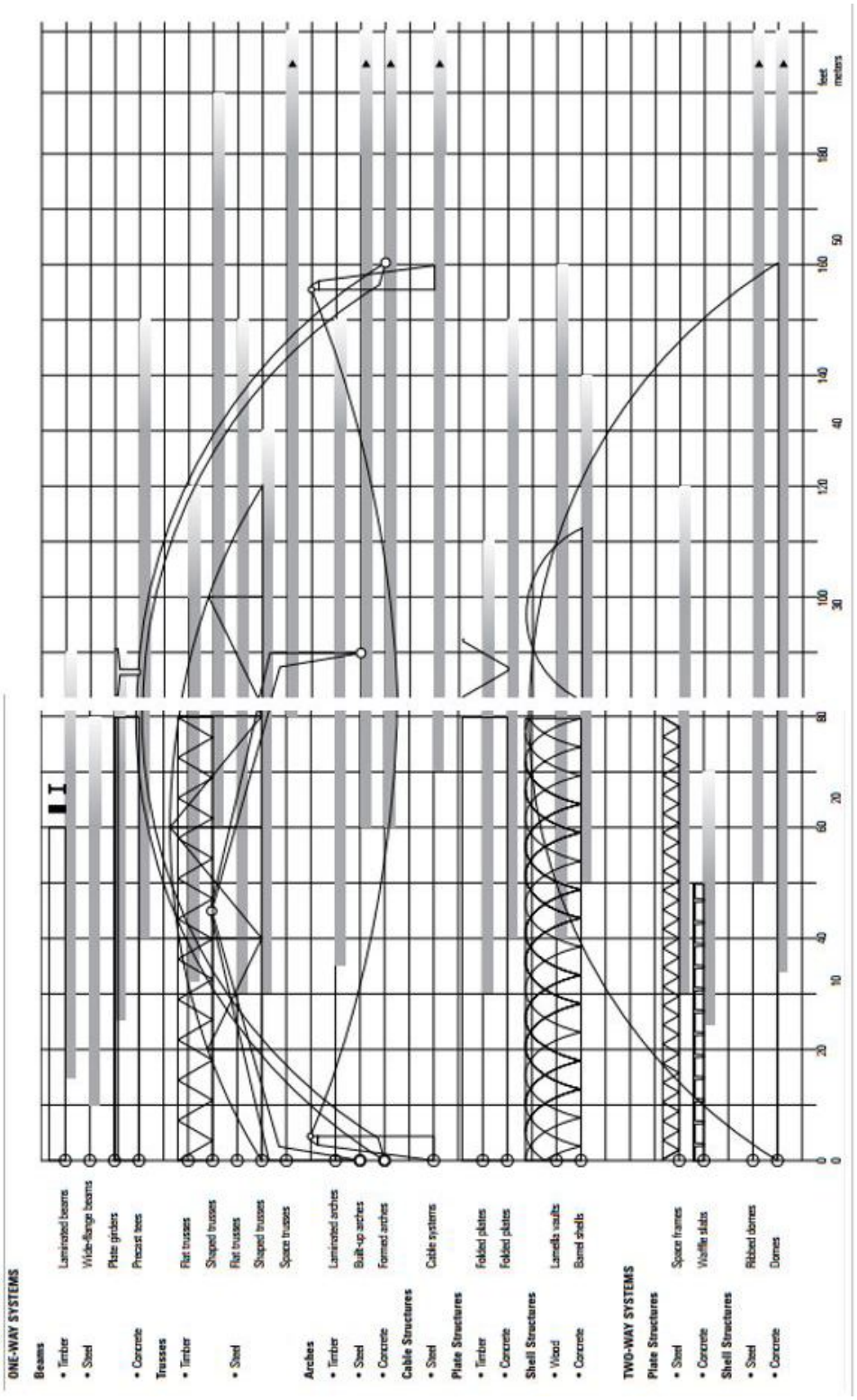
The span ranges for the basic types of long-span structures as shown in figure below are:

One-way System:

- Beams
- Trusses
- Arches
- Cable structures
- Plate structures
- Shell structures

Two-way System:

- Plate structures
- Shell structures




*Listed of span ranges for the basic types of long-span structures*