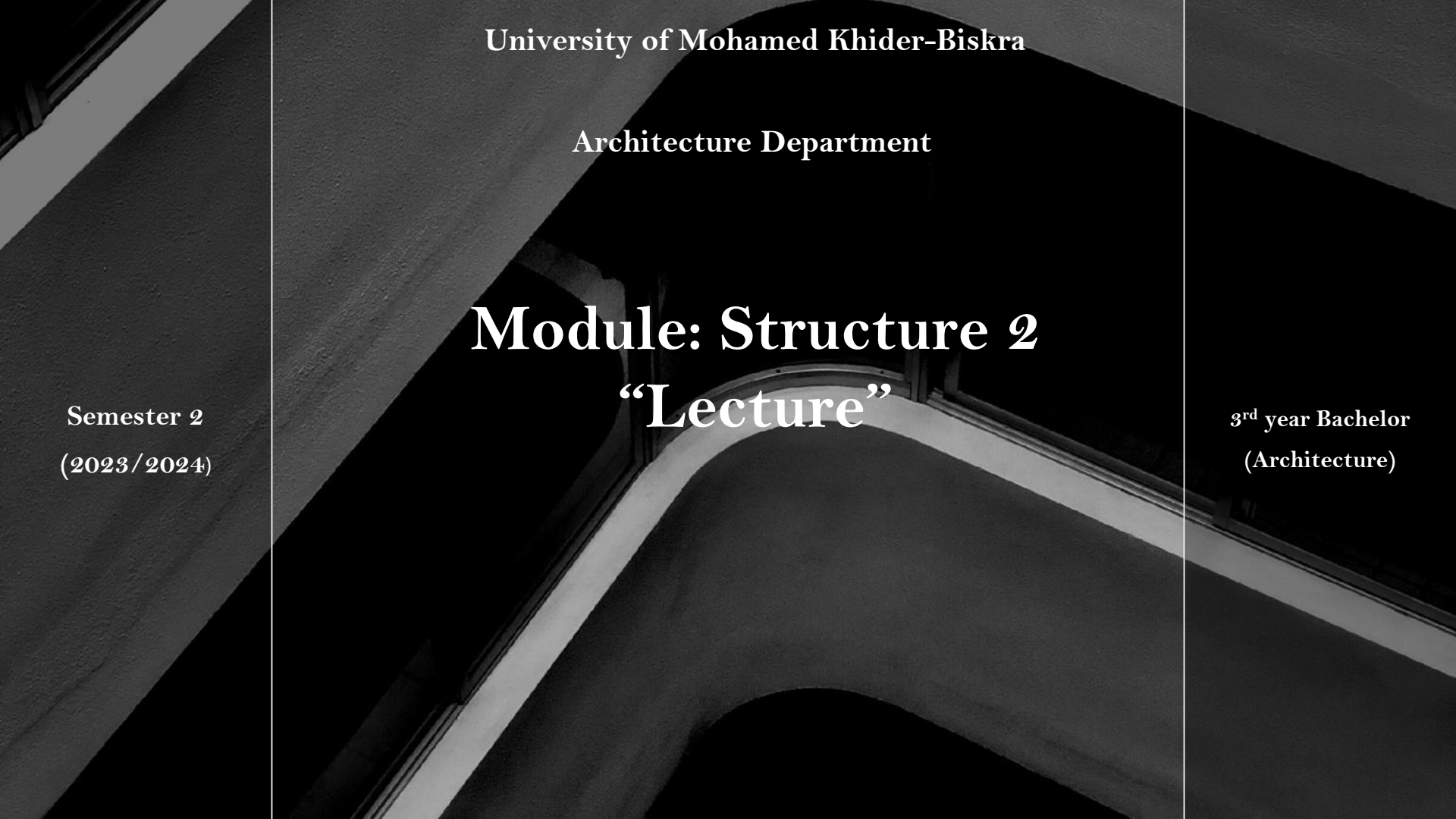


University of Mohamed Khider-Biskra

Architecture Department

Module: Structure 2
"Lecture"

Semester 2

(2023/2024)

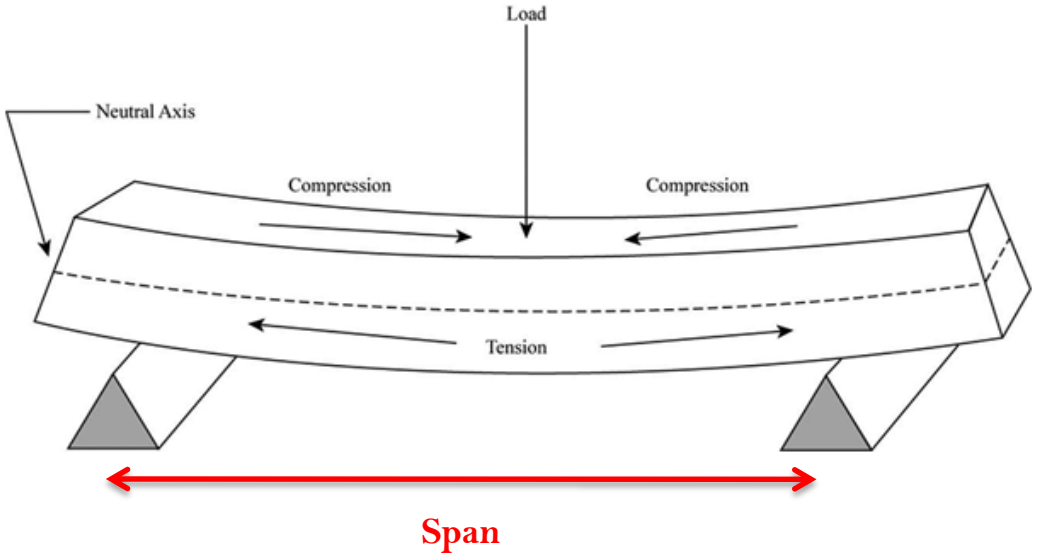
3rd year Bachelor

(Architecture)

I.1. Introduction:

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

A roof of Barcelona Airport


Load
Neutral Axis
Compression
Compression
Tension
Span

Is it possible to employ a simple span roof support over a distance greater than, say, 18m?

In essence, we want to:

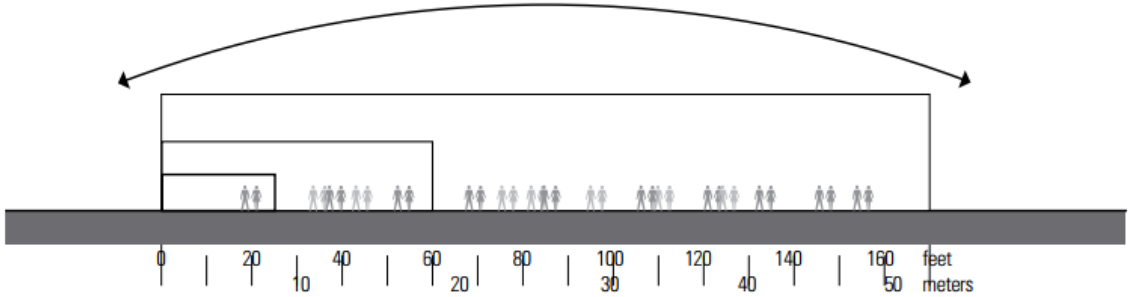
a) Increase a beam's resistance to bending

b) Whilst minimizing the self weight of structural member

c) Maximizing its efficiency both economically and structurally

I.2.Definition:

Buildings that create unobstructed, column-free spaces grater than 18 m for a variety function/activities.



Examples of relevant activities:

- **…where visibility is important such as: auditoriums, covered Stadiums and Lecture hall.**
- **…where flexibility is important such as: exhibition halls and certain type of manufacturing facilities**
- **…where large movable objects are housed such a: aircraft hangars**

Spectacular long-span structures in late 20th century

Upper limit of span for previously mentioned categories:

Largest covered stadium > 300 m Span

Awe-Inspiring stadium (Singapore)

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)

I.3.Purpose:

Communal activities:

Enables a large group of peopole to assemble without obstruction by the presence of Supporting column.

Economic activities:

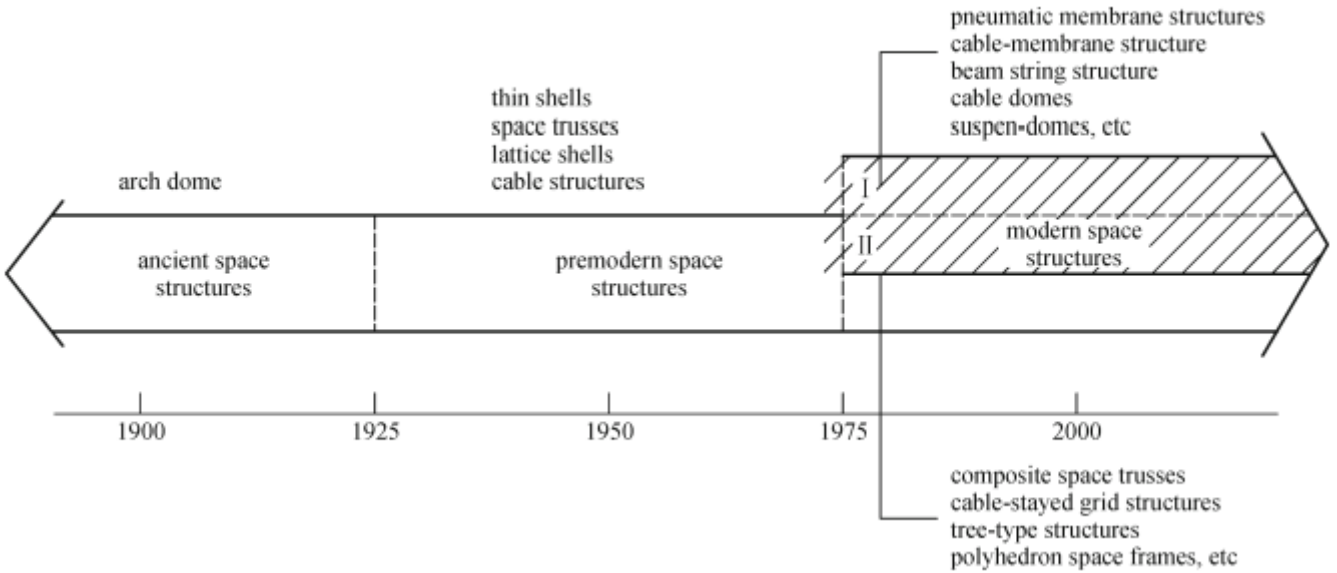
For manufacturing and commerce; e.g., atrium at shopping complex- events and promotional activities

Prestige & status:

Dominate the landscape and easily become landmark- free advertisement for the owner and even for the city

I.4.History:

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



Ancient long-span structures (before 1925):

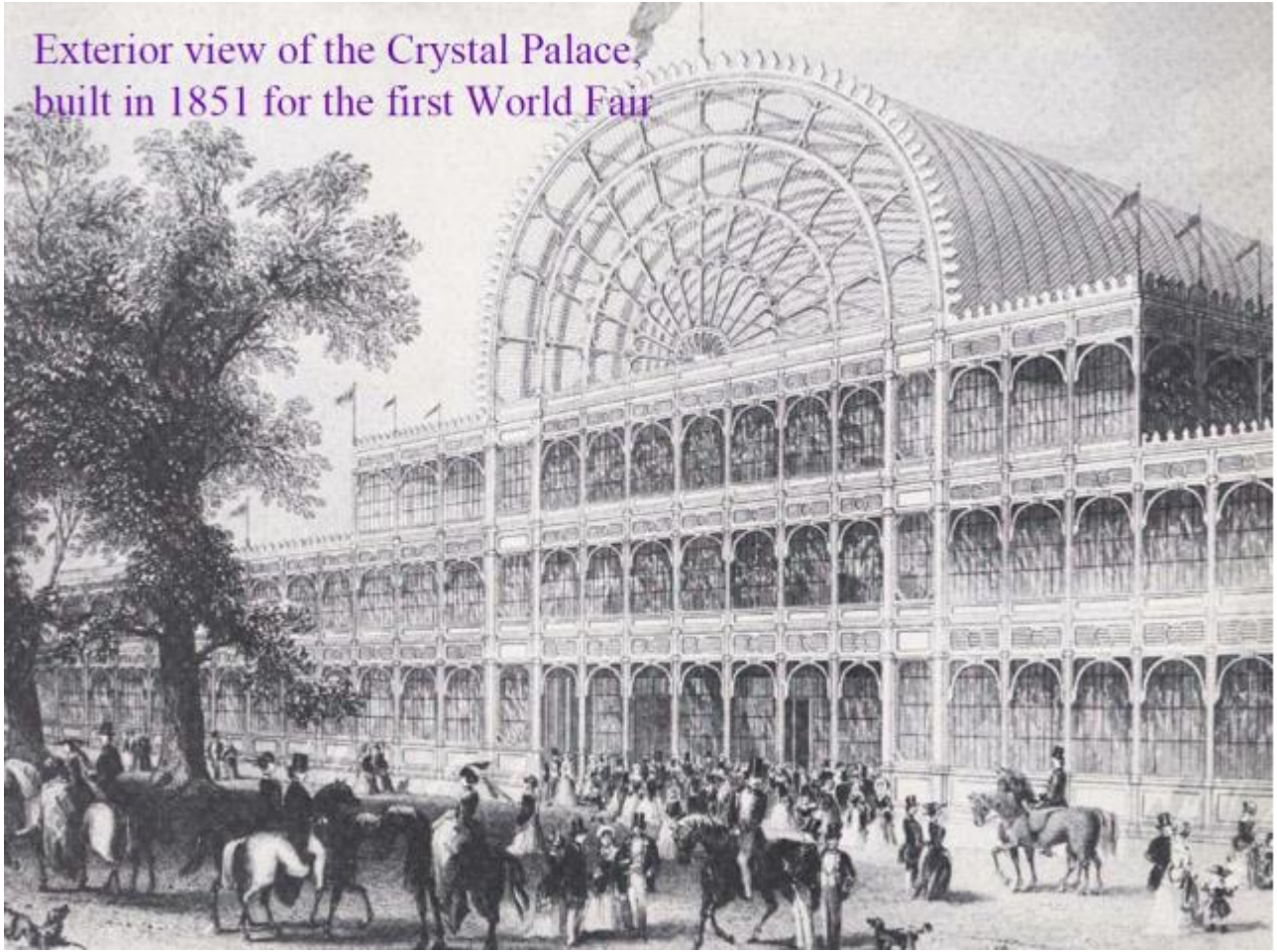
The only materials available in ancient times:

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

RESULT: Reaching long spans in such constructions = EXTREMELY DIFFICULT!

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

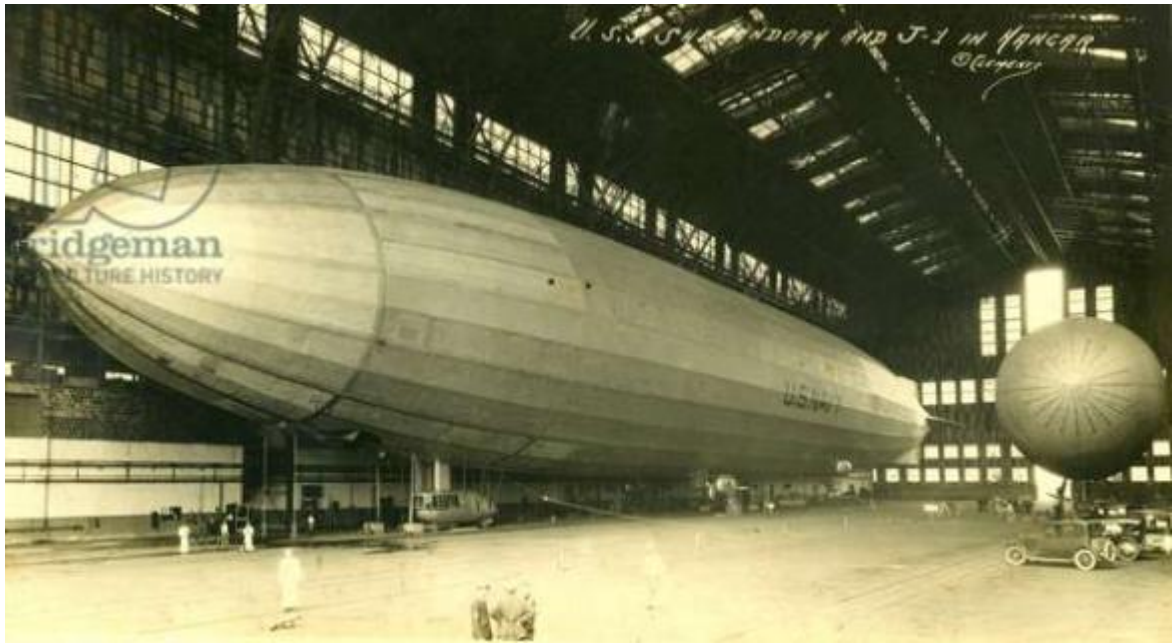
Example: Crystal palace-London (Uk)



Later ancient space structures (between 1920 and 1975)

Examples:

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



• **1937: Glenn L. Martin Co. Aircraft Assembly Building Baltimore –Flat truss 91 m span**

Modern space structures (after 1975)

Examples:

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

- 1988: Tokyo Dome = air supported membrane structure (ellipse 180 m x 150 m)

What are the factors that must be taken into account in the design and selection of a suitable roof structure?

- **Function of the building**
- **Span of the roof**
- **Height of the space**
- **Aesthetic and design requirements**
- **Economic considerations**
- **Construction considerations**
- **The environment**

I.5.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

I.6.Classification:

Classified into two groups:

- **Bending structures:** have both tensile and compressive forces such as plate girder and trusses.

- **Funicular structures:** work either in pure tension (cable-stayed roof and bicycle wheel) or in pure compression (parabolic arch and dome).

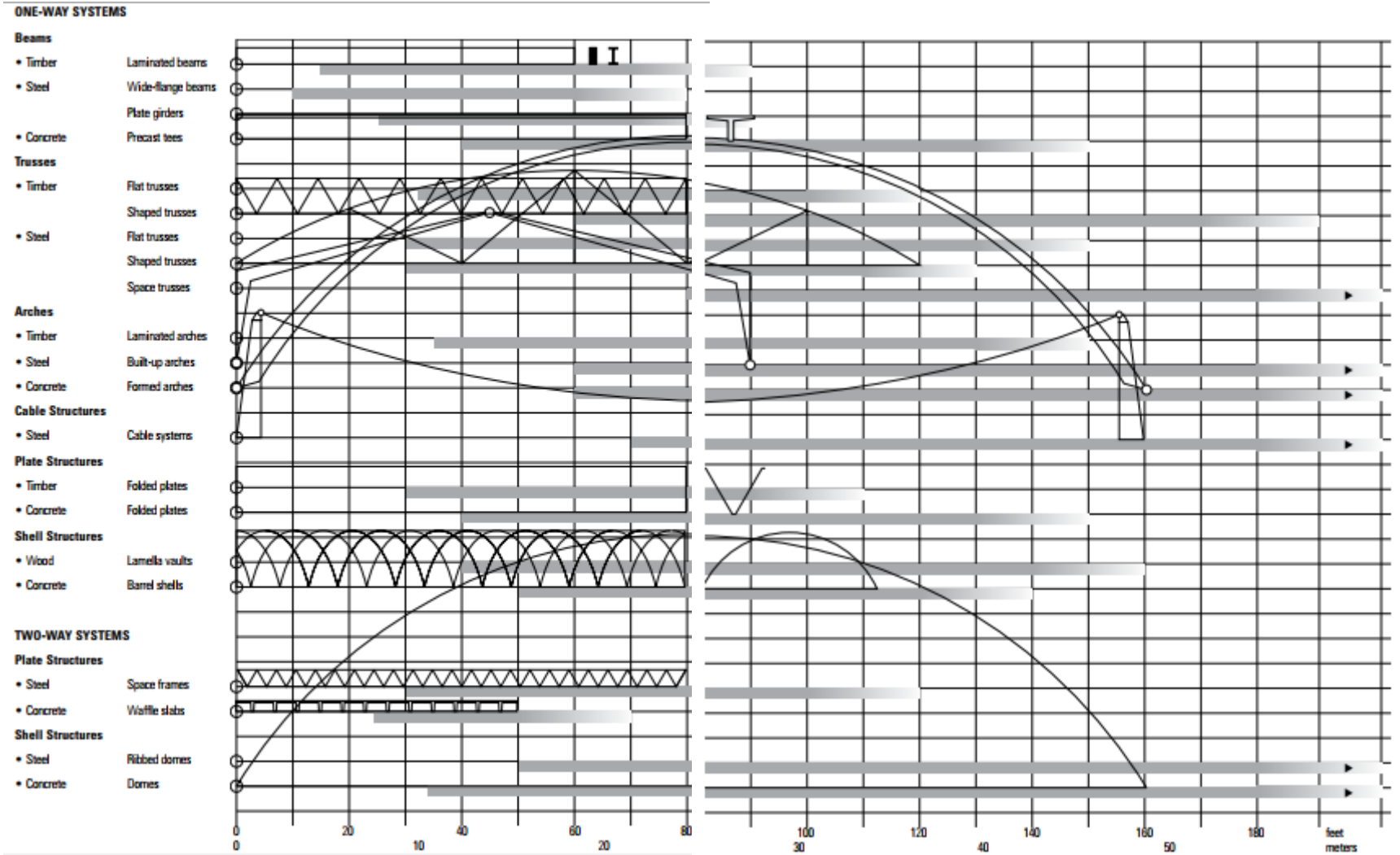
I.7.Basic Geometries:

One-way System: also known as **unidirectional system**, is a structural system in which the structural members primarily carry loads in one direction, such as:

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

Two-way System: also known as **bidirectional system**, is structural system in which the structural members primarily carry loads in two direction, such as:

- Plate structures
- Shell structures


ONE-WAY SYSTEMS
Beams
• Timber
Laminated beams
• Steel
Wide-flange beams
Plate girders
• Concrete
Precast tees
Trusses
• Timber
Flat trusses
Shaped trusses
• Steel
Flat trusses
Shaped trusses
Space trusses
Arches
• Timber
Laminated arches
• Steel
Built-up arches
• Concrete
Formed arches
Cable Structures
• Steel
Cable systems
Plate Structures
• Timber
Folded plates
• Concrete
Folded plates
Shell Structures
• Wood
Lamella vaults
• Concrete
Barrel shells
TWO-WAY SYSTEMS
Plate Structures
• Steel
Space frames
• Concrete
Waffle slabs
Shell Structures
• Steel
Ribbed domes
• Concrete
Domes
0
20
40
60
80
0
10
20
100
120
140
160
180
30
40
50
feet
meters

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