1.1 Introduction

Long span building structures are required in buildings where a large number of people congregate, especially in complex and institutional buildings. These buildings have large spans and often big heights, and cannot be constructed from common structures such as walls and simple roofs.

1.2 Definition of long span structures.

Structure with span larger than 20m can be regarded as long span structure for this span is usually unable to be achieved by ordinary RC structure

1.3 Materials used in long span structures.

- Reinforced concrete (in situ & precast)
- All metal (e.g. mild-steel, structural steel)
- Stainless steel or alloyed aluminium
• Timber
• Laminated timber
• Metal/ Reinforced concrete combined
• Plastic-coated Textile material
• Fibre reinforced plastic

1.4 **Common structural forms of long span building structures.**

• In situ RC, tensioned
• Precast concrete, tensioned
• Structural steel – erected on spot
• Structural steel – prefabricated and installed on spot
• Portal frame – in situ RC
• Portal frame – precast
• Portal frame – prefabricated steel

1.5 **History of long span structures.**

The development of long span structures

[Diagram showing the development of long span structures]
1.6  **Classification of long span and complex structures based on system of forces.**

- Form active systems
- Vector active systems
- Section active systems
- Surface active systems

1.7  **Form active structural systems: cable structures, tent structures, pneumatic structures, arch structures.**

These are systems of flexible, non-rigid matter, in which the redirection of forces is effected by particular form design and characteristic form stabilization. Examples are:

1. Cable structures
2. Tent structures
3. Pneumatic structures
4. Arch structures

1.7.1  **Cable structures**

Cable structure
Forms of cable structures

Example of form of cable structure
Example of cable structure
Cable structure. Exterior of the Georgia Dome showing the roof. Source: http://z.about.com/d/architecture/1/0/b/n/GeorgiaDomeStock00000411299Small.jpg


Cable structure. Schematic Diagram of the Georgia Dome Roof.
Cable structure. National stadium, Abuja.
1.7.2 Tent structures

Tent structure. National stadium, Abuja

Tent structure. National stadium, Abuja
Tent structure.

Tent structure.
Tent structure. The curved trusses are supported by a cable system.

1.7.3 *Pneumatic structures*

Forces acting on pneumatic structures
Parts of a pneumatic structure.

Examples of pneumatic structures
Examples of pneumatic structures

Example of pneumatic structures
Example of pneumatic structures
1.7.4 Arch structures

Parts of an arch

Keystone

Springers
Arches and vaults

Use of arches in a Gothic church
Use of arches in aqueduct

Use of arches in ceremonial architecture
Example of arch. Colosseum, Rome, Italy

Example of arch. St. Louis, USA.
1.8 Vector active structural systems: flat trusses, curved trusses, prismatic (3D) trusses, space trusses.

These are systems of short, solid, straight lineal members, in which the redirection of forces is effected by vector partition, i.e. by multidirectional splitting of single force simply to tension or compressive elements. Examples are:

1. Flat Trusses
2. Curved Trusses
3. Prismatic (3D) Trusses
4. Space Trusses

1.8.1 Flat Trusses
Flat truss shapes
Flat truss shapes.

Parts of a flat truss.
Example of flat truss.
Example of flat truss.

1.8.2 Curved Trusses

Curved steel truss

Double-curved steel truss

Curved truss (bowstring truss)
Curved timber truss
1.8.3 Prismatic (3D) Trusses
Curved 3D prismatic trusses

Curved 3D prismatic trusses, Hamburg airport departure hall

Curved 3D prismatic trusses, Hamburg airport departure hall
Curved 3D prismatic trusses, Hamburg airport departure hall

1.8.4 *Space Trusses*

Single layer space truss
Space truss (two-way truss system)

Double layer space truss
Curved double layer space truss

1.9 Section active structural systems: beam structures, frame structures, slab structures.

These are systems of rigid, solid, linear elements, in which redirection of forces is effected by mobilization of sectional forces. Examples are:

1. Beam structures
2. Frame structures
3. Slab structures

1.9.1 Beam structures

Post and beam construction
Post and lintel construction

Beach structure (Stonehenge)
One and two-bay beams

Beam grid systems

Post and beam structure
Example of post and beam structure
1.9.2 *Frame structures*

Frame structure schematic.

Parts of a frame structure.
Parts of a frame structure.

One and two-bay frames
Example of frame structure.

Example of frame structure.
Example of frame structure.
Example of frame structure.

Example of frame structure.
1.9.3 Slab structures

Types of slab structures
Types of slab structures
TWO-WAY SLAB WITH BEAMS

Slab structure

Slab structure
Example of slab structure. Waffle slab structure.

Example of slab structure.
1.10 Surface active structural systems: plate structures, folded structures, shell structures.

These are systems of flexible or rigid planes able to resist tension, compression or shear, in which the redirection of forces is effected by mobilization of sectional forces. Examples are:

1. Plate structures
2. Folded structures
3. Shell structures

1.10.1 Plate structures

A plate is a relatively thin rigid (solid) body bounded by two surfaces. It has uniform thickness and is flat in the unstressed state. These structures sustain loading using bending stresses. They resist loads by shear and moments. They act like membranes when their bending stiffness is reduced to zero.

A flat plate is a two-way reinforced concrete framing system utilizing a slab of uniform thickness, with neither drop panels nor column capitals to resist heavier loads.

Difference between slabs and plates.
1.10.2 Folded structures
Rigidity of folded plates

Geometry of folded plate structures
Folded plate types

Example of folded plate structure
Example of folded plate structure
1.10.3 Shell structures

A shell structure is a thin curved membrane or slab usually of reinforced concrete that functions both as structure and covering. The term “shell” is used to describe the structures which possess strength and rigidity due to its thin, natural and curved form such as shell of egg, a nut, human skull, and shell of tortoise.

Shell occurring in nature

Single curvature shells are curved on one linear axis and are a part of a cylinder or cone in the form of barrel vaults and conoid shells. Double curvature shells are either part of a sphere, or a hyperboloid of revolution. The terms single curvature and double curvature do not provide a precise geometric distinction between the forms of shell because a barrel vault is single curvature but so is a dome. The terms single and double curvature are used to distinguish the comparative rigidity of the two forms and complexity of centring necessary to construct the shell form.
Single and double curvature shells.

Example of shell structure. Sydney Opera House, Sydney, Australia.
Example of shell structure. Sydney Opera House, Sydney, Australia.

Shell roof structure
Pre-stressed concrete-shell

Concrete shell structure: McDonnell planetarium, St Louis, USA.
Concrete shell structure: McDonnell planetarium, St Louis, USA.

Example of concrete shell structure. TWA Terminal building, JFK Airport, New York, USA by Eero Saarinen.
Example of concrete shell structure. TWA Terminal building, JFK Airport, New York, USA by Eero Saarinen.