Long Span and complex Structure
Loads acting onto a structural systems

1. Dead load
2. Live load
3. Wind load
4. Stress created by temperature differences
5. Stress created by other form of disruption including ground movement, vibration, deformation or earthquake
How long is long-span for buildings

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.
Materials suitable for various forms of long span and complex structure

1. All reinforced concrete including precast
2. All metal (e.g. mild-steel, structural steel, stainless steel or alloyed aluminum,
3. All timber
4. Laminated timber
5. Metal/RC combined
6. Plastic-coated Textile material
7. Fiber reinforced plastic
1. Insitu RC, tensioned
2. Precast concrete, tensioned
3. Structural steel – erected on spot
4. Structural steel – prefabricated and installed on spot
5. Portal frame – insitu RC
6. Portal frame – precast
7. Portal frame – prefabricated steel
One way to classify long-span and complicated structures:

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

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

Example of structures:
1. Cable structures
2. Tent structures
3. Pneumatic structures
4. Arch structures
Illustrated examples of parallel cable structures
Examples of cable structures formed by arch
Examples of tent structures
Examples of pneumatic structures
Examples of pneumatic structures
Examples of arch structures
Vector active structural systems

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

Example of structures:
1. Flat trusses
2. Curved trusses
3. Space trusses
Flat truss systems

curved truss systems
Illustrated examples of flat truss structures
Illustrated examples of hinged truss structures
Section active structural systems

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

Example of structures:
1. Beam structures
2. Frame structures
3. Slab structures
1 & 2 bay beams

Beam-grid systems

1 & 2 bay frames

Slab structures
Hinged frame structures
Illustrated examples of multi-panel frame structures
Surface active structural systems

... 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

Example of structures:

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

Folded plate

Multi-bay structures

Shell structures
Various forms of folded structures

- Dreieckiger Grundriß, waagrechte Faltlinien; triangular floor plan, horizontal ridges
- Quadratischer Grundriß, fallende Faltlinien; square floor plan, ridges falling toward center
- Hexagonaler Grundriß, nebeneinanderliegende Faltlinien; hexagonal floor plan, ridges sloping to center
Examples of shell structures
Development History of Long Span Structure
The development of long span structures
How arch was constructed to provide a long span roof for traditional western buildings
Vaulted ceiling

Long span roof structure as seen from the interior
Exterior view of the Crystal Palace, built in 1851 for the first World Fair
The Gallery of Machine, constructed in 1889 for the Paris Exhibition.
Other Overseas Examples
The Munich Olympic Stadium
The Munich Olympic Stadium for the 1972 Olympic
Other Overseas Examples
The Melbourne Central
An openable roof operating on a Rail system
Other Overseas Examples
Sky Dome, Toronto
Toronto Tower

The Skydome
Openable roof
SkyDome is the first and only stadium to have a fully retractable roof. When the weather is good, usually from April 1 - October 1, we are able to roll back the roof, uncovering the complete field area and over 91% of the seats.

- The roof consists of four panels. One panel is fixed, and the other three are moveable.
- Panel One rotates around 180 degrees while Panels Two and Three telescope straight forward.
- The roof runs on a system of steel tracks and bogies. There are 76 bogies altogether, with 10 horsepower motors inside for a total of 760 horsepower.
- It takes 20 minutes for the roof to open or close as it moves at a rate of 71 feet (21 metres) per minute.
- The roof is made up of steel trusses covered by corrugated steel cladding. Covering the cladding (acting as a weather-proofing) is a PVC single ply membrane.
- It weighs 11,000 tons, the same weight as 3,734 automobiles.
- The roof spans eight acres and rises 282 feet (from field level) at its highest point.
- There are 250,000 bolts in the roof.
**Features of the roof system**

- SkyDome's roof system features a series of 3 moveable panels and 1 stationary panel.
- The roof operates on a system of steel tracks and is powered by a series of DC motors.
- Roof area is 31,525 sq metres.
- Weight is 11,000 tons.
- Span at widest point 209 metres.
- Height is 85m (from field level to highest point).
- Roofing material is PVC on insulated acoustic steel deck.
- 100% of the field & 91% of seating area exposed with the roof open.
- Pen/close time - 20 minutes (21m per minute).
Other Overseas Examples
Charles-de-Gaulle International
Airport, France
Charles-de-Gaulle International Airport, France, completed in 1998
Interior view of the airport concourse
Curving trusses extending from the roof to take up the external glass wall
The Louisiana Superdome, USA – a 580m clear span sport complex opened in 1975
Erecting the steel trusses for the Superdome, the towering structures in majority are the temporary supporting to facilitate the erection
A pneumatic exhibition hall in a construction plant expo in Las Vegas, USA.
Interior view of the exhibition hall and the air-pressurizing fans
Another example of Tent Structure – German Pavilion, Expo ’67, Montreal, Canada
Other Overseas Examples

Tenerife Exhibition Central Stadium
Tenerife Exhibition Centre in Spain, a shallow arch structure of 270m span completed in 1995.
85m-span ribbed arch that formed the podium deck of the exhibition space which is constructed by in-situ, post-tensioned concrete.
TGC Station at the Airport of Lyon, France, completed in 1994. (span 120m)
Station interior under the 120m span roof
The Hamburg Airport, UK
Airport Terminal at Stuttgart, Germany
Roof plan/detail of the Stuttgart Terminal Building
Example in China –

Guangzhou Olympus Stadium
Detail showing the form and shape of the cantilevered roof
Hoisting the cantilever truss
Placing the roof truss in position
Tie systems to stabilize the cantilevered roof
Enlarged details of the Tie systems
Decking system of the roof
Laying of the roof deck
Piers supporting the cantilever roof truss

Semi-cladded roof underside
The Guangzhou Gymnasium
The Shanghai Stadium
Beijing 2008 Olympus Centre – The Nest
Beijing 2008 Olympus Centre – The Nest
Example in Hong Kong
Hong Kong Cultural Centre and Space Museum
The Hong Kong coliseum
The Hong Kong coliseum
The Peak Tower
The Peak Tower
The Hong Kong Stadium
Hanger structure for HK Aircraft Engineering Company Ltd. (HAECO) at Chek Lap Kok Airport
Headquarter Building, Hong Kong $ Shanghai Bank
The Skylight structure of Festival Walk
The Interior Space housed the Shying Ring and food court inside Festival Walk.
Linking structure between the International Finance Center Phase I and II
The deck and roof structure of the HK Convention and Exhibition Centre
Hoisting of the 80m-span roof truss
Placing of the roof truss at the top of the core wall
Linking structure between Phase I and II of the HK Convention and Exhibition Centre
The New Hong Kong International Airport at Chek Lap Kok
The New Hong Kong International Airport at Chek Lap Kok
The Sky Dome, Cyber Port
The Sky Dome, Cyber Port
View of the mall interior under the Sky Dome in the Cyber Centre, Cyber Port
The Arch in Kowloon Station
The roof structure of Langham Place – Shopping Mall
The Grand Atrium in Langham Mall
New Lisbon Casino.
Macau
New Lisbon, the hotel tower
End of Presentation