Single Storey Long Span 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
Materials suitable for construction

1. All reinforced concrete
2. All metal (e.g. mild-steel, stainless steel or alloyed aluminium,
3. All timber
4. Laminated timber
5. Metal/RC combined
6. Plastic-coated Textile material
7. Fiber reinforced plastic

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Single Storey Long Span Structure

A suggested way to classify structural forms according to their structural activeness

- 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

Parallel cable  Radial cable  Biaxial cable
Examples of cable structures formed by arch

Examples of tent 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
Illustrated examples of flat 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
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
Various forms of folded structures

Examples of shell structures
Other Example of Long Span Structure applied in 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.

Common Structural Forms for Long Span Building Structures

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
Common Structural Forms (Cont.)

8. Cable suspended structures
9. Inflated structure
10. Vaulted or ribbed structure
11. Dome structure
12. Shell structure

Development History of Long Span Structure
The development of long span structures

Mosque in Istanbul, Turkey
Detail showing the close-up of dome of Mosque

Interior of the mosque
Dome roof of St Paul (left) and St Peter Cathedral

Dome roof and front/rear view of Pantheon, Rome
Long span space. The case for the Minster Church in York, England.

Scaled model of the dome structure.

A long span space in the form of a dome. The case for the Minster Church in York, England.
Inside the dome.

How arch was constructed to provide a long-span roof for traditional western buildings.
Long span roof structure as seen from the interior

Vaulted ceiling

Interior view of traditional western structure with arched roof or dome
Exterior and Interior view of traditional western structure with arched roof or dome

Dome roof
Dome roof

Interior view of traditional western structure with timber truss roof
Interior view of traditional western structure with timber truss roof; the York Minster, UK
Basic structural concept on Chinese roof truss
Typical Chinese roof truss (parallel truss system)

抬梁式結構屋面形態的多元變化
抬梁式結構屋面形態的多元變化
屋面形態透過柱位和梁架的轉變而產生眾多的造形變化

典型的抬梁式結構
屋內常見的梁架布局
Other milestone in the development of modern long span system

Exterior view of the Crystal Palace, built in 1851 for the first World Fair
Designed to celebrate French industrial prowess, the 1889 Paris Exhibition also marked the centenary of the French Revolution. The Gallery of Machines, on the Champs de Mars opposite the Eiffel Tower, was itself an engineering triumph. Framed in the new harder and stronger material—steel—instead of iron like the Crystal Palace, the Gallery’s glass panels were fixed to its exterior, shaping a vast inner, seemingly limitless, space. Twenty pairs of hinged girders formed arches at the apex. The pin supports at the arches’ top allowed the building to flex if its metal expanded in hot weather. The strikingly innovative building was demolished in 1910.

The Gallery of Machine, constructed in 1889 for the Paris Exhibition

Actual Example
Overseas Examples
Various Railway Stations in European Cities

Paris Central Station
The York Station, UK
The York Station, UK

Portal frame
Pin-joint to connect portal frame to base
Section of portal frames fabricated in workshop and deliver to site prepare for installation

Foundation for fixing/jointing the portal frame to be constructed on site at the same time

similar to the frame on left

Fix the frame onto the pin-joint of foundation
Lift the frames onto the right location and support them with a temporary stand.

Insert the jointing pin and remove the temporary stand. Portal frame is now completed.

Step 3

Step 4

Other Overseas Examples
The Munich Olympic Stadium
for the 1972 Olympic

The Millennium Egg, London
One of the anchor that tie down the Millennium fibre dome

The interior of the Millennium Egg, a shopping and entertainment centre

A pneumatic exhibition hall in a construction plant expo in Las Vegas, USA
Air pump to keep the interior under higher air pressure

Interior view of the exhibition hall and the air-pressurizing fans

Other Overseas Examples

The Melbourne Central
Other Overseas Examples
Sky Dome, Toronto
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.

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.
Other Overseas Examples
Heathrow Airport Terminal
Other Overseas Examples
Commercial Centre in Paris
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
Other structures for transportation facilities

Light Rail Station, London
Light Rail Station, London

Southern Cross Station at Melbourne, Australia
Typical column support and truss system of the station

Typical roof truss detail showing the complicated configuration of the roof
Roof decking detail and other interior features

Roof canopy of a shopping centre in Las Vegas
Walt-Disney Concert Hall in Las Angeles
Example in China –

Olympus Grand Stadium in Beijing

Beijing 2008 Olympus Centre – The Nest
Beijing 2008 Olympus Centre – The Nest
Example in China –

The Science Centre at Guangzhou New University City
External view of the Centre
Roof truss of the Grand Atrium

External view of the Centre (completed)
Example in China –

The Guangzhou Olympus Stadium
External view of 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

Stadium after completion
The Guangzhou Gymnasium

Stadium after completion
Example in China –

China pavilion and other major facilities in 2010 World Expo, Shanghai
The China Pavilion
The cultural performance Centre

The Saudi Arabia Pavilion
The cultural performance Centre
Other Examples in China
The Shanghai Stadium

Roof of People Centre in Shenzhen
Detail of the roof truss and the laying of the deck panels

Detail of the roof truss framing and the roof supporting tower
Entrance Canopy for Guangzhou Convention and Exhibition Center

Shenzhen Exhibition Centre
Long Span Structure

Hong Kong Examples
Sport ground in Tseung Kwan O

Member Centre of the Hong Kong Jockey Club
Member Centre of the Hong Kong Jockey Club

Span about 25m

Hong Kong coliseum
The Hong Kong coliseum
The Hong Kong Stadium
Cultural Center and Space Museum

Hanger structure for HK Aircraft Engineering Company Ltd. (HAECO) at Chek Lap Kok Airport
Hanger structure for HK Aircraft Engineering Company Ltd. (HAECO) at Chek Lap Kok Airport
Actual Example –
Headquarter Building, Hong Kong $ Shanghai Bank

Actual Example –
The Skylight structure of Festival Walk
Other long-span spaces within Festival Walk – the public bus terminus
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

multi-axis trolley to transport the pre-fabricated steel truss
Hydraulic system (strand jack) and rail for the lifting and horizontal sliding of the 400-ton 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
Peak Tower

The Peak Tower
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
Canopy for the New Stand/Race-practicing Court for the HK Jockey Club
The roof structure of Langham Place – Shopping Mall

The Grand Atrium in Langham Mall
Extension to Hong Kong Convention and Exhibition Centre
Extension to HK Convention and Exhibition Centre

Tamar Government Headquarters Complex

- CGC Office Block (West Wing)
- CGC Office Block (East Wing)
- LegCo High Block
- LegCo Complex
- LegCo Low Block
- CGC Low Block
- Green Carpet
- Link to Waterfront Promenade
New Lisbon Casino.
Macau
New Lisbon, the hotel tower
Cruise Terminal in Kai Tak

The Cruise Terminal in Kai Tak
Other Examples – miscellaneous nature

Roof constructed in RC arch-truss, in-situ
Roof constructed in RC truss, precast
Roof constructed in steel space-frame

Roof constructed in simple steel truss
A Park Pavilion in a Residential Estate in Shanghai

A tent-cover for swimming pool
A tent-structure pavilion in an open square in Science Park, Hong Kong
Summary:

1. Construction usually involve lifting of long and heavy components such as a truss or a girder, which are prefabricated in steel workshop and delivered to site for installation.

2. Long elements (say, a 60m steel truss) are often broken down into smaller sections (say, 3 x 20m) and install onto the required level for fixing and connection. Temporary intermediate supports are erected until the final fixing of the system.

3. While the weight of the steel structure increases as the gradual completion of the installed structure, deflection starts to appear in various locations which makes the dimensional control very difficult. Detail adjustment is required from time to time in order this kind of deformation.

4. Final releasing of the temporary support also cause similar deflection problem but on a reverse manner.

End of Presentation