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 alumimium,
3. All timber
4. Laminated timber
5. Metal/RC combined
6. Plastic-coated Textile material
7. Fiber reinforced plastic

Single Storey Long Span Structure

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

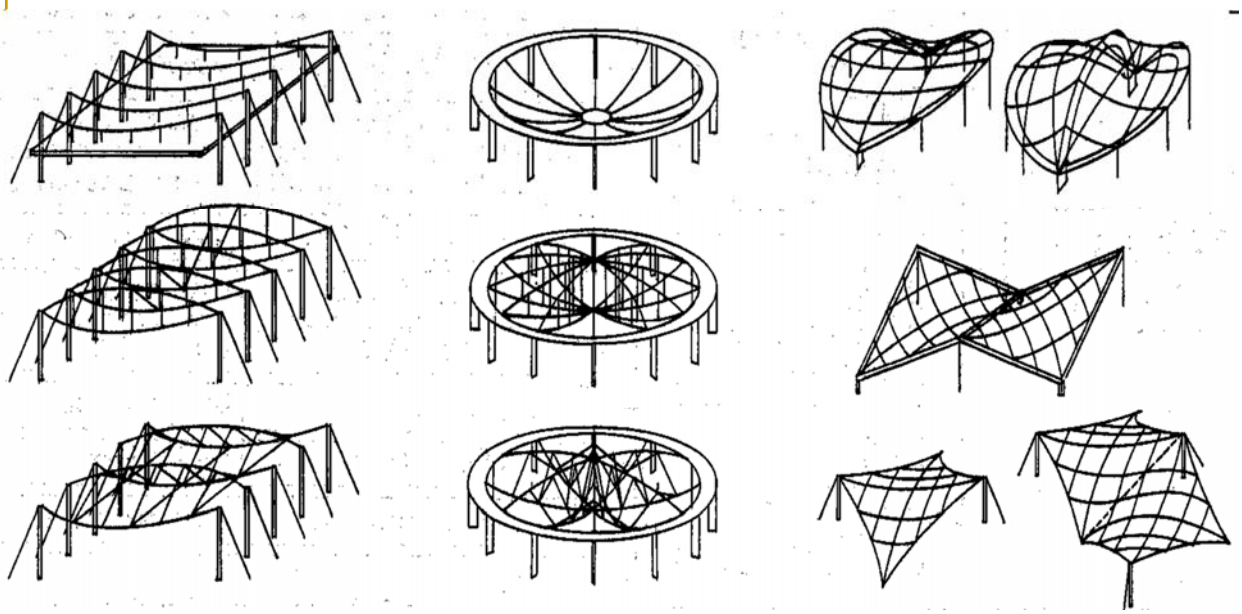
- Form active systems
- Vector active systems
- Section active systems
- Surface active systems

Form active structural systems

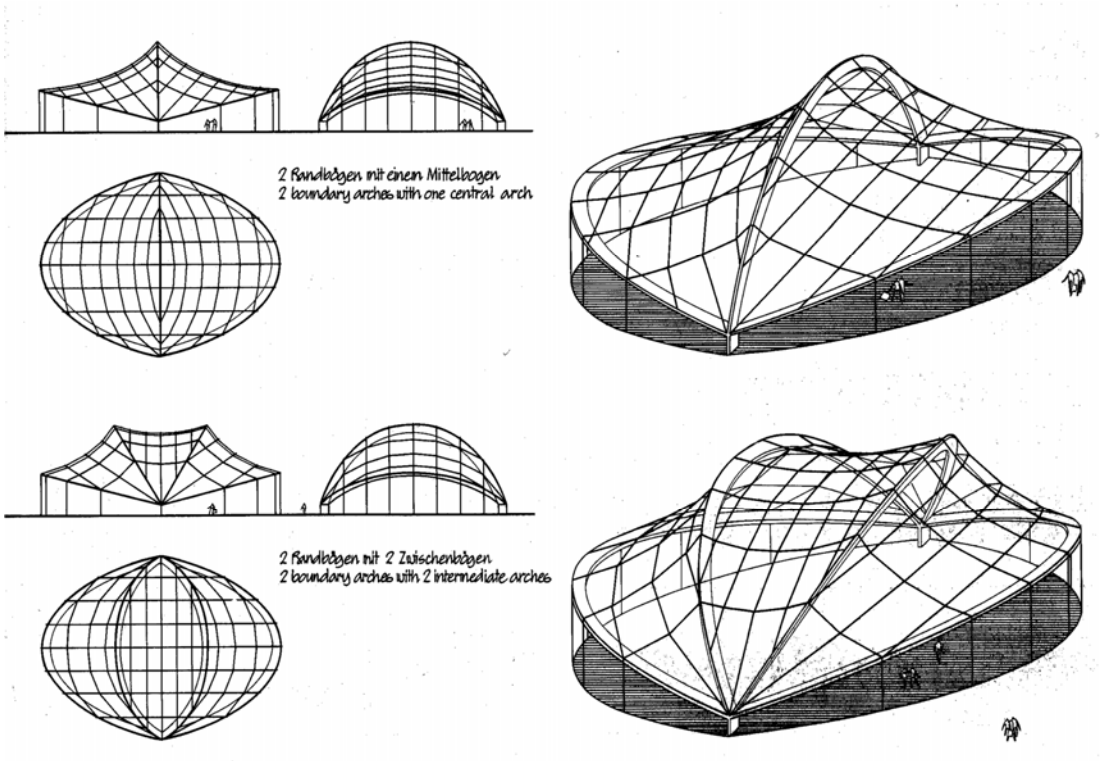
. . . are systems of flexible, non-rigid matter, in which the redirection of forces is effected by particular form design and characteristic form stabilization

Example of structures:

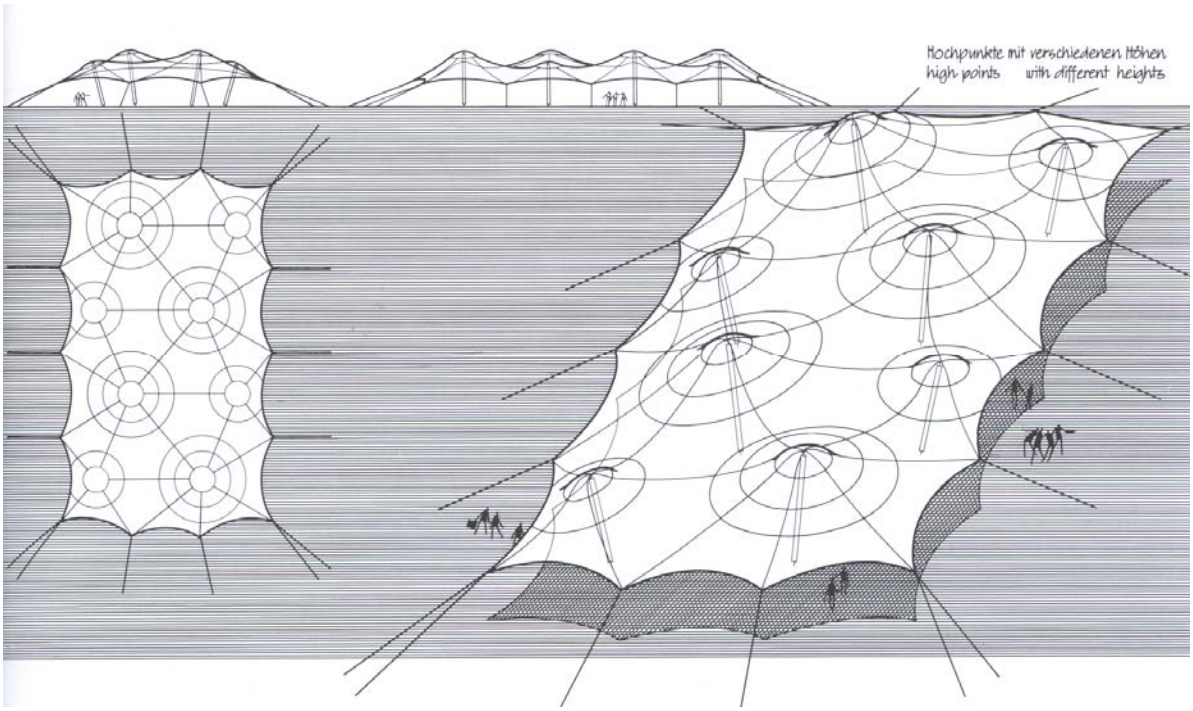
1. Cable structures
2. Tent structures
3. Pneumatic structures
4. Arch structures



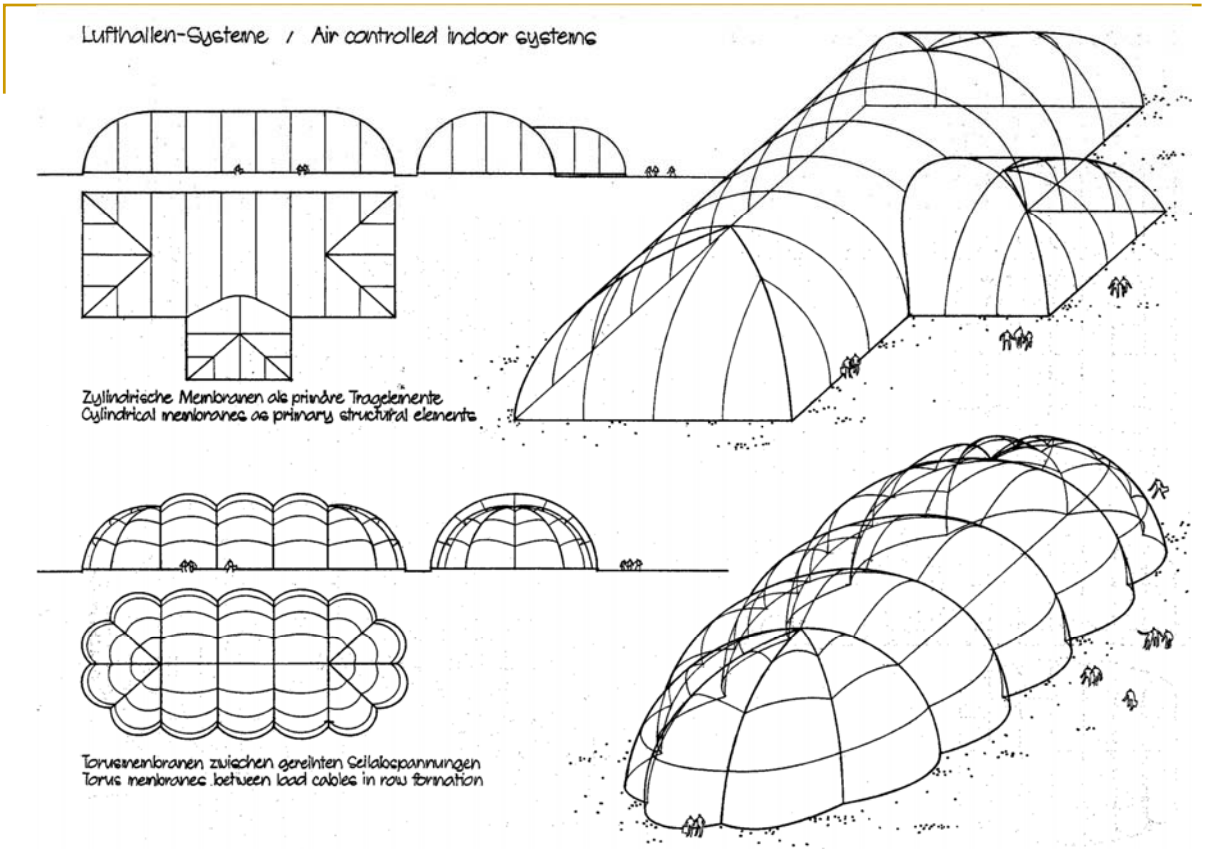
Parallel cable Radial cable Biaxial cable



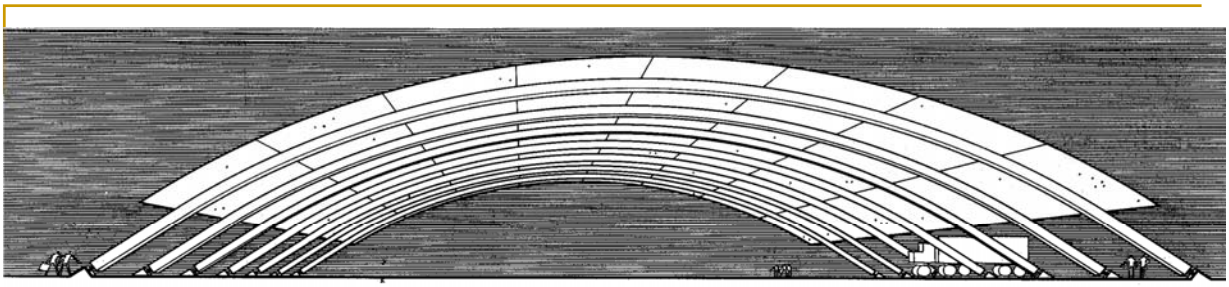
Examples of cable structures formed by arch



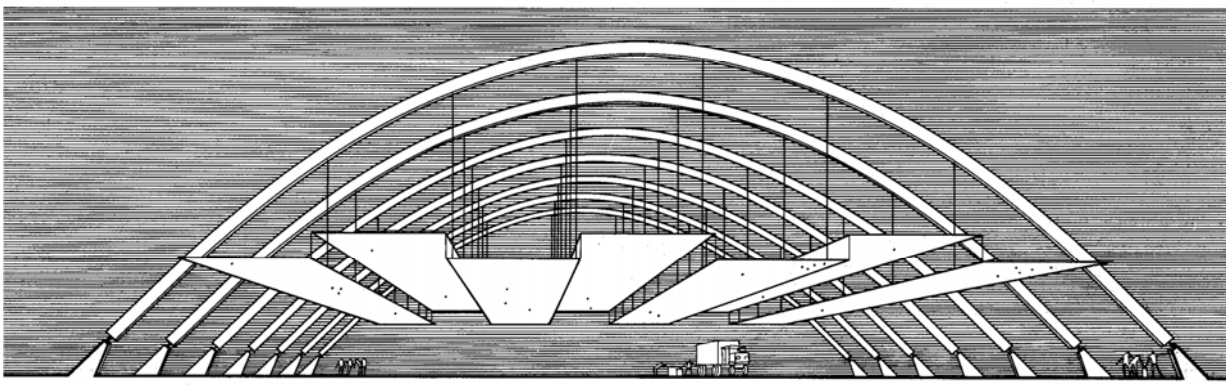
Examples of tent structures



Examples of pneumatic structures



Eraverankerte Bögen mit aufliegender gewölbter Dachkonstruktion — Form der Stützlinie: Kettenlinie — Scheitelhöhe = 1/5 Spannweite
foundation arches with curved roof structure on top — funicular curve: catenary — arch rise = 1/5 span



Abgestrebte Bögen mit abgehängter horizontaler Dachkonstruktion — Form der Stützlinie: parabolisches Polygon — Scheitelhöhe = 1/5 Spannweite
buttressed arches with suspended horizontal roof structure — funicular curve: parabolic polygon — arch rise = 1/5 span

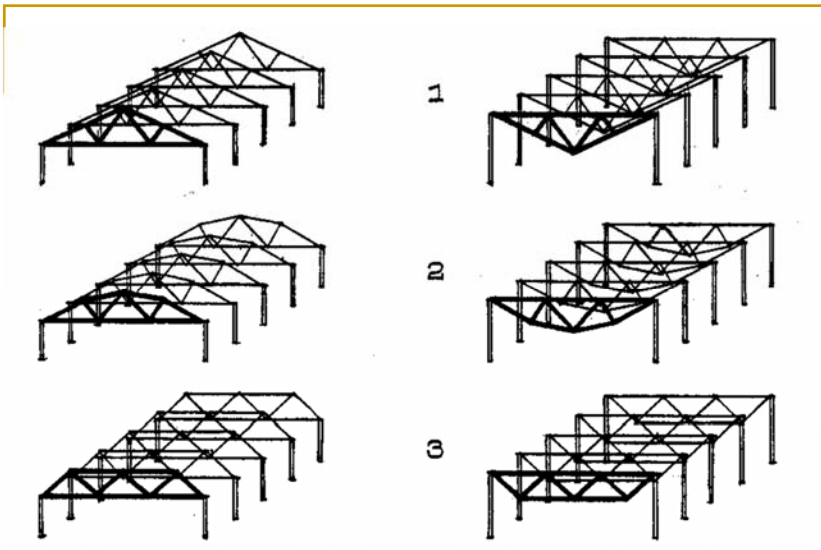
Examples of arch structures

Vector active structural systems

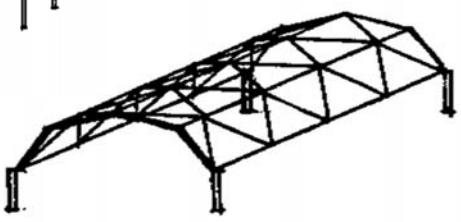
. . . are systems of short, solid, straight lineal members, in which the redirection of forces is effected by vector partition, i.e. by multi-directional splitting of single force simply to tension or compressive elements

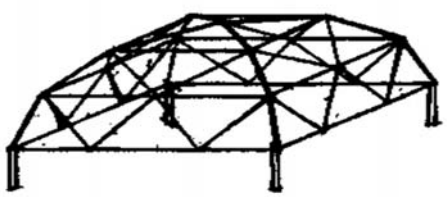
Example of structures:

1. Flat trusses
2. Curved trusses
3. Space trusses

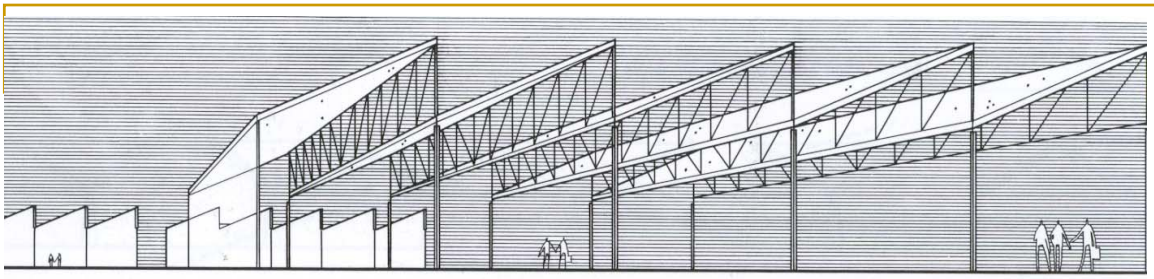


Flat truss systems



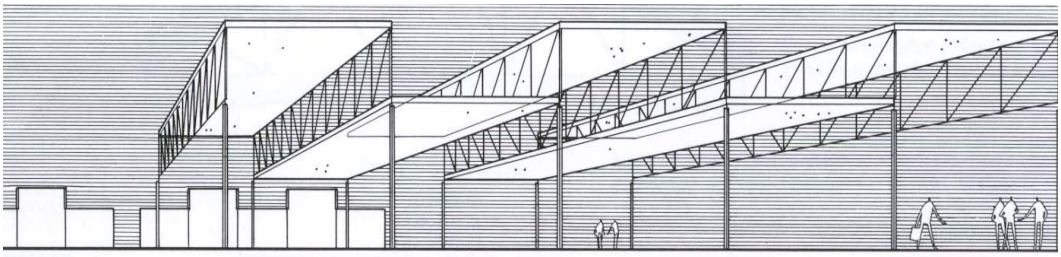


curved truss systems



ichen beidseitig unterstützt

inclined roof planes with both ends supported



izontale Dachflächen beidseitig unterstützt

alternating horizontal roof planes with bothends supported

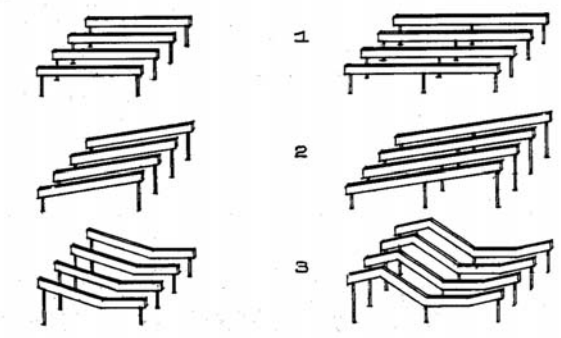
Illustrated examples of flat truss structures

Section active structural systems

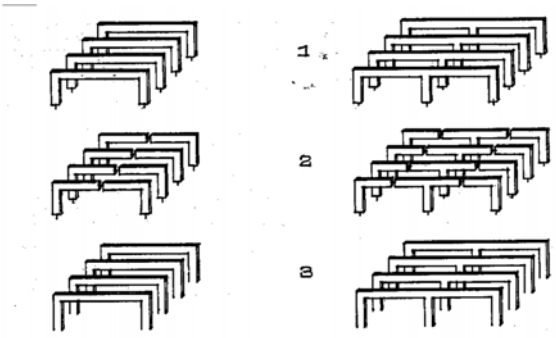
. . . are systems of rigid, solid, linear elements, in which redirection of forces is effected by mobilization of sectional forces

Example of structures:

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

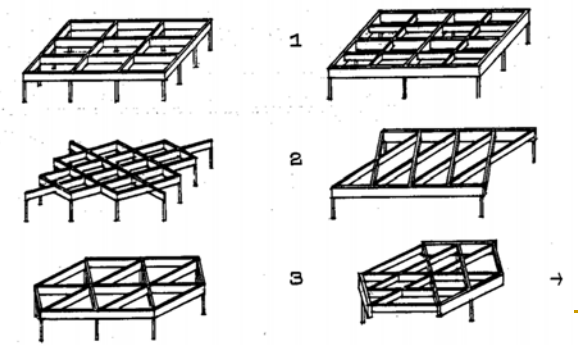


1 & 2 bay beams

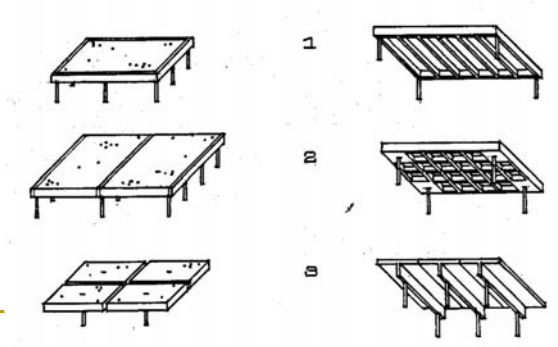


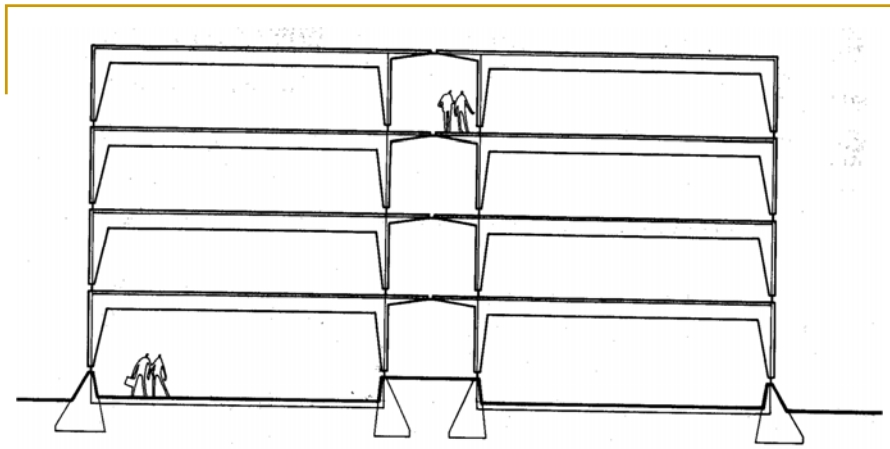
1 & 2 bay frames

Beam-grid systems

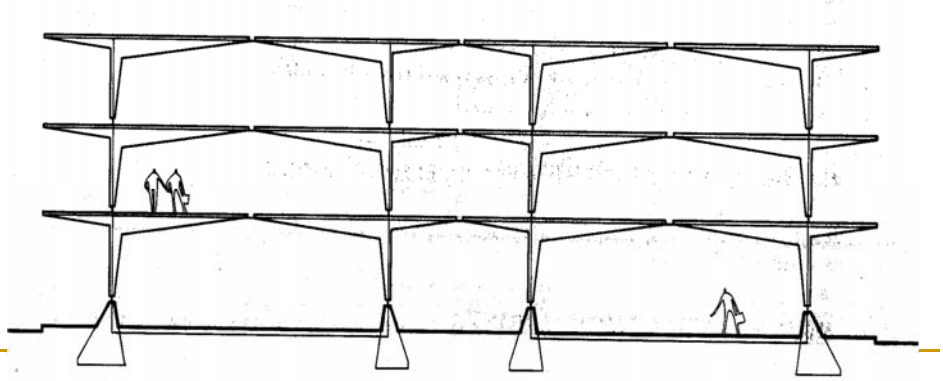


Slab structures





Hinged frame structures

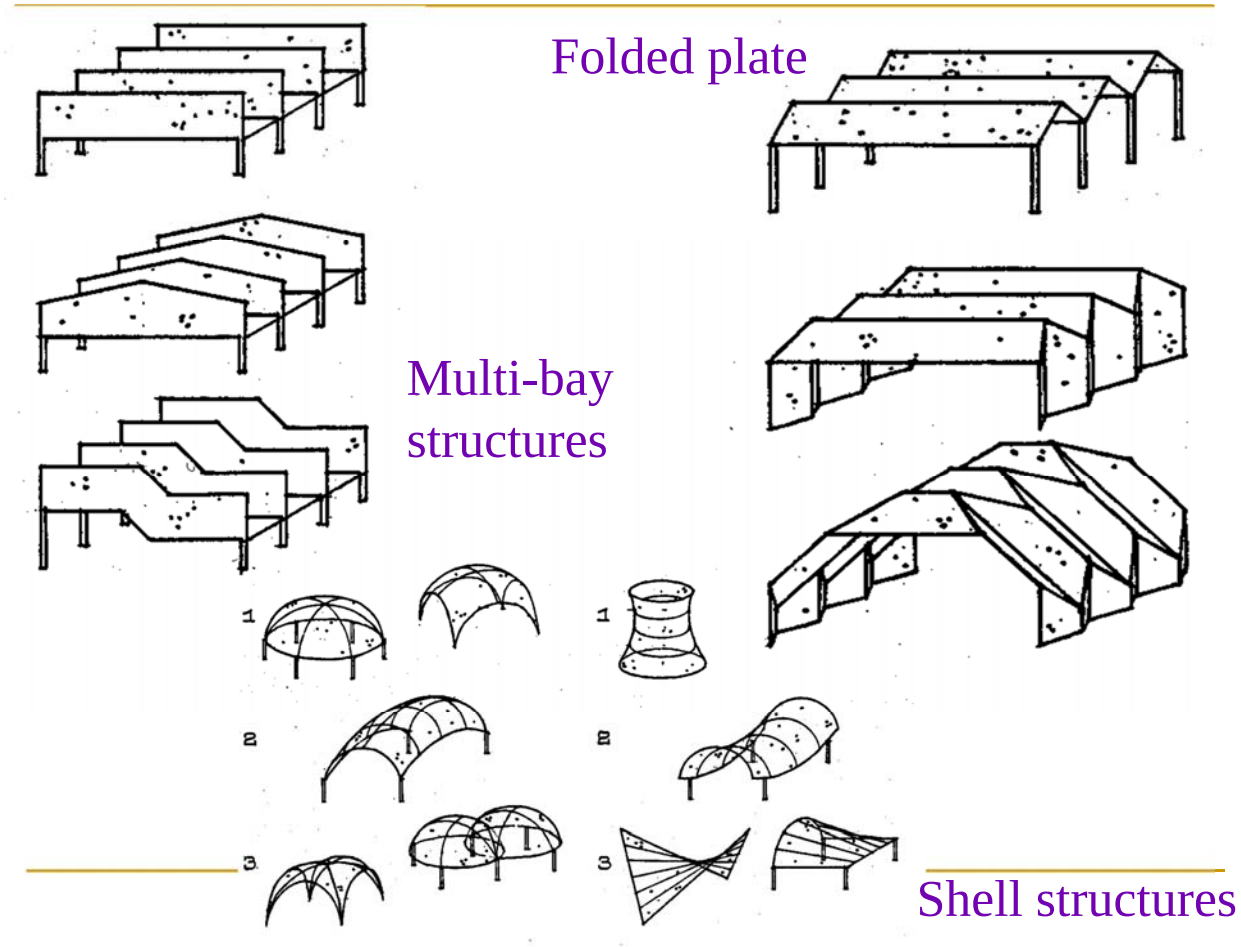


Surface active structural systems

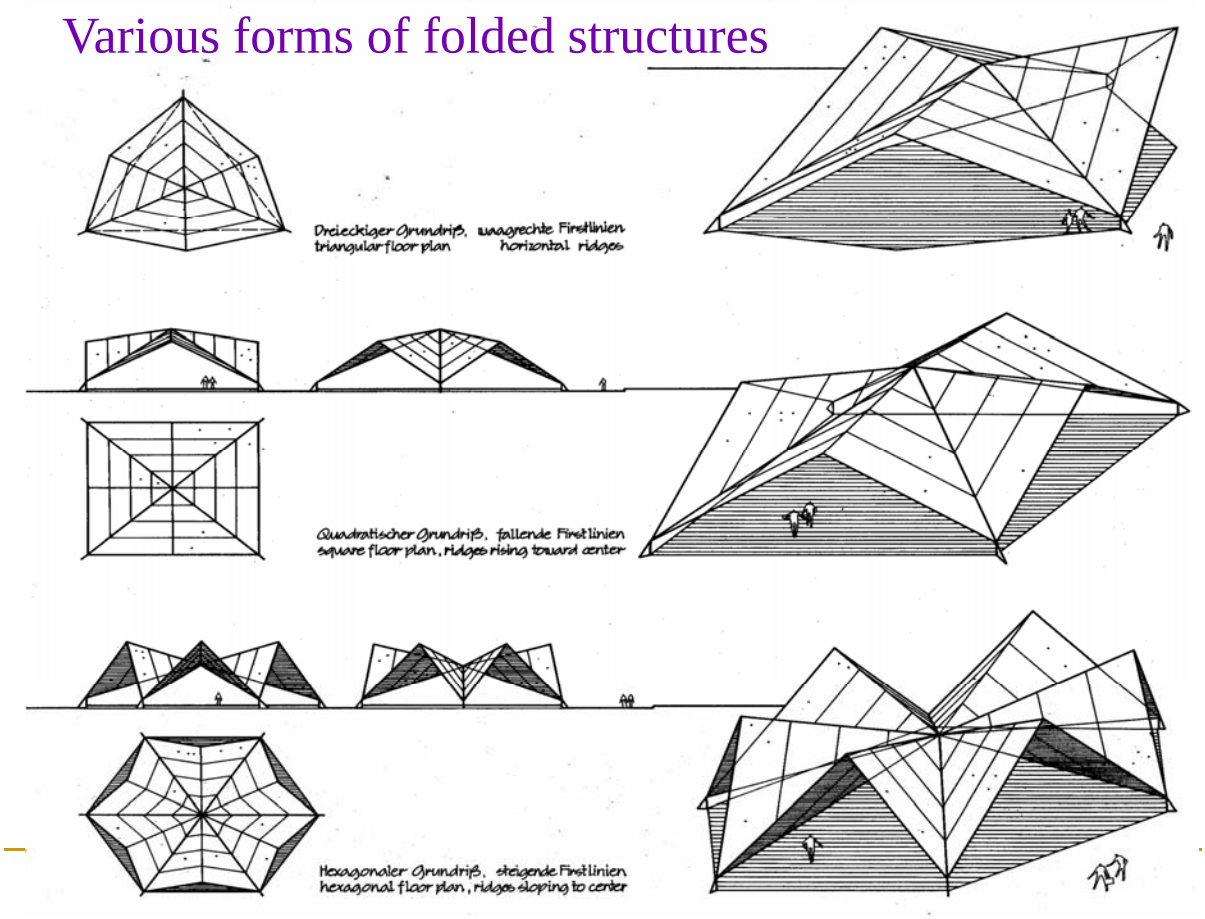
. . . are systems of flexible or rigid planes able to resist tension, compression or shear, in which the redirection of forces is effected by mobilization of sectional forces

Example of structures:

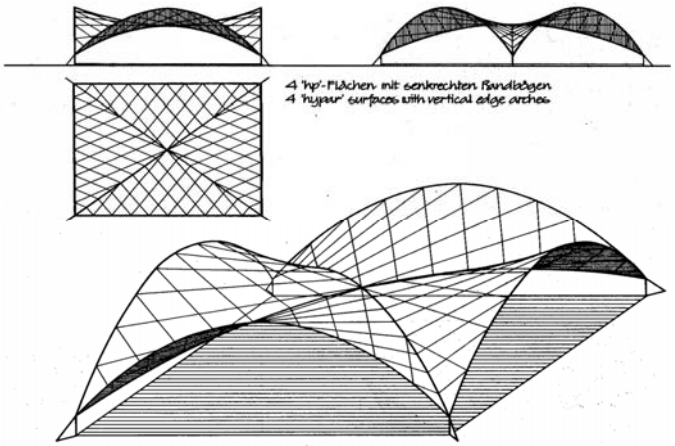
1. Plate structures
2. Folded structures
3. Shell structures

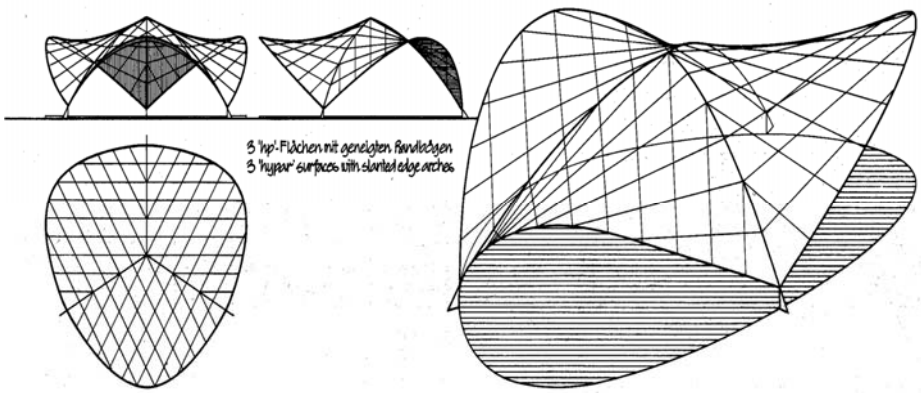


Various forms of folded structures



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.

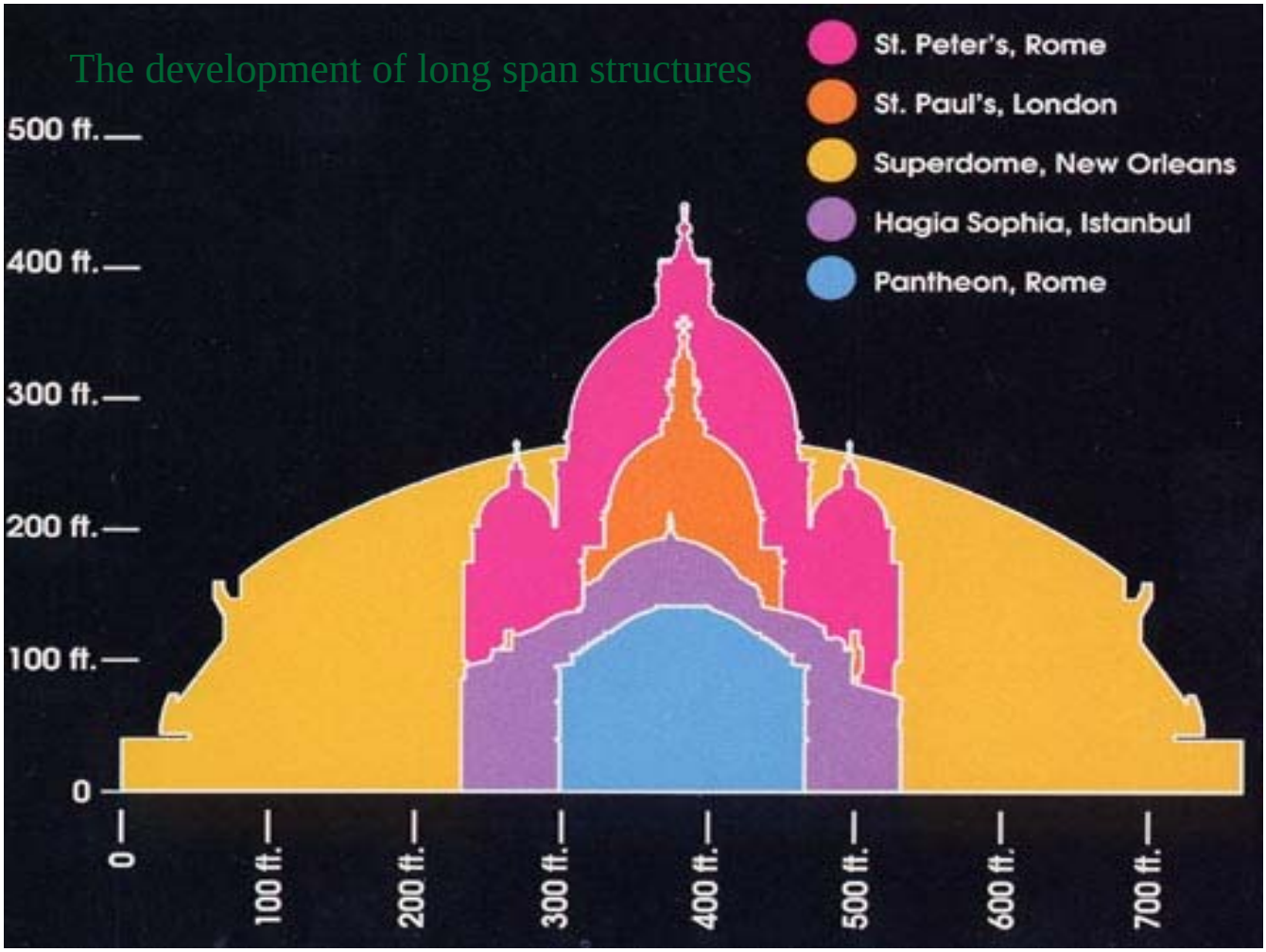
Common Structural Forms for Long Span Building Structures

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

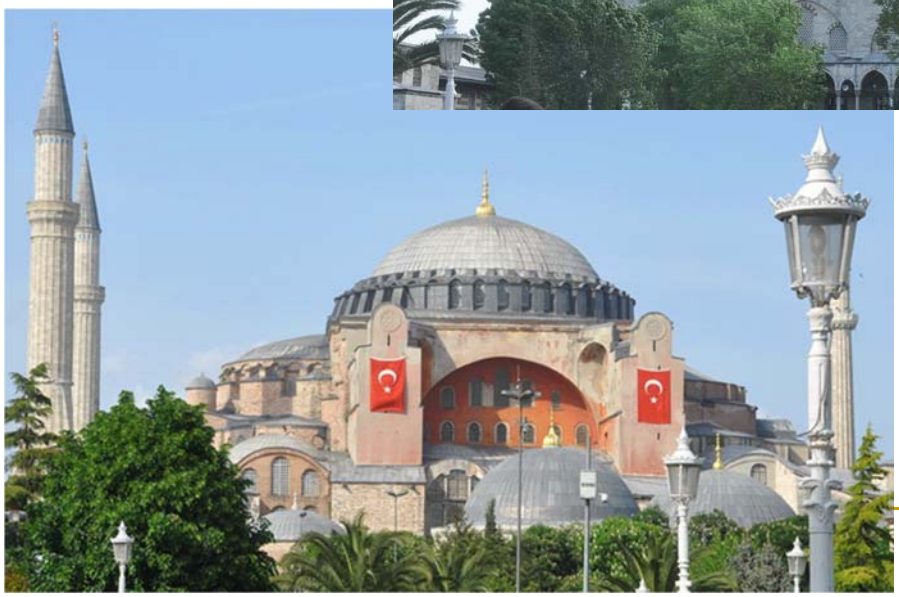
Common Structural Forms (Cont.)

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

Development History of Long Span Structure



Mosque in Istanbul, Turkey

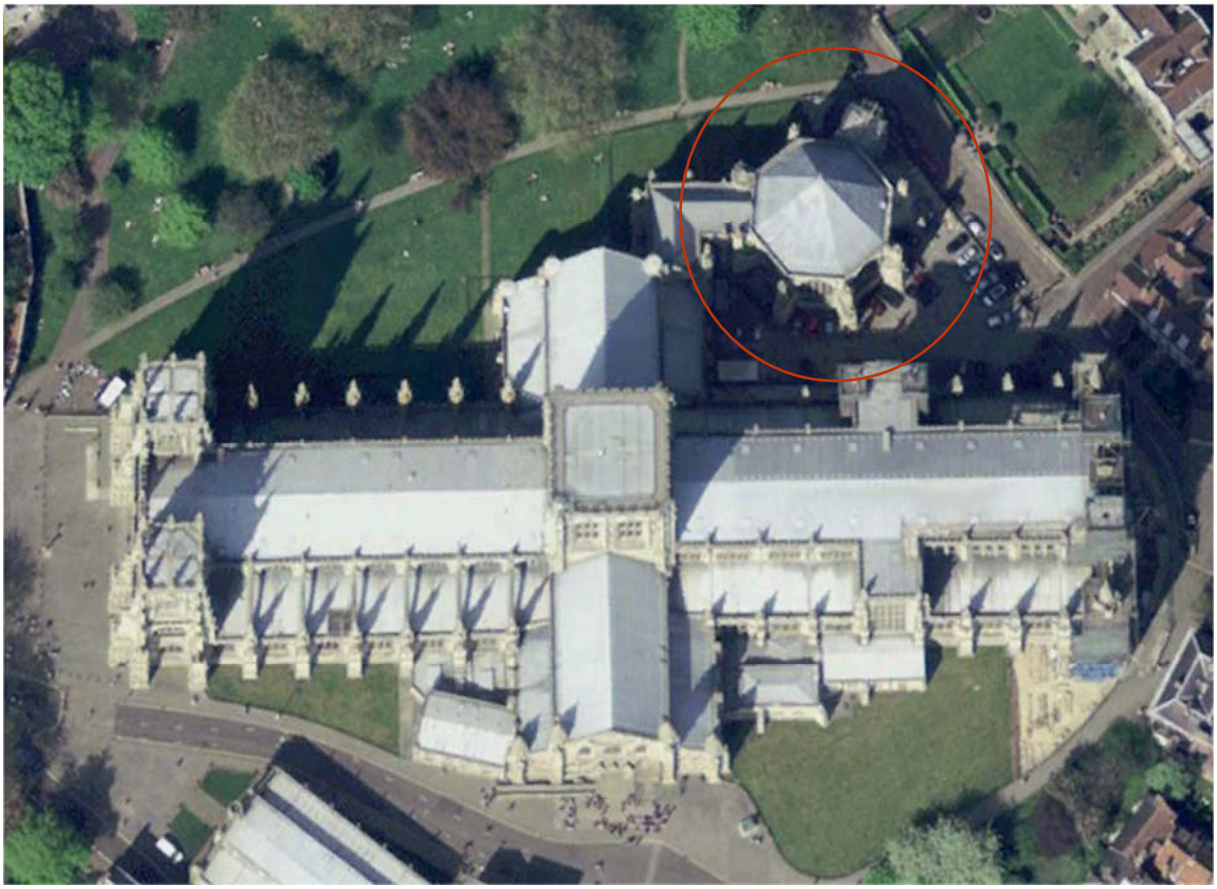


Detail showing the close-up of dome of Mosque

Interior of the mosque

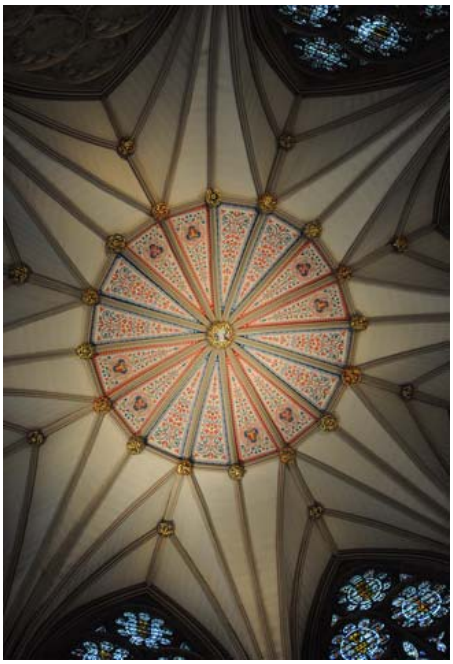
Dome roof of St Paul (left) and St Peter Cathedral

Dome roof and front/rear view of Pantheon, Rome



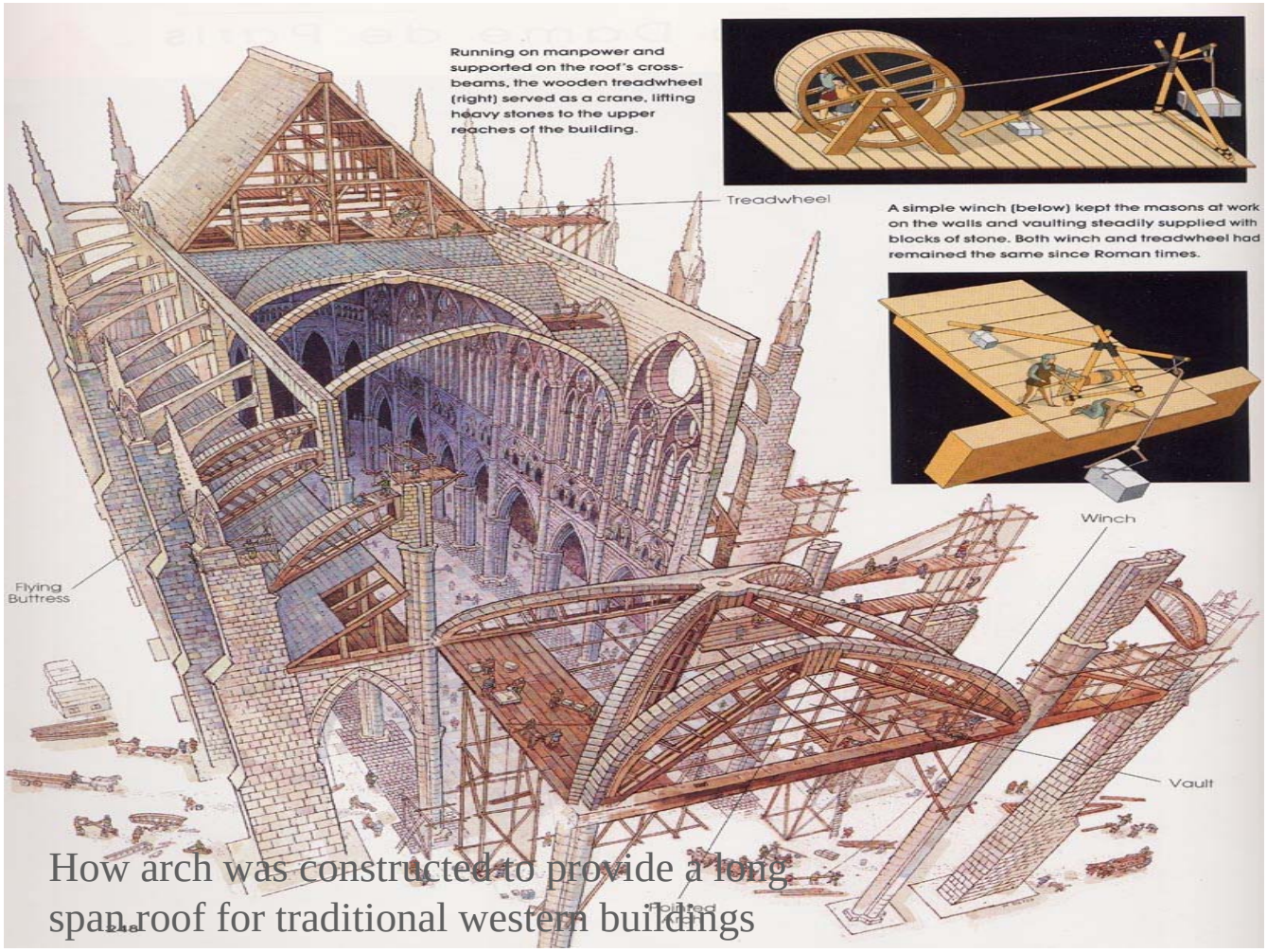
Long span space. The case for the Minster Church in York, England.

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

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

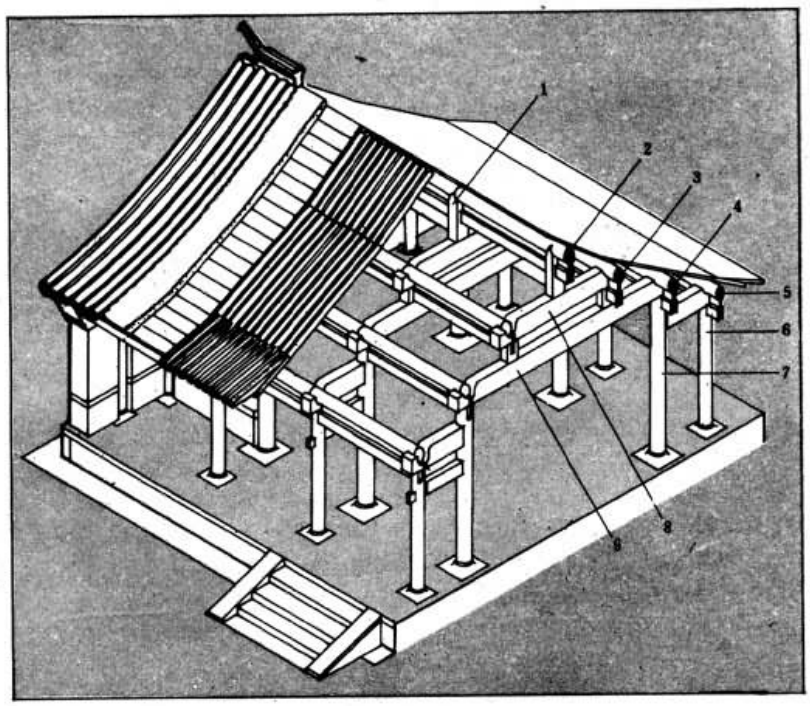
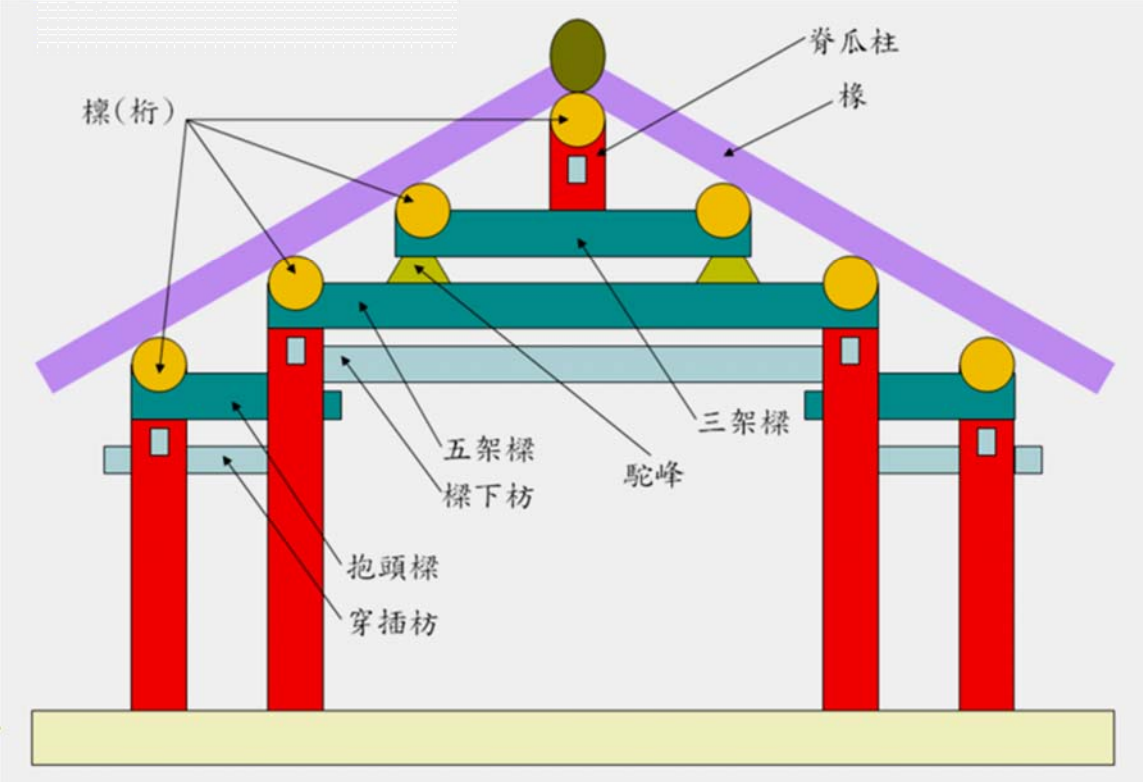


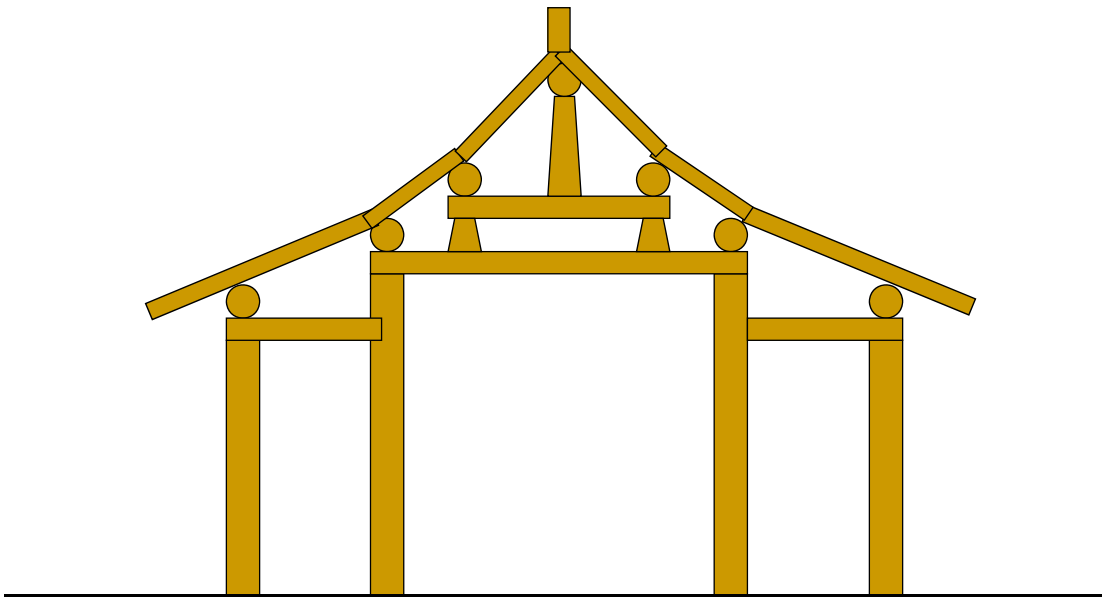
图 2　清七檩硬山大木小式构架

1 脊瓜柱　2 脊檩(垫、枋)　3 金檩(垫、枋)　4 老檐檩(垫、枋)　5 檐檩(垫、枋)　6 檐柱　7 老檐柱　8 三架梁　9 五架梁

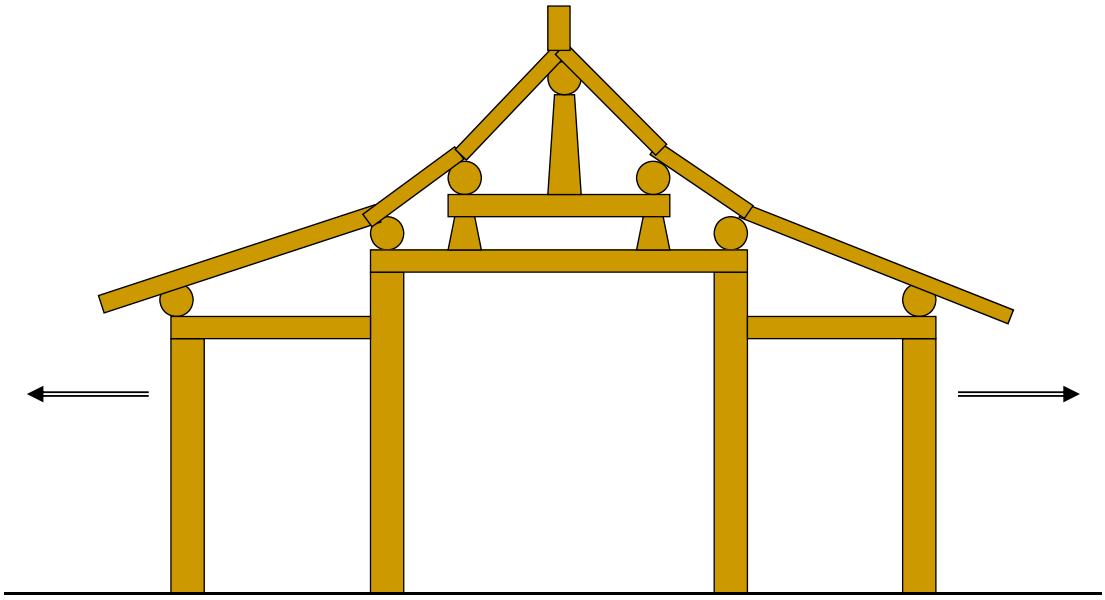
Basic structural concept on Chinese roof truss

Typical Chinese roof truss (parallel truss system)

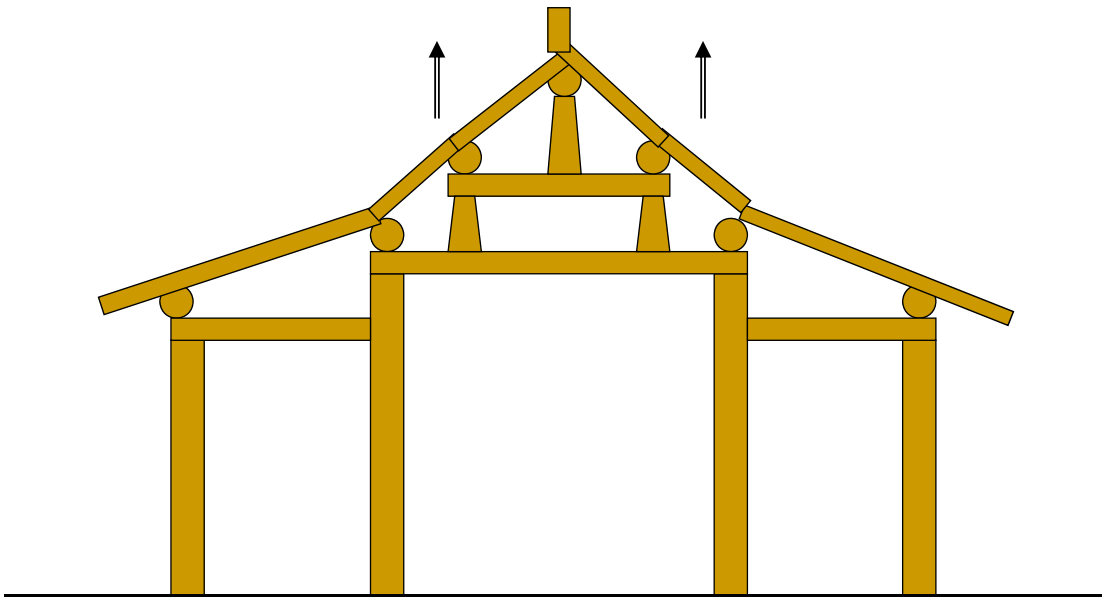




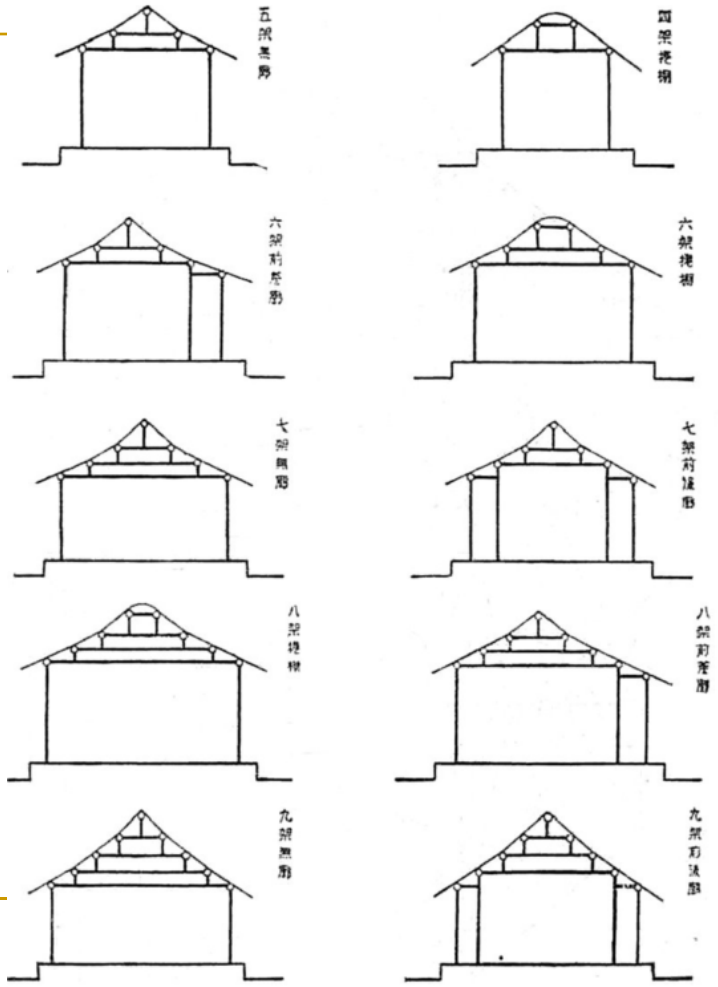
抬梁式結構屋面形態的多元變化



抬梁式結構屋面形態的多元變化

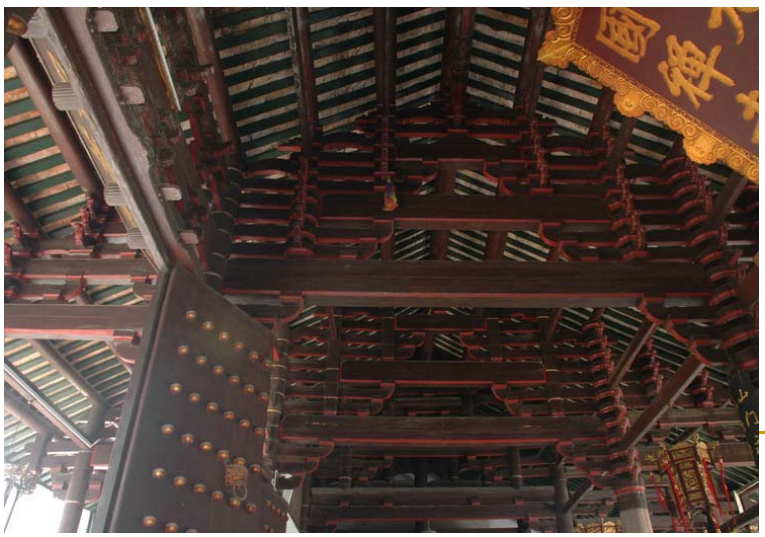


抬梁式結構屋面形態的多元變化

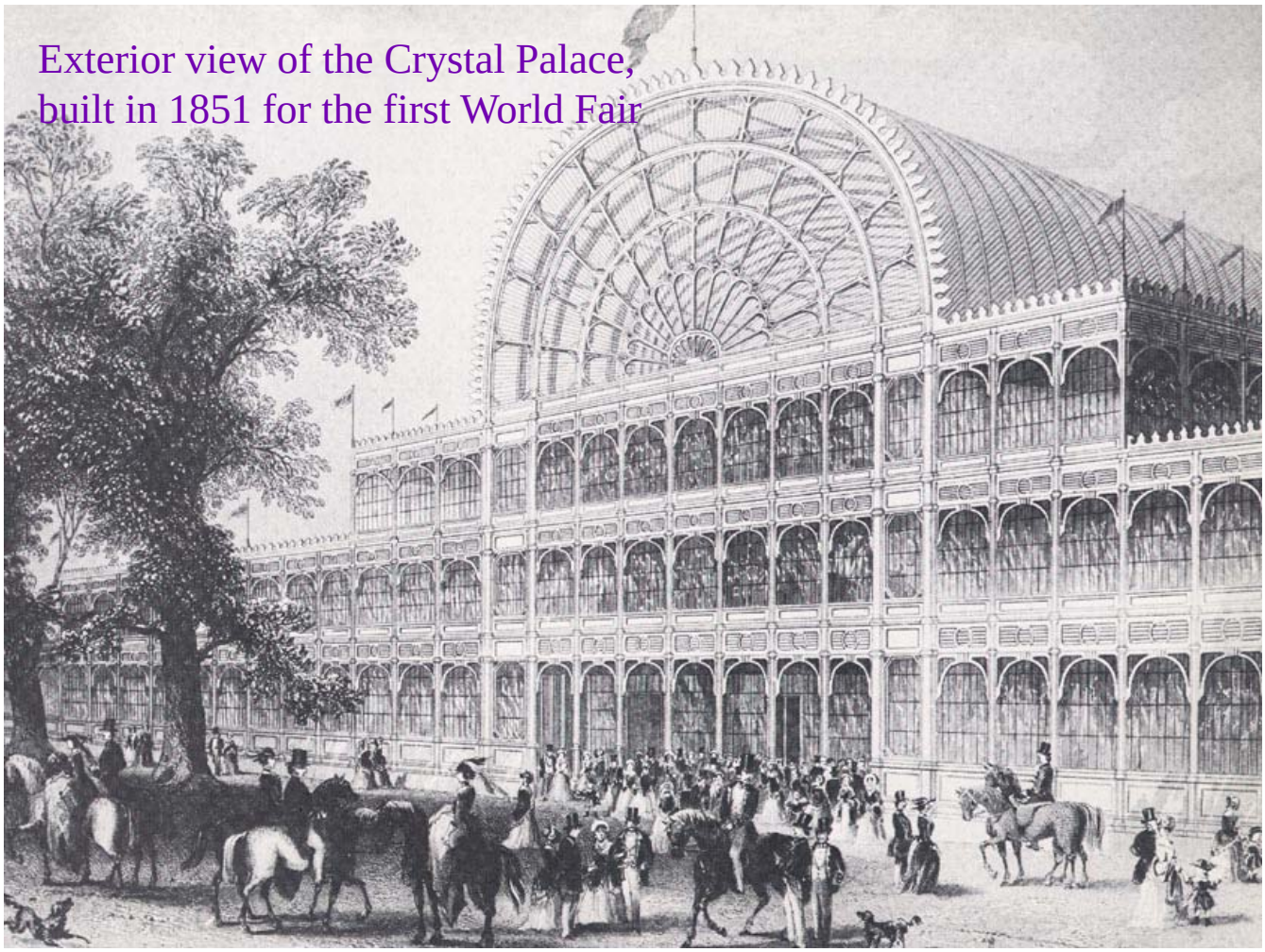


屋面形態透過柱位和梁架的轉變而產生眾多的造形變化

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
apex. The pin supports at the arches' to
building to flex if its metal expanded
The strikingly innovative building was d

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

Actual Example

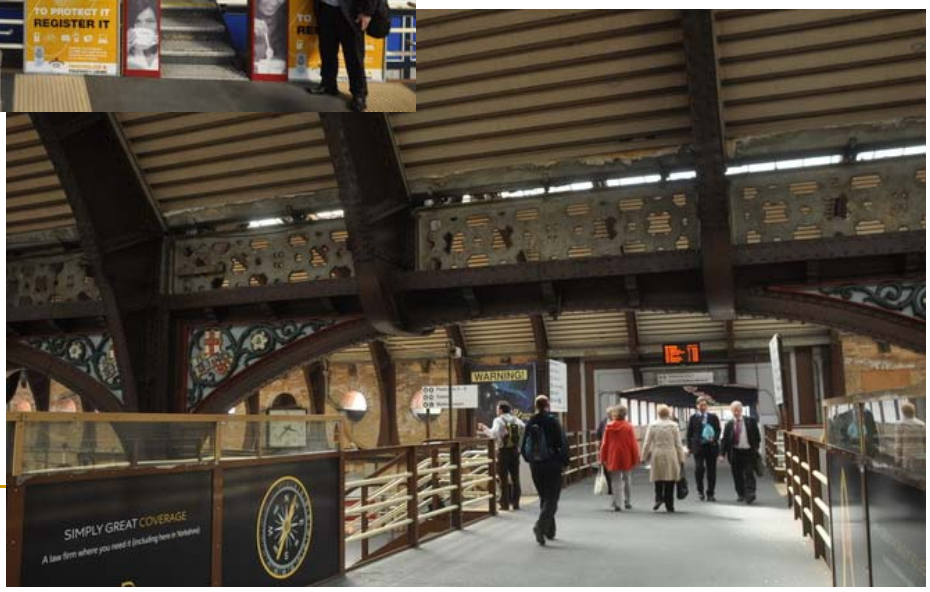
Overseas Examples

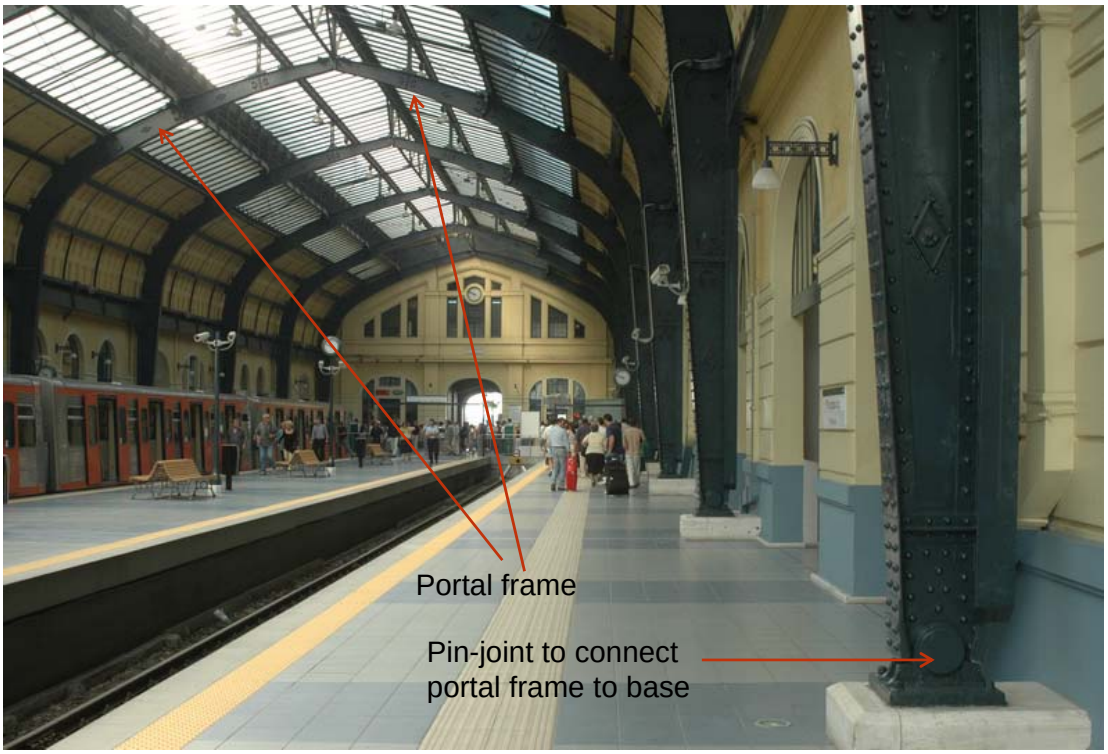
Various Railway Stations in European Cities

Paris Central Station

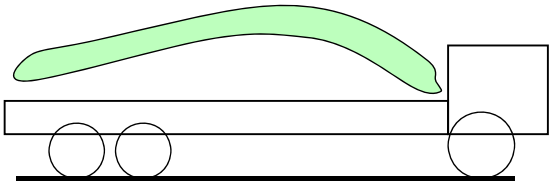
The York Station, UK

The York Station, UK

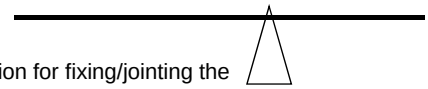




Step 1



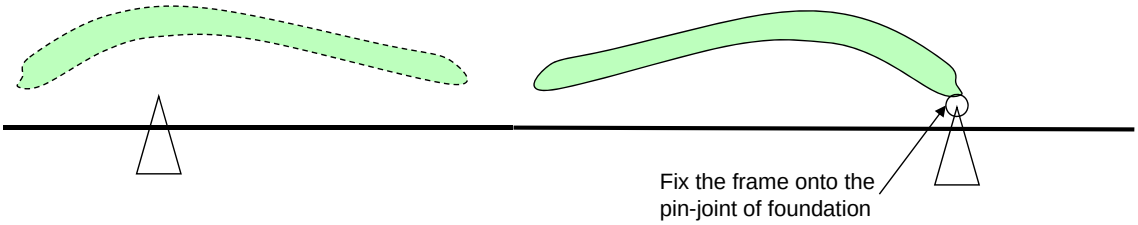
Section of portal frames fabricated in workshop and deliver to site prepare for installation

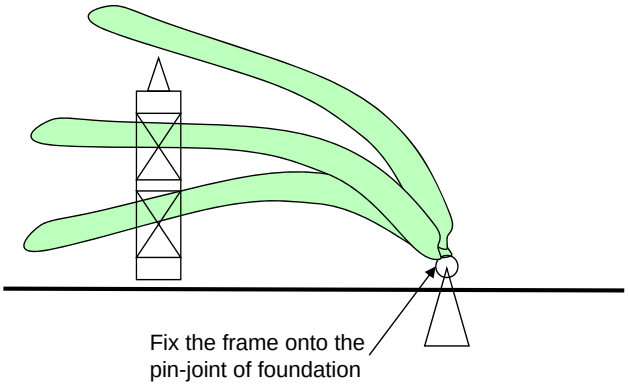


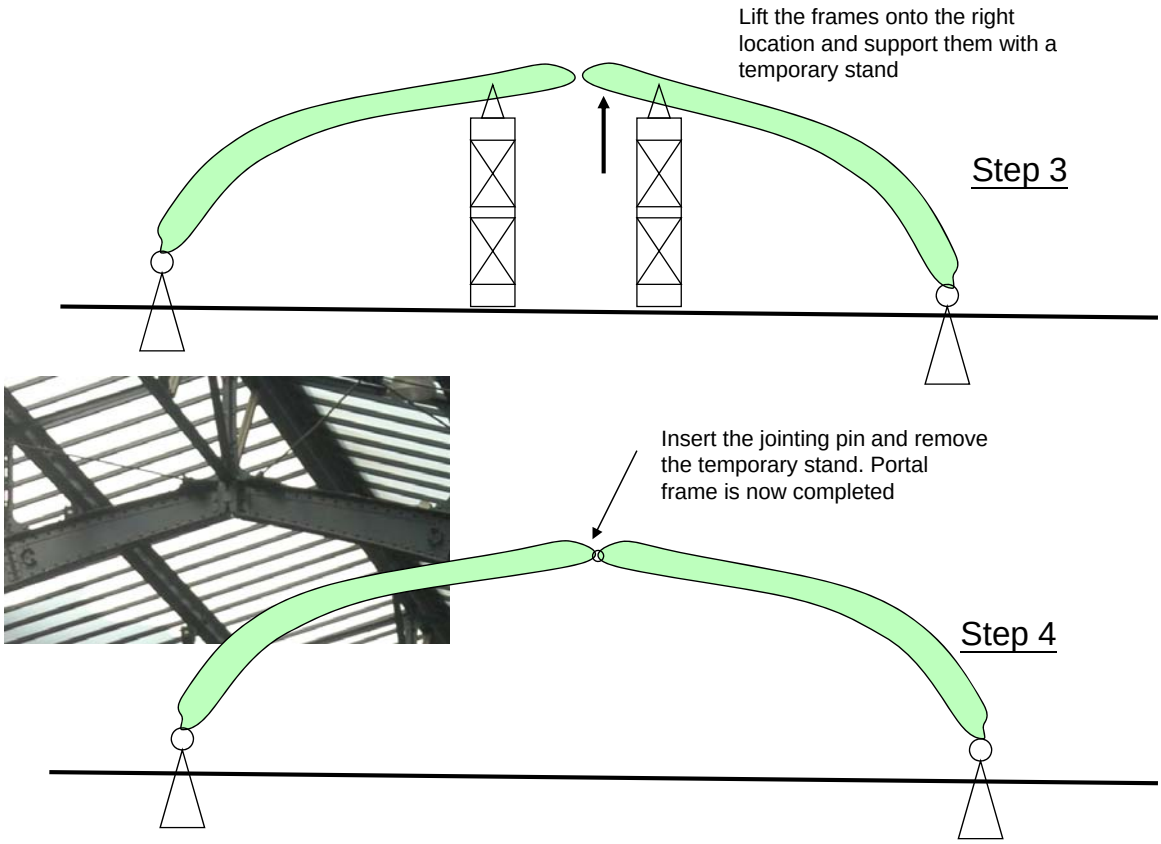
Foundation for fixing/jointing the portal frame to be constructed on site at the same time

Step 2

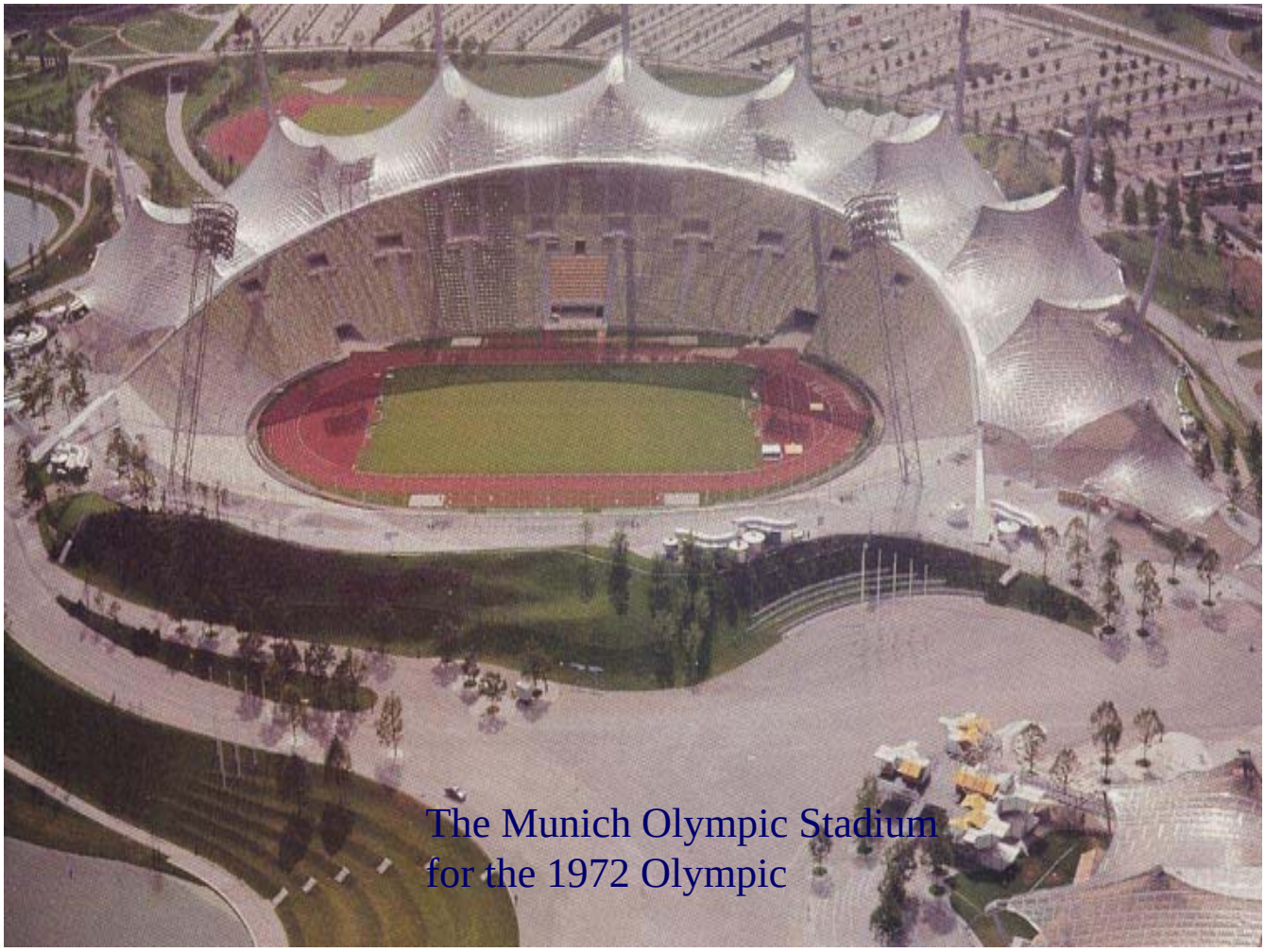
similar to the frame on left







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 Les Vegas, USA

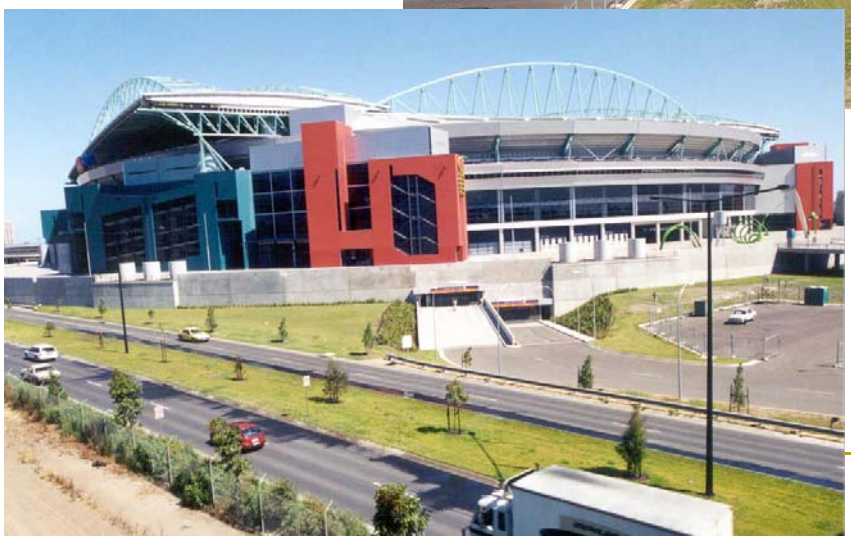
Air pump to keep the interior under higher air pressure

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

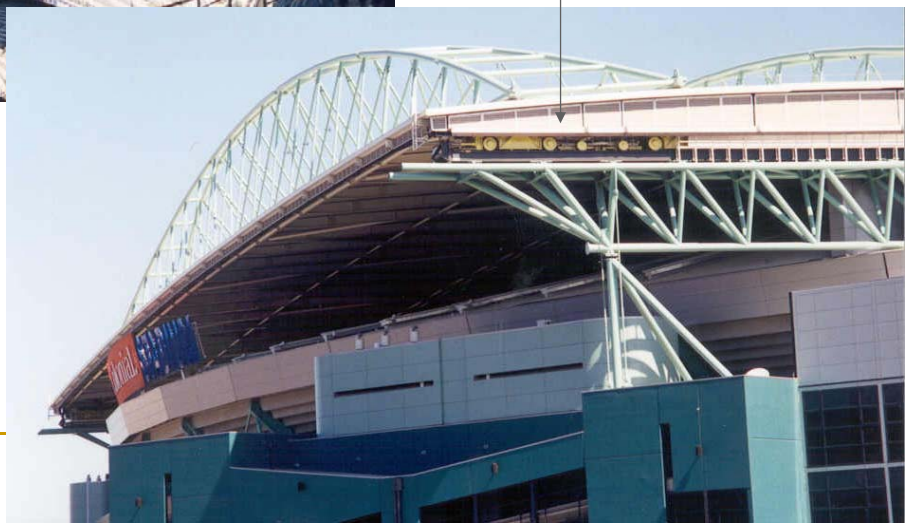
Other Overseas Examples

The Melbourne Central


YOU COULD LOCATE
YOUR BUSINESS HERE
6672 6666



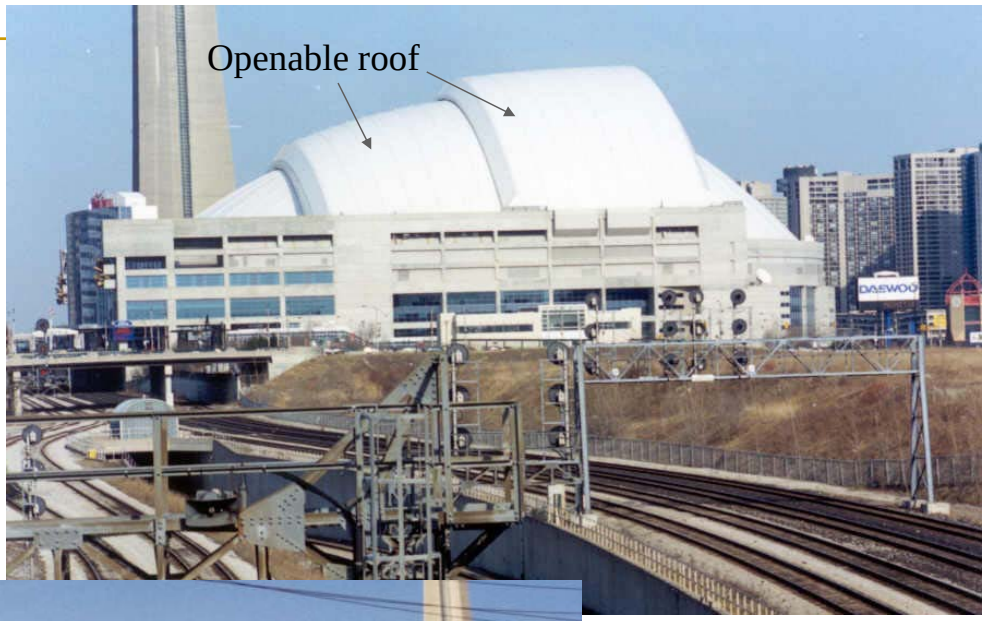
An openable roof operating on a Rail system



Other Overseas Examples

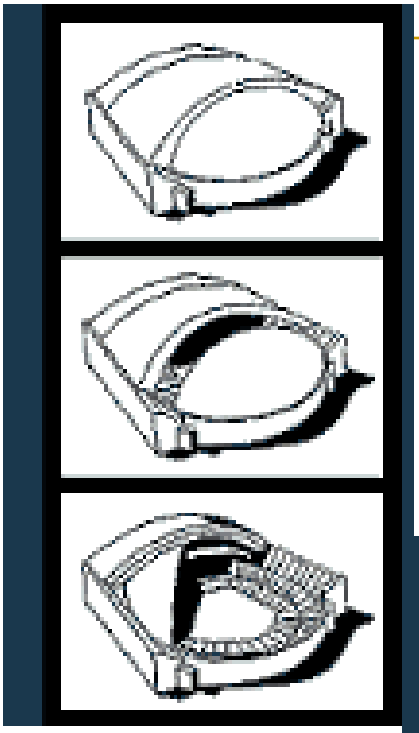
Sky Dome, Toronto


Toronto Tower
The Skydome


Openable roof
DAEWOO


DAEWOO


ROGERS CENTRE



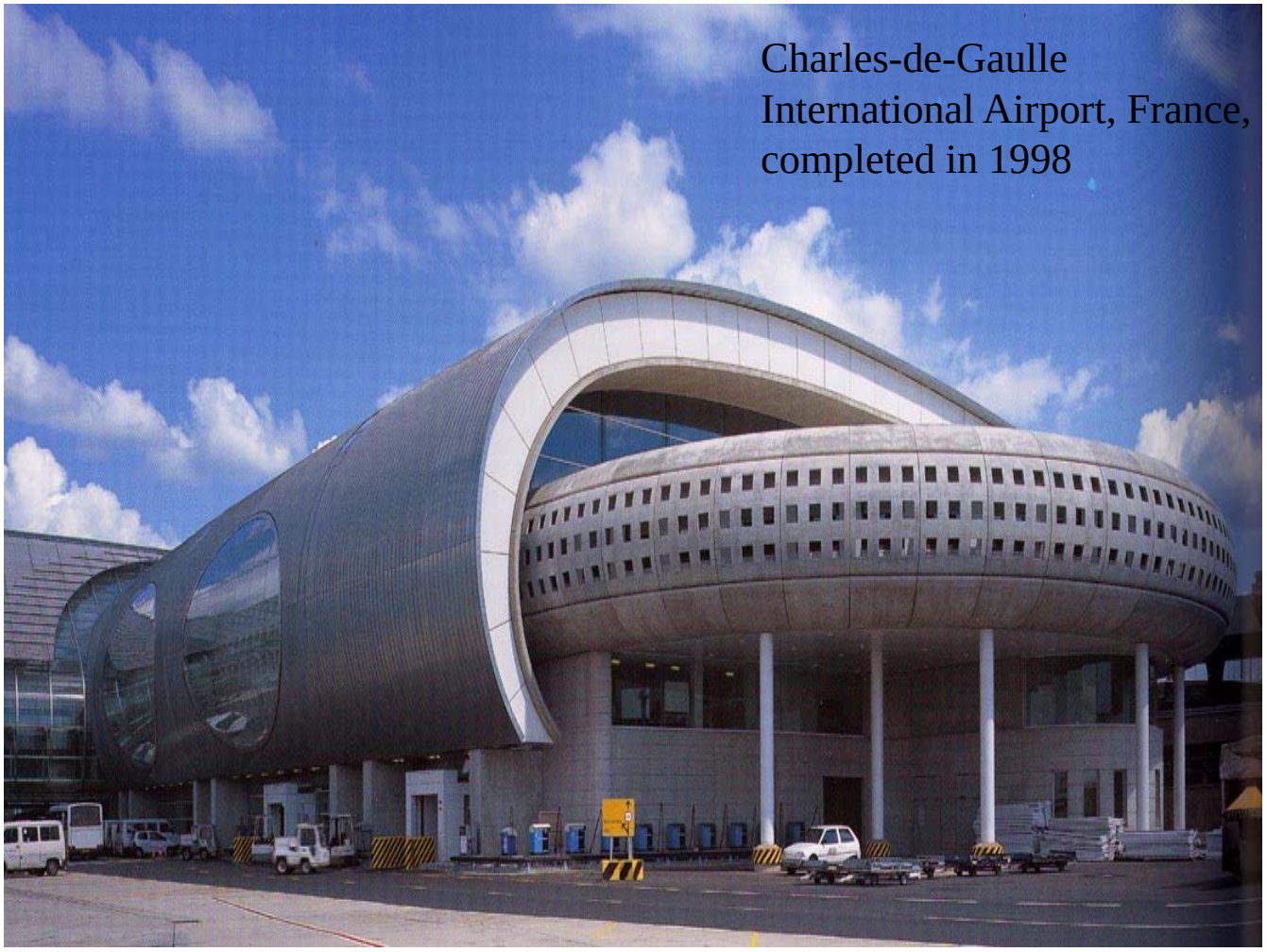
SkyDome is the first and only stadium to have a fully retractable roof. When the weather is good, usually from April1 - October 1, we are able to roll back the roof, uncovering the complete field area and over 91% of the seats.

- 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.

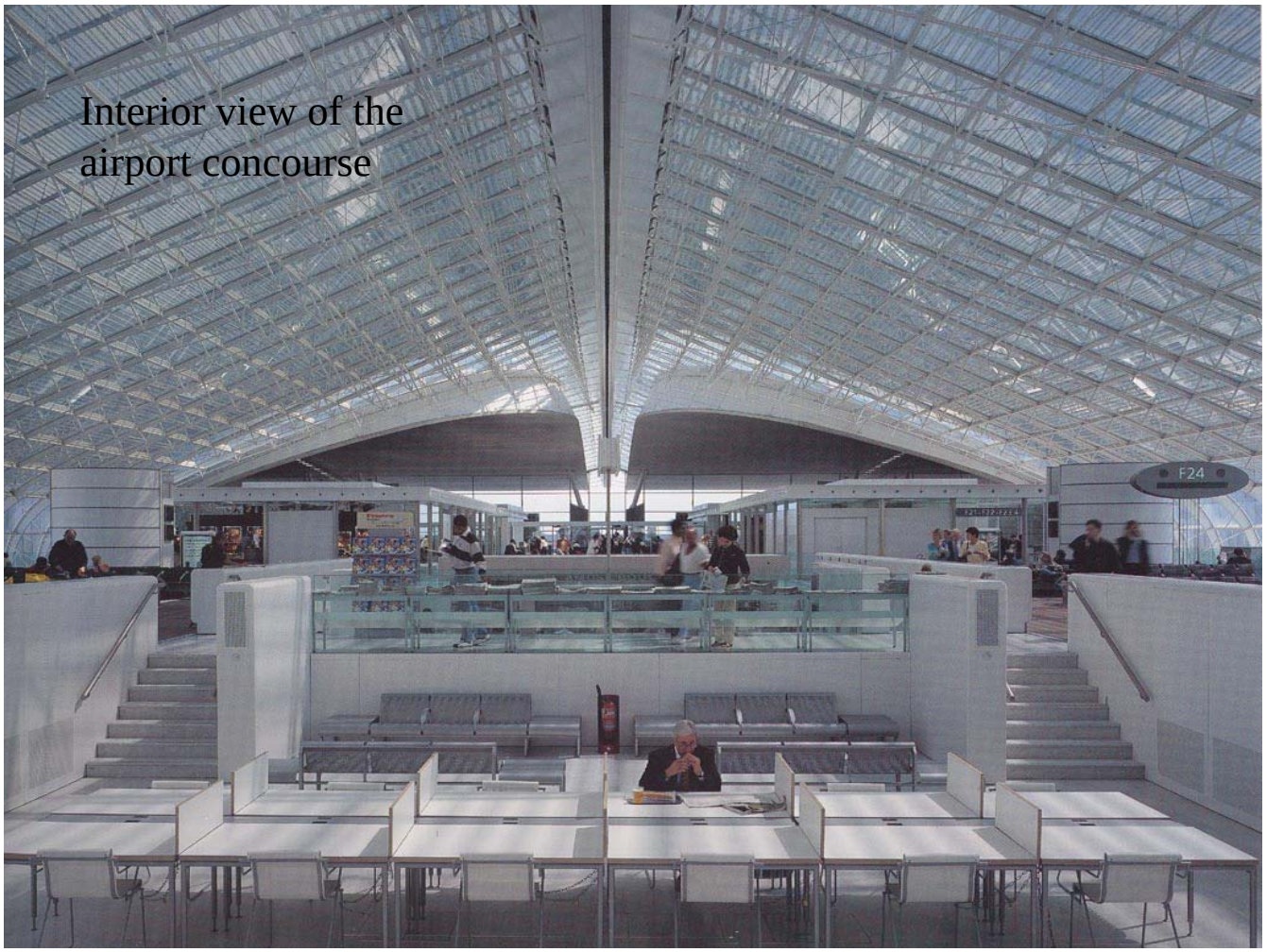
The Skydome

Other Overseas Examples

Charles-de-Gaulle International Airport, France

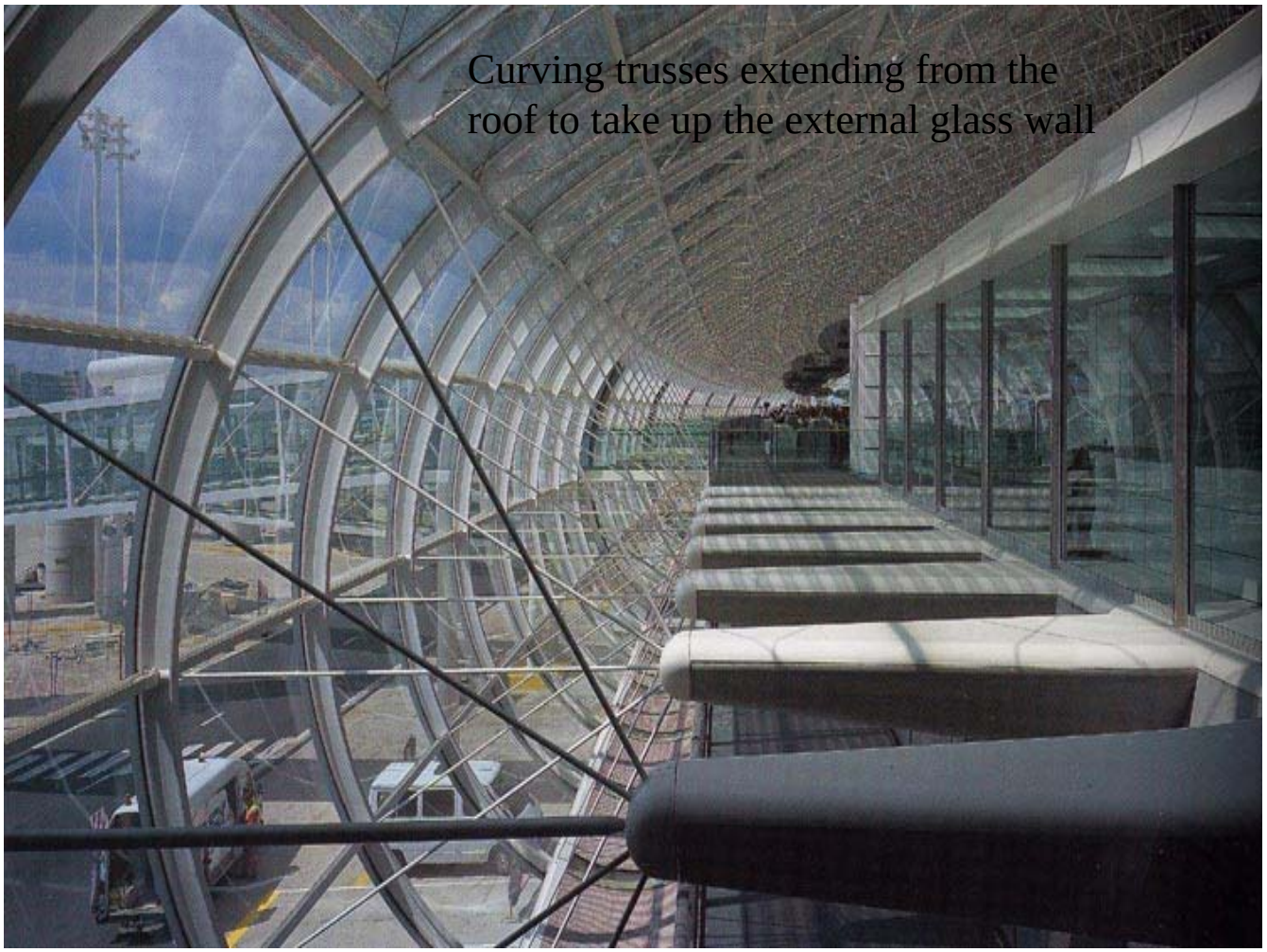


Charles-de-Gaulle International Airport, France, completed in 1998



Interior view of the airport concourse

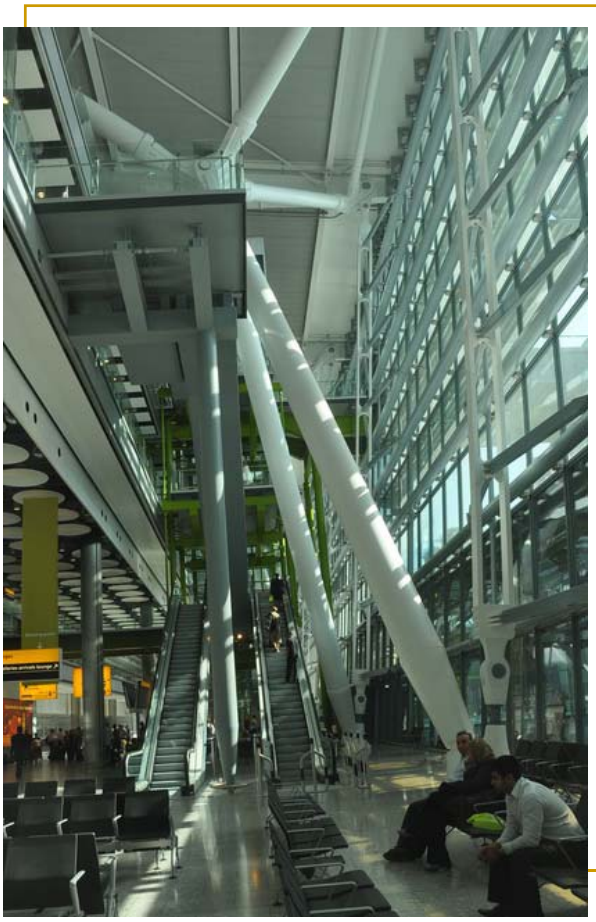

F31
F30
F32
F29


Curving trusses extending from the
roof to take up the external glass wall

Other Overseas Examples

Heathrow Airport Terminal

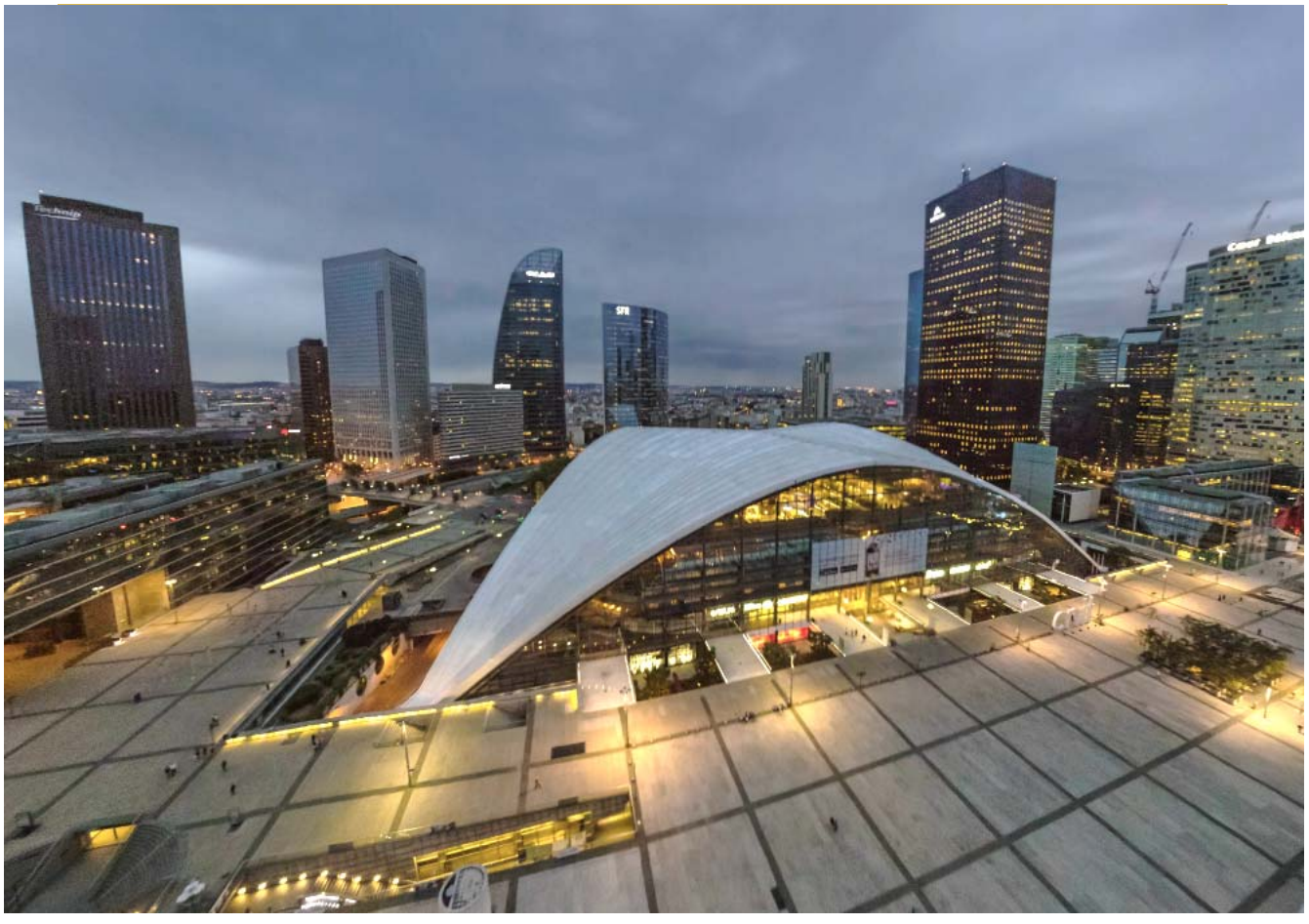

wagamama



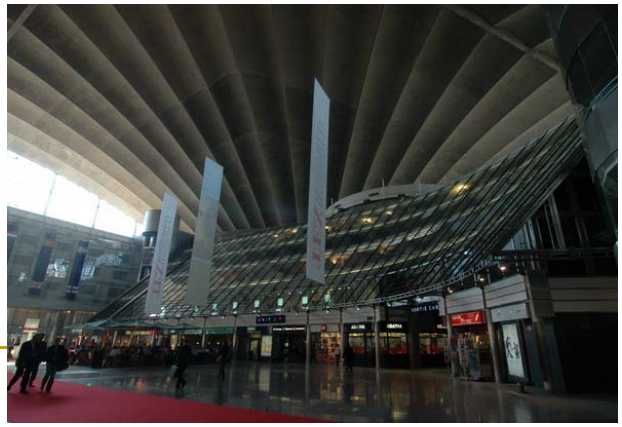

STARBUCKS COFFEE

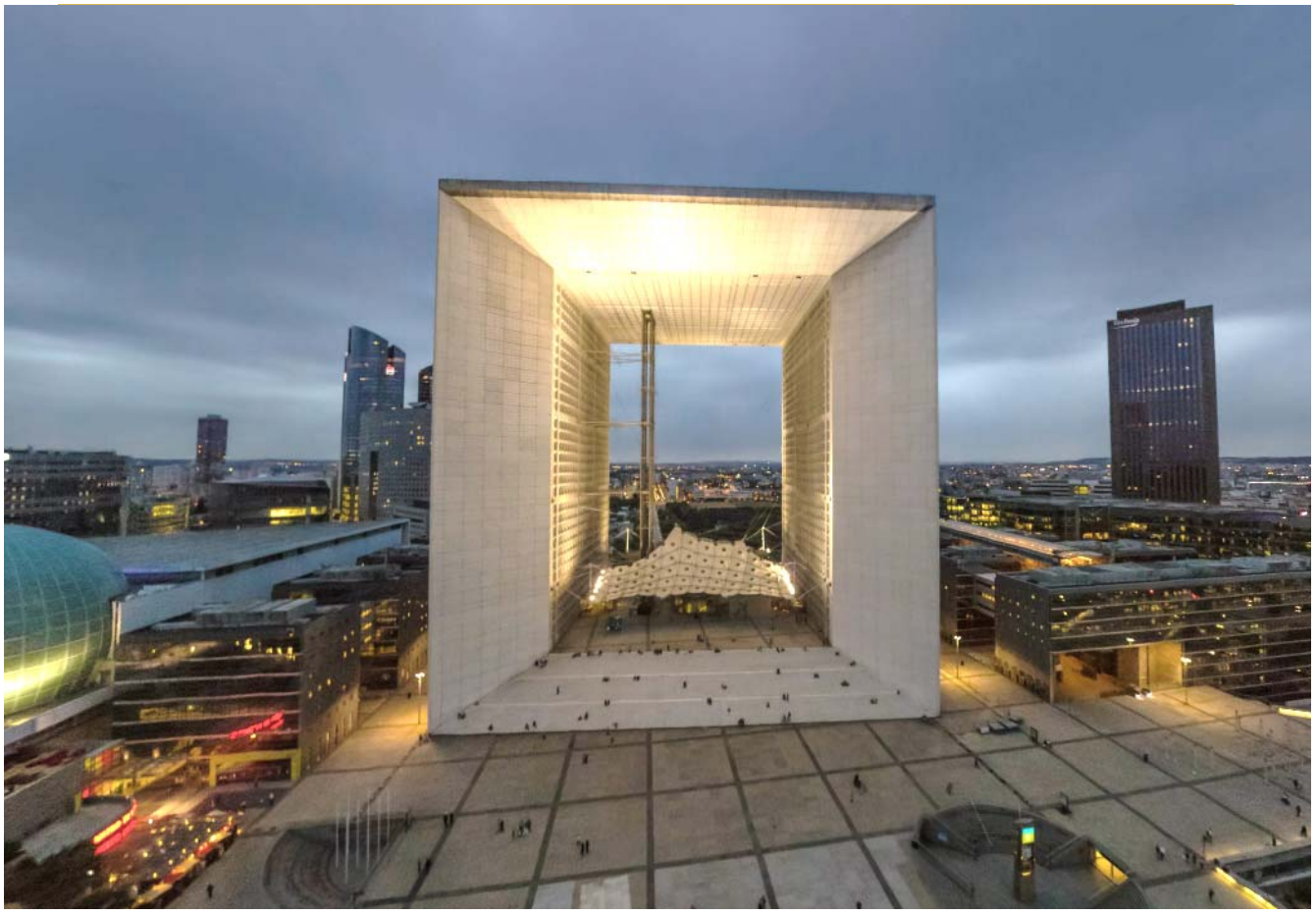
Other Overseas Examples

Commercial Centre in Paris



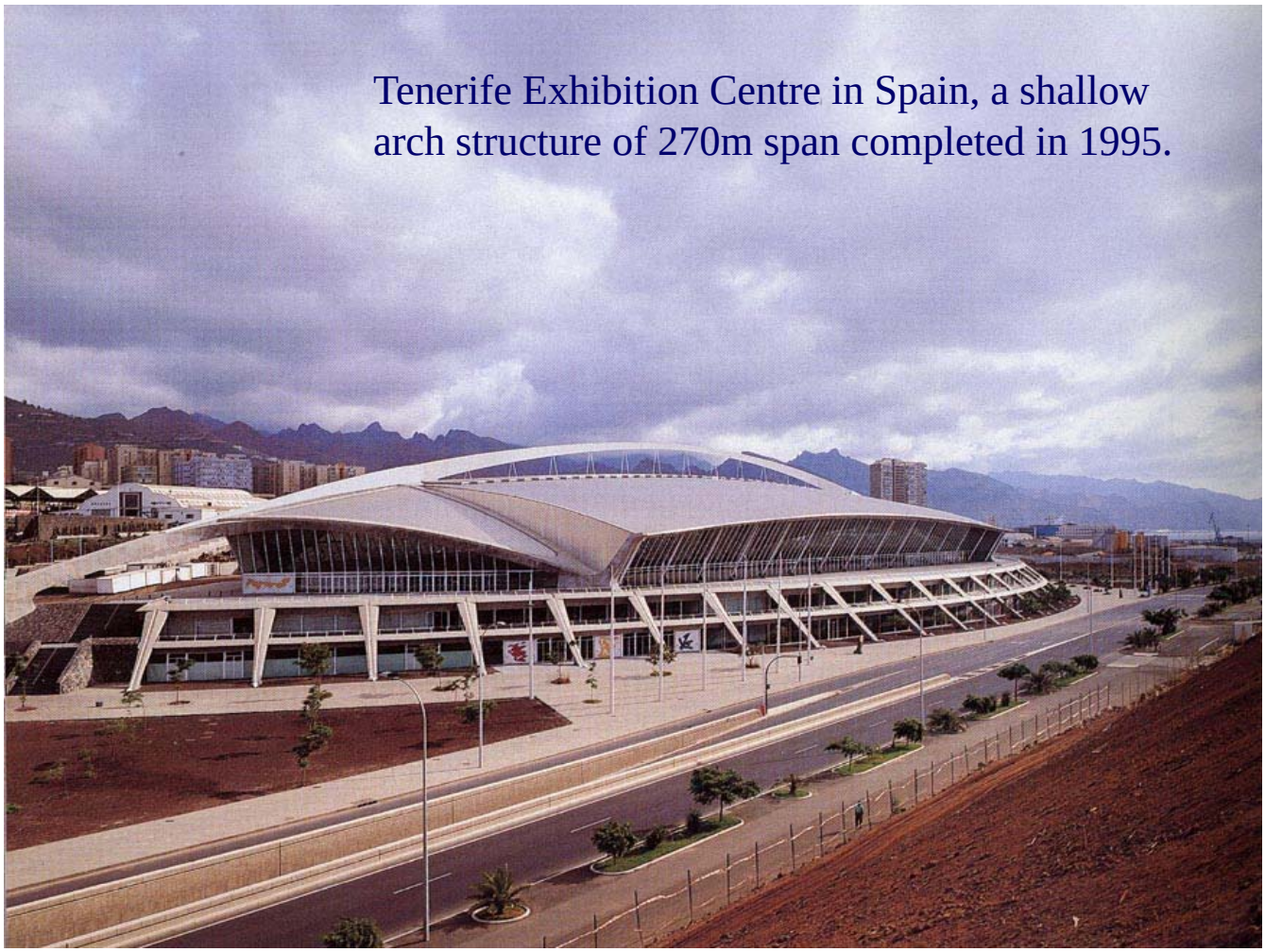

fnac
AIR FRANCE

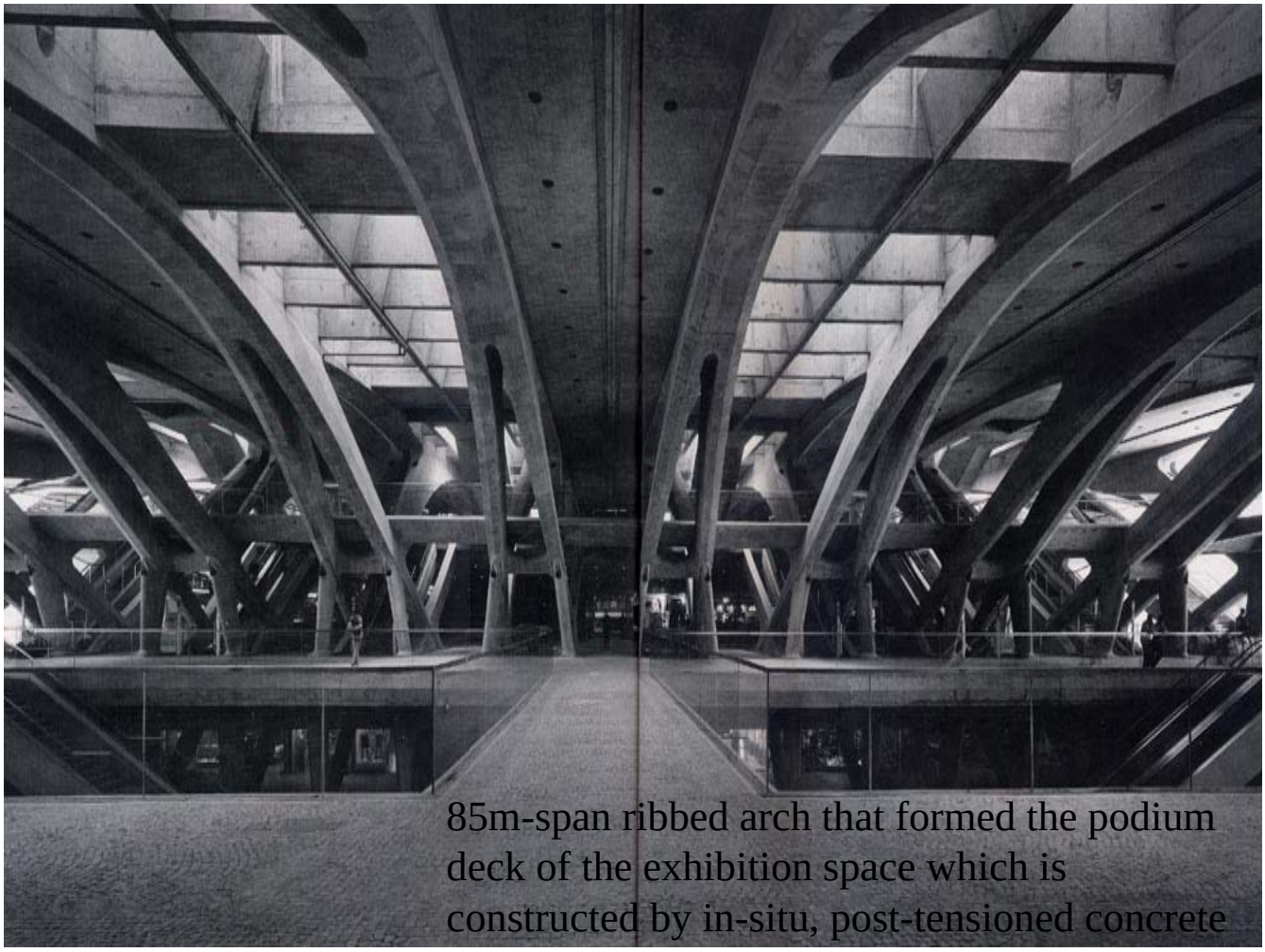




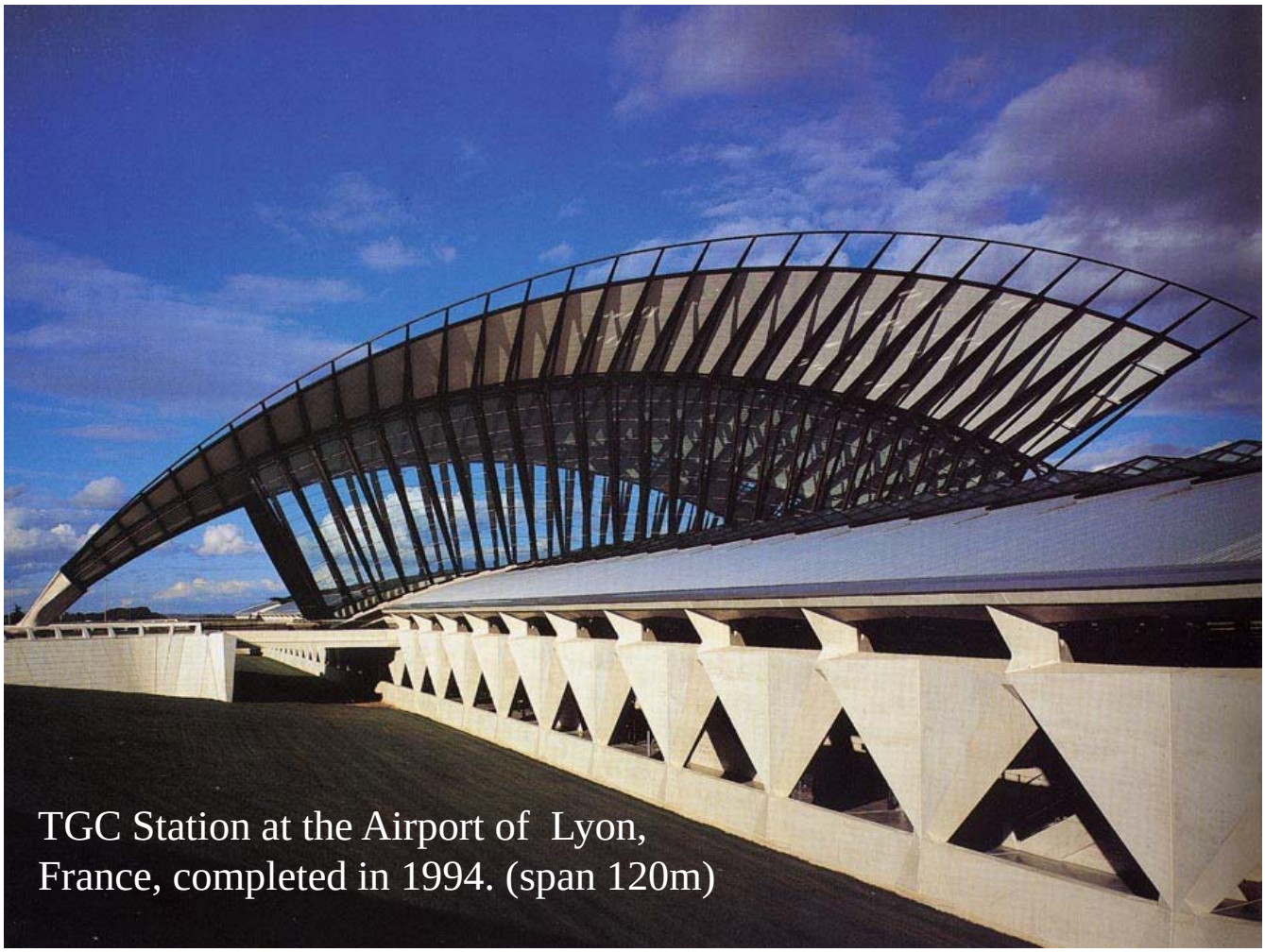
Other Overseas Examples

Tenerife Exhibition Central Stadium

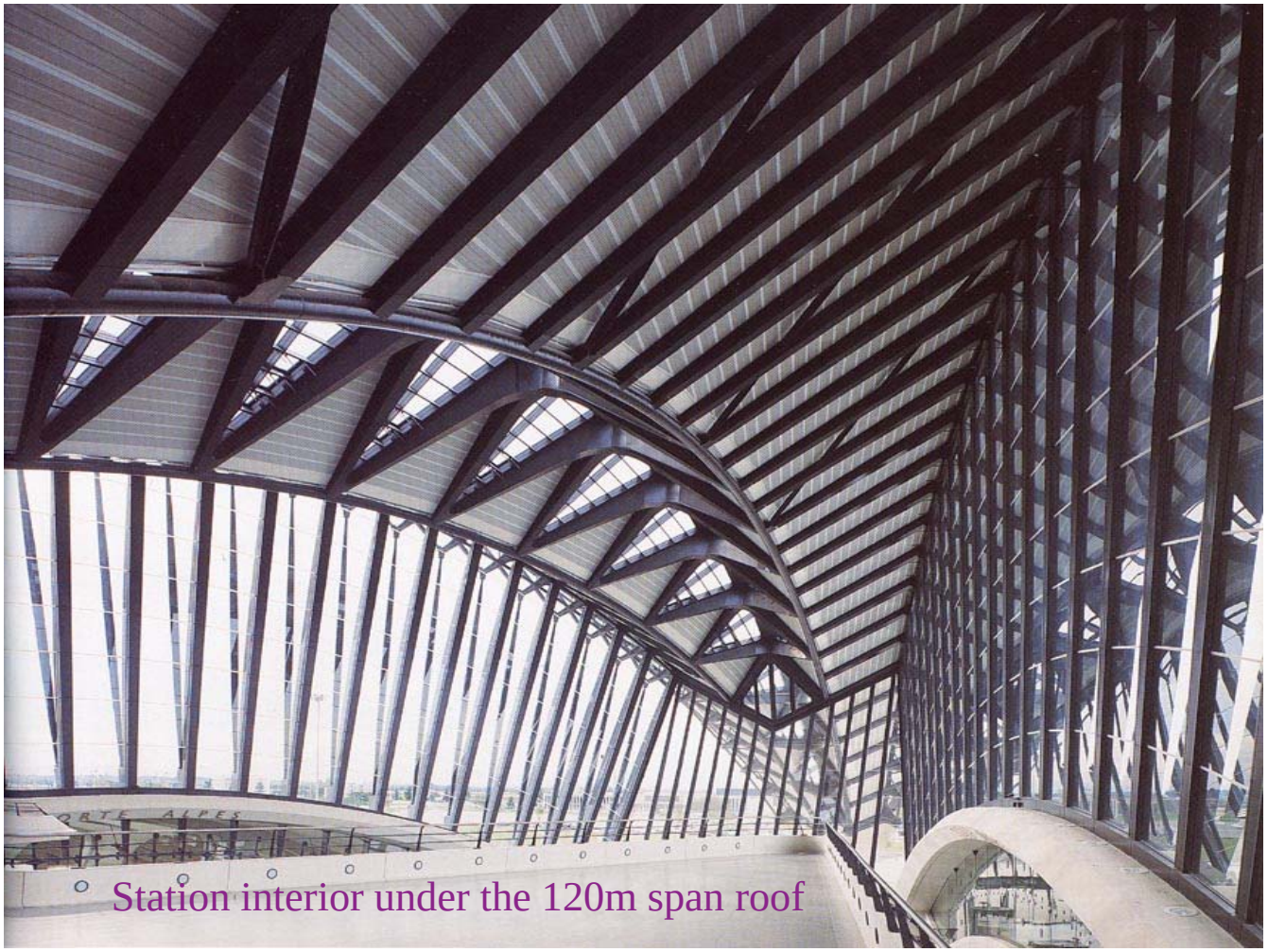




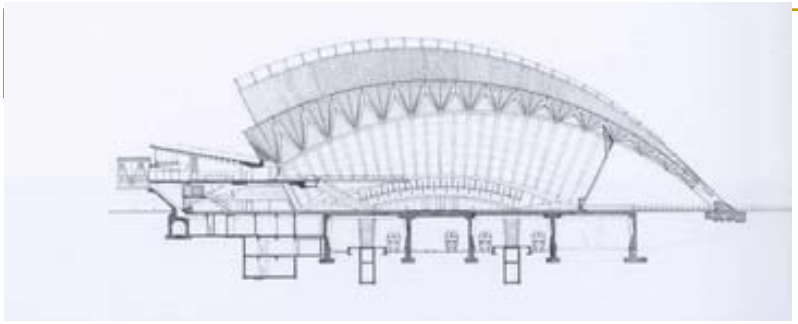
85m-span ribbed arch that formed the podium deck of the exhibition space which is constructed by in-situ, post-tensioned concrete

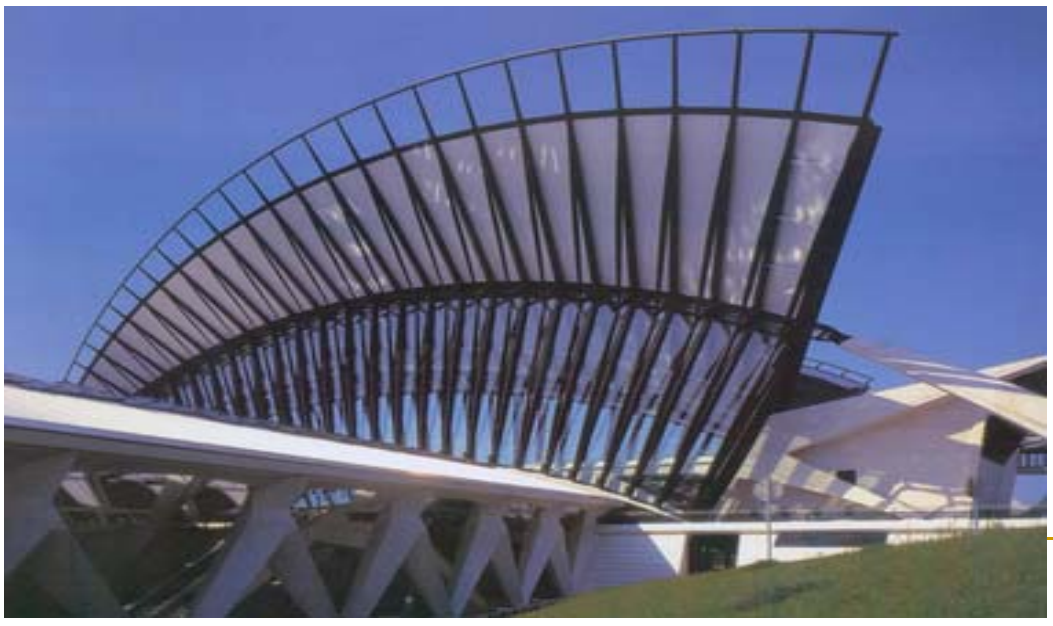


TGC Station at the Airport of Lyon, France, completed in 1994. (span 120m)



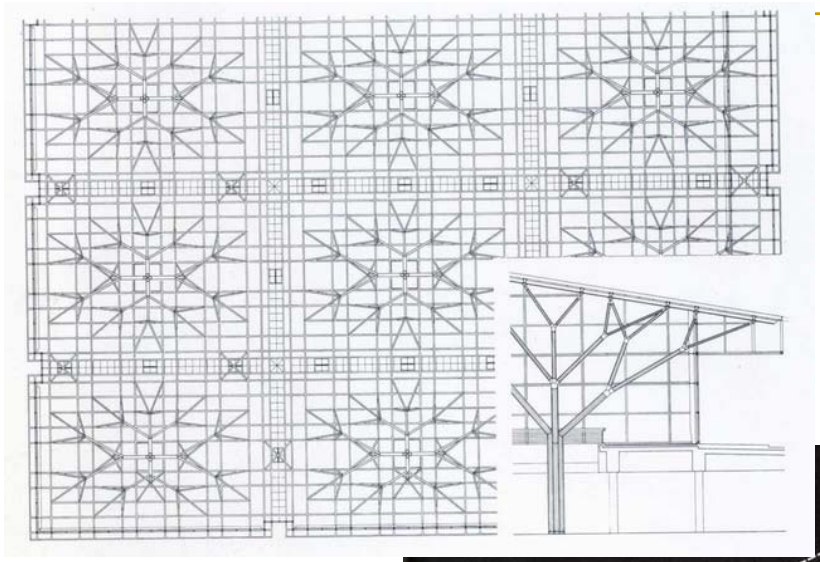
Station interior under the 120m span roof



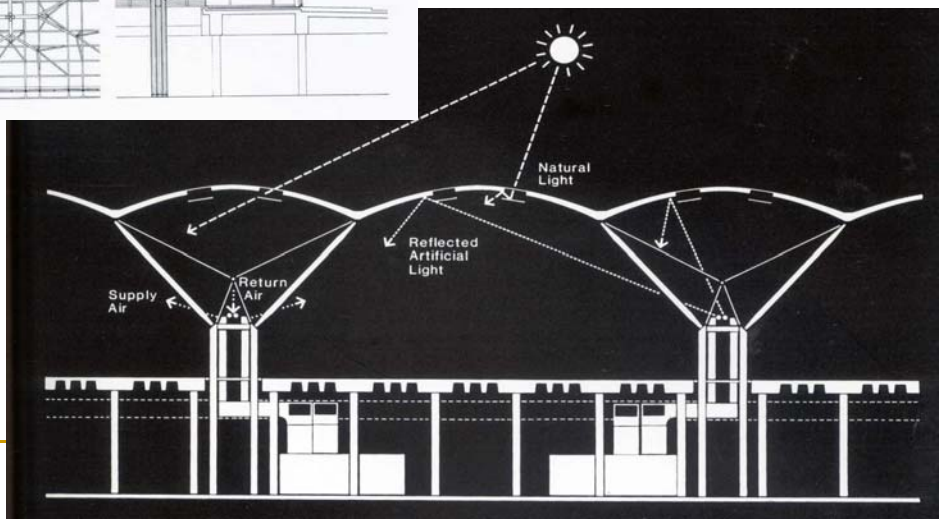


The Hamburg Airport, UK

Airport Terminal at Stuttgart, Germany

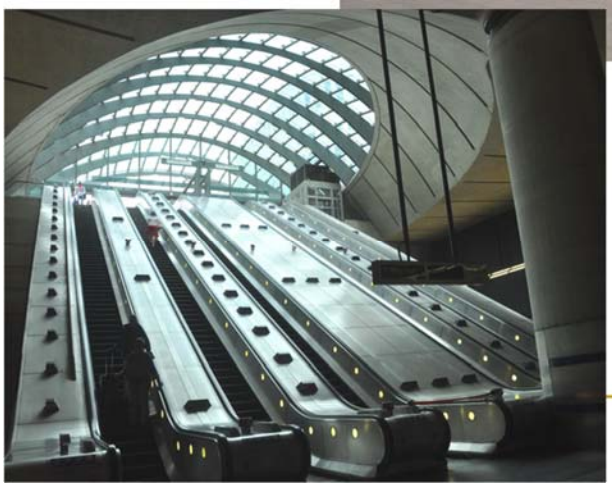


Roof plan/detail of the Stuttgart Terminal Building



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

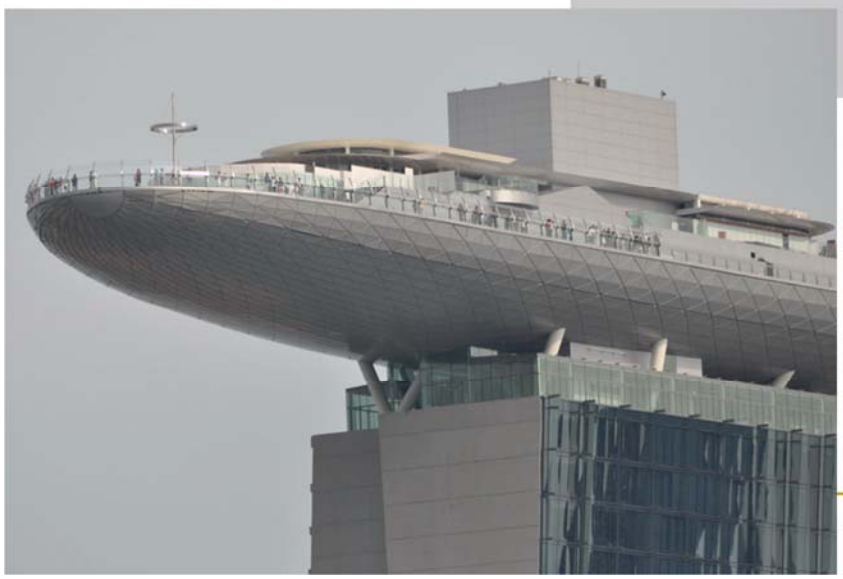
Typical roof truss detail showing the complicated configuration of the roof

Roof decking detail and other interior features

Roof canopy of a shopping centre in Las Vegas

Walt-Disney Concert Hall in Las Angeles

Sands Hotel, Singapore

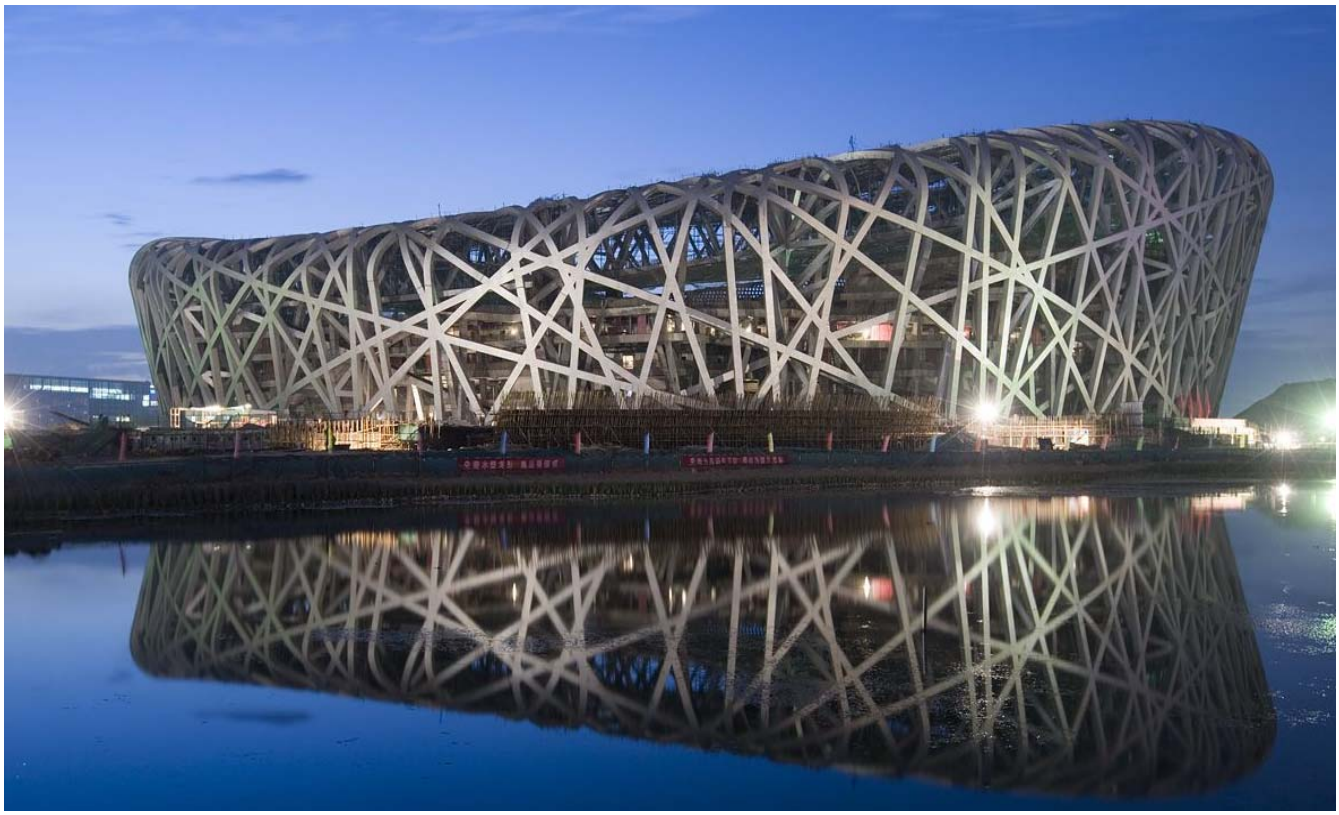



Panoramic views

Example in China –

Olympus Grand Stadium in Beijing

Beijing 2008 Olympus Centre – The Nest

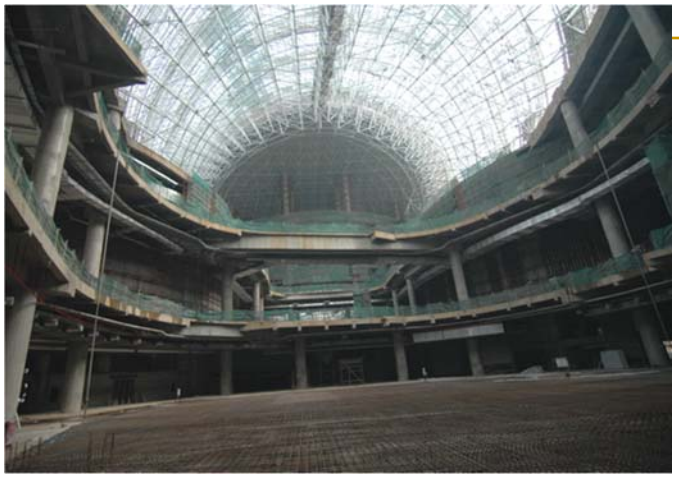


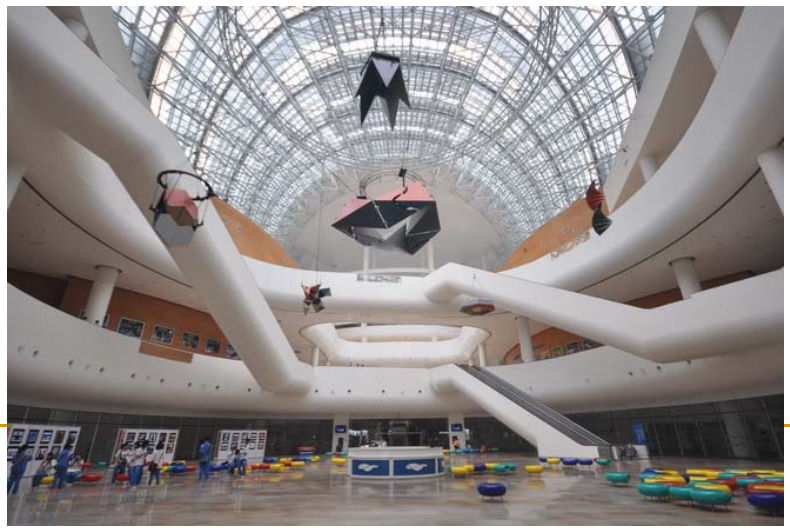
Beijing 2008 Olympus Centre – The Nest

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)

Underside showing the main span of individual exhibition hall

Example in China –

The Guangzhou Olympus Stadium

External view of Stadium

Detail showing the form and shape of the cantilevered roof

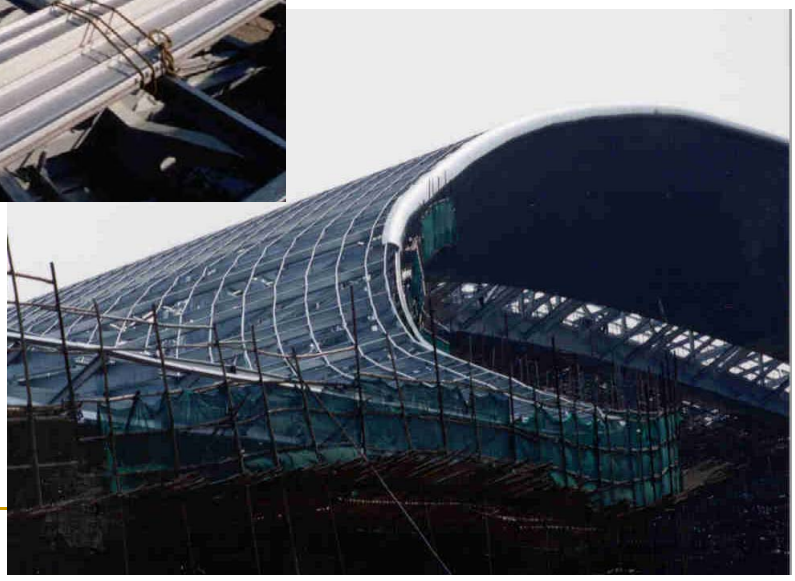
Hoisting the cantilever truss

Placing the roof truss in position

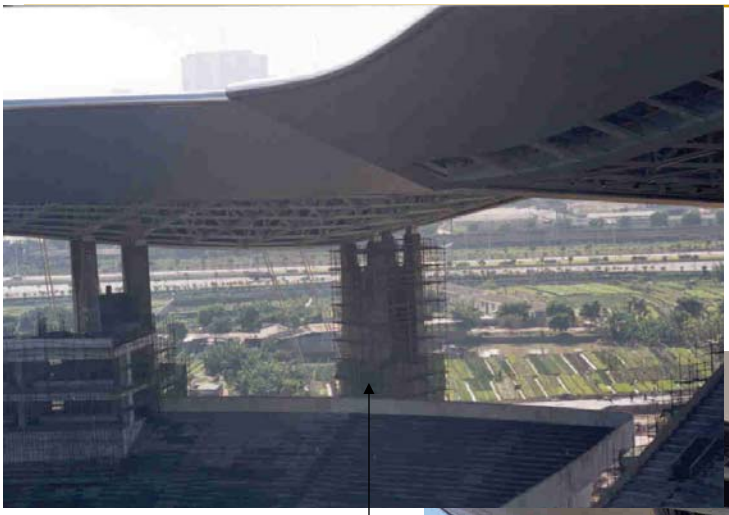
Tie systems to stabilize the cantilevered roof

Enlarged details
of the Tie systems

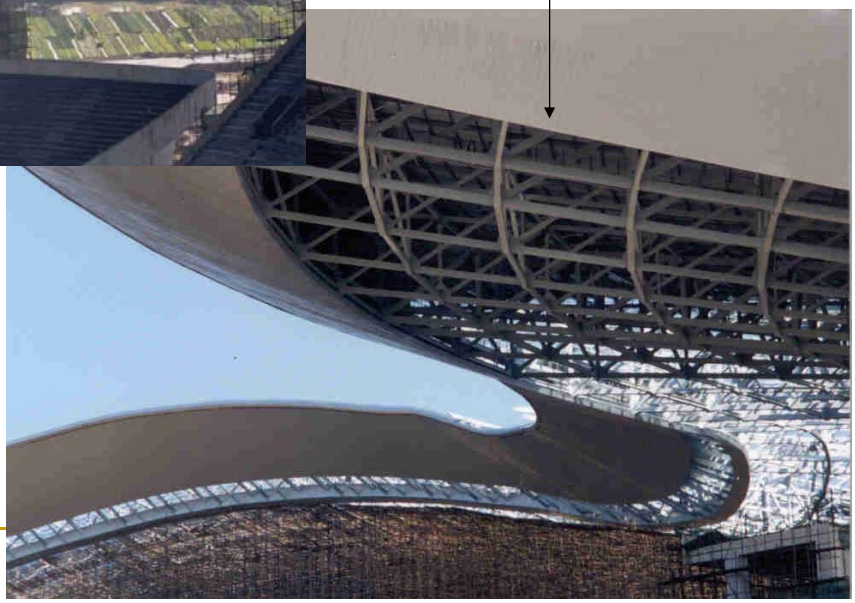
Decking system of the roof



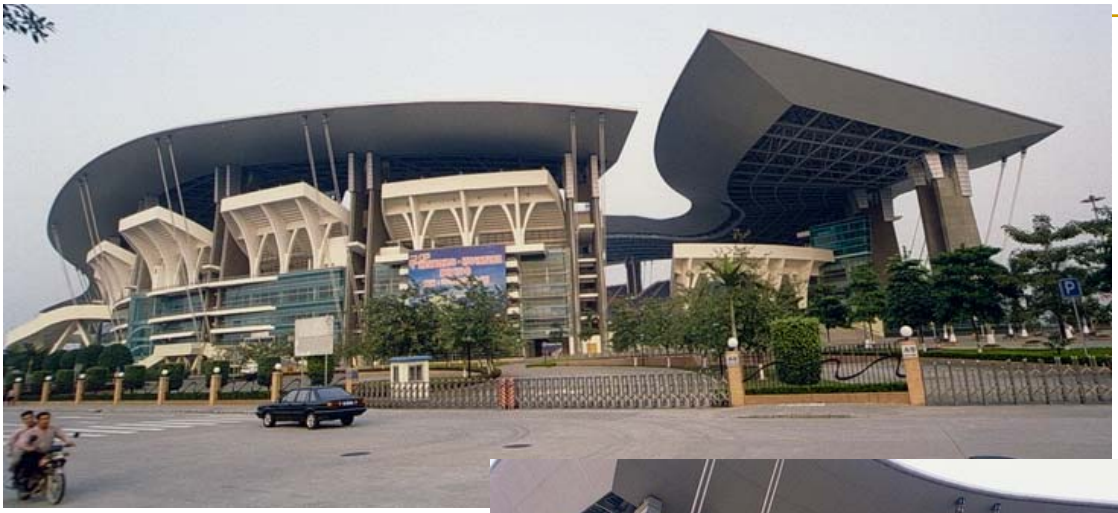
Laying of the roof deck



Semi-cladded roof underside



Piers supporting the cantilever roof truss



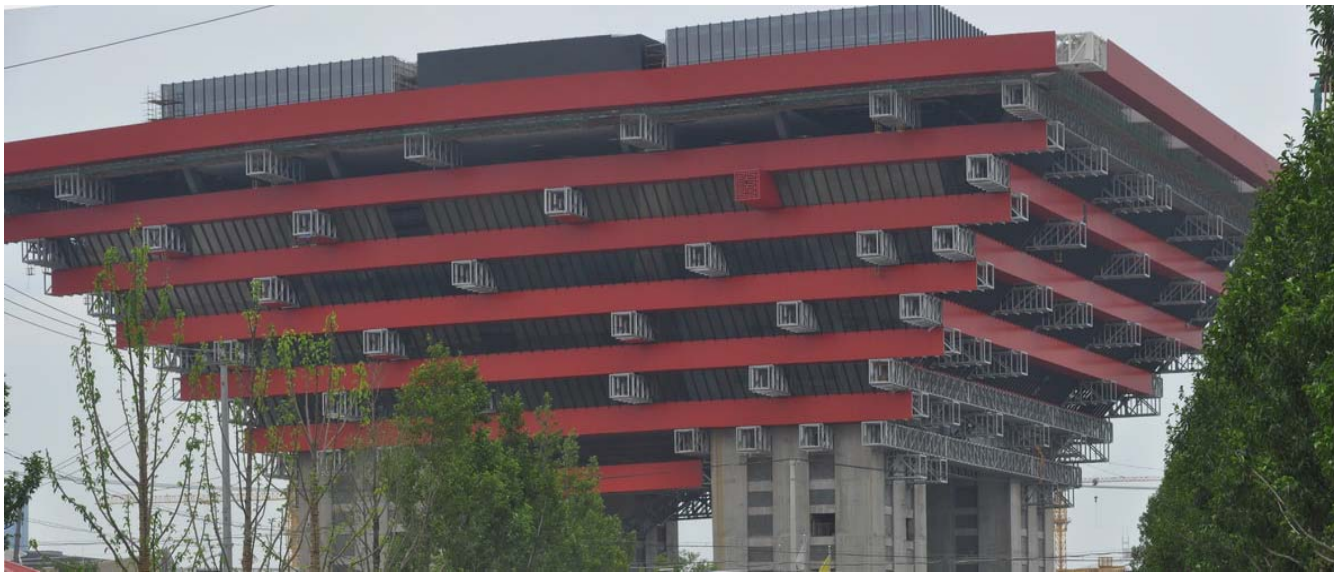
Stadium after completion

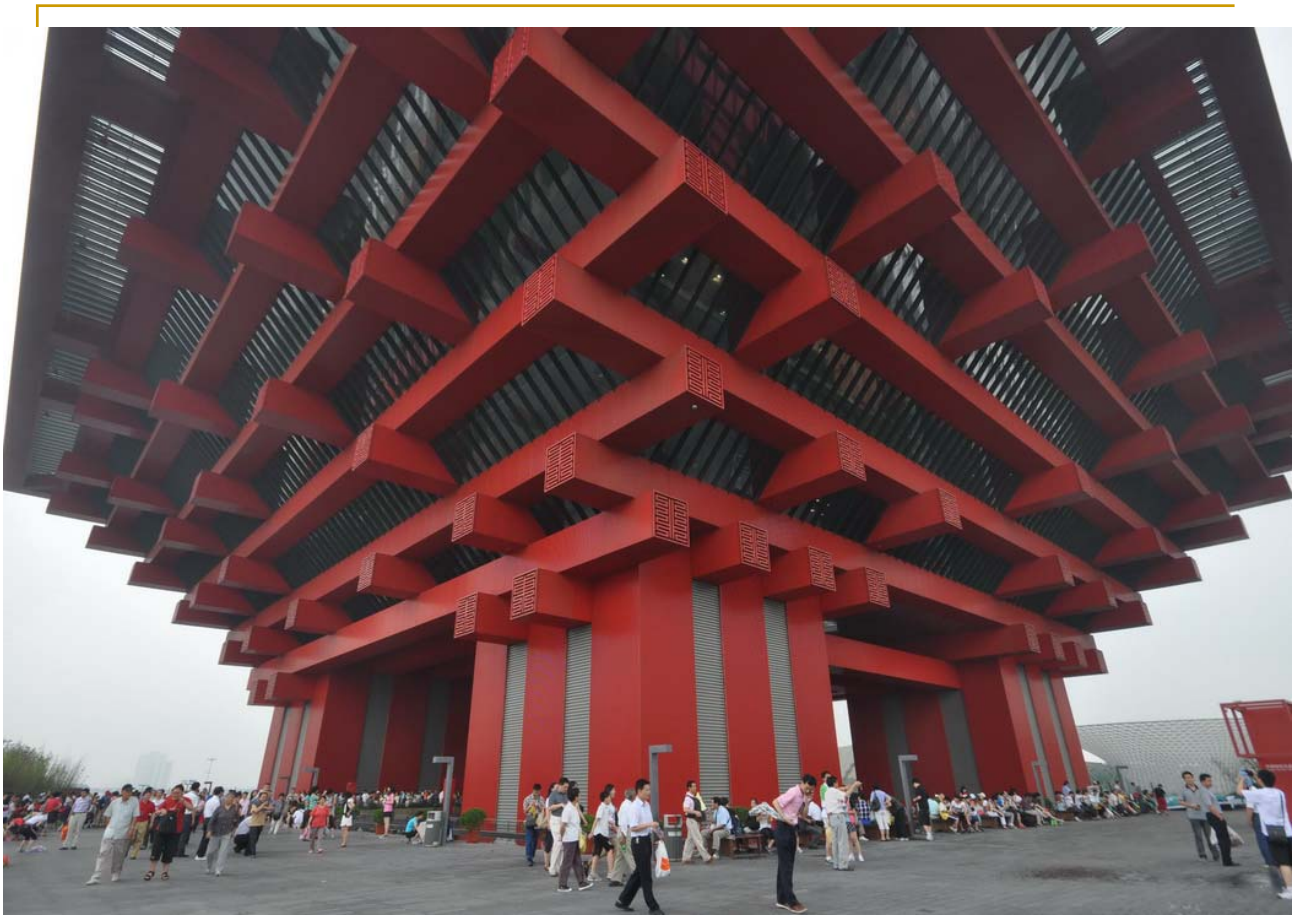
The Guangzhou Gymnasium

Stadium after completion

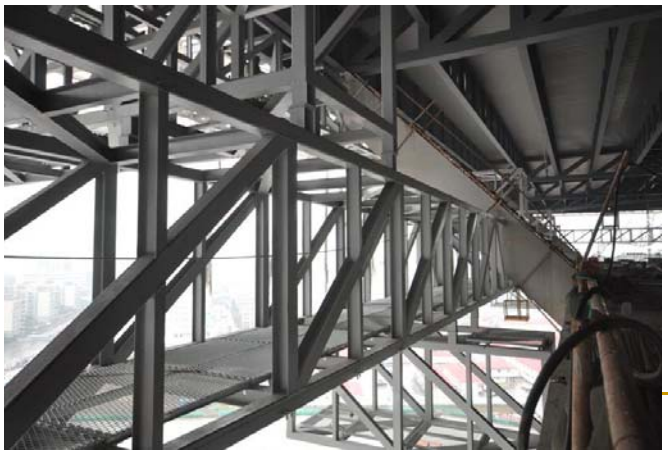
Example in China –

China pavilion and other major facilities in 2010 World Expo, Shanghai

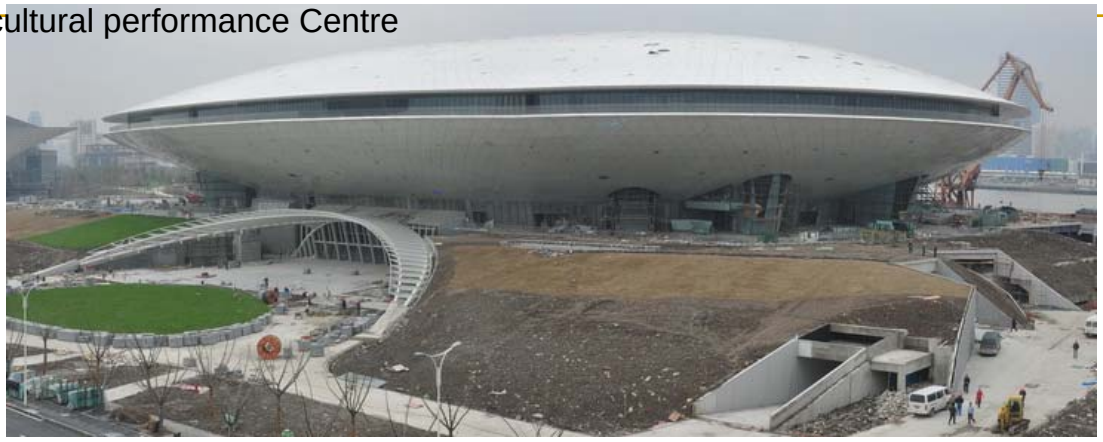




The China Pavilion

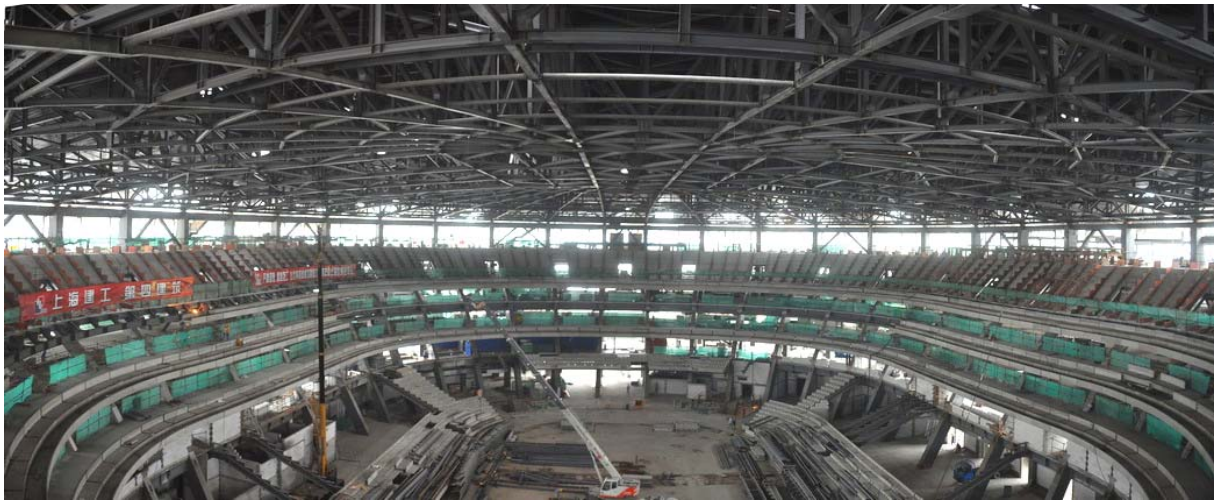


The cultural performance Centre



The Saudi Arabia Pavilion

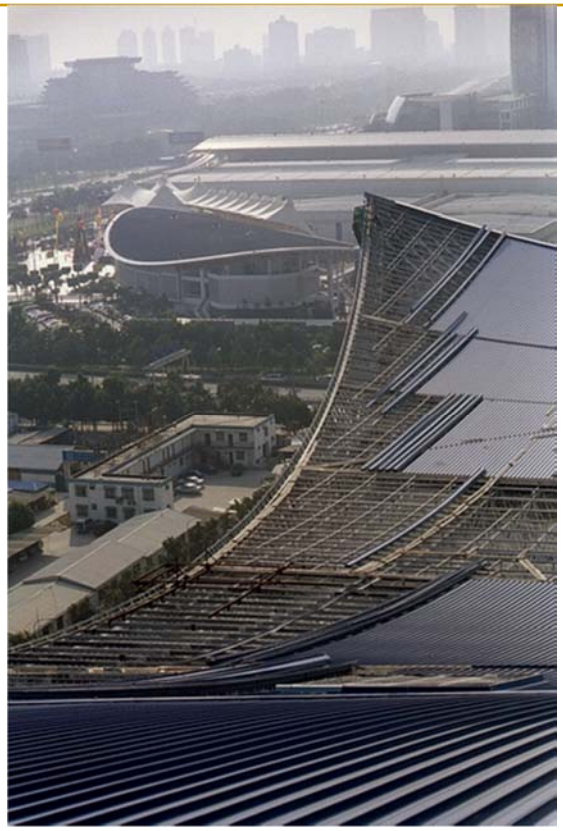
The cultural performance Centre

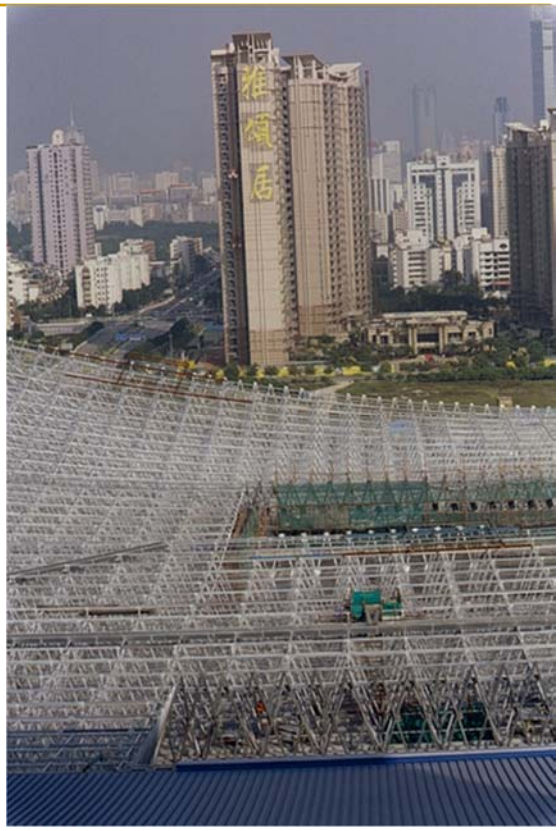


Other Examples in China

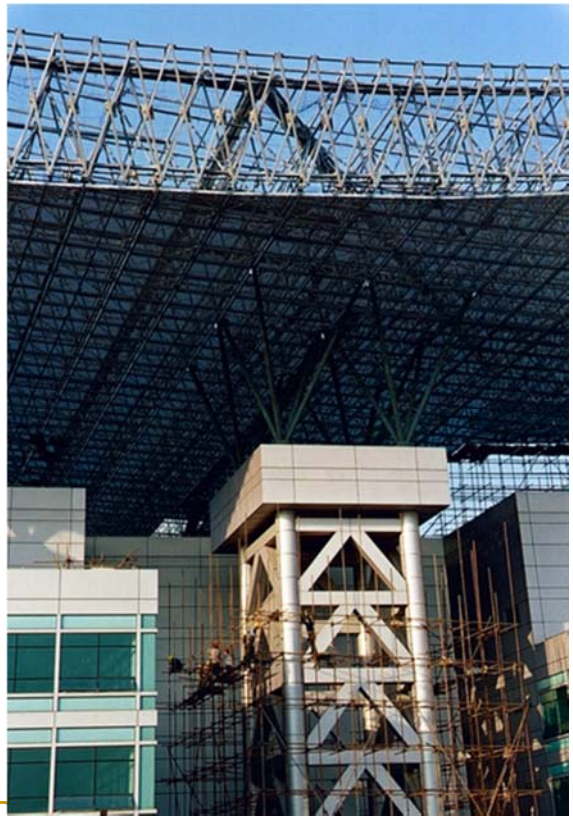
The Shanghai Stadium

Roof of People Centre in Shenzhen



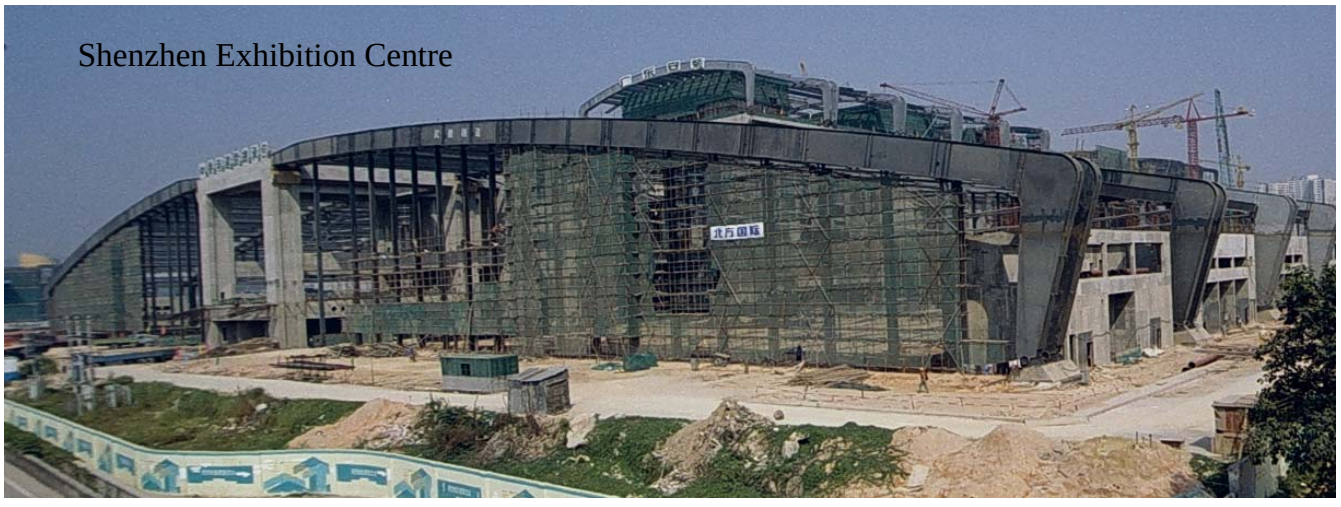


Detail of the roof truss and the laying of the deck panels

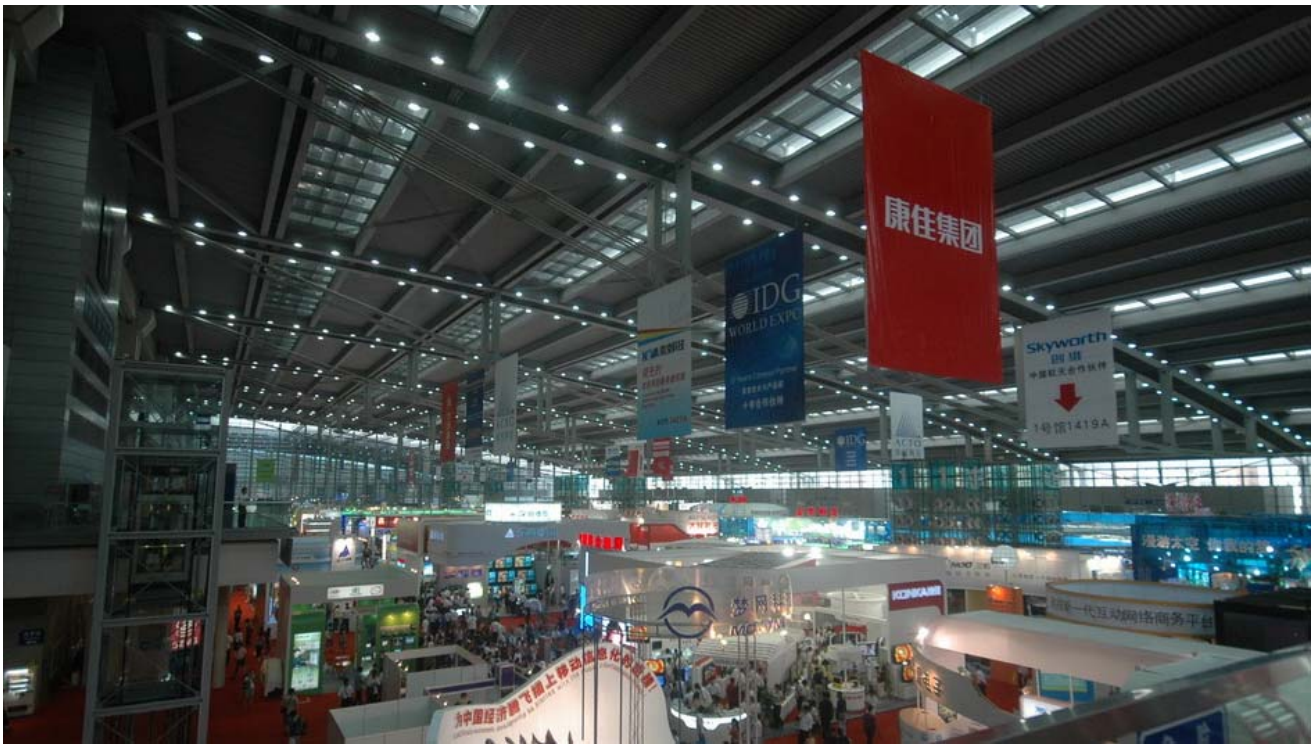


Detail of the roof truss framing and the roof supporting tower

Entrance Canopy for Guangzhou Convention and Exhibition Center



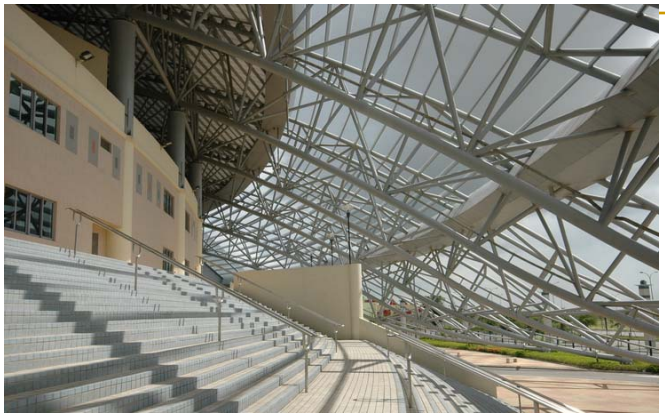
Shenzhen Exhibition Centre



Shanghai
South Station

Shanghai South Station

Macau Stadium




Long Span Structure

Hong Kong Examples

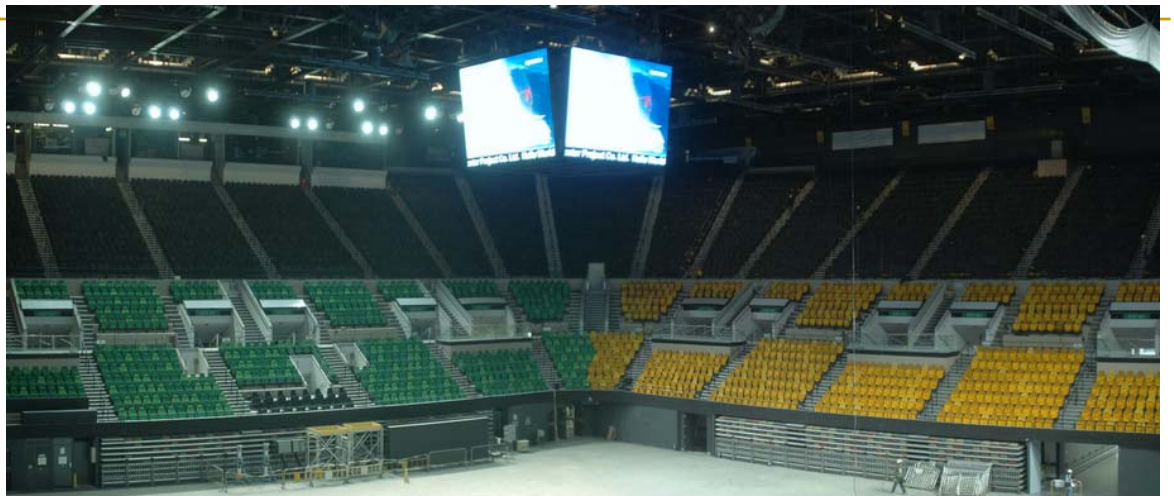
Sport ground in Tseung Kwan O

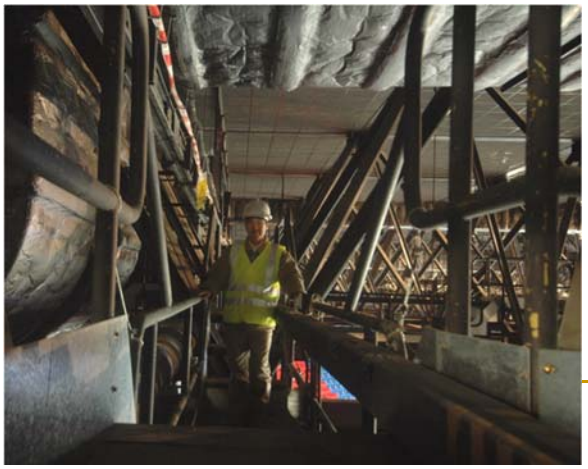
Member Centre of the Hong Kong Jockey Club

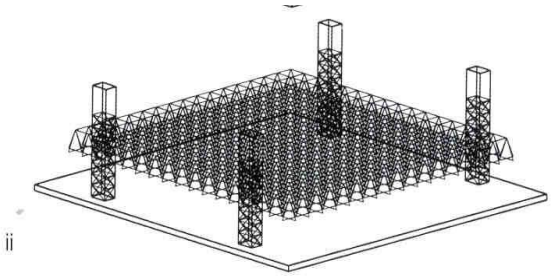
Member Centre of the Hong Kong Jockey Club

Span about 25m

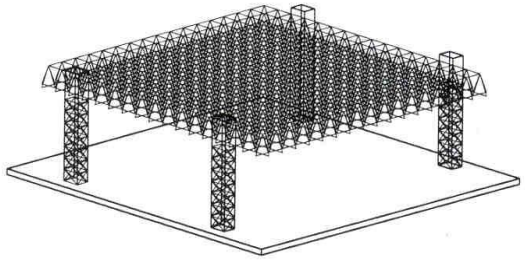
Hong Kong coliseum



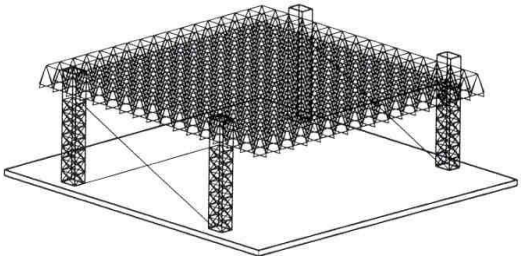


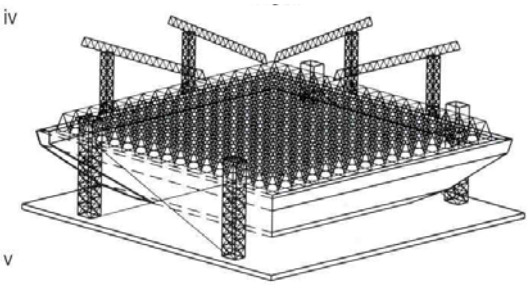


ii



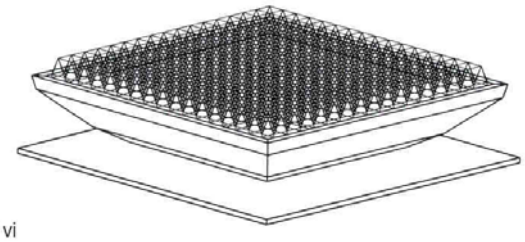
iii





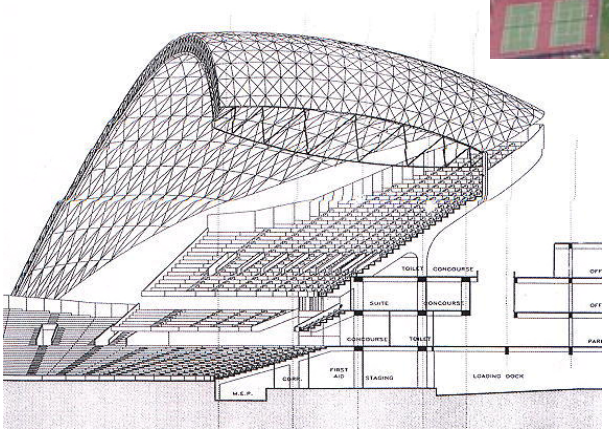
iv

v

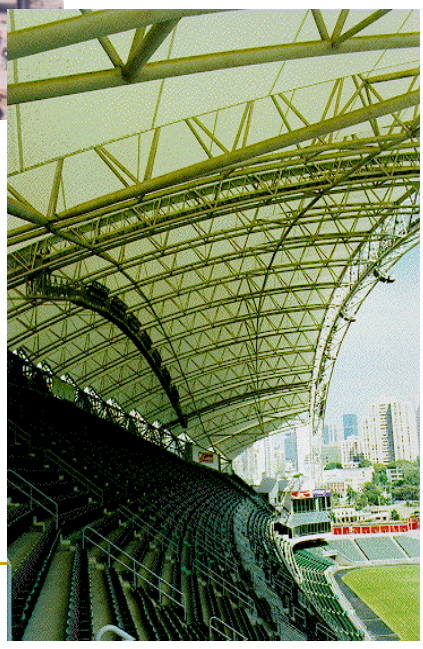


vi

The Hong Kong coliseum



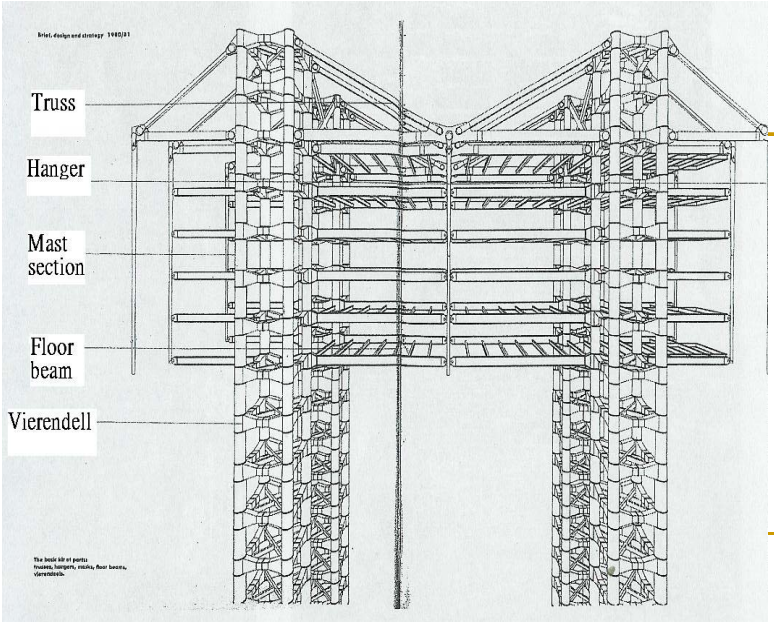
The Hong Kong Stadium



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

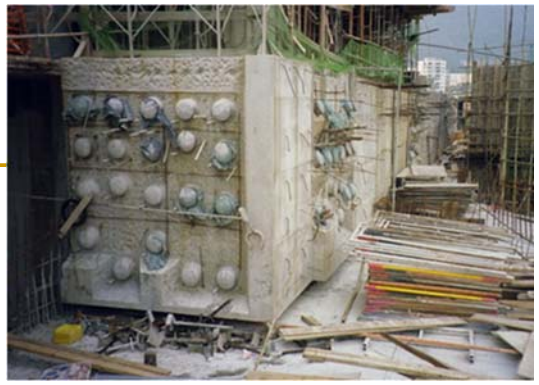


Actual Example –

Headquarter Building, Hong Kong $ Shanghai Bank

Actual Example –

The Skylight structure of Festival Walk




Tic Tac


KFC

Other long-span spaces within Festival Walk constructed using in-situ method

Other long-span spaces within Festival Walk – the public bus terminus

Linking structure between the International Finance Center Phase I and II

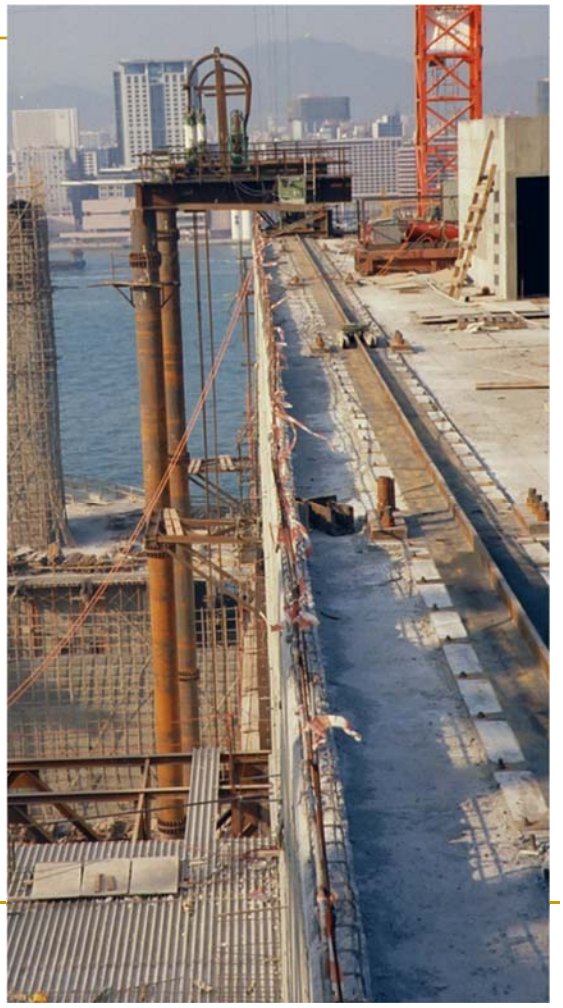
Hong Kong Convention and Exhibition Centre

The deck and roof structure of the HK Convention and Exhibition Centre

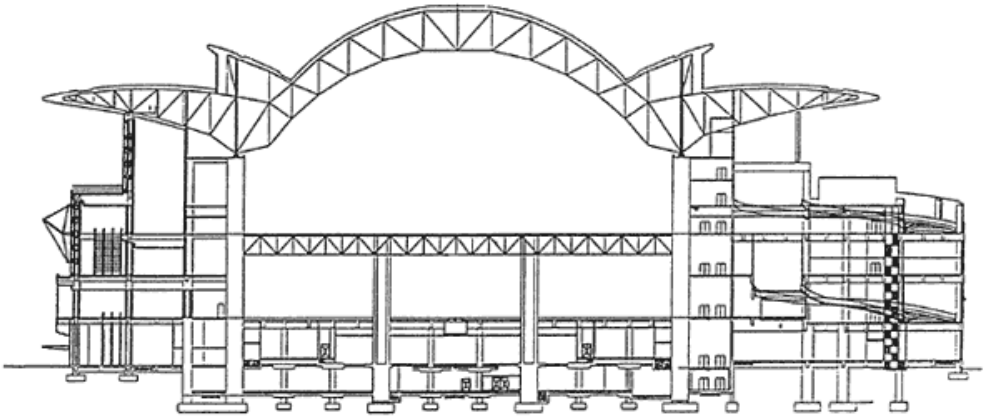
Hoisting of the 80m-span roof truss

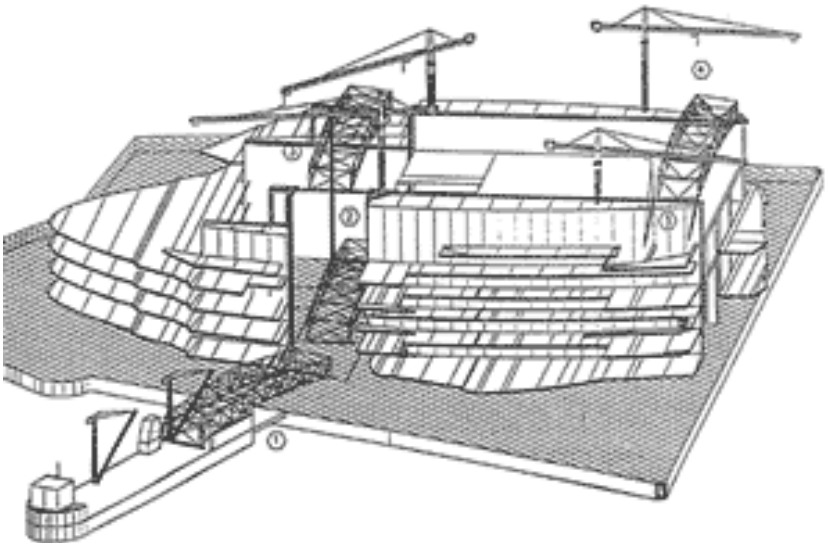
multi-axis trolley to transport the pre-fabricated steel truss

Hydraulic system (strand jack) and rail for the lifting and horizontal sliding of the 400-ton roof truss



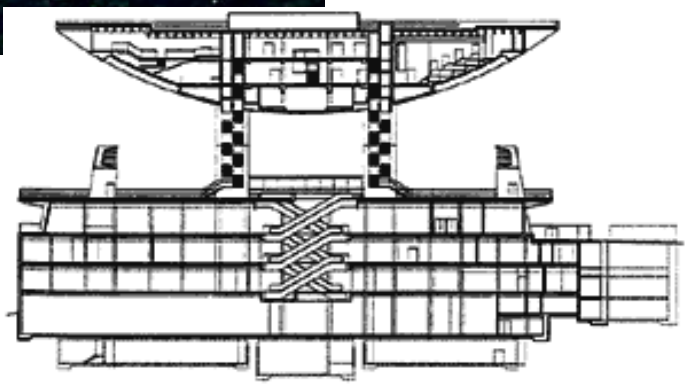
Placing of the roof truss at the top of the core wall





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

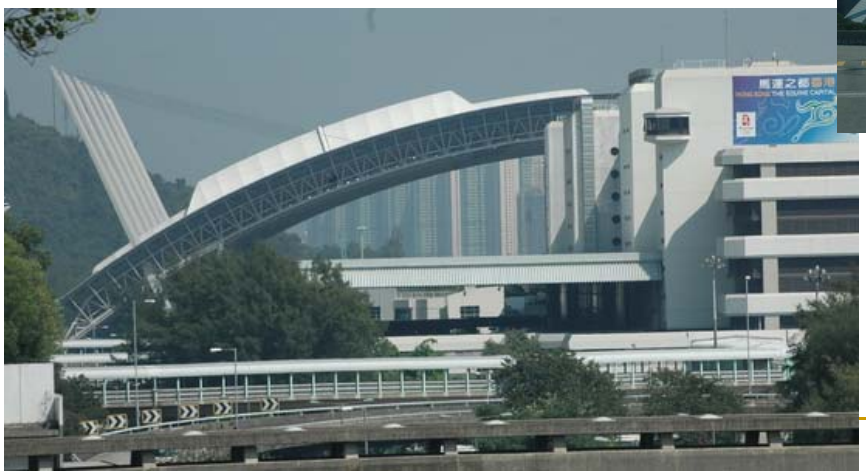
The Sky Dome, Cyber Port

The Sky Dome, Cyber Port

View of the mall interior under the Sky Dome in the Cyber Centre, Cyber Port

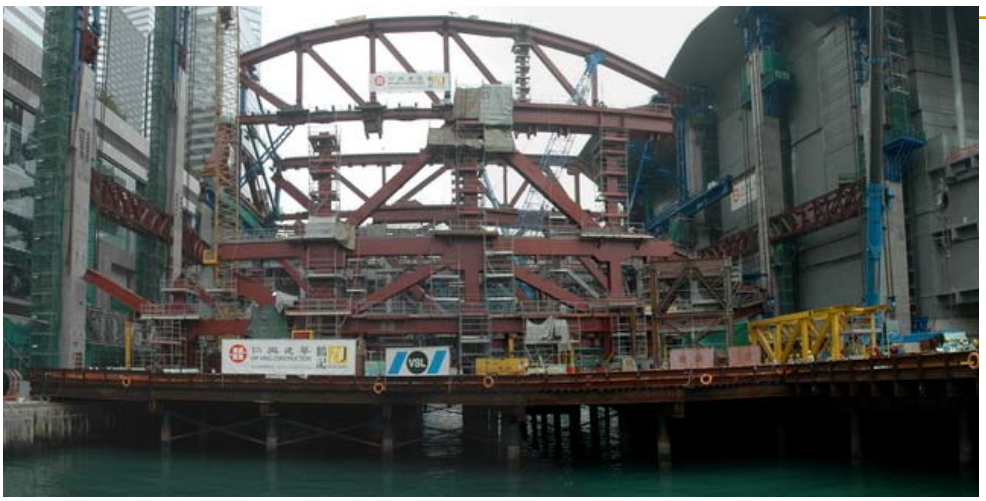
The Arch in Kowloon Station

Canopy for the New Stand/Race-practicing Court for the HK Jockey Club



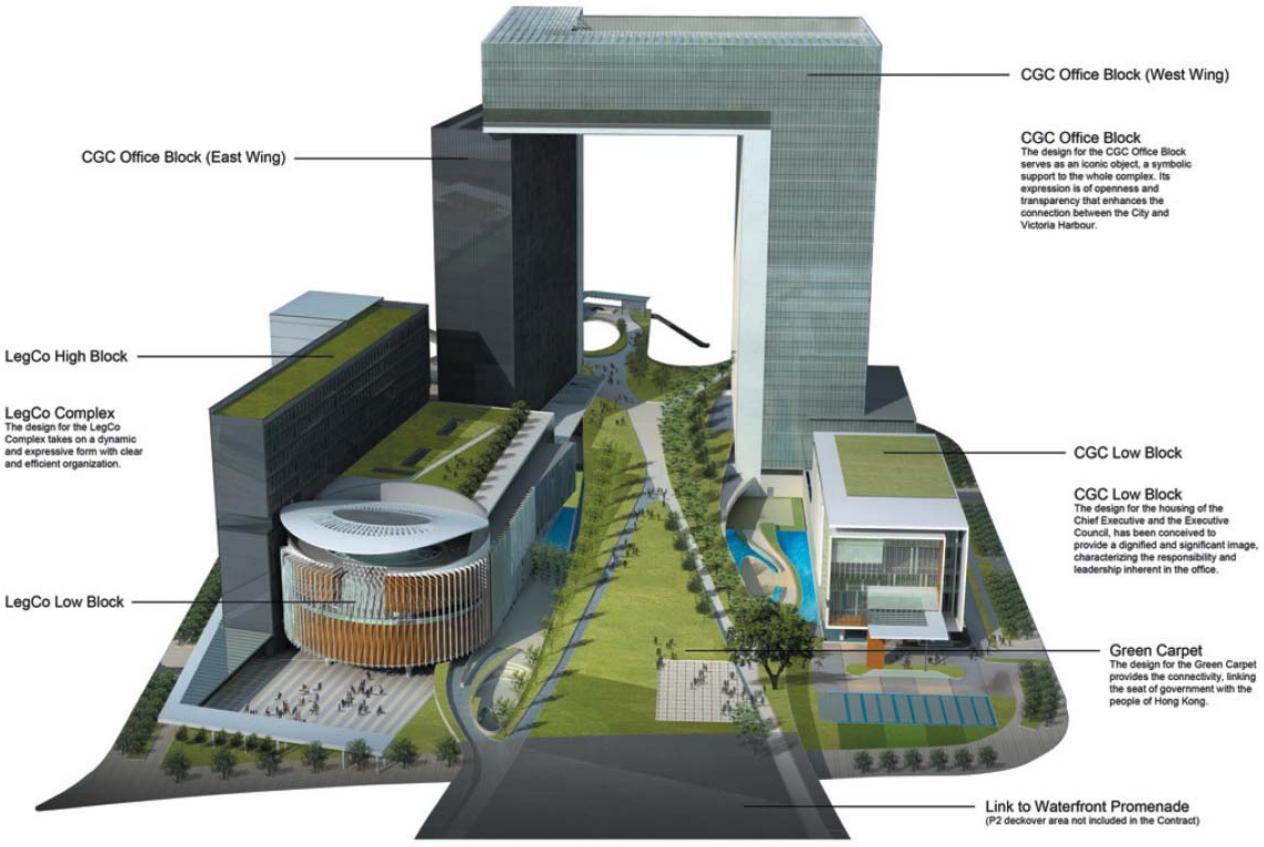
The roof structure of Langham Place – Shopping Mall

The Grand Atrium in Langham Mall



Extension to Hong Kong Convention and Exhibition Centre

Extension to HK Convention and Exhibition Centre

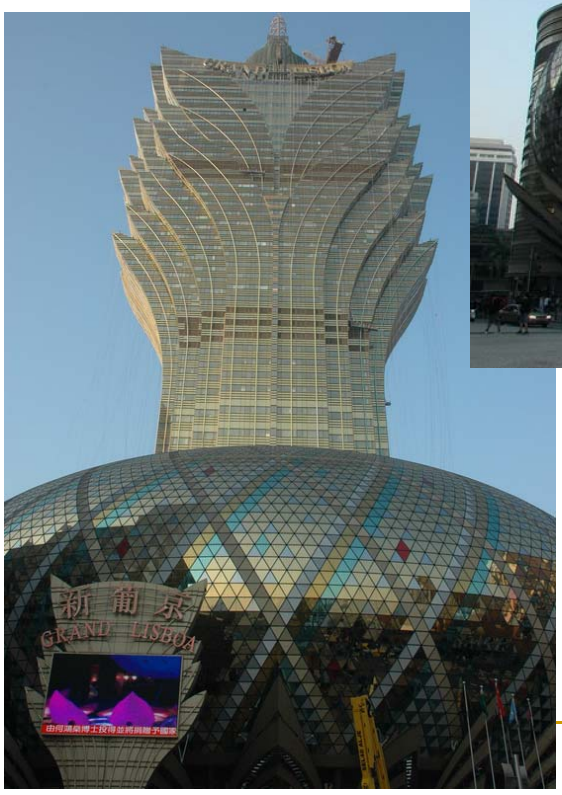


Tamar Government Headquarter Complex


ROAD

New Lisbon Casino.
Macau

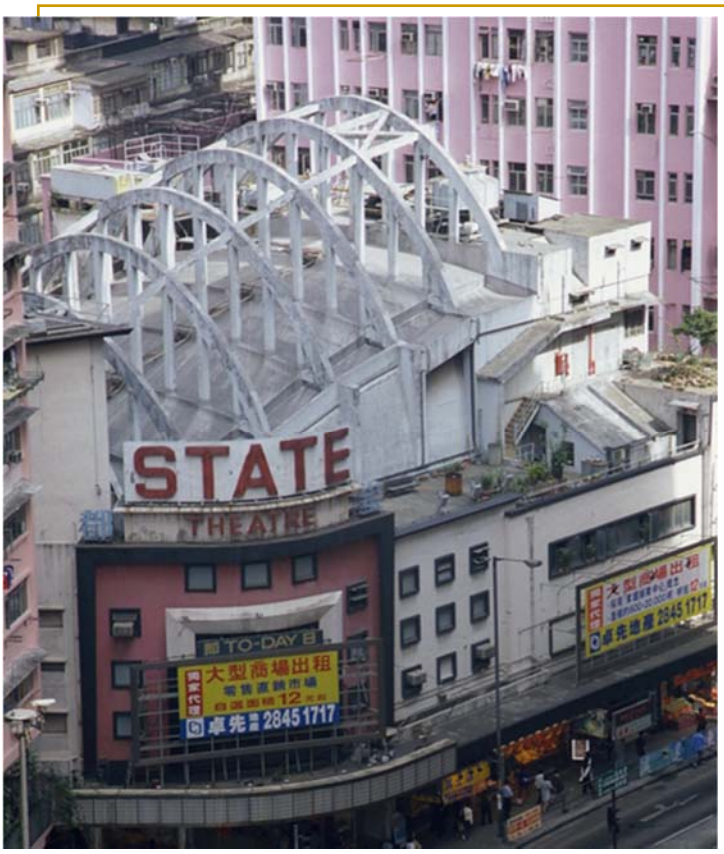
New Lisbon, the hotel tower



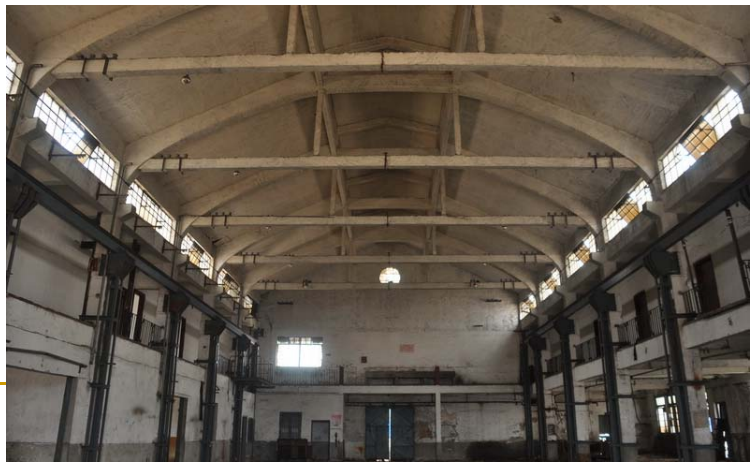
Cruise Terminal in Kai Tak

The Cruise Terminal in Kai Tak

Other Examples – miscellaneous nature

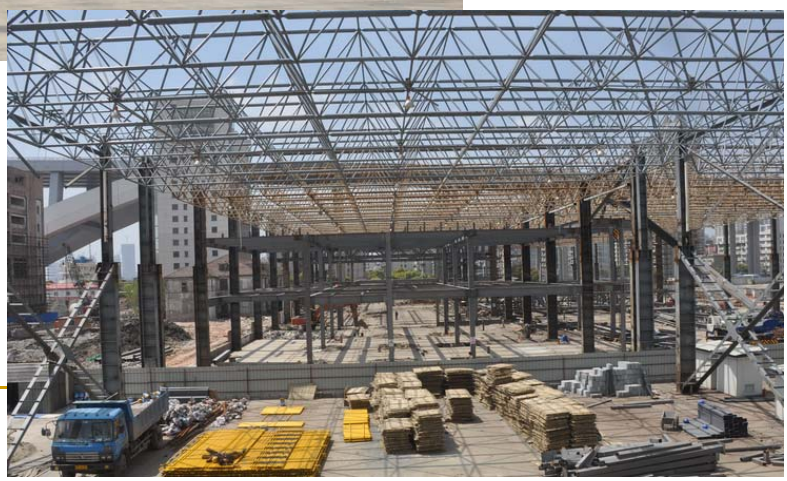


Roof constructed in RC arch-truss, in-situ



Roof constructed in
RC truss, precast

Roof constructed in
RC truss, precast

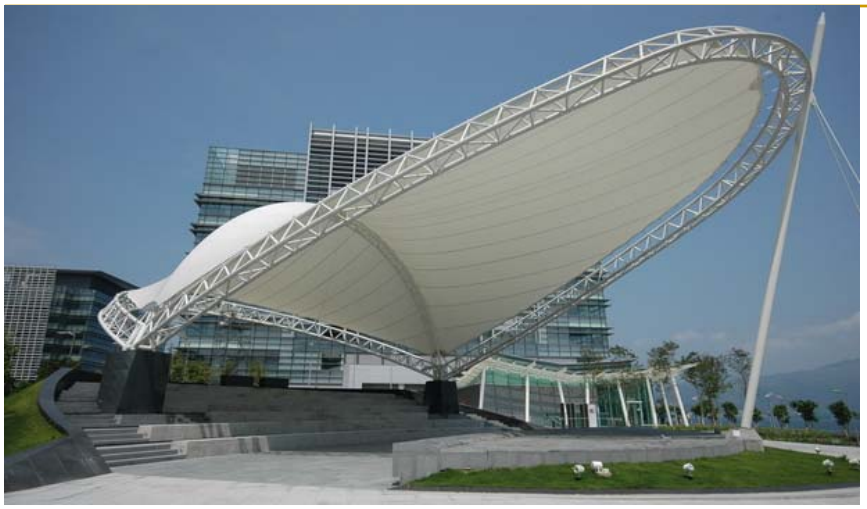


Roof constructed in steel space-frame

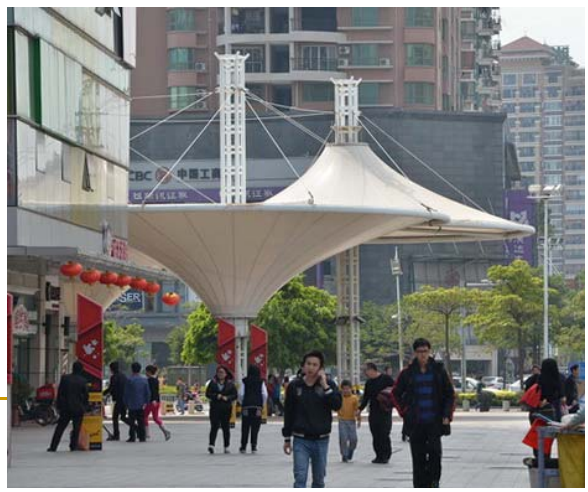
Roof constructed in simple steel truss

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