Metal Structures II

Lecture V

Long span structures

Contents

Introduction

Photo: syrek.com.pl

Photo: tatasteeleurope.com

Distance between supports for office buldings is about 10 m.

Photo: metroland.com.au

Distance between supports for industry halls reachs 40-50.

Photo: ocmer.com.p

Photo: traskostal.pl

Photo: holland.com

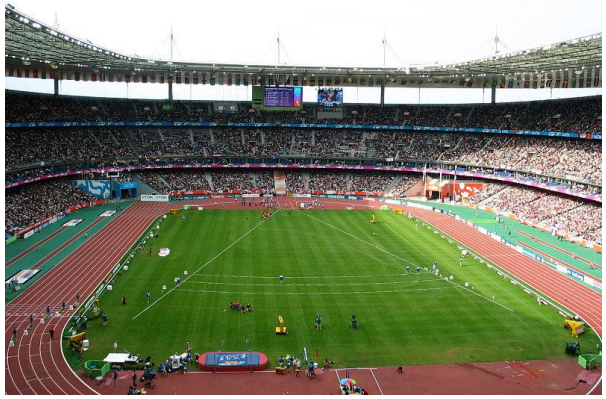


Photo: wikipedia

But sometimes we need more than 100 meters between supports for roofs...

Photo: wikipedia

...and more than 1000 m for other type of structures.

Long span structures in the most often cases are intended for:

- Exhibition hall & exhibition centres
- Sport facilities
- Amusement centres
- Railway stations & airport halls
- Special industrial facilities
- Special transport facilities
- Landmarks
- Bridges



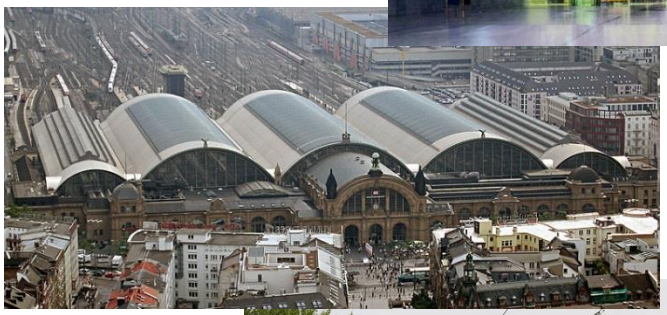
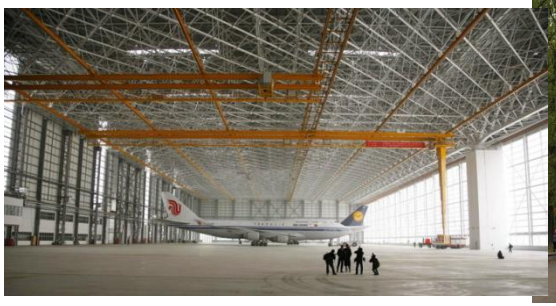





Photo: e-architect.co.uk, ballparkofbaseball.com, wikipedia, glebokie4.pl, rodaxx.com

Steel hall

Hall: repetitive arrangement of flat frames (steel or concrete), interrelated by bracings.

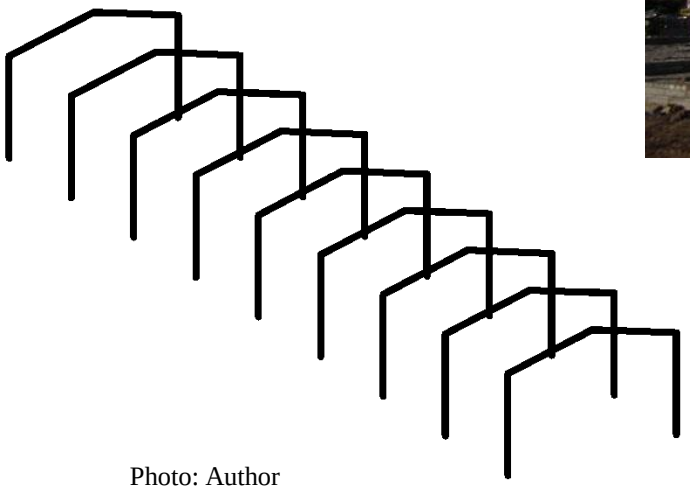


Photo: Author

Photo: shaymurtagh.co.uk

Photo: weldon.pl

Halls: industrial, warehouse, trade, cooler, garage, hangar, office, agricultural, sport, exhibition…

Photo: steel.com.au

Photo: easyhalls.com

Photo: ekbud.lublin.pl

Photo: pebsteel.com

Photo: toiowo.eu

Photo: aviationbuildingsystem.com

Photo: internationalsteelspan.com

Photo: sztuka-architektury.pl

Based on types of loads, there are two possibilities for steel hall:

- "heavy" hall with cranes act on hall structure;
- "light" hall without crane act on hall structure;

Photo: eci.com.pl

Photo: spawstal.pl

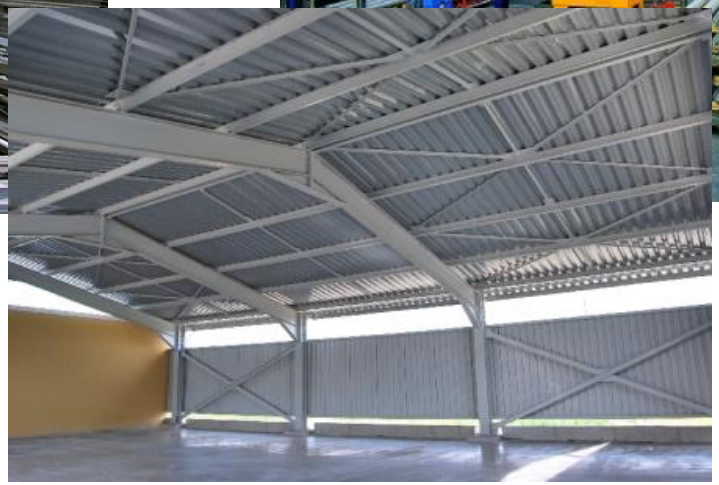


Photo: weldon.pl

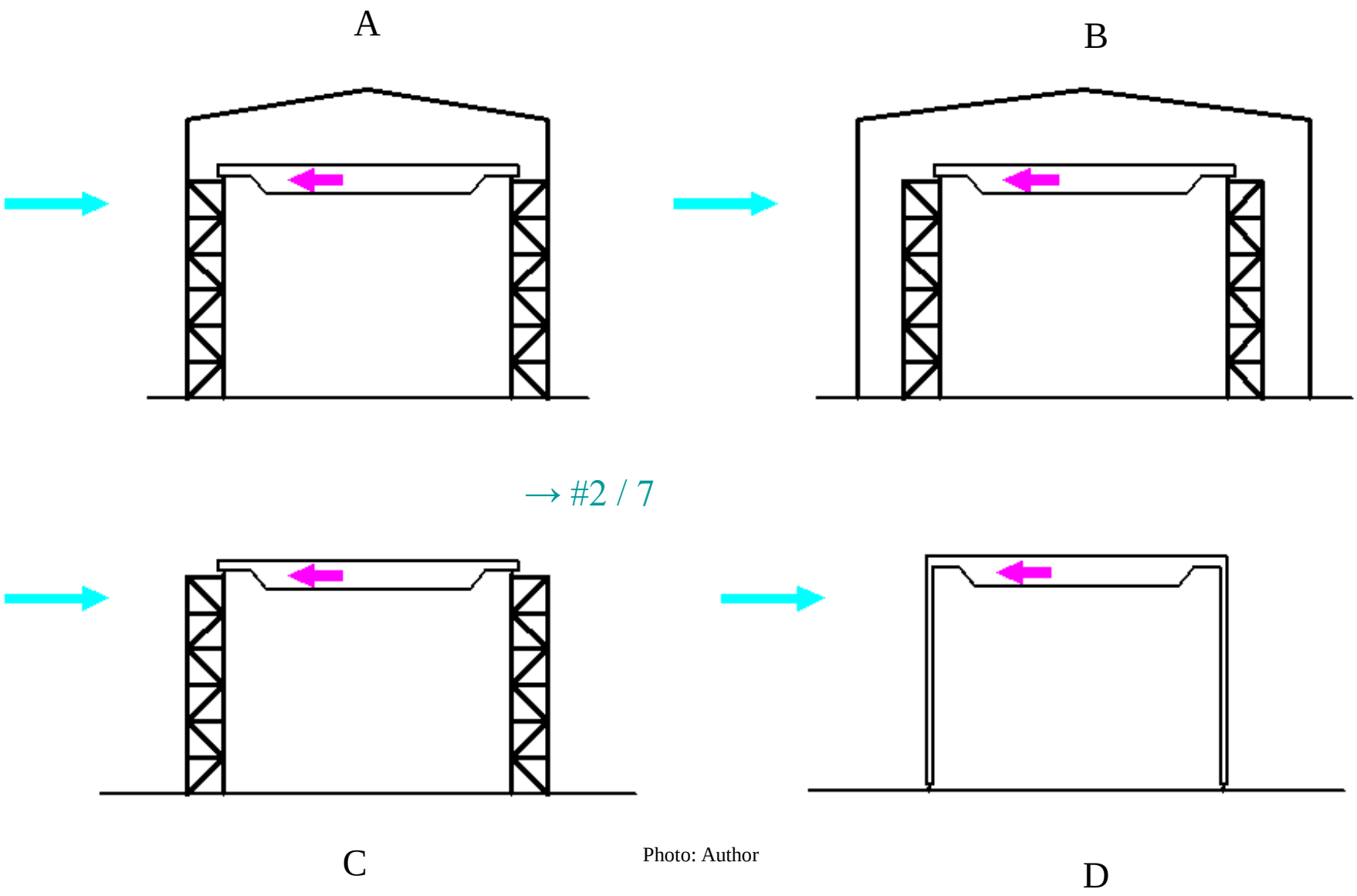


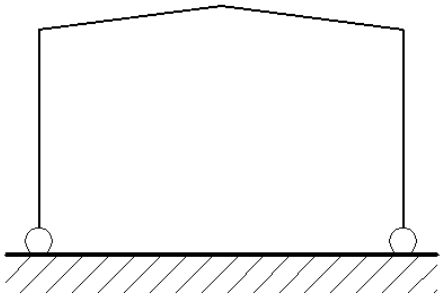
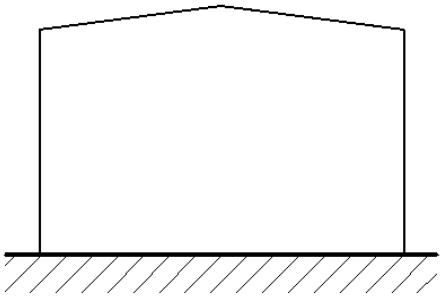
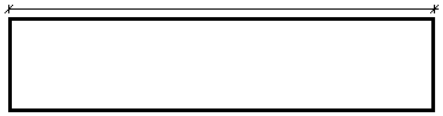
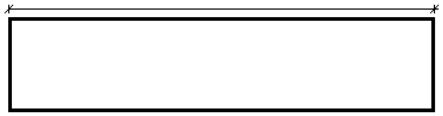
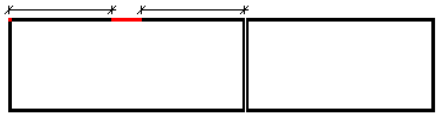
Photo: Author

According to situation A-D, there are three possibilities:

Situation	Type of hall
A	"Heavy"
B	"Light"
C	No hall
D	
Hall without crane	"Light"

General rules

Photo: Author

	"Light" hall	"Heavy" hall
Static scheme		
Max length of building / max distance between dilatations	150 m 	120 m 
Max longitudinal distance between front wall / dilatation and vertical wall bracing	60 m 	

Value of loads

Photo: Author

Width of hall 30,0 m
Longitudinal distance between columns 12,0 m

Vertical loads act on 4 columns on area 30,0 x 12,0 (360,0 m^2):

	"Light" hall	"Heavy" hall
Snow (~ 1,50 kN / m^2)	540 kN	540 kN
Wind (~ 0,60 kN / m^2)	216 kN	216 kN
Roofing (~ 0,15 kN / m^2)	54 kN	54 kN
16x purlins (~ 0,25 kN / m)	230 kN	230 kN
2x roof girders (~ 3,25 kN / m)	195 kN	195 kN
Crane (30 m span) + hoist load		520 – 2035 kN
SUM	**1235 kN**	**1755 – 3270 kN**
Proportion	1,0	1,42 – 2,65

Each structure can be presented as a complex of supermembers. External part for each structure is roofing/housing. For steel hall supermembers can be presentes as follow:

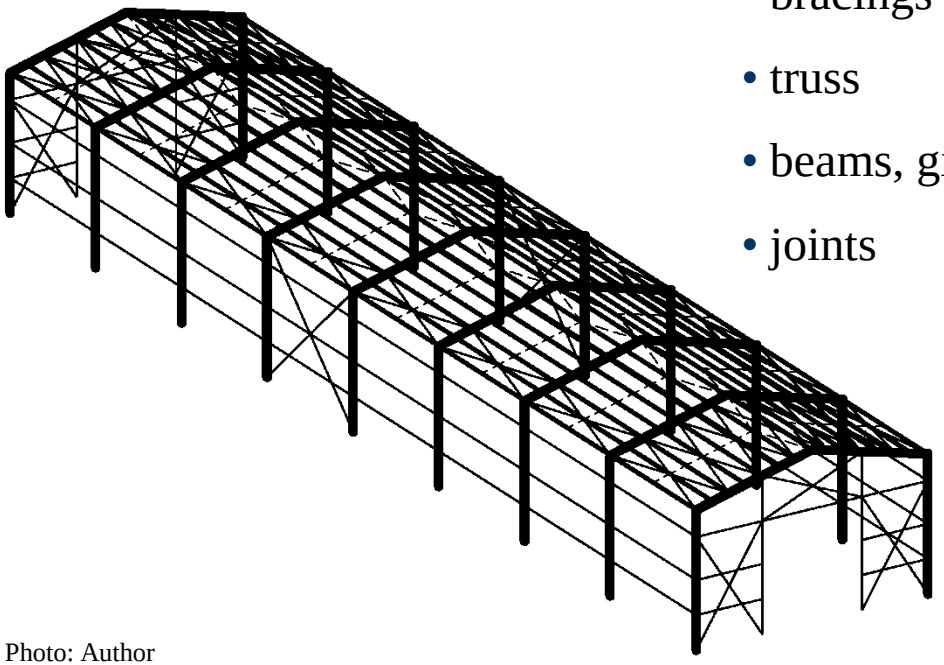
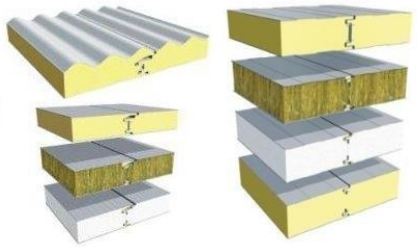
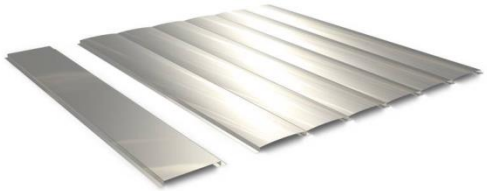
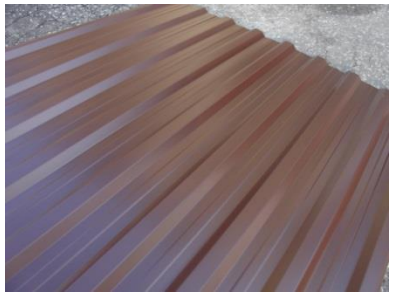


Photo: Author

- roofing and housing
- purlins
- wall girts
- bracings
- truss
- beams, girders, columns
- joints

Roofing / housing	Thermal isolation	Factory-made connecting latch	Anti-buckling protection for purlins according to EN
 Photo: steelprofil.pl	☺	☺	☹
 Photo: pruszynski.com.pl	☹	☺	☹
 Photo: amarodachy.pl	☹	☹	☺ (per 5 - 10 years from erection)

Skylights

(not always)

Photo: globalprayers.info

Photo: euroexport.pl

Photo: euroexport.pl

System solutions

Recommended types of purlins for different length of span (distance betwen supports)

Length	Continous, cold-formed	Continous, suspended cold formed	One-span hot-rolled	Castellated	Truss
< 3					
3 – 4					
4 – 6					
6 – 8					
8 – 9					
9 – 12					
12 – 18					

Roof bracings, most often used types

"Heavy" hall - roof girders

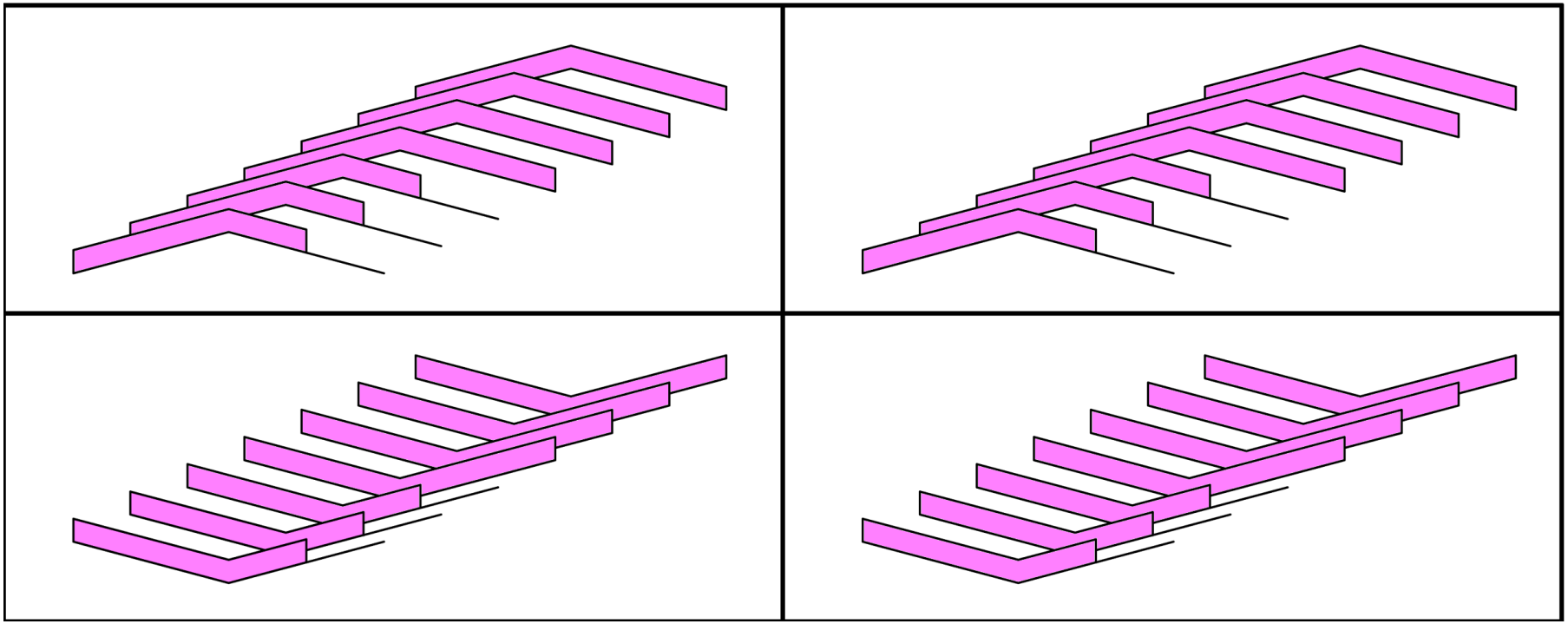


Photo: Author

"Light" hall - roof girders

"Heavy" hall - horizontal upper transversal bracings

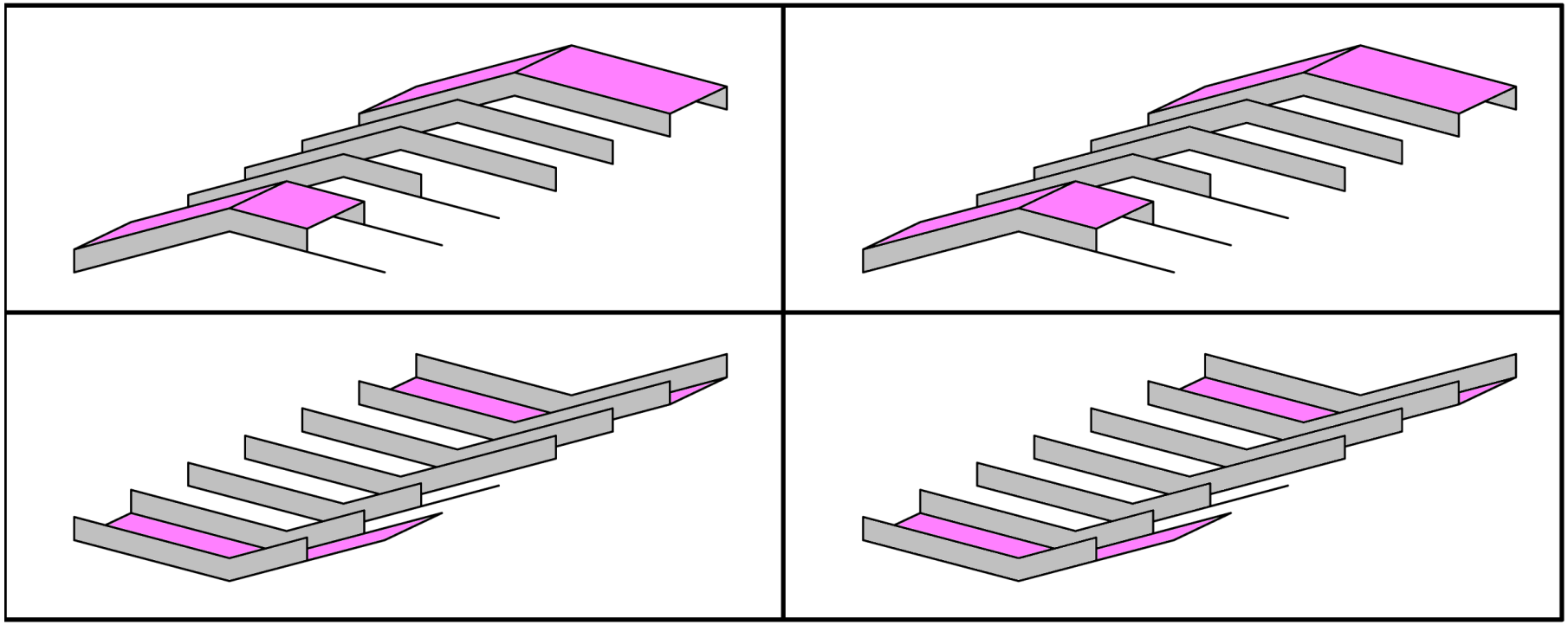


Photo: Author

"Light" hall - horizontal upper transversal bracings

"Heavy" hall - vertical longitudinal bracings

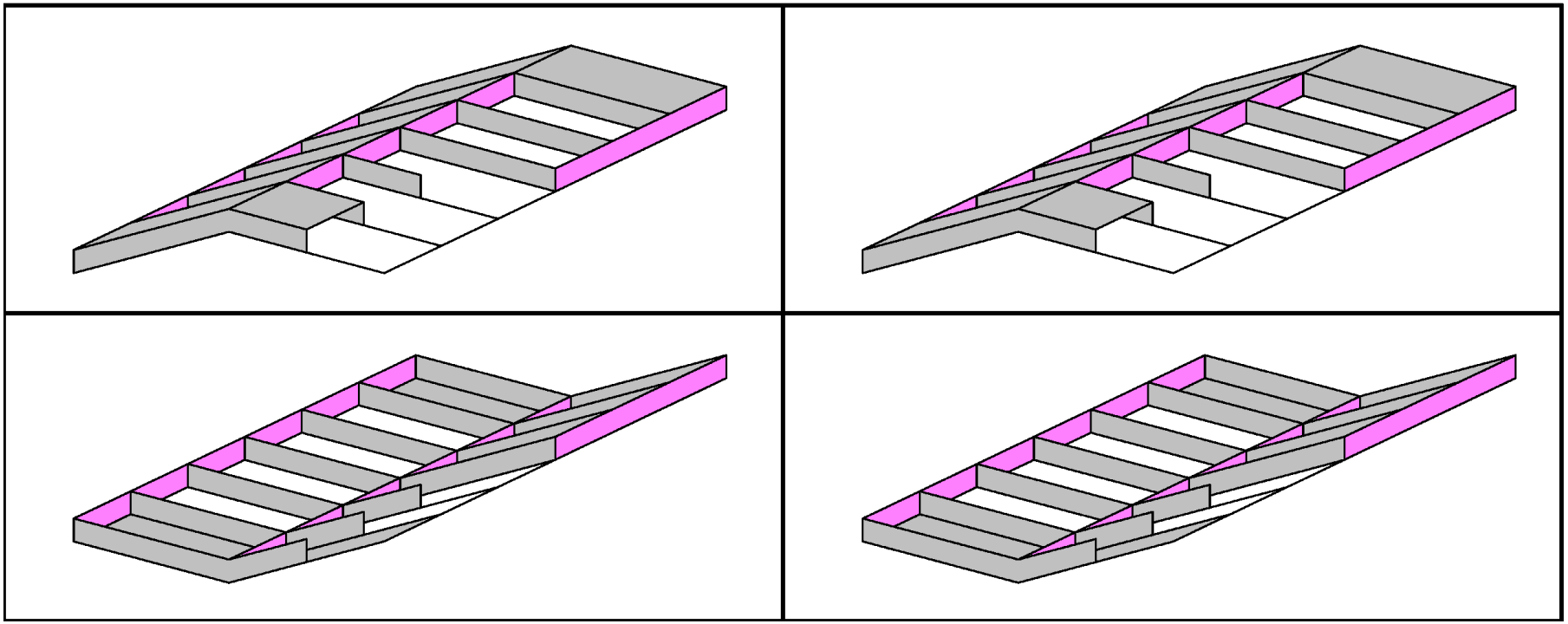


Photo: Author

"Light" hall - vertical longitudinal bracings

"Heavy" hall - horizontal upper longitudinal bracings

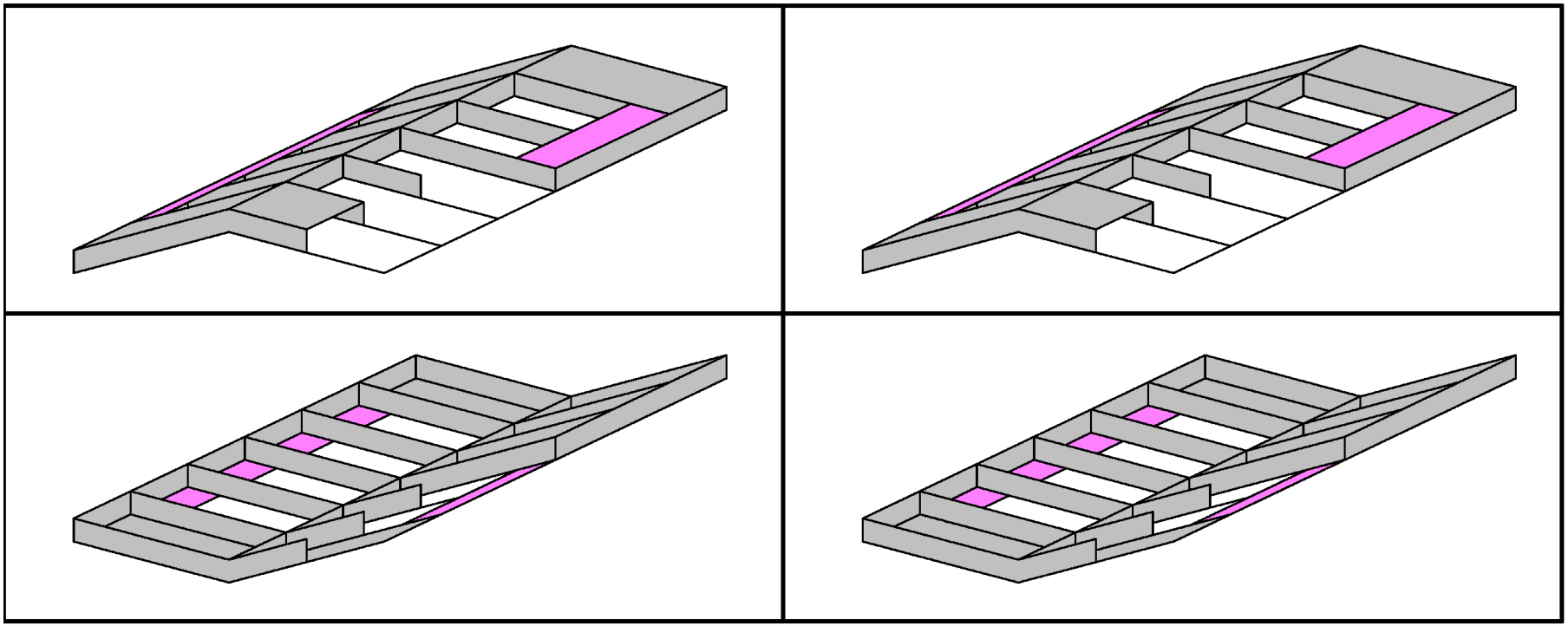


Photo: Author

"Light" hall - horizontal upper longitudinal bracings (not always)

"Heavy" hall - horizontal lower transversal bracings

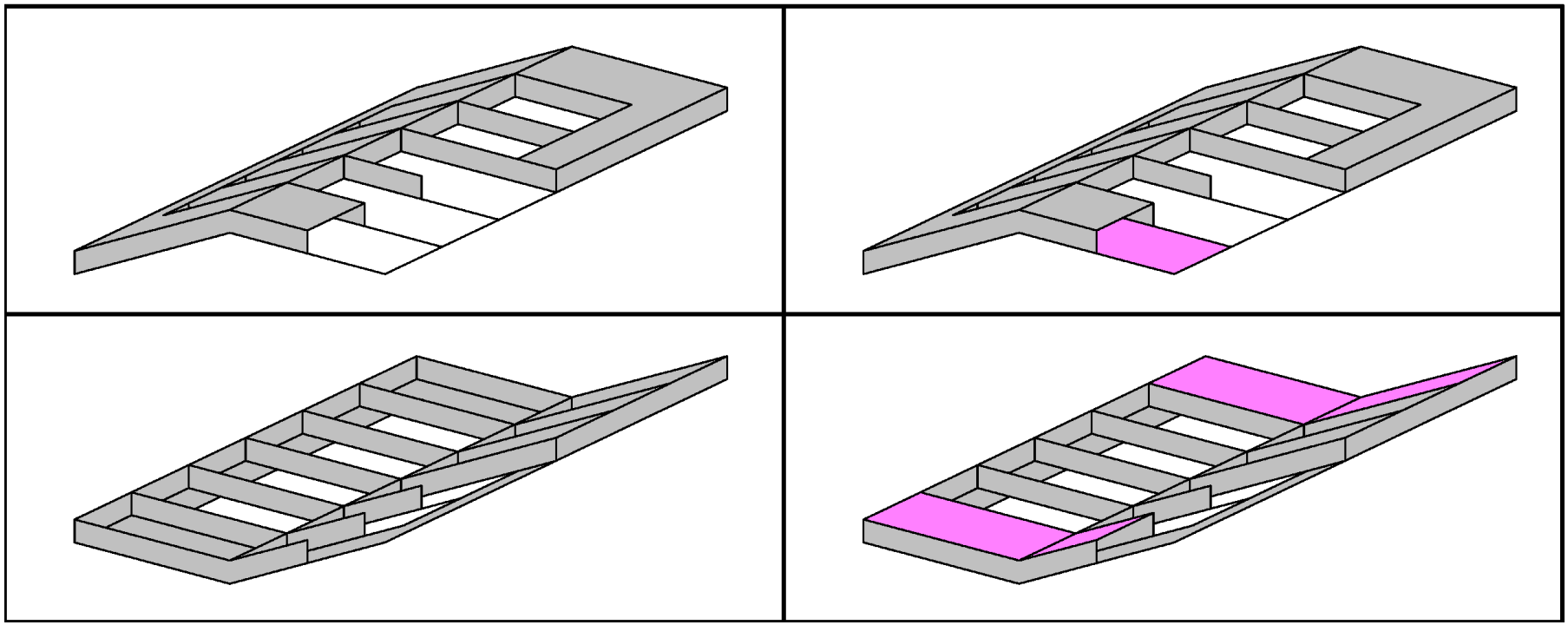


Photo: Author

"Light" hall - no horizontal lower transversal bracings

"Heavy" hall - horizontal lower longitudinal bracings

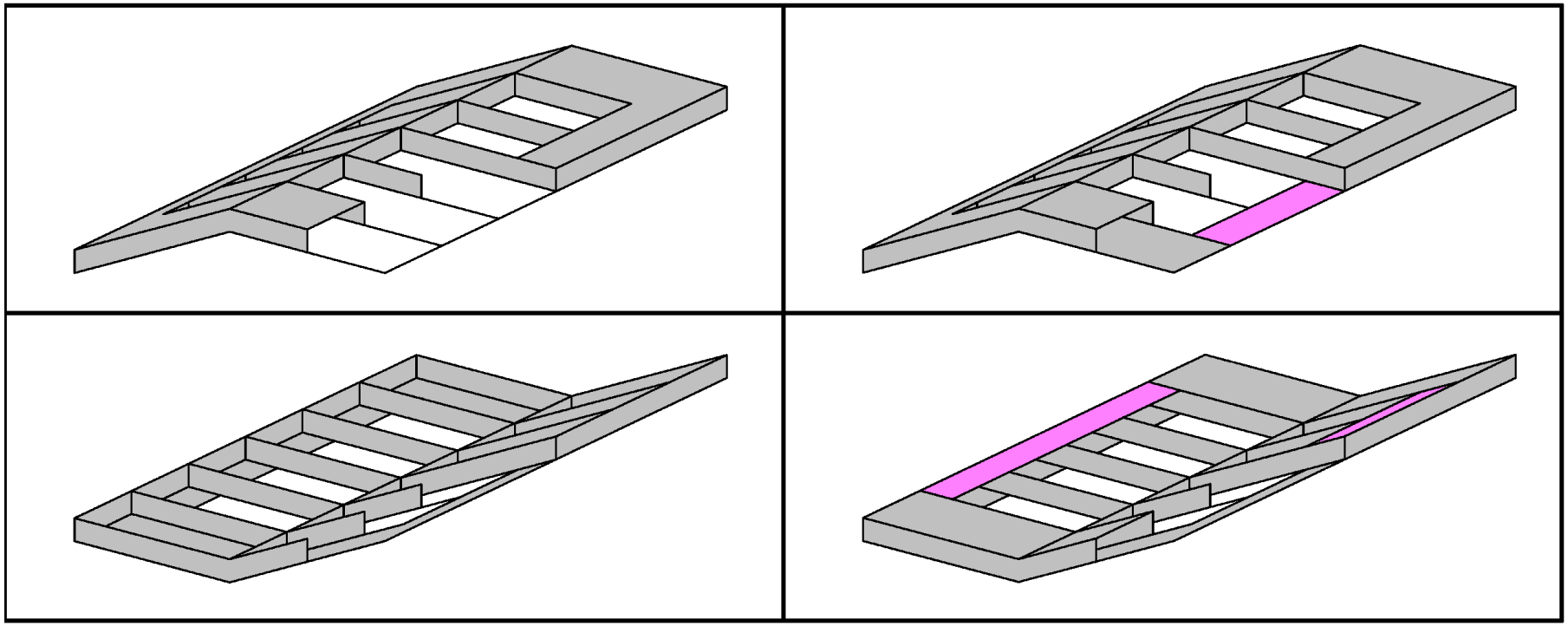


Photo: Author

"Light" hall - no horizontal lower longitudinal bracings

"Heavy" hall, wall bracing - top part of column

For halls with cranes;

Under transverse roof bracings;

Transmission of loads from top part of wall (wind on front wall, prevention of girder buckling and crane loads) to bases;

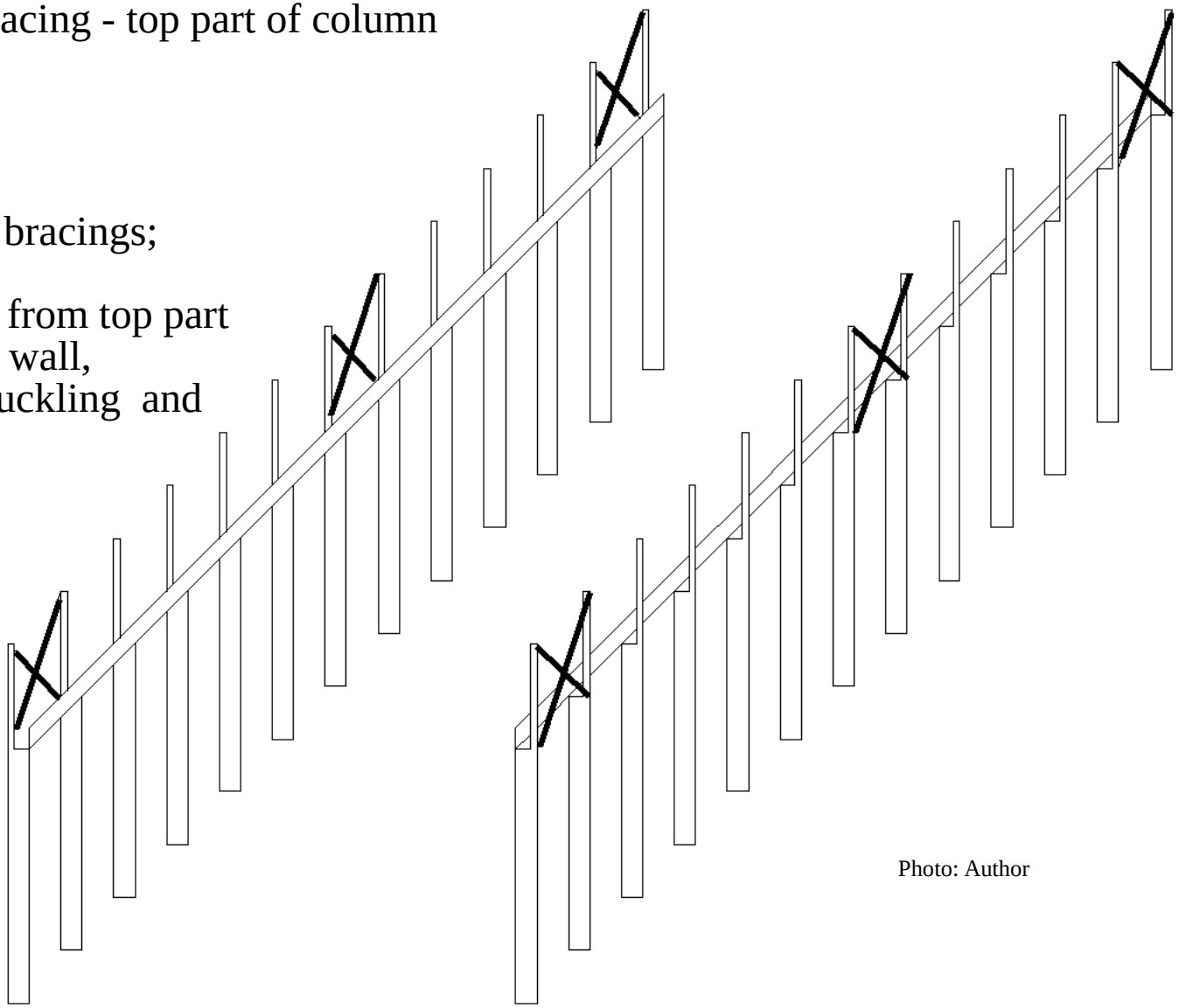


Photo: Author

"Heavy" hall, wall bracing - bottom part of column

For each types of halls;

Under transverse roof bracings in central part of hall between expansion joints;

Transmission of loads from wall (wind on front wall, prevention of girder buckling and crane loads, imperfections of columns) to bases;

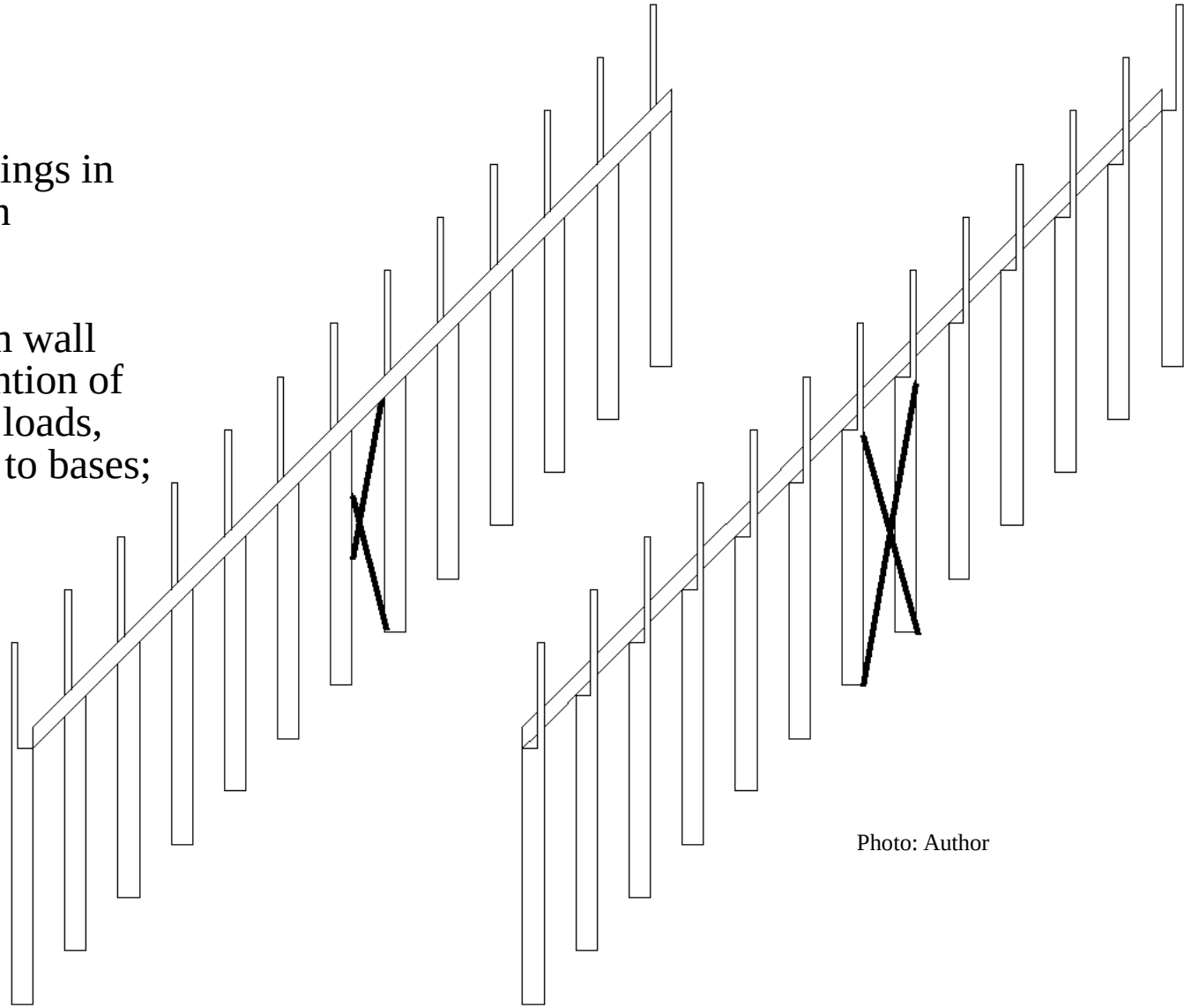


Photo: Author

"Light" hall, wall bracing - only one part of column

For each types of halls;

Under transverse roof bracings in central part of hall between expansion joints;

Transmission of loads from wall (wind on front wall, prevention of girder buckling, imperfections of columns) to bases;

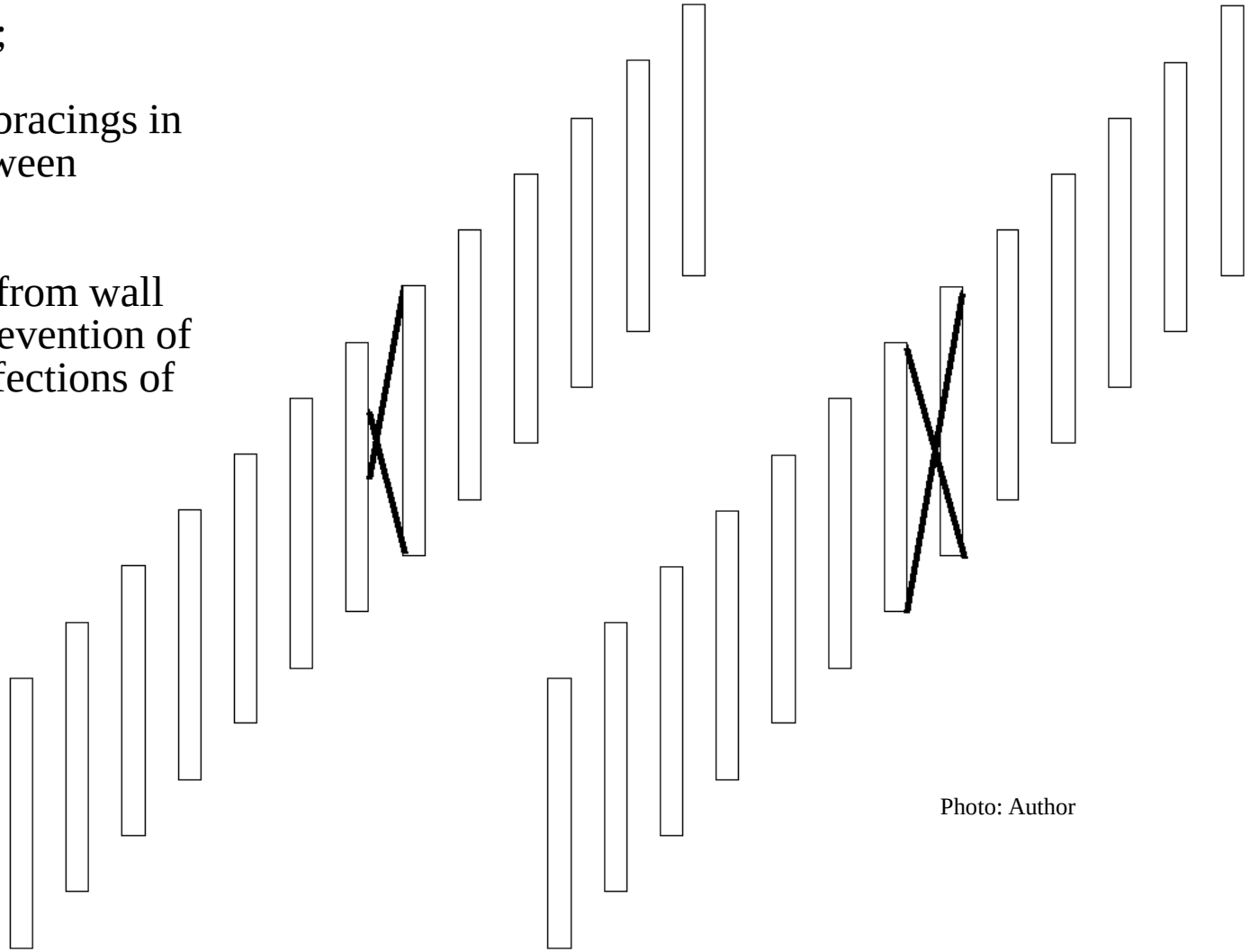


Photo: Author

Frames

Photo: ubcoholdings.com

L < 25 - 30 m → hot rolled I-beam IP

L > 25 - 30 m → welded I-beam IK

L > 40 - 45 m → roof girder: welded I-beam IK or truss

"Heavy" hall; additional elements for run-beams:

Photo: lindab.com/

Hangers (monorail hoist block, overhead underslung crane)

Photo: udhavind.com

Cantilevers (top-mounted crane)

"Heavy" hall; columns:

Photo: stabud.eu

Massive welded I-beams

Laced

Photo: pebsteel.com

Battened

Photo: hak.com.pl

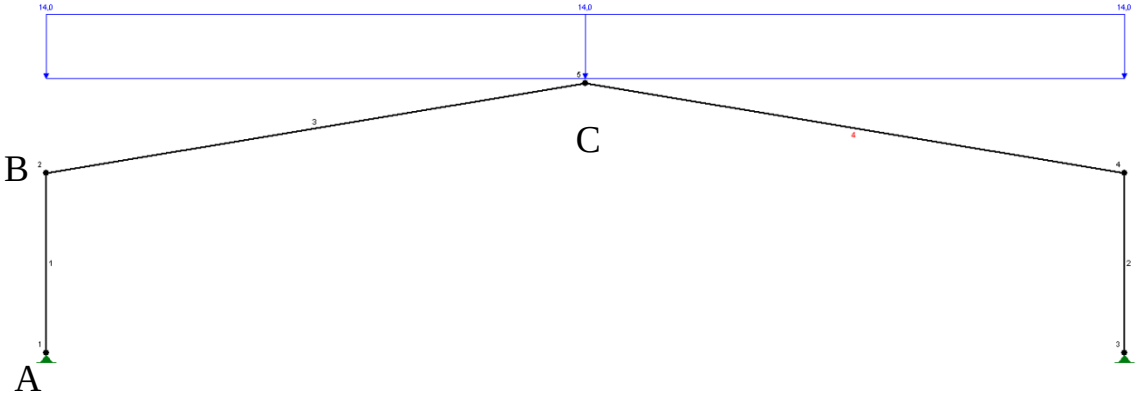
Tied portal frame

Enormous reduction of bending moments in roof girders and columns, enoromus tensile force in tie-beams

Photo: lindab.com

Portal frame vs. tied portal frame

Two frames, span 2 x 15,00 m, height 5,00 + 2,50 m, continous load 14 kN / m:



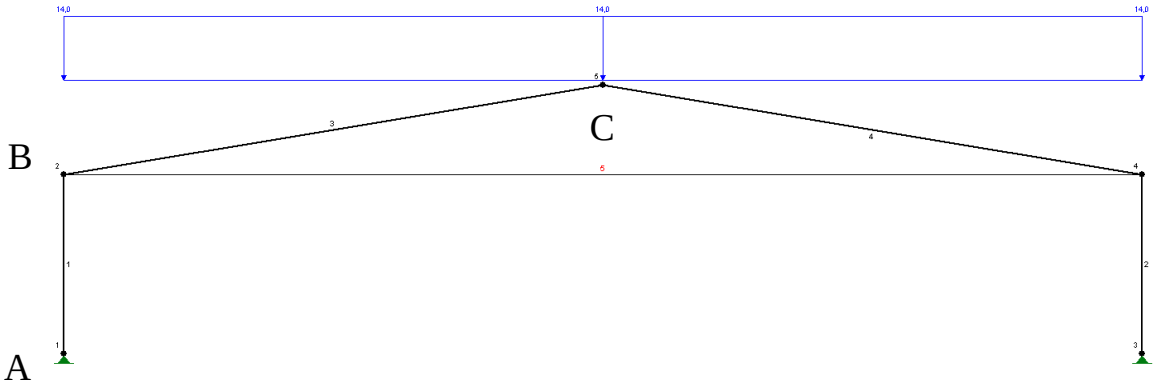


Photo: Author

Member	Point	Portal frame			Tied portal frame		
		M_{Ed} [kNm]	V_{Ed} [kN]	N_{Ed} [kN]	M_{Ed} [kNm]	V_{Ed} [kN]	N_{Ed} [kN]
Roof girder	C	375,8	28,4	170,2	271,1 (0,721)	112,0 (3,944)	708,6 (4,163)
	$M_{opposite}$	403,6			163,2 (0,404)		
	B	862,6	191,2	206,8	237,7 (0,276)	107,6 (0,563)	672,0 (3,250)
Column	B	862,6	172,5	222,6	237,7 (0,276)	47,5 (0,275)	222,6 (1,000)
	A	0,0	172,5	226,8	0,0	47,5 (0,275)	226,8 (1,000)
Tie beam	C						- 633,7

"Light" hall vs. "heavy" hall

Aspect	„Light” hall	„Heavy” hall
Conseqence class	The most often CC2.	Industry hall, for example arms industry → possibility of economic, social or environmental consequences very heavy → CC2 or CC3.
Roofing and housing	Each types of roofing can be applied.	For "heavy" halls we rather not take into consideration anty-buckling protection for purlins by corrugated sheet.
Skylight	• There is no special difference between both types of halls for applying of skyligths; • We need additional vertical bracings in roof, under edges of skylights.	
Purlins	Each types of purlins can be applied.	Cold-formed purlins are not recommended for "heavy" halls; especially for purlins cooperating with roof bracings.

Aspect	„Light” hall	„Heavy” hall
Wall girts	There is no special difference between both types of halls for applying of girts.	
Roof bracings	Only „simple” complex of bracings.	Full complex of bracings.
Wall bracings	One part of column.	Top and bottom part of colum.
Main frame	Hot-rolled & welded cross-sections, tied frame and truss roof girders.	• Hot-rolled & welded cross-sections and truss roof girders; • Tied frame are not recommended; • Additional elements for suspension / support of run-beams • Columns much more massive (battened, laced, welded).
Column support	Hinge.	Rigid.
Bolted joint	Static type of actions → bolted joints cathegory A, B, D.	Often dynamic type of actions → bolted joints cathegory C, E.

An important aspect are specific types of snow and wind loading the hall roofs:

Multi-bay hall → multi-span roof

Photo: bryla.pl

Eaves over warehuse ramps

Photo: bestor.com.pl

Skylights, air-condition, solar thermal collectors, smoke installations, supporting structure for advertising, attics, different height of building parts...

Photo: krajewski-konstrukcje.pl

Each of these elements change value of snow loads (drifting) and wind actions

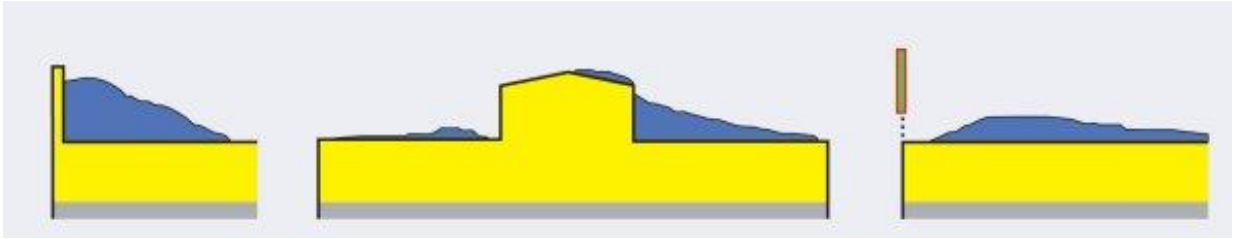


Photo: inzynierbudownictwa.pl

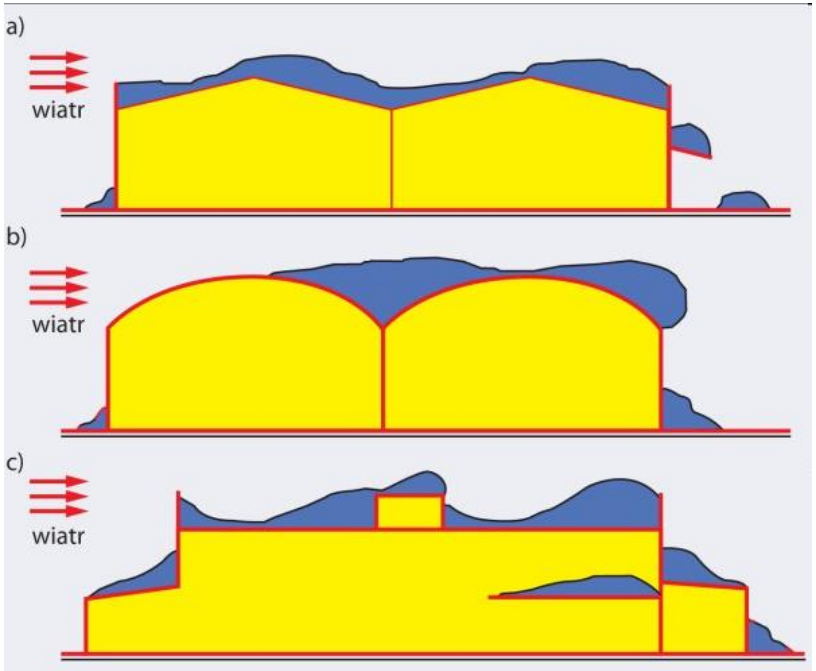
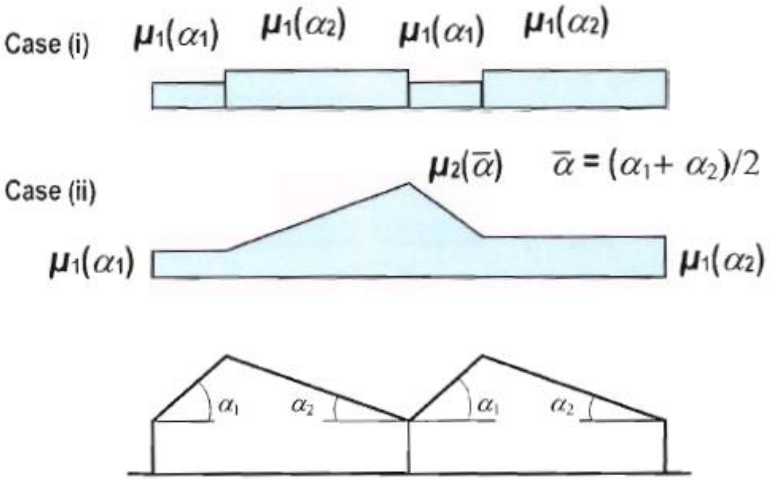


Photo: inzynierbudownictwa.pl

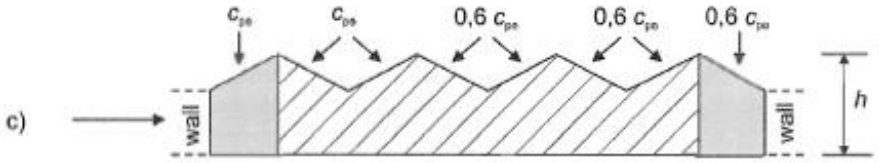
Photo: izolacje.com.pl

Multi-span roof



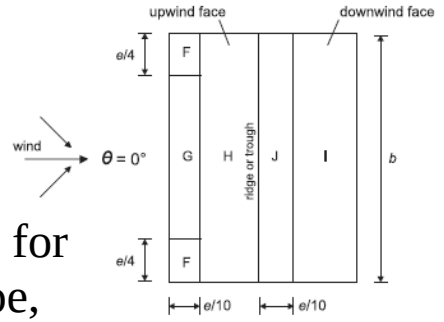
Snow

Photo: EN 1991-1-3 fig. 5.4



Wind

EN 1991-1-7 fig. 7.10

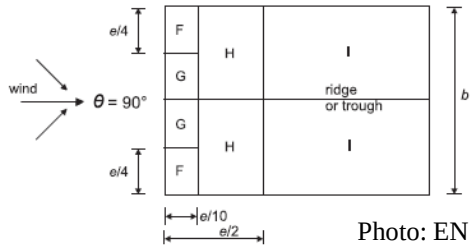


(b) wind direction $\theta = 0°$

$e = b$ or $2h$ whichever is smaller

b : crosswind dimension

"Prependicular" wind - the same for first, second and third roof slope, 60% for next.



(c) wind direction $\theta = 90°$

"Parallel" wind - no difference fc one-span and multi-span roof

Photo: EN 1991-1-4 fig. 7.7

Snow - attic, skylight, different height, additional elements

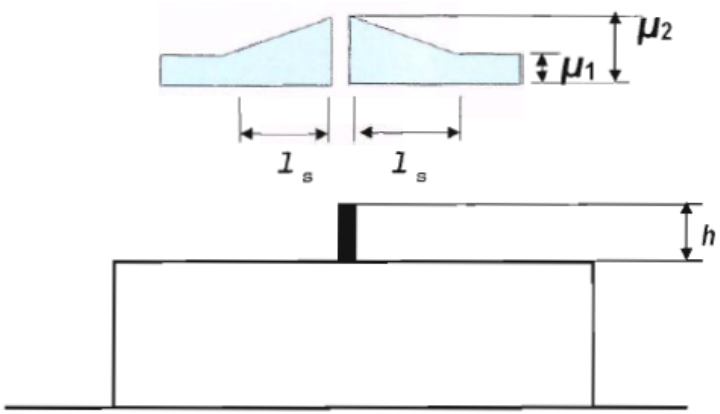


Photo: EN 1991-1-3 fig. 6.1

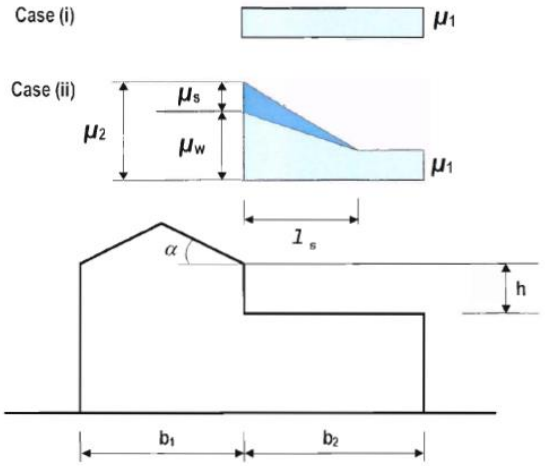
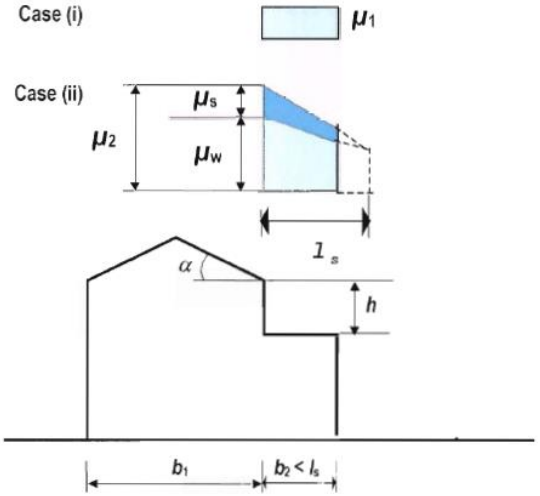
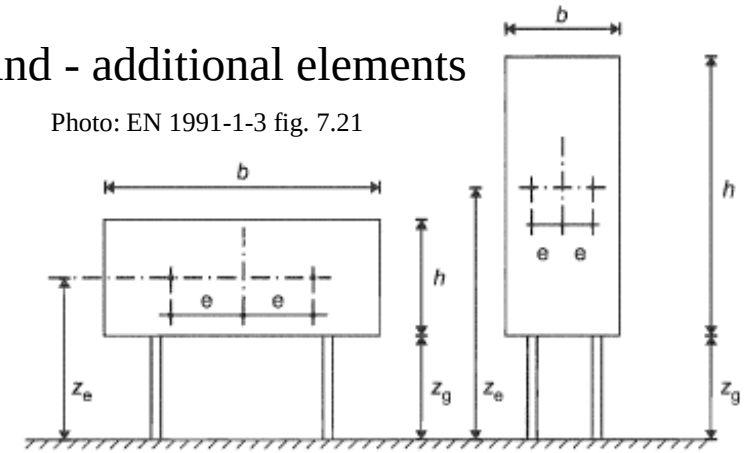


Photo: EN 1991-1-3 fig. 5.7



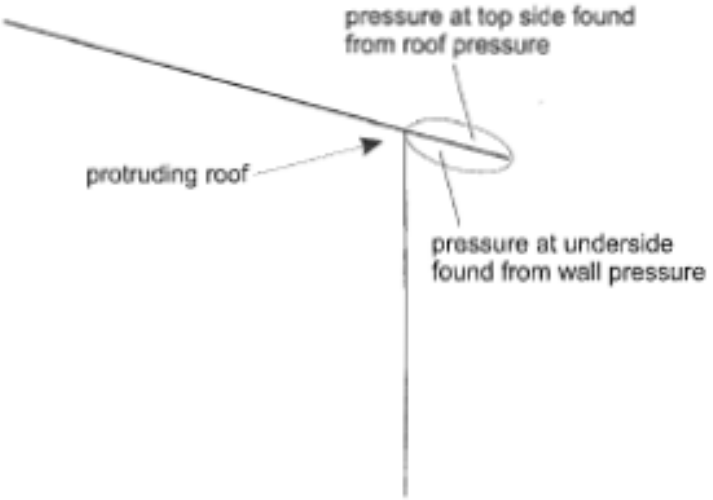
Wind - additional elements

Photo: EN 1991-1-3 fig. 7.21



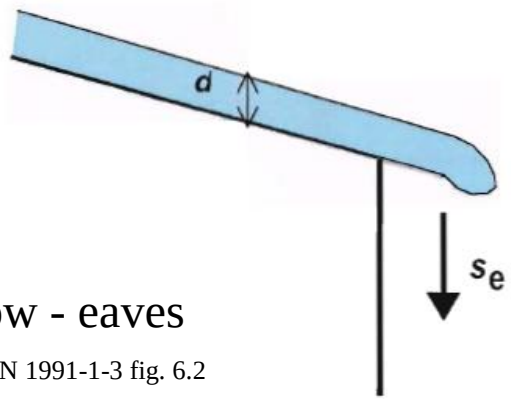
NOTE 1 reference height: $z_e = z_g + h/2$

NOTE 2 reference area: $A_{ref} = b \cdot h$



Wind - attic and eaves

Photo: EN 1991-1-3 fig. 7.3



Snow - eaves

Photo: EN 1991-1-3 fig. 6.2

Long span structures

Lec #6

Advanced

Complex

Simple

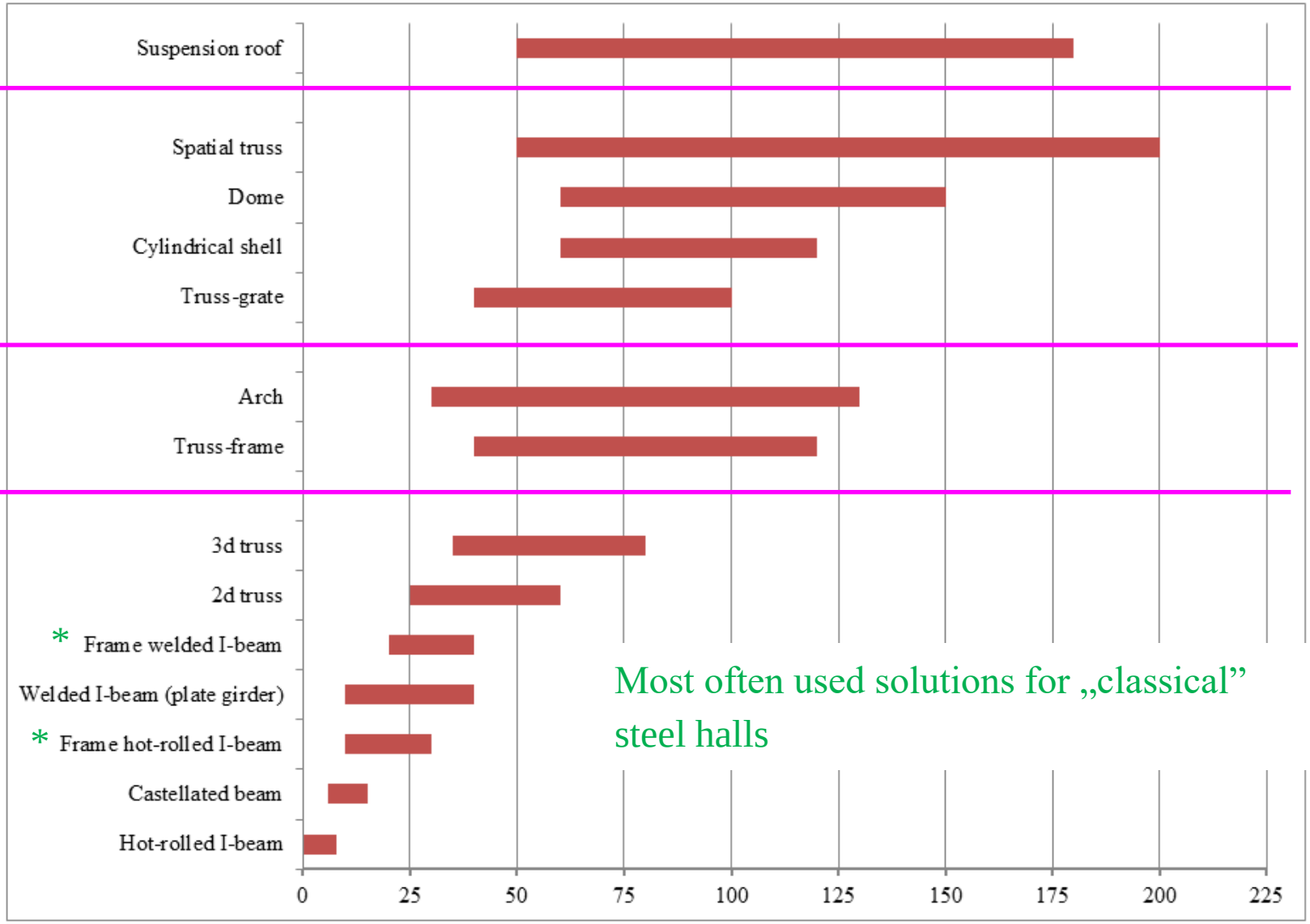
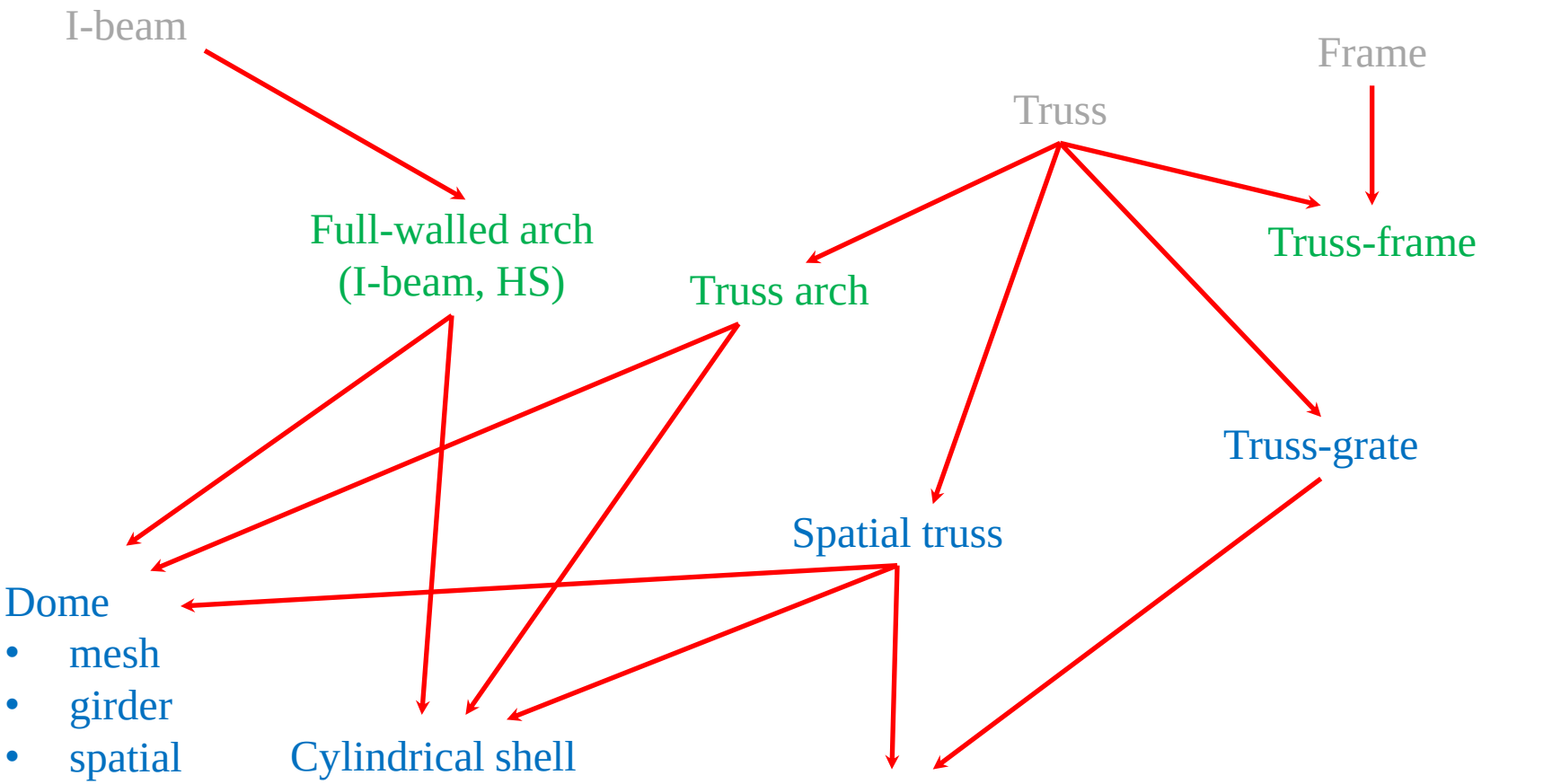


Photo: Author

Recommended length for different types of long span structures.

Simple, complex and advanced



One span I-beam

h = L (1/20 ~ 1/25)

Photo: Author

Requirements:

$V_{Ed} / V_{Rd} \leq 1,0$

$M_{Ed} / M_{Rd} \leq 1,0$

$f / f_{sls} \leq 1,0$

$$V_{Ed} / V_{Rd} \leq 1,0 \rightarrow (q\,L / 2) / (A_V\,f_y / \sqrt{3}) = L\,[q\,A_V\,f_y / (2\,\sqrt{3})] = L\,a$$

$$L\,a \leq 1,0$$

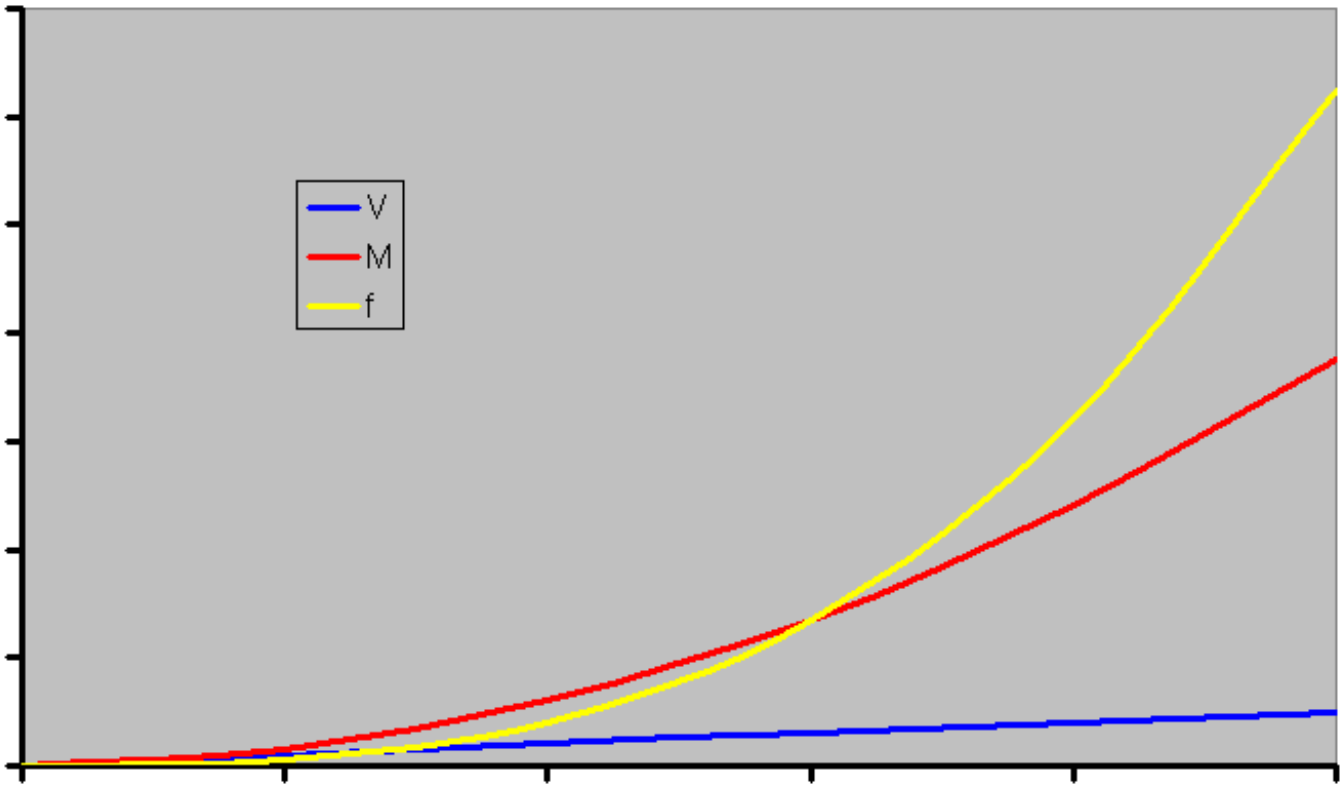
$$M_{Ed} / M_{Rd} \leq 1,0 \rightarrow (q\,L^2 / 8) / (W\,f_y) = L^2\,[q / (8\,W\,f_y)] = L^2\,b$$

$$L^2\,b \leq 1,0$$

$$f / f_{sls} \leq 1,0 \rightarrow [5\,q\,L^4 / (384\,E\,J)] / (L / \alpha) = (L^4 / L)\,[5\,q\,\alpha / (384\,E\,J)] = L^3\,c$$

$$L^3\,c \leq 1,0$$

Photo: Author



Regardless values of a, b, c,

- for very short elements the most important is condition for V_{ed};
- for medium length of elements the most important is condition for M_{ed};
- for long elements elements the most important is condition for f;

Generally, condition for V_{ed} is important for very short caltilevers only.

Photo: udhavind.com

$L = 0 \sim 6$ m $\rightarrow$ more important is condition $M_{Ed} / M_{Rd} \leq 1{,}0$

$L \geq \sim 6$ m $\rightarrow$ more important is condition $f / f_{sls} \leq 1{,}0$

One span castellated beam

h_{start} = L (1/20 ~ 1/25)

Photo: gunungsteel.com

Dead weight (I-beam) ≈ dead weight (castellated)

J (castellated) >> J (I-beam)

Photo: Author

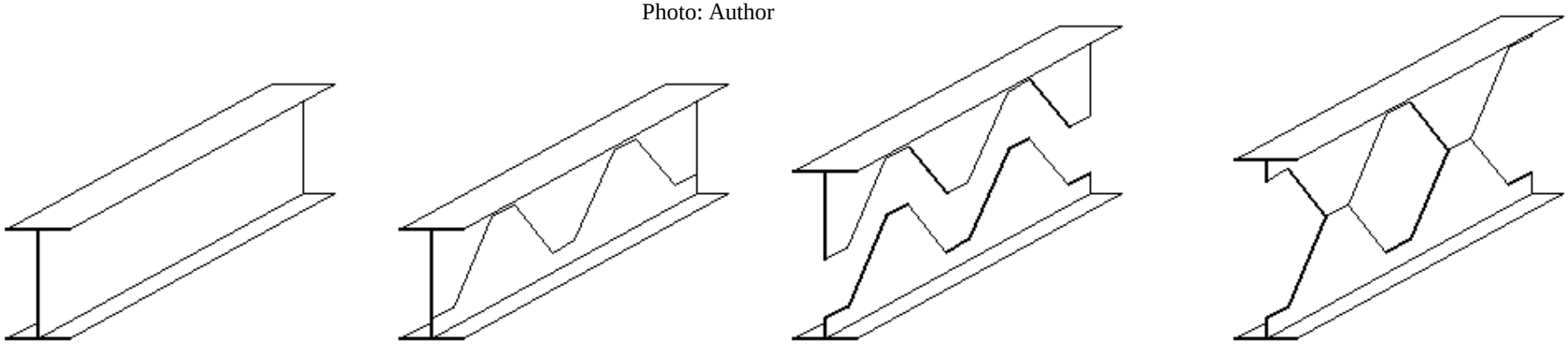


Photo: weldingweb.com

Plate girder

h = L (1/10 ~ 1/16)

IPE, HE, HL - constant dimensions of cross-section
Plate girder - the possibility to change dimensions of cross-section

Maximum high:
IPE 750: 753 - 770 mm
HE 1000: 970 - 1055 mm
HL 1100: 1090 - 1118 mm
...
Plate girder - no limit

Photo: r4engineers.com

Truss (2D)

$h = L\ (1/10 \sim 1/15)$

Photo: doubletreestructures.com

Photo: waldenstructures.com

Truss (3D) = multi-chords truss

Photo: steelconstruction.info

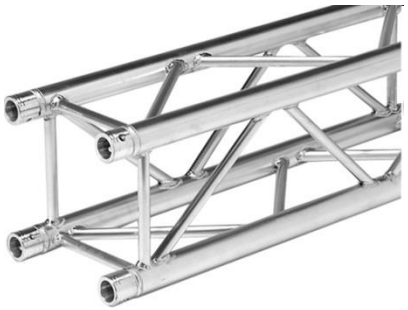


Photo: conference-truss-hire.co.uk

Photo: multimetalgb.ca

Frame (hot-rolled I-beam)

h = L (1/40 ~ 1/50)

Photo: setrometalgroup.com

Frame (welded I-beam)

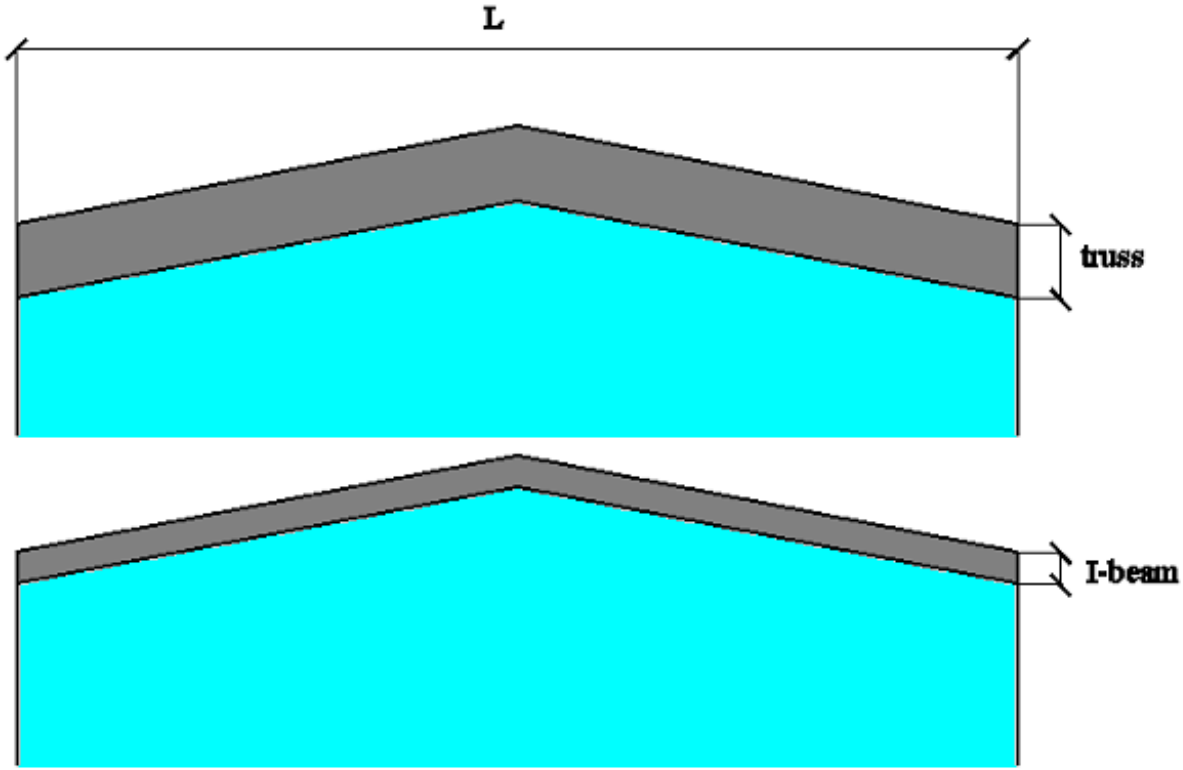
h = L (1/30 ~ 1/40)

Photo: traskostal.pl

Frame (I-beam) ↔ truss → economy

Photo: doubletreestructures.com

Photo: traskostal.pl



$H_{truss} = L\ (1/10 \sim 1/15)$

$H_{frame} = L\ (1/40 \sim 1/50)$

$H_{frame} << H_{truss}$

There is more usefull space for frame structure than for truss structure.

Photo: Author

Arch

f = L (1/1 ~ 1/80)

Photo: lusas.com

Photo: dziennikpolski24.pl

Reactions:

Arch ↔ Arch + tie-beam

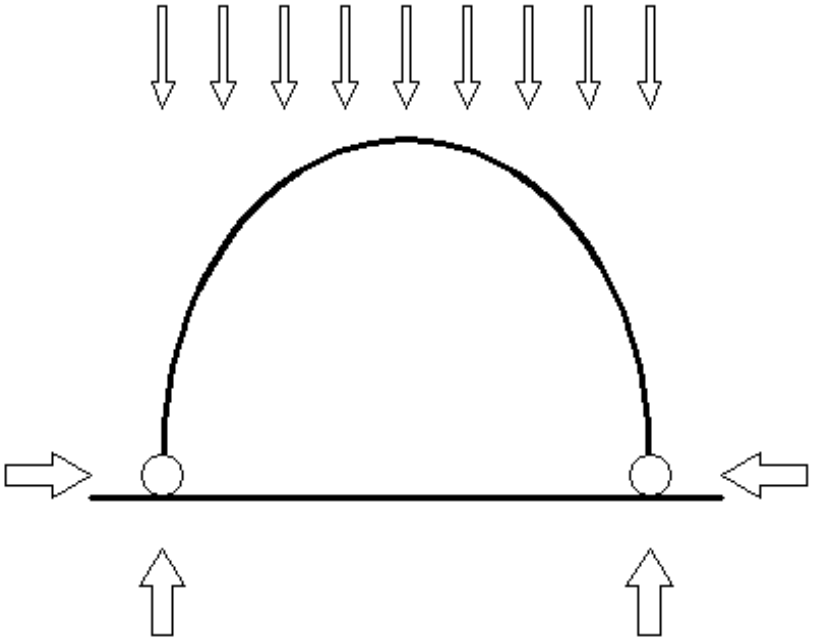
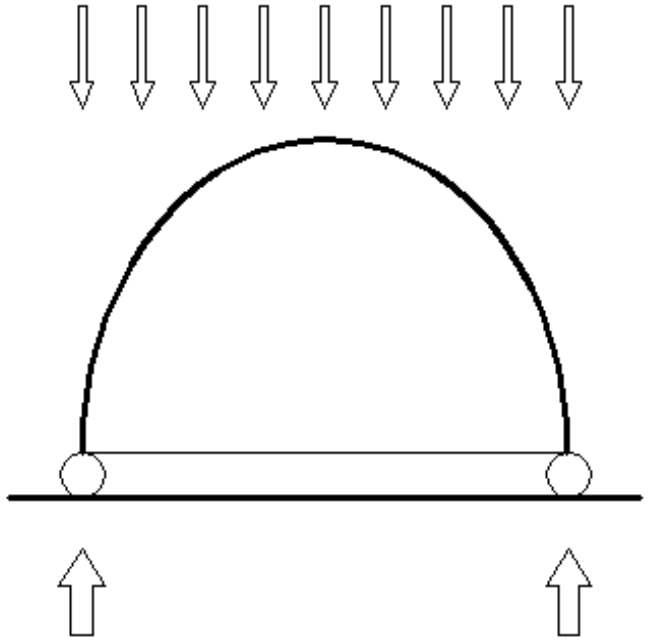


Photo: Author



Frame-truss

Idea of „classical” frame, made on truss

h = L (1/12 ~ 1/20)

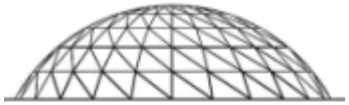
Photo: wikipedia

Mesh structure (net structure)

Bar structure; curved surface formed from triangular arrangement of bars. Cross-section of each bar is generally the same. Stiffness comes from curvature of surface and triangular arrangement.

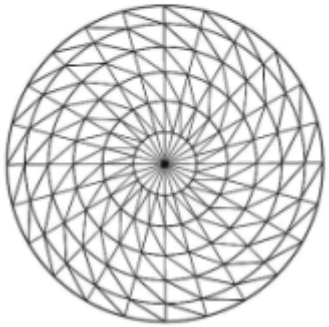
Photo: wellter.com.cn

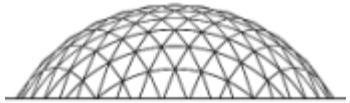
Photo: hindustanalcoxlimited.wordpress.com



Schwedler’s dome - meridional and latitudinal bars, connected by diagonal ones.

Photo: chodor-projekt.net





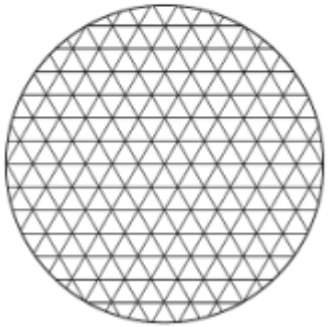


Photo: chodor-projekt.net

Three-way dome - arrangement of bars in three directions, at angles of 60^{o} to each other. When viewed from above, it forms equilateral triangles. In fact, the closer to base, the more triangles differ from each other.
This solution could be applicated to cylindrical shells.

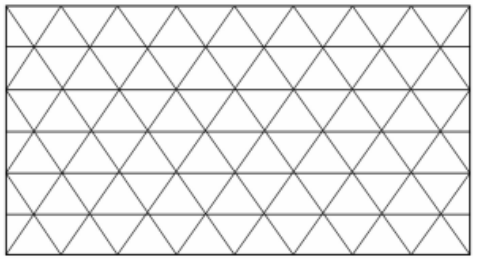


Photo: chodor-projekt.net

Lamella dome (stright or curved) - latitudinal bars (circles) with an arrangement of bars in two other directions (straight or curved bars).

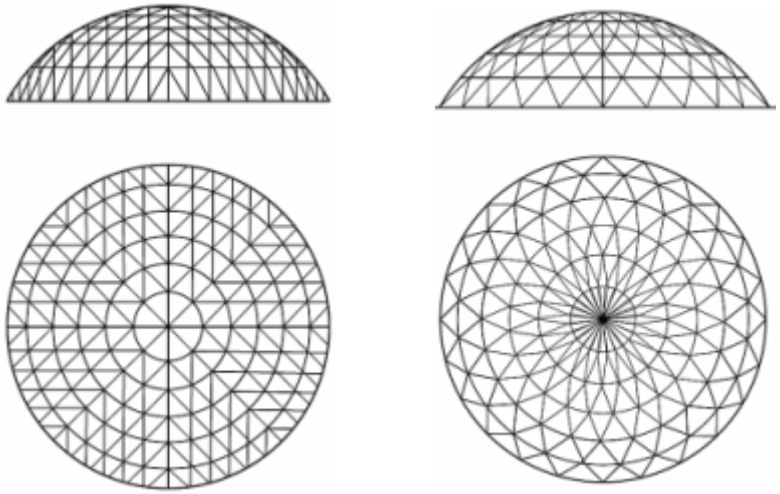


Photo: chodor-projekt.net

Solution also used for cylindrical shells: Lamella (rhombic arrangement) or Lamella-Föppl (triangular arrangement).

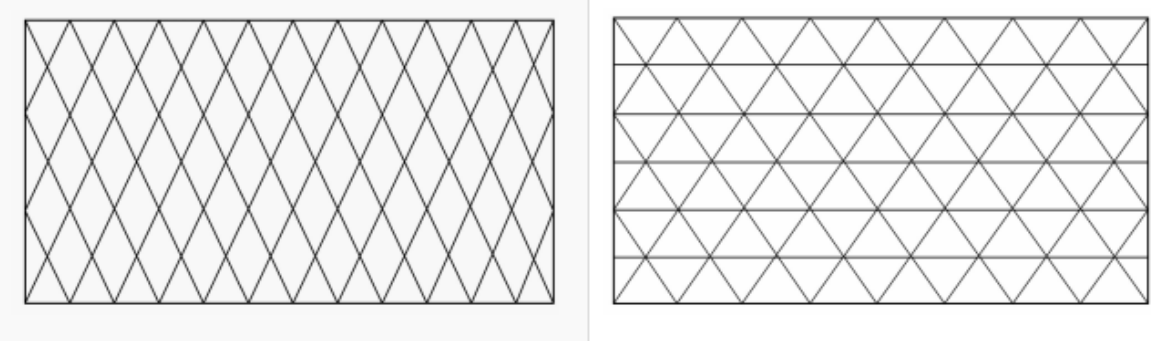
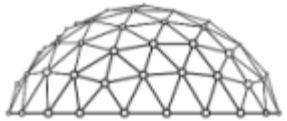


Photo: chodor-projekt.net

Geodesic dome - all triangles forming the mesh are equilateral or almost equilateral.One of the most often applicated solution.



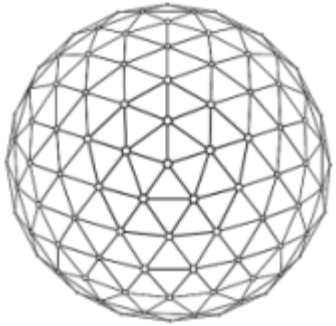


Photo: chodor-projekt.net

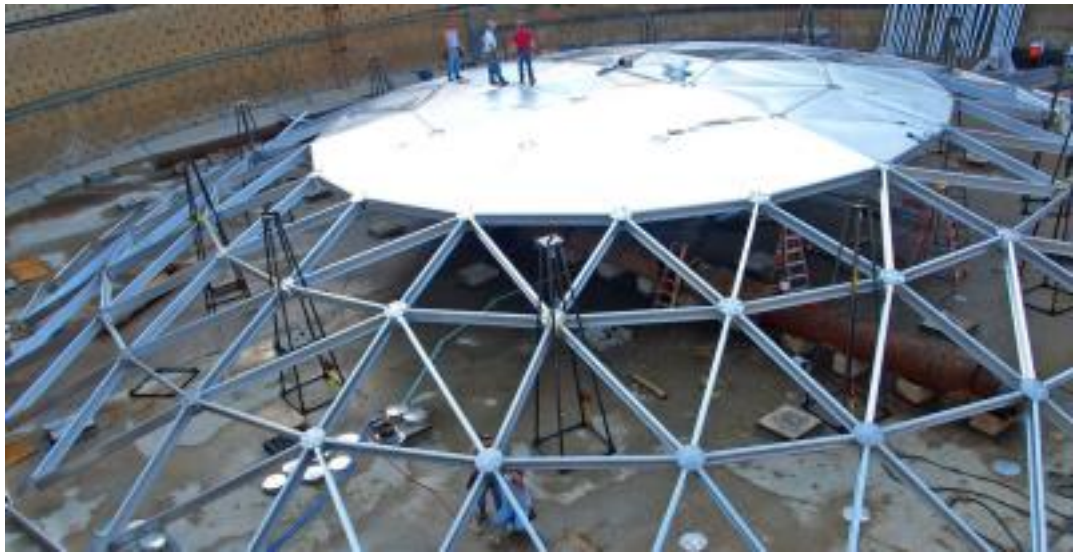


Photo: eeaustin.com

For cylindrical shells, orthogolna systems are applicated: longitudinal and transversal bars connected by diagonal ones.

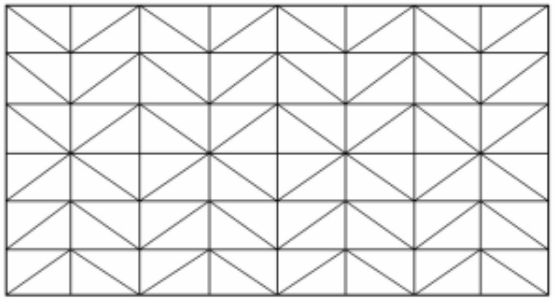


Photo: chodor-projekt.net

Warren sub-type (diagonal bars must be placed in such a way as to avoid compression)

Pratt sub-type

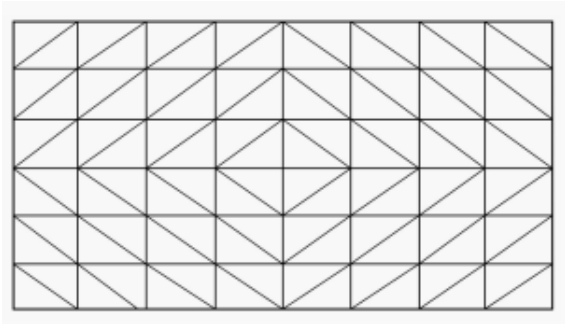


Photo: chodor-projekt.net

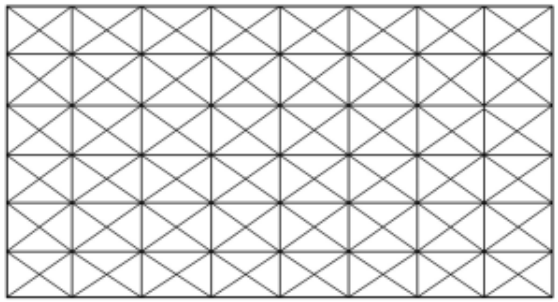


Photo: chodor-projekt.net

X sub-type

Girder structure

Bar structure; main elements are girders (full-walled or trussed), one- or two-way, supplemented by system of secondary beams.

Photo: wikipedia

Photo: wasatchsteel.com

One-way girders, cilindrical shell and dome.

Photo: videohive.net

Girder dome (one-way),
truss arches

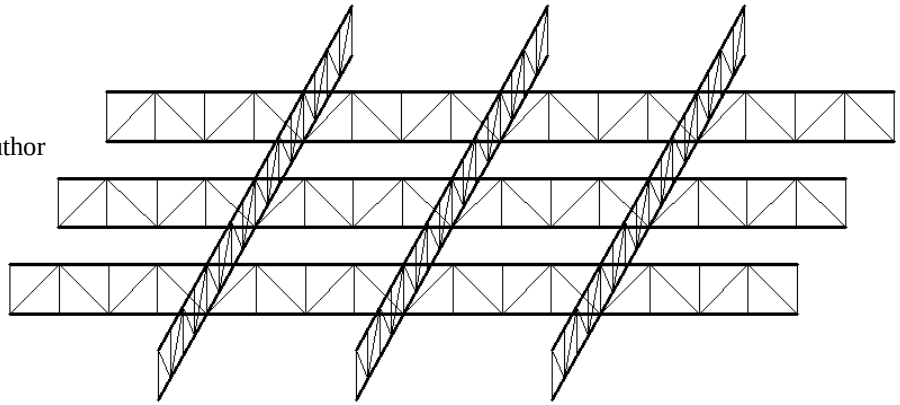
Photo: lfspaceframe.com

Truss-grates

Photo: cdn8.muratorplus.smcloud.net

Photo: qdjinfei.en.made-in-china.com

Photo: Author



Complex of trusses of the same height, perpendicular each other (two-way girders): flat structures, cylindrical shells, domes.

Steel grate (two-way girders, flat structure), full-walled girdes

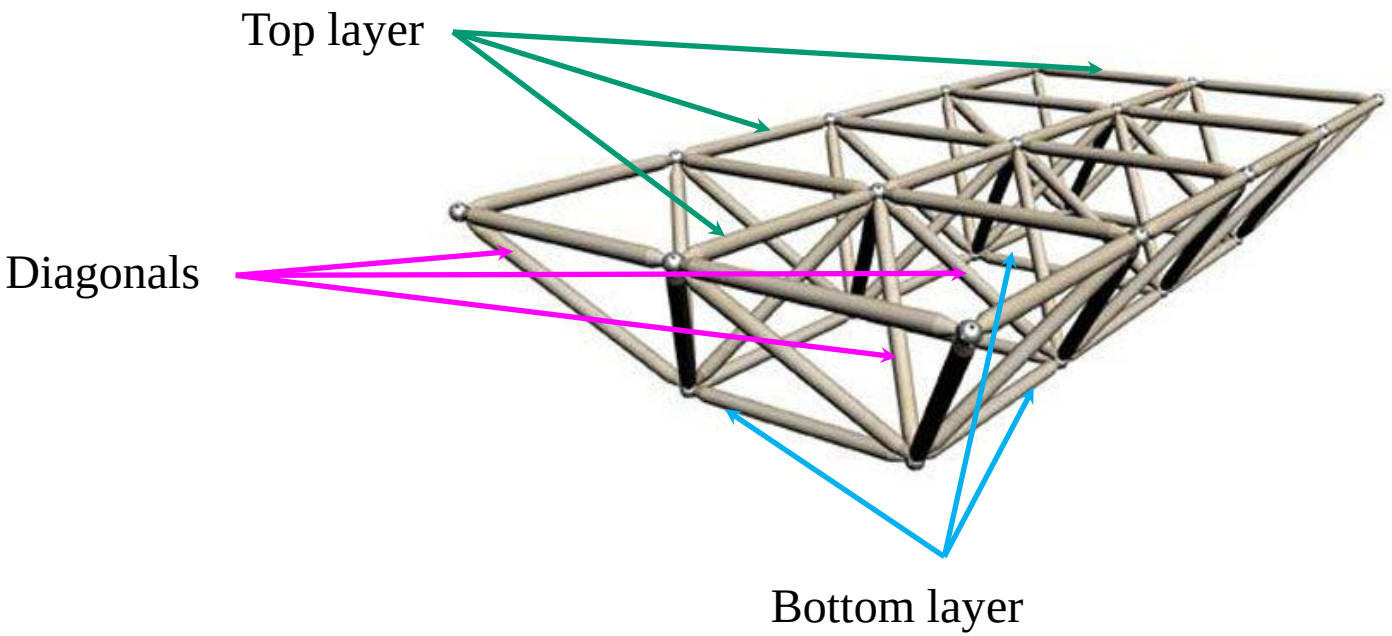
Photo: steelbuildingstructure.com

Photo: dunkerley.co.uk

Spatial structure

Bar structure; two outer layers, connected by truss bars in pyramidal (triangular) arrangement (analogy to "classical" truss: two chords connected by truss bars in triangular arrangement). Cross-section of each bar is generally the same. Stiffness comes from pyramidal arrangement.

Photo: cnxzlf.com



In general, square grids are used in both outer layers and differ from each other by various relative positions (overlap, offset, 45° rotation)

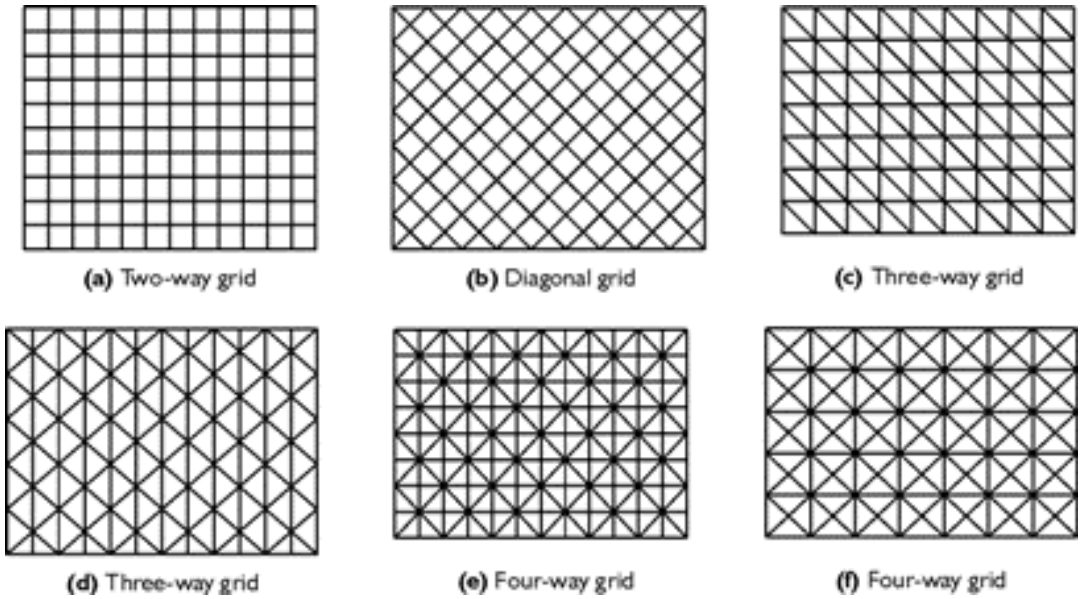


Photo: civiltech.ir

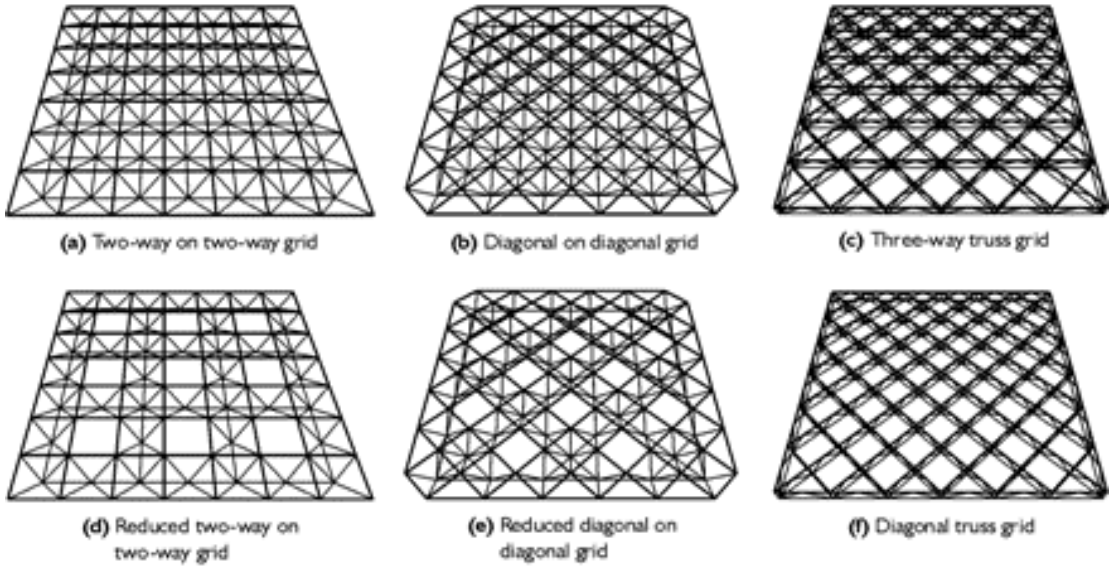
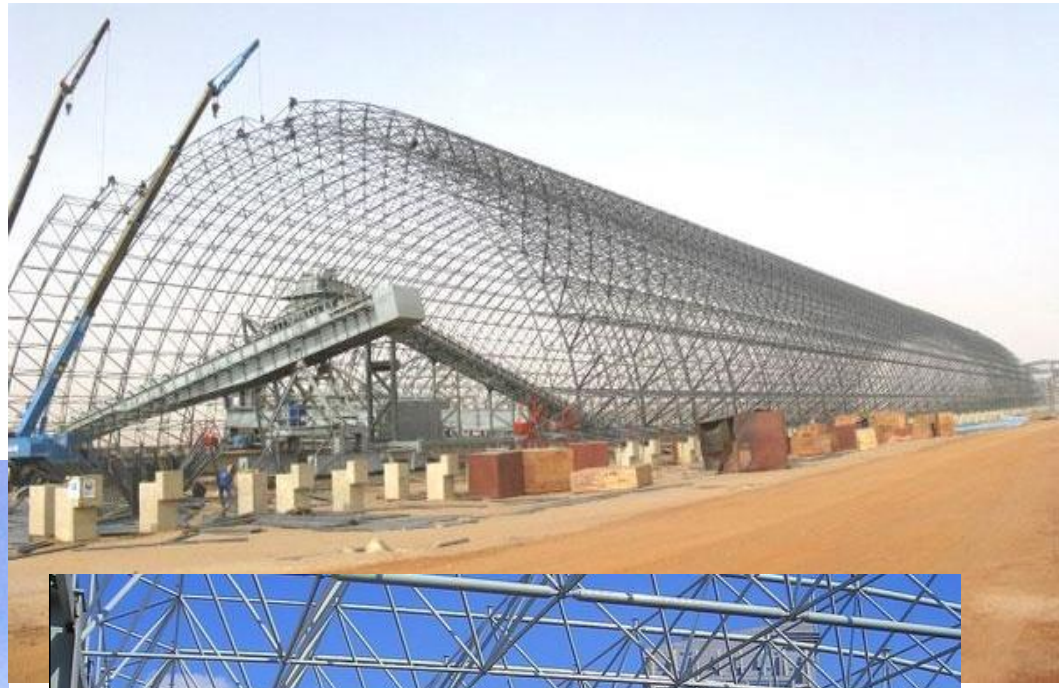


Photo: civiltech.ir

Photo: xzlf.en.hisupplier.com

Spatial structures can be applicated to flat surfaces, cylindrical shells and domes. Other name: multi-layes structures.



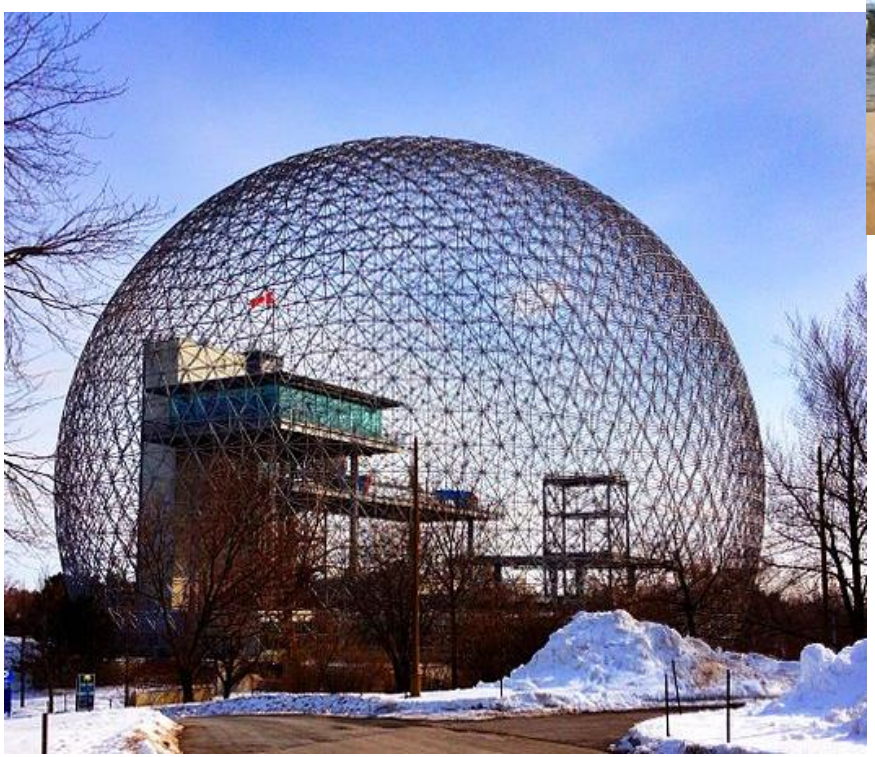
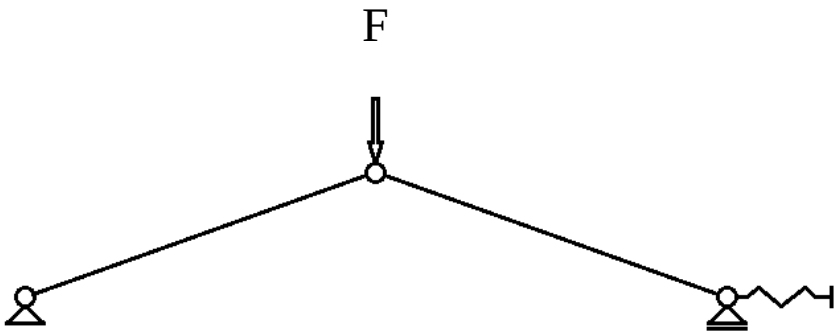
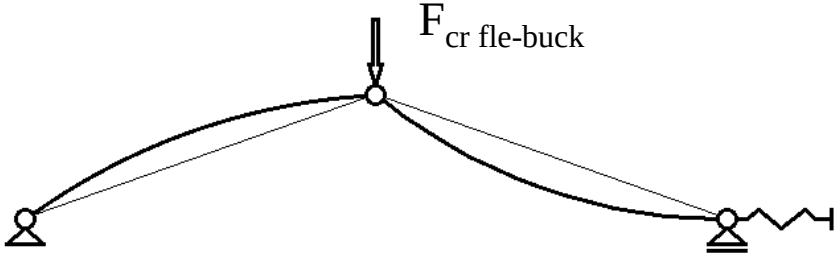


Photo: wikipedia

Photo: miripiri.co.in

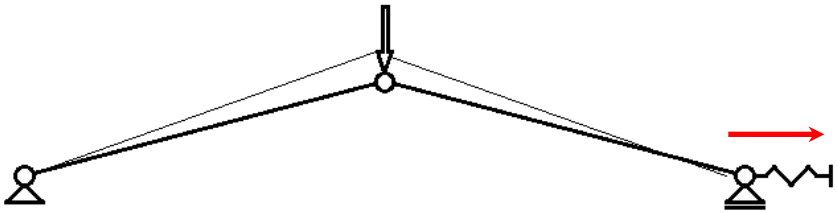
Special type of instability:



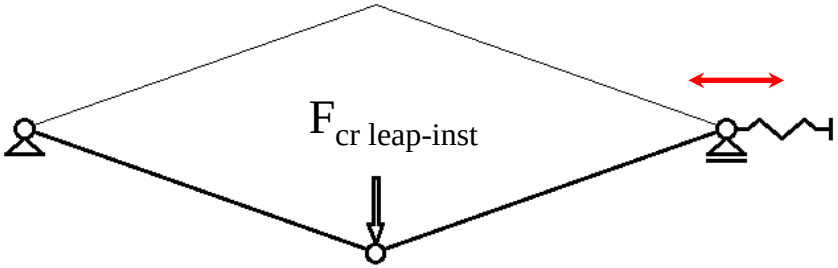


Flexural buckling of compressed bars

$F < \min (F_{cr\ fle\text{-}buck} ; F_{cr\ leap\text{-}inst})$



Deformation



Leaping instability

Photo: Author

Behavior of such structure depends on its span L, initial angle α and spring factor k.

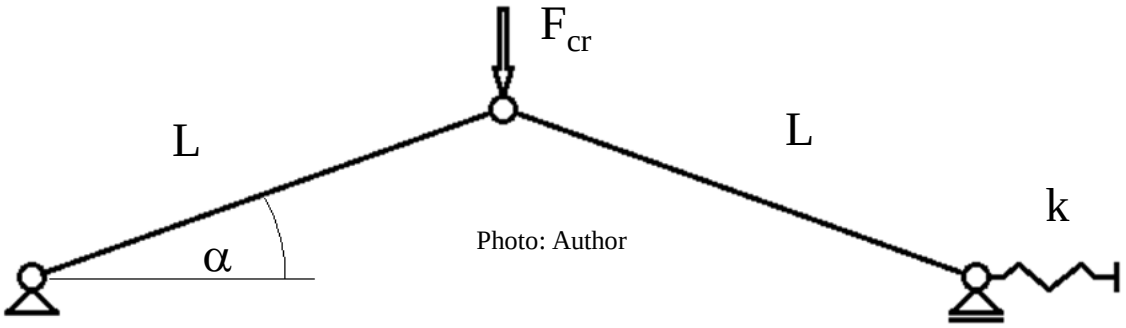


Photo: Author

For big values of L, α and k, more more probable is flexural buckling ($F_{cr\ fle\text{-}buck} < F_{cr\ leap\text{-}inst}$).
For small values, more probable is leaping instability ($F_{cr\ leap\text{-}inst} < F_{cr\ fle\text{-}buck}$).

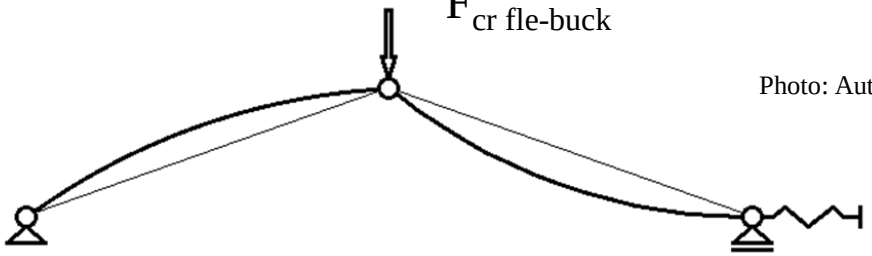
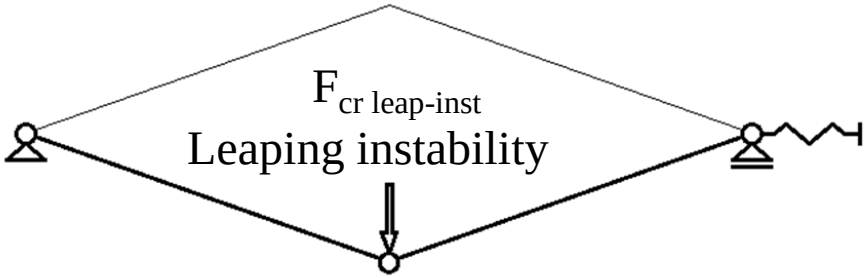


Photo: Author



Flexural buckling of compressed bars

Photo: gadzety-reklamowe.com

Photo: wroclaw.pl

The same as for simplified model, leaping instability for spatial trusses, cylindrical truss shells and domes potentially can occurs for critical load smaller, than critical load for flexural instability of bars. Spring in simplified model represents, first of all, stiffness resuting from geometry of steel structure. One of the most important parameter is distance between upper and lower surface of bar nets. Increasing H means increasing spring factor k.

H

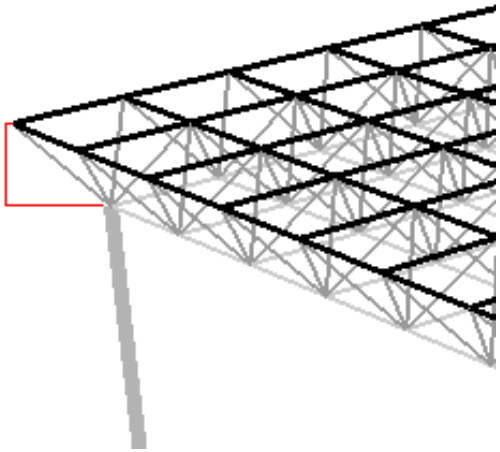


Photo: geometrica.com

Photo: steelstructureschina.com

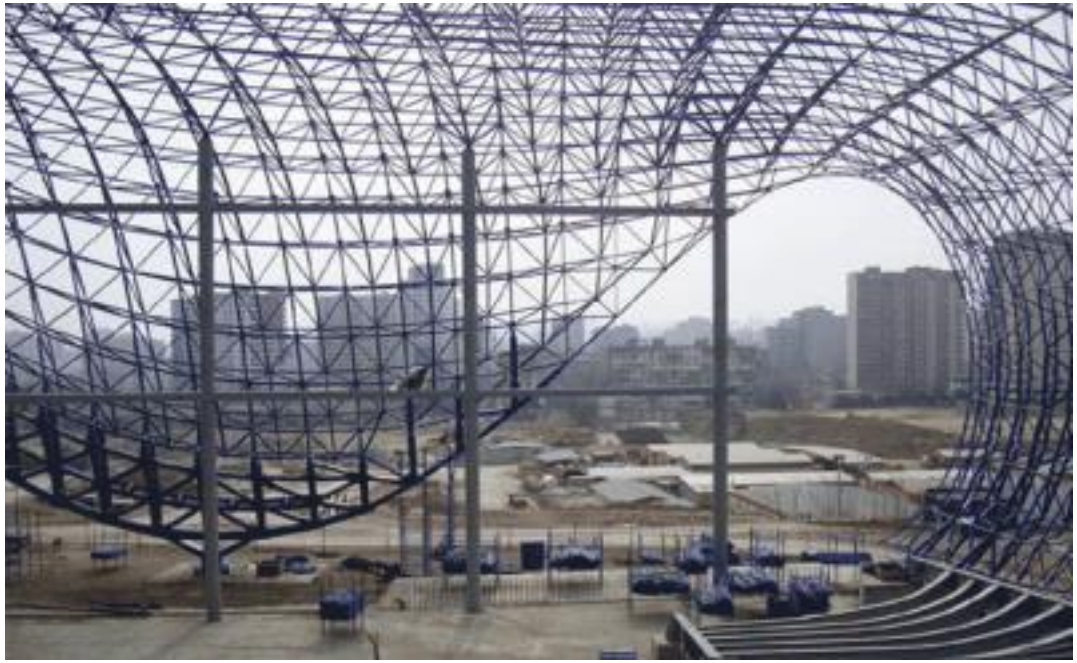
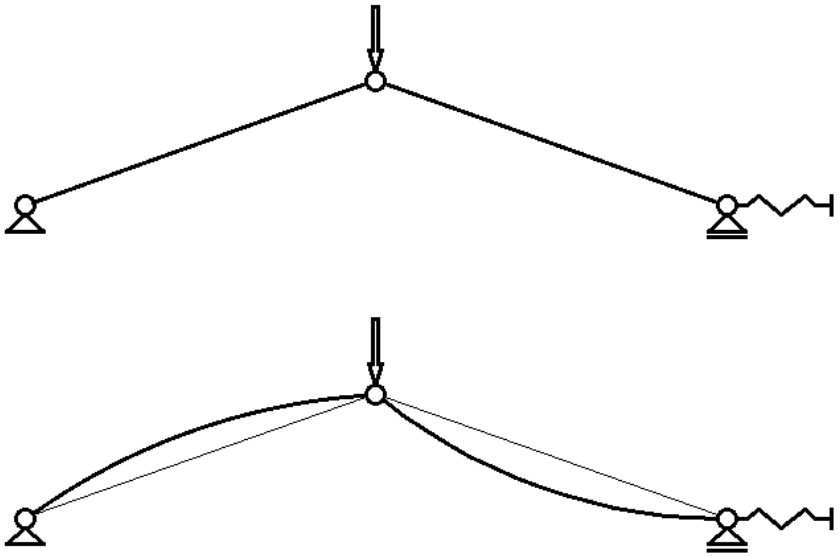


Photo: cnxzlf.com

Photo: Author

Other very important parameters are number and stiffness of columns (supports) and shape of surface. Curvature of surface also make impact on factor k.

Leaping instability isn't easy to analyze. „Classical" analysis - geometrically linear – of instability will reveal only buckling of bars. If $F_{cr\ leap\text{-}inst} < F_{cr\ fle\text{-}\ buck}$ it is a dangerous situation for structure (too optimistic definition of resistance).



Detection of leaping is only possible in geometrically nonlinear stability analysis.

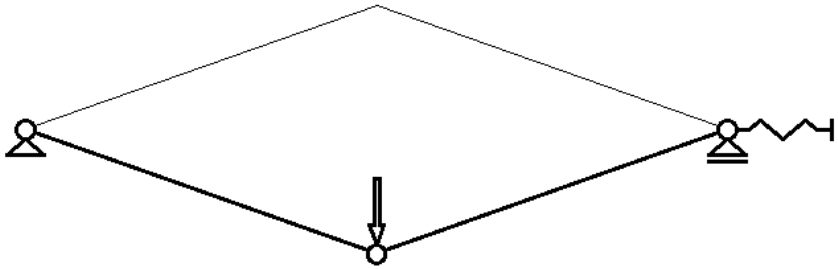


Photo: Author

Spatial structure:

Flat

Cylindrical

Dome

Prefabrication systems:

Mero

SDC

Pyramitec

Unibat

Tesep

Tridimatec

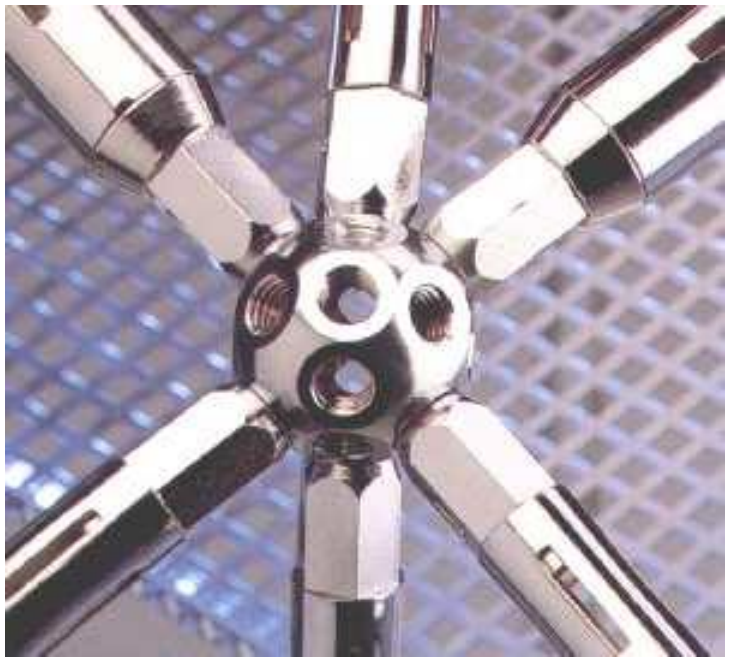
...

Mero system - the most popular

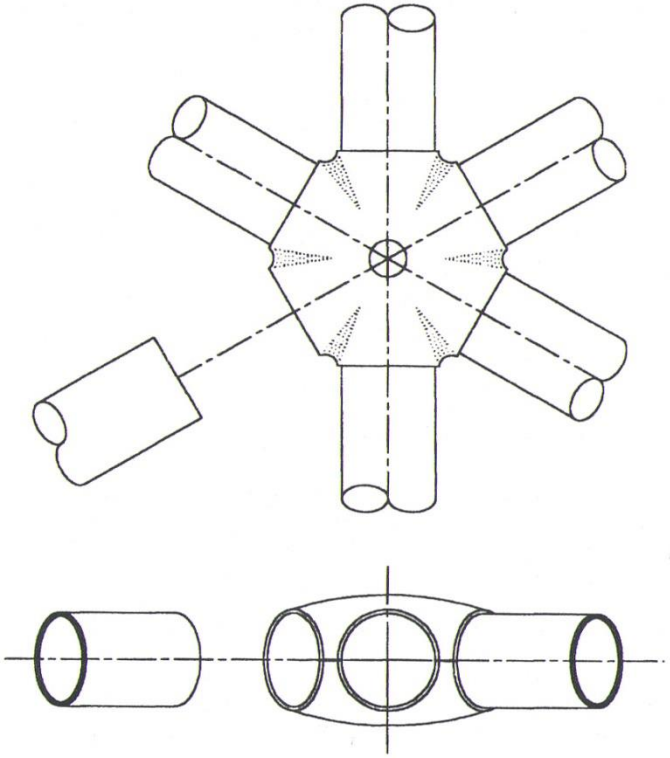
Photo: pic2fly.com

Photo: pic2fly.com

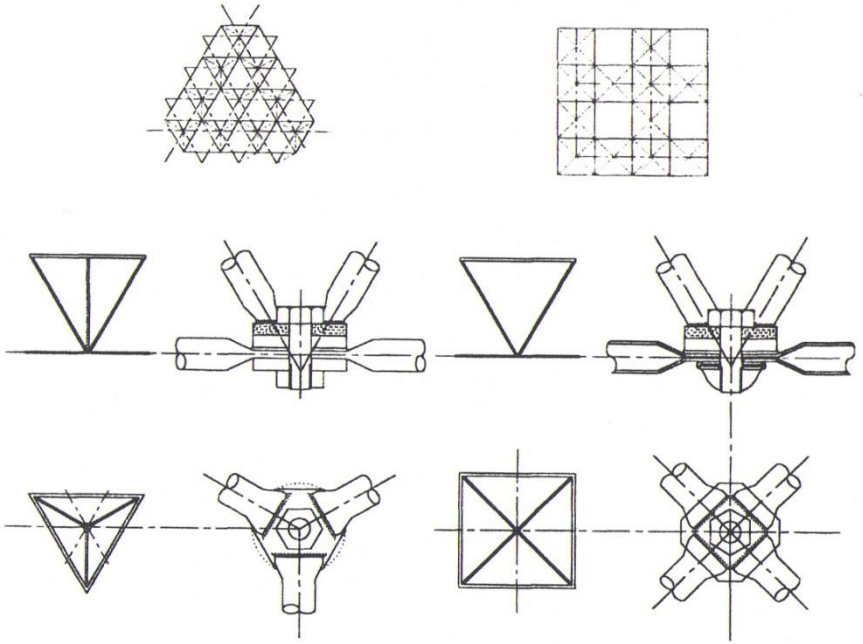
Photo: signs.pl



SDC, pyramitec, cirotec, bacotec, tridimatec, unibat, spherobat, tridiblau, flotau, pyramibat, bamboutec, dodecavis - systems by Polish architect Stefan du Chateau



SDC



Pyramitec

Photo: vt.edu

There is information in EN 1993-1-8 7.1:

deformation ends of element are not accepted.

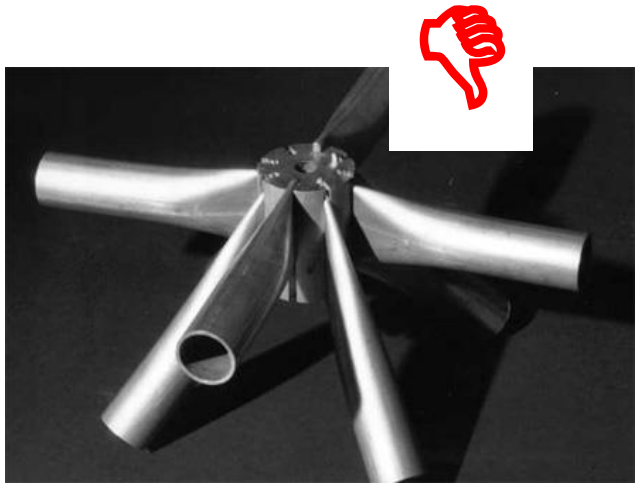


Photo: tatasteelconstruction.com

This information is not important for prefabricated systems. For this situation, resistance of joints is tested experimentally, not only calculated during design process.

Examples

- Exhibition halls
- Sport facilities
- Entertainment centres
- Railway stations & airport halls
- Special industrial facilities
- Special transport facilities
- Landmarks
- Bridges

Comparison of dimensions:
Kraków Main Square: 200x200 m;
Hejnalica: 82 m;
Distance: Cracow University of Technology - Wawel Hill: 2 000 m;

Photo: e-architect.co.uk

Neue Messe Central Hall, Leipzig (Glass Palace)

Exhibition centre, former railway station

length 238 m
width 80 m
height 28 m

Arches and cylindrical shell

Photo: e-architect.co.uk

Kraków Main Square: 200x200 m;

Montreal Biosphère Museum

Former EXPO ’67 pavilion,
today tourist attraction

diameter 76 m
height 62 m

Spherical dome

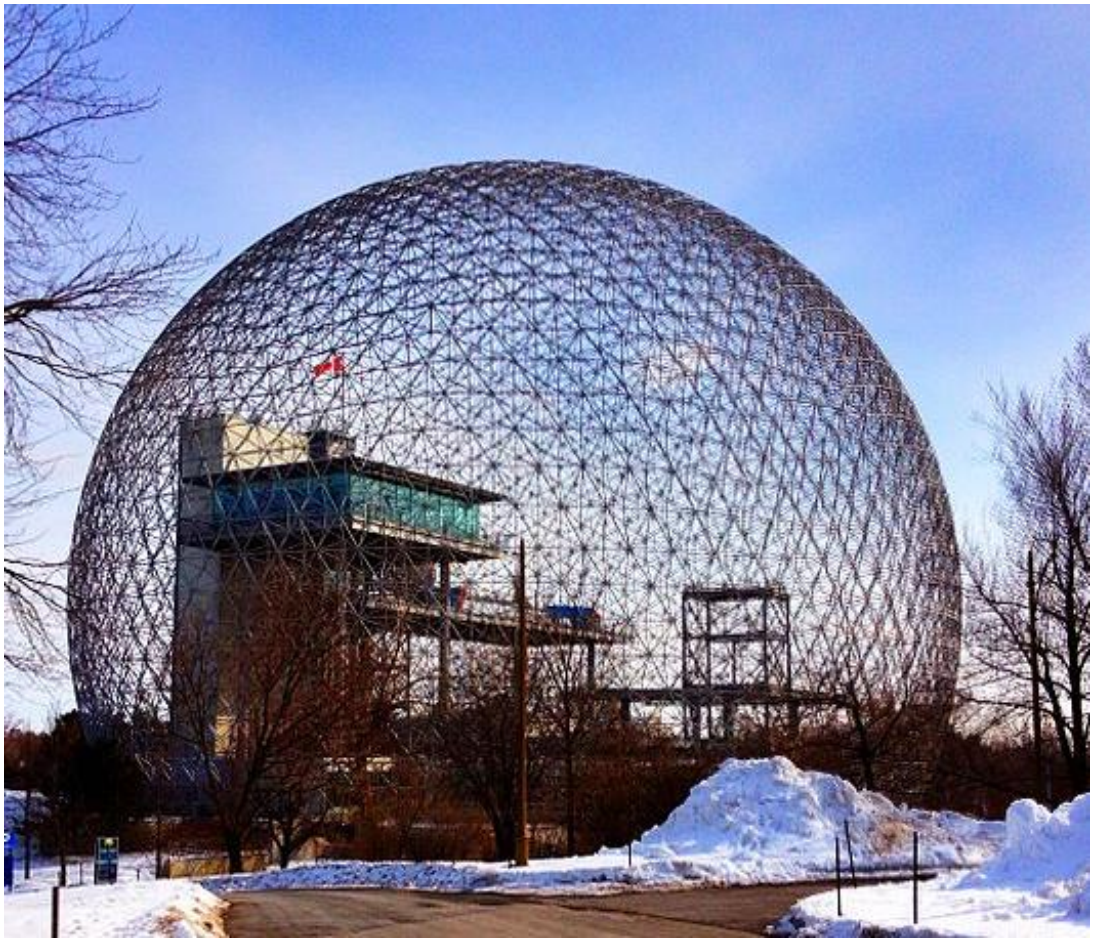
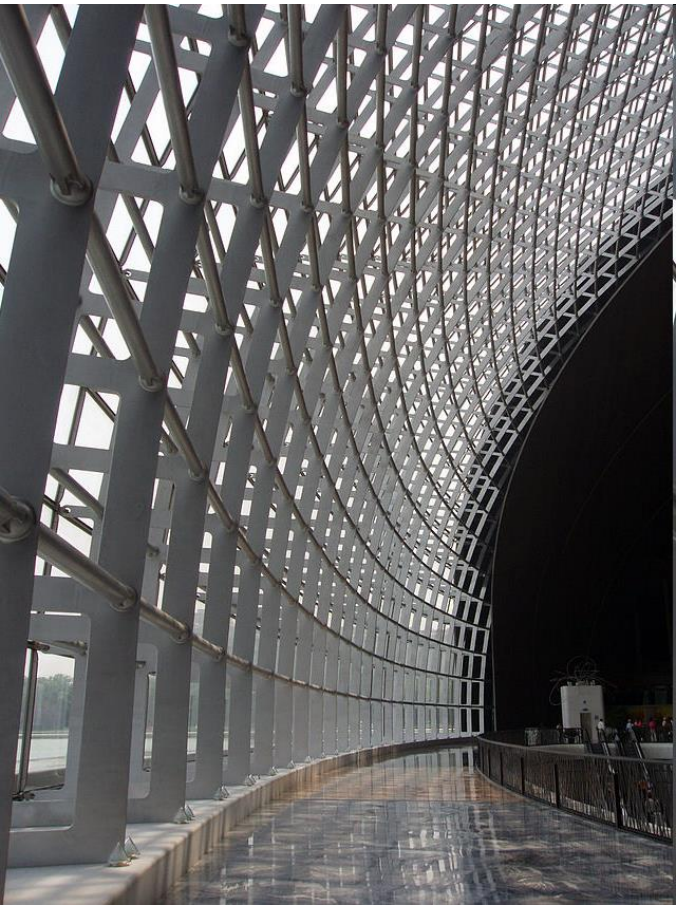


Photo: wikipedia

Hejnalica: 82 m;

Photo: wikipedia



National Centre for the Performing Arts, Beijing

length 212 m
width 144 m
height 46 m

Eliptical dome

Kraków Main Square: 200x200 m;
Hejnalica: 82 m;

Photo: wikipedia

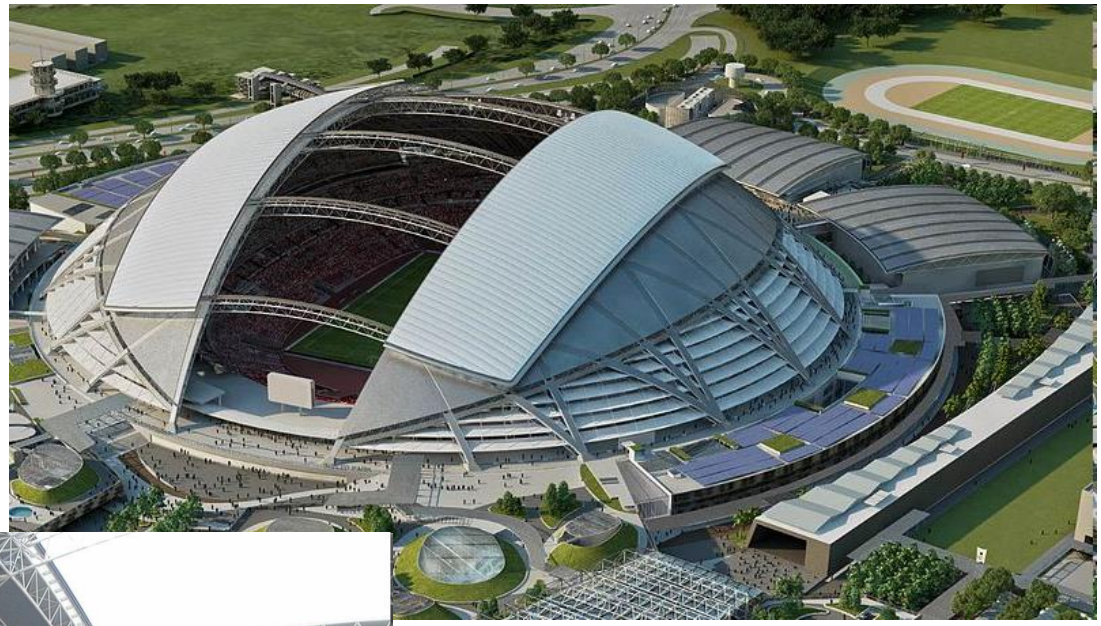
National Sport Stadium,
Singapore

diameter 310 m
height 85 m

Complex of arches,
retractable roof.

The world's largest dome
structure

Photo: wikipedia



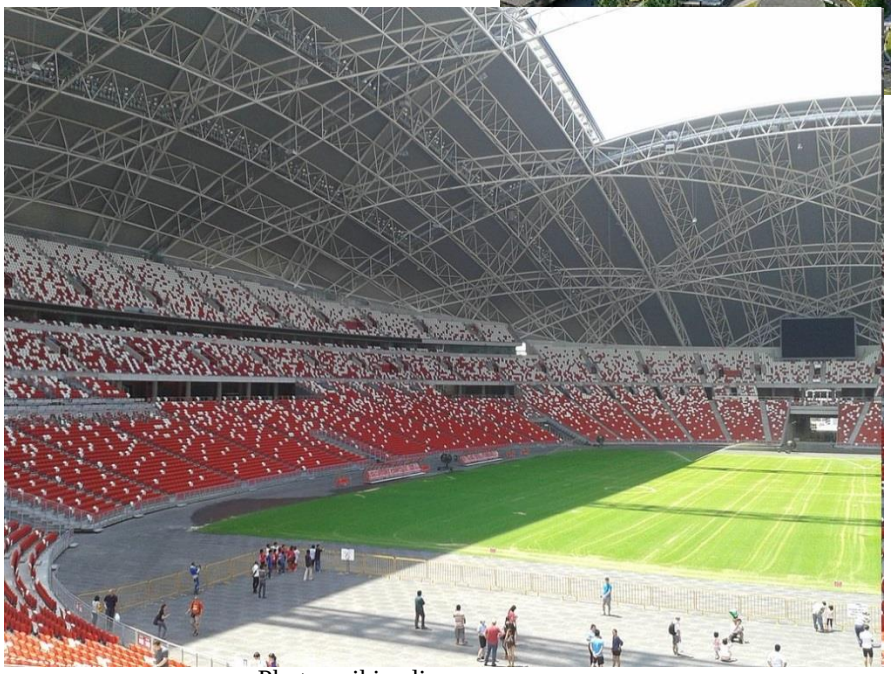


Photo: wikipedia

Kraków Main Square: 200x200 m;

Hejnalica: 82 m;

Photo: wikipedia

Tauron Arena, Kraków

Soprt arena, entertainment center

diameter 166 m
height 27 m

Eliptical dome

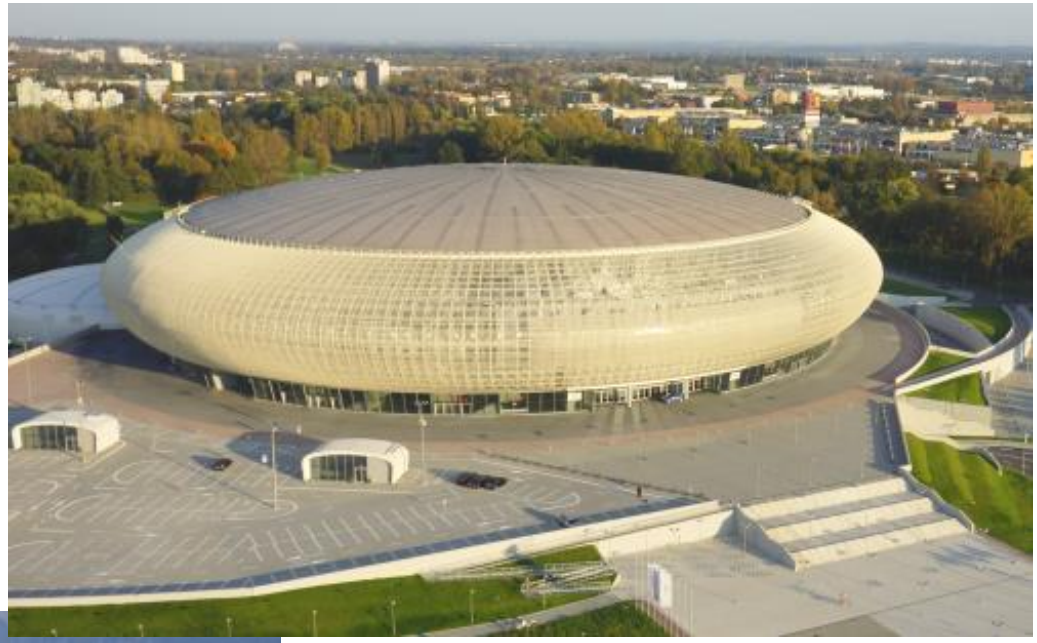


Photo: wikipedia

Kraków Main Square: 200x200 m;

Photo: wikipedia

Houston Astrodome

Sport arena

diameter 220 m
height 63 m

Dome

Kraków Main Square: 200x200 m;
Hejnalica: 82 m;

Photo: ballparksofbaseball.com

Ferrari Wolrld, Abu Dhabi

Entertainment center

diameter (total) 775 m
height 62,5 m

Photo: arhinovosti.ru

Spatial truss

Photo: themeparkreview.com

Distance: Cracow University of Technology - Wawel Hill: 2 000 m;

Photo: satimagingcorp.com

Disney Spaceship Earth, Orlando

Entertainment center

diameter 50 m

Spherical dome

Photo: wikipedia

Hejnalica: 82 m;

Photo: glebokie4.pl

Tropical Island (Aerium),
Dahme-Spreewald

Aquapark, former airship hangar

length 360 m
width 210 m
height 107 m

Complex of arches

Photo: wikipedia

Photo: wikipedia

Kraków Main Square: 200x200 m;

Hejnalica: 82 m;

Hauptbahnhof,
Frankfurt

Railway station

large halls:
length 186 m
width 50 m
height 28 m

Complex of arches

Photo: wikipedia

Photo: wikipedia

small halls:
length 186 m
width 31 m
height 20 m

Kraków Main Square: 200x200 m;

Hejnalica: 82 m;

Suvarnabhumi Airport, Bangkok

Wing parts
length 3 213 m
width 40 m
height 25 m

Comples of arches and suspension roof

Main part
length 444 m
width 111 m
height 28 m

Spatial truss

Kraków Main Square: 200x200 m;

Hejnalica: 82 m;

Distance: Cracow University of Technology - Wawel Hill: 2 000 m;

Photo: wikipedia

Photo: wikipedia

Photo: wikipedia

New Safe Confinement shield for Czarnobyl reactor

length 150 m
width 270 m
height 105 m

Steel arches and cylindrical shell

Kraków Main Square: 200x200 m;

Hejnalica: 82 m;

Photo: wikipedia

Photo: xzlf.en.hisupplier.com

Lime storage, Yunnan Kungang

Industry hall

length 148 m
width 125 m
height 30 m

Circular shell

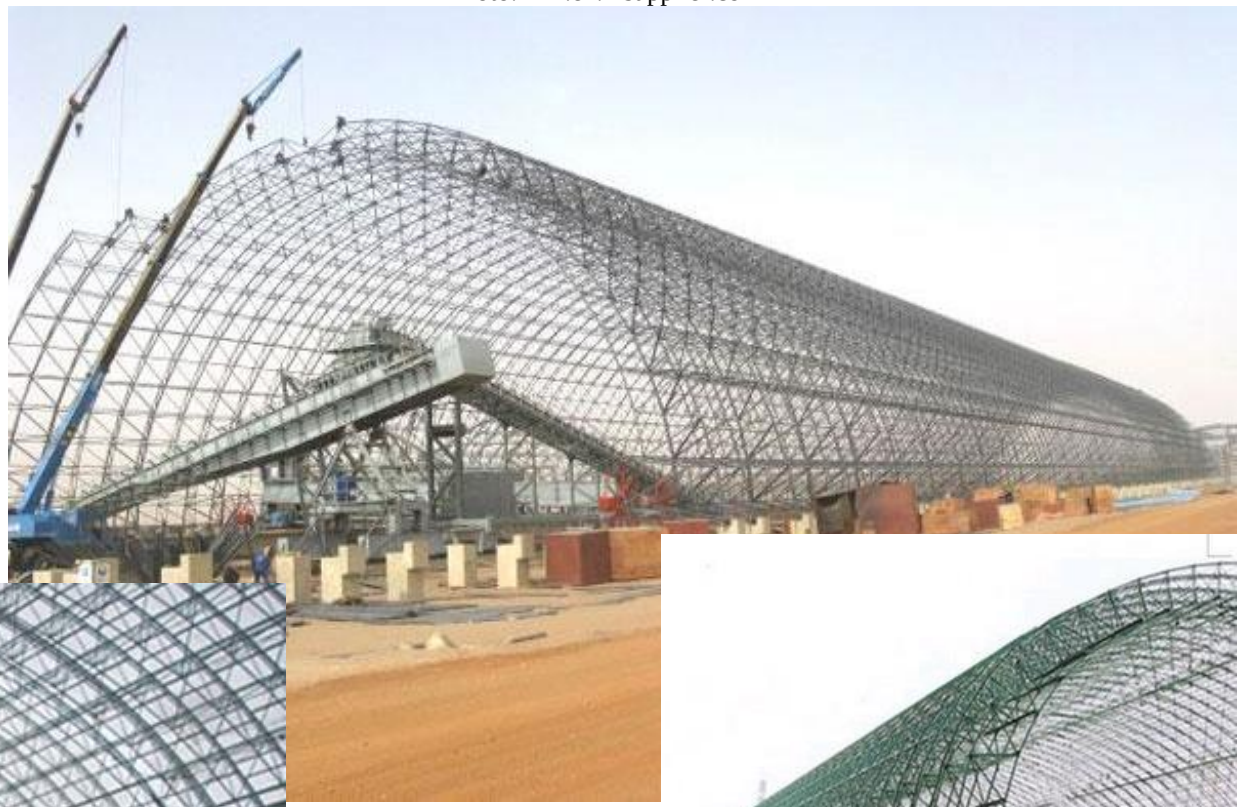
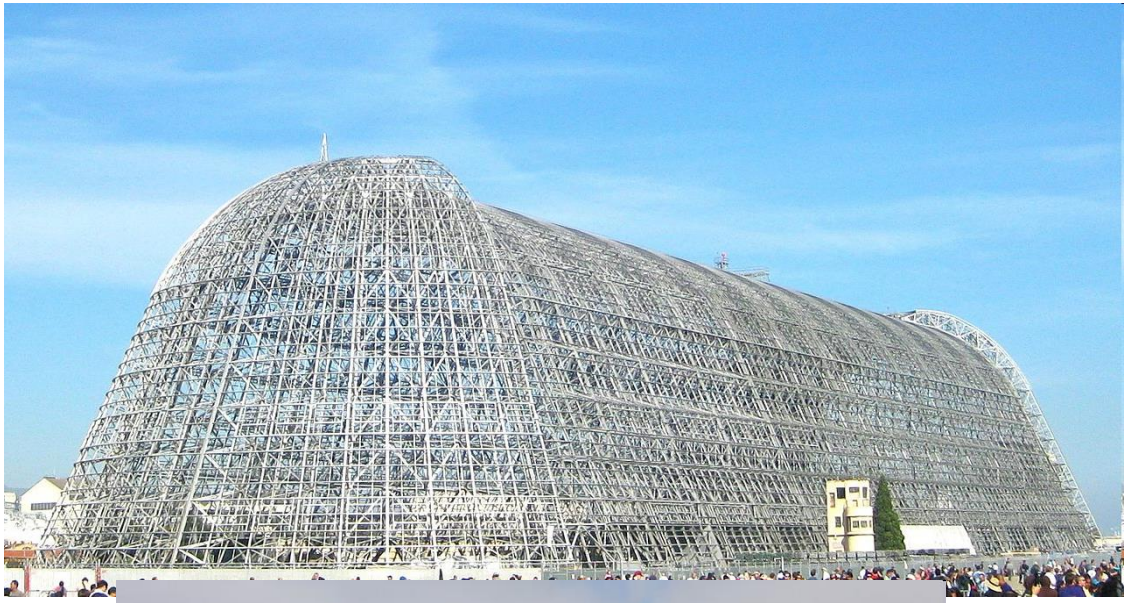


Photo: xzlf.en.hisupplier.com

Photo: xzlf.en.hisupplier.com

Kraków Main Square: 200x200 m;
Hejnalica: 82 m;

Photo: wikipedia



Hangar One,
Mountain View

Airplane hangar, former airship hangar

length 345 m
width 94 m
height 60 m

Cylindrical shell

Kraków Main Square: 200x200 m;

Hejnalica: 82 m;

Photo: wikipedia

Photo: theguardian.com

Airplane hangar, Pekin

length 352 m
width 110 m
height 38 m

Spatial truss

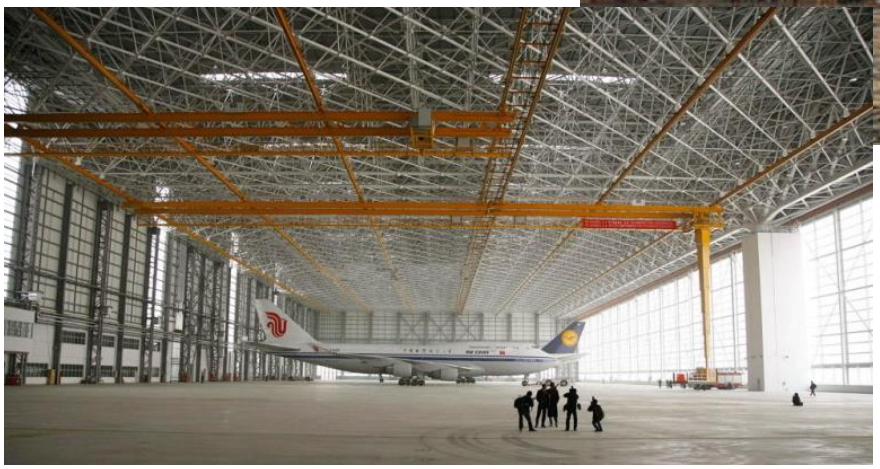


Photo: rodaxx.com

Kraków Main Square: 200x200 m;
Hejnalica: 82 m;

Gateway Arch, Saint Louis

Landmark

span 192 m
height 192 m

Steel arch

Photo: wikipedia

Kraków Main Square: 200x200 m;

Hejnalica: 82 m;

Ring of Life, Fushun

Landmark

diameter 157 m

Steel arch

Photo: dailymail.co.uk

Kraków Main Square: 200x200 m;
Hejnalica: 82 m;

Photo: wikipedia

Chaotianmen Bridge,
Chaotianmen

length 552 m
height 142 m

Steel arch

Kraków Main Square: 200x200 m;

Hejnalica: 82 m;

Examination issues

"Light" hall and "heavy" hall, similiarities and differences

Technical solutions for long span structures

Leaping instability, short characteristic

Roofing - poktycie dachu
Housing - obudowa ścian
Sandwich panels, wall laminboard - płyty warstwowe
Cladding panels - panele ścienne
Self-tapping screw - wkręty samogwintujące
Purlin - płatew
Girt - rygiel obudowy
Castellated beam - belka ażurowa
Tie-beam - ściąg
Frame - rama
Tied frame - rama ze ściągiem
Girder - dźwigar
Ridge - kalenica
Eaves - okap
Drifting - zaspy
Multi-bay hall - hala wielonawowa
Multi-span roof - dach wieloprzesłowy (wielopołaciowy)
Plate girder - blachownica
Spatial truss / space frame - przekrycie strukturalne

Thank you for attention

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