EP-USP

PEF2602
Estruturas na Arquitetura I I - Sistemas Reticulados

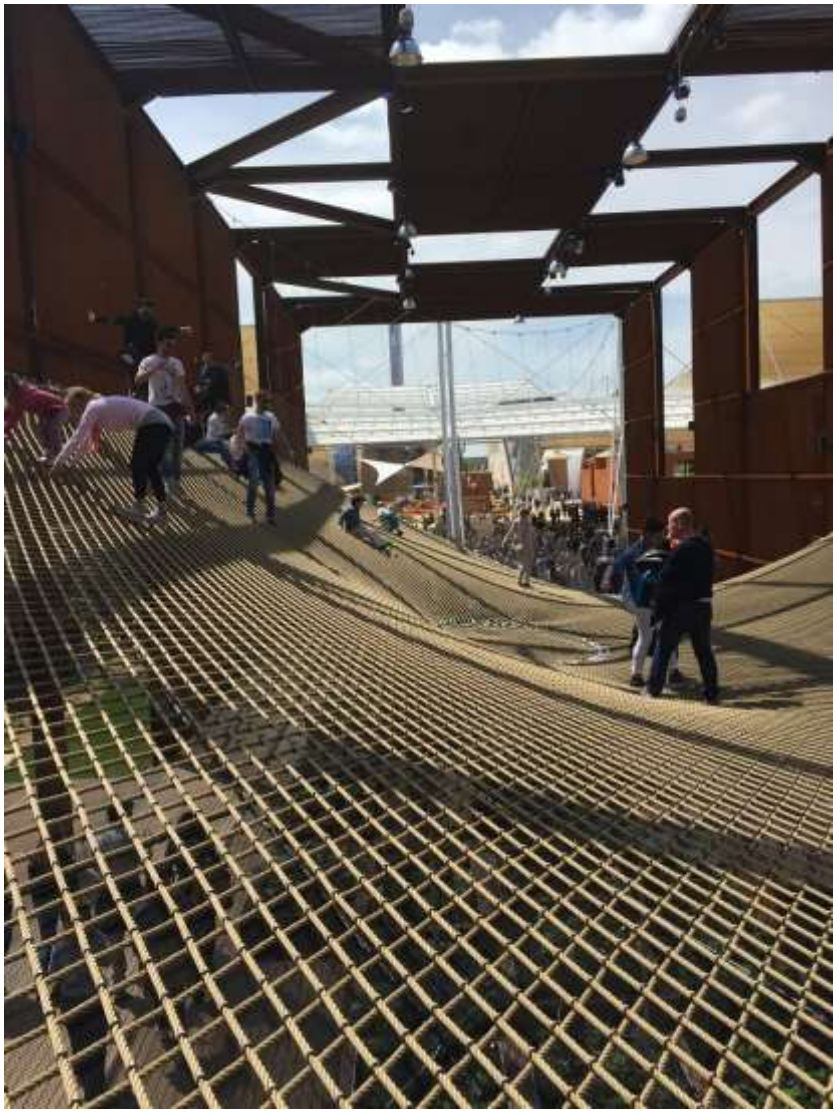
2º Semestre 2018

FAU-USP

Sistemas Reticulados

Professores
Ruy Marcelo Pauletti, Leila Meneghetti Valverdes, Luís Antônio Bittencourt Jr.

Redes

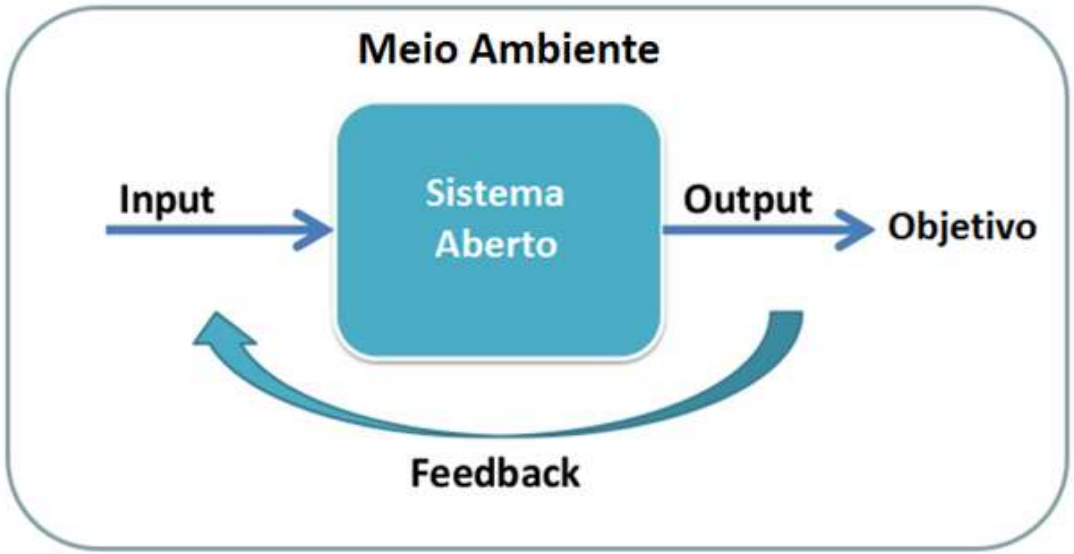


Pavilhão Brasileiro da Expo Milão 2015
Studio Arthur Casas + Atelier Marko Brajovic

Algumas definições...

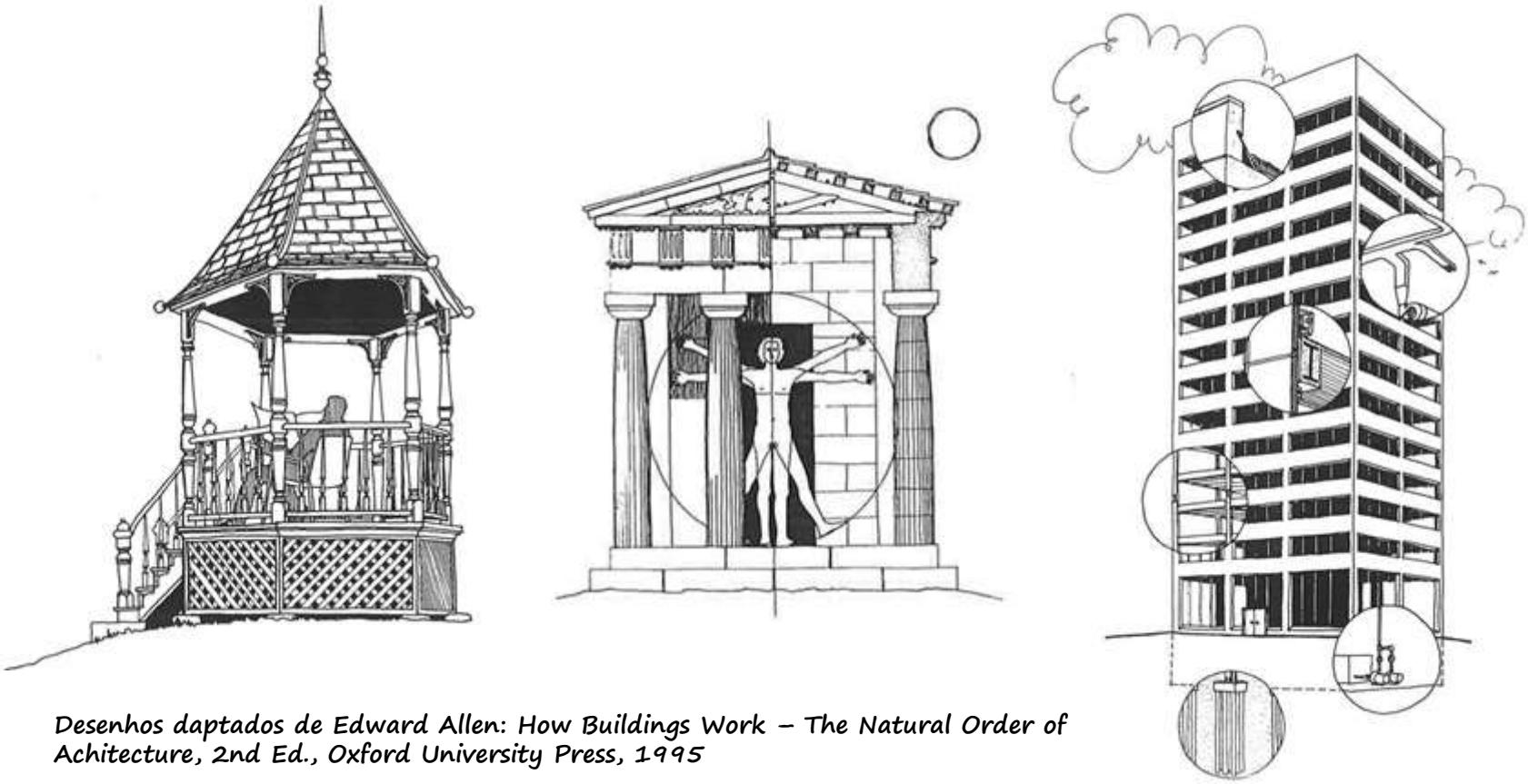
Sistema:

conjunto de elementos relacionados funcionalmente, dotado de um caráter unitário, que se descreve por seu comportamento e sua estrutura.



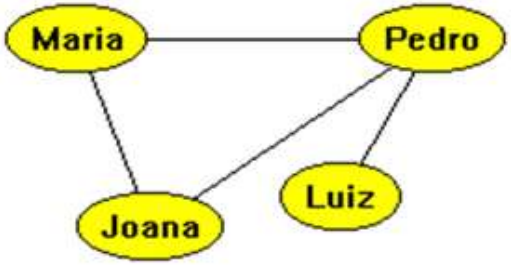
Sistema Estrutural:

conjunto de elementos físicos, relacionados funcionalmente, dotado de um caráter unitário, que se destina à manutenção da forma, sob a ação de forças de natureza diversa.

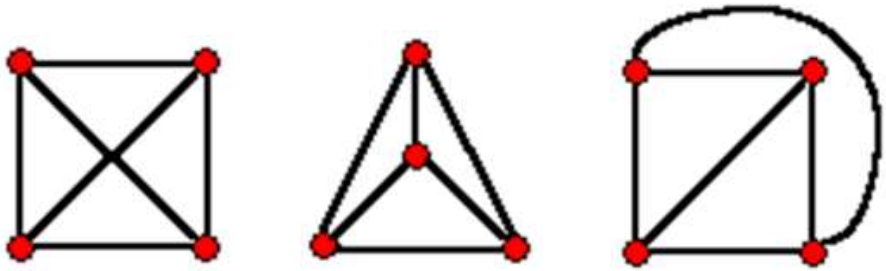


Desenhos daptados de Edward Allen: How Buildings Work – The Natural Order of Achitecture, 2nd Ed., Oxford University Press, 1995

Grafo: conjunto de objetos (ou 'vértices') e de relações entre estes objetos (ou 'arestas')



Diferentes representações geométricas de um mesmo grafo:



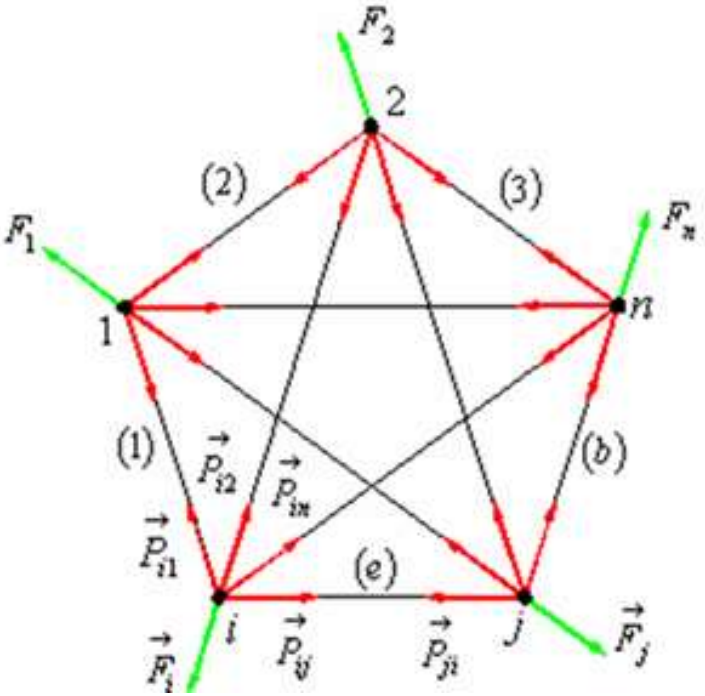
Sistemas Reticulados:

Grafos em que a disposição geométrica dos elementos é relevante

Sistemas Estruturais Reticulados:

Sistemas estruturais cujos elementos composto por vértices (ou 'nós') interconectados por linhas materiais que tranmitem forças e momentos.

Exemplo: 'Sistemas de Forças Centrais'

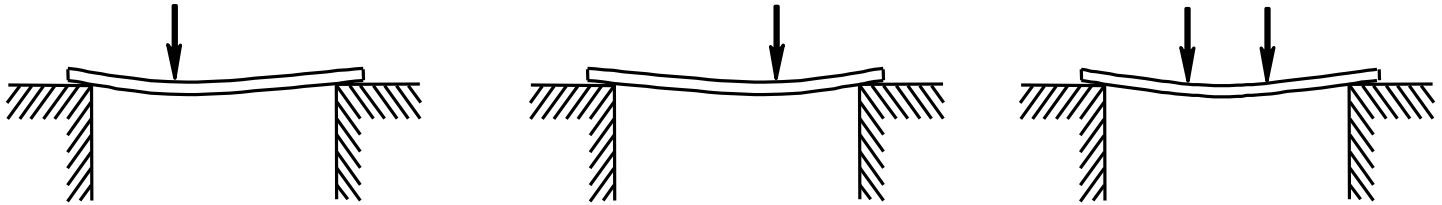


Sistema Arquitrave

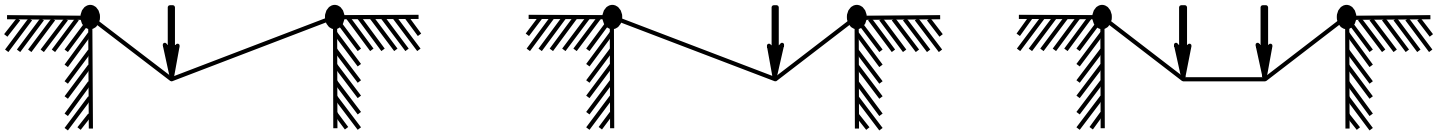
Parthenon
Arquitetos: Ictinus e Callicrates, sob a supervisão do escultor Phidias. Início da construção 447 AC

Museu do Amanhã
Santiago Calatrava, Rio de Janeiro, 2016

Sistemas Rígidos x Sistemas Flexíveis:

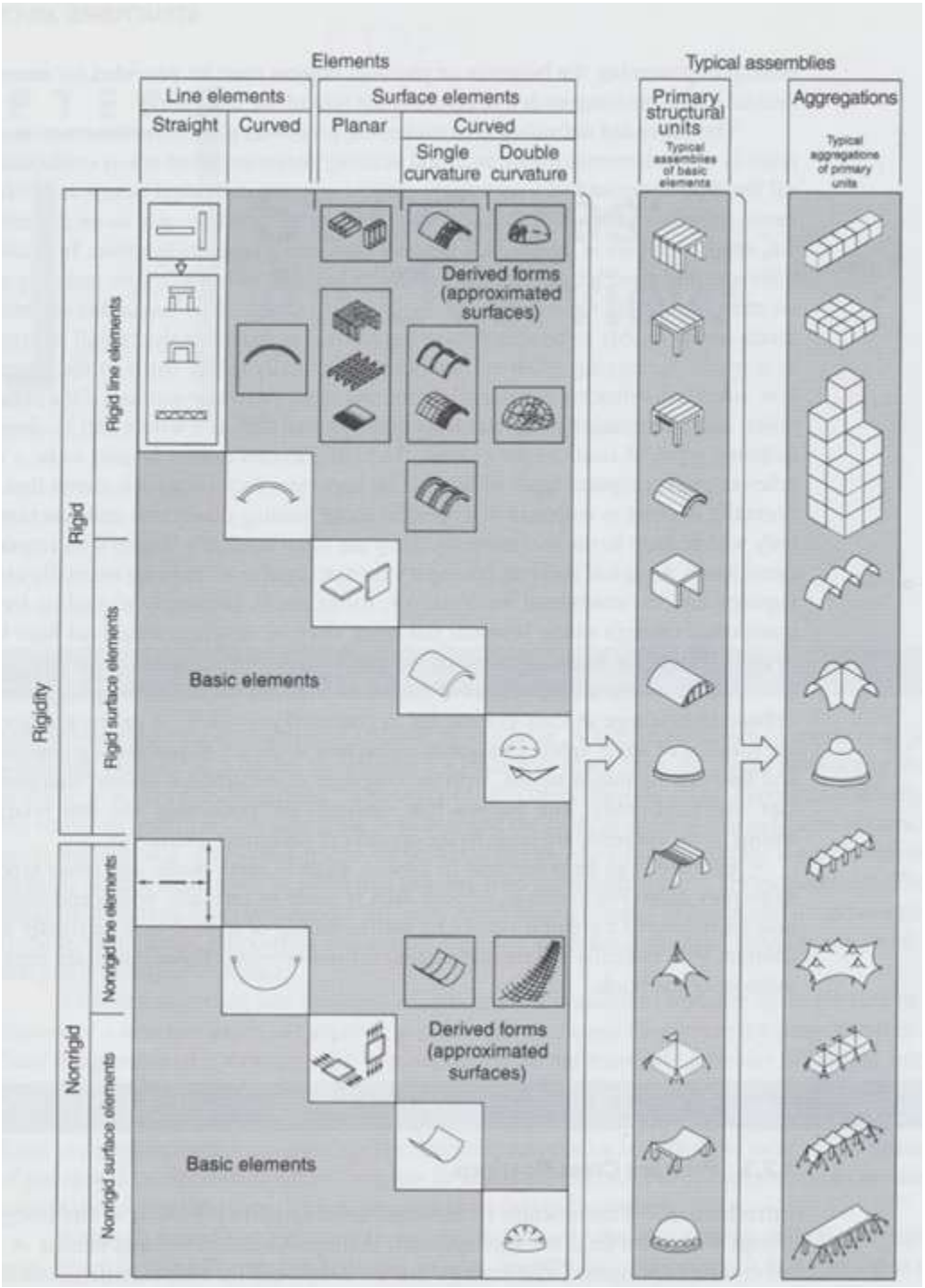


(a) Um sistema rígido, como uma viga, não muda drasticamente sua forma quando o carregamento varia



(b) Um Sistema 'flexível, como um cabo, pode mudar mudar drasticamente de forma, quando carregamento varia

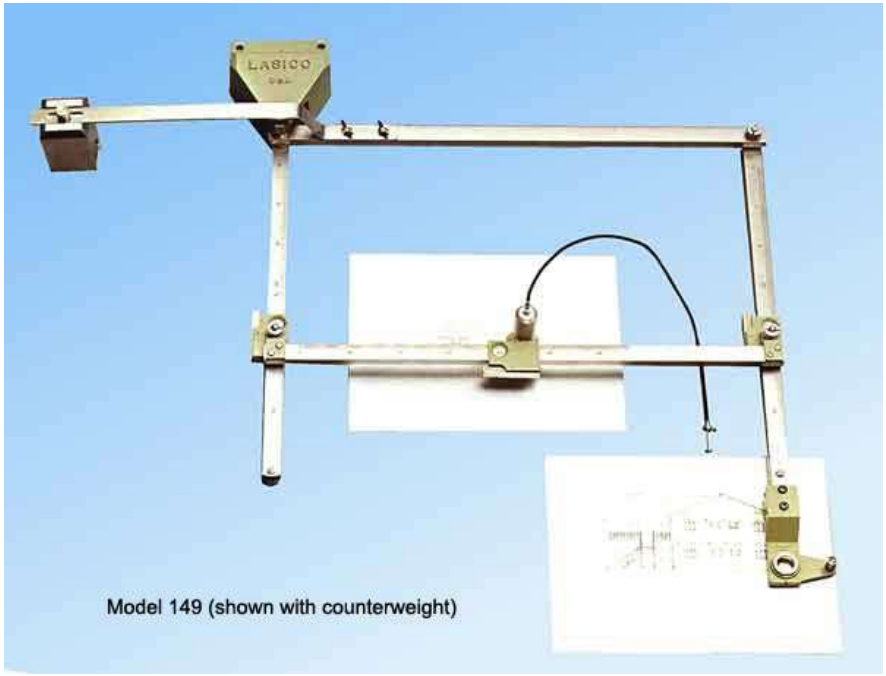
Daniel Shodek, 'Structures', 1992



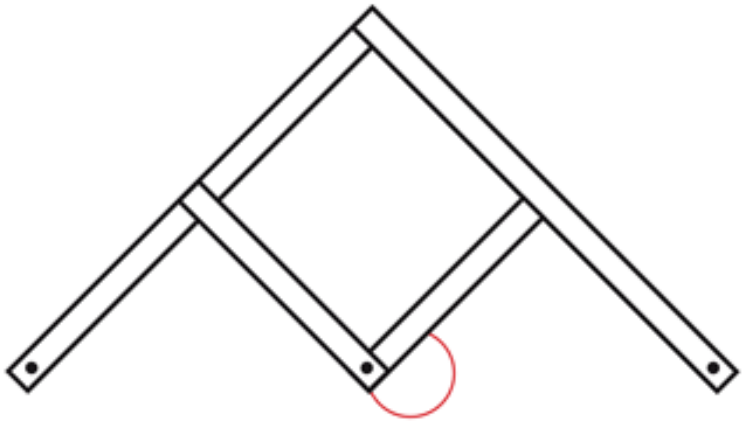
Classification of basic structural elements according to geometry and physical characteristics.

Daniel Shodek, 'Structures', 1992

Pantógrafos

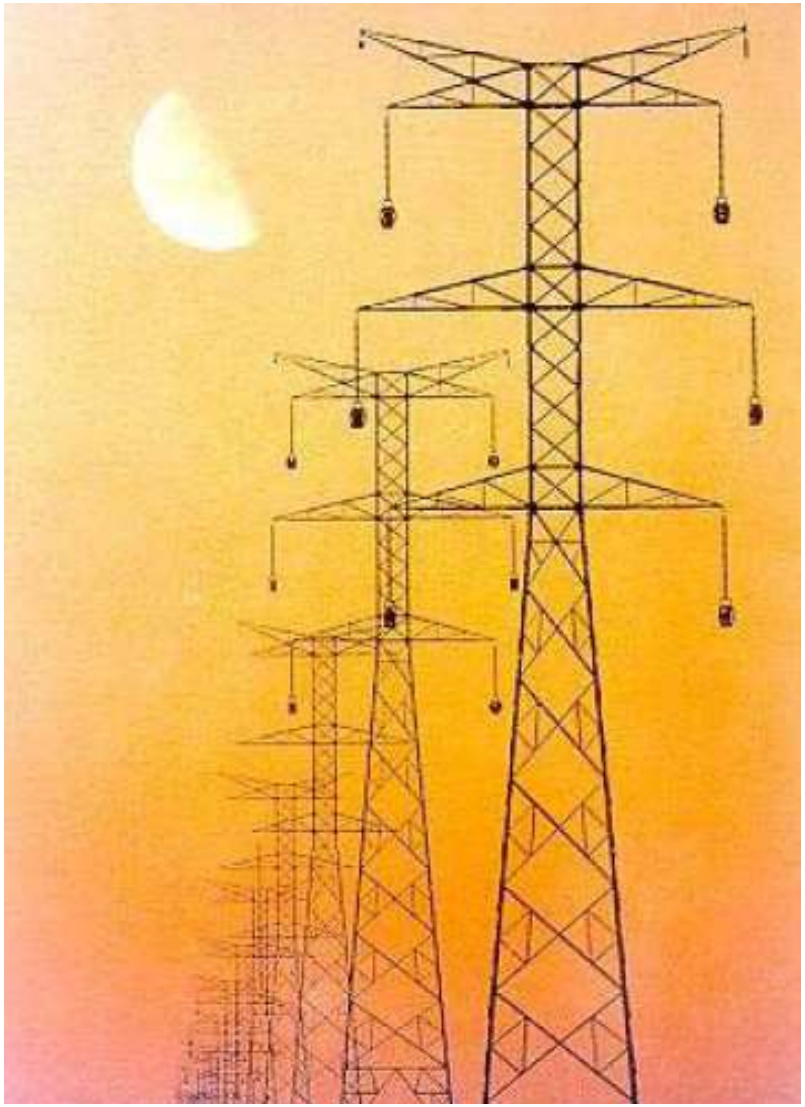


Model 149 (shown with counterweight)



Pantógrafos são mecanismos, que podem ser empregados como estrutuuturas:

Treliças Planas



Pórtico Treliçado:
Sainsbury Centre for Visual Arts (Norman Foster, 1974)
East Anglia University, Norwich, Inglaterra

Sainsbury Centre for Visual Arts (Norman Foster, 1974)

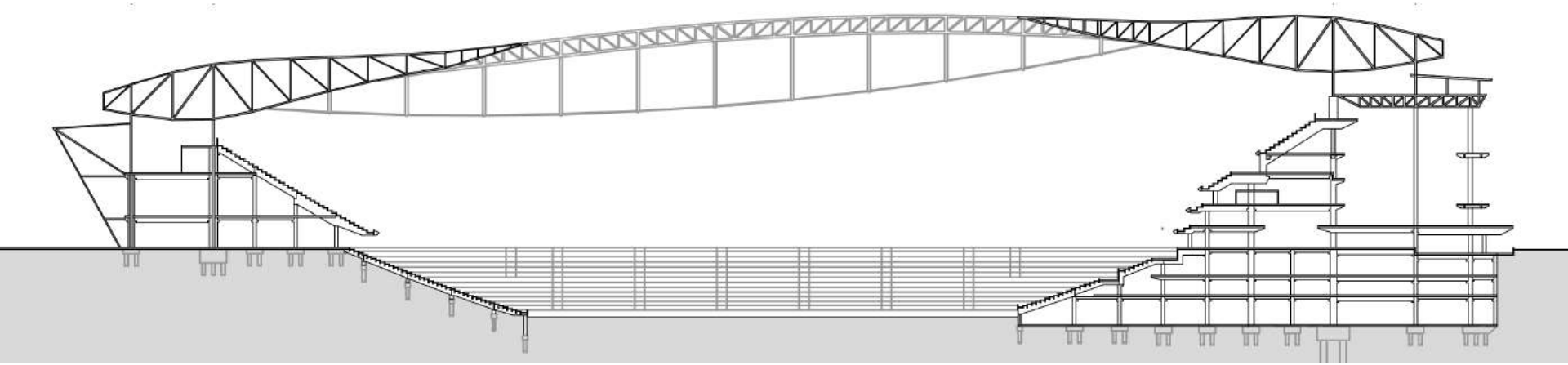
East Anglia University, Norwich, Inglaterra

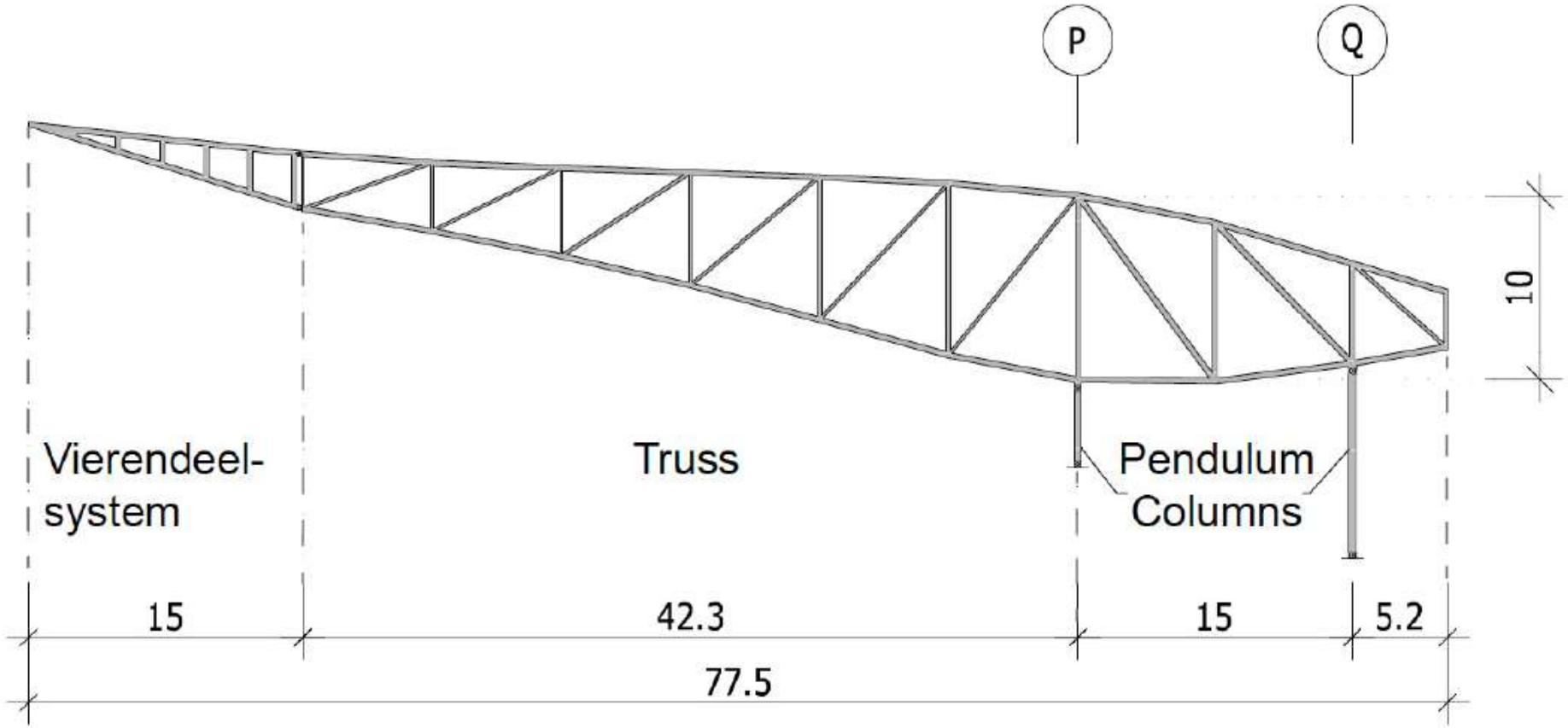
Sainsbury Centre for Visual Arts (Norman Foster, 1974)

East Anglia University, Norwich, Inglaterra

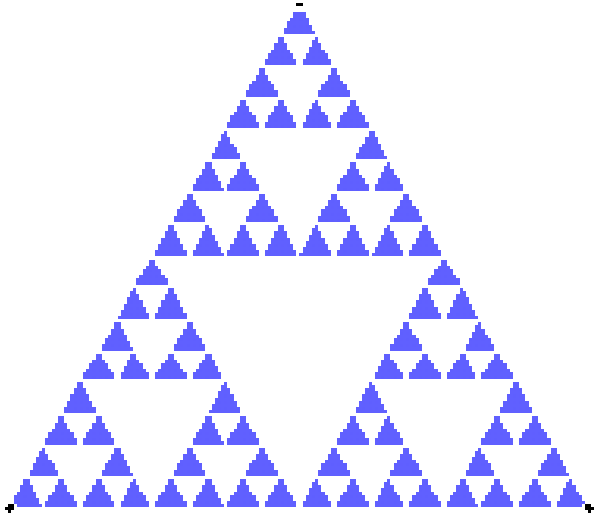
Pórtico treliçado e estaiado:
Escola Panamericana de Arte, Ziegbert Zanettini, 1999

Treliças, pórticos, cabos e sistema Vierendeel:
Arena Corinthians, Arq. Anibal Coutinho, 2016
Cobertura: Werner Sobek

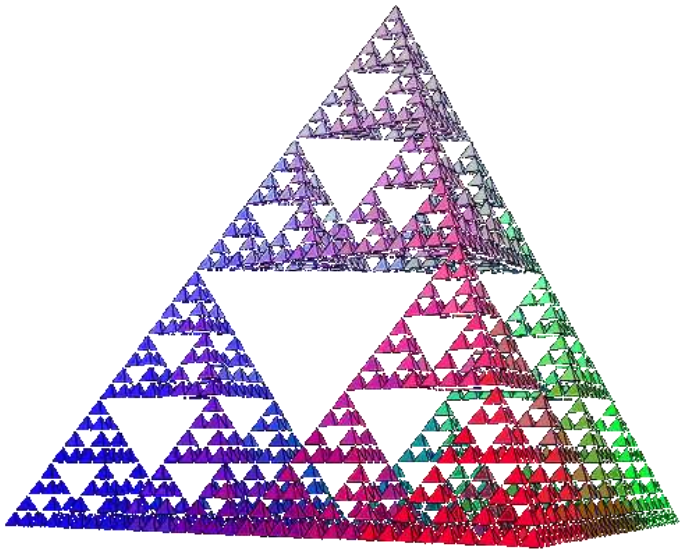



P
Q
10
Vierendeel-
system
Truss
Pendulum
Columns
15
42.3
15
5.2
77.5

Treliças Planas x Treliças Espaciais



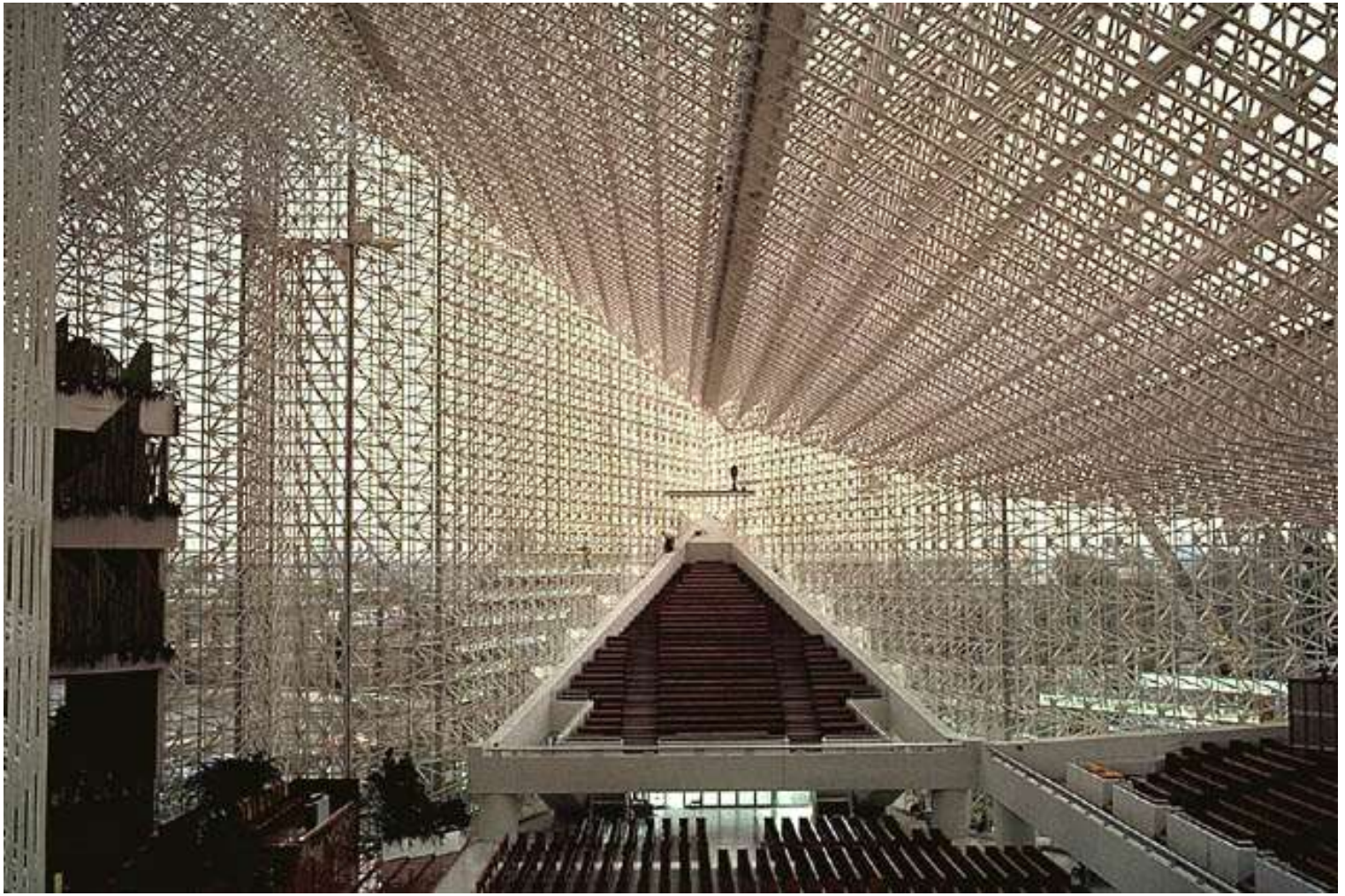
Triangulo de Sierspinski



Pirâmide de Sierspinski

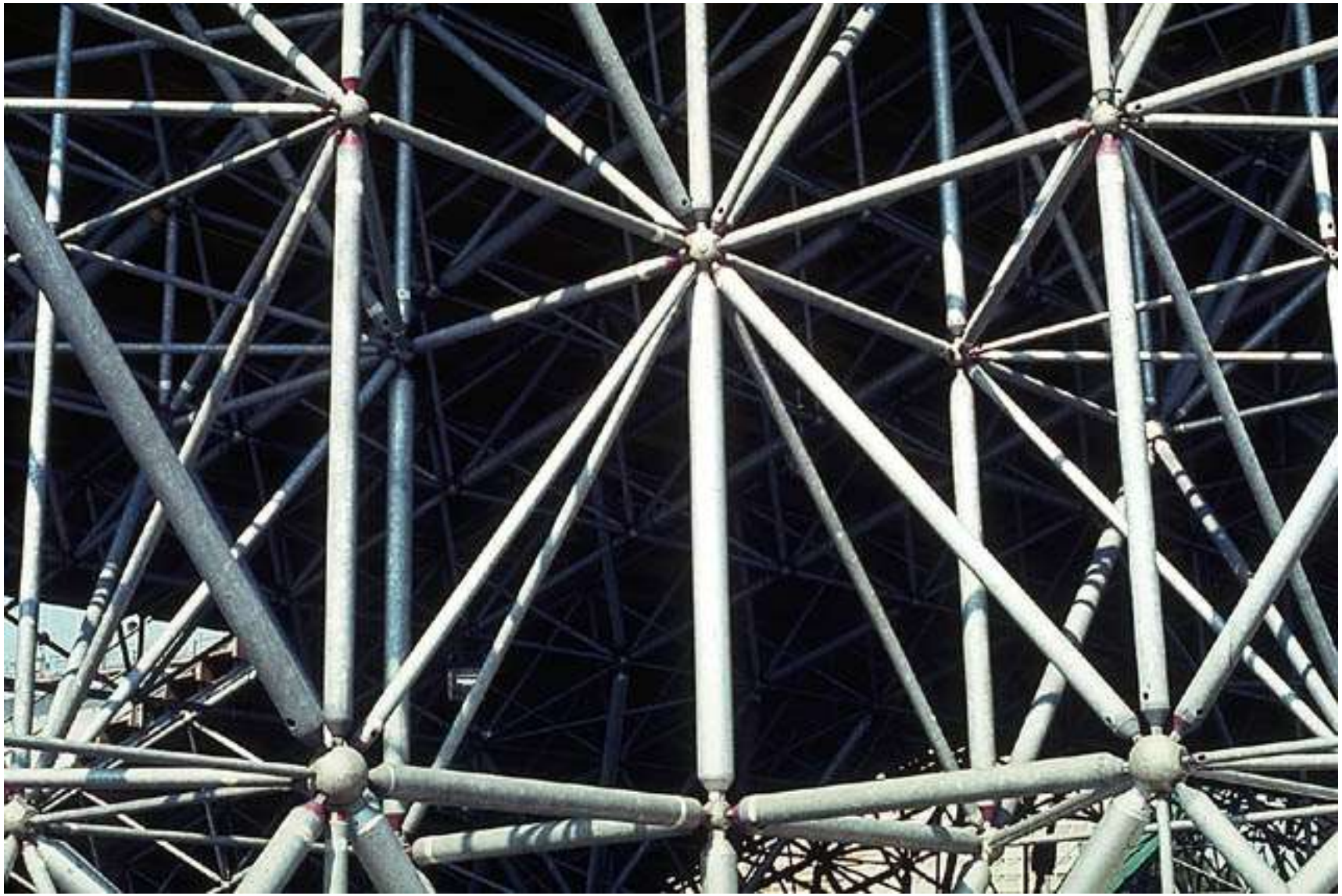
Treliças Planas x Treliças Espaciais

Treliças Espaciais

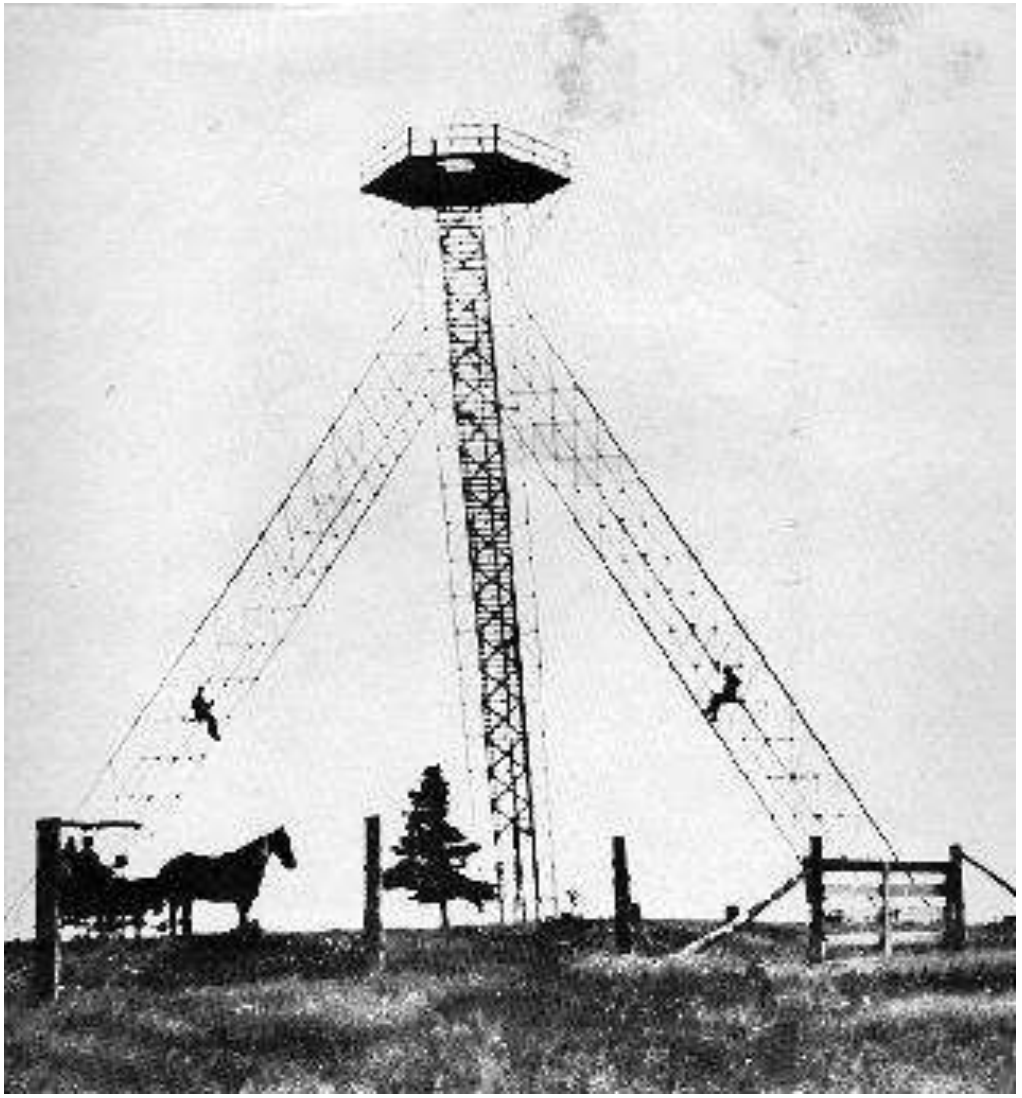


Catedral de Cristal, Arq. Johson Burgee, Garden Grove, California, EUA, 1978-80

Exemplos: Treliças Espaciais



Alexander Graham Bell and the Octet Truss



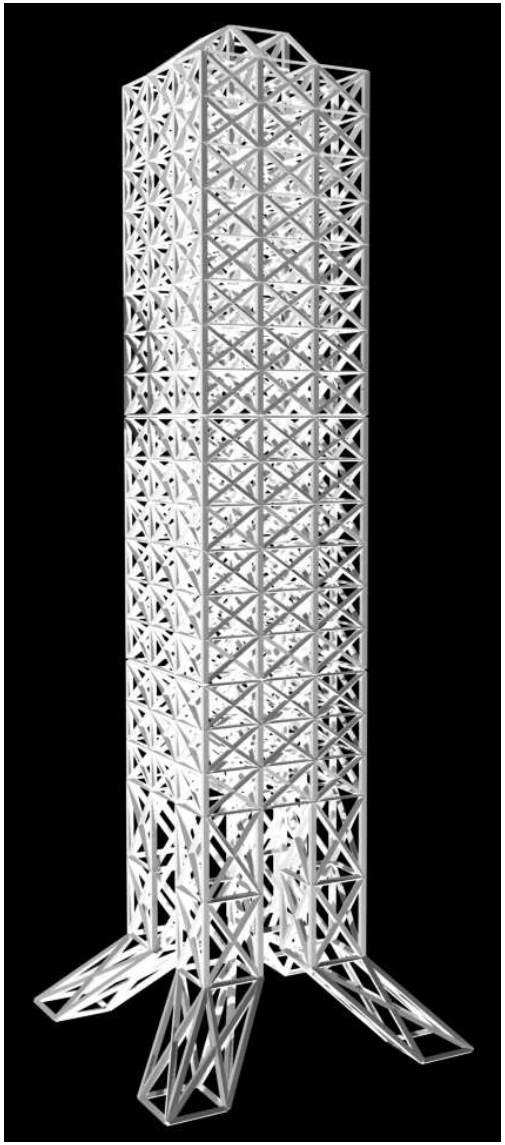
A. Graham Bell
Has New Idea
In Architecture

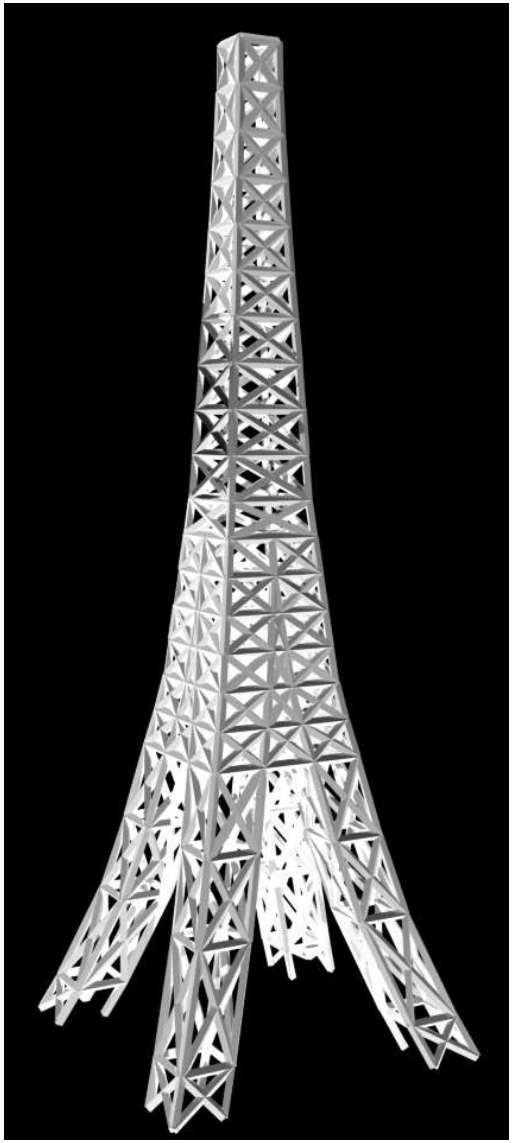
Opening of the Tetrahedral Tower, Seventy Feet High on Beinn Bhreagh.

It May Become an Important Factor in Building of the Future.

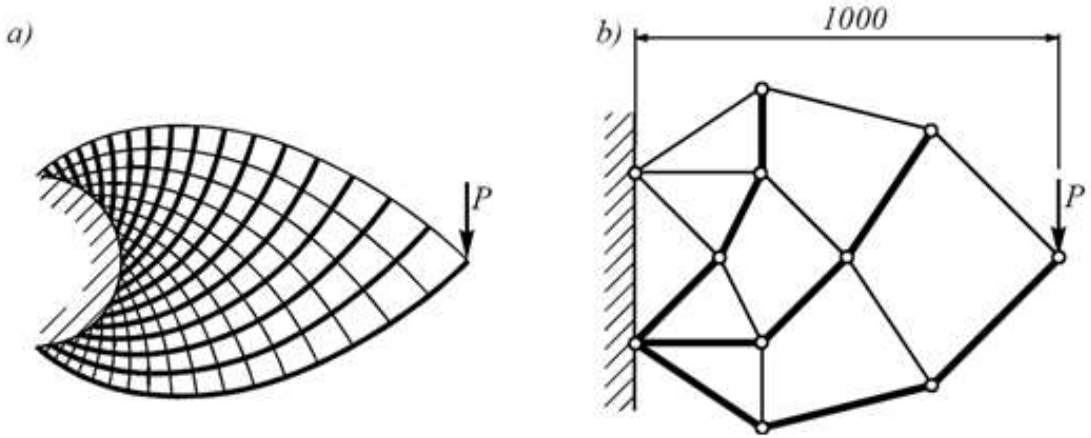
"Climaxing Bell's architectural experiments with tetrahedral structures was an observation tower at Beinn Bhreagh, his summer estate near Baddeck, Nova Scotia. Each unit for this tower consisted of six 4-foot pieces of ordinary galvanized iron pipe and four connecting nuts; the units, themselves, were riveted together in the field by unskilled labor. Upon its completion in September 1907, the tower stood nearly 80 feet high."

Torre Eiffel – uma estrutura otimizada

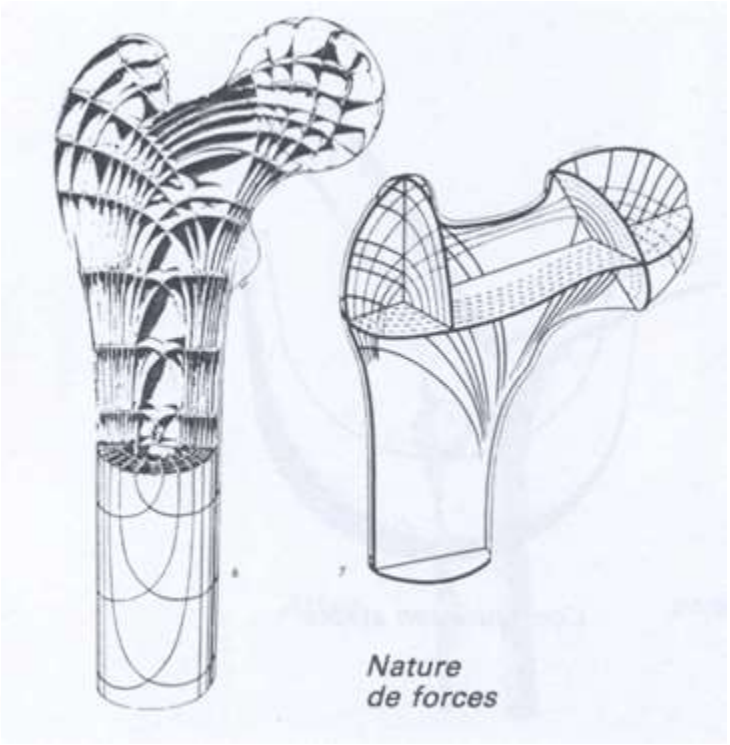


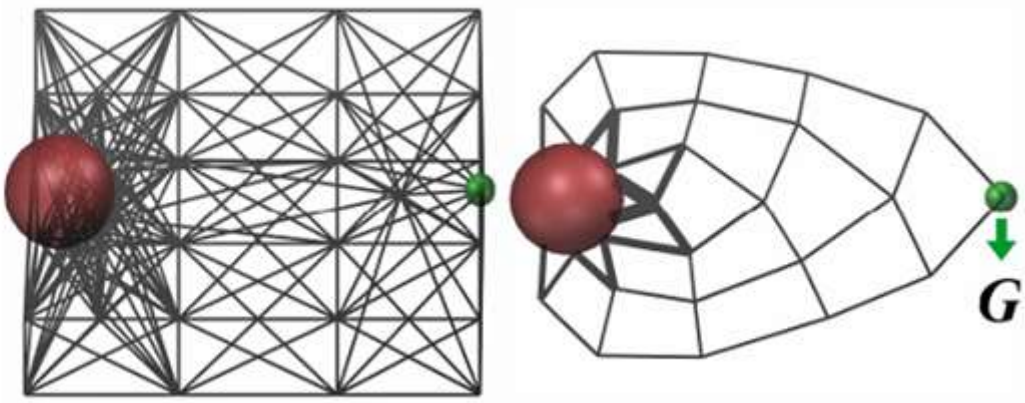


Michell's Truss (~1900)

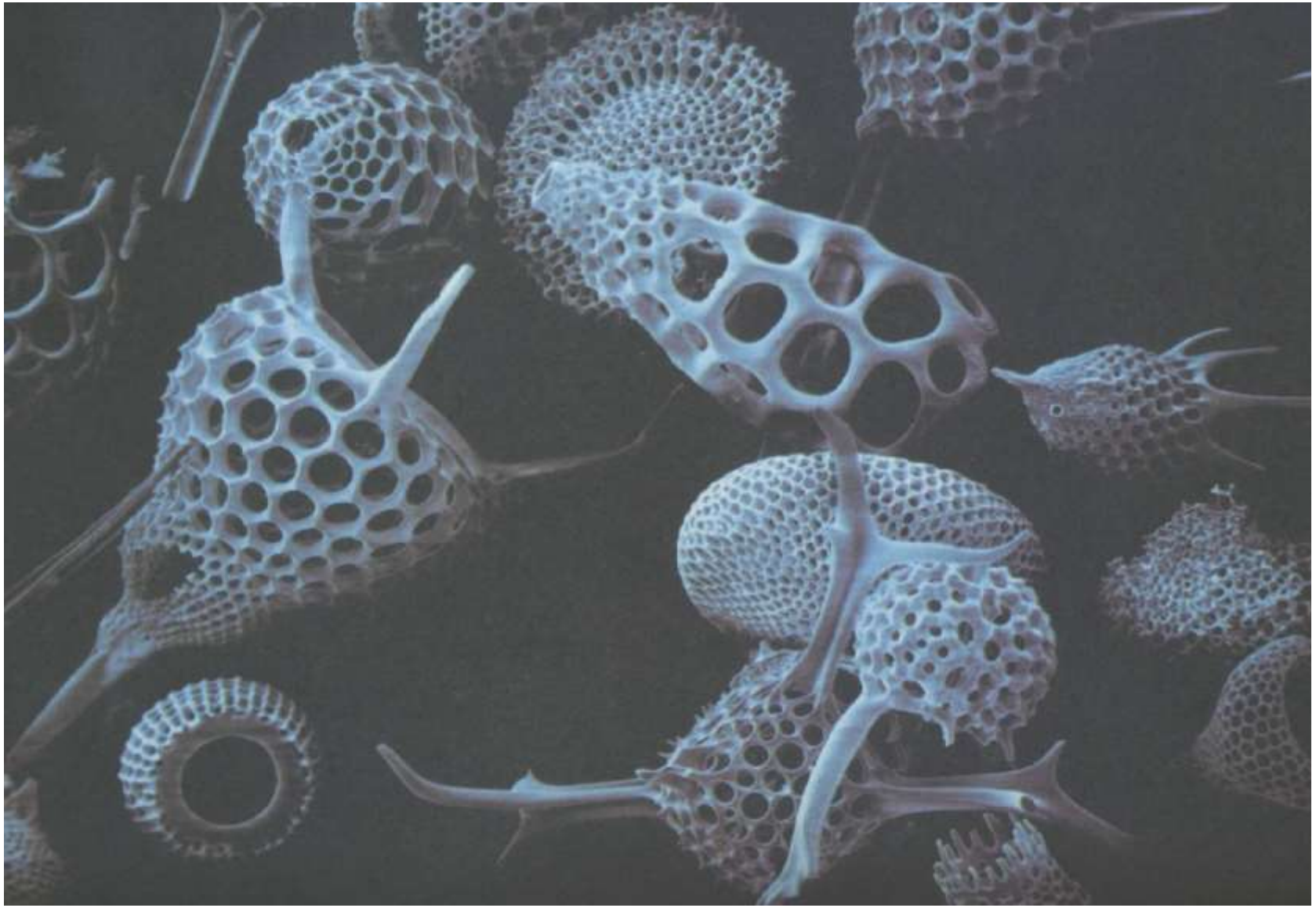


a) Michell structure (approximate rendition)
b) Similar truss structure, simplified





‘Radiolara’



Árvores:
Aeroporto de Stuttgart,
Architect: Gerkan, Mag, and Partners, Hamburg (1981-1991, planejamento / construção) .

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Aeroporto de Stuttgart,

Architect: Gerkan, Mag, and Partners, Hamburg (1981-1991, planejamento / construção) .

Sibelius Hall
Finlândia

Sibelius Hall
Finlândida, 2000.

Architects Kimmo Lintula and Hannu Tikka.

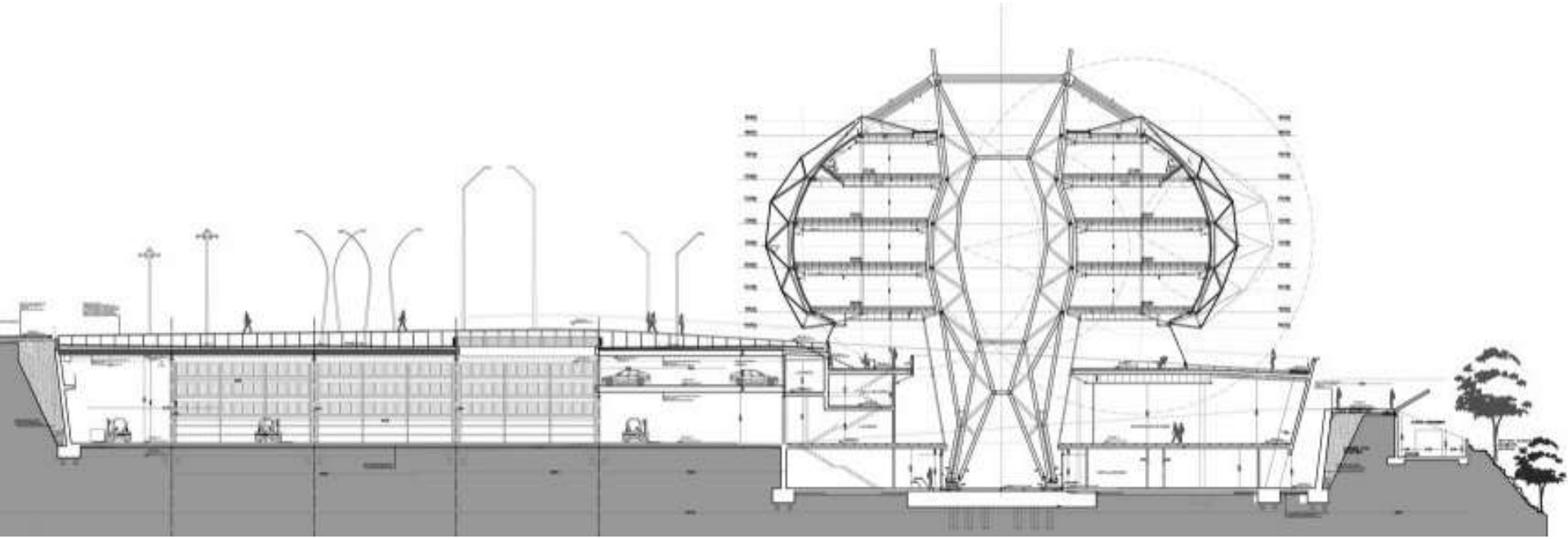
Domos Geodésicos

Pavilhão norte-americano da EXPO 1967 (Montreal)
R. Buckminster Fuller.

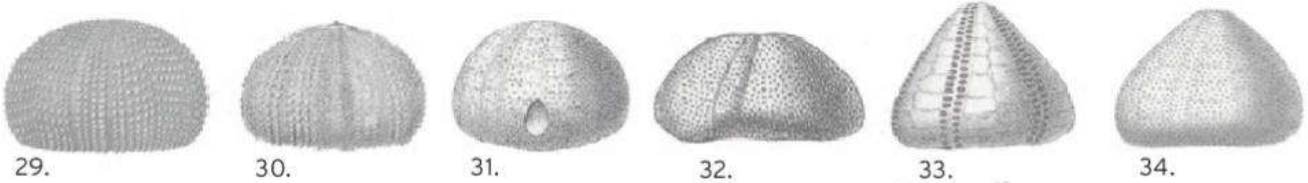
Domo Geodéscio – iGuzzini (Josep Miás, 2011)

¡Guzzini (Josep Miás, 2011)

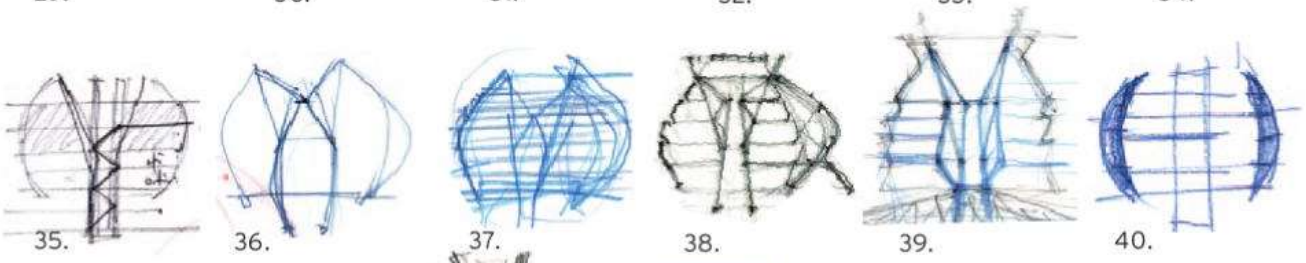
iGuzzini (Josep Miás, 2011)



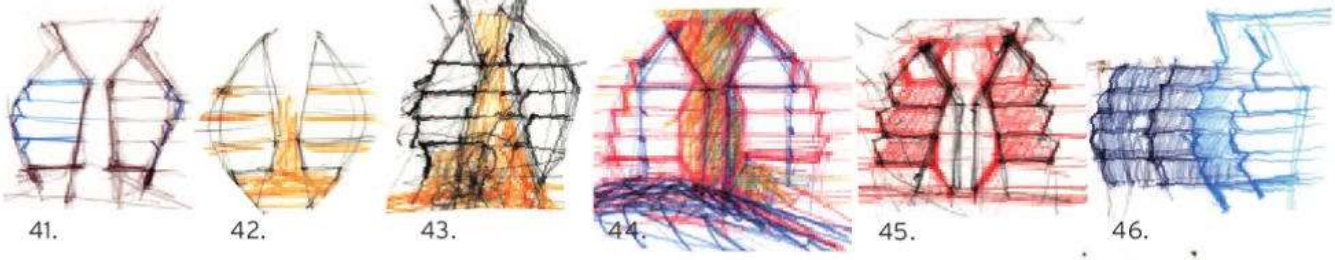
Edifício sede da iguzzini illuminazione ibérica s.a.
Barcelona, 2006 (concurso) 2008-2011 (construção)
Arquiteto: Josep Miàs
Área: 9,000 m²
Orçamento: 12m €



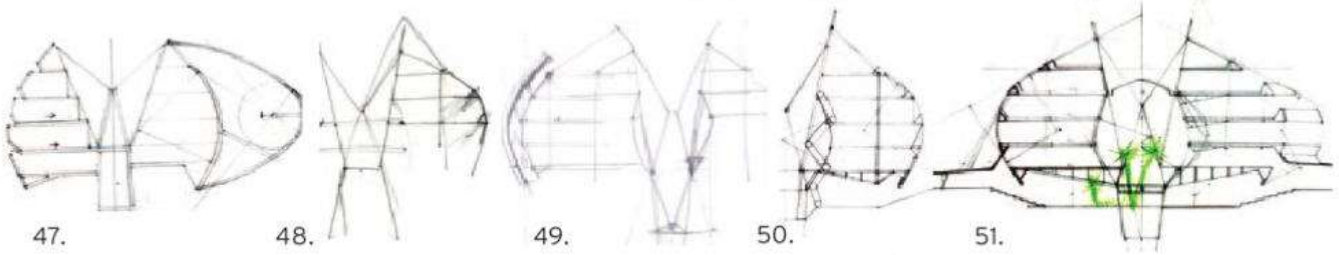
29. 30. 31. 32. 33. 34.



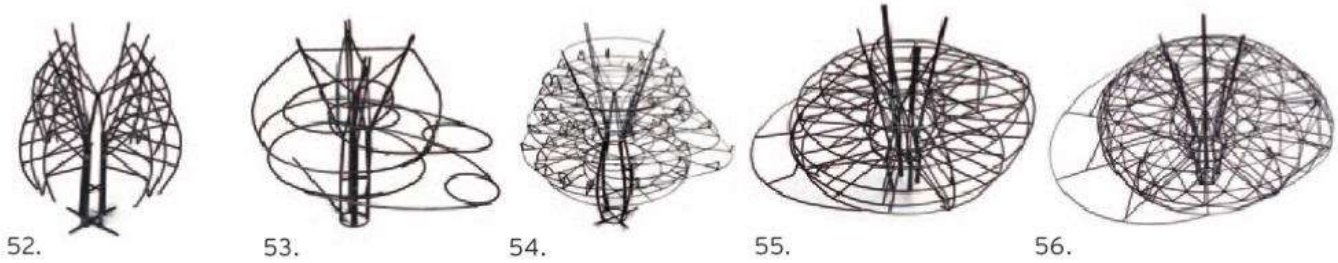
35. 36. 37. 38. 39. 40.



41. 42. 43. 44. 45. 46.



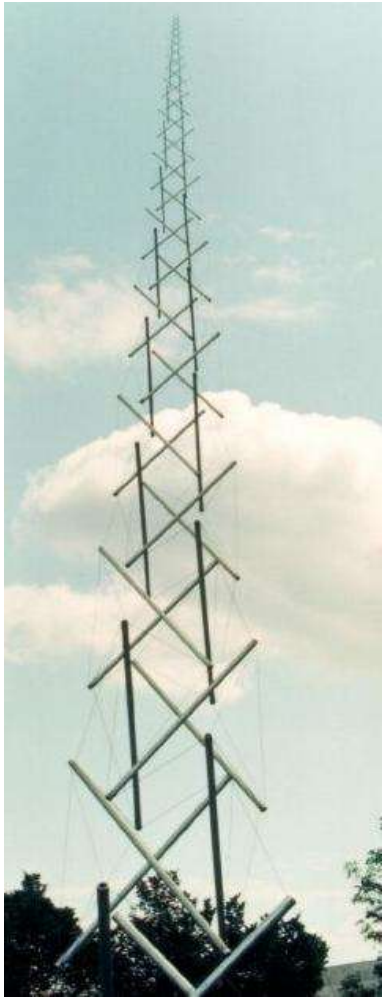
47. 48. 49. 50. 51.



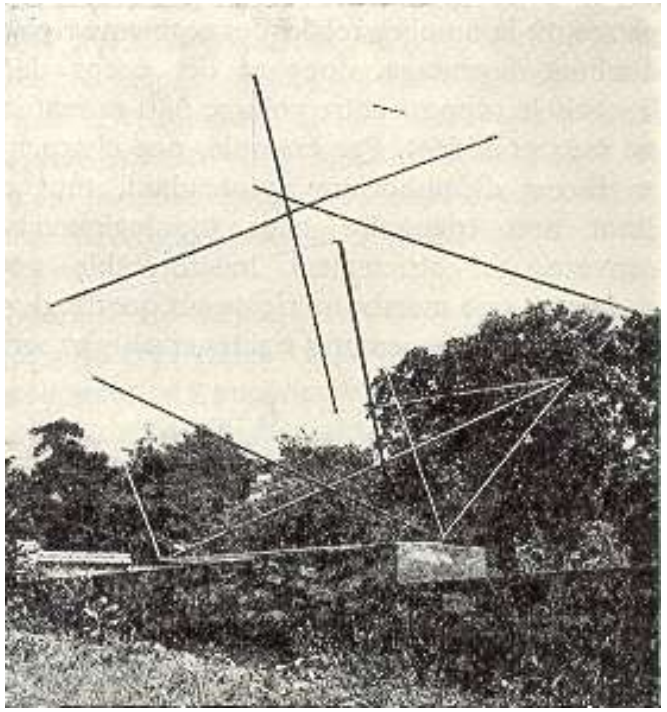
52. 53. 54. 55. 56.

29. 30. 31. 32. 33. 34. Engravings depicting sea urchins with round and ellipsoidal shapes.
35. 36. 37. 38. 39. 40. Early study sketches of the relationship between the overall volume and the courtyard.
41. 42. 43. 44. 45. 46. Sectional study sketches of the central pillar and enclosure.
47. 48. 49. 50. 51. Sectional drawings of the overall project made during the competition stage.
52. 53. Early study model with 4-base geometry. Scale: 1:300 Material: soldered wire.
54. 55. Study model of the volume and the skin deformation with 4-base geometry. Scale: 1:150. Material: soldered wire.
56. Study model of the skin grid with 5-base geometry-based and the sunscreen. Scale: 1:150. Material: soldered wire.

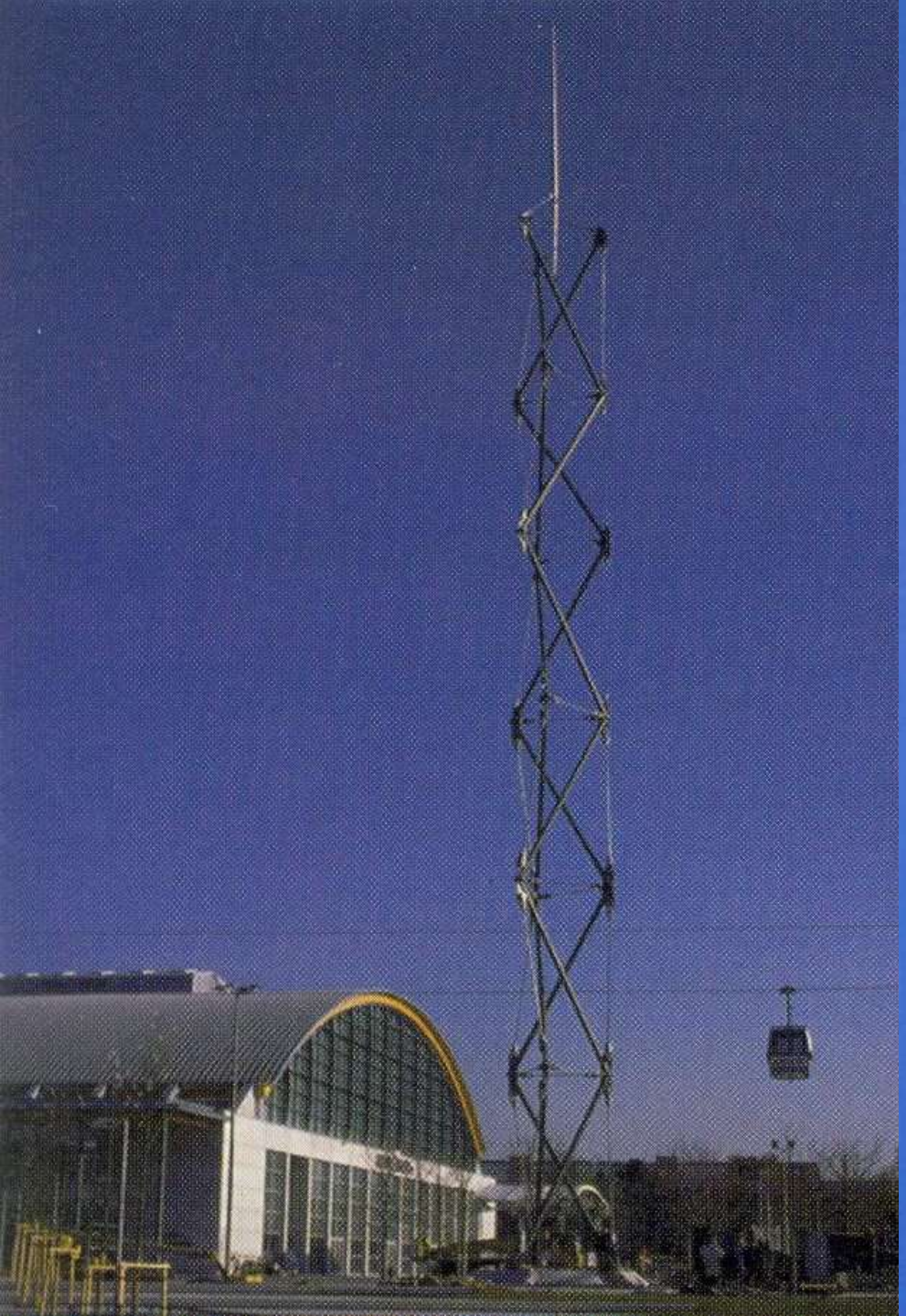
Estruturas ‘tensegrity’



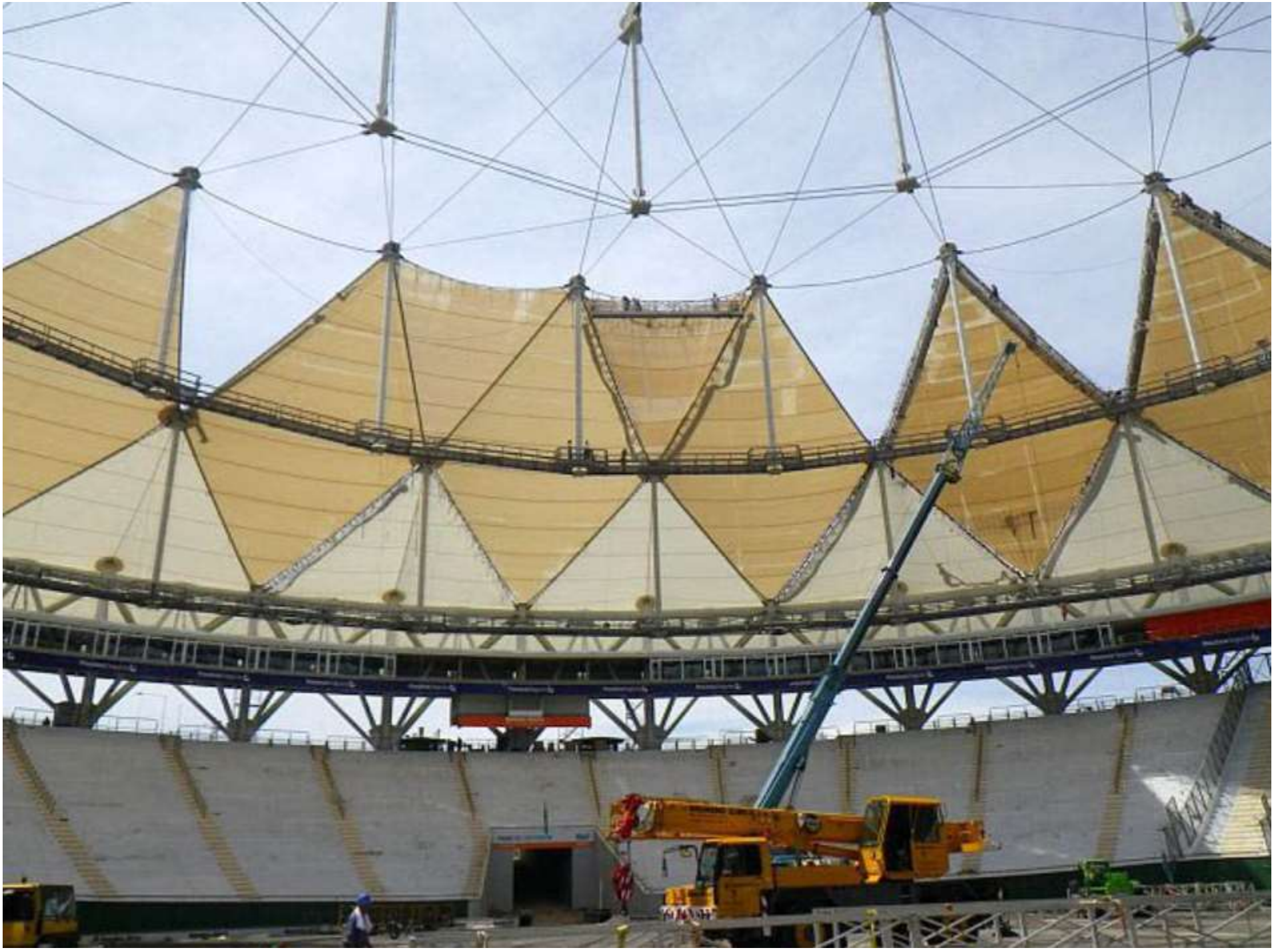
“Needle Tower”,
Keneth Snelson, 1948



Monument à la Forme Futile
Emmerich, 1966

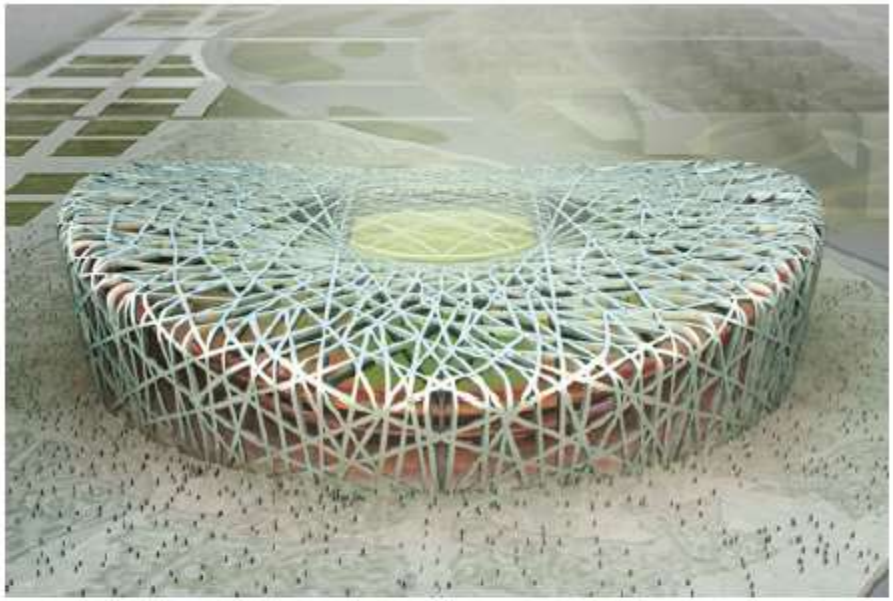


Estadio Único Ciudad de La Plata
Roberto Ferreira & Arquitectos Asociados
Conclusão: 2011



"Cestos", gridshells:

(a)



(b)

Figure 1. Basket-like structures. (a) The "5-dimensional quasi-periodic" garden pavilion by Olafur Eliasson in Holbaek, Denmark, 1998 (courtesy of Mr Eliasson). (b) The Beijing Olympic Stadium designed by Herzog & de Meuron for the 2008 Olympic Games (taken from the Internet).

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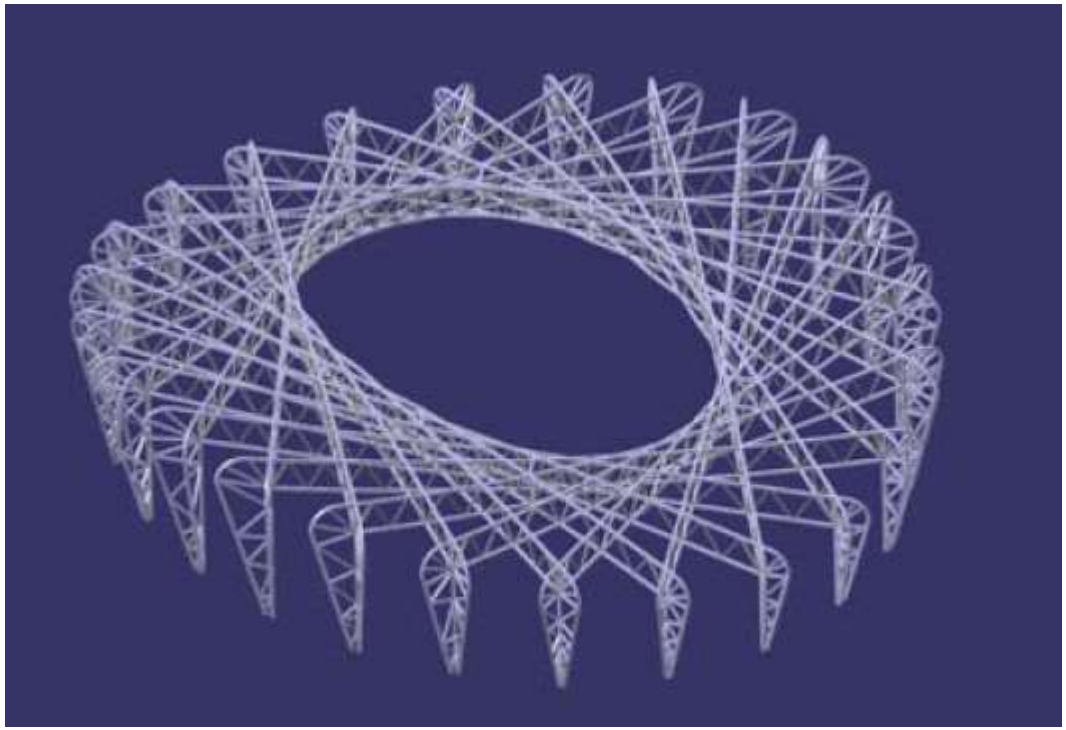
NEW SHELL AND SPATIAL STRUCTURES

BASKETS

Tibor TARNAI
Professor, Department of Structural Mechanics, Budapest University of Technology and Economics, Budapest, Müegyetem rkp.3., H-1521 Hungary

Estádio Olímpico de Pequim
"Bird´s Nest"
Março, 2008

Location: Beijing, China
Broke ground: December 2003
Owner: Government of the People's Republic of China
Construction cost: ~USD $500 million
Architect: Herzog & de Meuron, ArupSport, CAG
Capacity: 80,000 / 91,000 (Olympics)



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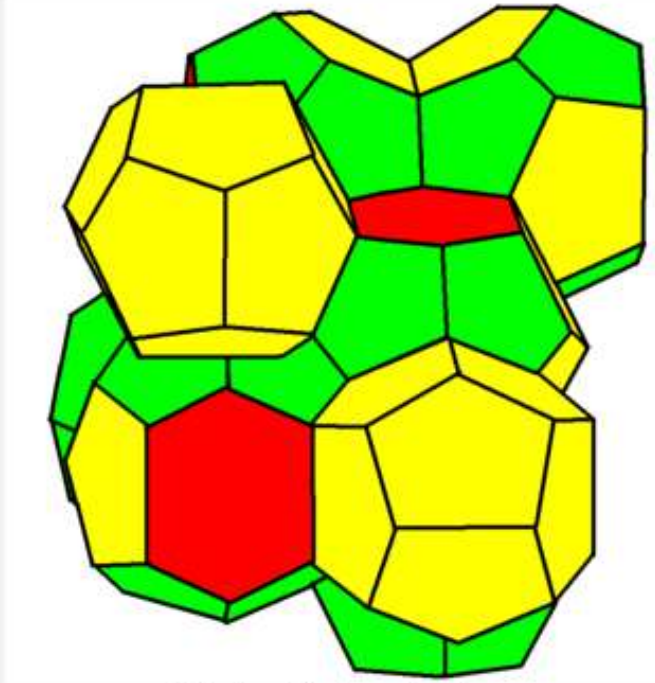
NEW SHELL AND SPATIAL STRUCTURES

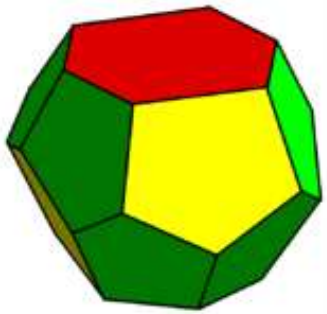
RESEARCH & DESIGN OF TWISTED BOX-SECTIONS OF PRIMARY STRUCTURES FOR NATIONAL STADIUM BEINJING

Zhong FAN[1], Yi PENG[2], Zhe WANG[2], Jiaru QIAN[3], Zuozhou ZHAO[4]

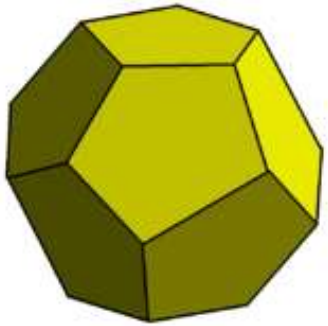

水立方欢迎您



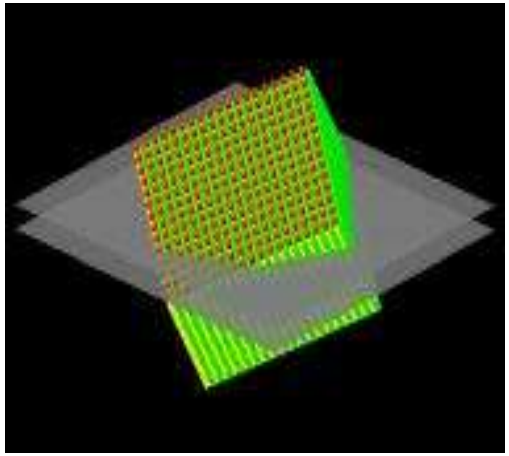
Weaire-Phelan structure
(as polyhedra)



irregular tetrakaidecahedron



irregular dodecahedron



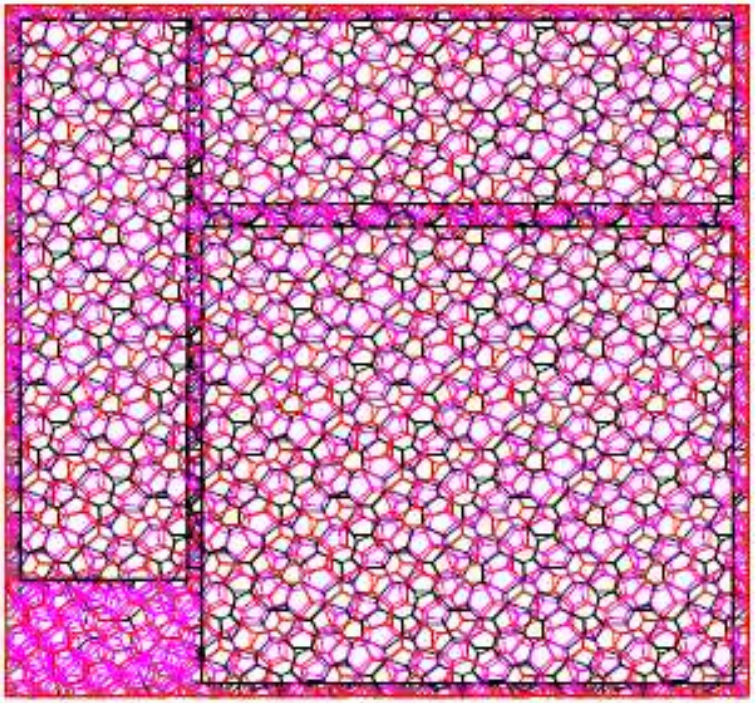


Figure 3. Architecture Plan View

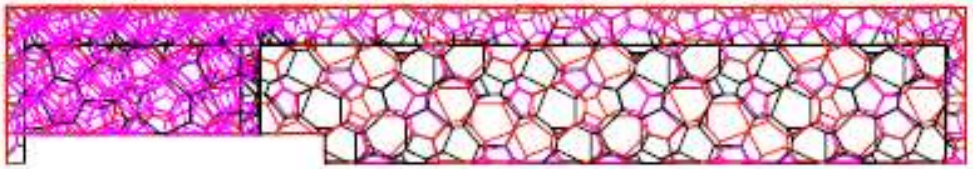


Figure 4. Architecture Elevation View

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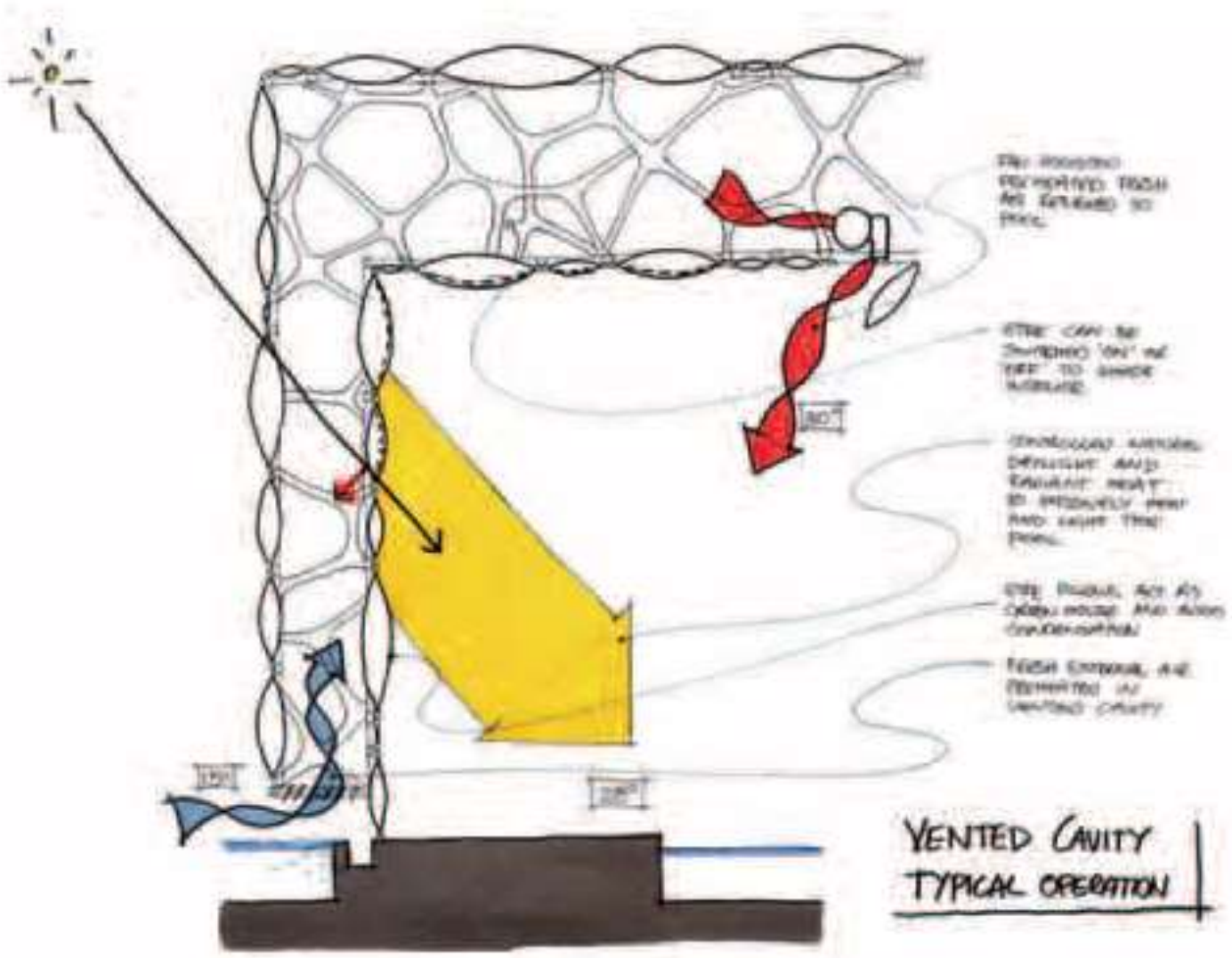
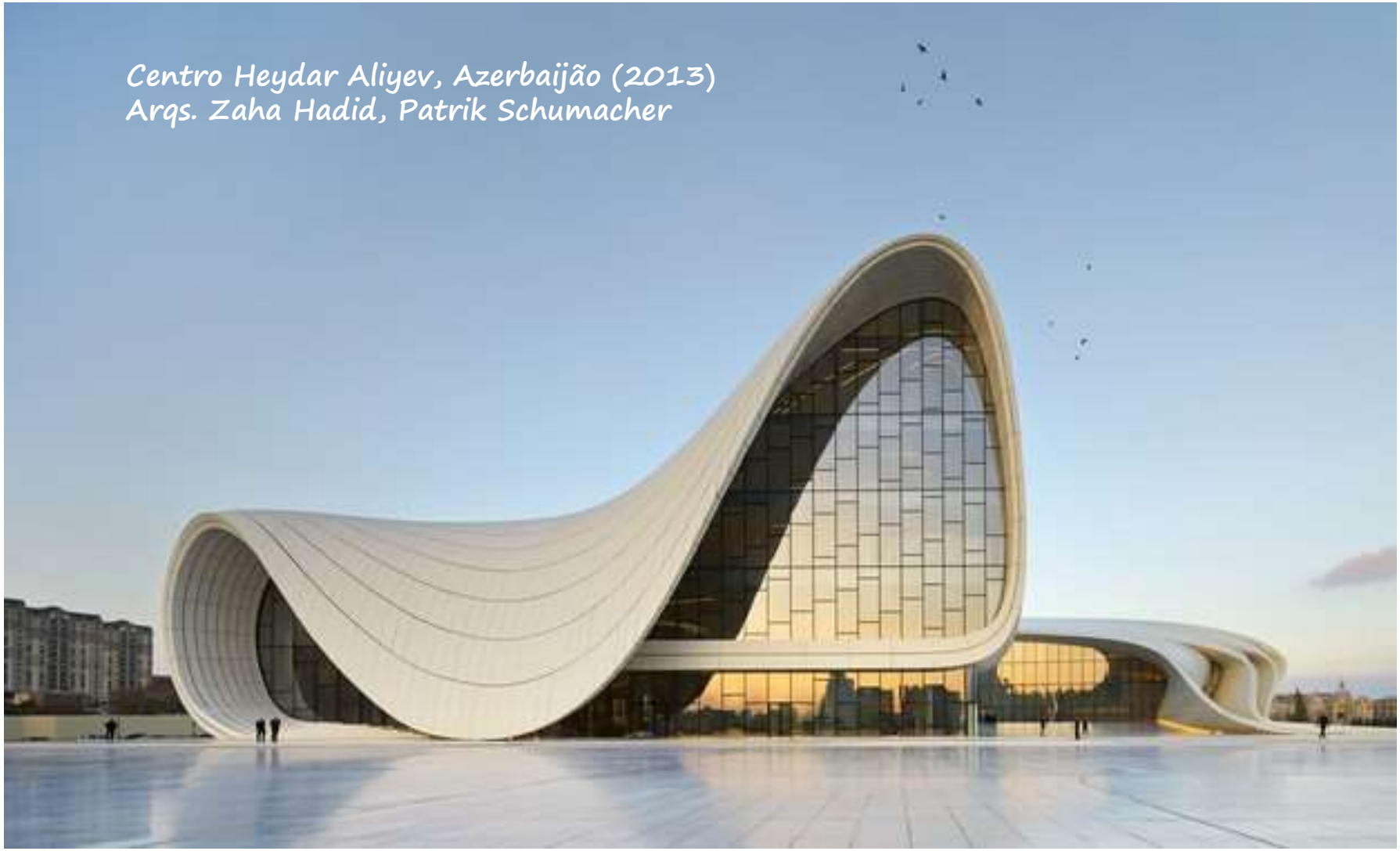
CONSTRUCTION TECHNOLOGIES STUDY OF POLYHEDRAL SPACIAL RIGID FRAME FOR NATIONAL SWIMMING CENTER

Guan-Gen ZHOU[1], Yang LIU[2]


VENTED CAVITY
TYPICAL OPERATION


Gridshell: Metropol Parasol
Jürgen Mayer H. Architects (2011)


Centro Heydar Aliyev, Azerbaijão (2013)
Arqs. Zaha Hadid, Patrik Schumacher

Gridshell – Anaheim Regional Transportation Intermodal Center (HOK, 2014)