Progressos no campo das Estruturas de Membrana

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EPUSP

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Progressos no campo das Estruturas de Membrana

1. O Projeto das Estruturas de Membrana – idéias básicas

2. Alguns Casos de Estudo

3. Tensoestruturas no Brasil

3. Evolução das Estruturas pneumáticas

4. Coberturas de estádios no Brasil e no mundo

5. Debate


CMSC

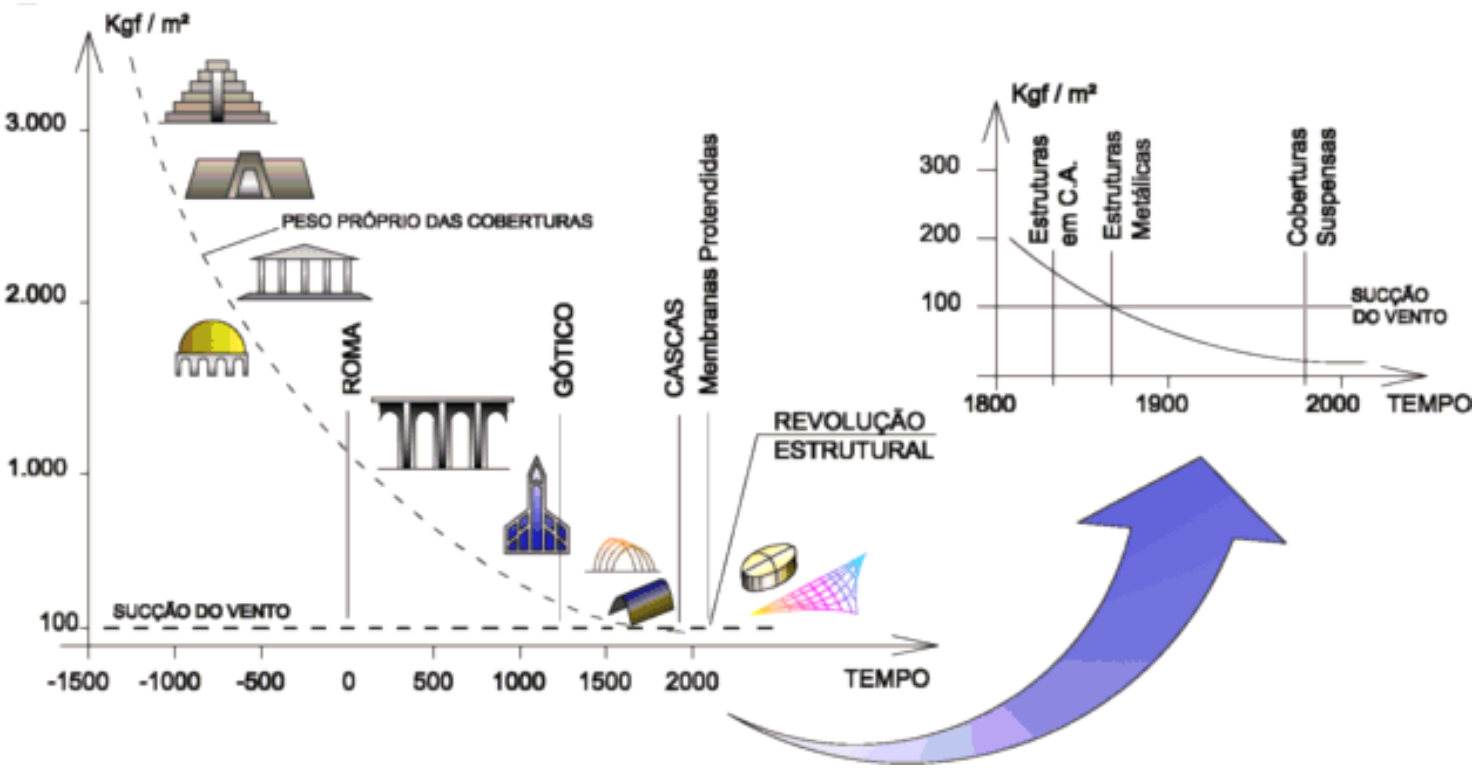
***Estruturas Retesadas ("Tensoestruturas")**:*

aquelas que, para funcionarem a contento, dependem de seus elementos estarem *retesados*, e não *frouxos*.

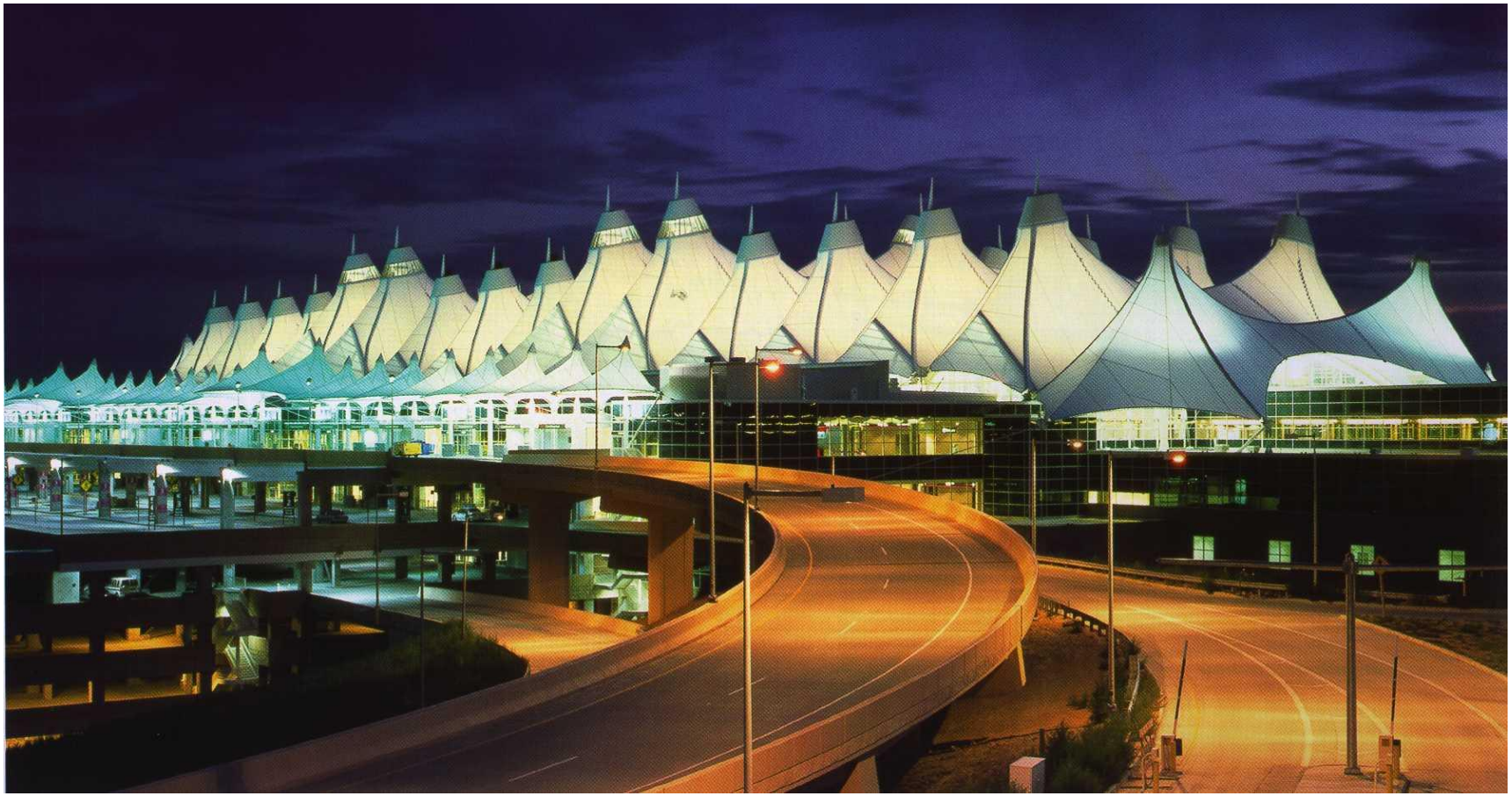
Retesar (v.t.): entesar, tornar tenso ou retesado, esticar, enrijar; pôr a direito. ***Retesado*** (adj.): entesado, enrijado, tenso, hirto, bem teso. ***Retesamento*** (s.m.): ato ou efeito de retesar.

[Caldas-Aulete, 1956]

'Estruturas leves' - *"Light structures"*

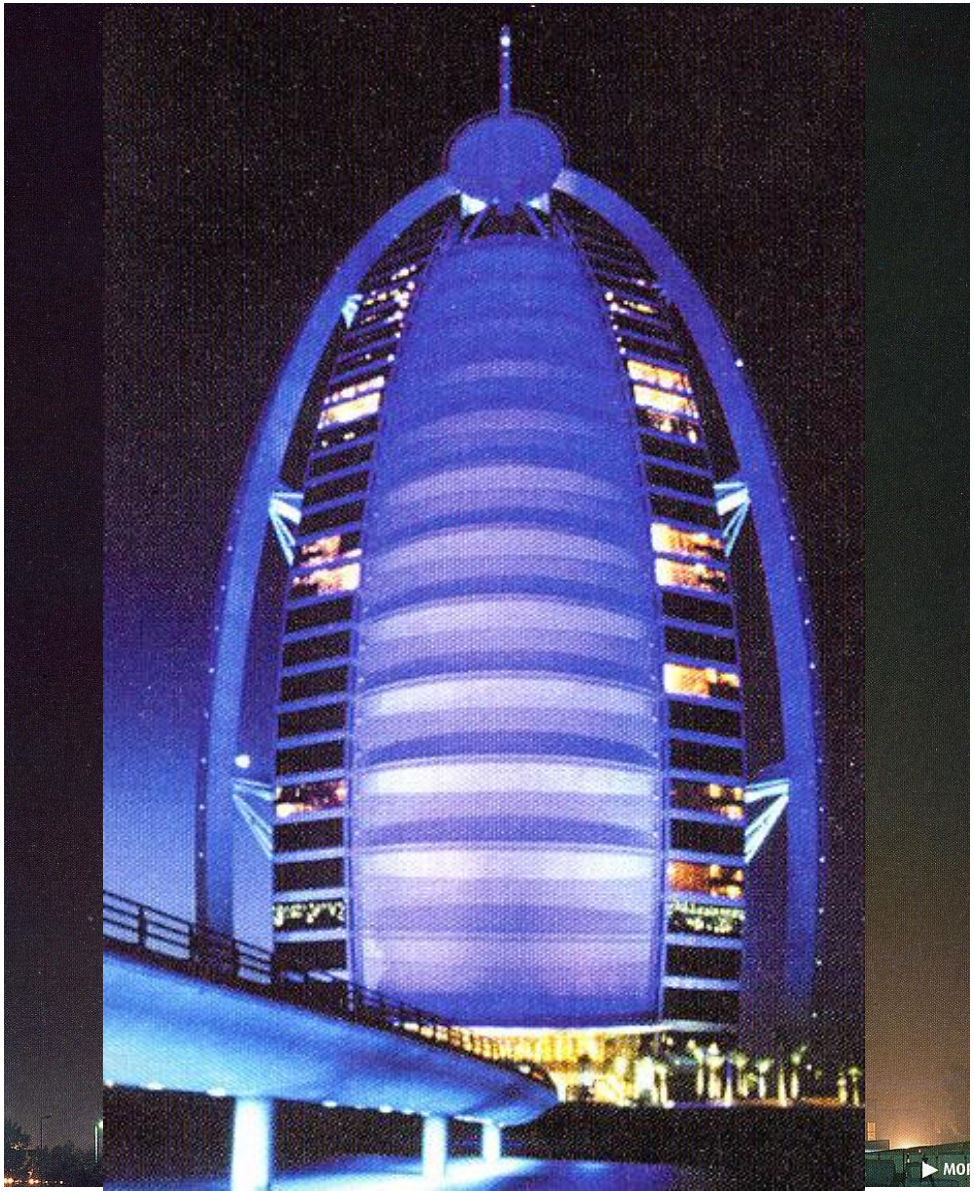


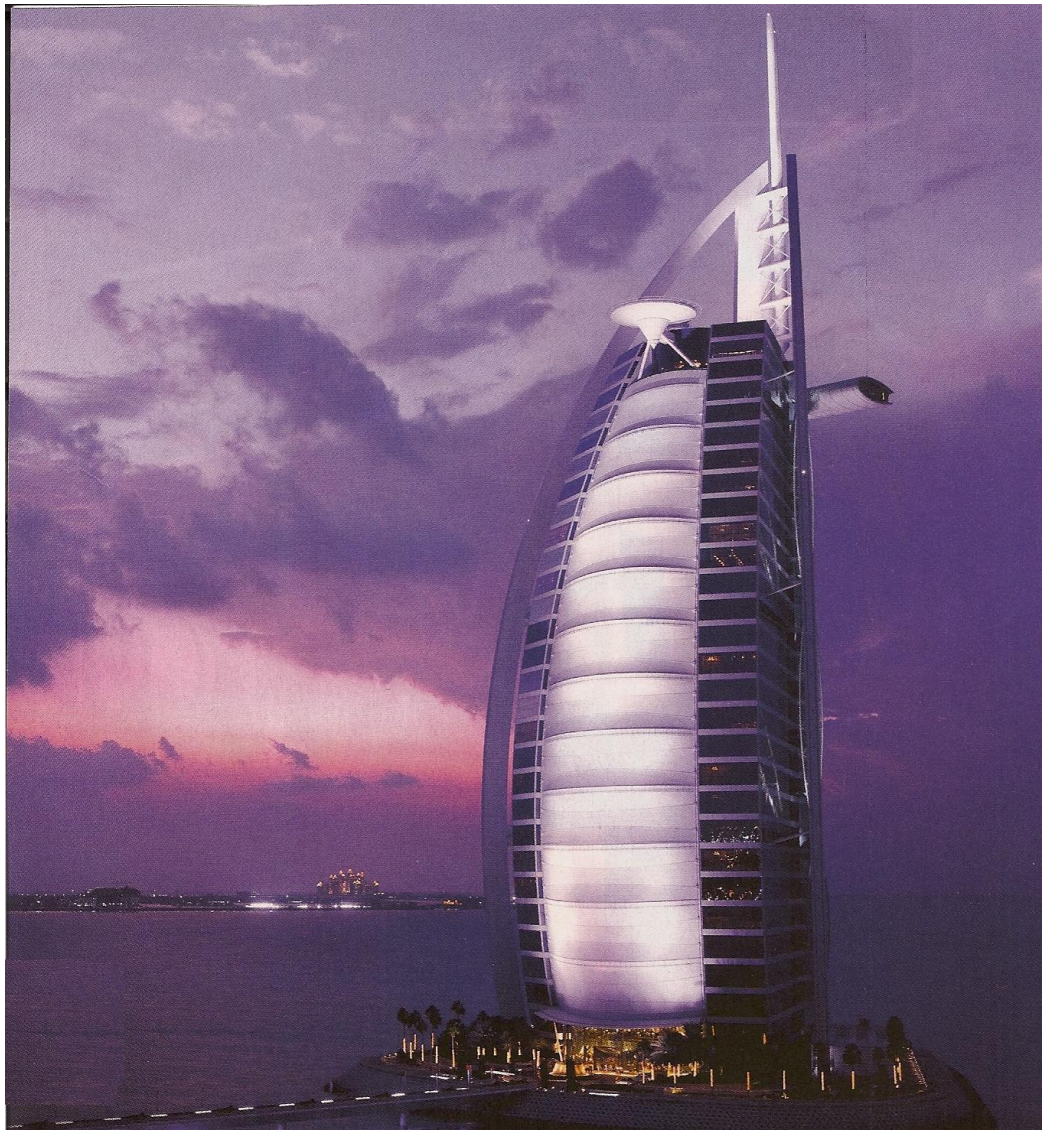
Estruturas luminosas ("Light structures, structures of light" – H. Berger)

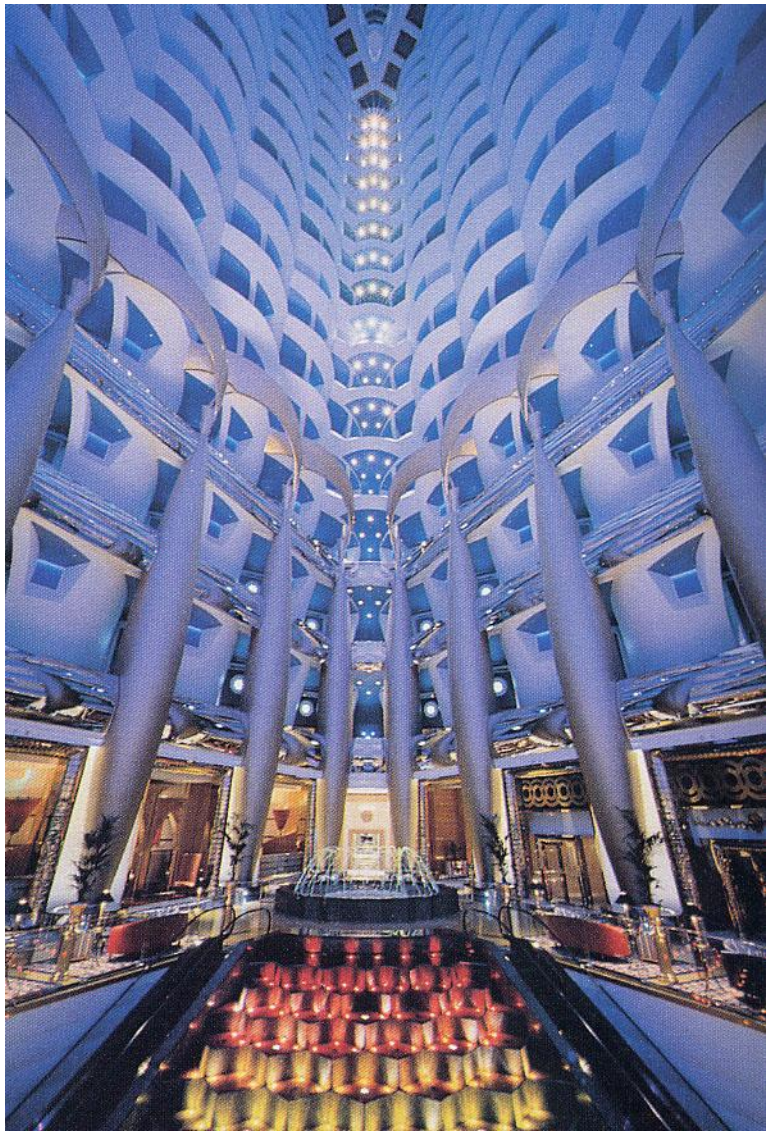


Estruturas luminosas ("Light structures, structures of light" – H. Berger)

‘Estruturas luminosas’ (“Light structures, structures of light” – H. Berger)







Vienna International Airport Control Tower, 2005

Suvarnabhumi Airport, Bangkok, Thailand


#Select Your Ultimate

Ocean Dome, Japan

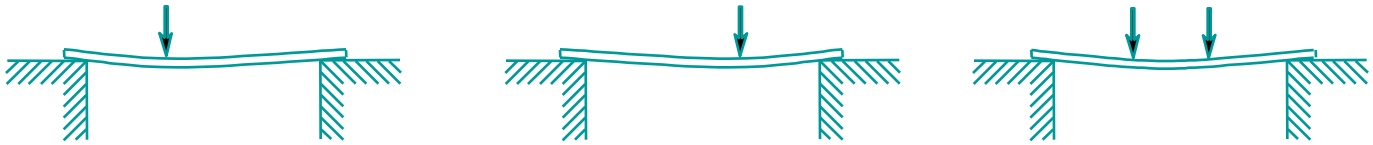
the world's largest indoor water park (300m-100m-38m), with a retractable roof.

Domo do Milênio
– Londres, 2000

Domo do Milênio: cobertura e sistema de cabos.

Detalhes Domo do Milênio...

Estruturas retesadas são 'flexíveis' :



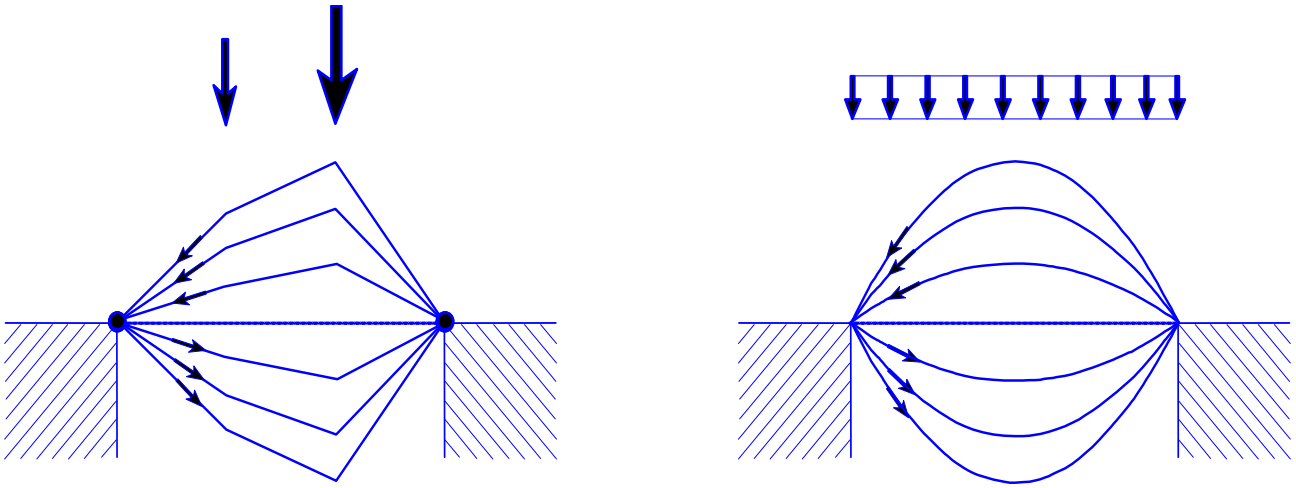
(a) uma estrutura 'rígida', como uma viga, não muda drasticamente de forma, ao variar do carregamento

(b) uma estrutura 'flexível', como um cabo, muda drasticamente de forma, ao variar do carregamento

Passarela semi-destruída em Mardan, Paquistão – agosto 2006

Por serem flexíveis, as estruturas retesadas devem se conformar às formas funiculares associadas a um dado padrão de carregamentos:

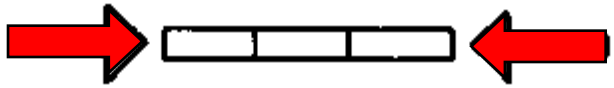
"Aquelas que equilibram um conjunto de cargas, sem o surgimento de esforços de flexão"



Ponte sobre o estreito de Menai (1826, vão livre 177m)

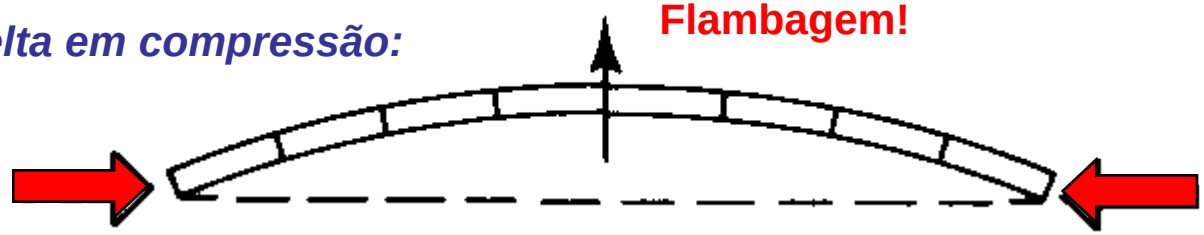
Estados de Solicitação Interna

- ***Barra curta em compressão:***



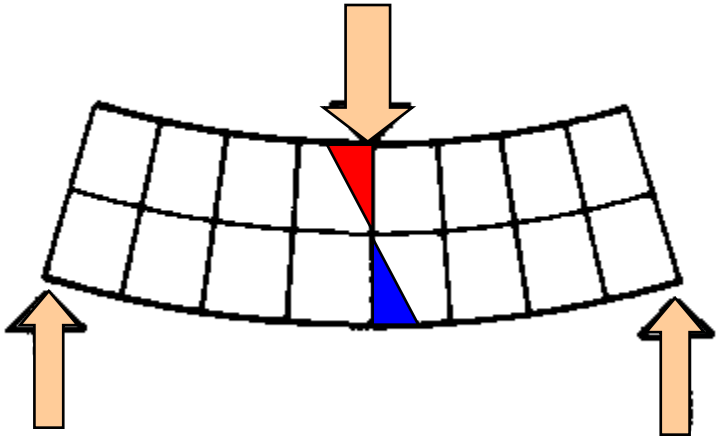
- ***Barra esbelta em compressão:***

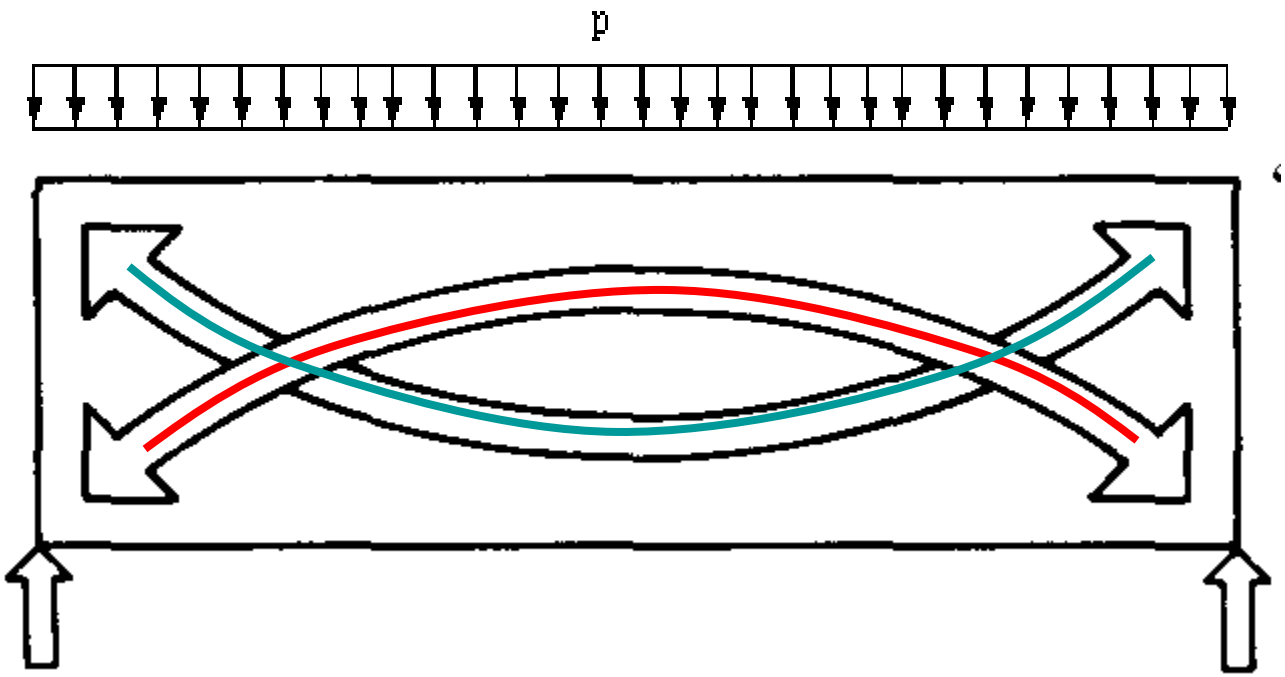
Flambagem!



- ***Barra esbelta em tração:***

- ***Barra sujeita à flexão:***

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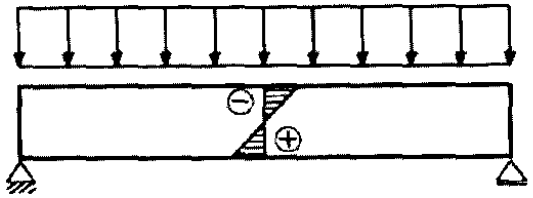
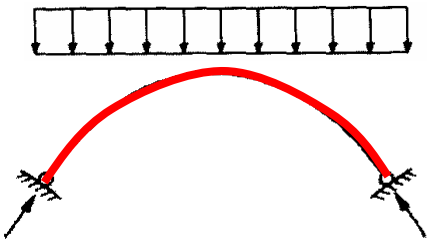
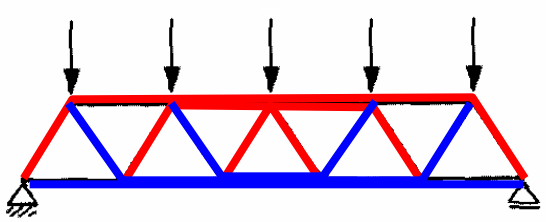
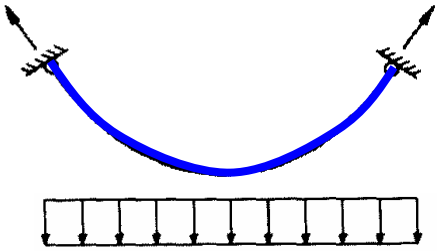
Flexão

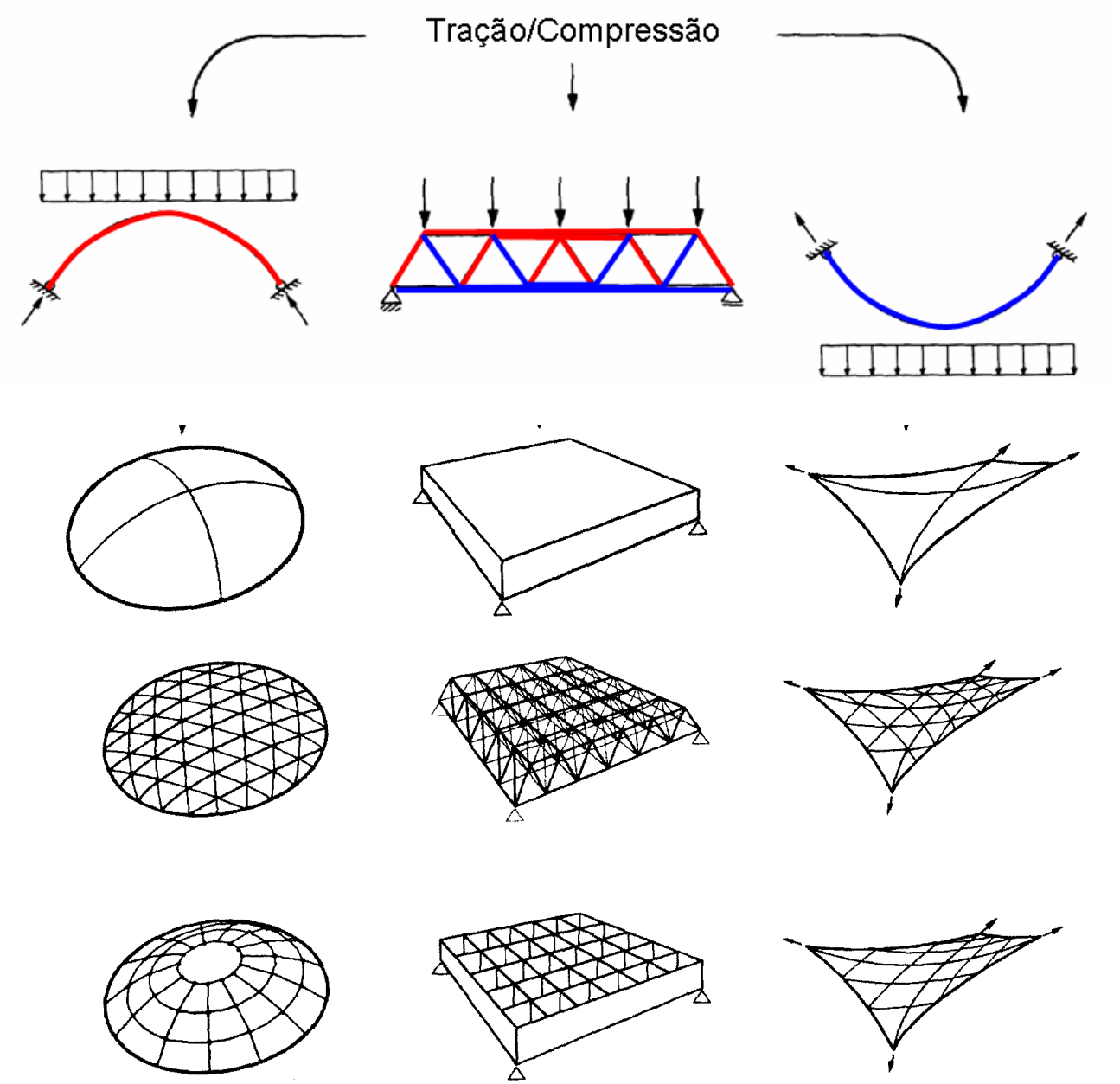


Compressão / Tração



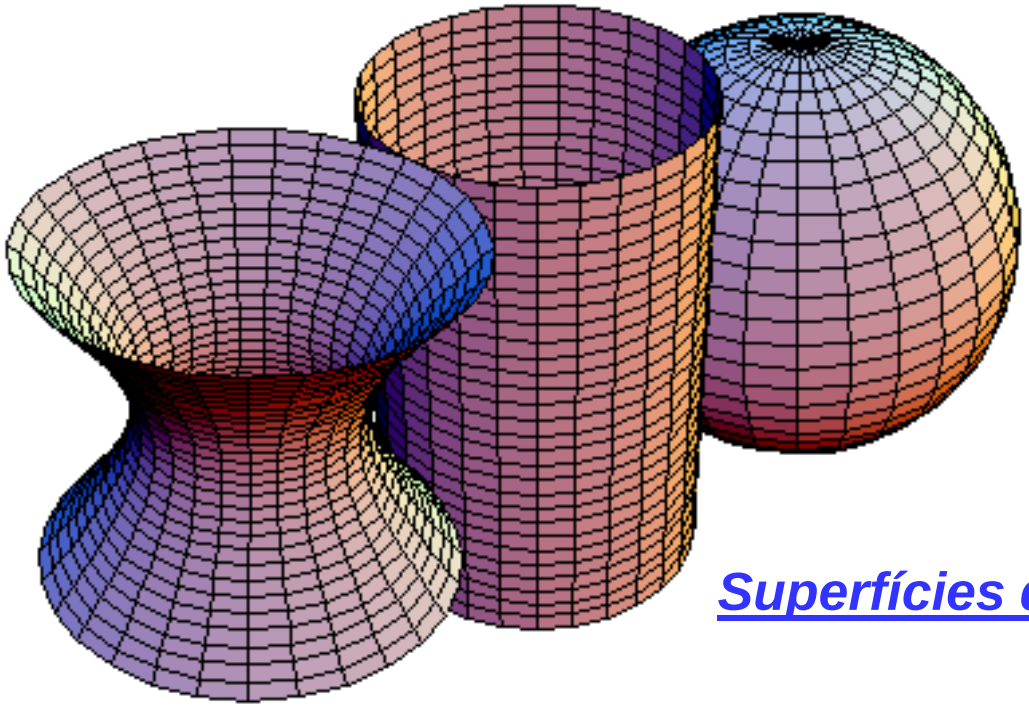






R.M.O.Pauletti - www.lmc.ep.usp.br/people/pauletti

Superfícies de dupla curvatura:



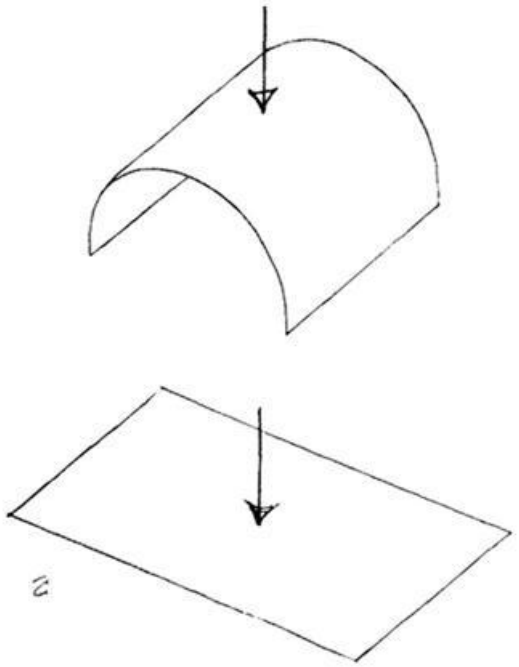
Superfícies sinclásticas:
dupla curvatura no mesmo sentido

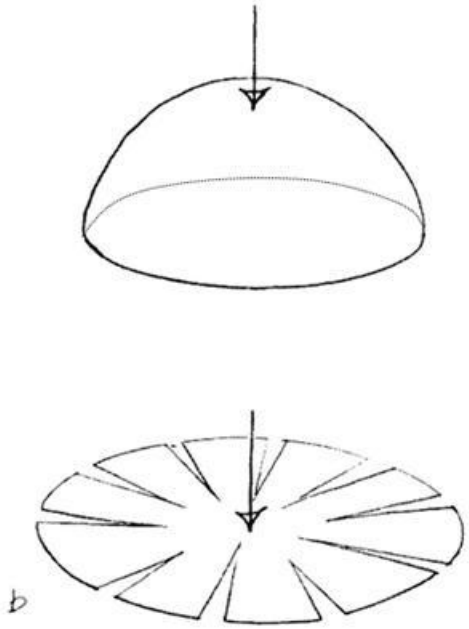
Superfícies de curvatura simples

Superfícies anticlásticas
dupla curvatura em sentidos reversos


SAVE
THE
CLIMATE
Liddell
Power Station

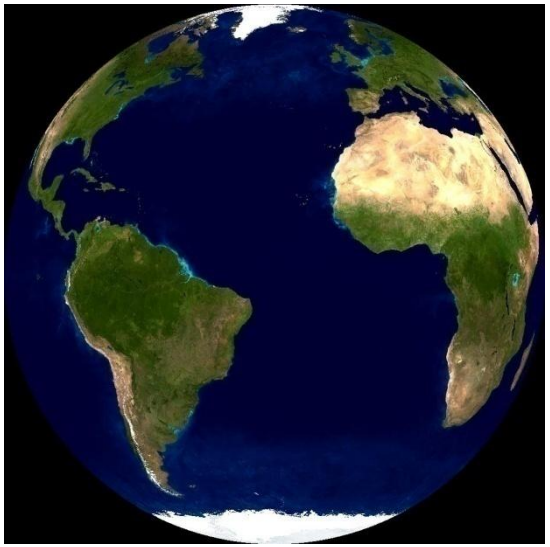
Planificação

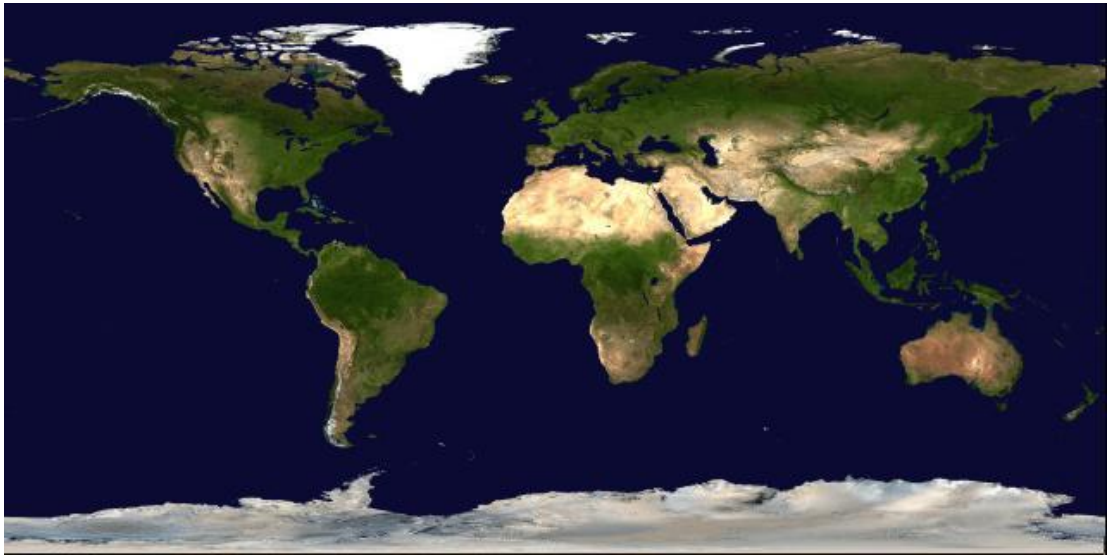


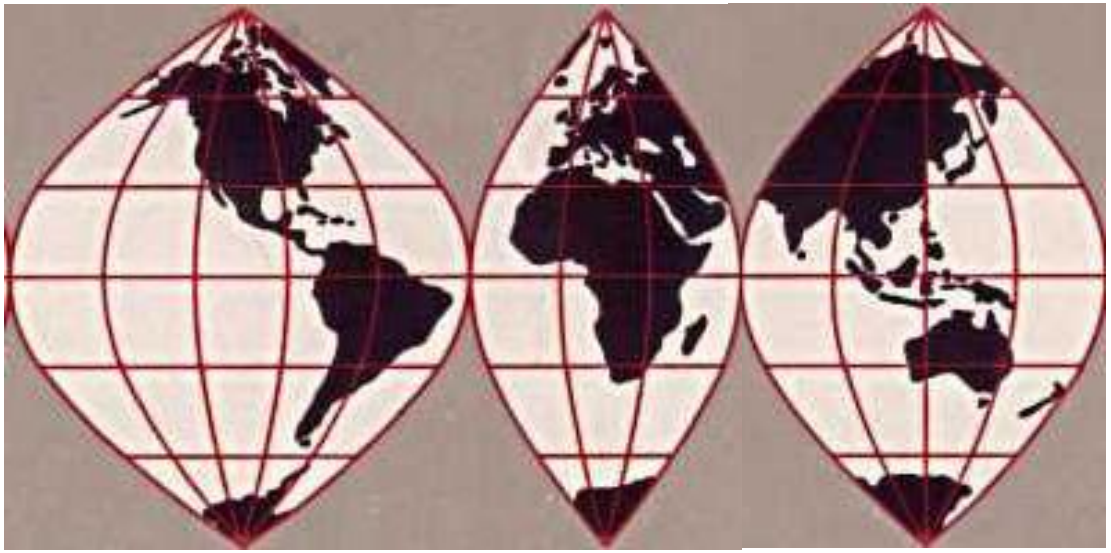


Superfícies de curvatura simples apenas podem ser planificadas sem distorção;

Superfícies de dupla curvatura sofrem distorção ao serem planificadas.







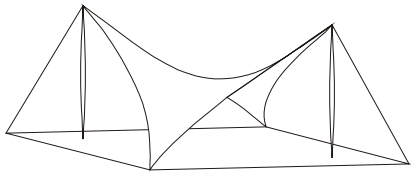
R.M.O.Pauletti - www.lmc.ep.usp.br/people/pauletti

O Processo de Projeto das Estruturas retesadas

"No other class of architectural structural systems is as dependent upon the use of digital computers as are tensile membrane structures".

David Campbel [*ASCE Second Civil Engineering Automation Conference,* 1991].

INTENÇÃO ARQUITETÔNICA:



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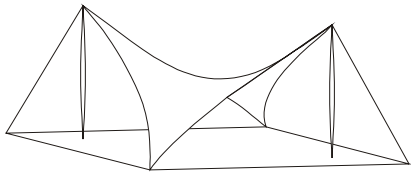
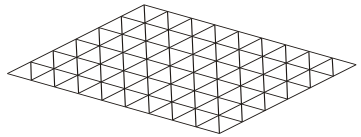
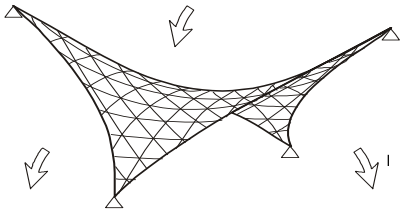


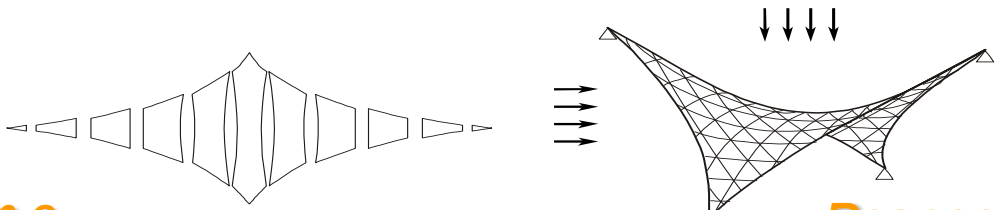
PROJETO / ANÁLISE:



Forma inicial, inviável



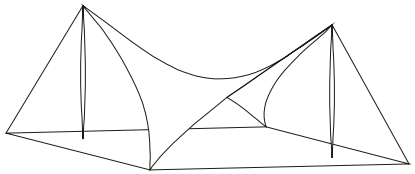
Forma final, viável



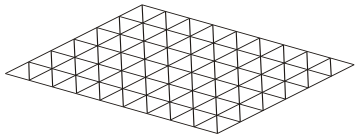
Padronagem e panificação

Resposta aos carregamentos

INTENÇÃO ARQUITETÔNICA:



PROJETO / ANÁLISE:



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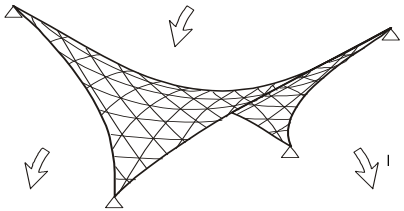
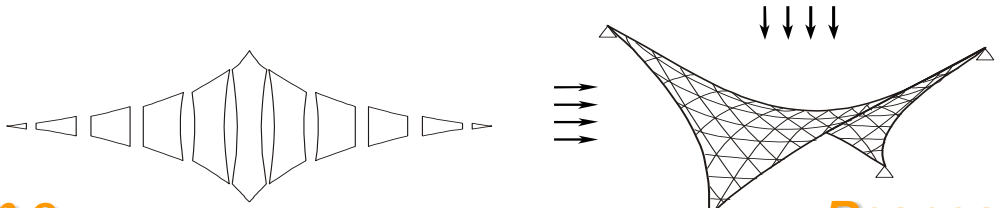


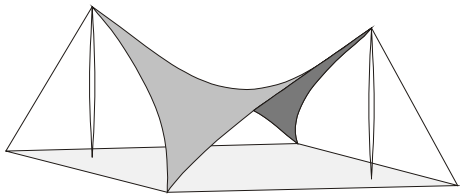
Forma final, viável



Padronagem e panificação

Resposta aos carregamentos

SOLUÇÃO DE PROJETO



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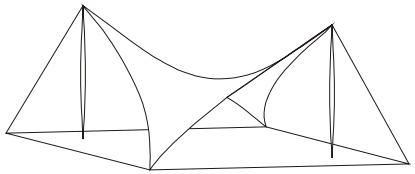
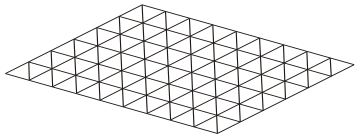
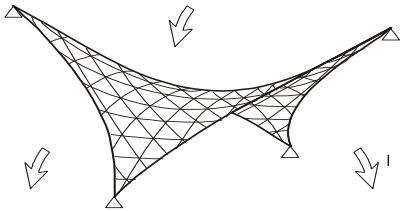


PROJETO / ANÁLISE:



Forma inicial, inviável



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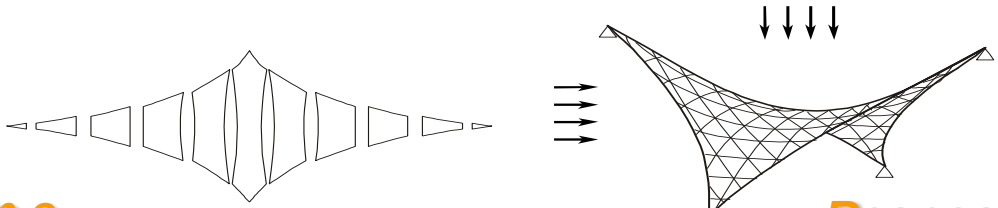
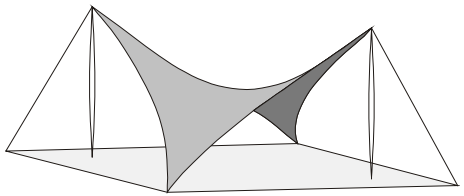


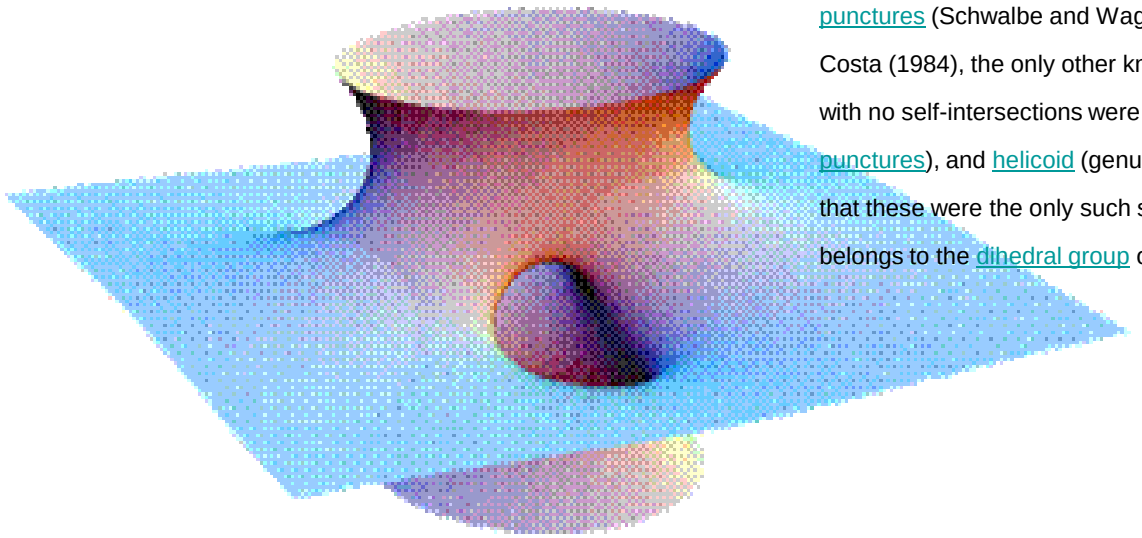
Padronagem e panificação

Resposta aos carregamentos

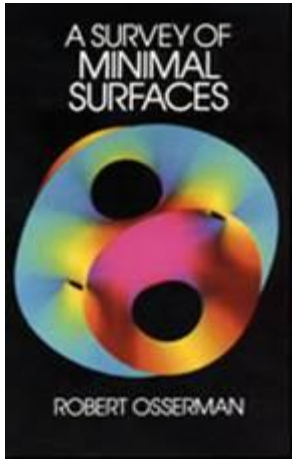
SOLUÇÃO DE PROJETO



Costa Minimal Surface



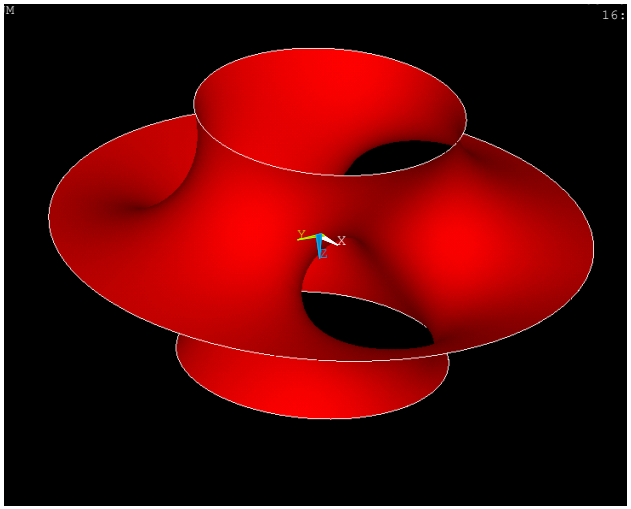
The Costa surface is a complete minimal embedded surface of finite topology (i.e., it has no boundary and does not intersect itself). It has genus 1 with three punctures (Schwalbe and Wagon 1999). Until this surface was discovered by Costa (1984), the only other known complete minimal embeddable surfaces in with no self-intersections were the plane (genus 0), catenoid (genus 0 with two punctures), and helicoid (genus 0 with two punctures), and it was conjectured that these were the only such surfaces. Rather amazingly, the Costa surface belongs to the dihedral group of symmetries.

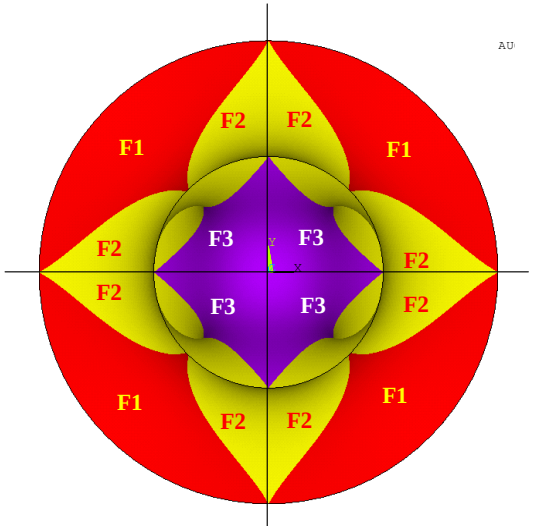


Helaman Ferguson, 1999

Helaman Ferguson, 2008

It has also been constructed as a snow sculpture (Ferguson *et al.* 1999, Wagon 1999; left figure). On Feb. 20, 2008, a large stone sculpture by Helaman Ferguson was installed on the south deck of the Olin-Rice Science Center at Macalester College (left figure; photo courtesy of Stan Wagon).




F1
F2
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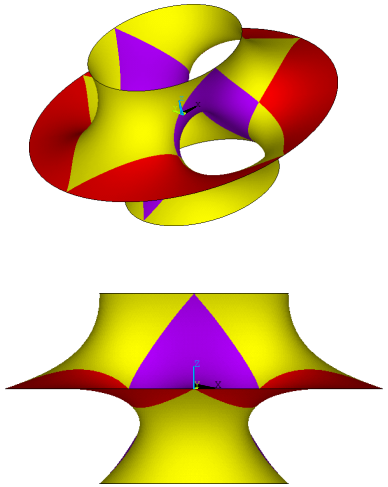
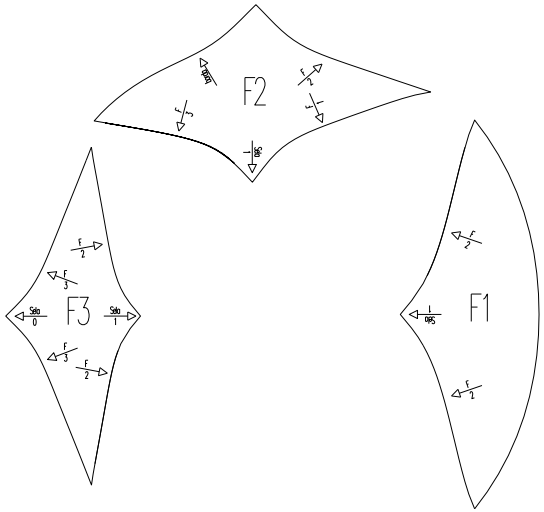



F2
F3
F1

AUSTRALIAN WILDLIFE HEALTH CENTRE

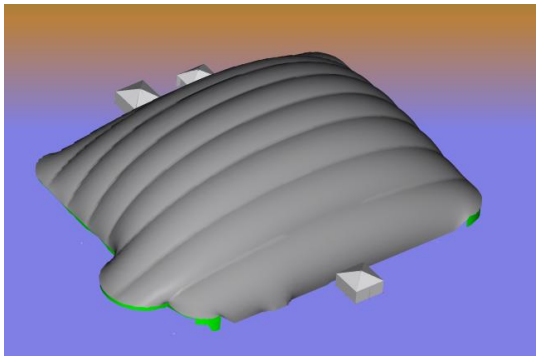
(extracted from http://www.archmedia.com.au)

Estruturas Retesadas – Casos de Estudo

Memorial dos Povos de Belém do Pará

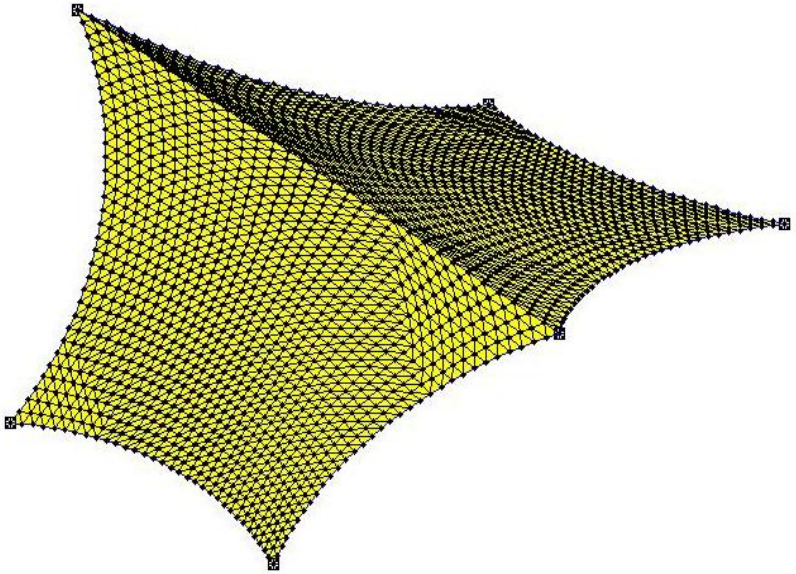
Igreja Batista Central, Fortaleza

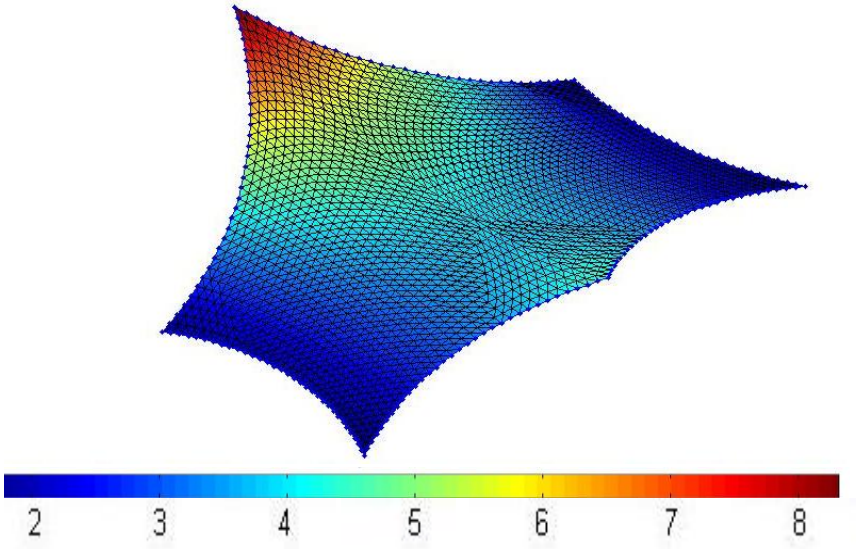
Mercado Aberto de Goiânia



Domo Pneumático de Angra III

The membrane roof of the “Memorial dos Povos” of Belém do Pará

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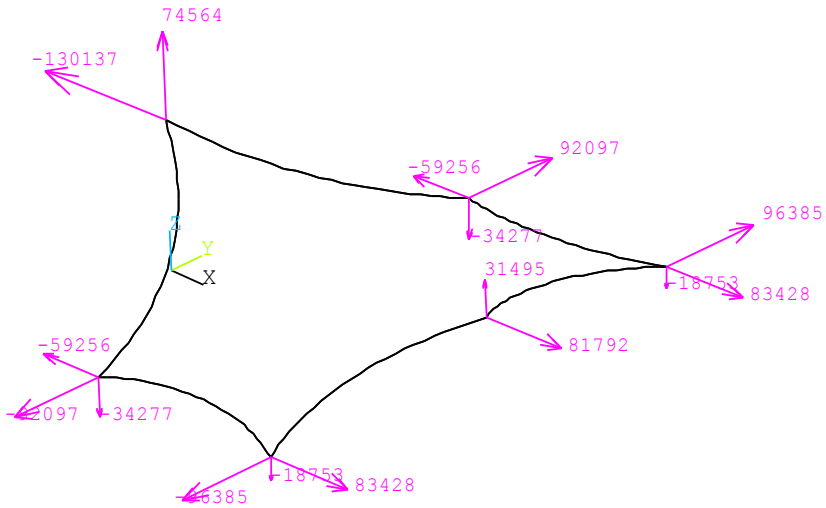
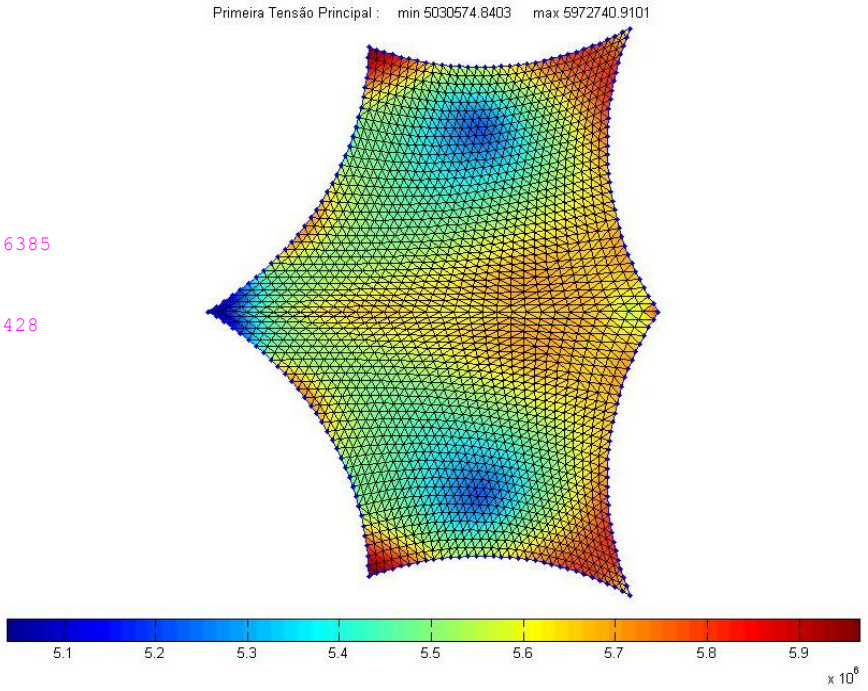
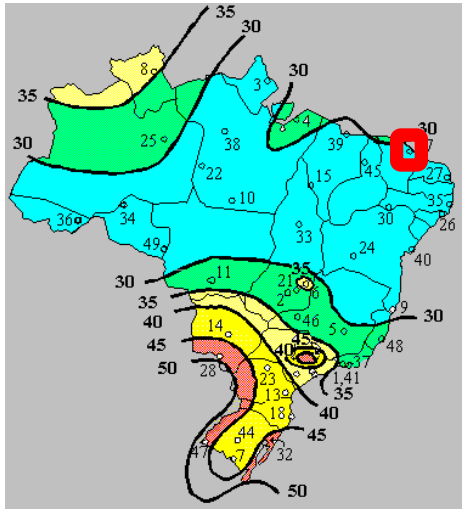
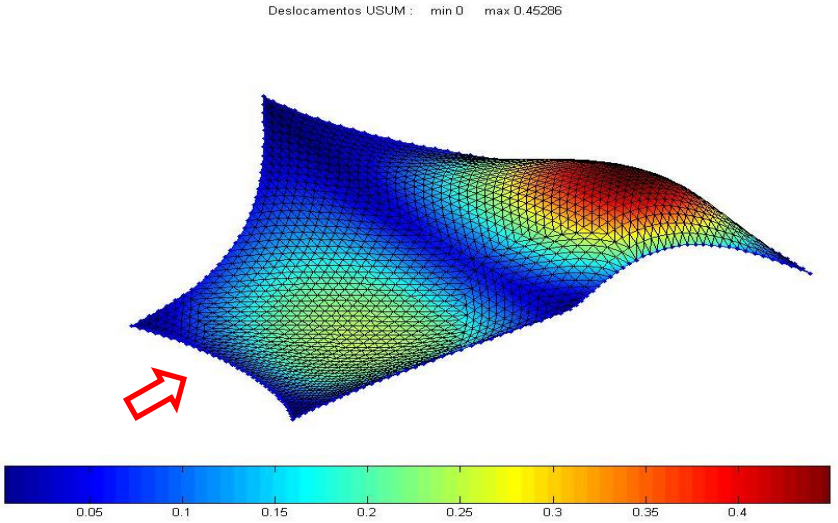

74564
-130137
-59256
92097
96385
-34277
31495
-18753
83428
81792
-59256
-34277
83428
Z
Y
X

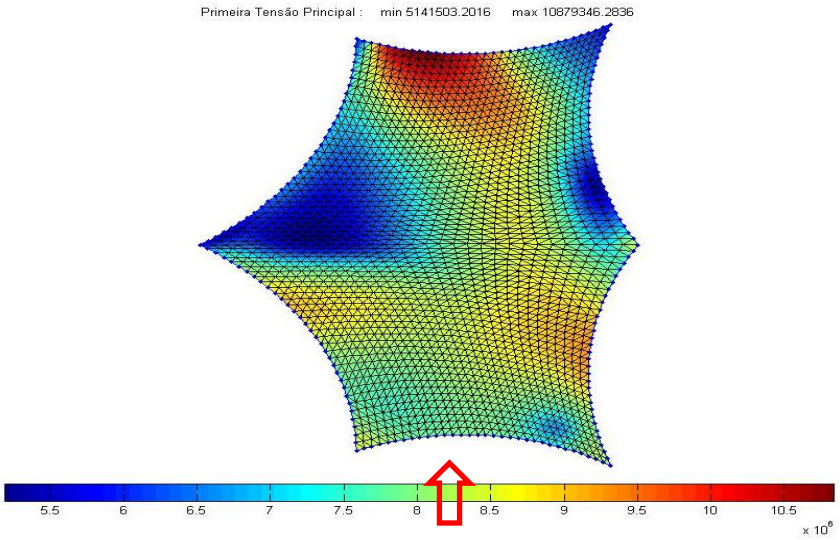

Primeira Tensão Principal : min 5030574.8403 max 5972740.9101
5.1
5.2
5.3
5.4
5.5
5.6
5.7
5.8
5.9
x 10^6

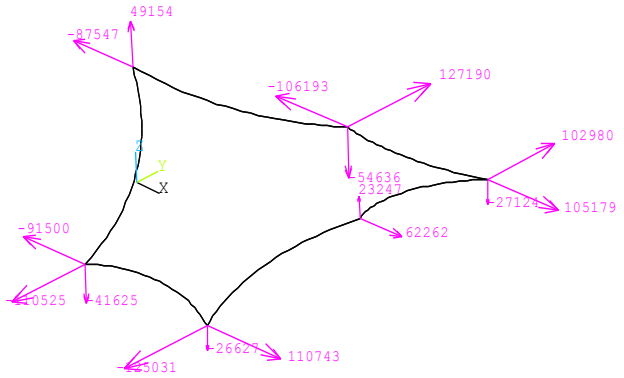
Esforços devidos ao vento lateral





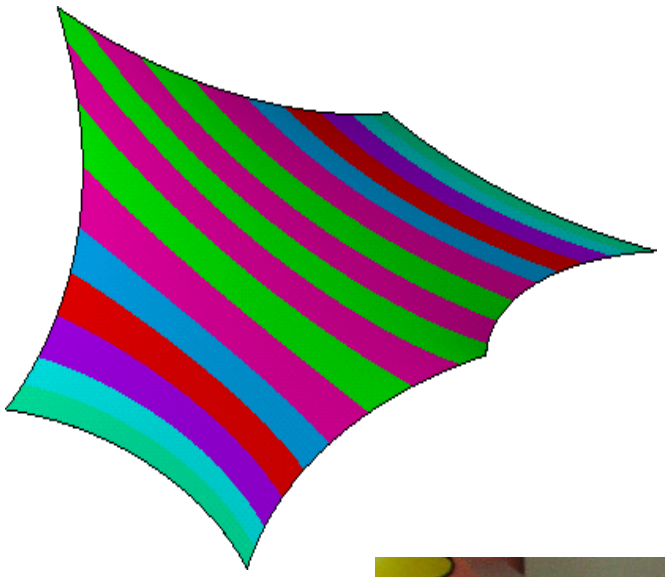
displacement norms, for the Y-wind load case

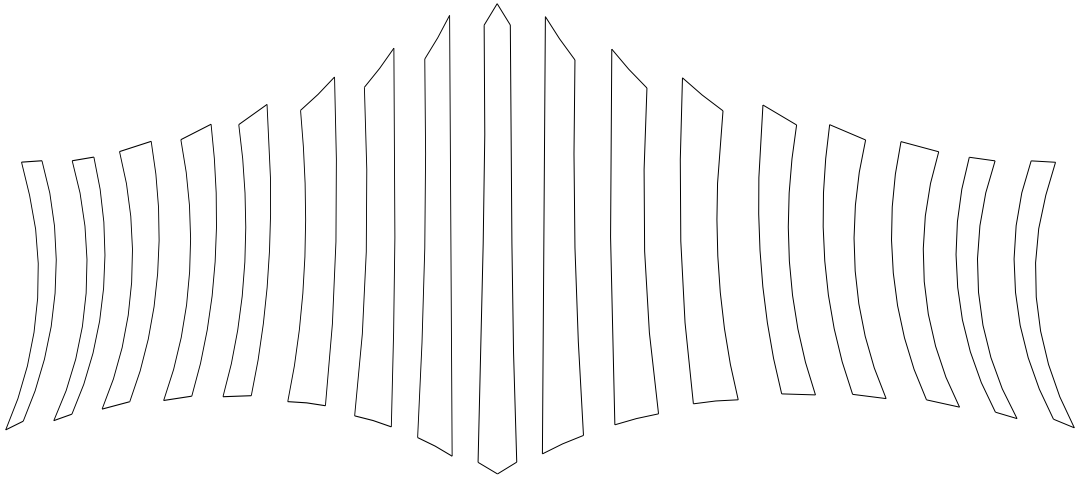


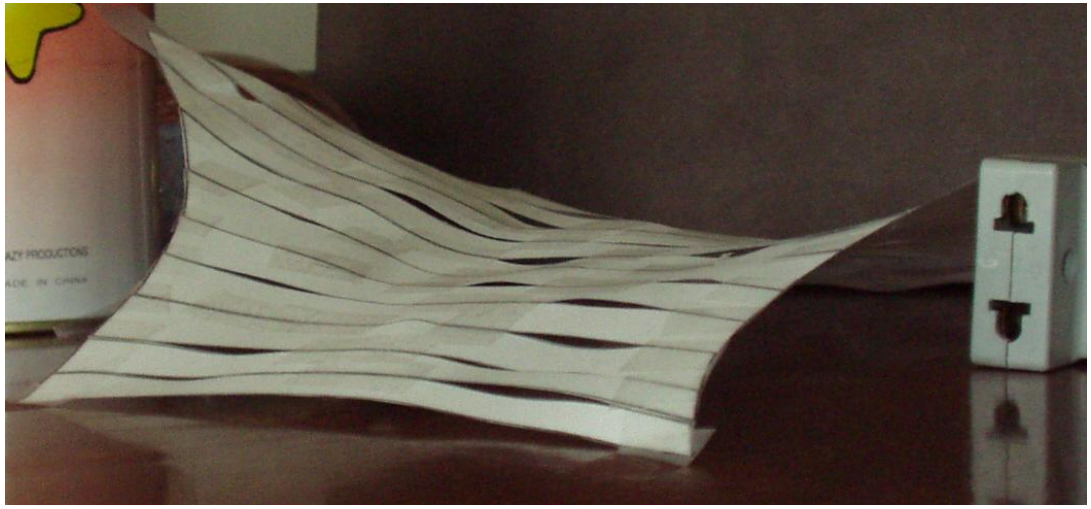


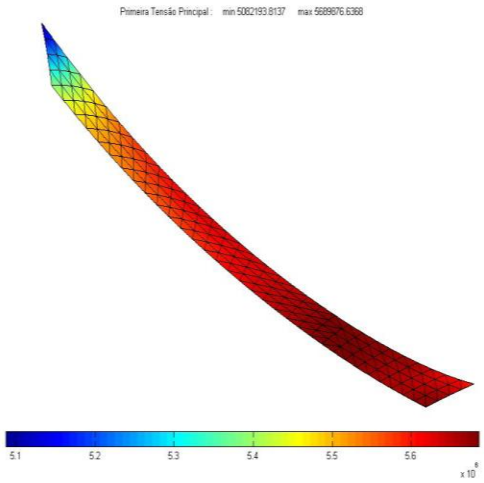
Maximum 1st principal stresses (S1) for the Y-wind load case

Cutting patterns



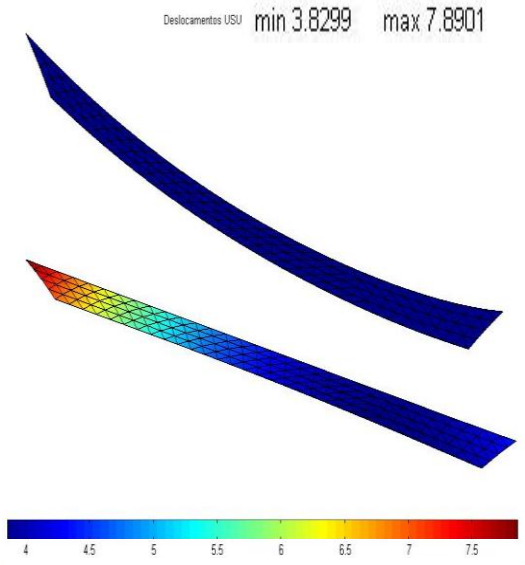




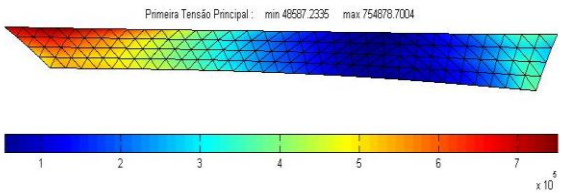


min 5082193.8137 max 5689876.6368

1st principal stresses Before flattening

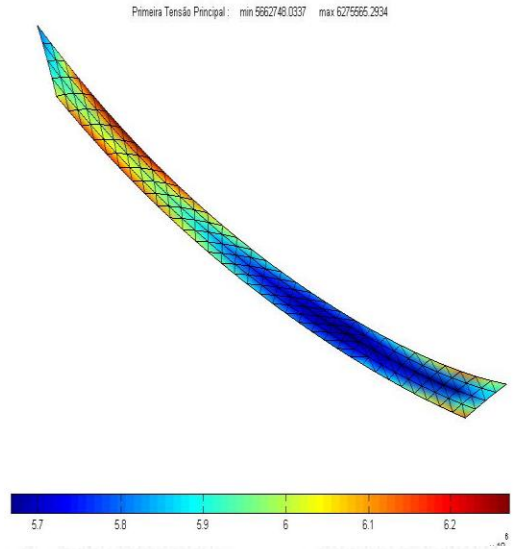


Flattening process



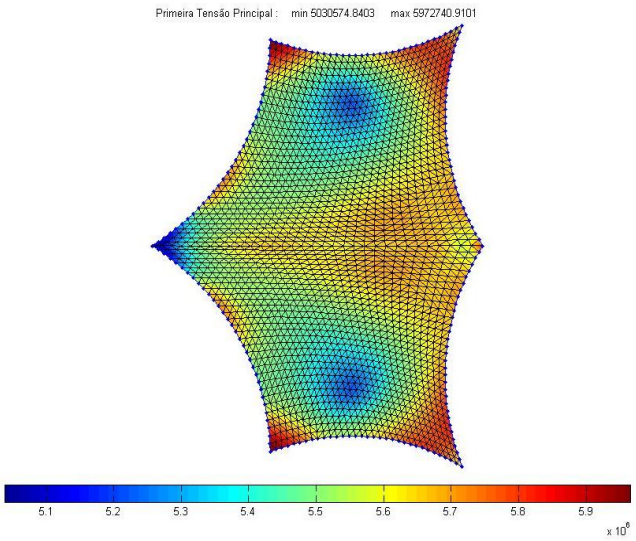
min 48587.2335 max 754878.7004

1st principal stresses after flattening (residual stresses)

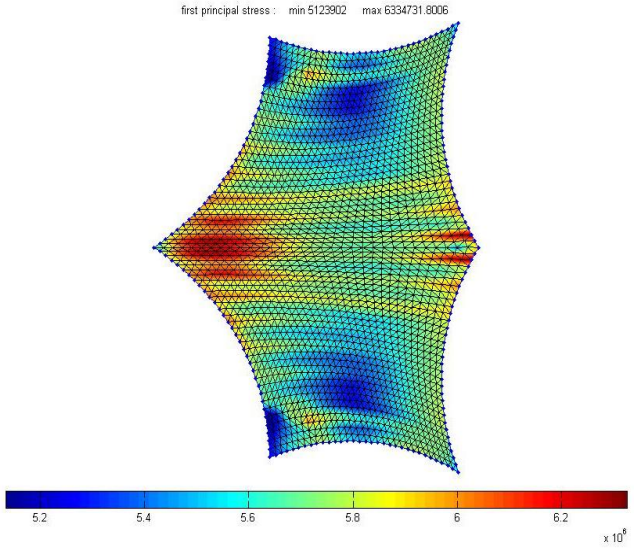


min 5662748.0337 max 6275565.2934

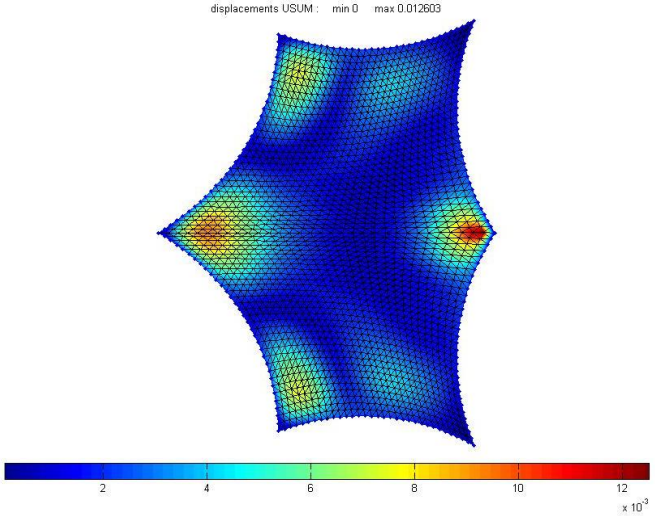
1st principal stresses after pull-back



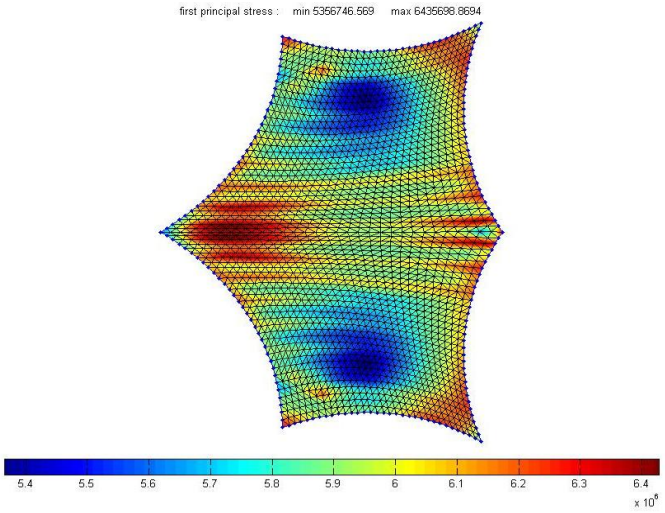
Maximum first principal stresses for the prestress load case, as initially calculated



Maximum first principal stresses after planification and pull-back



Displacements due to relaxation of pull-back stresses



Maximum first principal stresses after relaxation of pull-back stresses

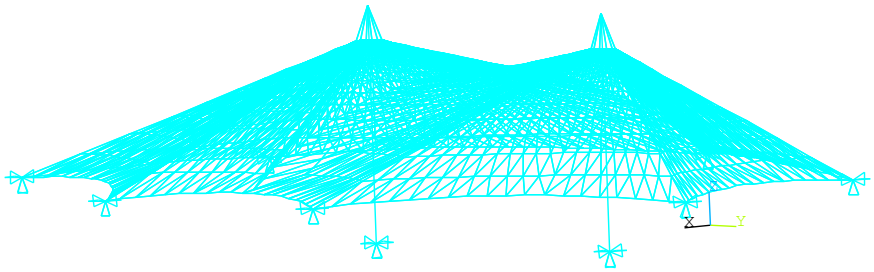
Cobertura em
Membrana Retesada

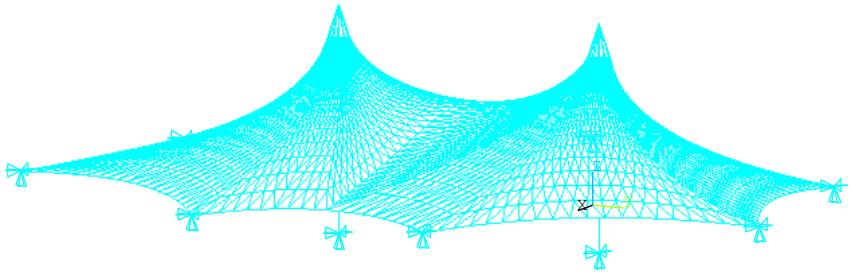
Igreja Batista Central Fortaleza

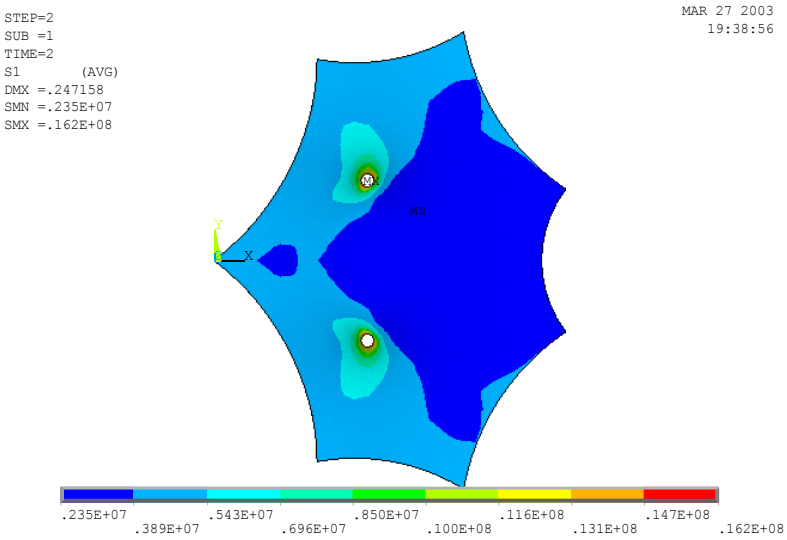
Concepção Arquitetônica:
Nasser-Hissa Arquitetos Associados

Projeto e Análise Estrutural da Membrana:
Ruy Marcelo Pauletti
Reyolando M.L.R.F. Brasil

Estrutura Metálica:
Paulo André Barroso



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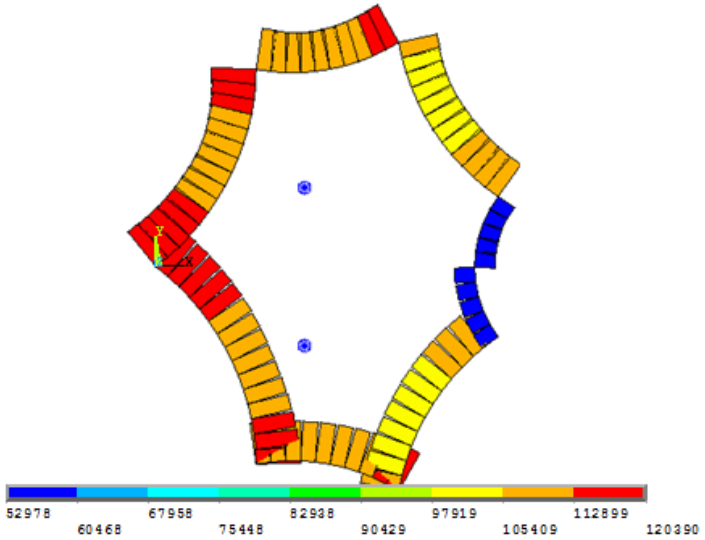
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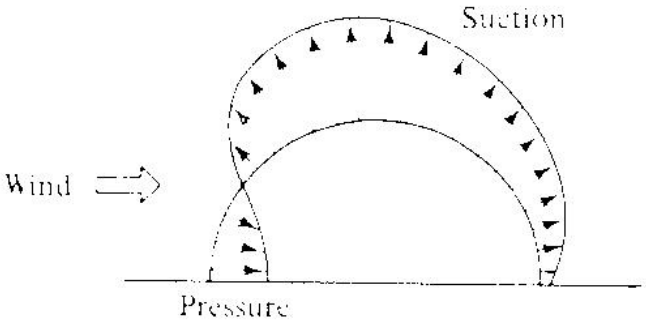
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Wind
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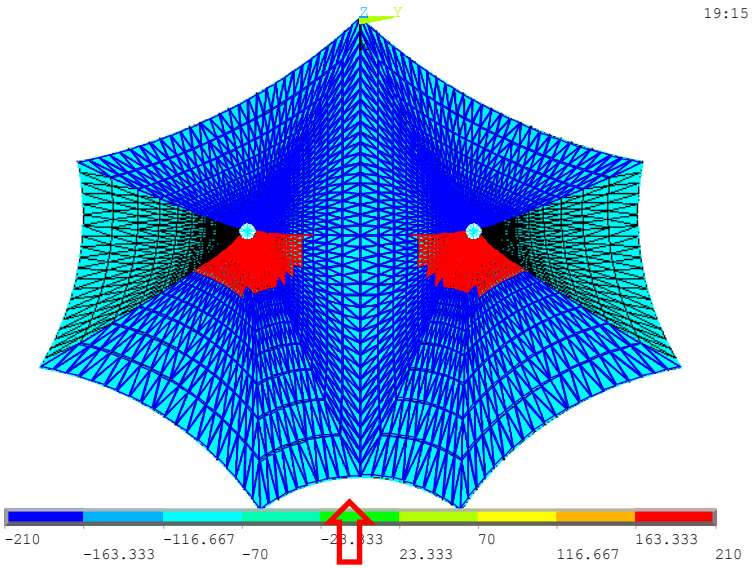
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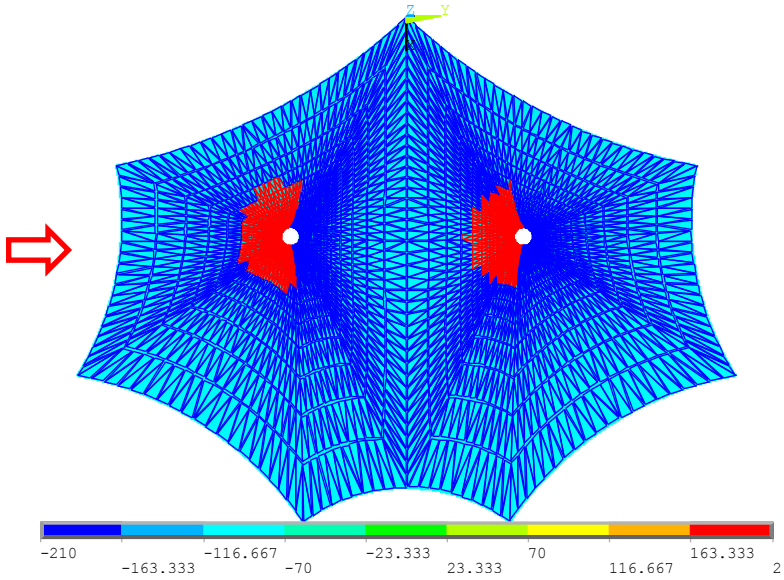
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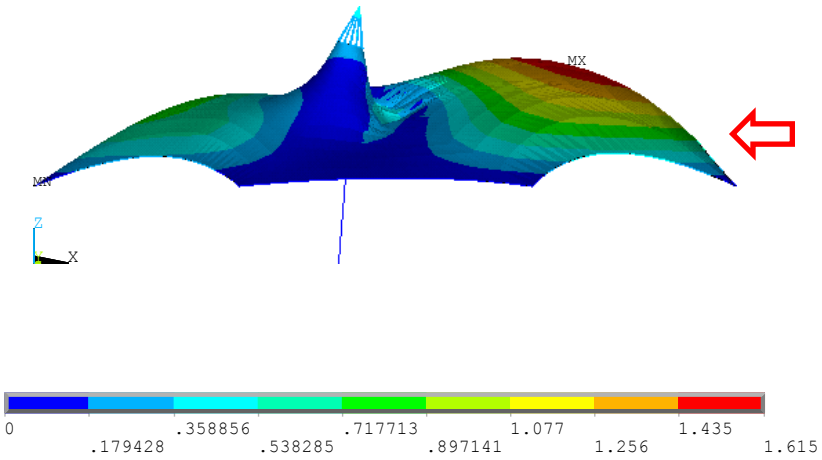
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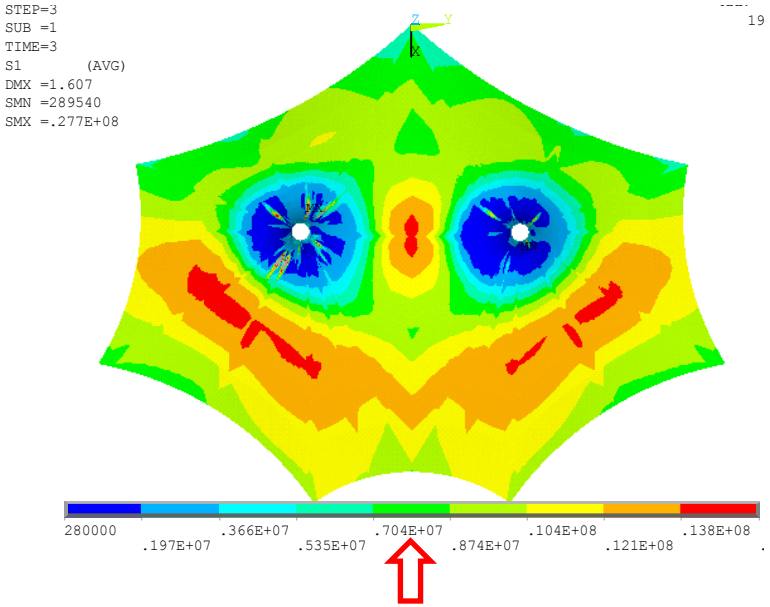
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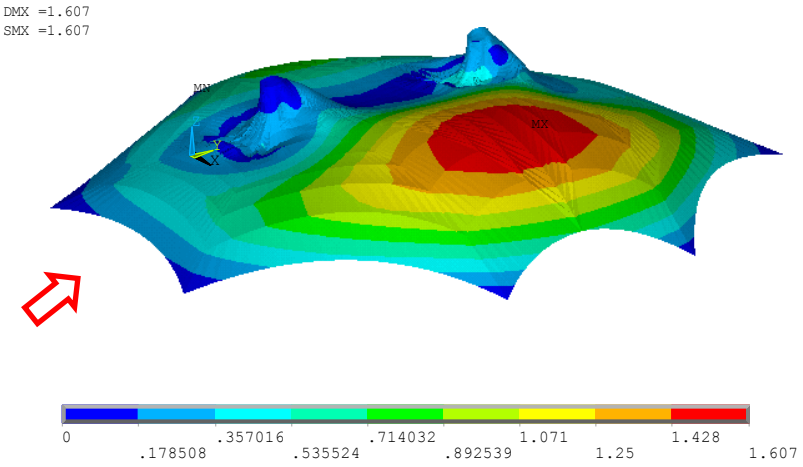
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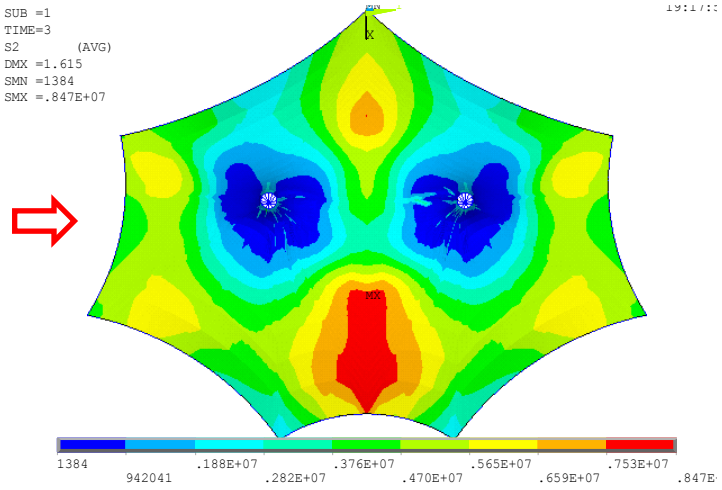
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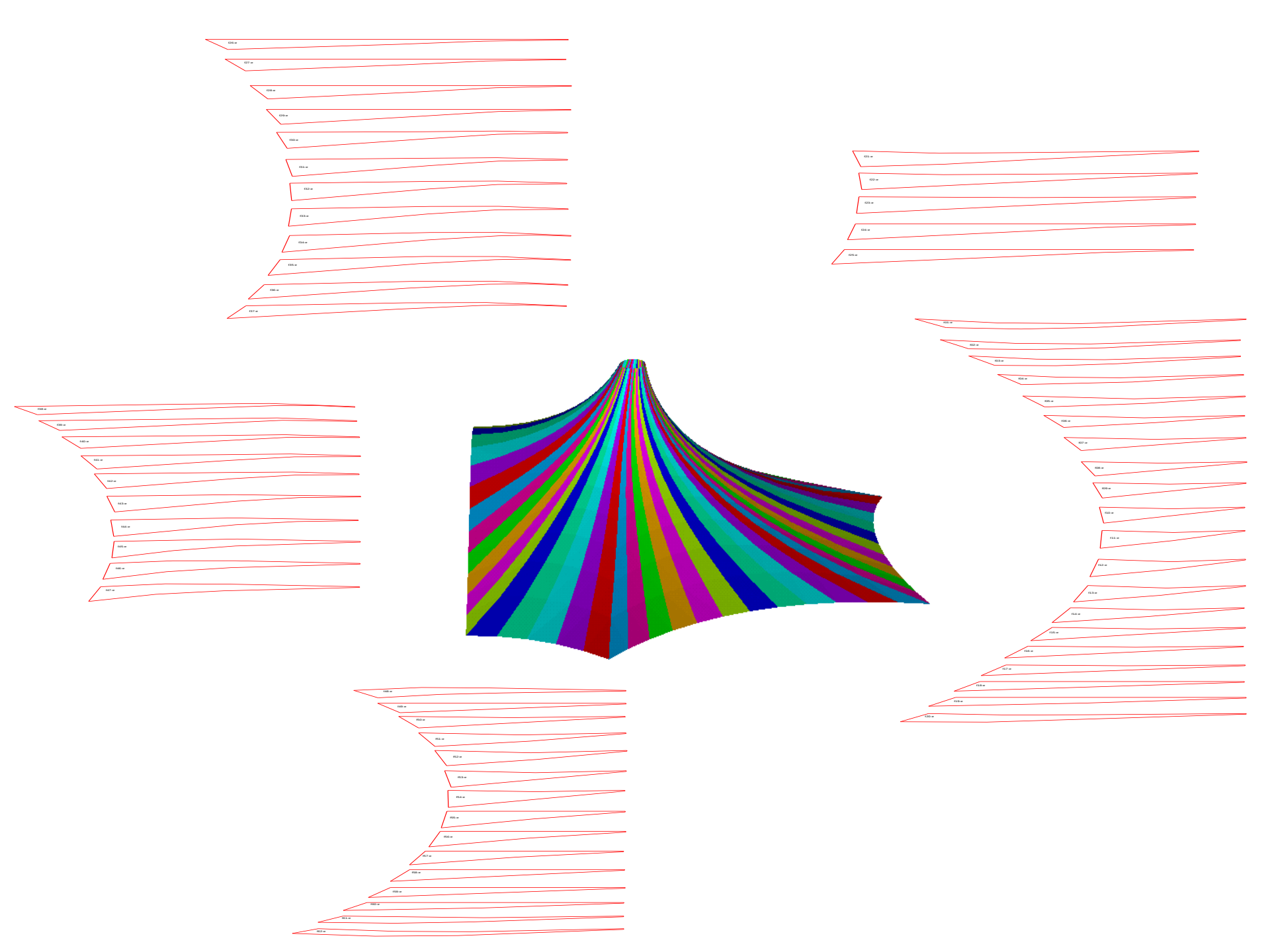
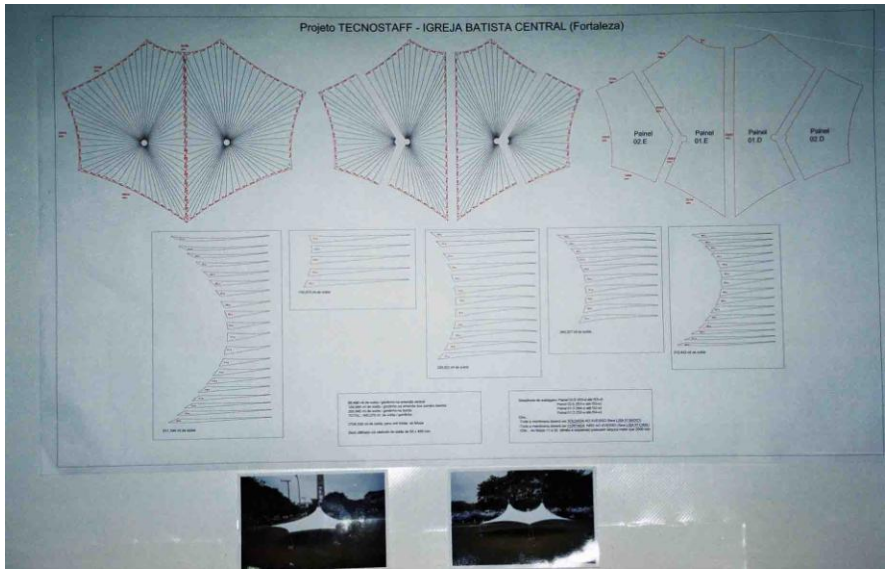
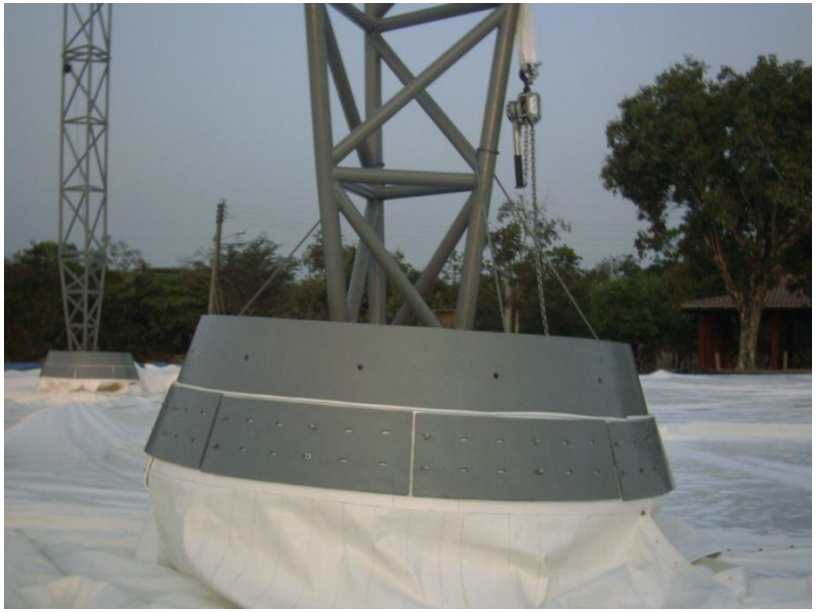
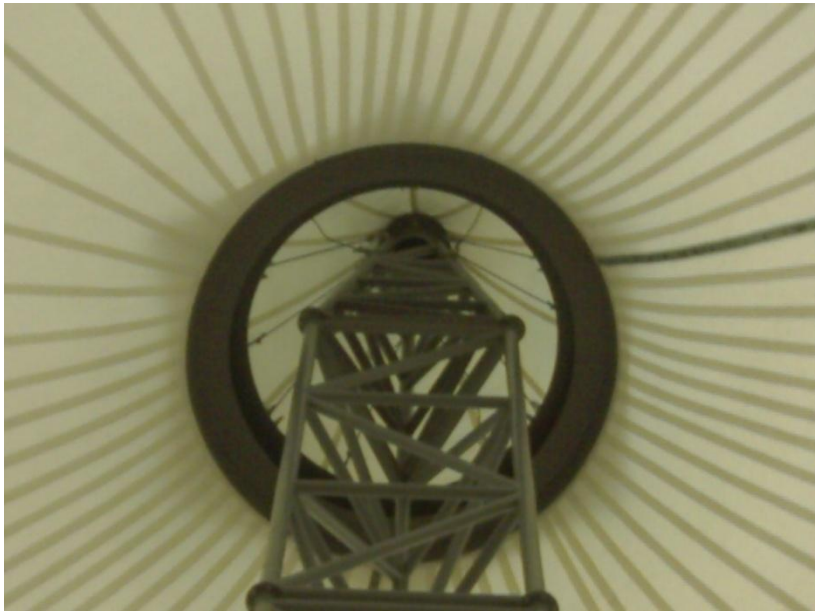




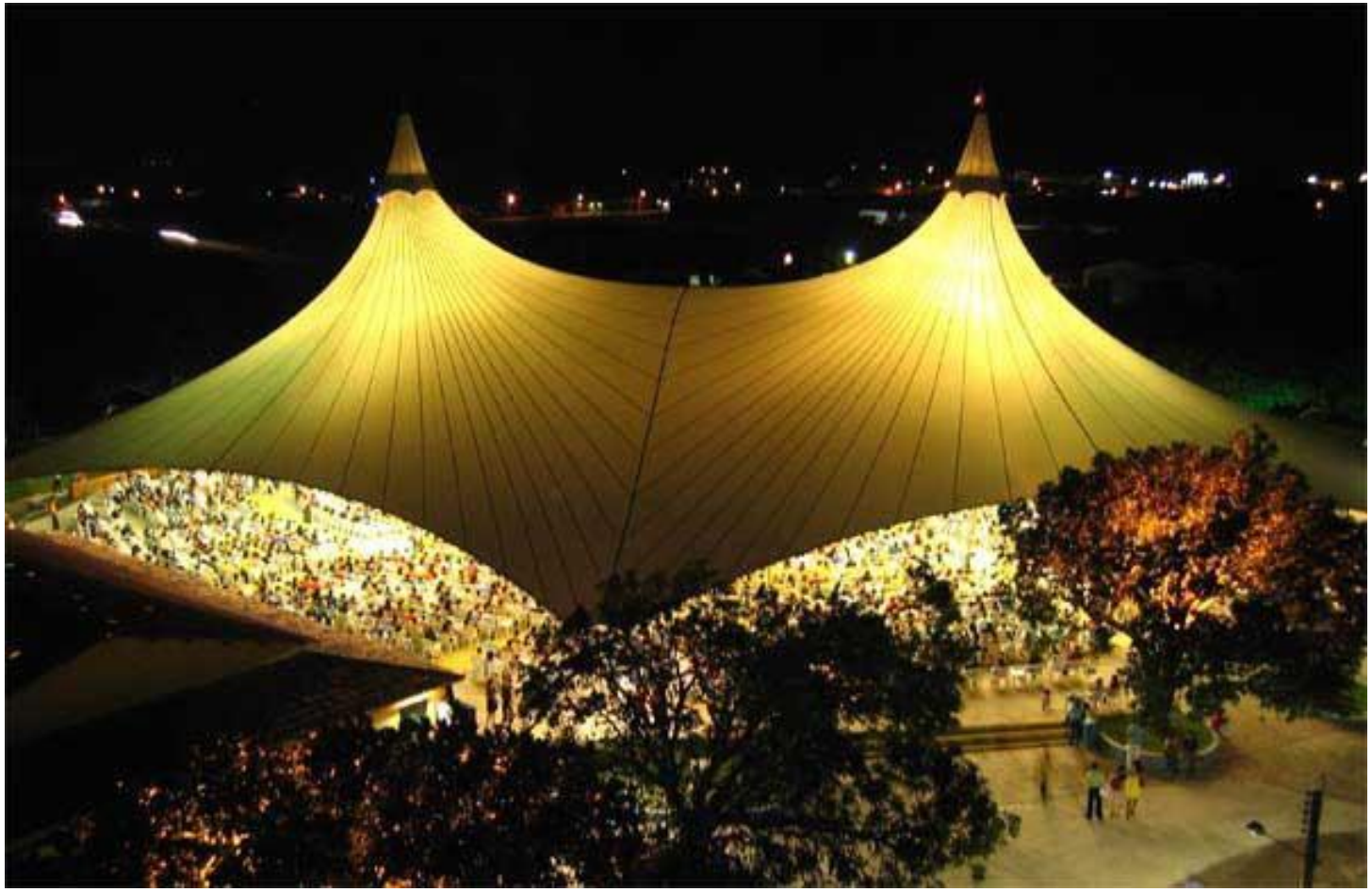
R.M.O.Pauletti - www.lmc.ep.usp.br/people/pauletti


Formatto
Coberturas Especiais
4-3111

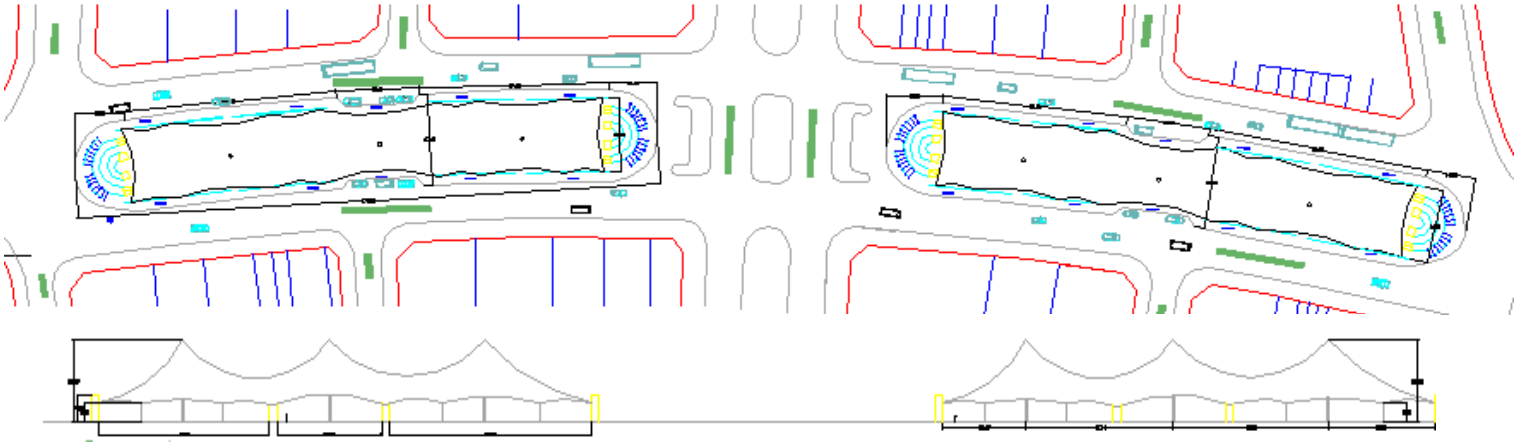


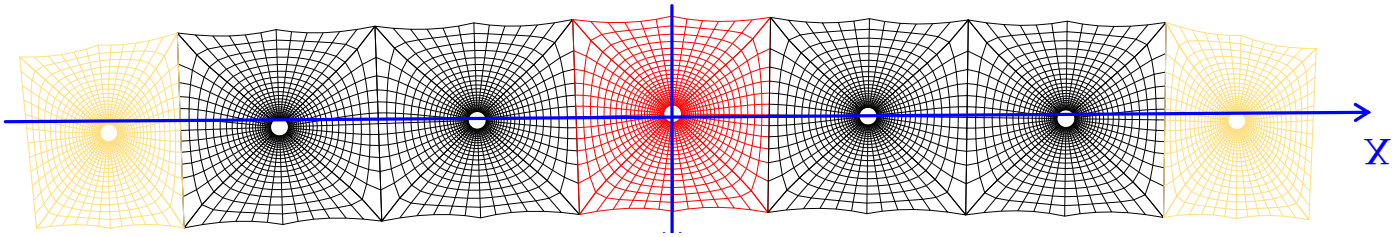


Inauguration , Nov 27, 2003



Goiânia´s Open Market (2006)

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C
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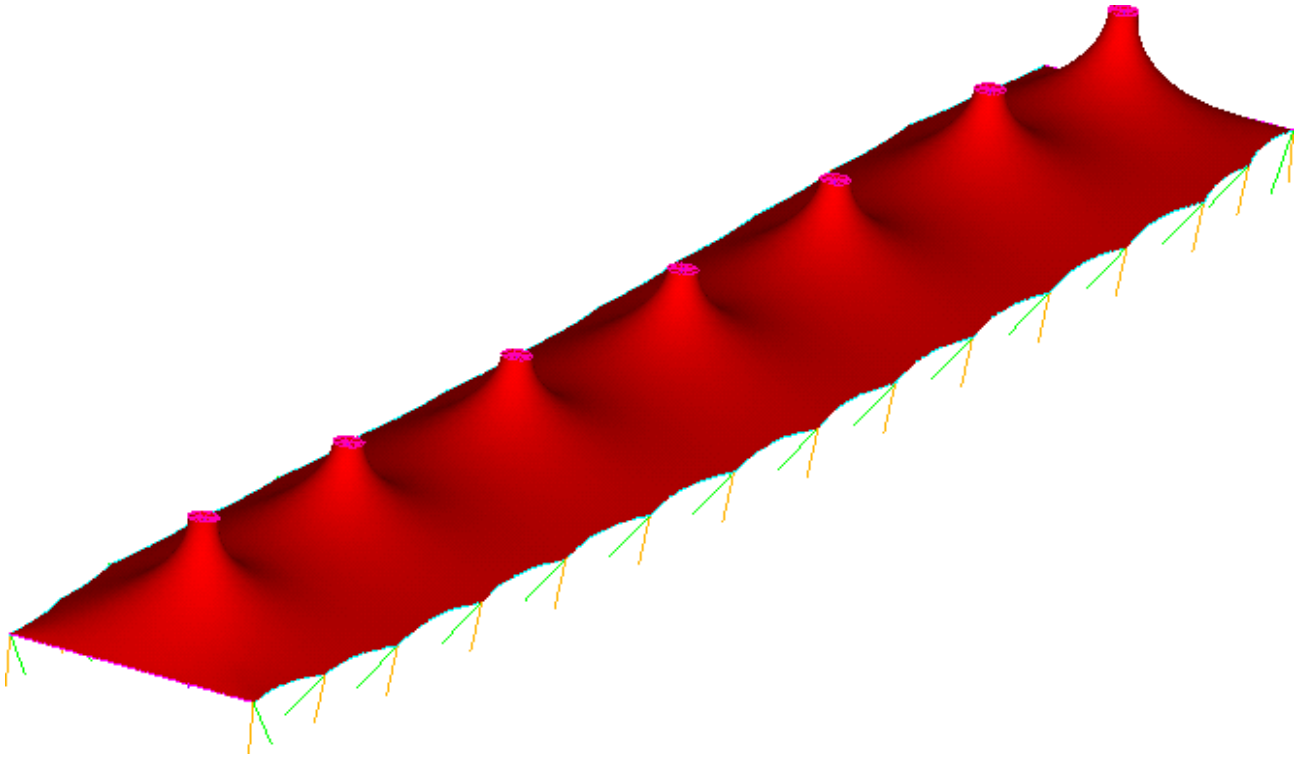
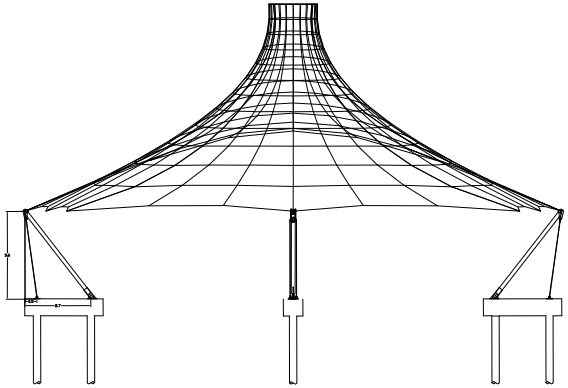
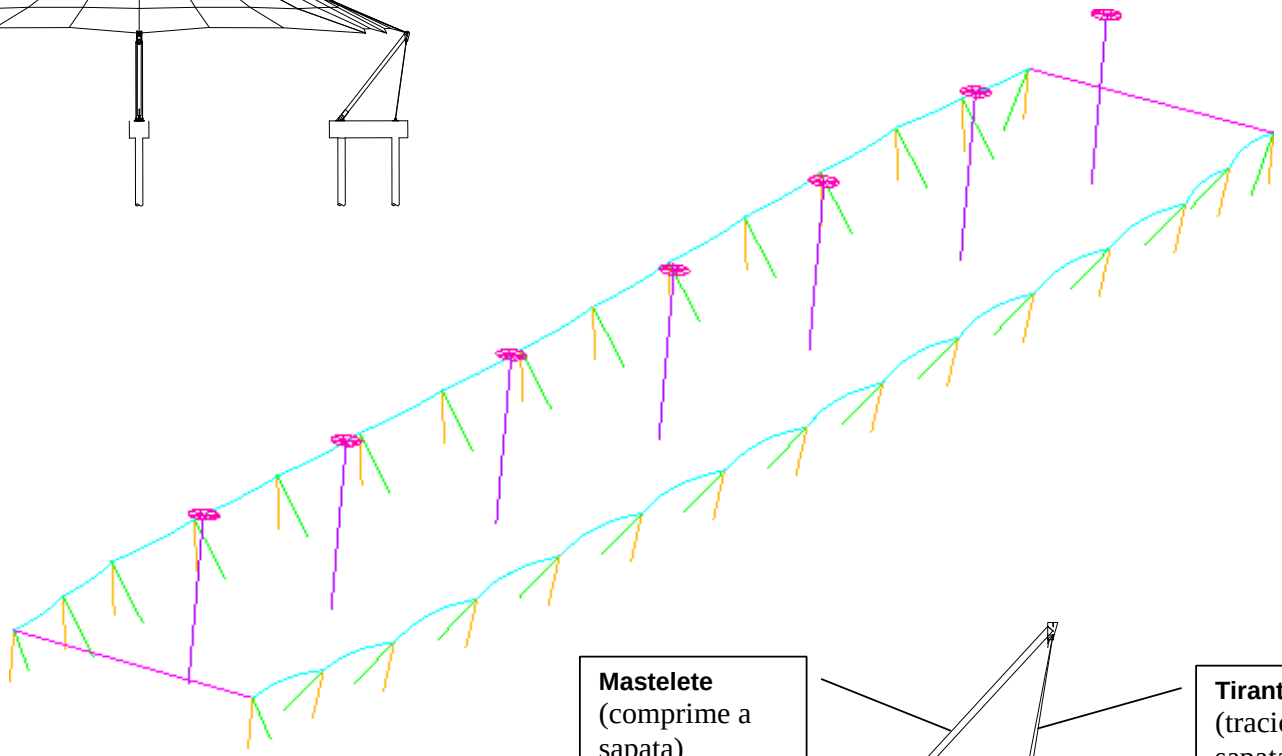
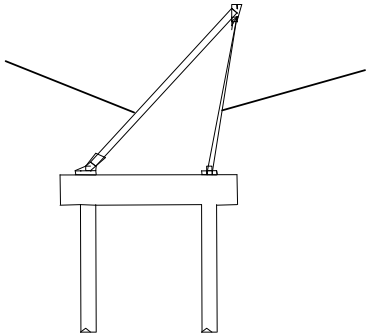
A
B



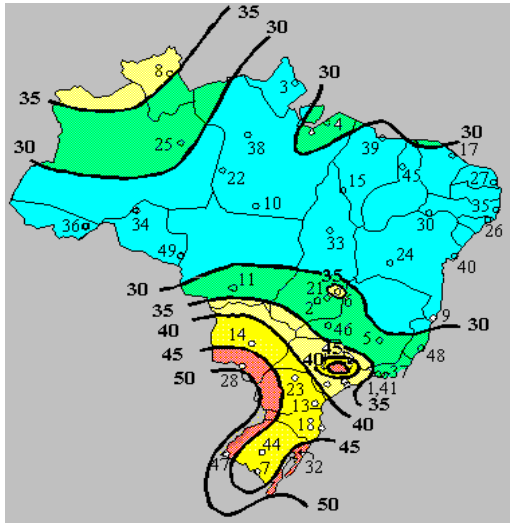




Mastelete (comprime a sapata)



Tirante (traciona a sapata)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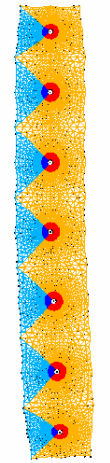

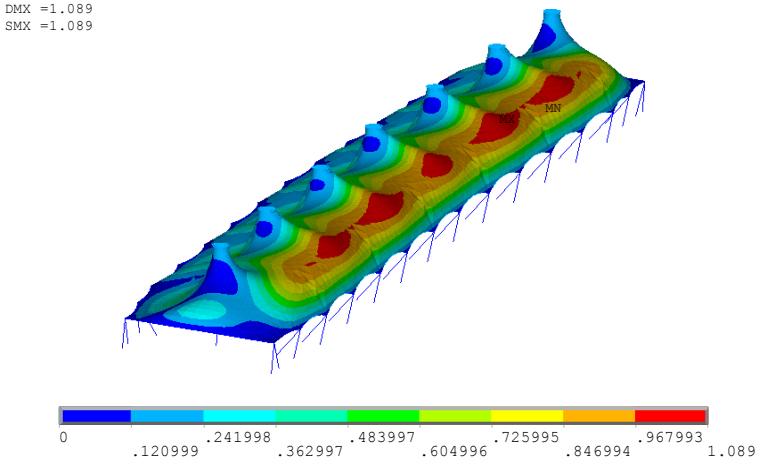
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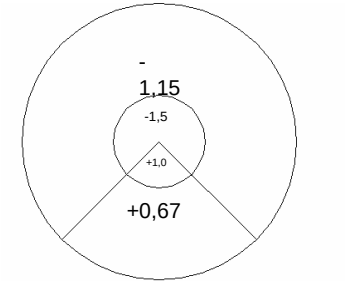
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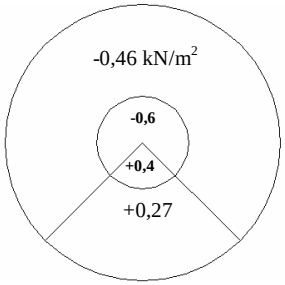
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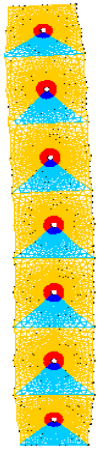

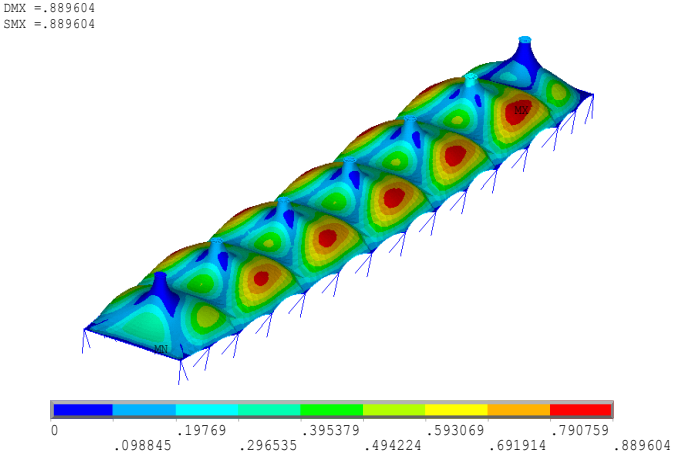
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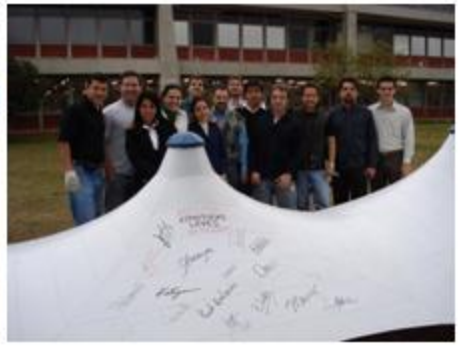
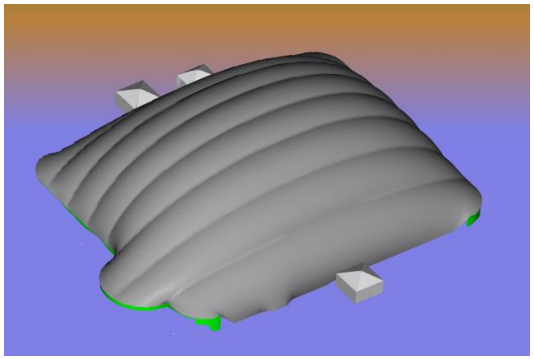
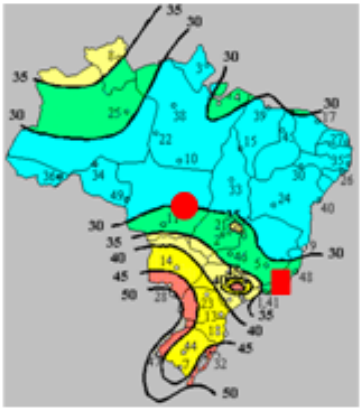
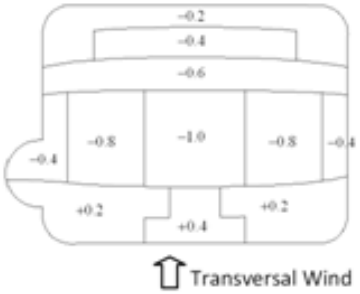
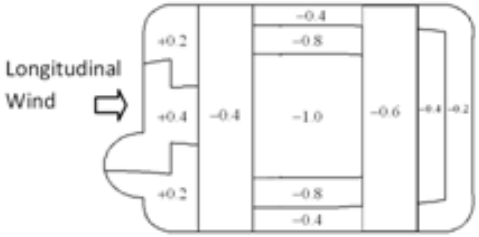


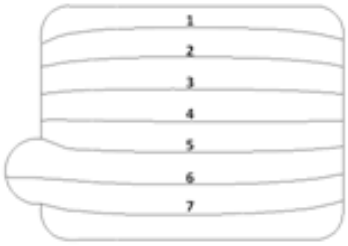

Domo Pneumático para Angra III











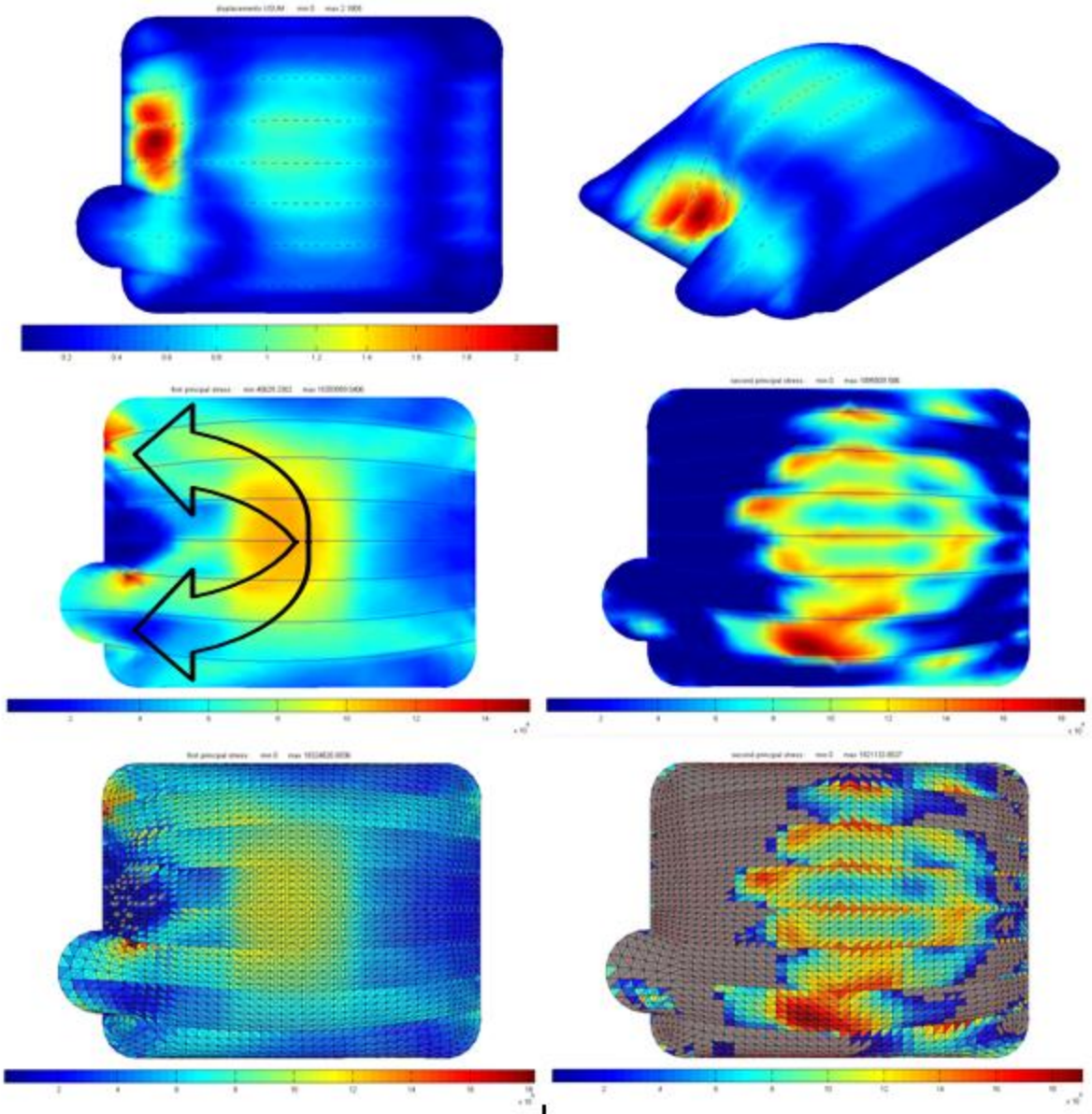


Figure 16 – Results for LC2A – Longitudinal wind, adherent cables: *(a)* field of displacement norms; *(b) idem*, isometric view; *(c)* σ_1 stress field; *(d)* σ_2 stress field.

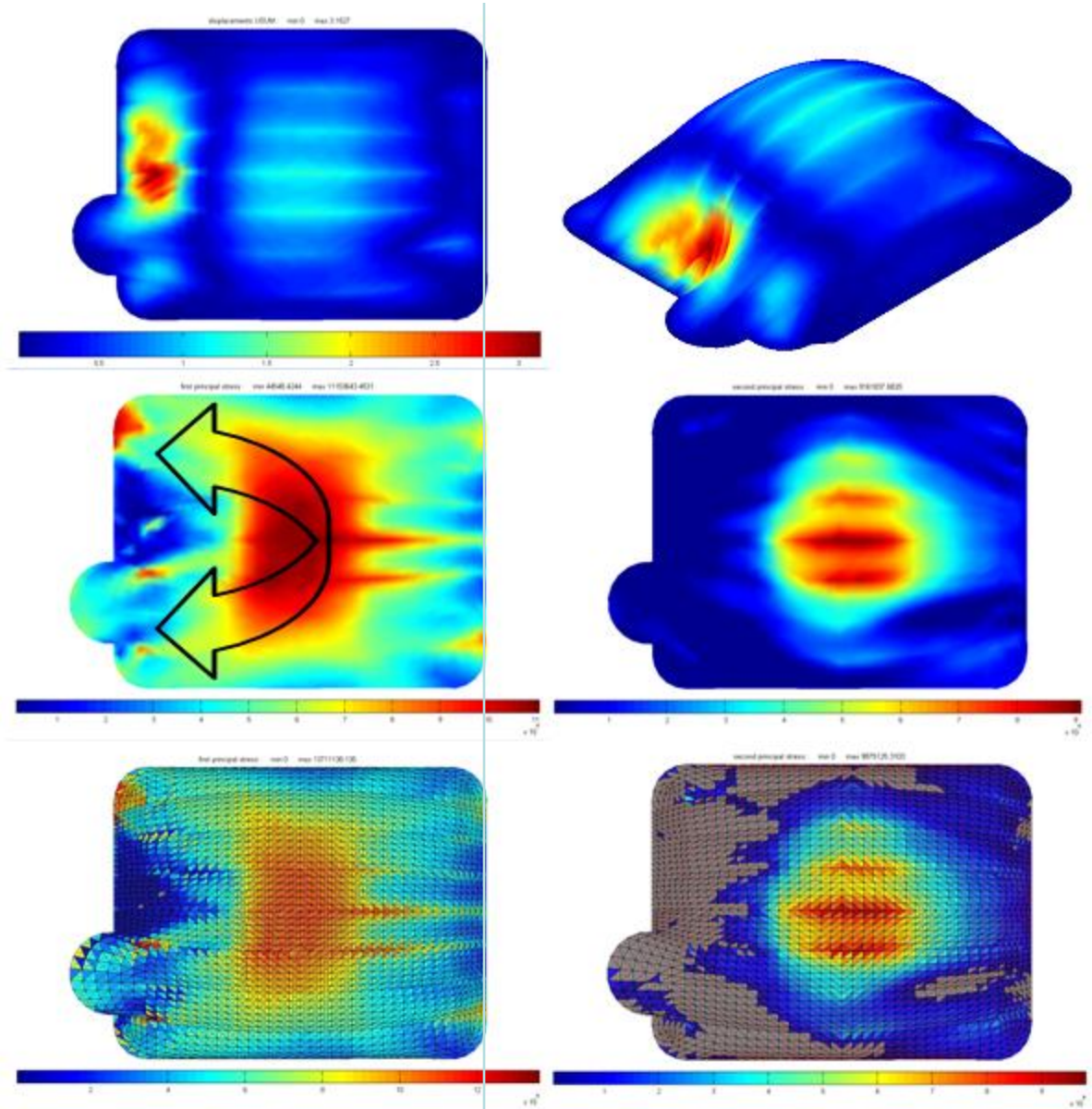
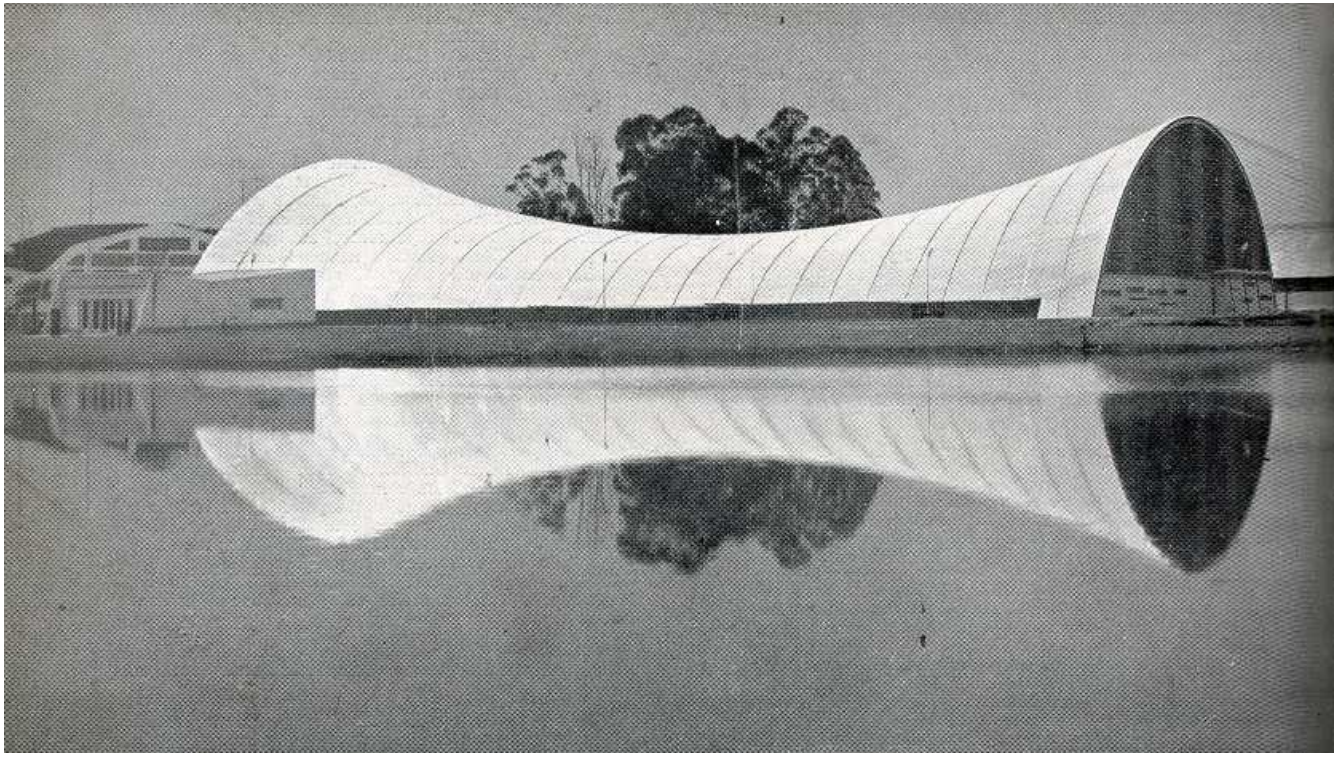


Figure 17 – Results for LC2S – Longitudinal wind, sliding cables: *(a)* field of displacement norms; *(b) idem*, isometric view; *(c)* σ_1 stress field; *(d)* σ_2 stress field.

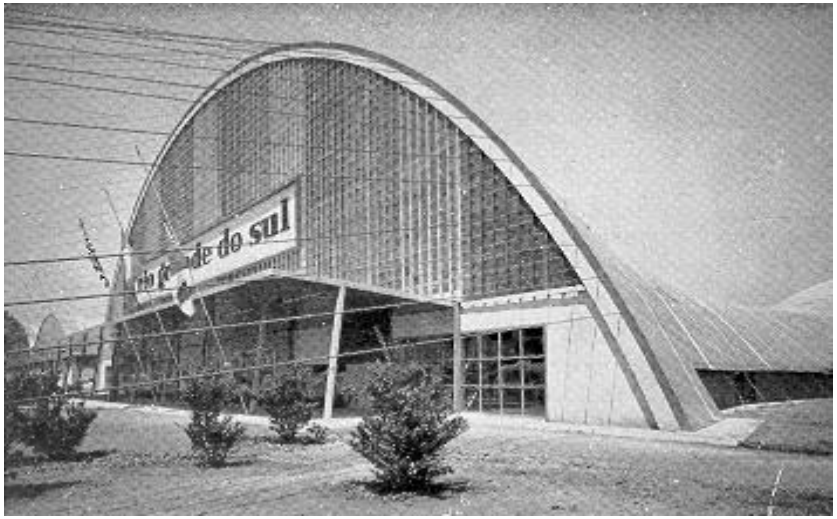
Tension Structures in Brazil

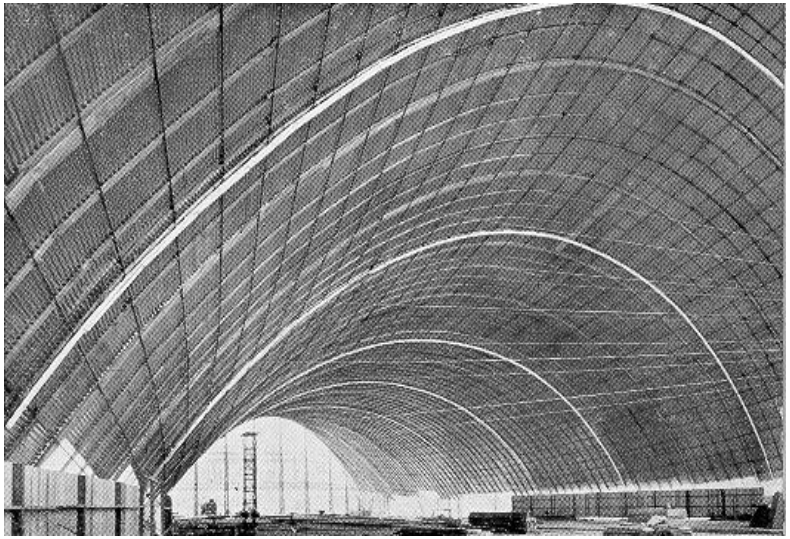
Ruy Marcelo de Oliveira Pauletti
University of São Paulo

Samka
a hammock produceb by indians
Kinja / Waimiri-Atroari / Crichaná
(Amazonas and Roraima)



Pavilhão de Exposições do Rio Grande do Sul
São Paulo´s IV Centennial Celebrations, 1954
Archs. A. Borges and R.C. Alliana
(102m x 60m in plant; 20m maximum height)



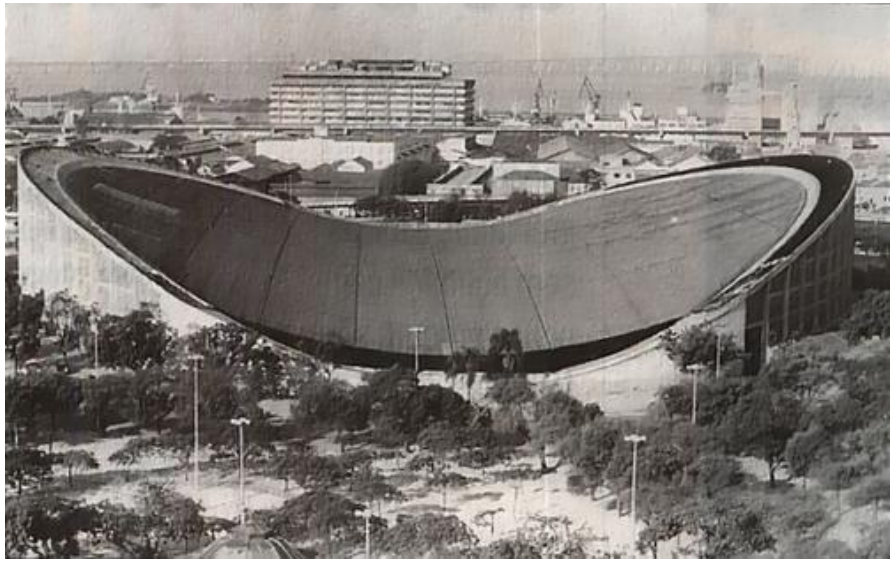


Ibirapuera Park (1954)

Pavilhão de São Cristovão,

Archs. Sérgio Bernardes and Paulo Fragoso

Built in 1957, for the 1958 International Exposition of Industry and Commerce



1978

The 32,000m2 roof, word record of free span at the time, collapsed in 1991, due to fire

1991

Today: Centro de Tradições Nordestinas Luiz Gonzaga

Auditório Araújo Vianna – Porto Alegre (1964)

Membrane Roof – 1996 – Nelson Fiedler

(closed since 2005 due to membrane deterioration)

I Simposio Latinoamericano de Tensoestructuras - 6 / 7 May, 2002

I Simpósio Nacional sobre Tensoestruturas

1st National Symposium on Tension Structures

USP Universidade de São Paulo
BRASIL

Convidado Especial / Special Guest

Emeritus Prof. Dr. Frei Otto - Universitat Stuttgart – *Germany*

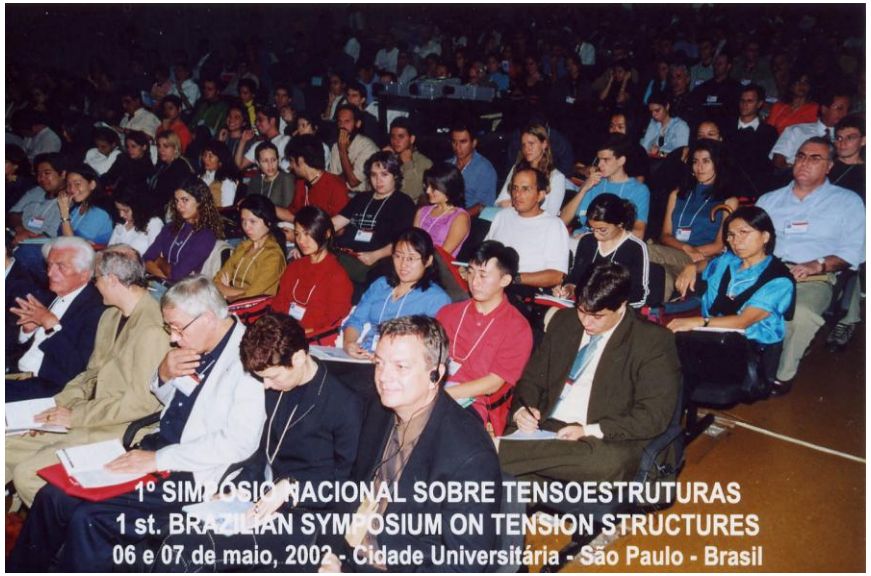
Palestrantes Convidados / Invited Speakers

Prof. Dr. Todd Dalland , FTL-Design and Engineering Studio – *USA*
Prof. Dr. Massimo Majowiecki , Università degli Studi di Bologna – *Italy*
Prof. Dr. Vinzenz Sedlak , University of New South Wales – *Australia*
Prof. Dr. Baltazar Novák , Universitat Stuttgart – *Germany*

Organização / Organizations

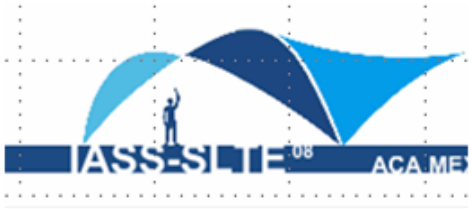
Universidade de São Paulo
Escola Politécnica
Faculdade de Arquitetura e Urbanismo

Universidade Mackenzie
Faculdade de Arquitetura e Urbanismo



492 participantes inscritos ;
196 estudantes de graduação ou pós-graduação;
35 participantes estrangeiros, provenientes de 14 países

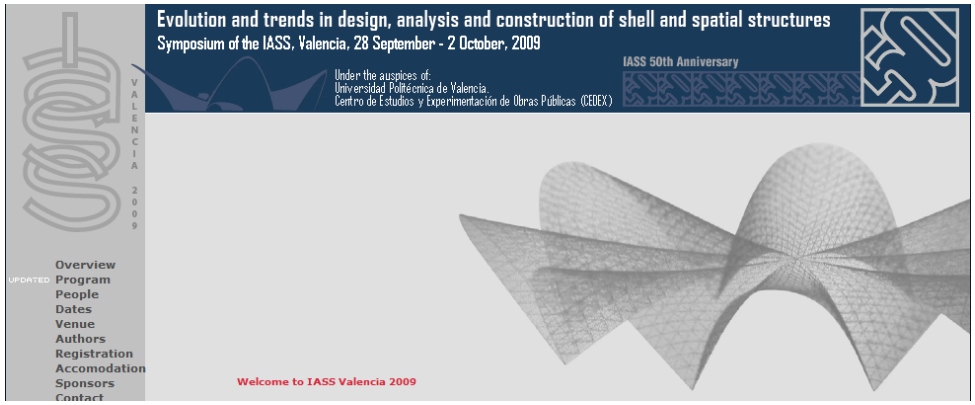
"I Simposio Latinoamericano de tensoestructuras"



IASS-SLTE 2008 Acapulco, Mexico

October 27-31, 2008

New Materials and Technologies, New Designs and Innovations
-A Sustainable Approach to Architectural and Structural Design-



IASS – SLTE 2014

BRASIL ?!

Brazilian Companies on Membrane Structures

http://www.arquiteturatextil.com.br/
http://www.falcaotents.com.br/
http://fiedlertensoestruturas.com.br/
http://www.formatto.ind.br/files/default.asp
http://www.huntlereventos.com.br/
http://www.infla.com.br/
http://www.nautika.com.br/home/
http://www.noosfera.arq.br/
http://www.orvalhodosol.com.br
http://www.pistelli.com/
http://www.sotendas.com.br/
http://www.tecnostaff.com.br/
http://www.tensobras.com.br/
http://www.tensorestruturas.com/
http://www.toldosdias.com.br/
http://www.tensotech.com.br/

FALCÃO
ARQUITETURA E CONSTRUÇÃO TÊXTIL

NAUTIKA

SÓ TENDAS

Orvalho do Sol

TENSOTECH

Tensobras

Shopping Nova américa, RJ, 2006

Shopping Osasco, SP, 2006

Clube Hebraica, SP, 2004

PISTELLI ENGENHARIA

PELZ

Mercado Municipal Ver-o-Peso – Belém do Pará

Arch. Flavio de Carvalho and Pedro Rivera, 4.300m² (Ano 2000)

PISTELLI ENGENHARIA

PELZ

Arquibancada Beach Soccer
São Luiz, MA 750m² (2001)
Arq. Carlos Campello

Garagem Aeroporto Internacional do Recife
1500m² (2001)

Palco do Piscinão de Ramos - Rio de Janeiro – RJ - 1900m² (2001)

Capela de Frei Galvão e Sta. Crescencia – Guaratinguetá – SP (2007), Arqs. Lília Campelo, Artur Diniz; Carlos Bauer (membrane)

Usina Termo-elétrica Norte
Macaé – RJ, 160m² (2007)

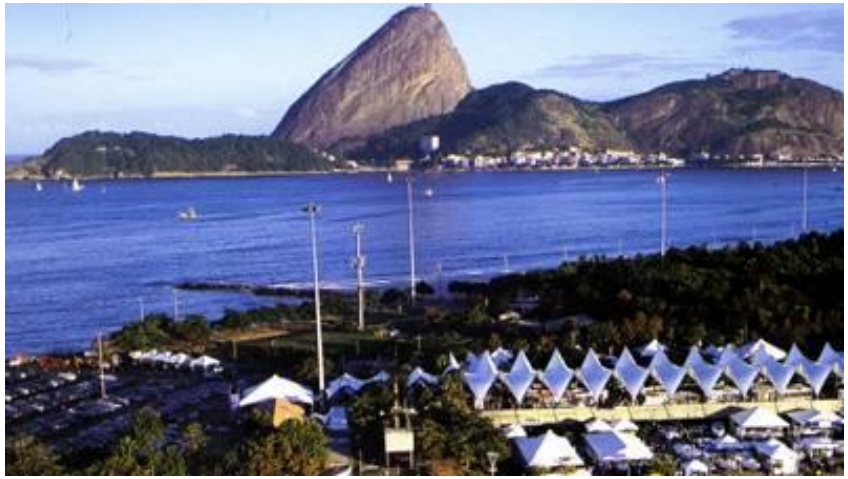
Anfiteatro Praça Salvador Arena, São Bernardo do Campo, SP, Arch. Jurandir , 1200m² (2005)

Paulínia Rodoviária Shopping – Paulínia – SP 2200m² (2006), Arch. Primi e Apolloni

Cabral Night Club – SP , 450m² (2003)
Arch. Paulo Del Santo

Rock in Rio

MTV Vídeo Music Awards Brasil 4.330 metros (2006)



Garrafas PET no Tietê -2008 - Artist: Eduardo Srur

"Feira da Cidade de Ananindeua, PA (2006)
Arch. José Maria Coelho Bassalo and Flávio Campos do Nascimento

"Feira da Cidade de Ananindeua, PA (2006)
Arch. José Maria Coelho Bassalo and Flávio Campos do Nascimento

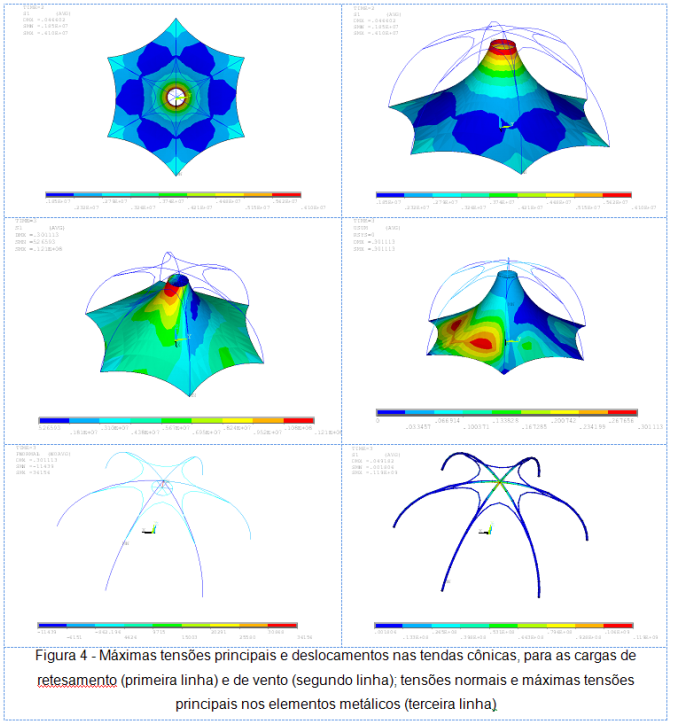


Figura 4 - Máximas tensões principais e deslocamentos nas tendas cônicas, para as cargas de retesamento (primeira linha) e de vento (segundo linha); tensões normais e máximas tensões principais nos elementos metálicos (terceira linha).

"Feira da Cidade de Ananindeua, PA (2006)
Arch. José Maria Coelho Bassalo and Flávio Campos do Nascimento

TECNO STAFF
ENGENHARIA E ESTRUTURAS

RMOP
Tensoestruturas

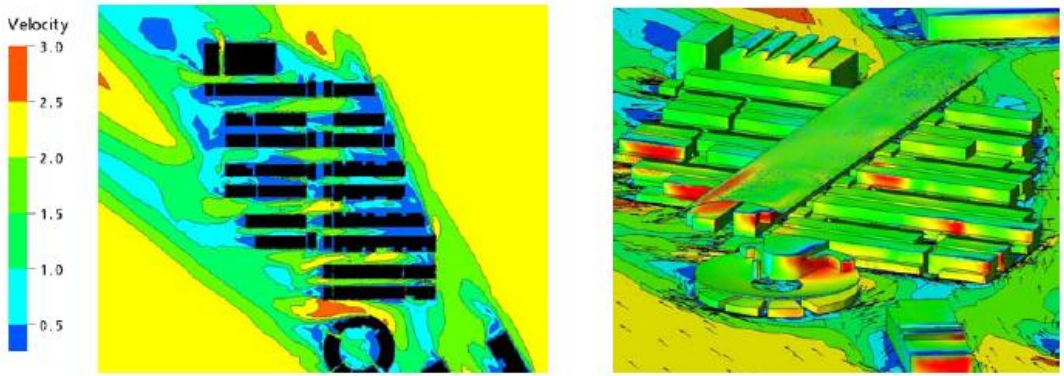
Formatta
Coberturas Especiais

RMOP
Tensoestruturas

CENPES II - Petrobrás Research Center

ZANETTINI Arquitetura

CENPES II



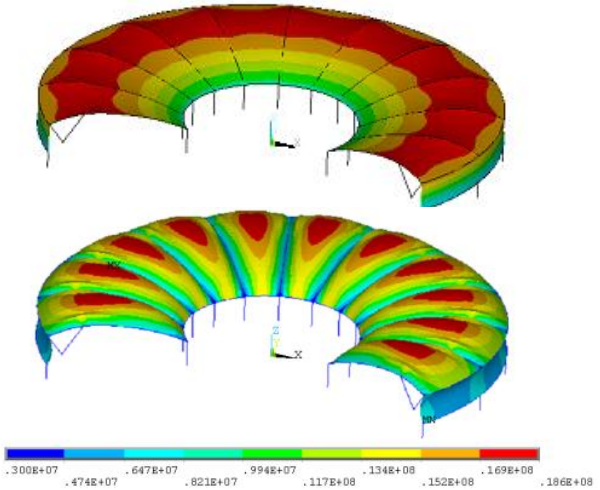
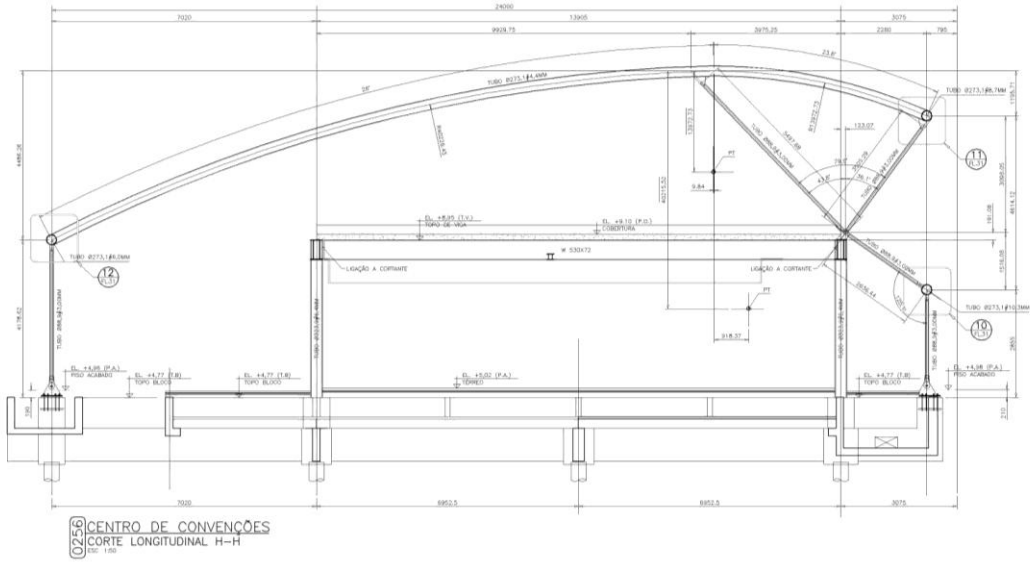
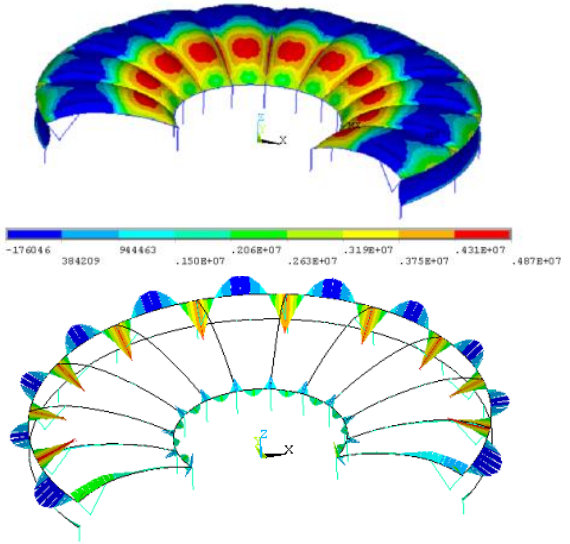


Figura 4 – À esquerda, distribuição da velocidade do vento no nível do pedestre, a 1,5m. Observar escala de velocidades de 0m/s a 3m/s. À direita, distribuição de pressões de vento sobre as envoltórias.



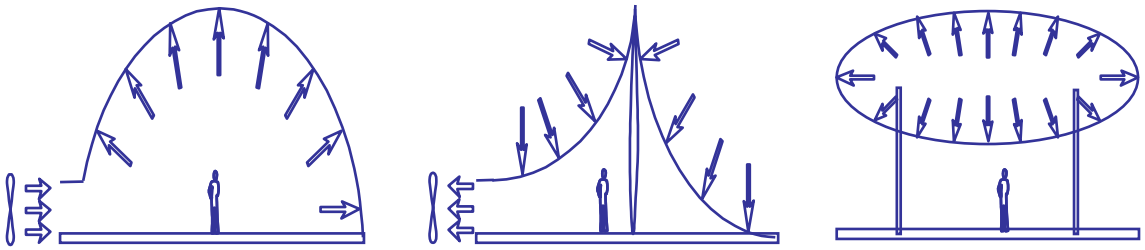


Some remarks on membrane market in Brasil:

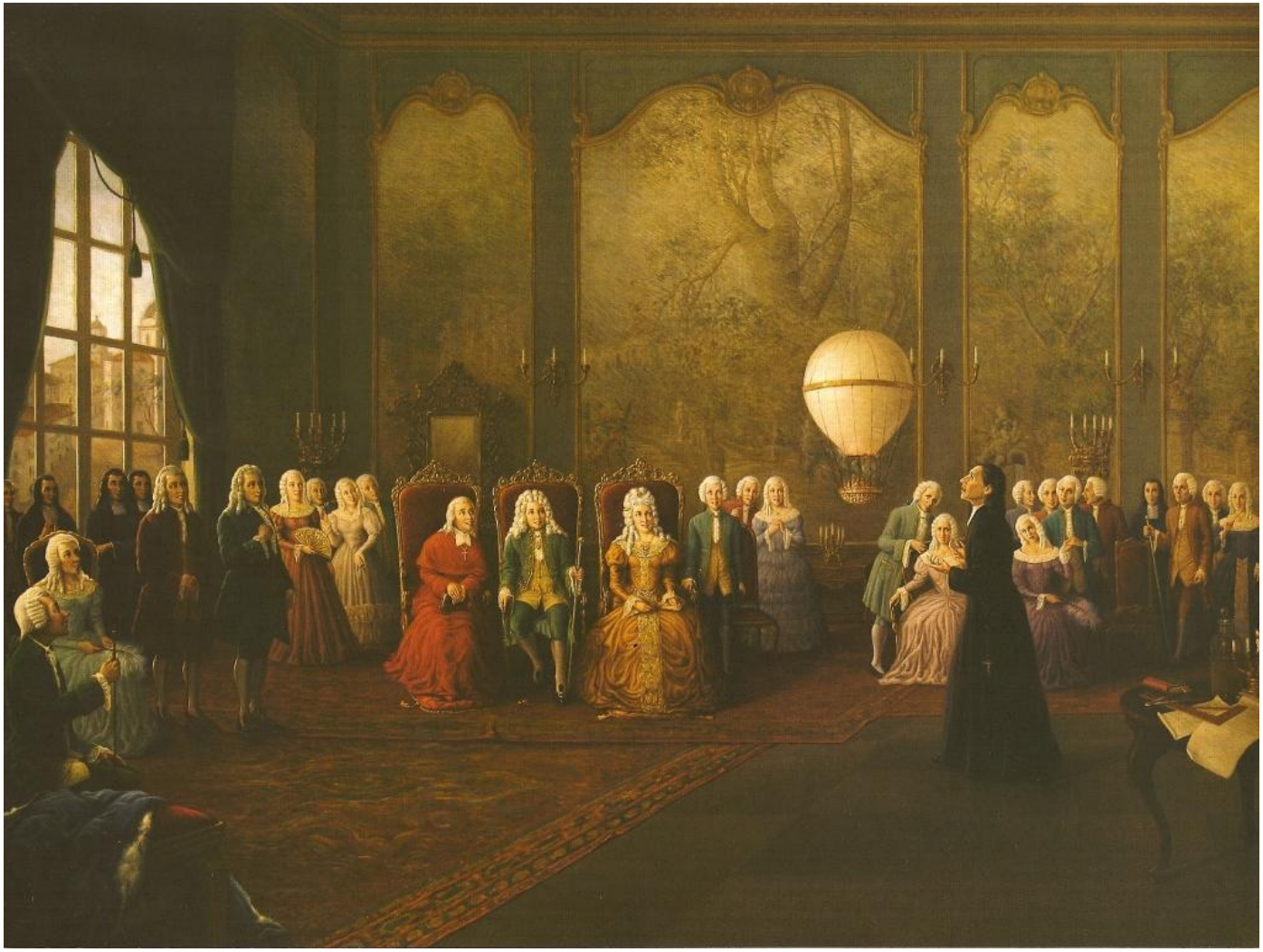
- Budgets are heavily constrained;
- No regulations at all;
- Membranes are seen as cheap, non-permanent structures;
- Because of that, clients are reluctant to invest in high quality solutions;
- A vicious cicle!
- Most architects still have limited formal repertoire and understanding on membranes;
- Few engineers are skilled enough to proper design…

  - Things are changing swiftly, and for the better…

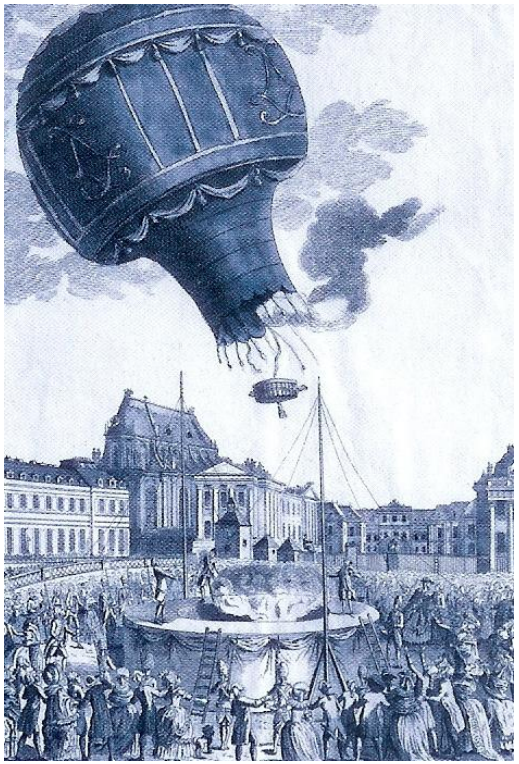
Pneumatic Structures

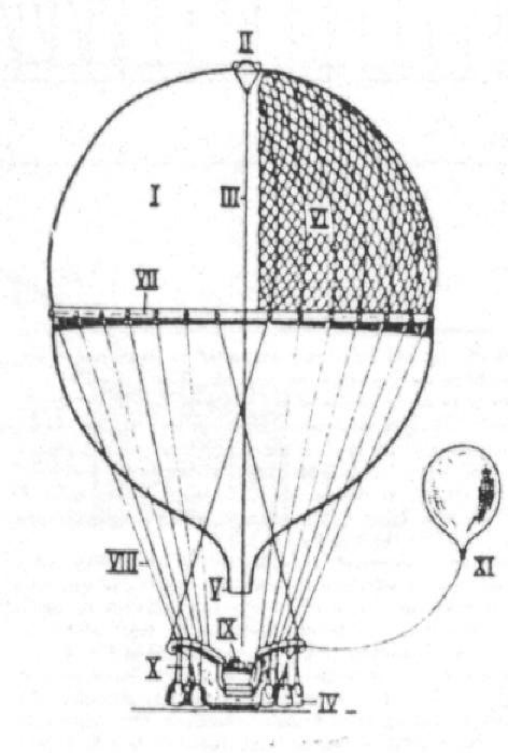


(a) Insufflated; (b) Aspirated; (c) Inflated

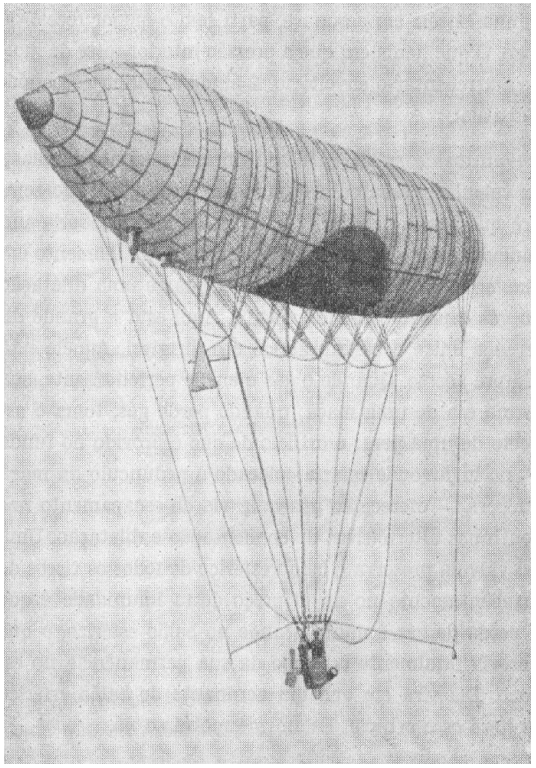


“Passarola” - The first known hot air baloon ever built (1709)
Bartolomeu de Gusmão, (1685-1724) Jesuit priest born in Santos, Brazil.



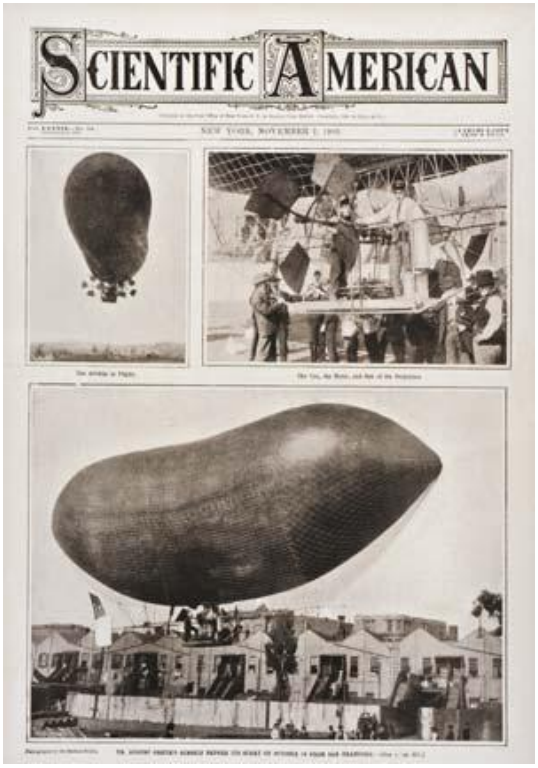


(a) Balão de ar quente dos irmãos Montgolfier (1783)
(c) Balão de hidrogênio de Jacques Charles (1783)

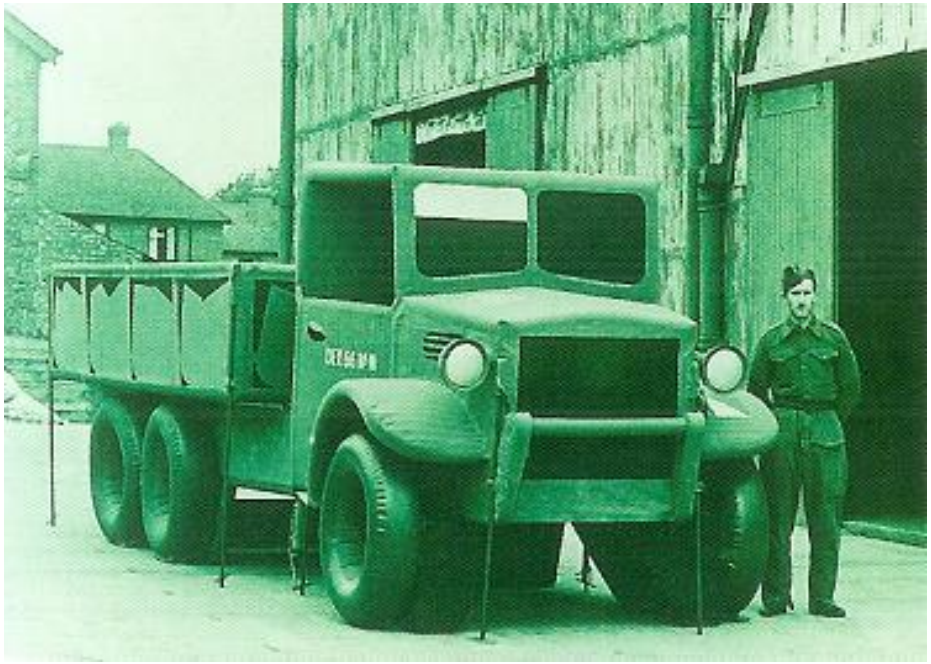


Santos Dumont s Dirigible n. 1 (1898)

Santos Dumont wins the Deutsch Prize with his dirigible n. 6 (1901)

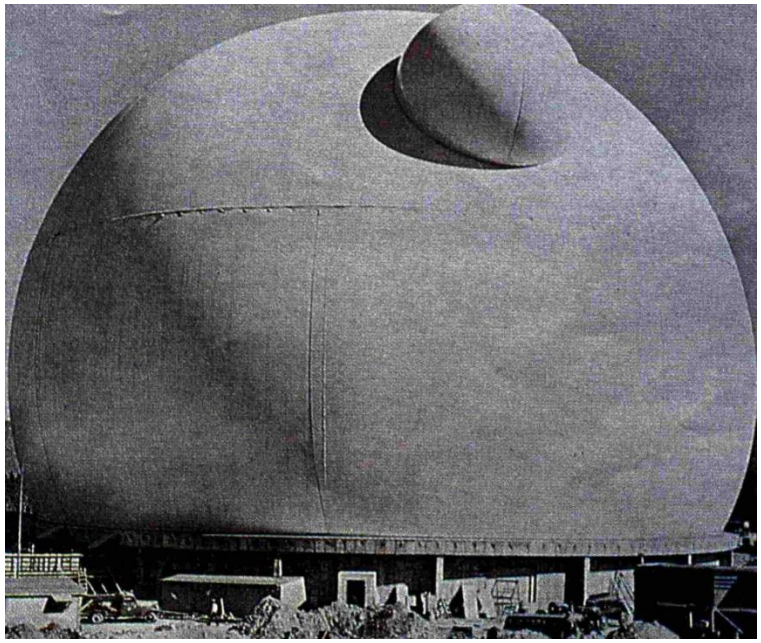


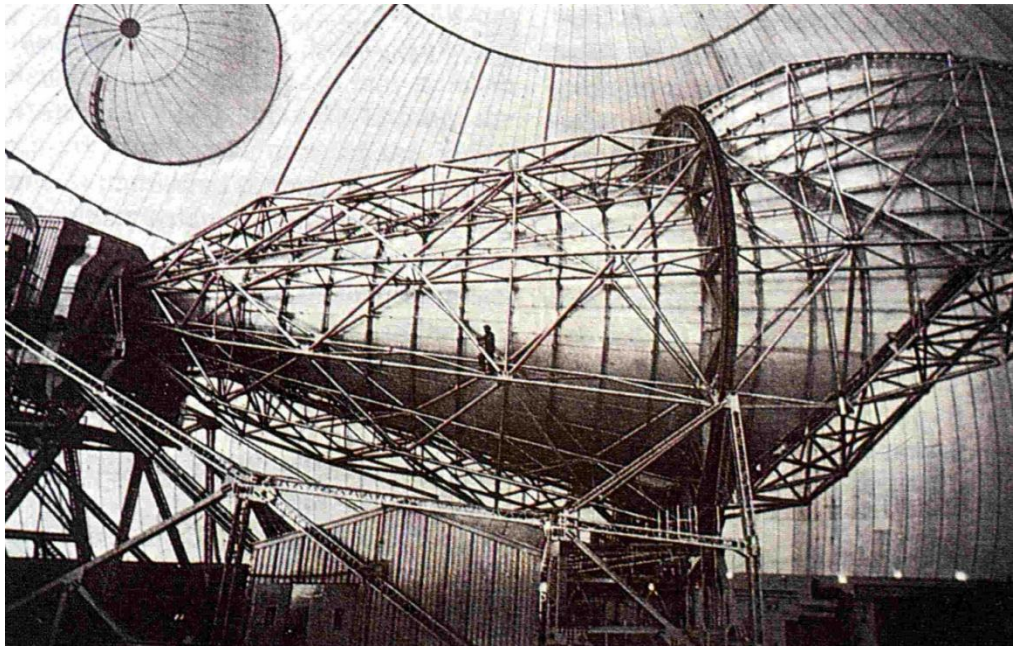
Dirigible n. 10 on Scientific American Nov. 7, 1903



Camuflagens infláveis empregadas pelos britânicos, durante a II Guerra Mundial

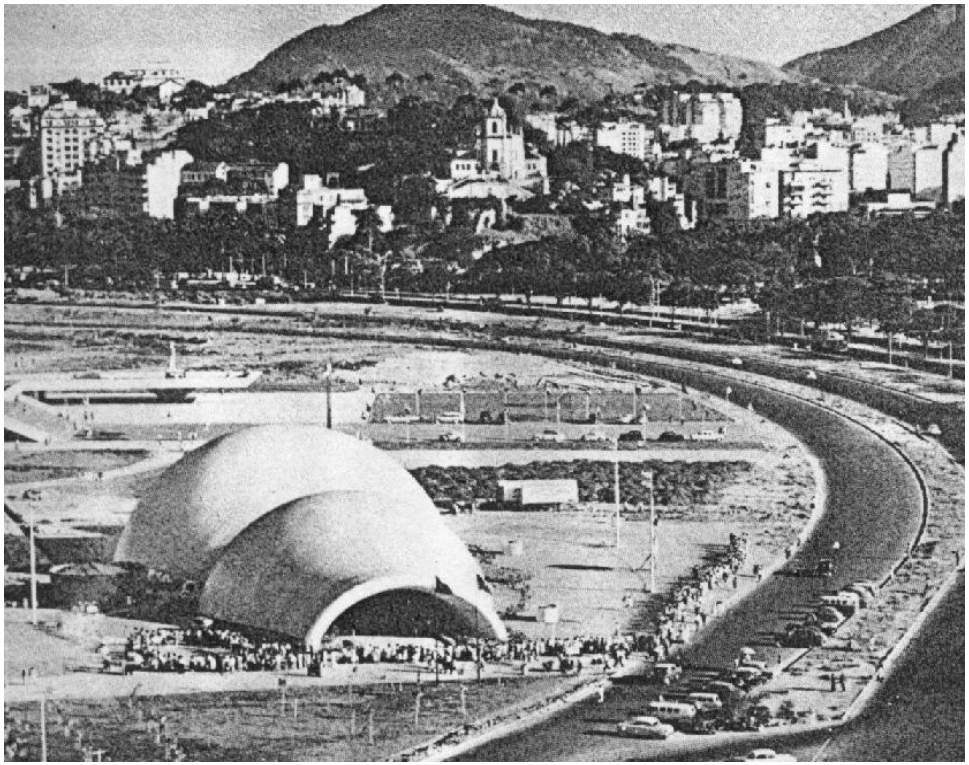
Radome no Maine, EUA (1961)

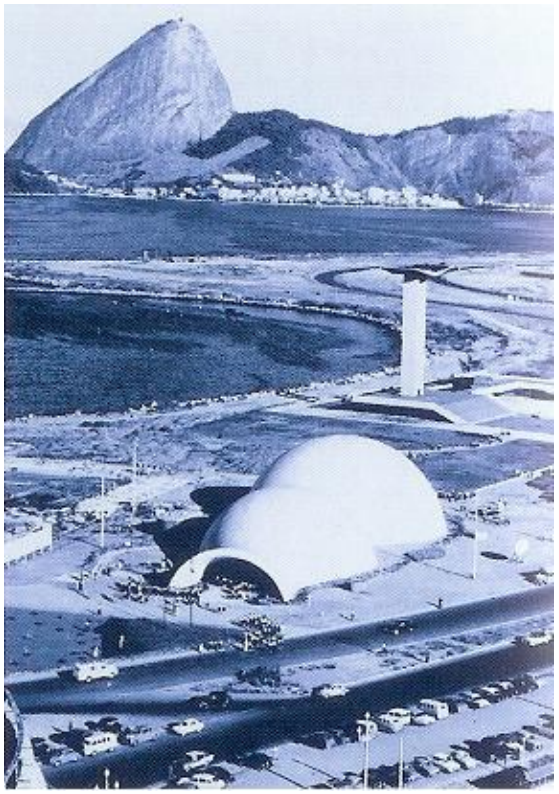




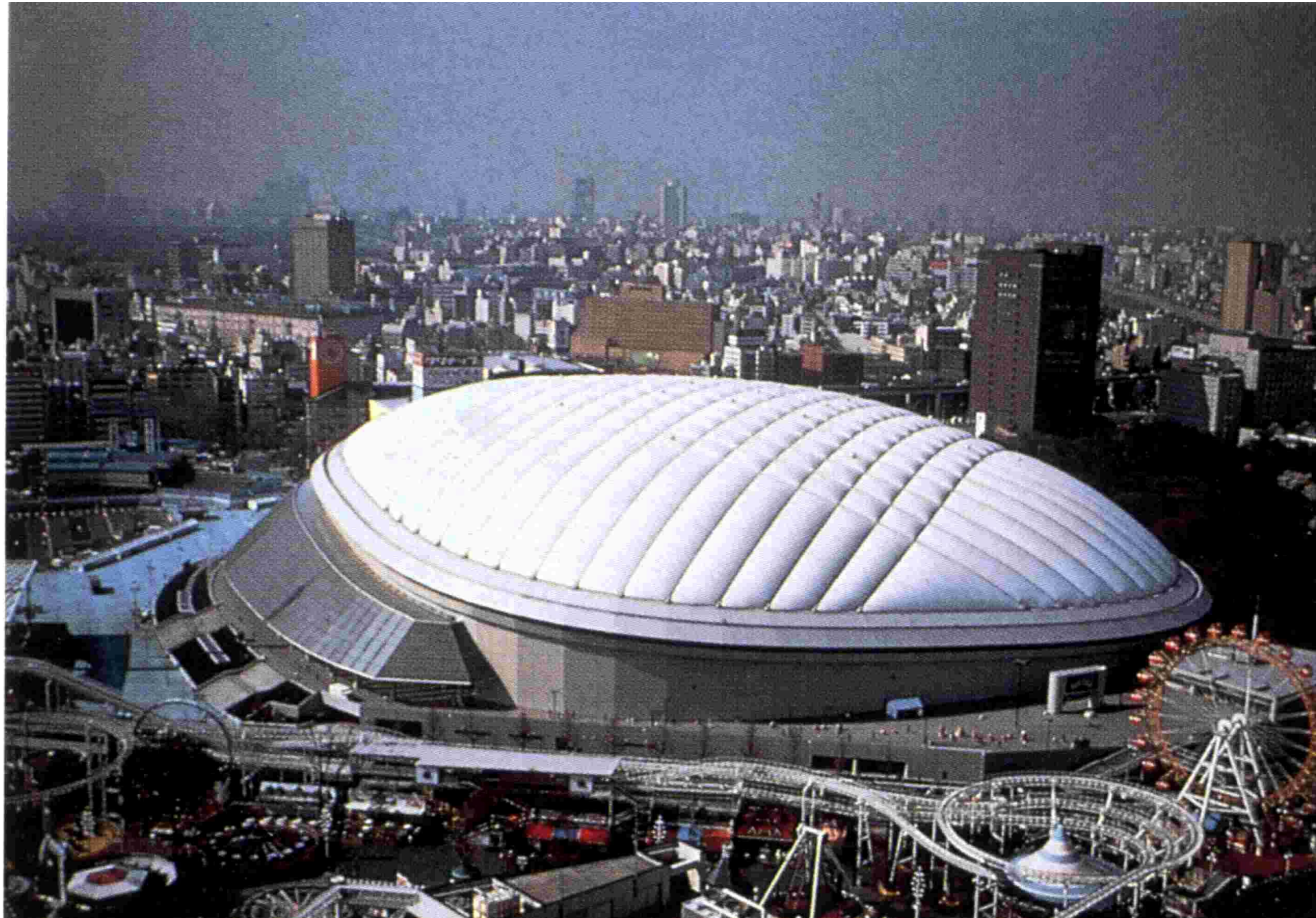
Pavilhão Atomos para a Paz, no Rio de Janeiro (1960)

Projetado por Victor Lundy, produzido por Birdair.





Tokio Big-Egg Dome (1988)



Tokio Big-Egg Dome (1988)

Guthrie Pavilion, Malásia (1998)

MILLENIUM ARCHES - STOCKHOLM
NEW YEAR, JANUARY 1, 2000

Dreamspace

Maurice Agis, 2000-2001


Archipelago
Alan Parkinson


Archipelago
Alan Parkinson

Garrafas PET no Tietê -2008 (concepção Eduardo Srur)

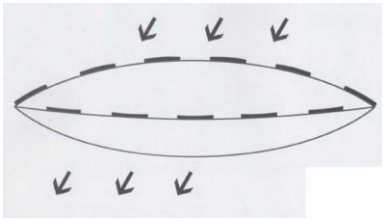
Pavilhão da Exposição
Petrobrás - A Energia de Um Sonho
Arq. José Wagner Garcia

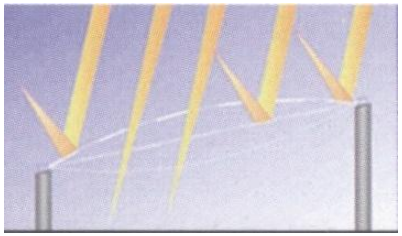
Eden Project, Cornwall, UK

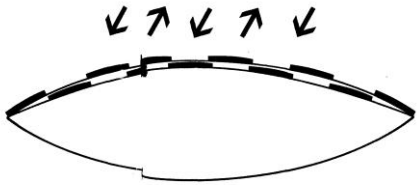
National Space Center, Leicester, UK

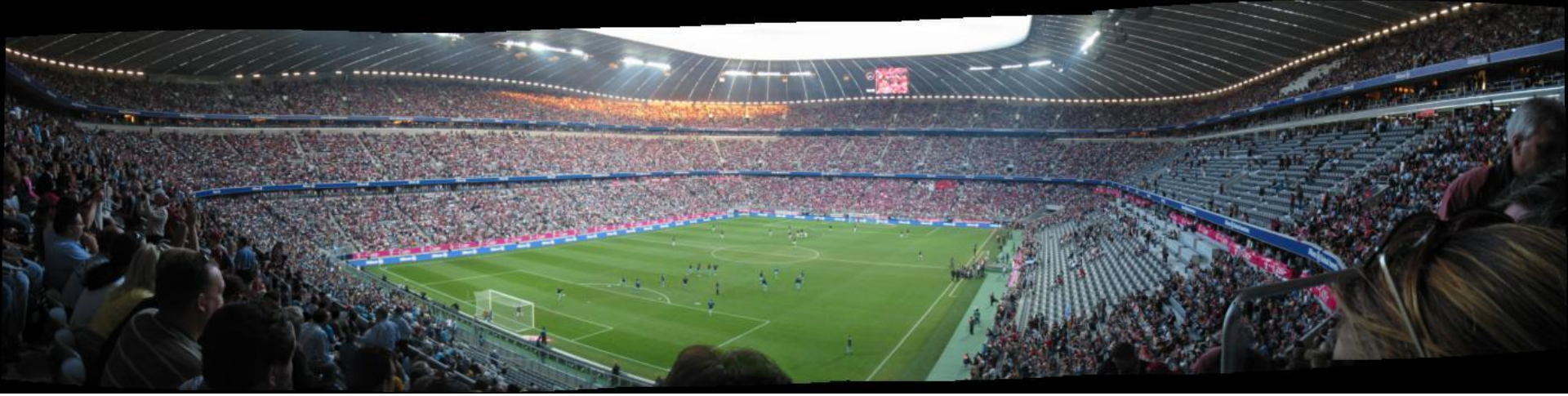

PGM 17
THOR

Festo Technology Centre





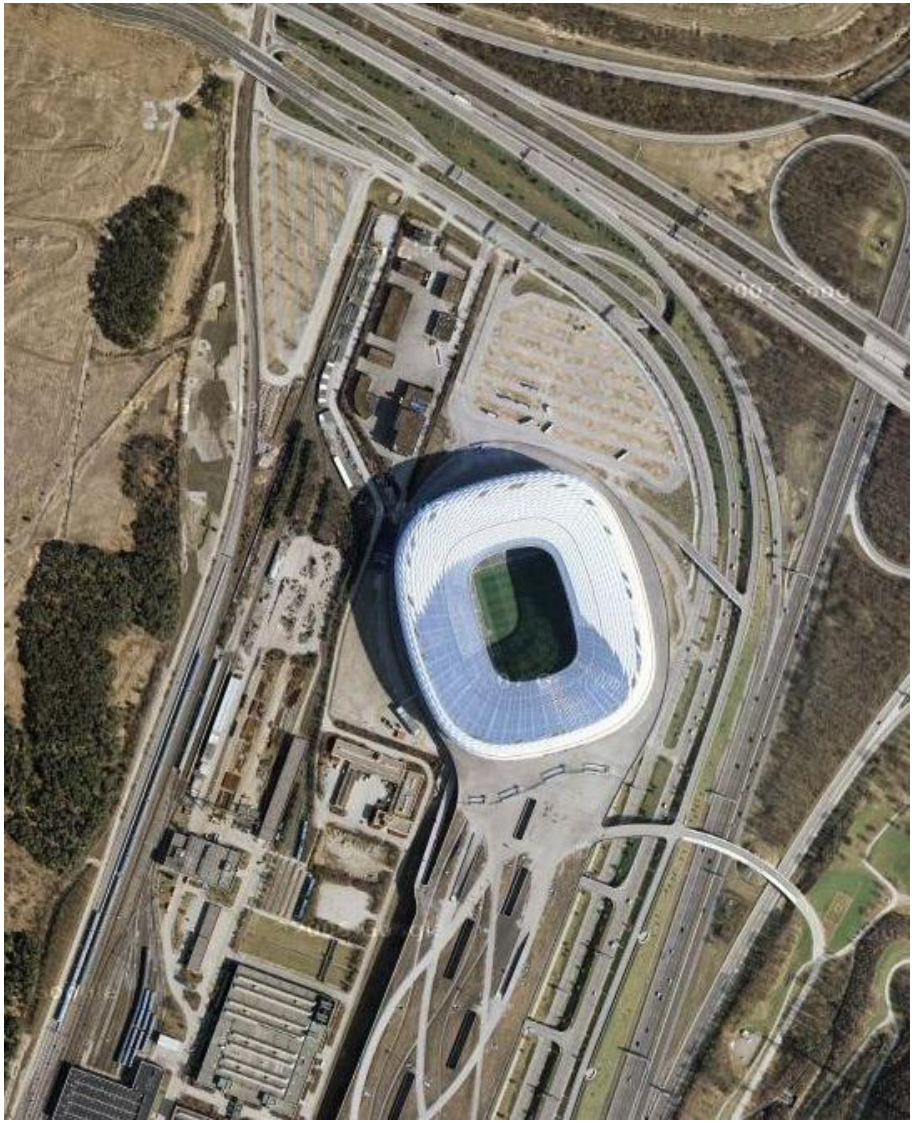





Allianz Arena


Allianz Arena


Allianz Arena
Allianz Arena
Allianz Arena



Complexo Aquático de Pequim
“Water Cube” , ou “H_2O^3”)

Março, 2008

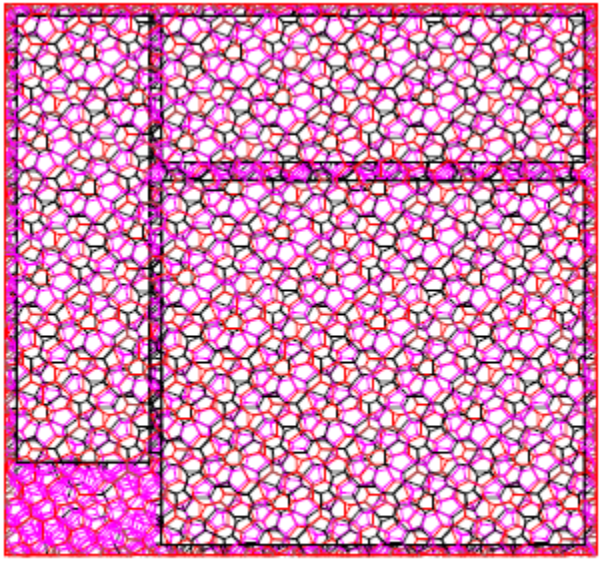


Figure 3. Architecture Plan View

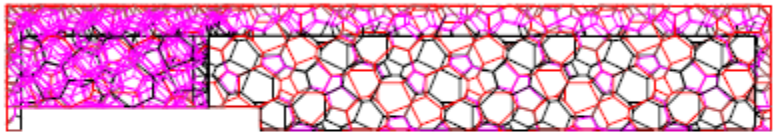
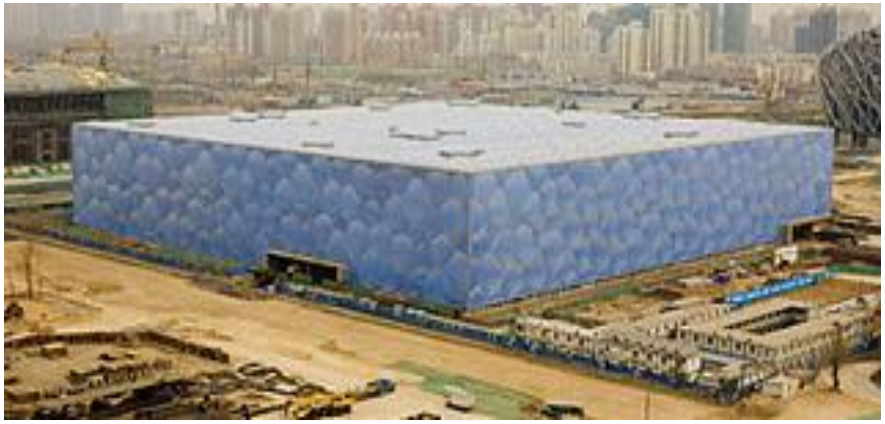
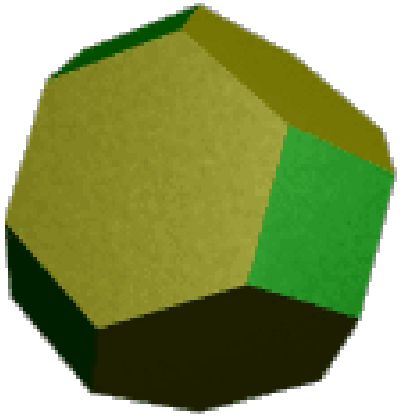


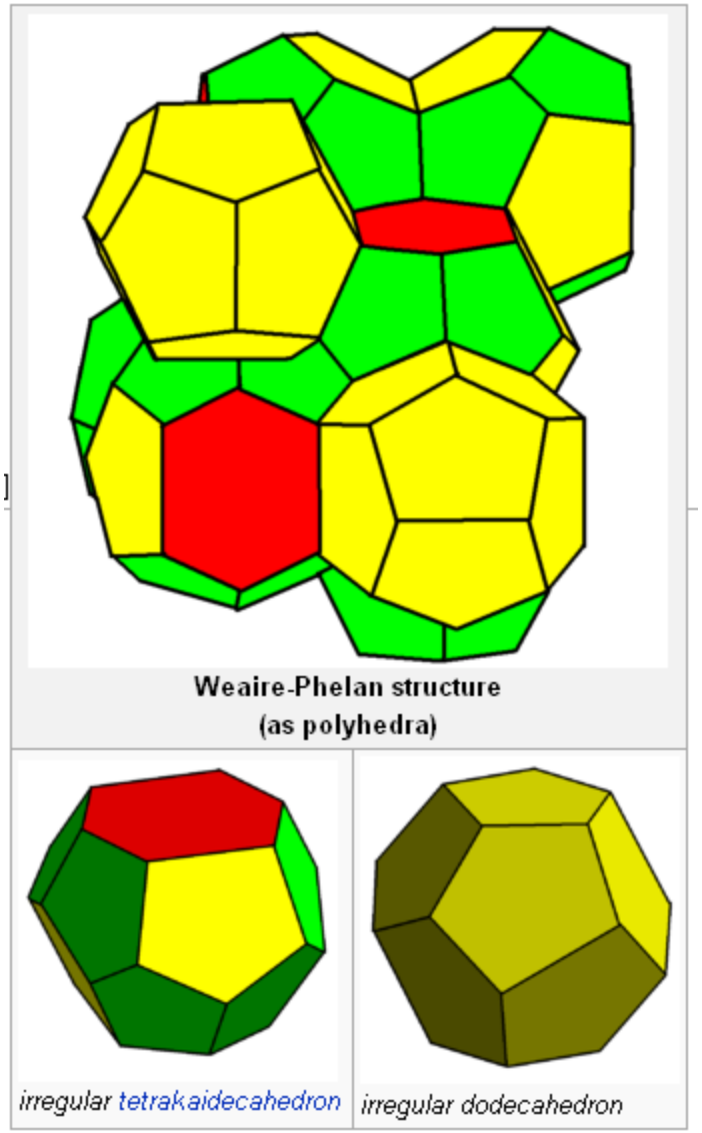
Figure 4. Architecture Elevation View

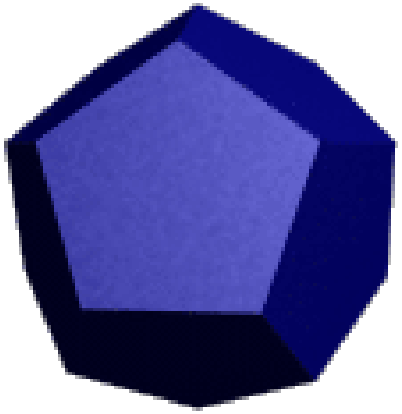


Estrutura de Kelvin:
Arranjo compacto de Octaedros Truncados

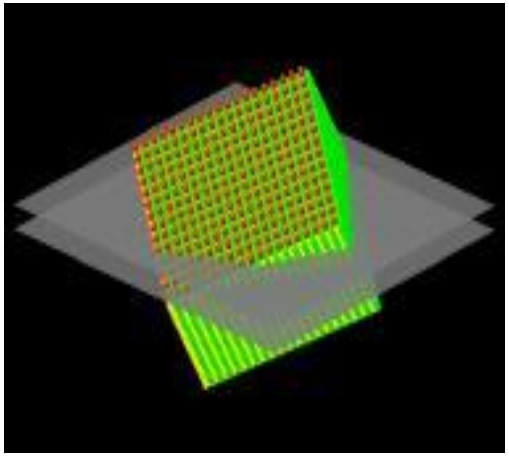


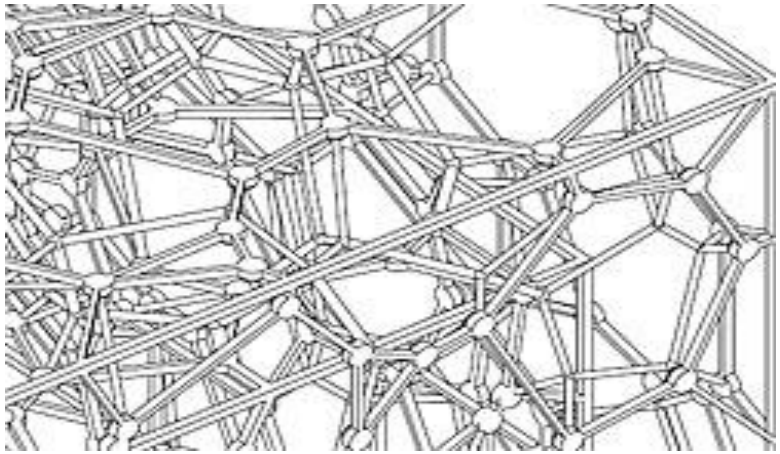
Estrutura de Wearie-Phelan:
Arranjo compacto de tetrakaidecaedros e dodecaedros irregulares

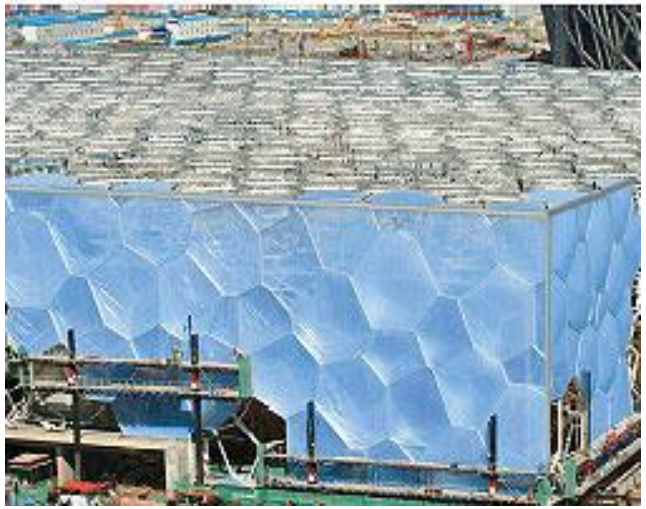




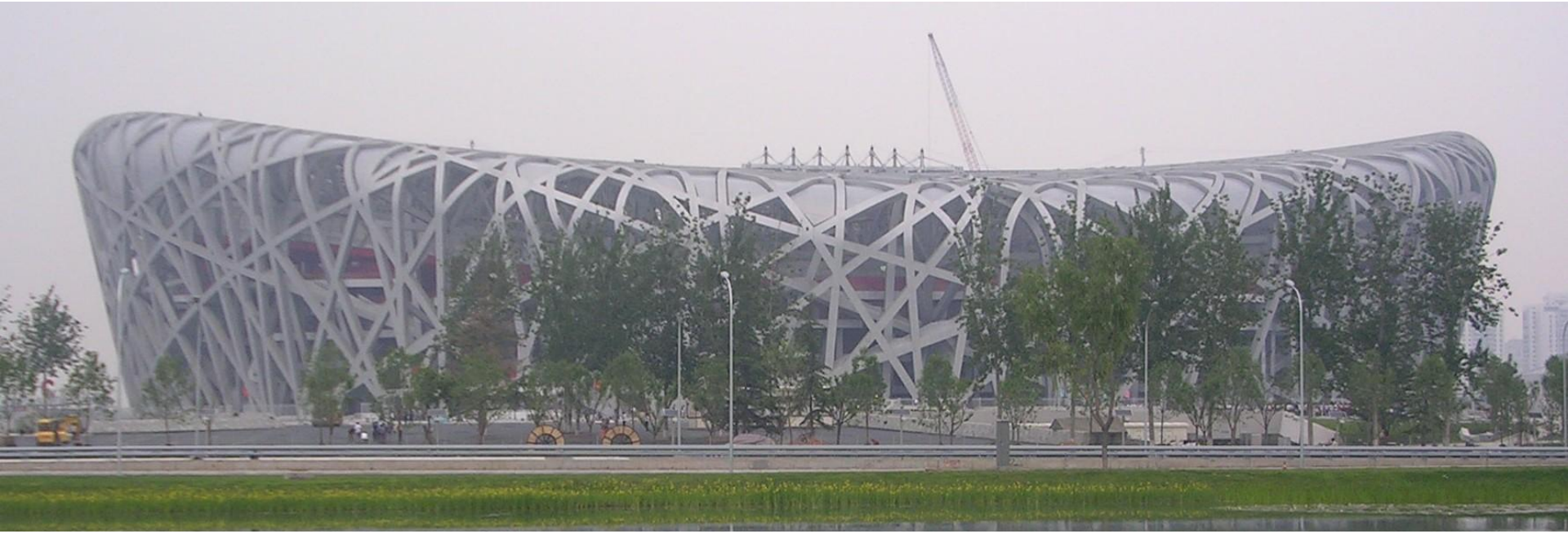
Um dodecaedro regular…



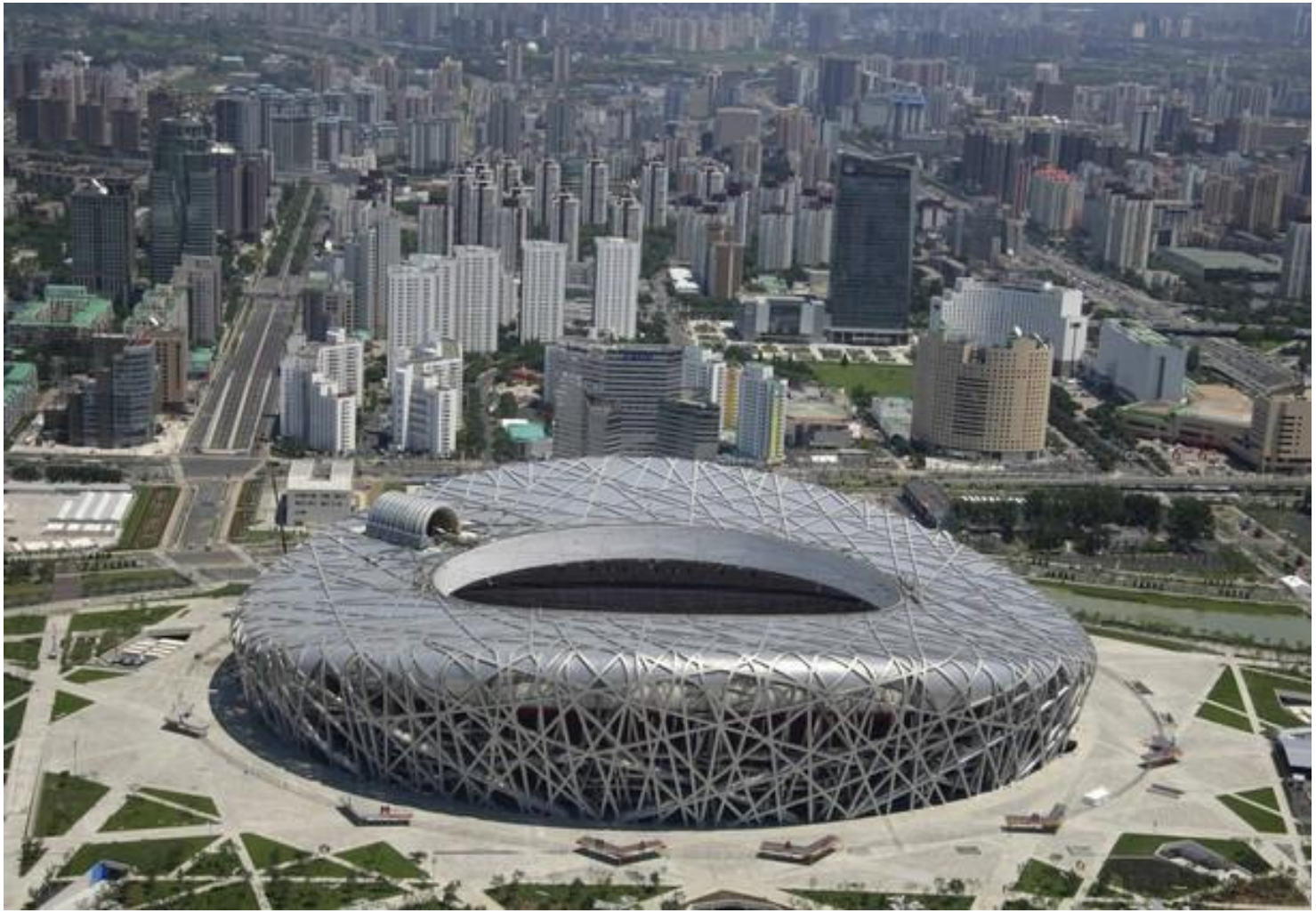




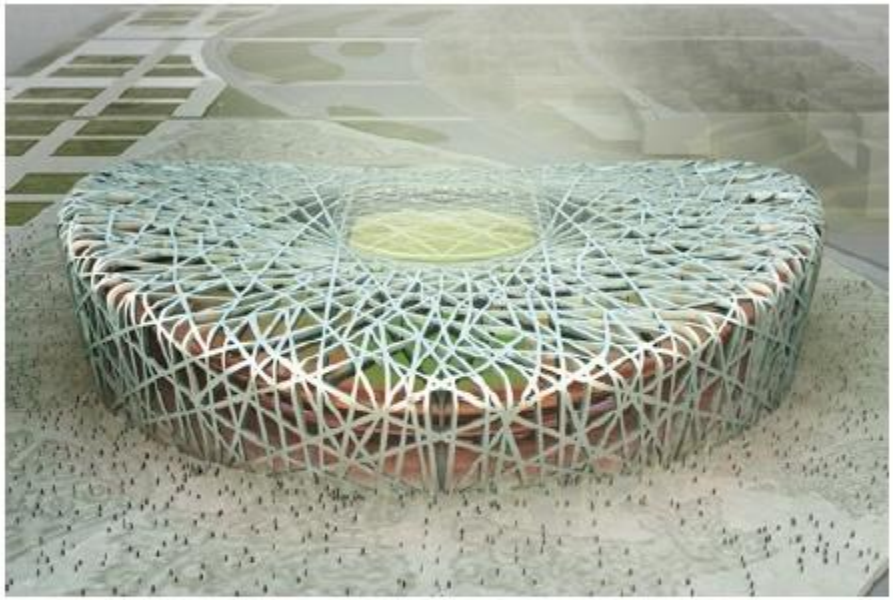
Estádio Olímpico de Pequim
“Bird´s Nest”
Março, 2008



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)



(a)



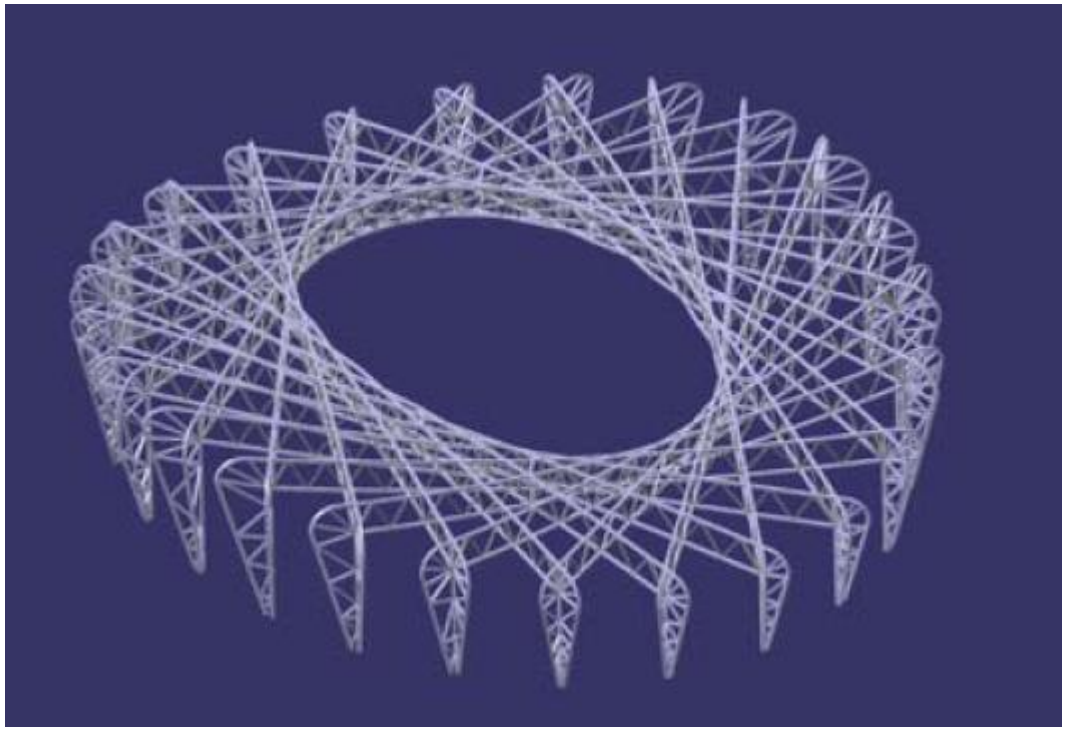
(b)

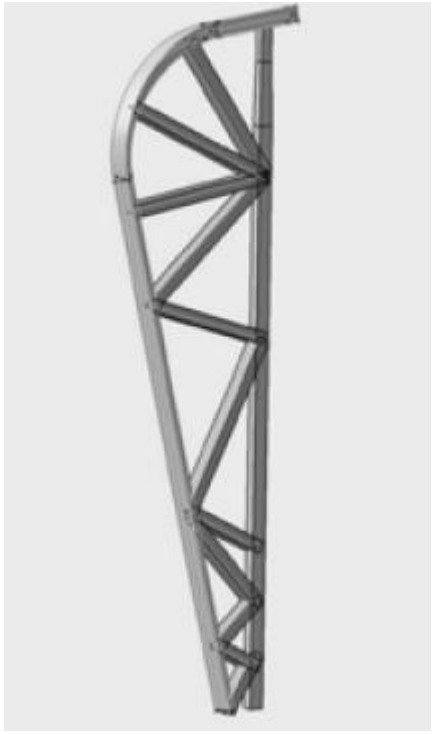
Figure 1. Basket-like structures. (a) The "5-dimensional quasi-periodic" garden pavilion by Olafur Eliasson in Holbaek, Denmark, 1998 (courtesy of Mr Eliasson). (b) The Beijing Olympic Stadium designed by Herzog & de Meuron for the 2008 Olympic Games (taken from the Internet).

2006 APCS
IASS SYMPOSIUM
APCS CONFERENCE
NEW OLYMPICS
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





2006 IASS SYMPOSIUM APCS CONFERENCE NEW OLYMPICS NEW SHELL AND SPATIAL STRUCTURES

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

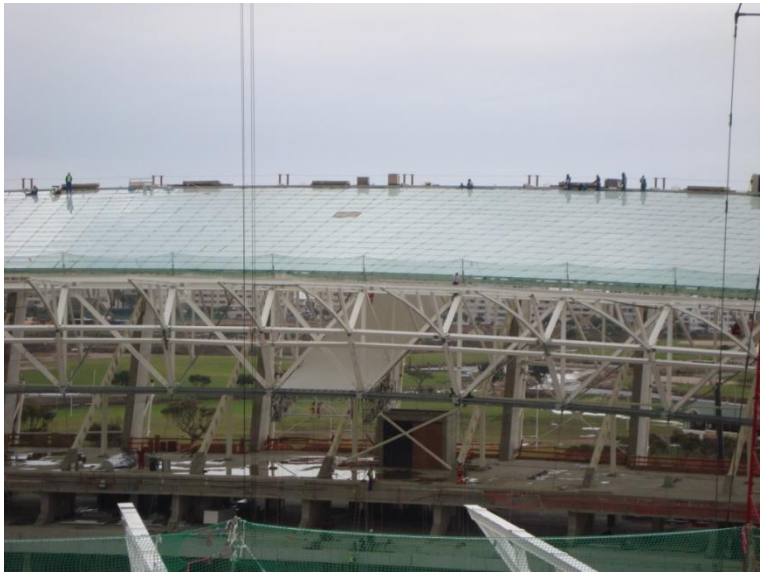
Zhong FAN[1], Yi PENG[2], Zhe WANG[2], Jiaru QIAN[3], Zuozhou ZHAO[4]

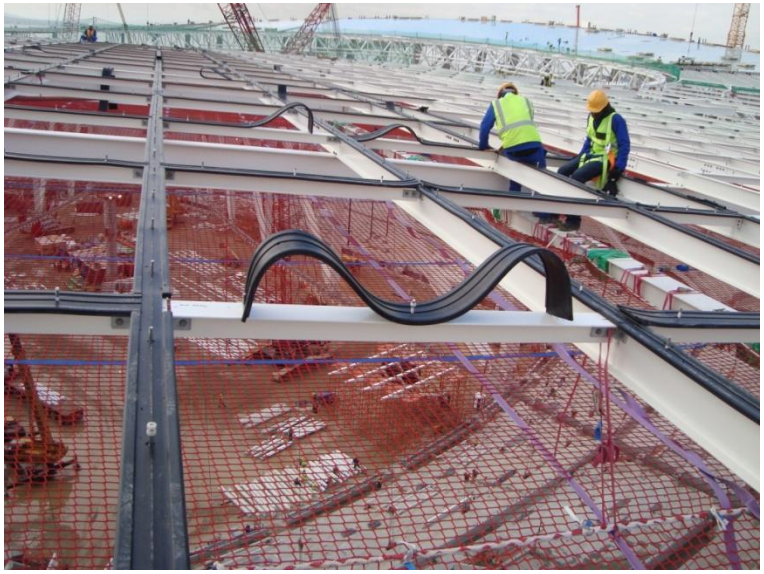
2010 WORLD CUP, África do Sul

Estadio de Green Point, Cidade do Cabo

2010 WORLD CUP, África do Sul

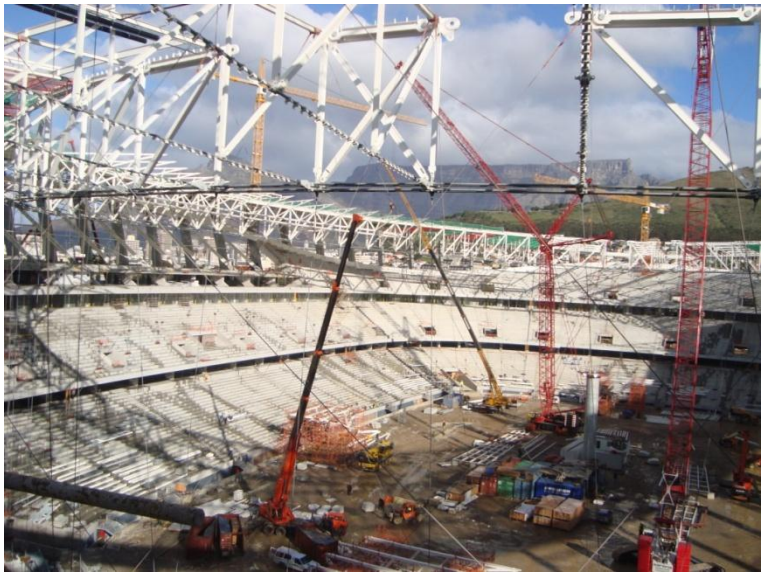
Estadio de Green Point, Cidade do Cabo





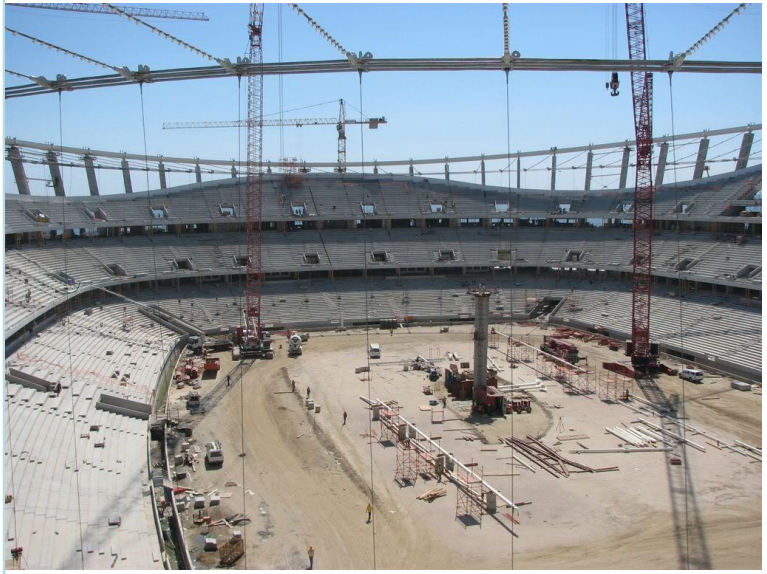
2010 WORLD CUP, África do Sul

Estadio de Green Point, Cidade do Cabo



2010 WORLD CUP, África do Sul

Estadio de Green Point, Cidade do Cabo



2010 WORLD CUP, África do Sul

Estadio de Porto Elizabete

2010 WORLD CUP, África do Sul

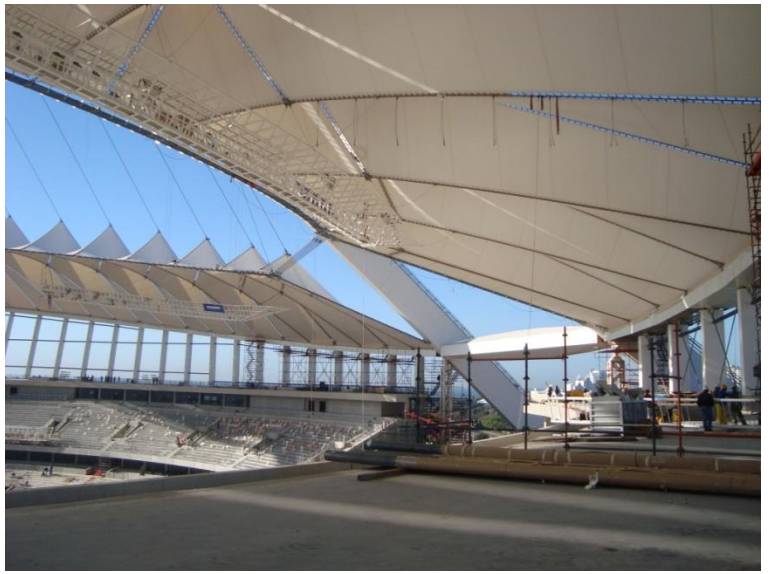
Estadio de Port Elizabeth

2010 WORLD CUP, África do Sul

Estadio Moses Mabhida, Durban

2010 WORLD CUP, África do Sul

Estadio Moses Mabhida, Durban

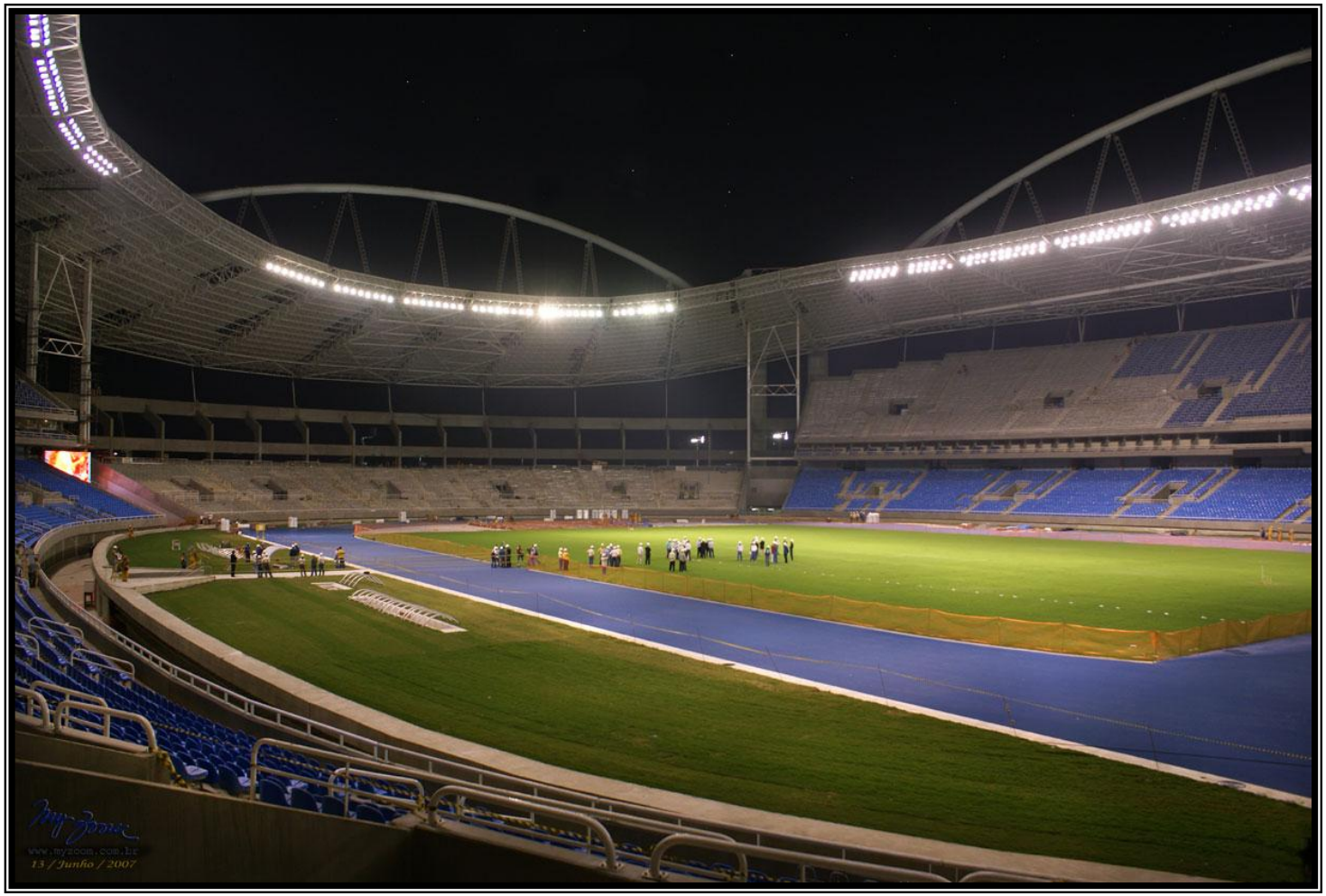


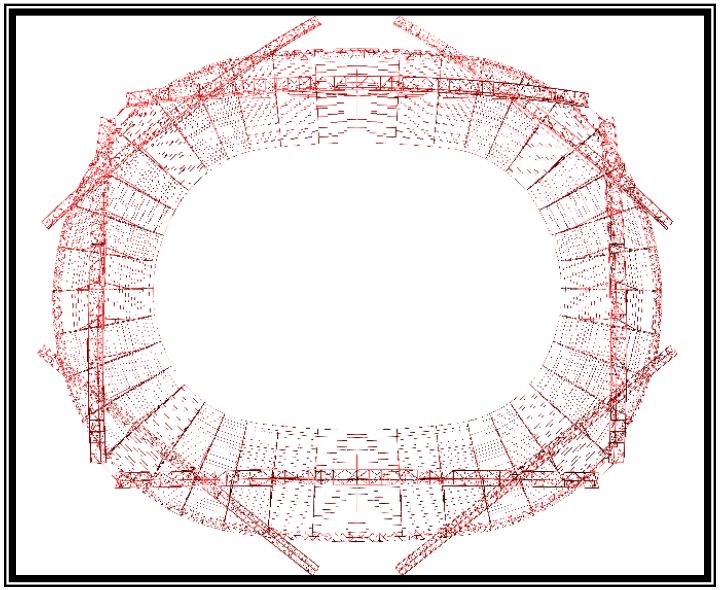
2010 WORLD CUP, África do Sul

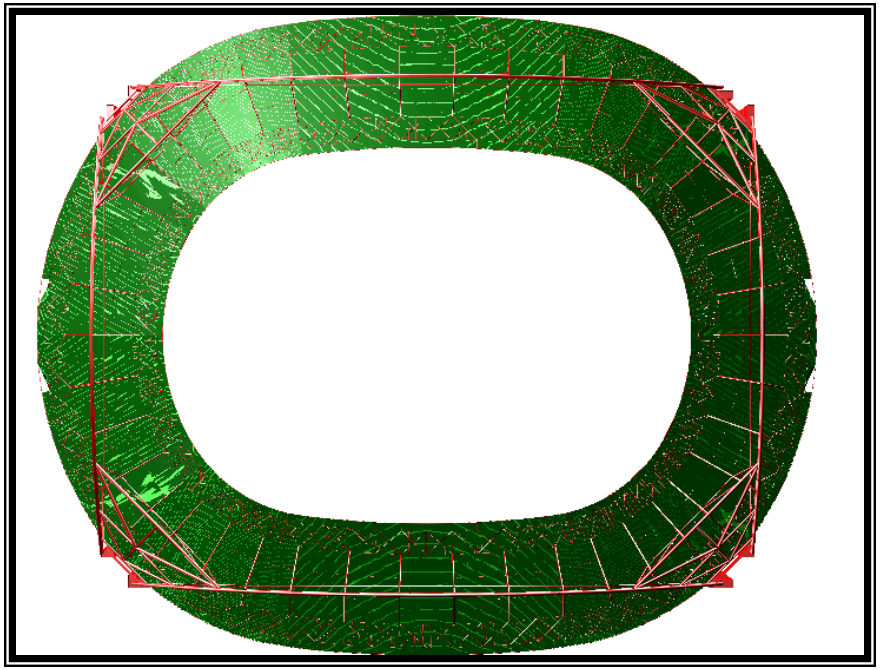
Estadio Moses Mabhida, Durban

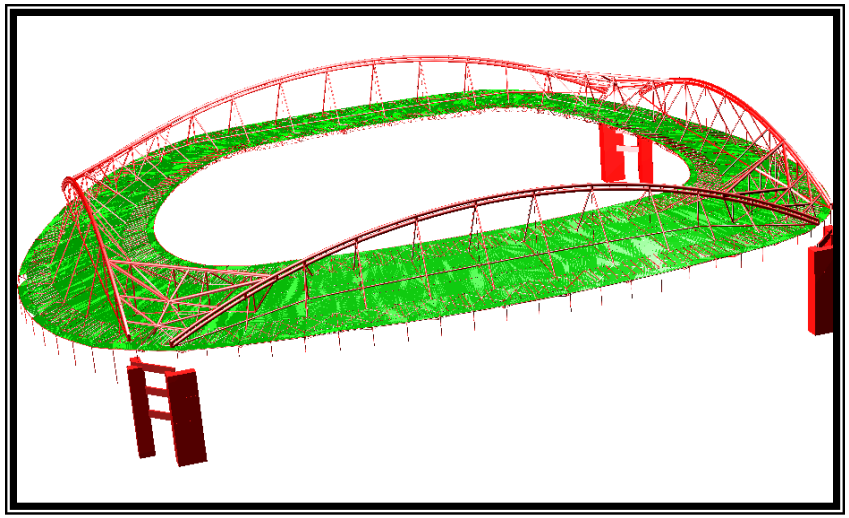
ESTÁDIO OLÍMPICO JOÃO HAVELANGE
Jogos Panamericanos 2007

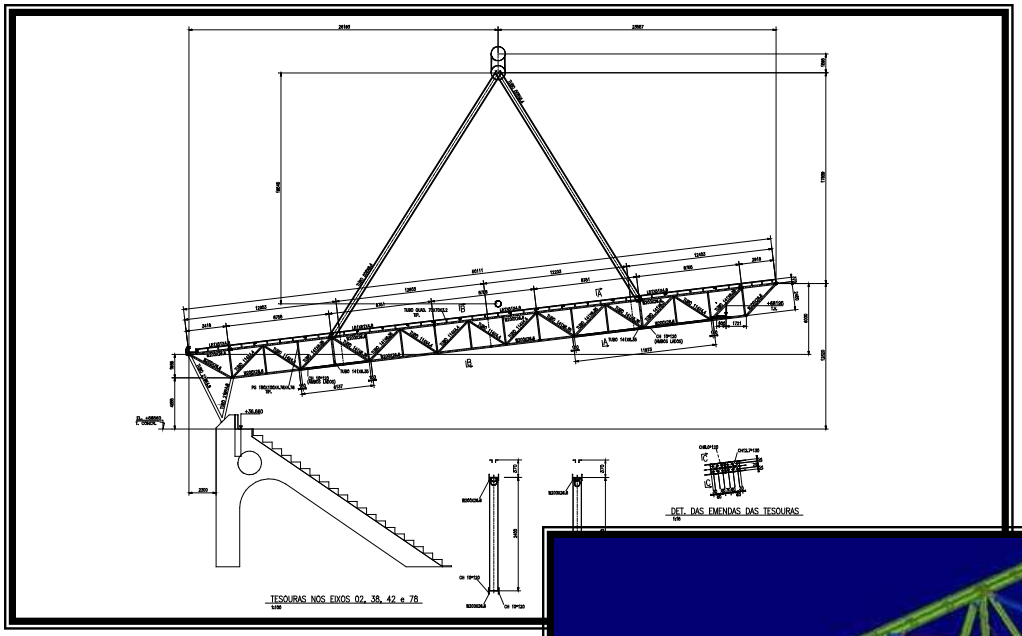
Arquitetura: CARLOS PORTO e GILSON RAMOS DOS SANTOS
PROJETO ESTRUTURAL DA COBERTURA: FLAVIO D ALAMBERT

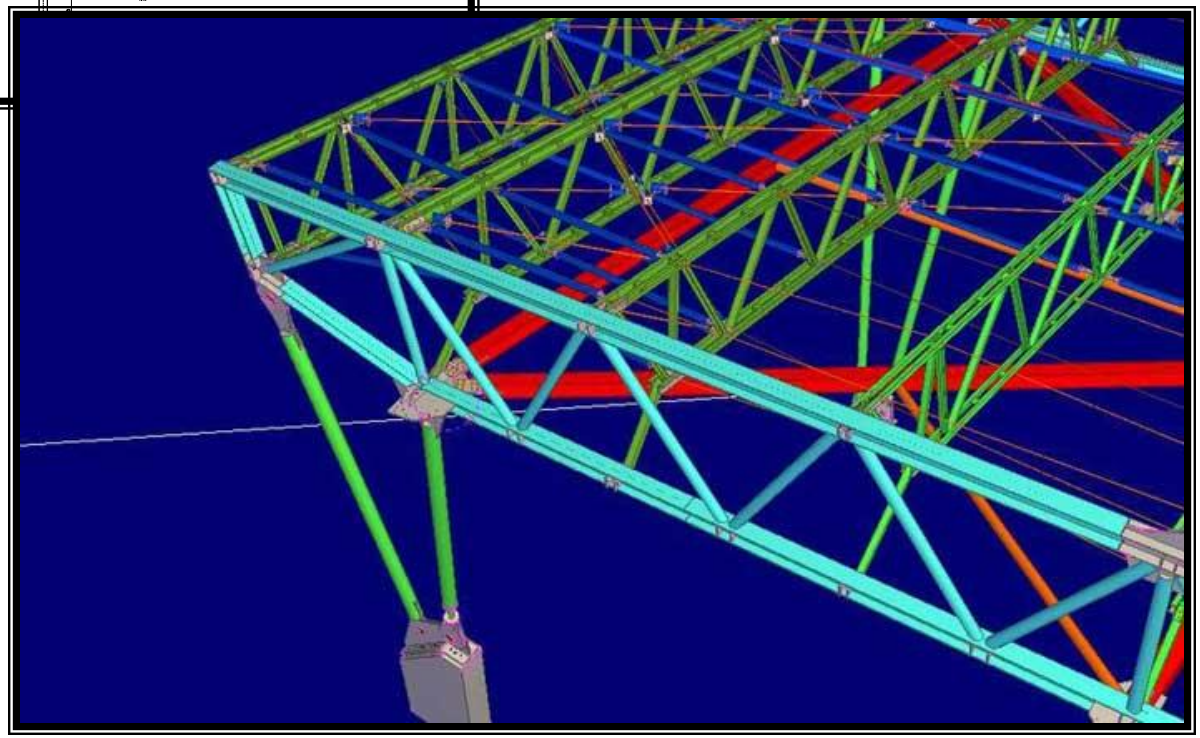

www.myzoom.com.br
13 / Junho / 2007

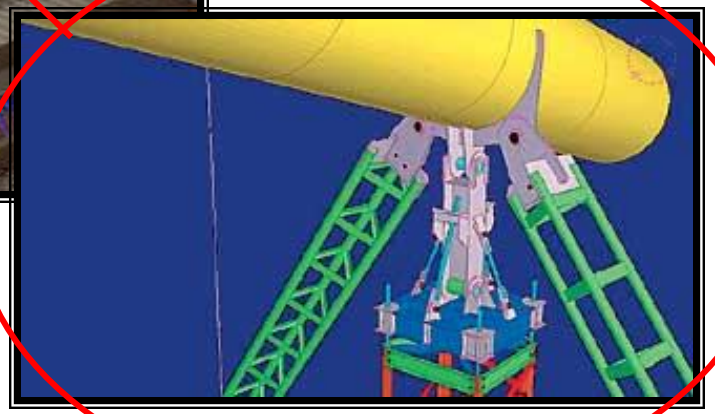


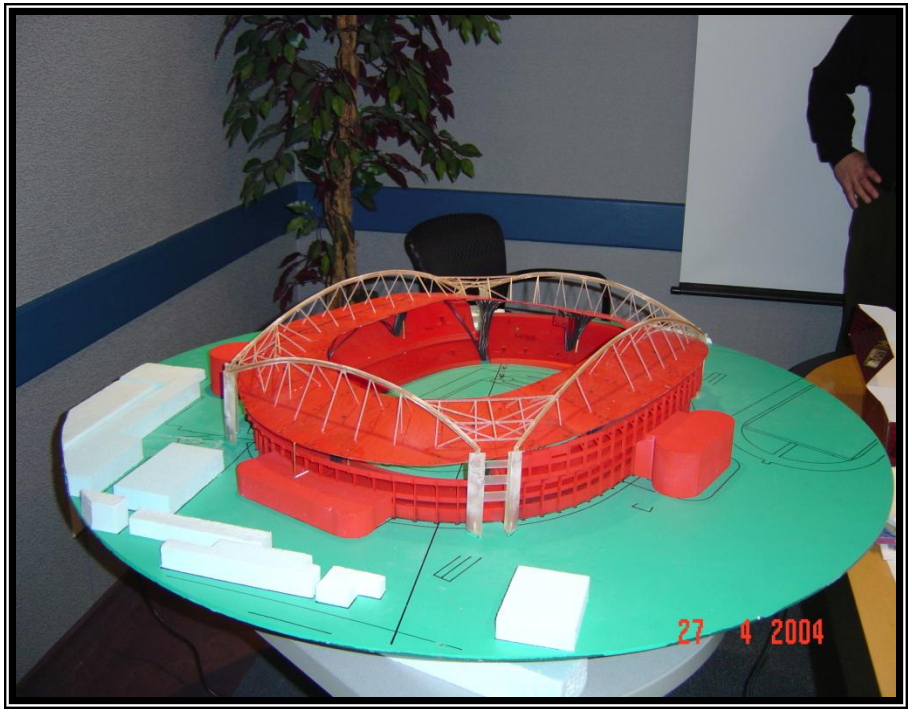


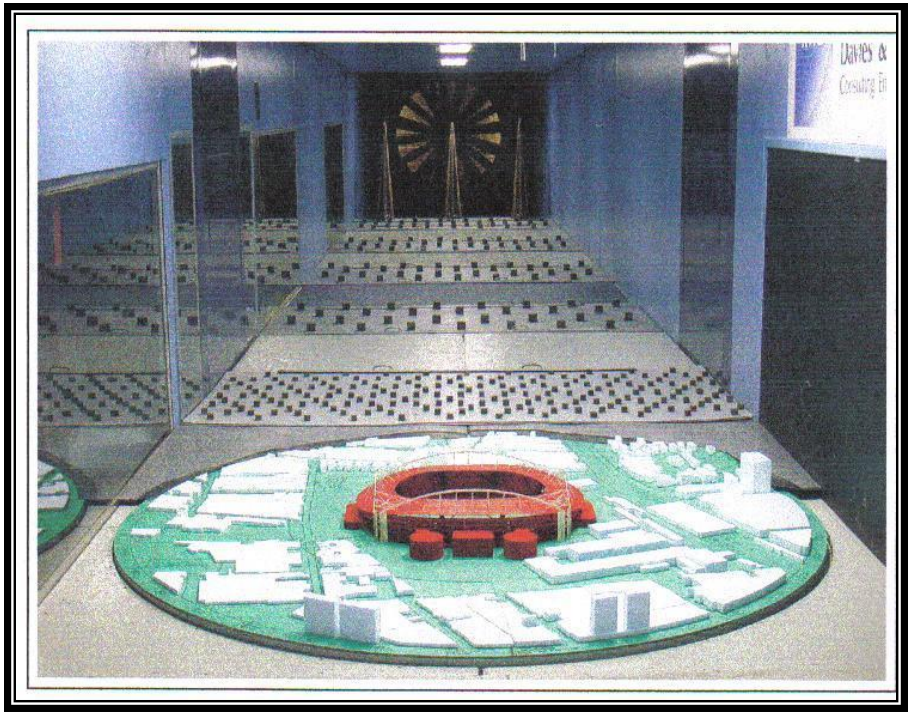



TESOURAS NOS EIXOS 02, 38, 42 e 78
DET. DAS EMENDAS DAS TESOURAS



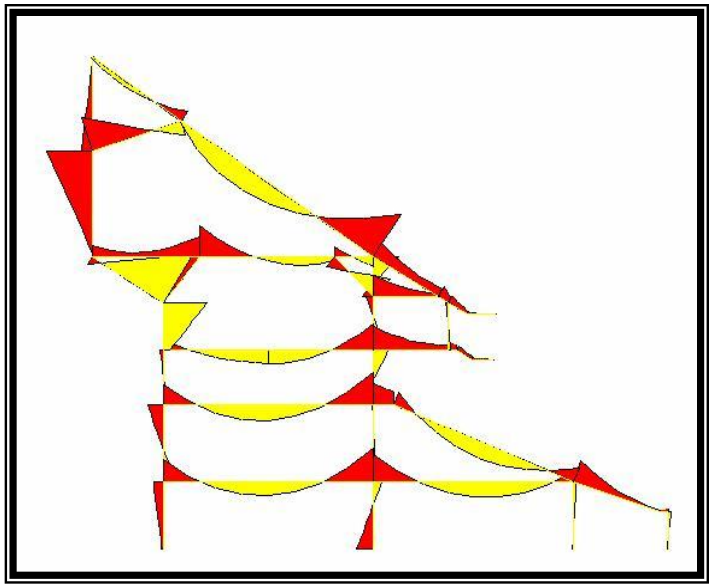


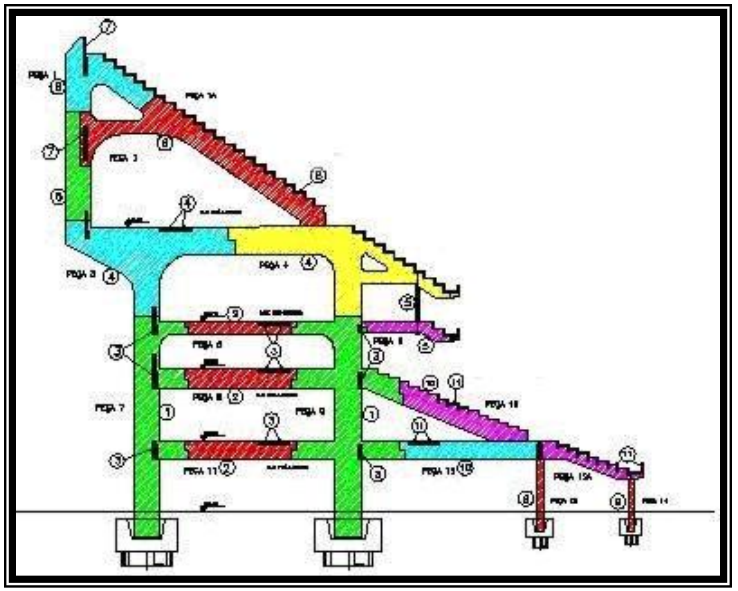




Modelo para ensaio em túnel de vento
escala 1:400

Ao estudarmos os pórticos,
veremos o caso das arquibancadas do ´Engenhão´:





2014 WORLD CUP STADIA

Cidades-Sede

Belo Horizonte: Mineirão

Brasília: Estádio Nacional de Brasília

Cuiabá: Verdão

Curitiba: Arena da Baixada

Fortaleza: Castelão

Manaus: Vivaldão

Natal: Cidade das Dunas

Porto Alegre: Arena do Beira-Rio

Recife: Cidade-Copa

Rio de Janeiro: Maracanã

Salvador: Fonte Nova

São Paulo: Morumbi

2014 WORLD CUP STADIA

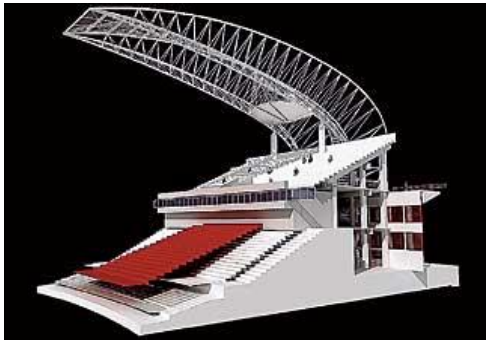
Estádio José Pinheiro Borda (BEIRA RIO)

Porto Alegre - RS

City: Porto Alegre/RS (1.5 millions)
Team: Sport Club Internacional
Current capacity: 56.000

2014 WORLD CUP STADIA

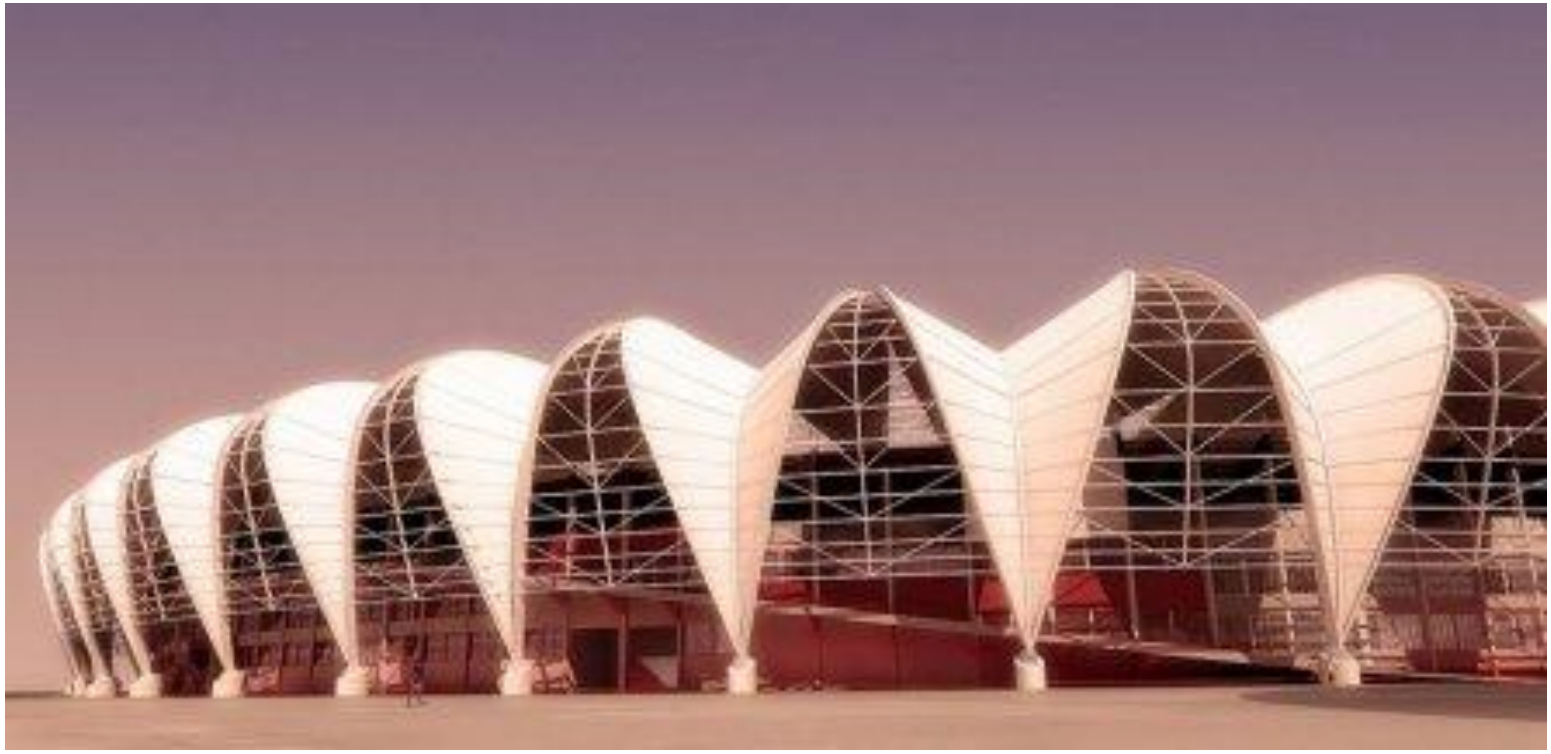
Estádio José Pinheiro Borda (BEIRA RIO)
Porto Alegre - RS

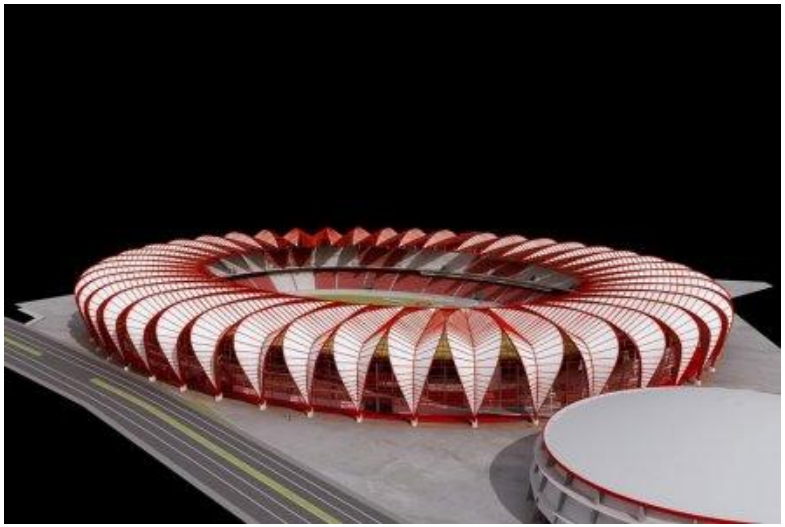


Project: Fernando Balvedi, Gabriel Garcia e Maurício Santos
Capacity: 60.000 pessoas
Roof: Membrana tensionada com estrutura metálica
Estimated value: R$ 60 millions

2014 WORLD CUP STADIA

Estádio José Pinheiro Borda (BEIRA RIO)
Porto Alegre - RS





2014 WORLD CUP STADIA

Arena do Grêmio - Porto Alegre - RS

City: Porto Alegre (1.5 million)
Capacity: 50.000 ; **Estimated value:** 270 millions
Project: **A**msterdan Arena Advisory; Odebrecht ,Construtora OAS Ltda. and Plarq Estudos de Arquitetura e Urbanismo Ltda

2014 WORLD CUP STADIA

Estádio Governador Magalhães Pinto (Mineirão)

Belo Horizonte - MG

City: Belo Horizonte/MG (2.45 millions)
Current capacity: 75.783

2014 WORLD CUP STADIA

Estádio Governador Magalhães Pinto (Mineirão)

Belo Horizonte - MG

Project: Marcelo Viana
Capacity: 74.300
Roof: 88 pórticos de concreto armado, dispostos radialmente em torno de uma elipse
Estimated value: 260 millions

2014 WORLD CUP STADIA

Mané Garrincha - Brasília - DF

City: Brasília/DF (2,4 millions)
Teams: Brasília EC and Unidos do Cruzeiro
Current capacity: 45.200

2014 WORLD CUP STADIA

Mané Garrincha - Brasília - DF

Project: Castro Mello Arquitetos ; **Capacity:** 76.232
Projeto Inicical: Roof: Cable Truss Structure; **Estimated value: R$**400 millions

2014 WORLD CUP STADIA

Mané Garrincha - Brasília - DF

Projeto Novo

2014 WORLD CUP STADIA

Estádio JOSÉ FRAGELLI (Verdão)

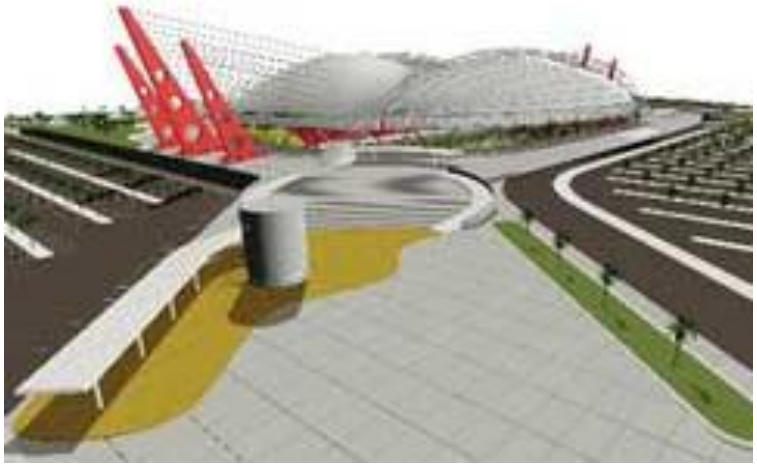
Cuiabá - MT

City: Cuiabá/MT (0.6 millions)
Teams: Dom Bosco e Mixto
Current capacity: 45.000

2014 WORLD CUP STADIA

Estádio JOSÉ FRAGELLI (Verdão)

Cuiabá - MT



Project original : Secretário-adjunto de Obras Públicas da Sinfra/MT Jean Martins e Silva Nunes
Capacity: 40.000
Estimated value: R$ 350 millions

2014 WORLD CUP STADIA

Capacidade: 48 Mil torcedores
Investimento: R$ 430 milhões

New Project

2014 WORLD CUP STADIA

Kyocera Arena
Curitiba - PR

City: Curitiba/PR (1.8 millions)
Team: Atlético - PR
Current capacity: 23.000

2014 WORLD CUP STADIA

Kyocera Arena
Curitiba - PR

Project: Vigliecca & Associados + Carlos Arcos
Capacity: 45.000
Roof: telhas translúcidas
Estimated value: R$ 30 millions

2014 WORLD CUP STADIA

Estádio Governador Plácido Castelo (Castelão)

Fortaleza - CE

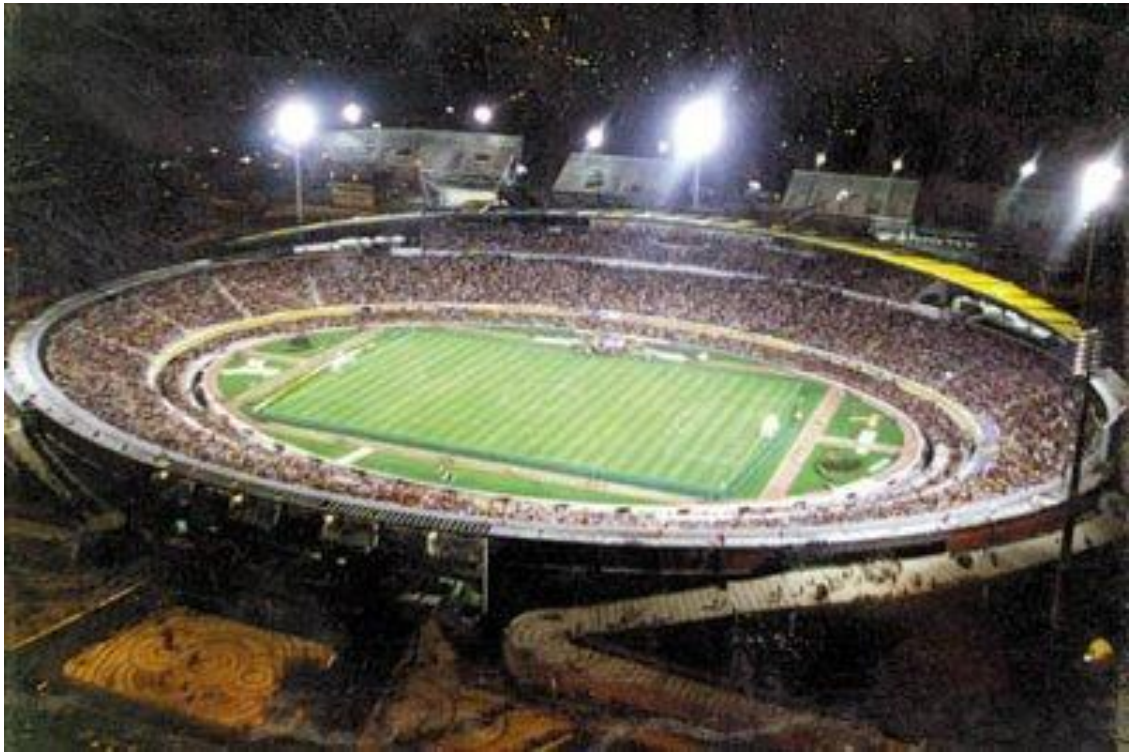
City: Fortaleza – CE (2.4 millions)
Capacity: 60.000
Project: José Liberal de Castro, Gehard Ernst Borman, Reginaldo Mendes Rangel, Marcílio Dias de Luna e Ivan da Silva Britto; Hugo Alcântara Mota

Capacidade: 54 Mil torcedores
Investimento: R$ 400 milhões

2014 WORLD CUP STADIA

Estádio Vivaldo Lima (Vivaldão)

Manaus/AM

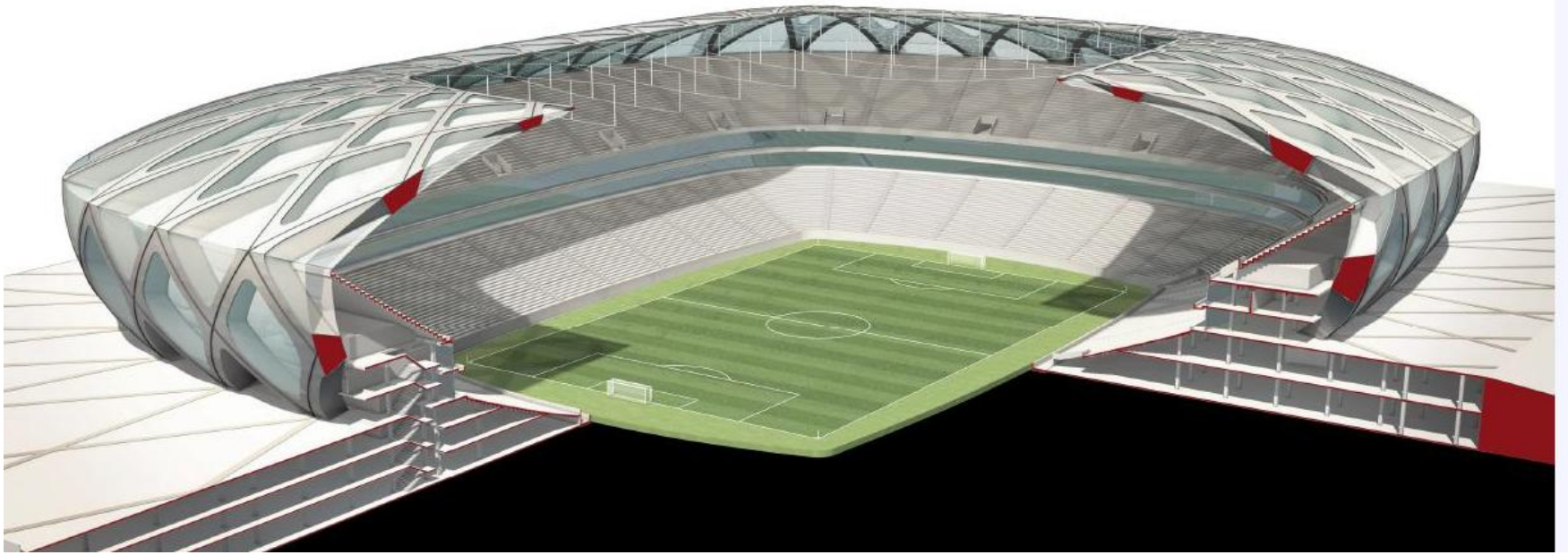


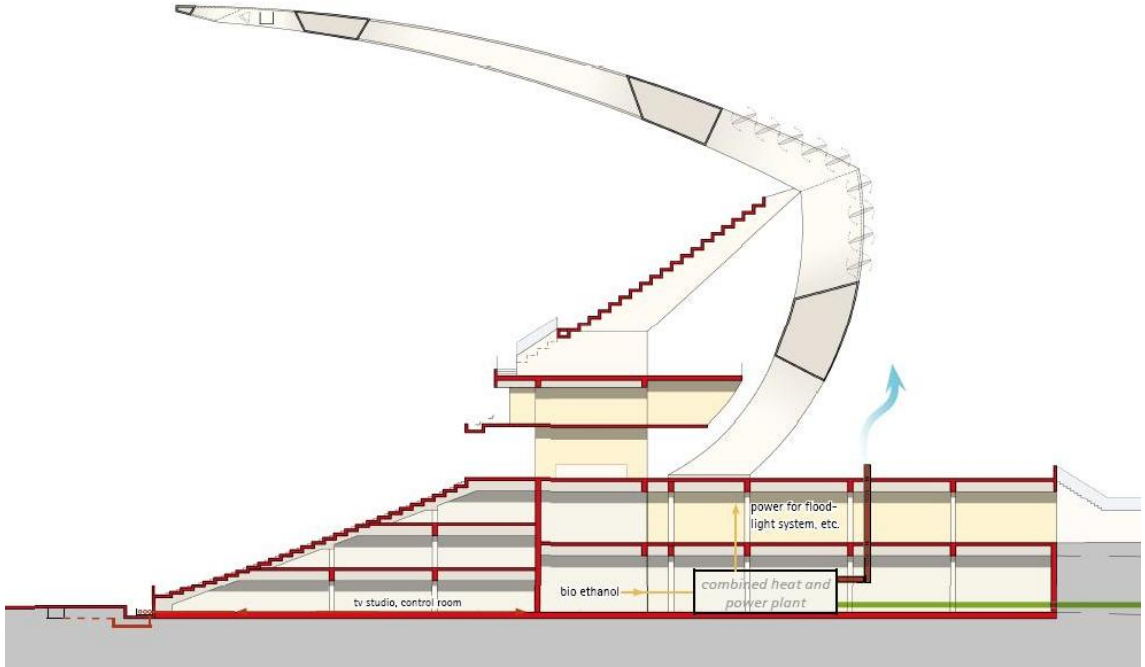
City: Manaus/AM
Population: 1,65 millions
Capacity: 32.000

2014 WORLD CUP STADIA

Estádio Vivaldo Lima (Vivaldão) - Manaus/AM

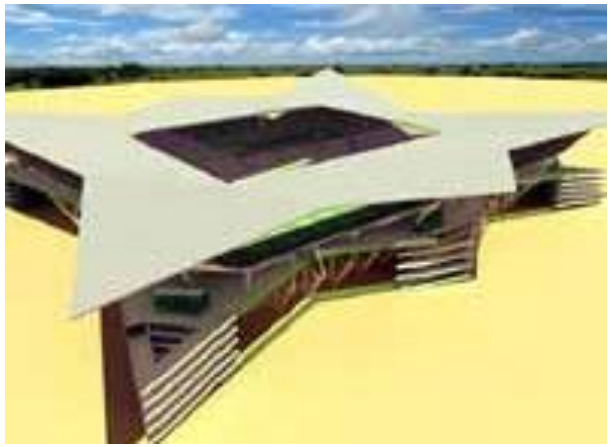
Project: Schlaich, Bergermann und Partner
Capacity: 60.000
Estimated value: 500 millions

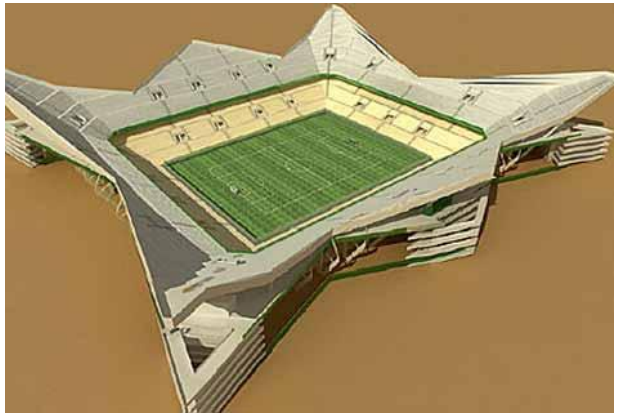



power for flood-
light system, etc.
bio ethanol
combined heat and
power plant
tv studio, control room

2014 WORLD CUP STADIA

Estádio Estrela dos Reis Magos - Natal - RN

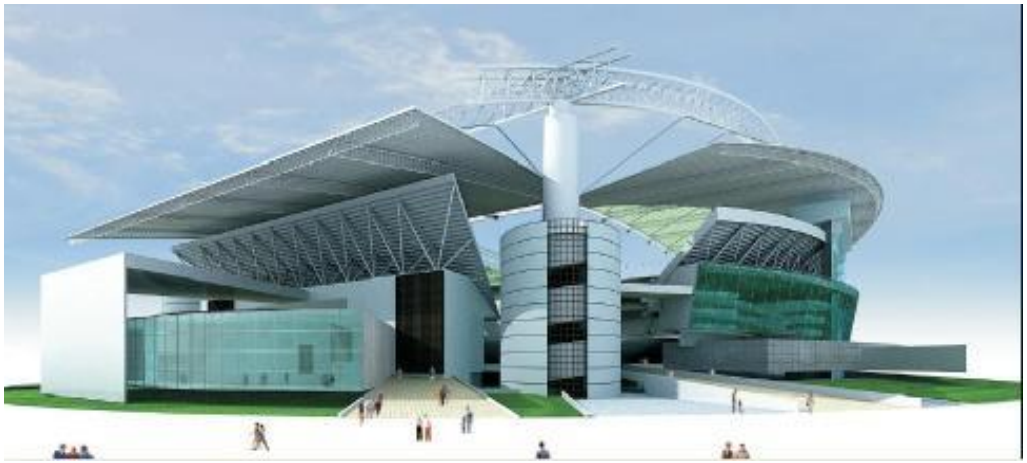




City: Natal/RN
Estádio: new
Population: 774.205
Capacity: 65.100
Roof: not available
Estimated value: R$ 260 millions
Project inicial: Gley Karlys

2014 WORLD CUP STADIA

Arena cidade da Copa Recife



City: Recife/PE & Olinda 2.0 millions
Estádio: Ainda não construído

Project: inicial Arquiteto Zeca Brandão
Capacity: 45.500

Capacidade: 46 Mil torcedores
Investimento: R$ 500 milhões (somente estádio)

2014 WORLD CUP STADIA

Estádio Jornalista Mário Filho (Maracanã)

Rio de Janeiro - RJ

City: Rio de Janeiro/RJ (6.15 millions)
Teams: Botafogo, Flamengo and Fluminense
Current capacity: 86.100
Project: Rafael Galvão, Orlando Azevedo, Antônio Dias Carneiro e Pedro Paulo Bernardes Bastos

2014 WORLD CUP STADIA

Estádio Jornalista Mário Filho (Maracanã)

Rio de Janeiro - RJ

Project: Inicial: Ricardo Rüther
Capacity: 86.100
Estimated cost: 500 to 1000 millions R$

2014 WORLD CUP STADIA

Estádio Otávio Mangabeira (Fonte Nova)

Salvador - BA

SETEPLA TECNOMETAL engenharia
Consultoria · Projeto · Gerenciamento

SCHULITZ ARCHITEKTUR + TECHNOLOGIE

Capacidade: 55 Mil torcedores
Investimento: R$ 400 milhões

Waldstation - Frankfurt

AOL Arena - Hamburg

2014 WORLD CUP STADIA

Estádio Cícero Pompeu de Toledo (Morumbí)

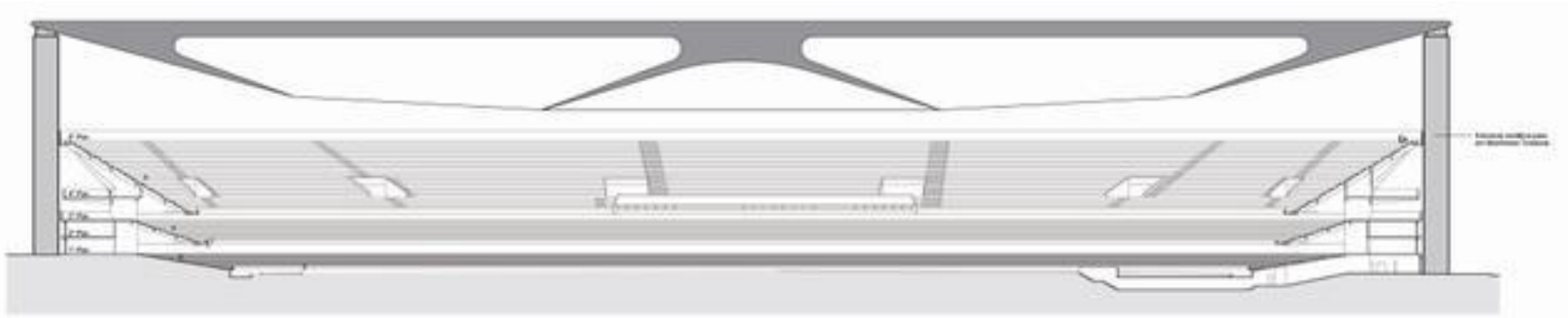
São Paulo - SP

City: São Paulo/SP (11 millions)
Team: São Paulo FC
Capacity: 80.000

2014 WORLD CUP STADIA

Estádio Cícero Pompeu de Toledo (Morumbi) - São Paulo - SP

Project: Arch. Ruy Ohtake
Capacity: 67.000
Estimated value: R 180 millions



Seção B - Longitudinal
Esc.: 1:200