EP-USP

PEF2603
Estruturas na Arquitetura III –
Sistemas Reticulados e Laminares

FAU-USP

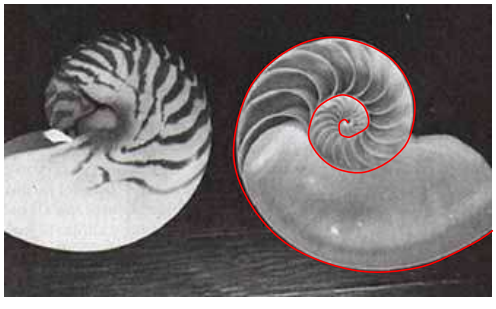
Cascas

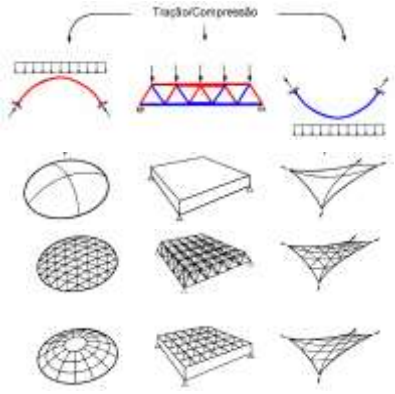
Uma Visão Geral

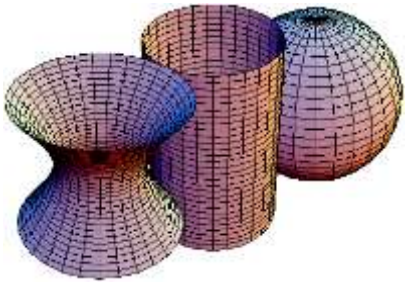
(05/06/2017)

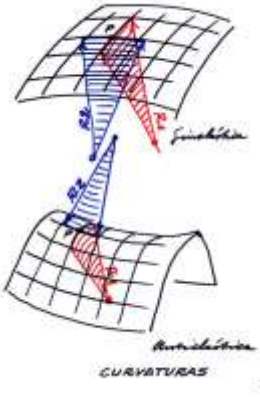
Professores
Ruy Marcelo O. Pauletti , Leila Cristina Meneghetti, Luís Bitencourt Jr.

1º Semestre 2017

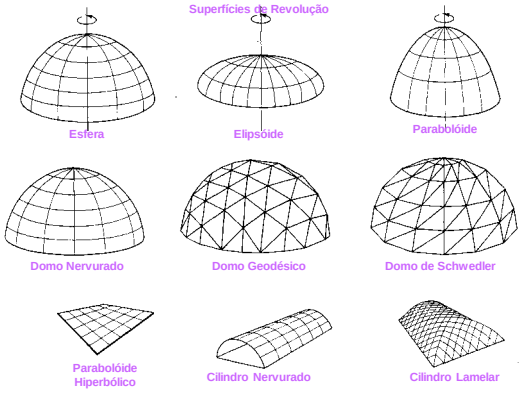




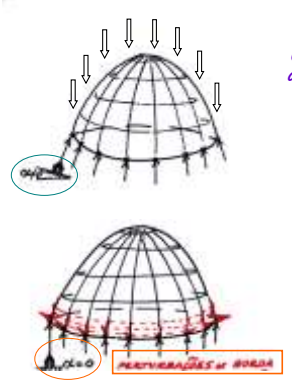




Esquemas originais
– Prof. Mário Franco



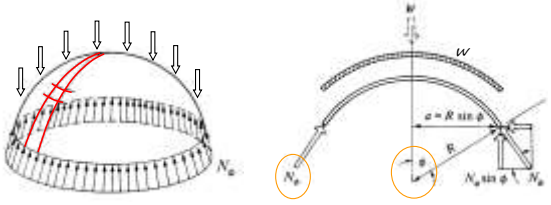
Cascas



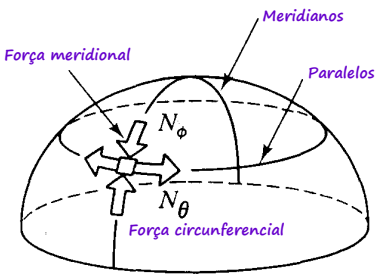
Casca Funicular
ao carregamento

Esquemas originais – Prof. Mário Franco

Casca esférica sujeita a cargas verticais



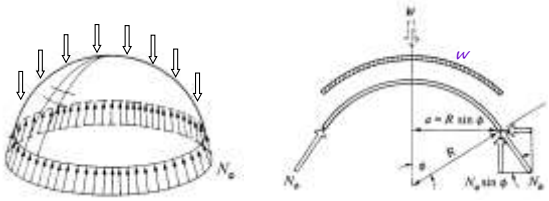
Casca parabólica:



Recordando a Equação de Laplace-Young:

$$\frac{N_\theta}{R_\theta}+\frac{N_\phi}{R_\phi}=p_r$$

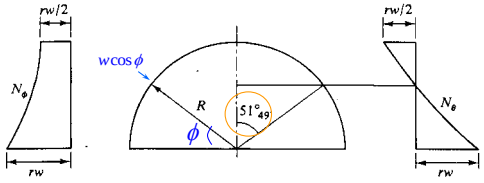
Casca esférica sujeita a cargas verticais



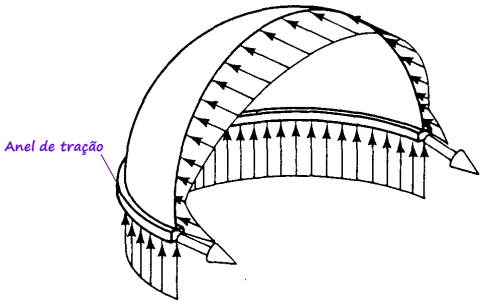
$$N_\phi=\frac{Rw}{1+\cos\phi}$$

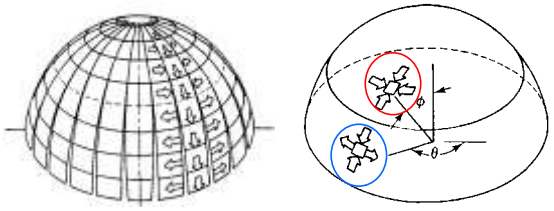
Eq. Laplace:

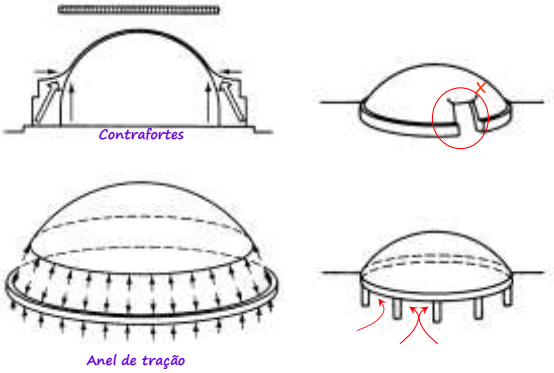
$$\frac{N_\theta+N_\phi}{R}=p_r=w\cos\phi$$



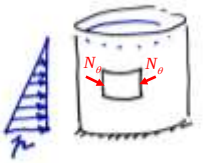
$$N_\theta=Rw\left(\cos\phi-\frac{1}{1+\cos\phi}\right)$$





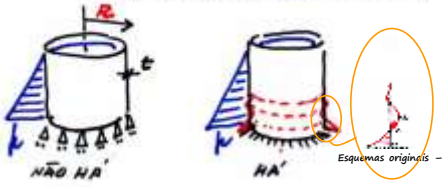


Reservatórios

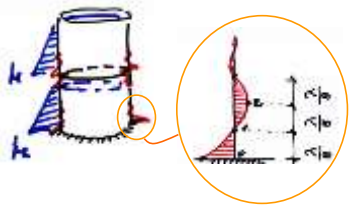


$$\frac{N_\theta}{R} = p_r$$

PERTURBAÇÕES DE BORDA



Esquemas originais – Prof. Mário Franco



$$\lambda = 4.83\sqrt{Rt}$$

$$M_0 = 0.294\,pRt$$
$$M_1 = 0$$
$$M_2 = -0.061\,pRt$$

Exemplo:

$R = 4m, \quad t = 0.20m, \quad p = 150kN/m^2$

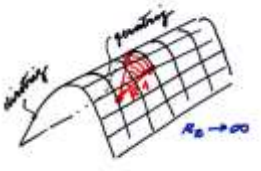
$N_\theta = 600kN/m; \quad \lambda = 4.32m$

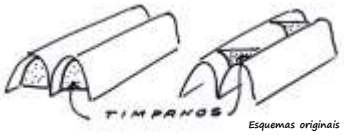
$M_0 = 35,3kNm/m$ (ϕ10 cada 10cm)

$M_2 = -7,3kNm/m$ (ϕ minimo)

Esquemas originais – Prof. Mário Franco

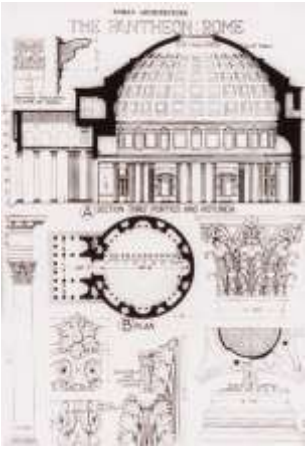
CASCA CILÍNDRICA

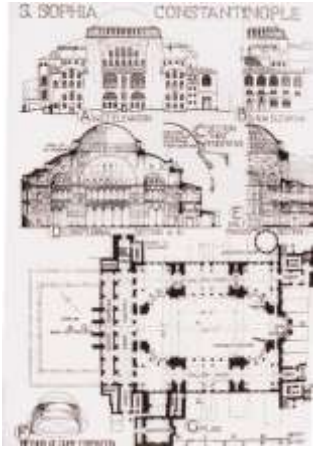


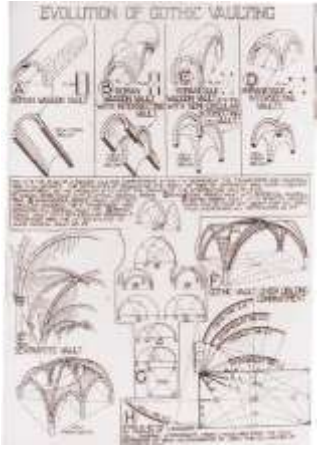


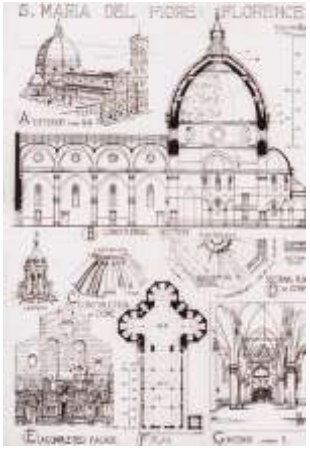
Esquemas originais – Prof. Mário Franco

Trullos


THE PANTHEON, ROME


S. SOPHIA CONSTANTINOPLE


EVOLUTION OF GOTHIC VAULTING


S. MARIA DEL FIORE FLORENCE

Vladimir Shukhov
First double curvature diagonally framed shell during construction, in Vyksa near Nizhny Novgorod, 1897

The world's first hyperboloid structure
Vladimir Shukhov, Nizhny Novgorod, 1896

Piscina Coberta Centro Esportivo Baby Barioni - SP - 1948
Ícaro de Castro Mello

Palácio das Artes - SP - 1951
Oscar Niemeyer, Zenon Lotufo, Hélio Uchôa, Eduardo K. de Mello

Planetário - SP - 1955
Eduardo Corona & Roberto José Goulart Tibau & Antônio Pitombo

Palazzetto dello Sport – 1956 – 1957
Pier Luigi Nervi, Annibale Vitellozzi
1960 Olympics

Xochimilco Restaurant Los Manantiales, Mexico, 1957/1958
Felix Candela (Eng), Fernando Alvarez Ordóñez; Joaquin Alvarez Ordóñez (Arqs)

CNIT

Centre des nouvelles industries et technologies,

Paris, 1956 - 1958

Architect	Robert Edouard Camelot
	Jean de Mailly
	Bernard Louis Zehrfuss
Engineer	Nicolas Esquillan
	Jean Prouvé
Consultant	Pier Luigi Nervi

TWA Terminal at JFK International Airport , New York, 1956-1963

Design engineer: Boyd G. Anderson

Architect: Eero Saarinen

St. Louis Abbey (or the Priory Chapel)
Gyo Obata of Hellmuth, Obata & Kassabaum (HOK) with Pier Luigi Nervi, consultant
1962

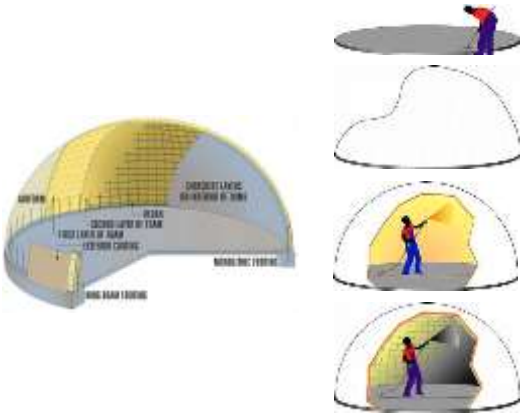
H. Isler, Wyss Garden Center, Suíça, 1961

Heinz Isler – Bürgi Garden Center – Suíça, 1973

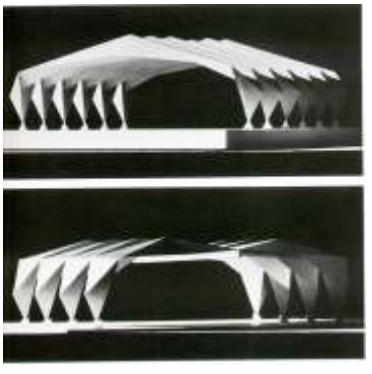
Heinz Isler – Bürgi Garden Center – Suíça, 1973

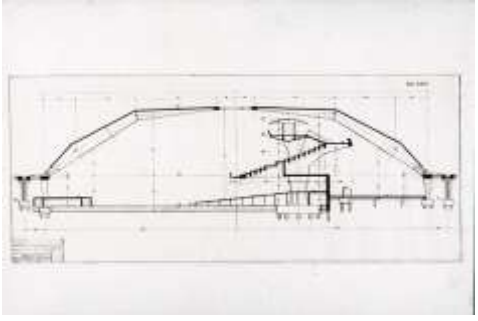
H. Isler, Brühl Sports Center , Suíça, 1982

Sistema Bini
The Kallangur Shopping Center, Queensland, Australia

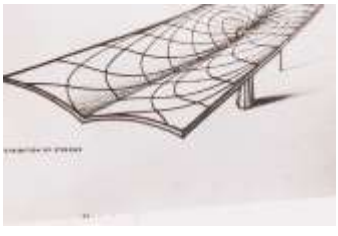


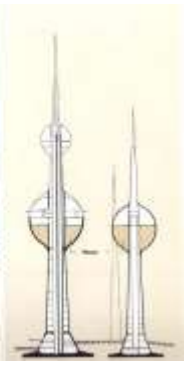
Palácio das Convenções - SP - 1967
Miguel Juliano e Silva, Jorge Wilheim





Posto Catacumba - RJ - 1968
Dilson Gestal Pereira, Waldyr Antunes Figueiredo, Paulo Roberto M. Souza, Alfredo Lemos





Sydney Opera House (1958 – 1973)

Double thin shell ribbed ; Concept designer Jørn Utzon; Architect E. H. Farmer , Peter Hall, David Littlemore, Lionel Todd ; Engineer: Ove Nyquist Arup

Fariborz Sahba (canadian architect)

Memorial da América Latina - SP - 1987
Oscar Niemeyer

Museu de Arte Contemporânea - RJ - 1996
Oscar Niemeyer

L'Oceanogràfic, Valencia , 2002
Félix Candela

Santiago Calatrava
Tenerife Concert Hall, 1996
Canary Islands, Spain

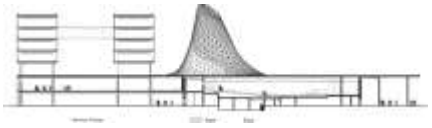
The all-concrete building is characterized by the dramatic sweep of its roof. Rising off the base like a crashing wave, the roof soars to a height of 58 meters over the main auditorium before curving downward and narrowing to a point. The building's plinth forms a public plaza covering the site and allows for changes in grade between the different levels of the adjacent roads.

Guggenheim Museum, Bilbao, 1997
Architect: Frank Owen Gehry

Viveiro dos hipopótamos do zoológico de Berlim
Arq. J. Griebl (1999)
Desgin: Jorg Schlaich

Viveiro dos hipopótamos do zoológico de Berlim

Fiera di Milano Exhibition Centre, Milan, Italy
Massimiliano Fuksas, 2005



Anaheim Regional Transportation Intermodal Center
Anaheim, California, 2015
HOK Architects

Metropol Parasol
Arq. Jürgen Mayer H. Architects (2011)

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

Arnhem Central Station, the Netherlands, 2015
Architects: UNStudio

Bosjes Chapel, Witzenberg, South Africa, 2017
Steyn Studio (UK) & TV3 Architects (SA)