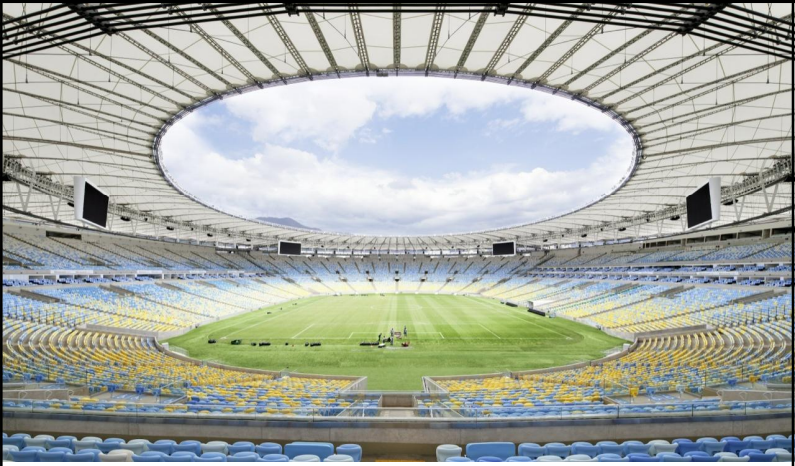


Cubiertas de grandes luces para estadios deportivos
Evolución y Tendencias actuales



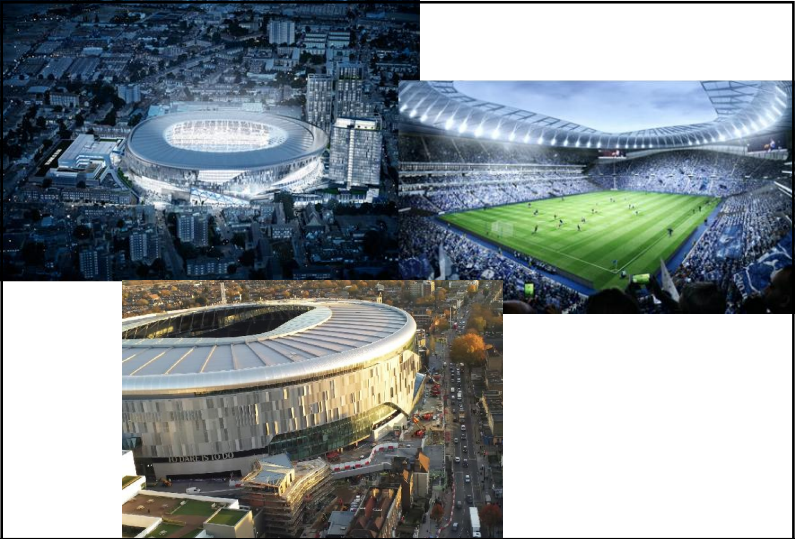
Dr. Ing. Fernando Sima
19.12.2018



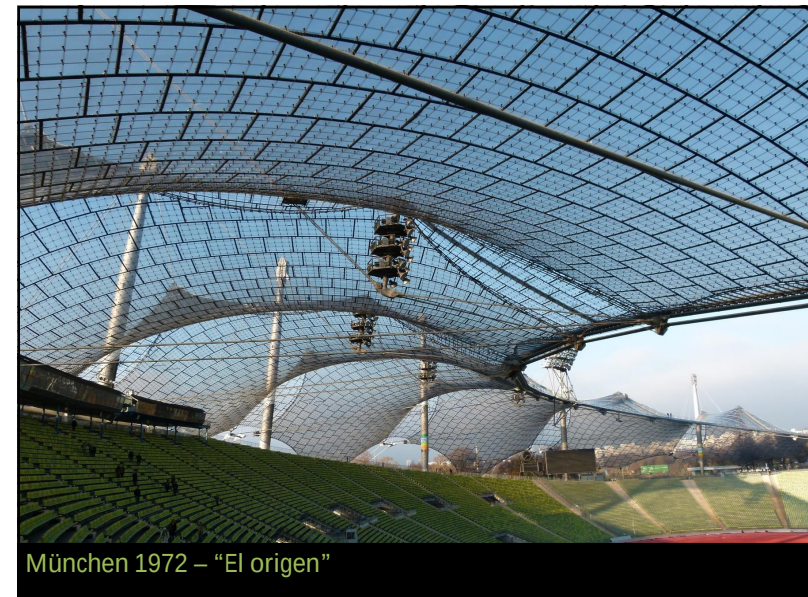
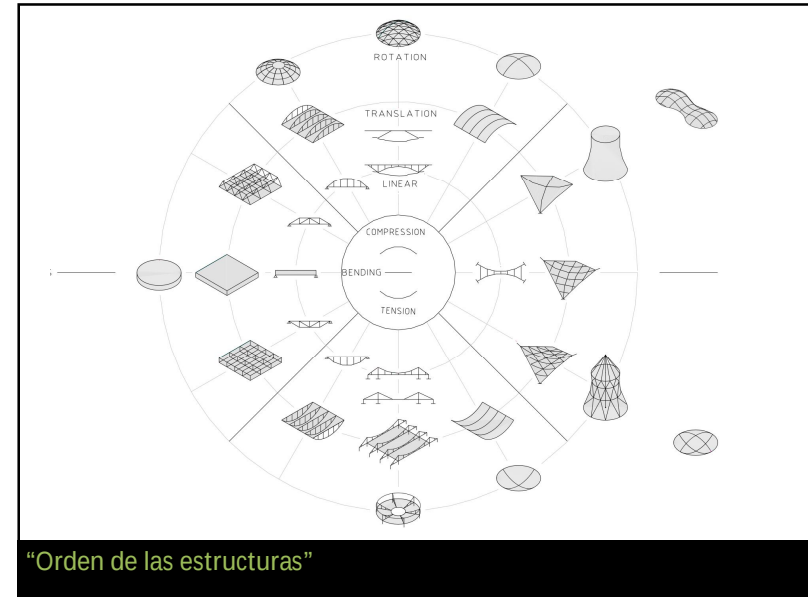
Introducción



Berlin 1936 y la TV



Más que un estadio...





München 1972 – “El origen”

Cordón en espiral abierto (Open Spiral strand – OSS)

Varias capas de alambres helicoidales con dirección alternada y paso menor

E=170 Gpa
Resistencia 0.9 fctb

Verificación del estado de tensión
Measurement of cable elongation

Materiales – Cables de acero de alta resistencia

Cable cerrado (Full locked cable – FLC)

Alambres interiores circulares

1 a 3 capas de alambres en Z

Relleno interior

Alambres 1370-1570 MPa
E=160 +/- 10 GPa

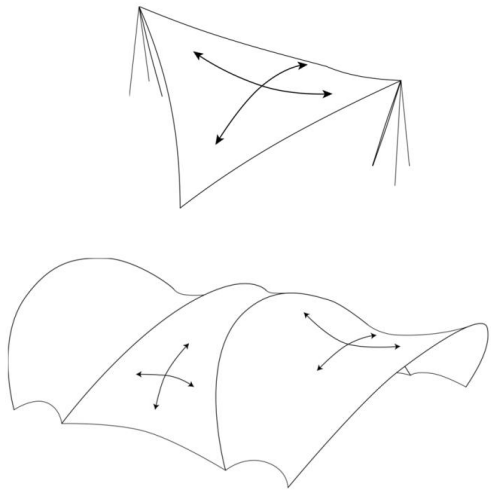
Menor relación de vacíos que cualquier otro tipo de cable

Cables Pfeifer

Größe size	Charakt. Bruchkraft character. breaking load F _{0.2} DIN 15000* kN	Grenzkraft limit tension F _{0.2} DIN 15000 kN	Metall. Querschnitt metallic cross section ca. Japan mm²	Gewicht weight ca. Japan kg/m	Konstruktion construction VVS	Seil-Querschnitt rope cross section mm²
PV 40	405	245	281	2.4	VVS-1	21
PV 60	621	375	430	3.6	VVS-1	28
PV 80	816	505	534	5.3	VVS-2	31
PV 100	1170	730	805	8.0	VVS-2	35
PV 150	1520	921	1000	8.9	VVS-2	40
PV 180	1820	1100	1170	11.2	VVS-2	45
PV 240	2380	1442	1540	13.0	VVS-2	50
PV 300	3020	1830	2090	17.2	VVS-3	55
PV 360	3660	2178	2460	20.5	VVS-3	60
PV 420	4220	2558	2820	24.1	VVS-3	65
PV 480	4800	2964	3200	27.9	VVS-3	70
PV 540	5420	3400	3680	32.1	VVS-3	75
PV 600	6060	3873	4200	36.4	VVS-3	80
PV 720	7210	4370	4900	41.1	VVS-3	85
PV 810	8090	4903	5600	46.2	VVS-3	90
PV 910	9110	5521	6300	52.0	VVS-3	95
PV 1010	10100	6121	6990	57.6	VVS-3	100
PV 1110	11100	6722	7710	63.5	VVS-3	105
PV 1220	12200	7394	8480	69.7	VVS-3	110
PV 1340	13420	8132	9240	76.2	VVS-3	115
PV 1450	14580	8788	10100	83.2	VVS-3	120
PV 1580	15800	9570	10900	89.8	VVS-3	125
PV 1720	17200	10485	11900	96.7	VVS-3	130
PV 1880	18800	11273	13000	104.8	VVS-3	135
PV 2000	20000	12121	14200	112.8	VVS-3	140

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Superficie Anticlástica



Materiales – Membrana

Formfinding

Proceso de obtención de la forma que permite el óptimo flujo de esfuerzos dentro de una estructura, para un estado determinado de cargas y condiciones de contorno.

“Form follows force”

Especialmente relevante en estructuras que transfieren los esfuerzos puramente a través de esfuerzo axial o fuerzas en su plano (membrana).

Tracción
↓
Cables
Redes de cables
Membranas
....

Compresión
↓
Arcos
Bóvedas
Cáscaras
....

↓
Estructuras híbridas

Form-finding

Formfinding “Analogico”

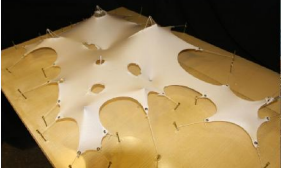
A. Gaudi (Colonia Guell)



Frei Otto (Manheim)



Frei Otto (Pabellón Alemán 1967)



Form-finding

Formfinding “digital”

Malla plana de elementos

↓

10

10

Γ_0

Form finding

Γ

Condiciónes de contorno y carga

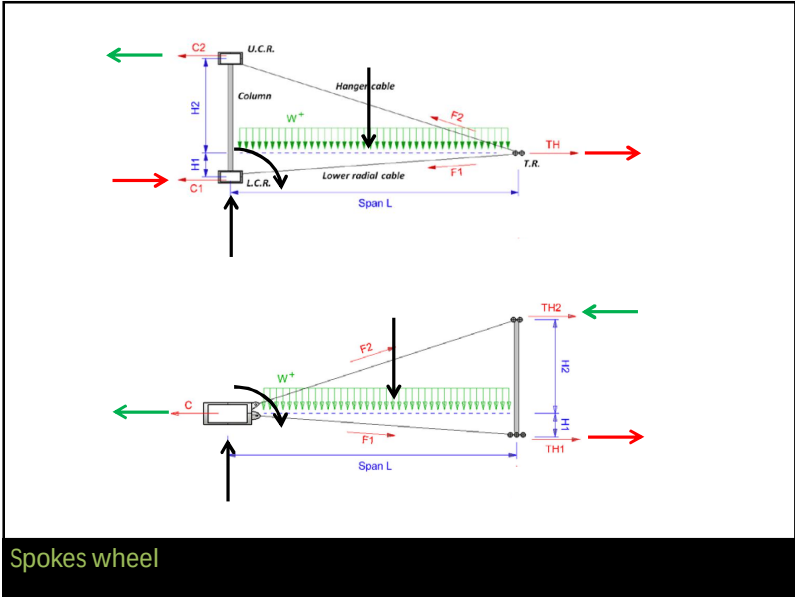
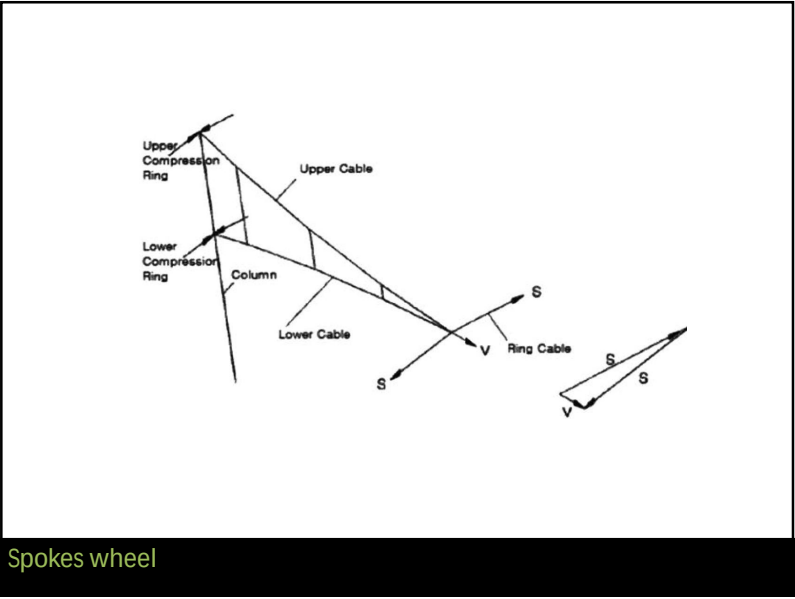
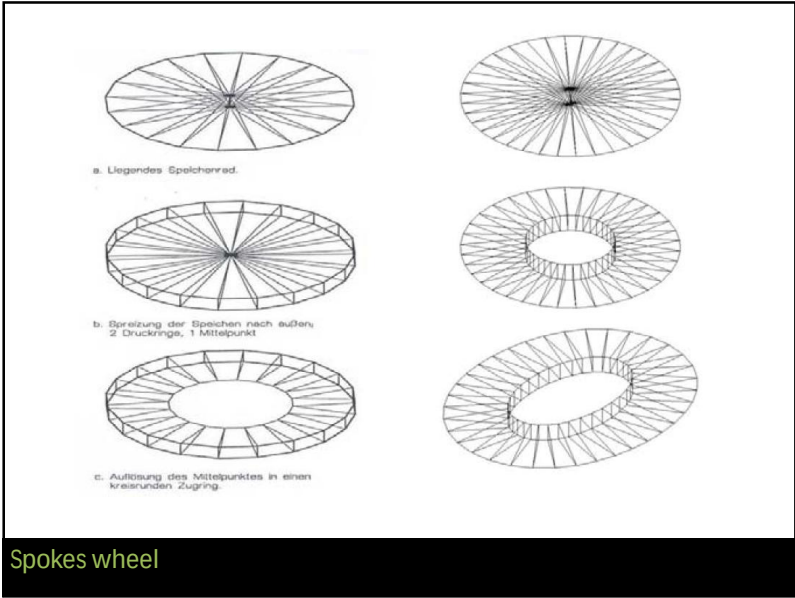
Formfinding

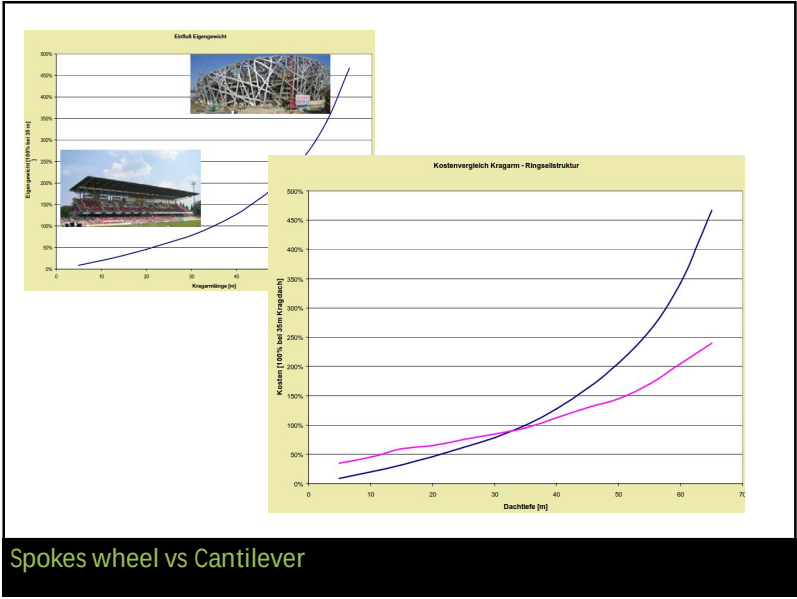
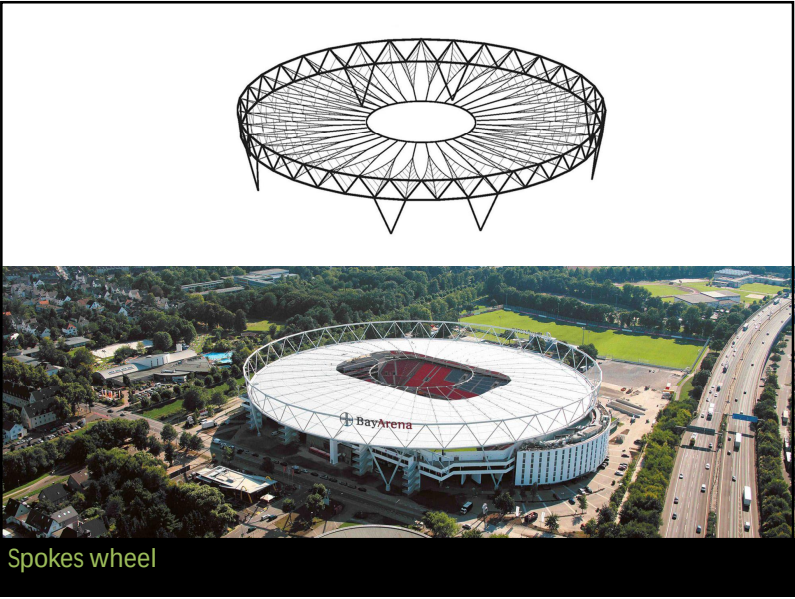
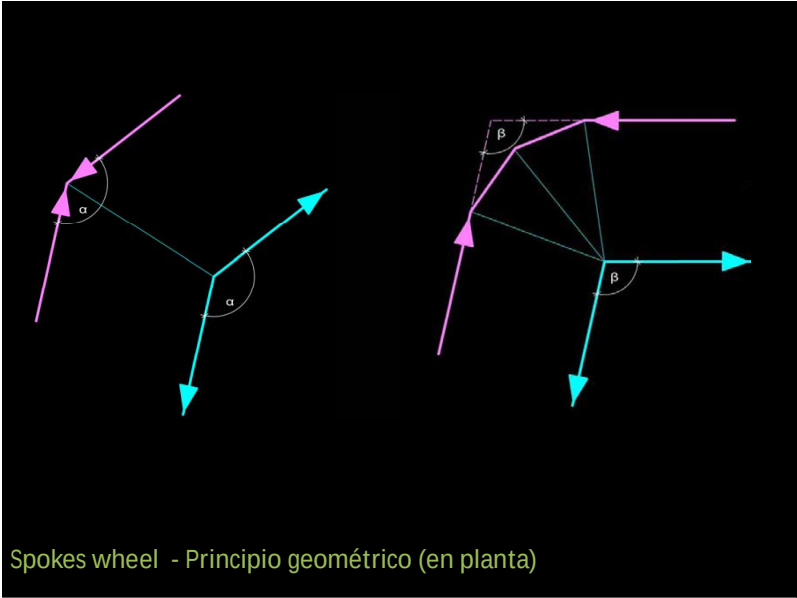
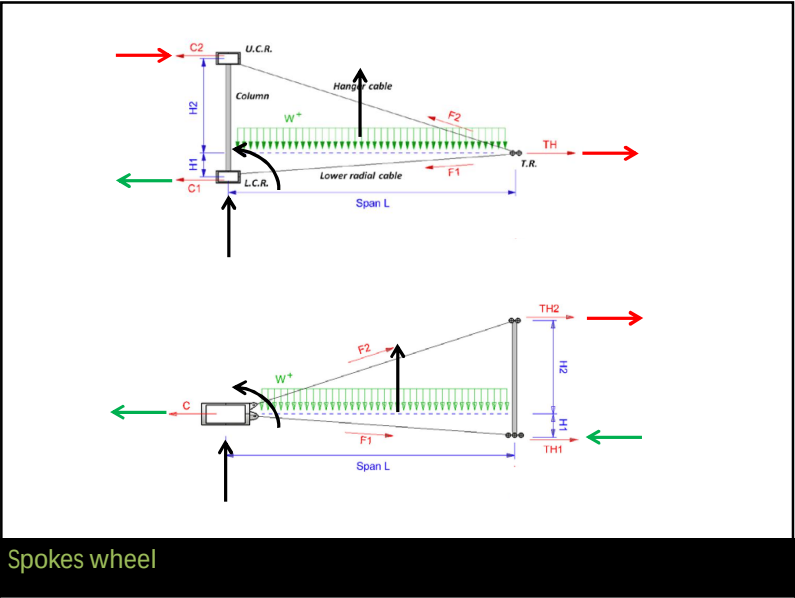
Malla plana de elementos

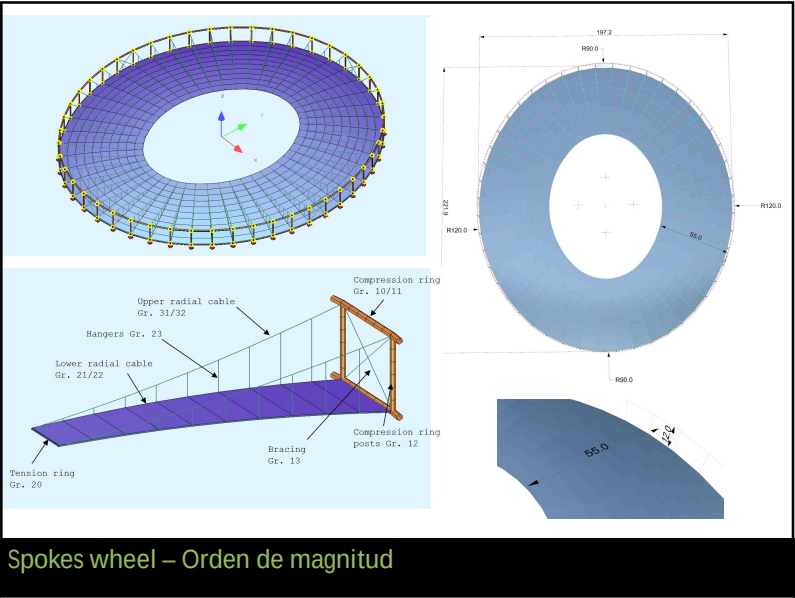
↑

Condiciónes de contorno y carga

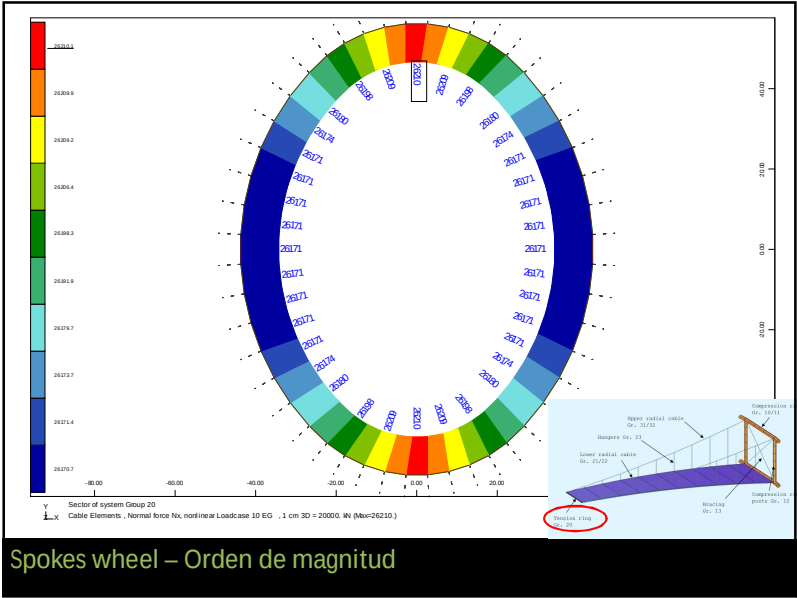
Form-finding



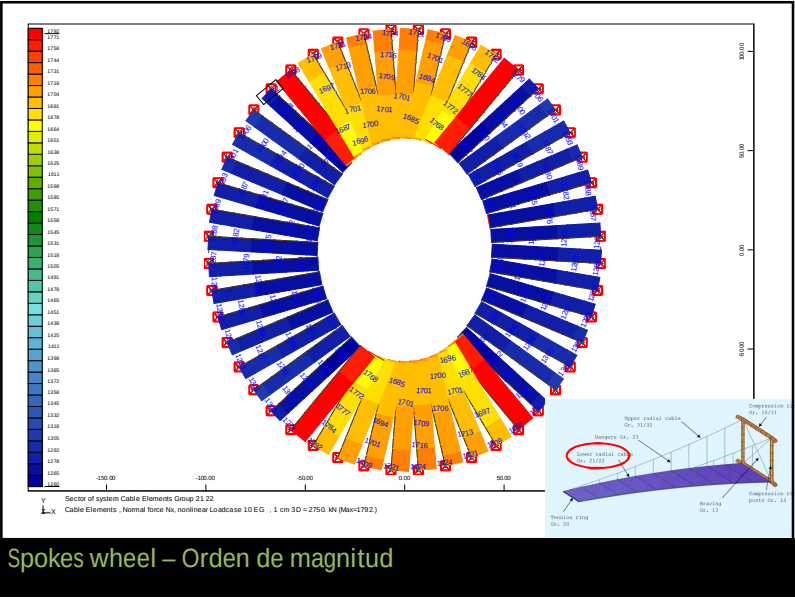




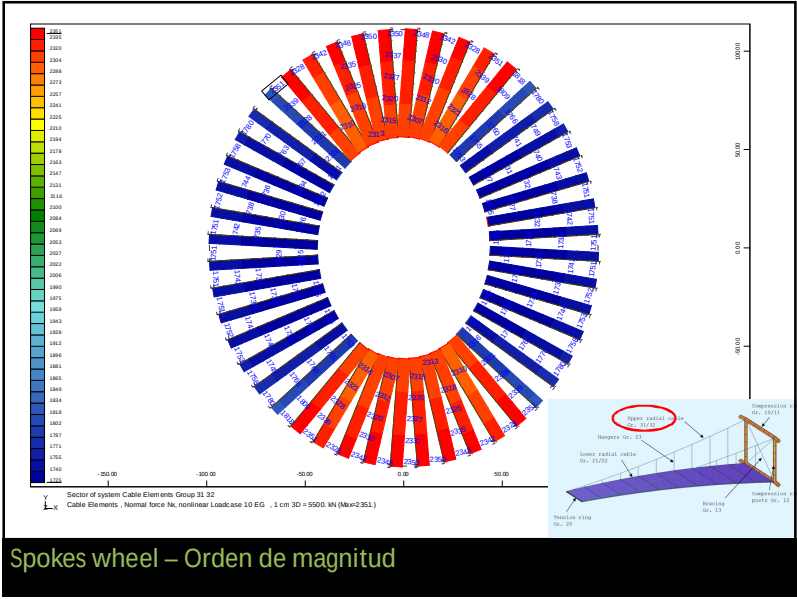
Spokes wheel – Orden de magnitud



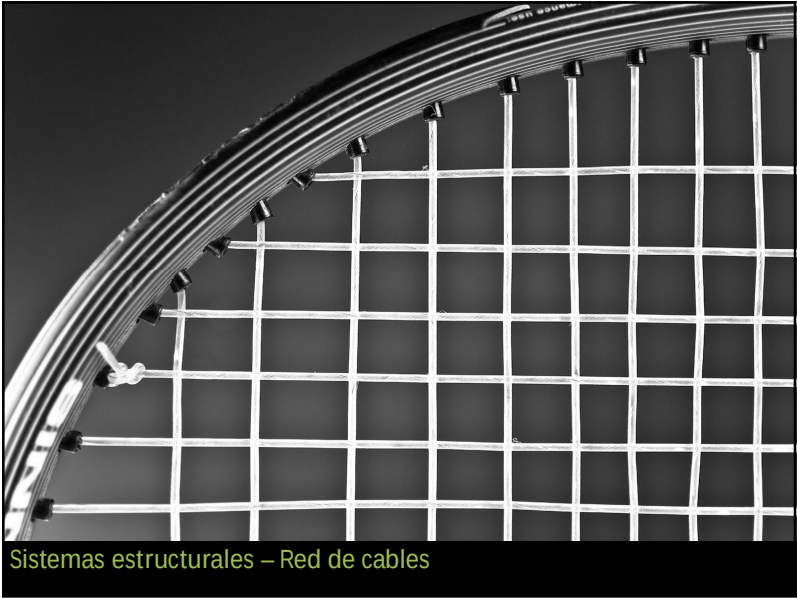
Spokes wheel – Orden de magnitud



Spokes wheel – Orden de magnitud



Spokes wheel – Orden de magnitud



Sistemas estructurales – Red de cables



Velódromo olímpico Londres 2012



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