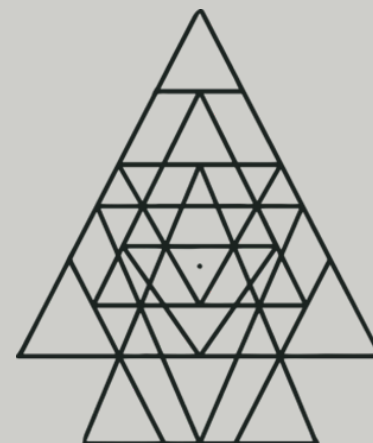




12 Bamboo Structures

12 practical tips for the analysis and structural design of
12 bamboo structures

Esteban Morales - Structural Engineer
www.bambooengineers.com



Chiribiquete

ORIGIN

THOMAS VAN DER HAMMEN

September 27, 1924, Schiedam, Netherlands

March 12, 2010, Chia, Colombia



YURUPARÍ
BAMBOO
FLUTES



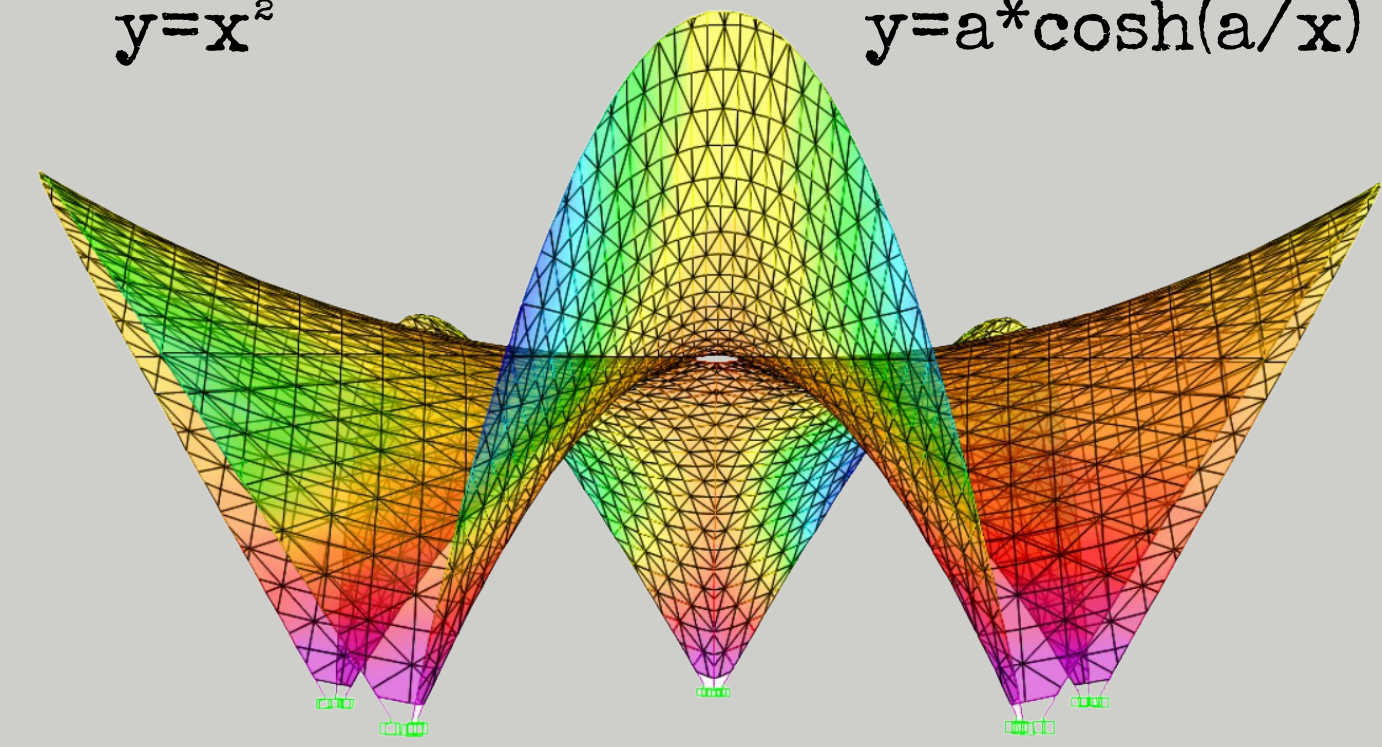


1. Luum Temple

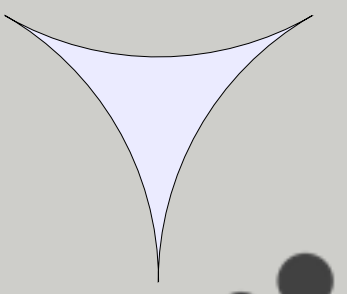
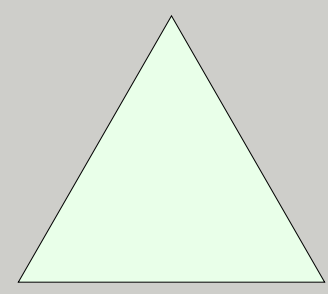
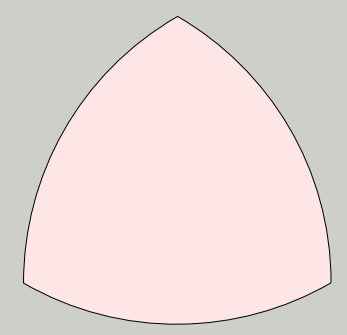
GEOMETRY

$$y=x^2$$

$$y=a*\cosh(a/x)$$



Elliptical, Euclidean, and
Hyperbolic Triangles



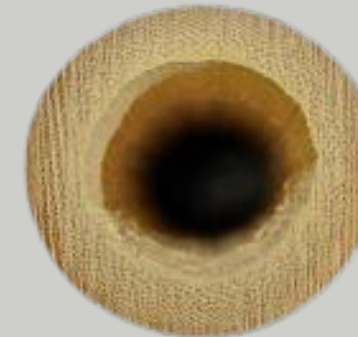


2. Sports Hall

MATERIALS

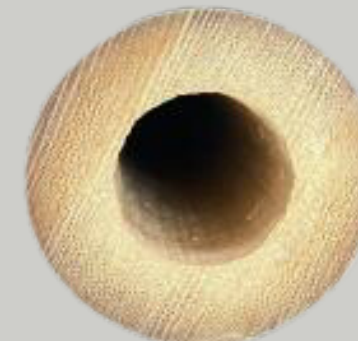
Thyrsostachys oliveri

Upper



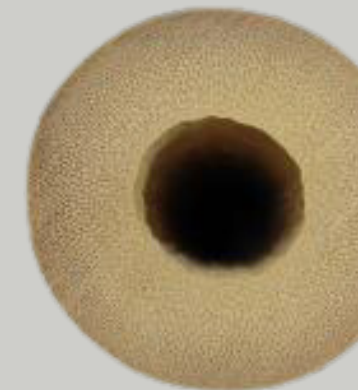
- $D = 6 \text{ cm}$
- $d = 2 \text{ cm}$
- $\rho = 640 \text{ kg/m}^3$
- $\text{MOE} = 19700 \text{ MPa}$
- $\mu = 0.38$

Middle



- Tension: 135 MPa
- Bending: 120 MPa
- Compress: 57 MPa
- Shear: 4.30 MPa

Botton



6 cm





3. Shell

CROSS SECTIONS

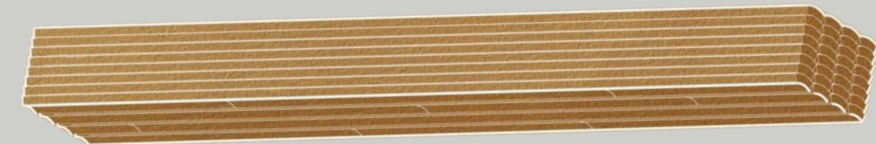
- Complete (1)

$$E = 9000 \text{ MPa}$$



- Split (1/8)

$$E = 1200 \text{ MPa}$$



- Further Split (1/16)

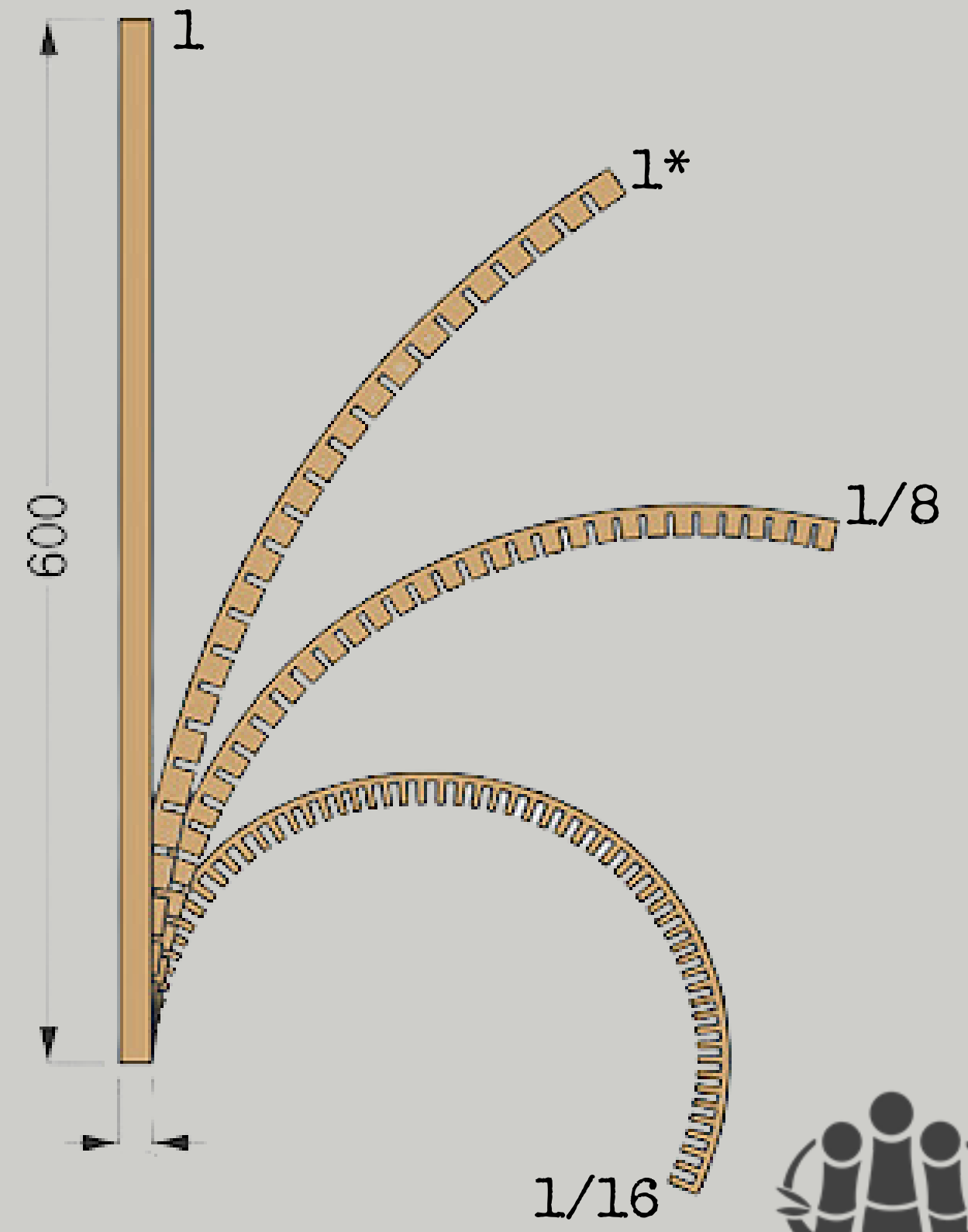
$$E = 400 \text{ MPa}$$





4. Kanai Cenote

CURVATURES

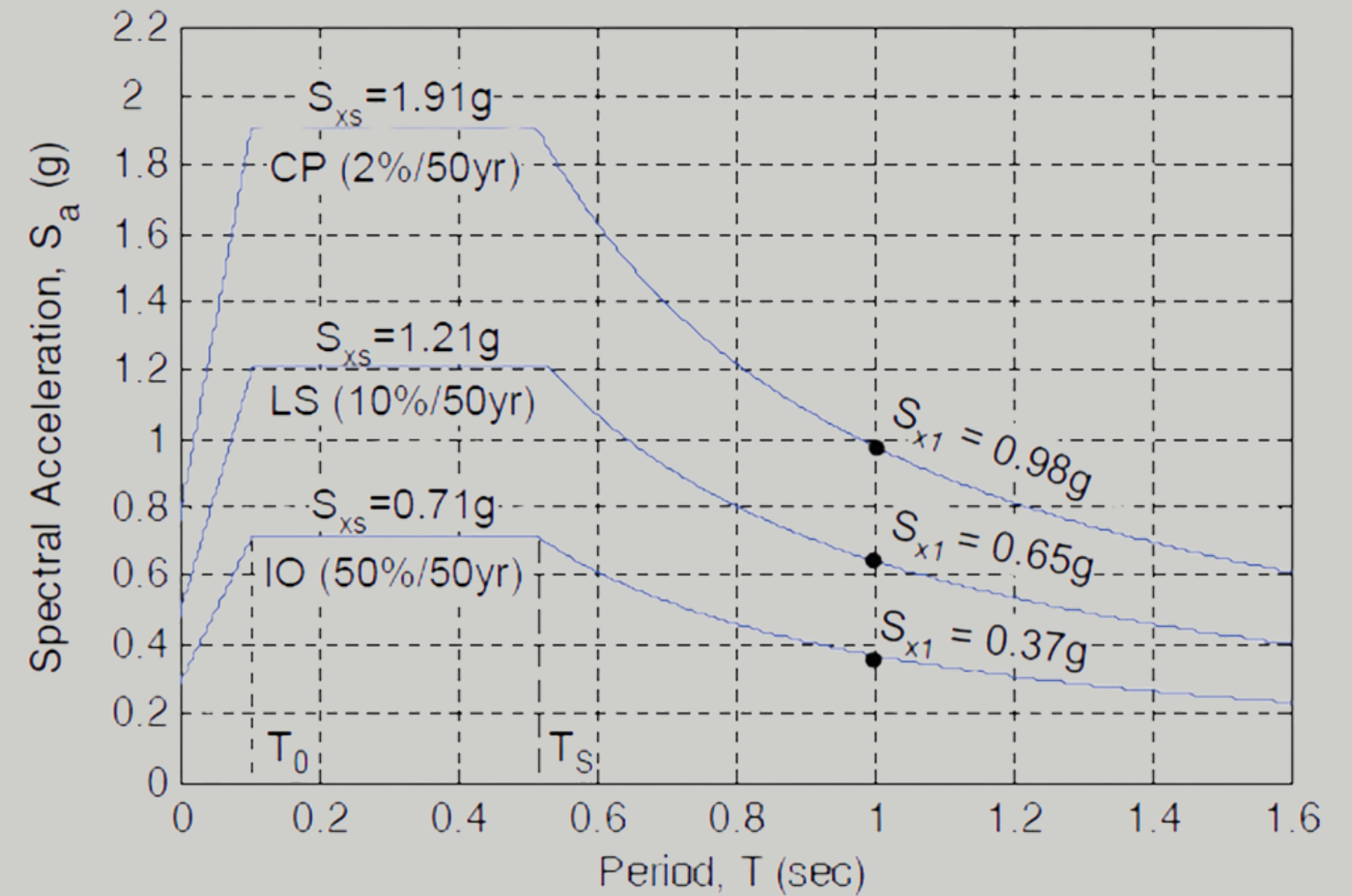




5. Bamboo Hotel

SEISMIC EFFECTS

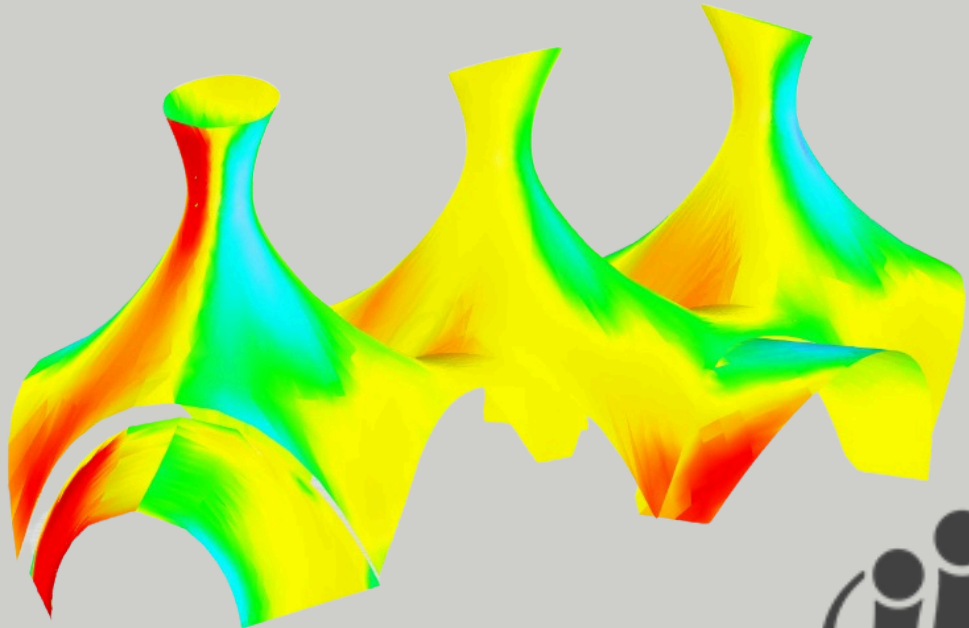
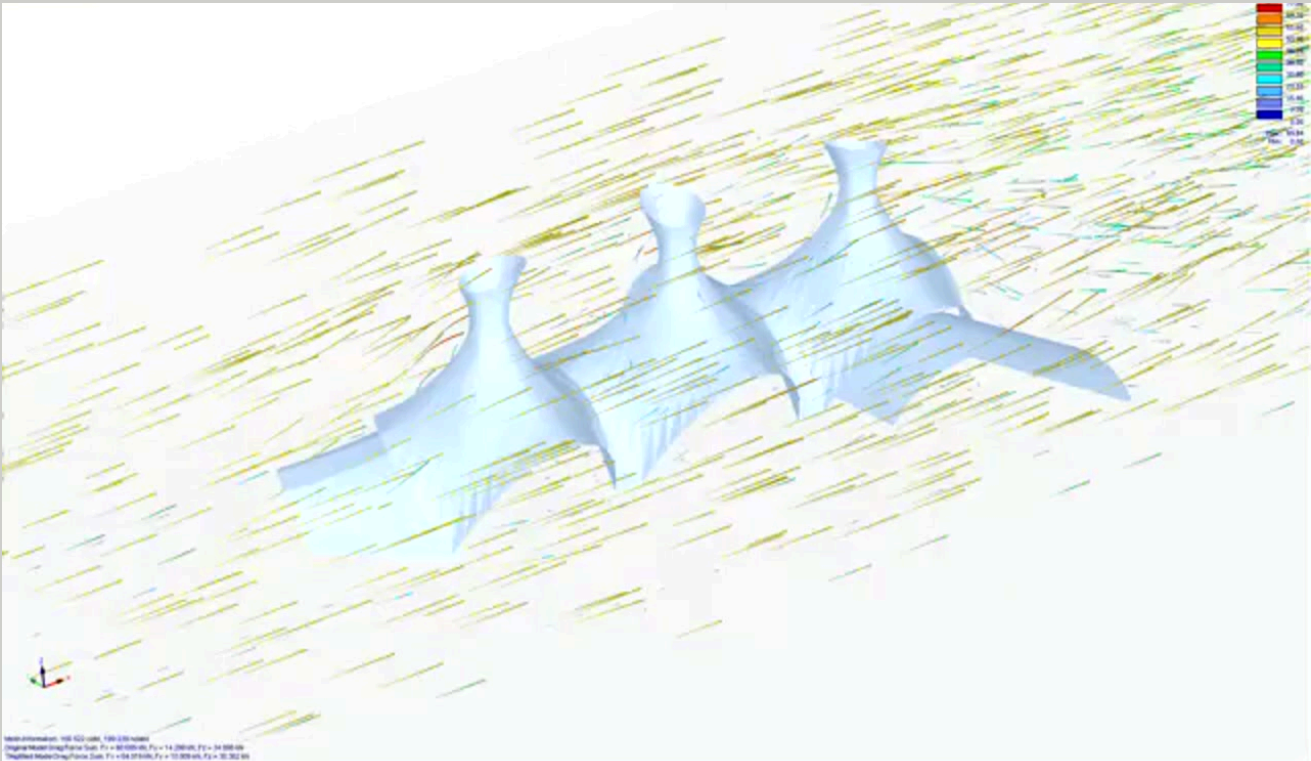
Performance-based seismic design method





6. Valle Sagrado

WIND FORCES

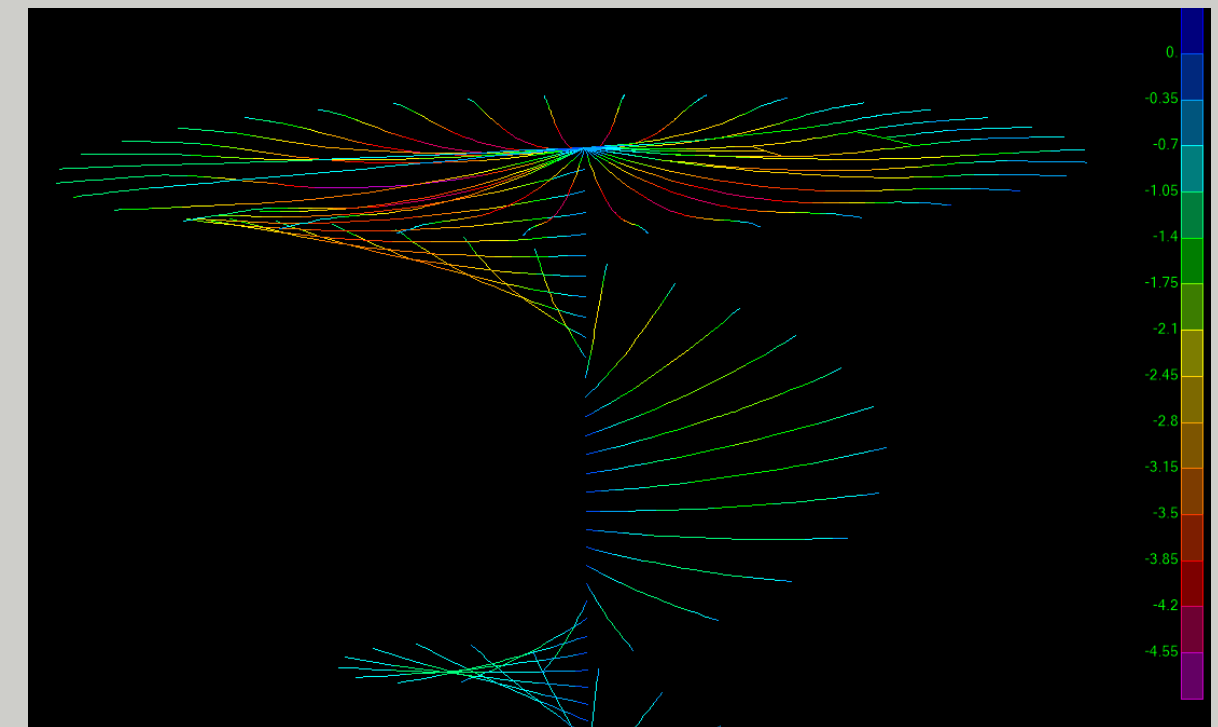




7. Tower Tekit

GRAVITATIONAL FORCES

- Weight = 18 tonf
- Live load = 0,5 tonf /m²

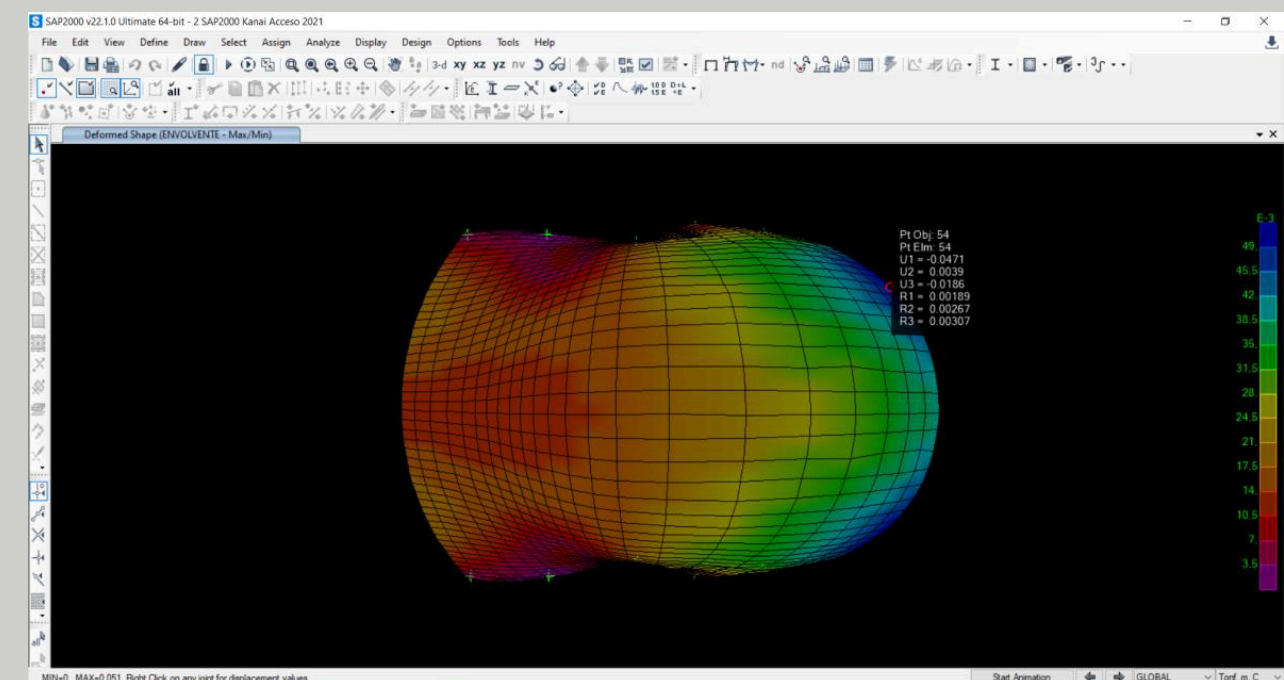
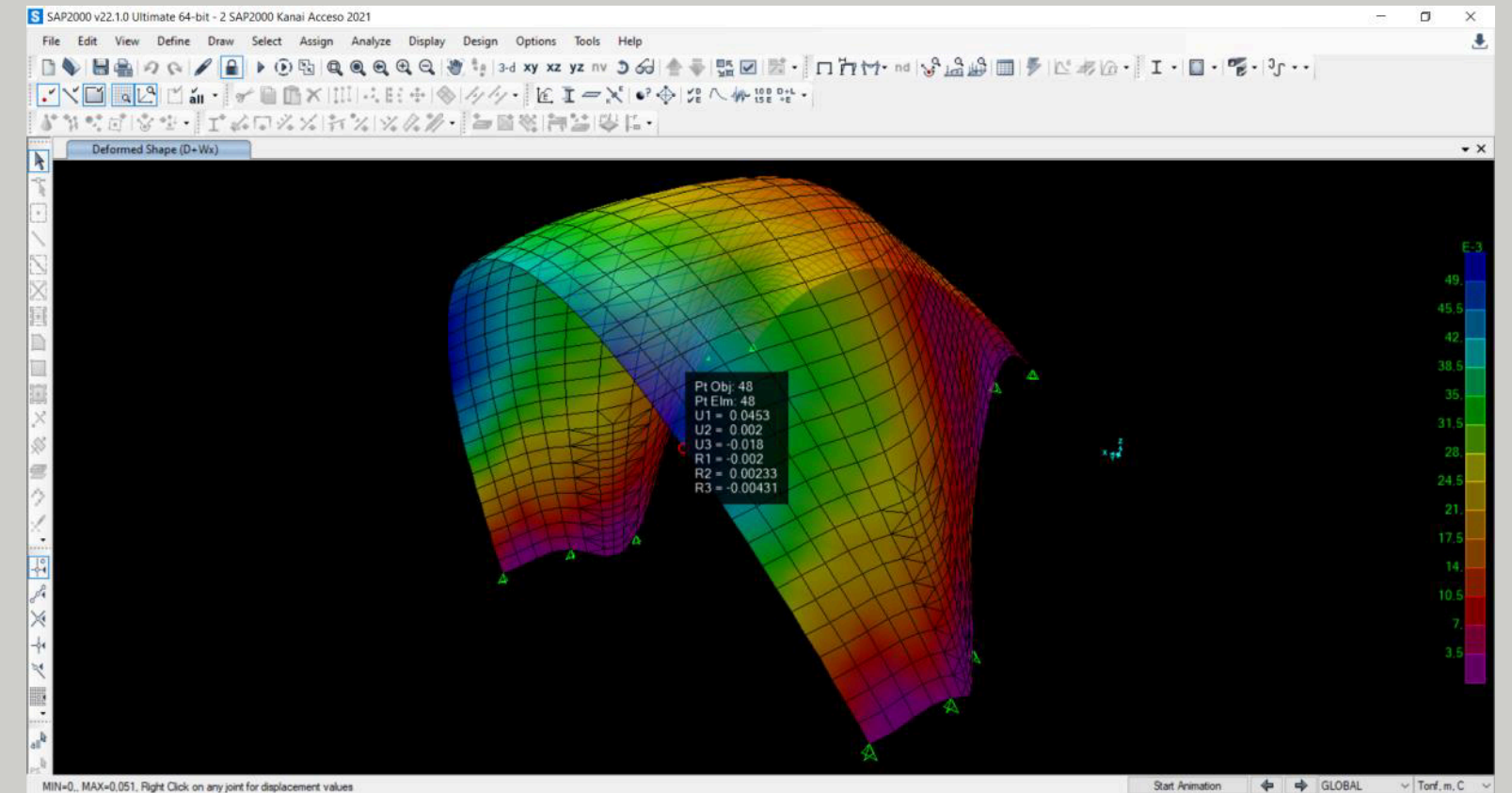


- Deflection = 5 mm



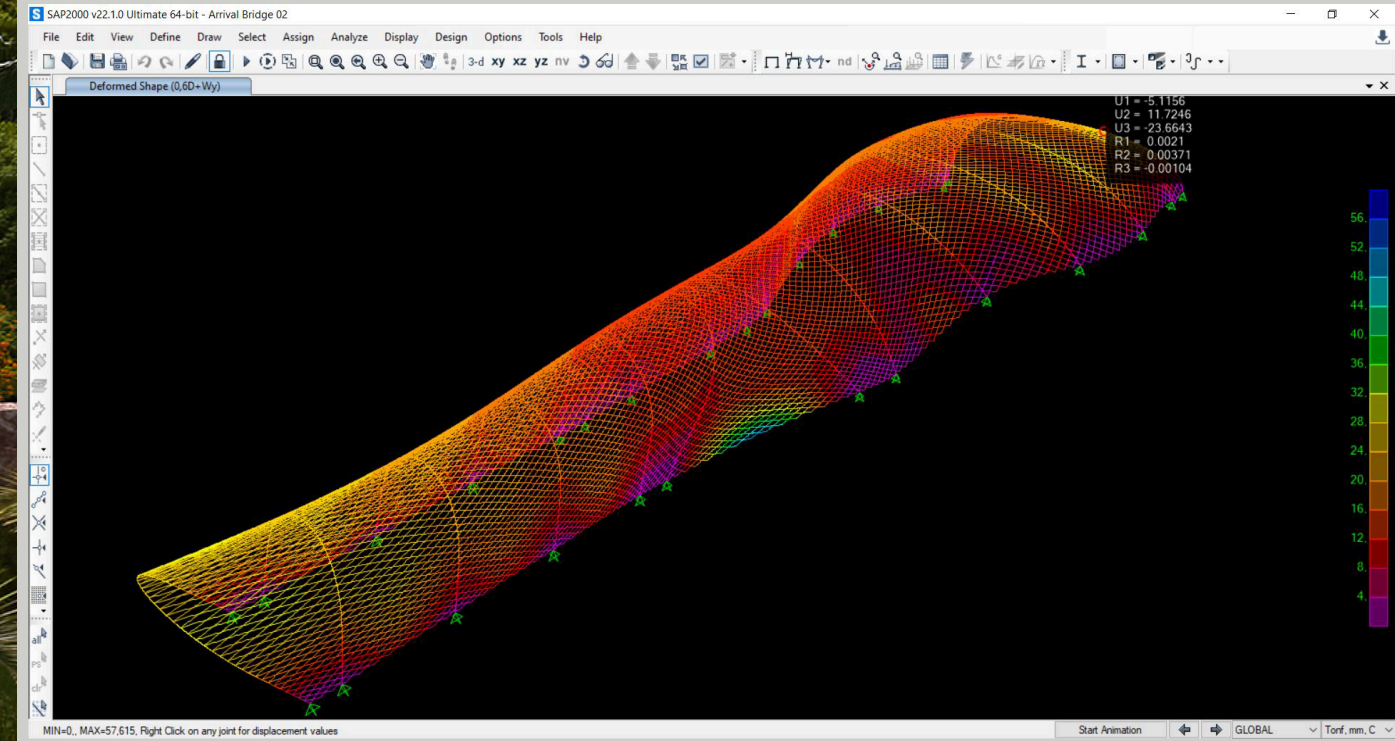
8. Kanai Tunnel

FINITE ELEMENT ANALYSIS



9. Naviva Resort

STIFFNESS



Estado Límite	Amenaza Sísmica	Límite de Deriva
Ocupación Inmediata (IO)	50% en 50 años	1%
Protección de la Vida (LS)	10% en 50 años	2%
Prevención de Colapso (CP)	2% en 50 años	3%

$$\Delta = \frac{0,03 \text{ m}}{2,300 \text{ m}} = 0,013 \times 100 = 1,3 \% < 1,5\%$$



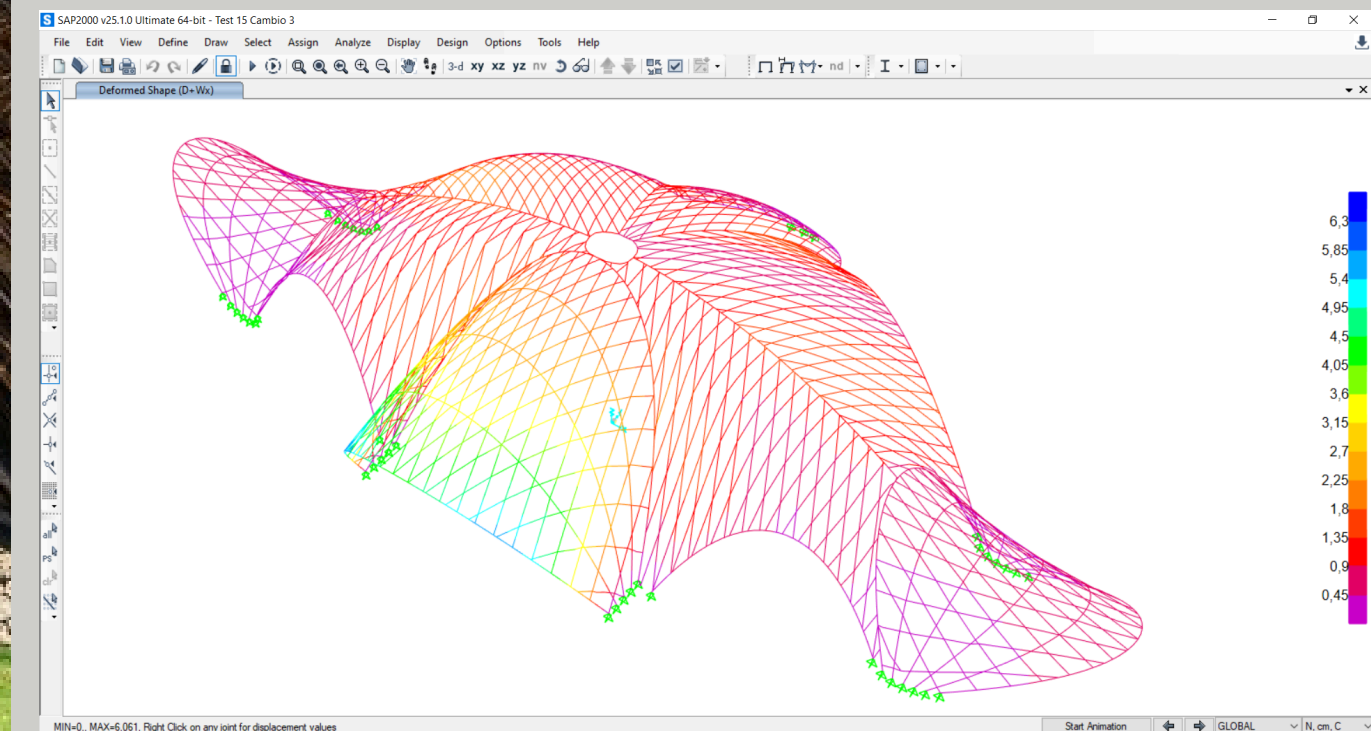
10. Manta Shala

RESISTANCE

SAP2000:
Internal forces

Fuerzas Máximas de Elemento (Para la Combinación Envolvente)

Elemento Tipo	Signo	P	V2	V3	M2	M3
		N	N	N	N-mm	N-mm
Arcos principales	(+)	54'302	13'922	12'304	5'005'050	7'243'470
(2x2 culmos)	(-)	-76'720	-12'450	-12'304	-5'005'050	-7'855'790
Arcos secundarios	(+)	20'232	4'325	3'215	2'531'170	3'853'870
(1x2 culmos)	(-)	-21'666	-4'152	-3'168	-2'531'170	-3'866'000
Viguetas y conectores	(+)	18'284	7'550	9'181	1'847'010	1'479'180
(1 culmo)	(-)	-18'400	-8'230	-9'181	-1'847'010	-1'348'320

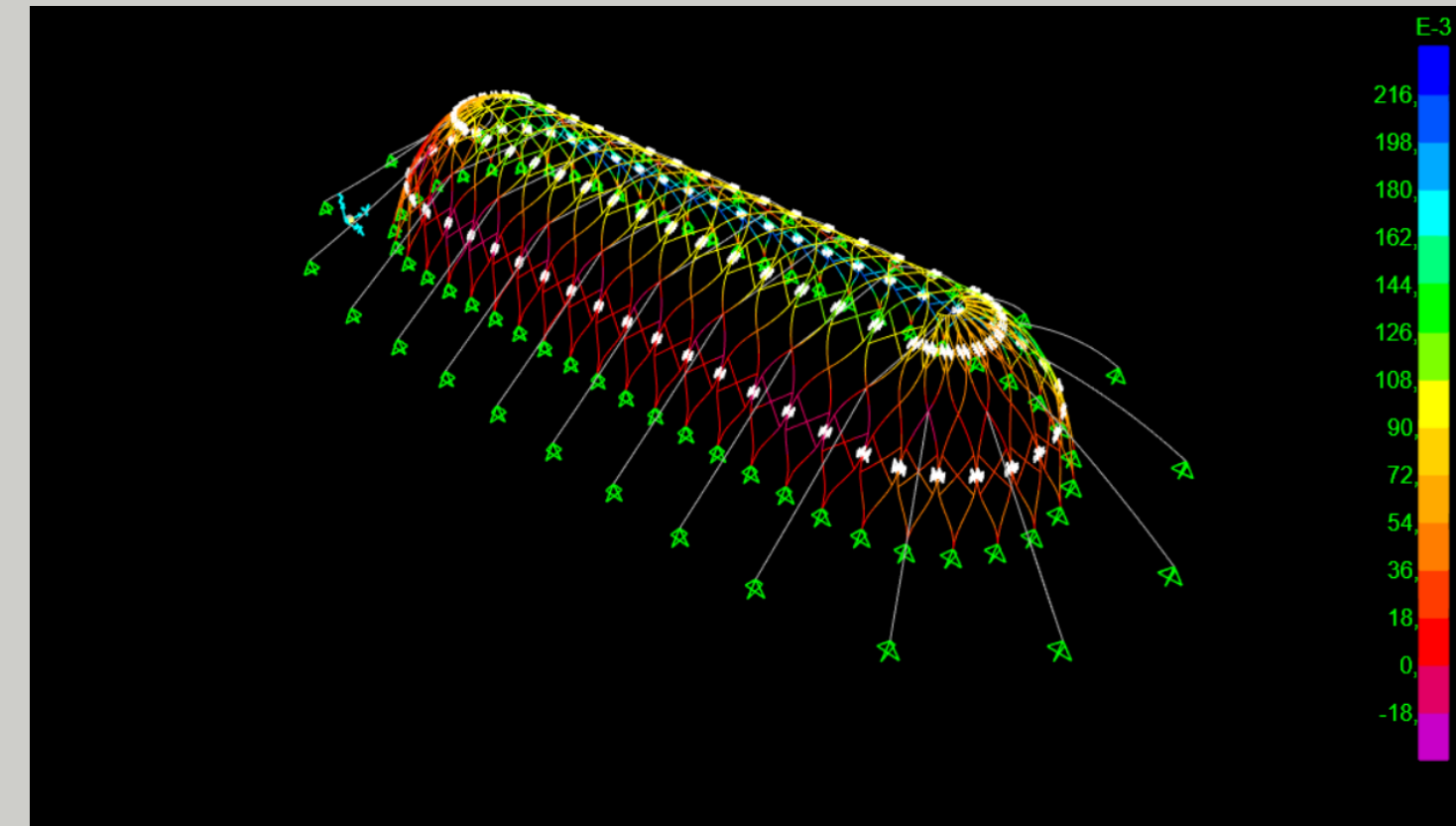


ISO22157:2019:
Procedure

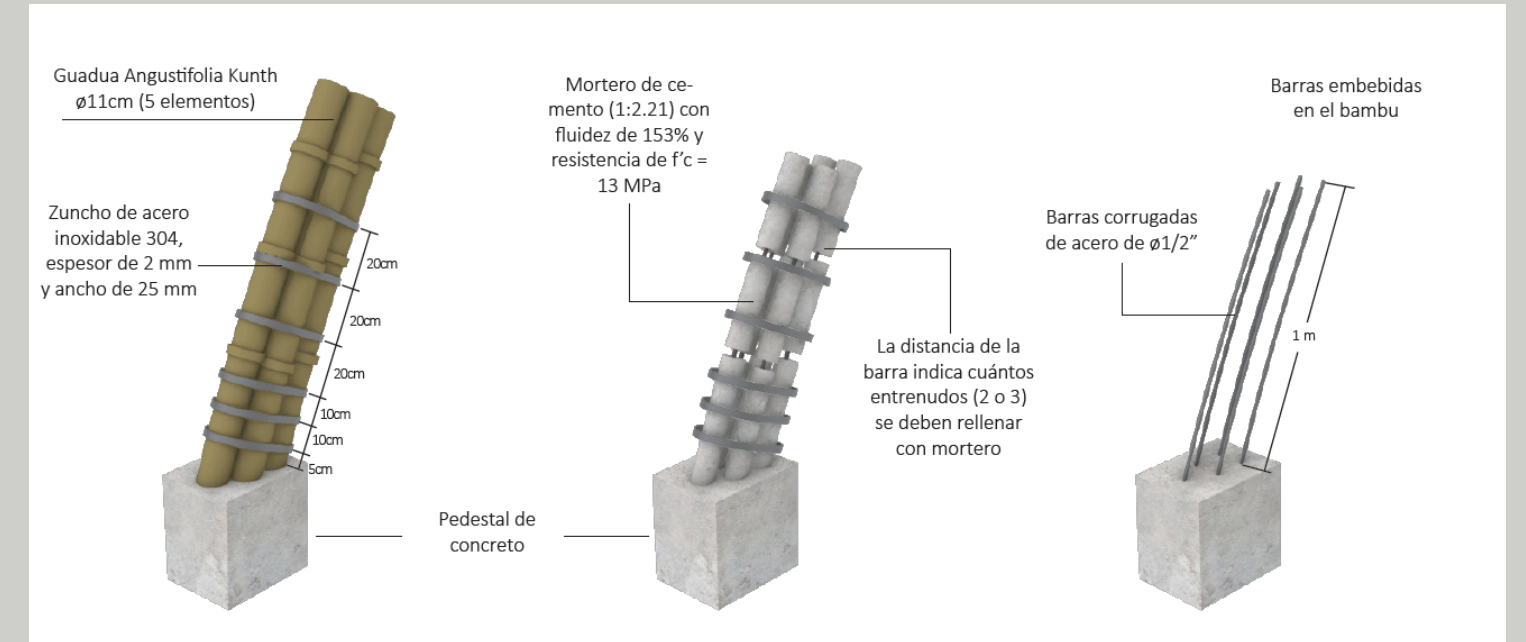


11. Ogees Pavilion

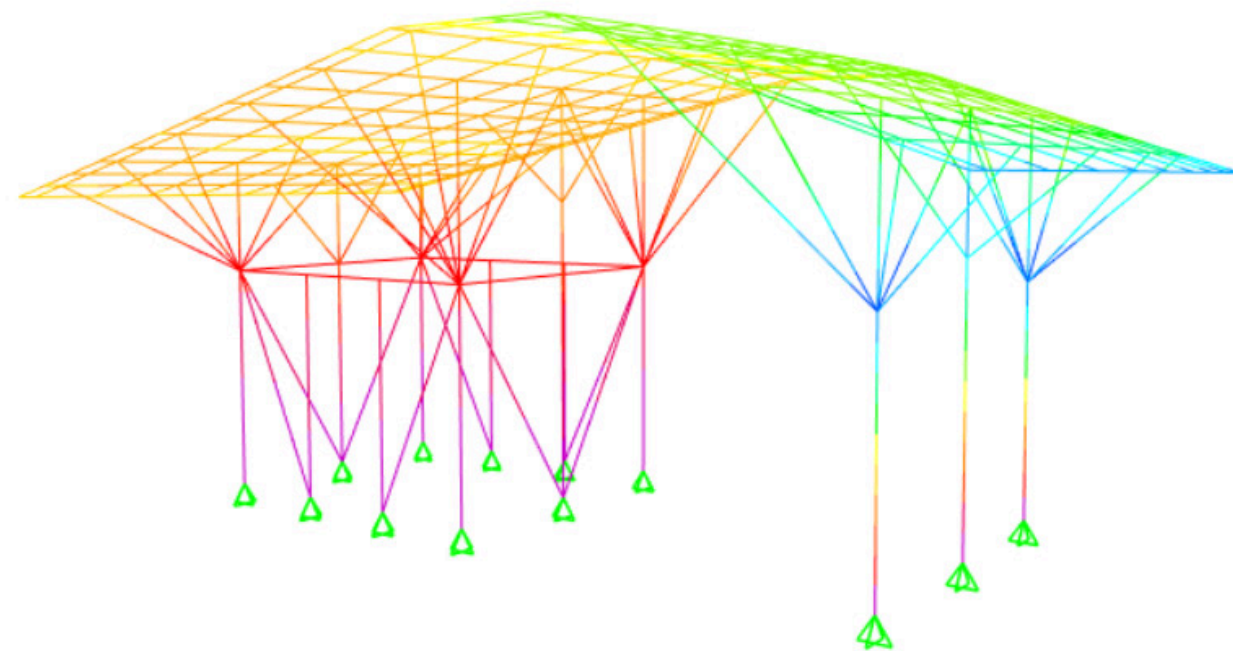
FOUNDATIONS



12. Women's Pavilion JOINTS



J.F. Correal: 5 Tonf



T.Obermann: 3 Tonf





"Science and art are made from the same raw material, the forms are in the stone, they just need to be carefully extracted, it only requires affection, love for Nature, for all living things, and interest in finding the essence of things. Nature is my teacher."

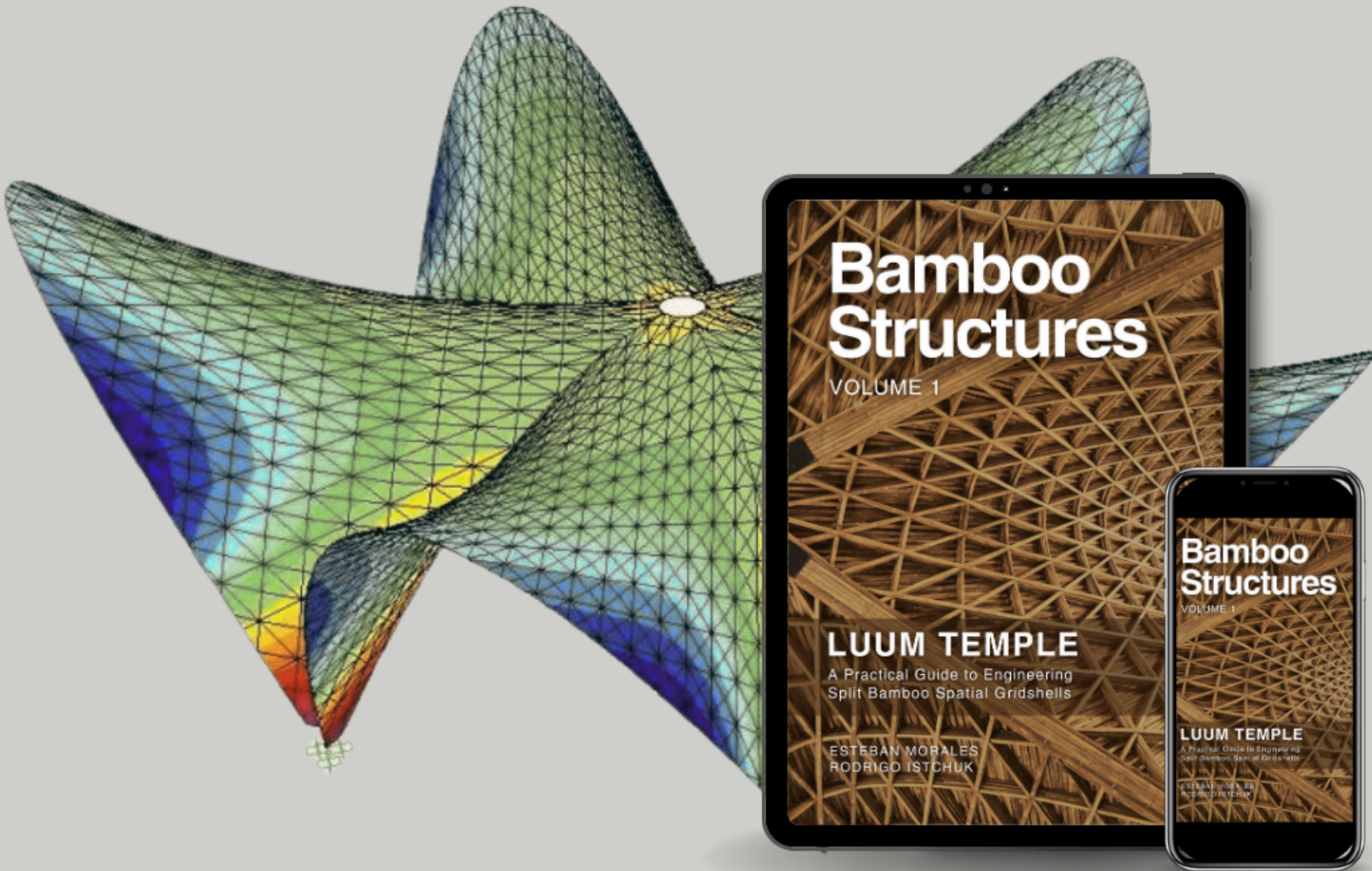
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EBOOK



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