Verification Example

Program: RFEM 5

Category: Isotropic Linear Elasticity, Geometrically Linear Analysis, Shell

Verification Example: 0083 – Scordelis-Lo Roof

0083 – Scordelis-Lo Roof

Description

A shell roof structure under pressure load p is modeled, where the straight edges are free, while at the curved edges the y- and z-translations are constrained, cf. **Figure 1**.

Neglecting self-weight, compute the maximal (absolute) vertical deflection $u_{z,\max}$, and compare the results with ®COMSOL Multiphysics 4.3, see [1]. The problem is described by the following set of parameters.

Material	Modulus of Elasticity	E	432.000	MPa
	Poisson's Ratio	ν	0.000	—
Geometry	Roof Radius	R	25.000	m
	Roof Angle	θ	40.000	°
	Length	L	50.000	m
	Thickness	t	0.250	m
Load	Pressure	p	90.000	Pa

Note that the given pressure p is equivalent to the self-weight of the roof, if its specific weight equals to $\gamma = 360.000$ N/m^3.

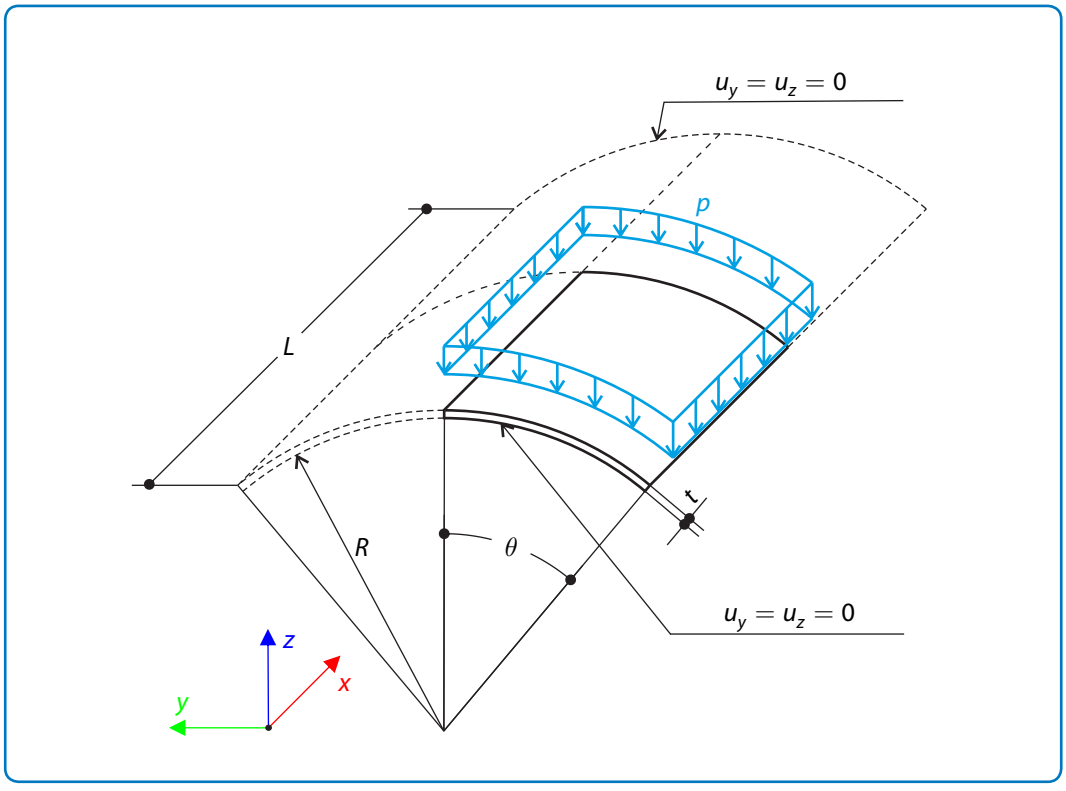

Figure 1: Problem Sketch

Analytical Solution

The theoretical value for the given problem is referenced to be[1]

$$u_{z,\max} \approx -0.3086 \text{ m}, \tag{83 – 1}$$

while, finite-element solutions tend to converge to a slightly lower value, reportedly to −0.302 m.

Due to symmetry, only one-quarter of the roof is considered, augmented with symmetry boundary conditions at the inner edges.

RFEM 5 Settings

- Modeled in RFEM 5.11.01
- Element size is $l_{FE} = 0.9$ m
- The number of increments is 1
- Isotropic linear elastic material (to incorporate the Lynn-Dhillon plate bending element) and Isotropic nonlinear elastic 2D/3D with the option *Linear only* (for the MITC4 element) is used

Results

Structure File	Program	Entity
0083.01	RFEM 5	Shell

Analytical Solution	RFEM 5 Lynn-Dhillon elements		RFEM 5 MITC4 elements		COMSOL Multiphysics 4.3	
$u_{z,\max}$ [m]	$u_{z,\max}$ [m]	Ratio [-]	$u_{z,\max}$ [m]	Ratio [-]	$u_{z,\max}$ [m]	Ratio [-]
−0.3086	−0.3012	0.9760	−0.3019	0.9783	−0.3015	0.9770

Note that there were 609 quadrilateral elements used in RFEM 5, while the comparable COMSOL results [1] have been obtained for 580.

[1] See [1] and the references therein, especially [2].

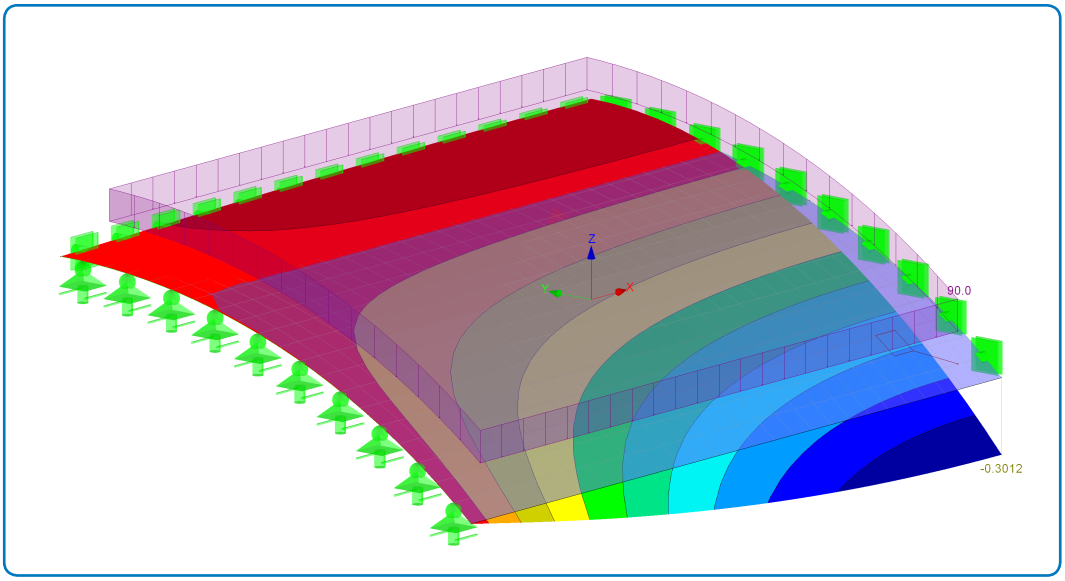

Figure 2: RFEM 5 shell results with Lynn-Dhillon elements - global deflection u_z [m]

References

[1] COMSOL INC., *Scordelis-Lo Roof Shell Benchmark*. 2012.

[2] MACNEAL, R. H. and HARDER, R. L.. Proposed standard set of problems to test finite element accuracy. *Finite Elements in Analysis and Design*, 1, 1985.