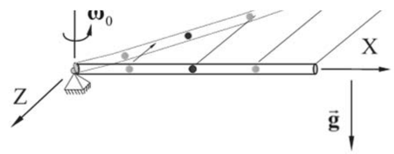
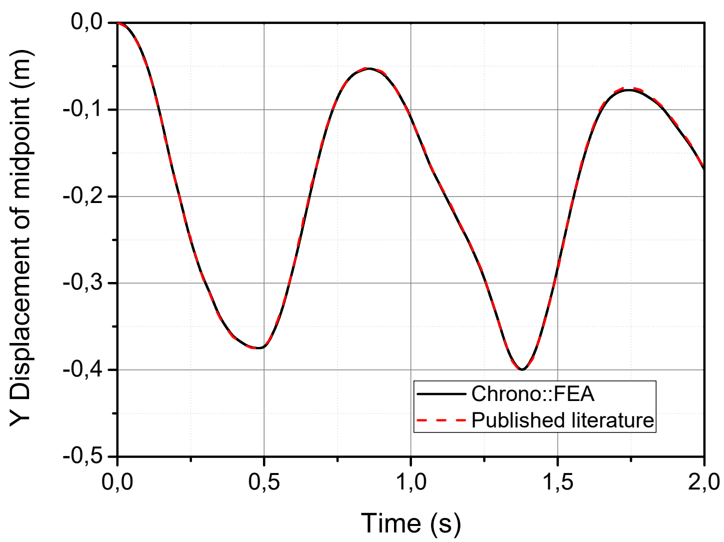
Chrono::FEA

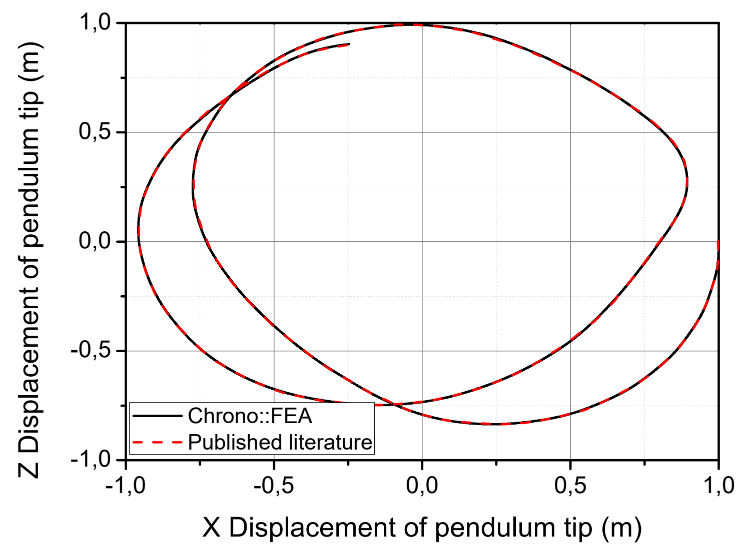
Validation

ANCF Cable



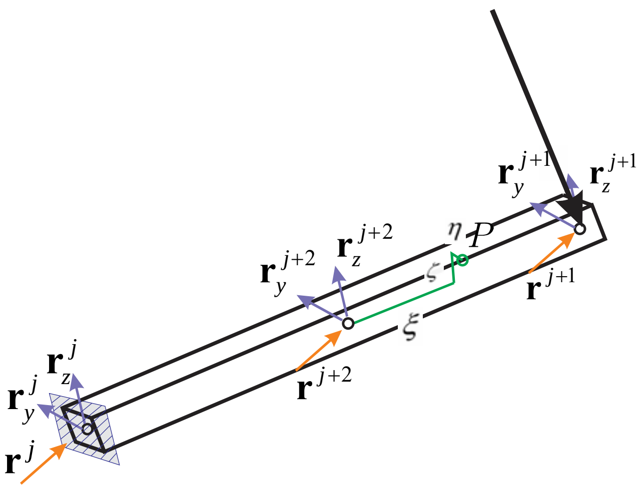
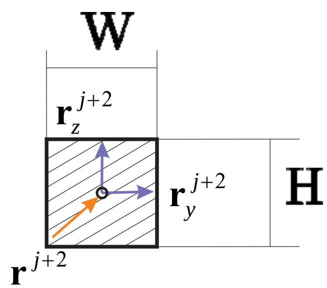
ANCF cable elements validated against published literature (see unit test `test_ANCFCable.cpp`)



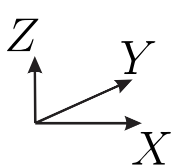


*Chrono's implementation has been verified against: Gerstmayr and Shabana, 2006, "Analysis of thin beams and cables using the absolute nodal coordinate formulation", Nonlinear Dynamics 45: 109–130

ANCF Beam

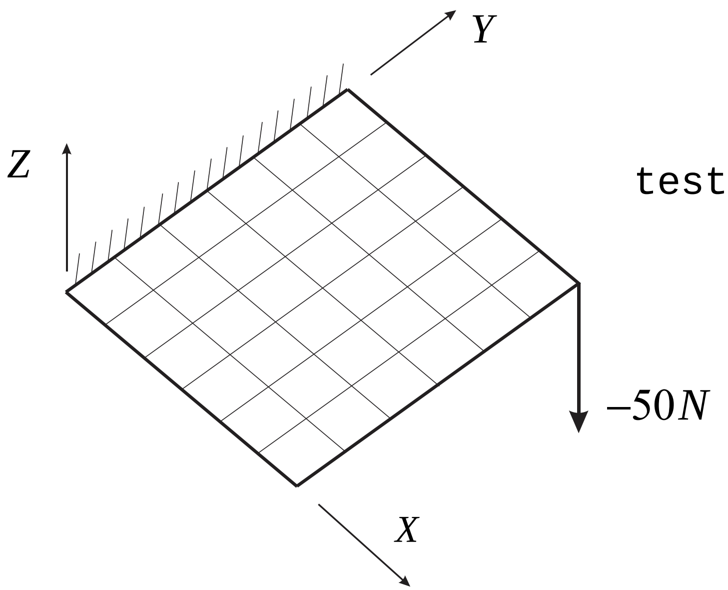



ANCF cable elements validated against published literature (see unit test `utest_ANCFBeam.cpp`)



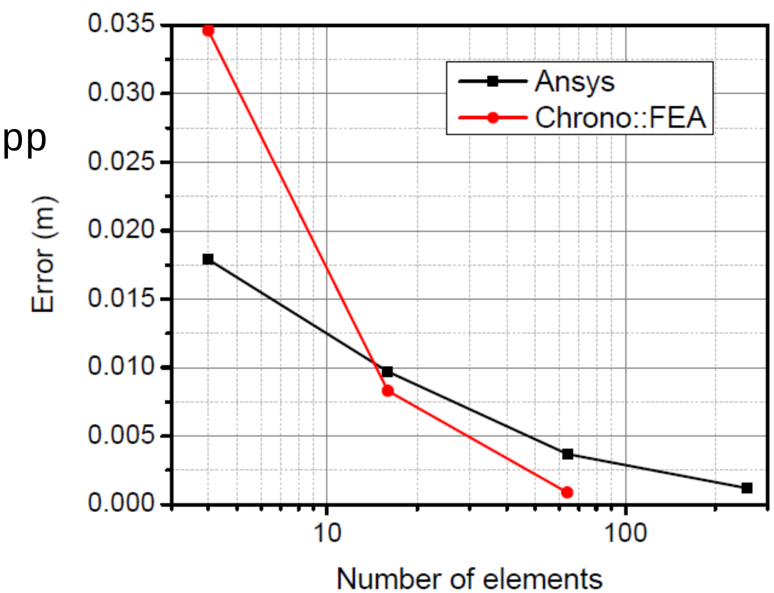
- H = 0.5m; W = 0.1m; L = 2.0m; 4 ANCF finite elements
- E = 2.07e11 Pa; Poisson ratio = 0.3; k1,k2 Timoshenko coefficients
- Force = -5e5 0.5^3 N
- Results match up to numerical precision with published in the literature: "Structural and continuum mechanics approaches for a 3D shear deformable ANCF beam finite element: Application to static and linearized dynamic examples", Journal of Computational and Nonlinear Dynamics, April 2013, Vol. 8/021004.
- Verified for small and large deformation

ANCF shell



Isotropic

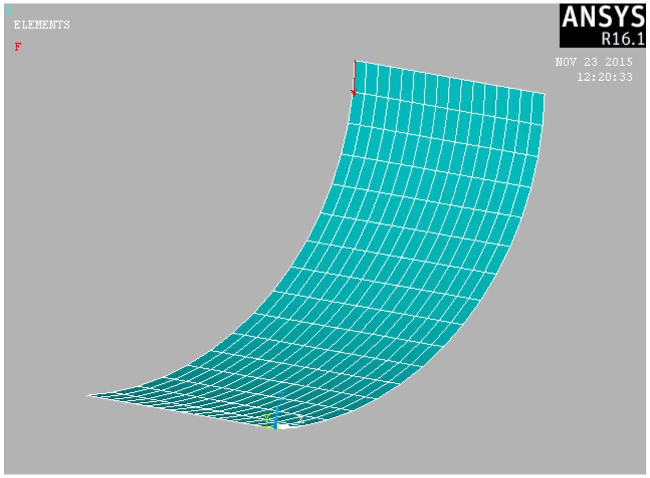
test_ANCFShell_Iso.cpp



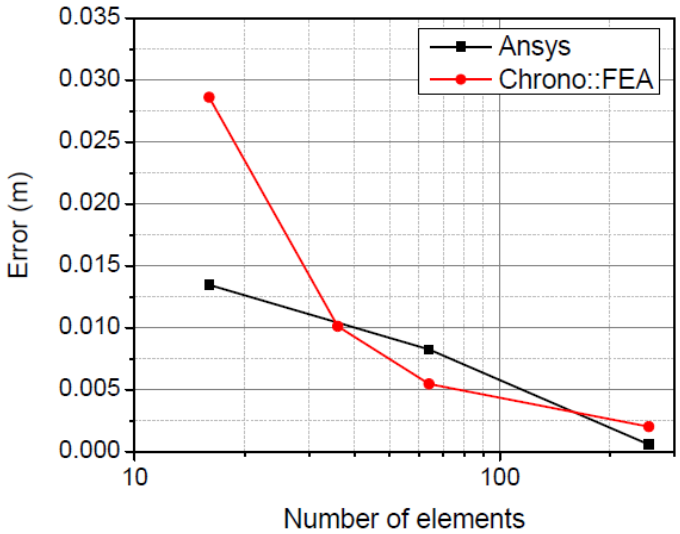
Dimensions	E (MPa)	G (MPa)	Density	Vertical Force	Simulation type	Ansys element	Converged disp
1mx1mx0.01 m	210	80.8	500 kg/m^3	-50N	Dynamic	Shell181 (EAS)	-0.649m

ANCF shell

Orthotropic and Composite

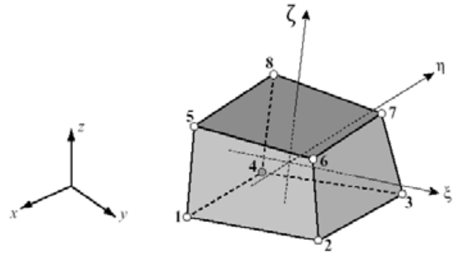


test_ANCFShell_Ort.cpp



Dimensions	Ex (MPa)	G (MPa)	Ey=Ez (MPa)	Density	Vertical Force	Simulation type	Number of layers	Thickness of each layer	Fiber angle	Converged disp.
1mx1mx 0.01m	200	38.5	100	500 kg/m^3	-10N	Dynamic	2	0.005m	20 degrees	-0.80207m

EAS Brick element

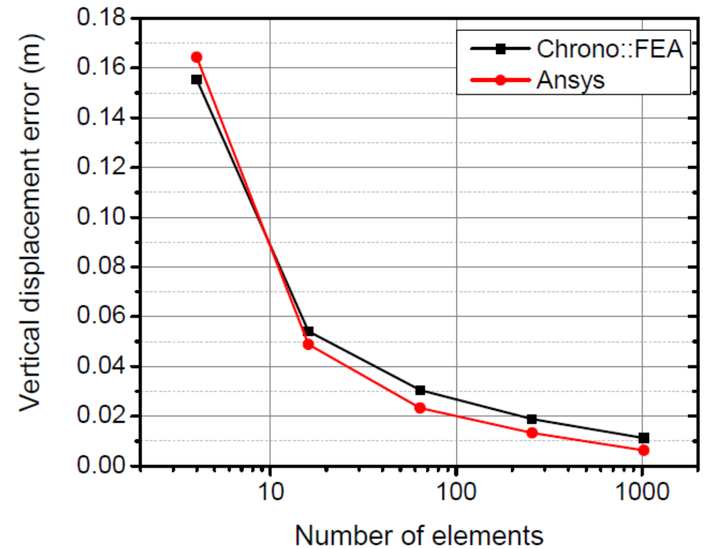


8-noded brick element

Isotropic and MR

test_EASBrickIso.cpp
test_EASBrickMooneyR_Grav.cpp

- Classical tri-linear element
- Implements Enhanced Assumed Strain formulation to alleaviate locking
- Constitutive equations: Linear isotropic and Mooney-Rivlin



Dimensions	C_{10} (kPa)	C_{01} (kPa)	Vertical Force	Simulation type	Converged disp.
1mx1mx 0.1m	50	10	-50N	Dynamic	-0.5762 m

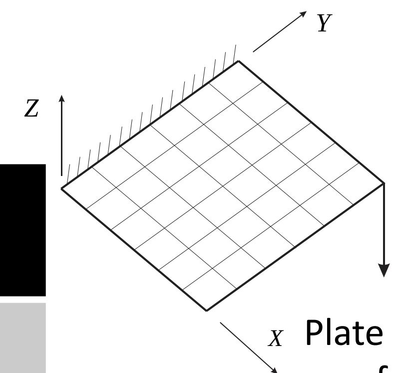


Plate geometry made up of brick elements

Brick 9: Capped Drucker-Prager –Punch Test

Soil Material Properties

$$\sigma_{yield} = 210926Pa$$

$$\beta = 51.7848^\circ$$

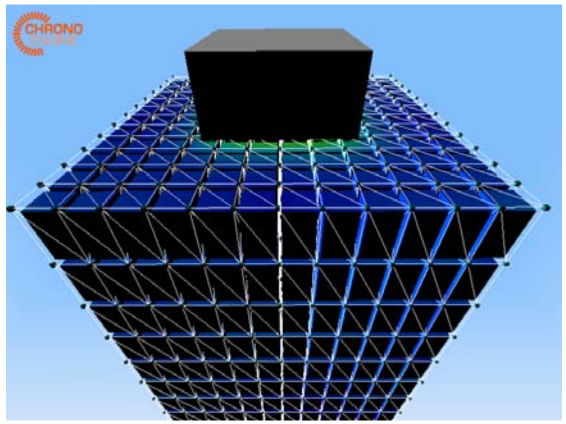
$$\phi = 51.7848^\circ$$

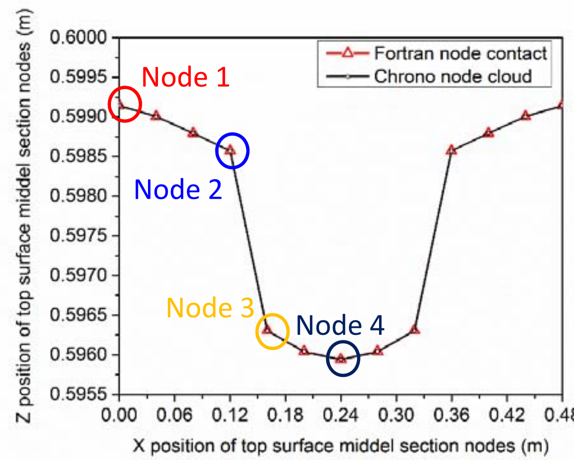
$$R = 0.5$$

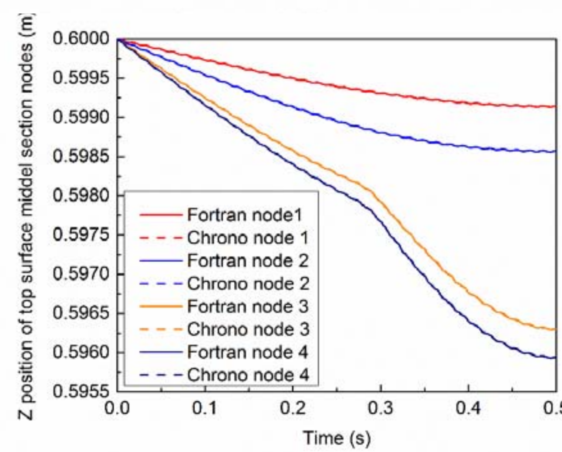
$$\rho = 2149 \, {}^{kg}\!/_{m^3}$$

$$E = 54.1MPa$$

$$\nu = 0.293021$$



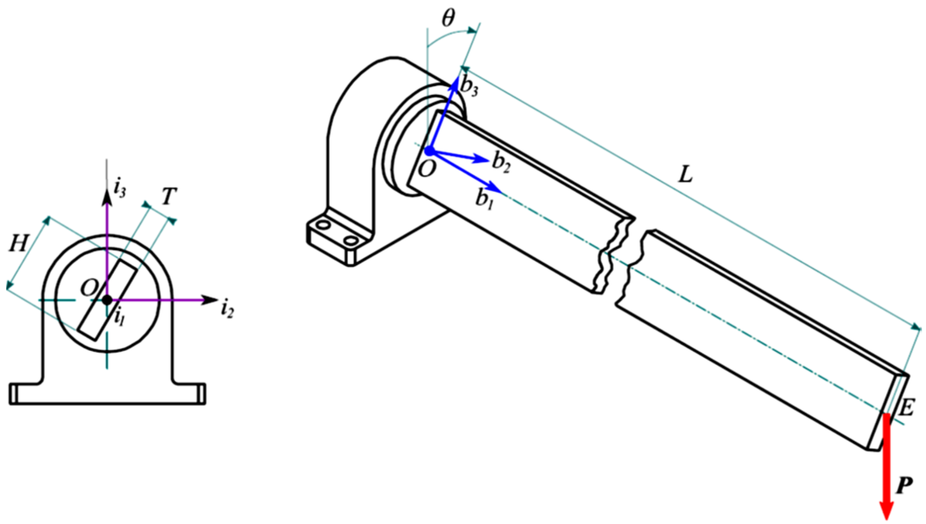




Chrono verification parameters

- Applied force : $-27000\sin(\pi t)$
- Contact stiffness : 165000 N/m
- Contact detection threshold : 0.009m
- Element number : 12*12*8
- Soil box dimension : 0.48m*0.48*0.6m
- Rigid punch dimension : 0.2m*0.2m*0.1m
- Bottom node fixed

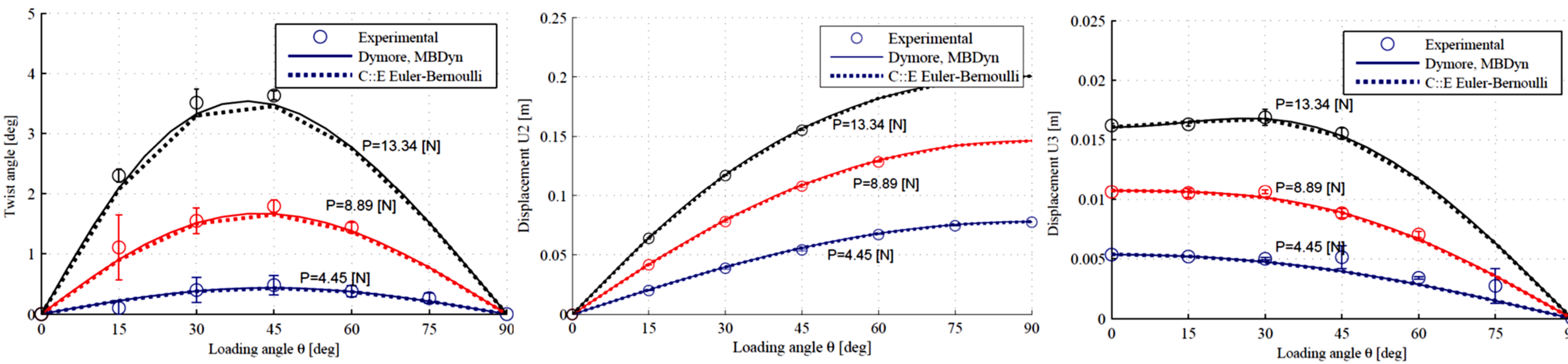
Corotational Euler-Bernoulli beam: Princeton benchmark



L =0:508m, T = 3.2024mm, H = 12.77mm,
Young modulus E = 71.7GPa, Poisson ratio= 0.31, G = 27.37GPa.

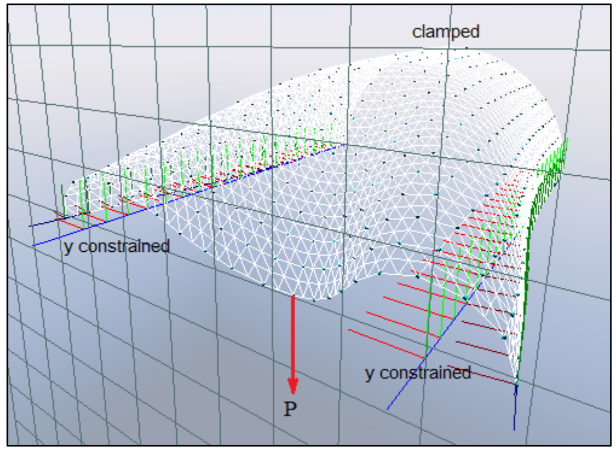
Three loading conditions are tested:
P1 = 4:448N,
P2 = 8:896N,
P3 =13:345N for increasing values of the angle

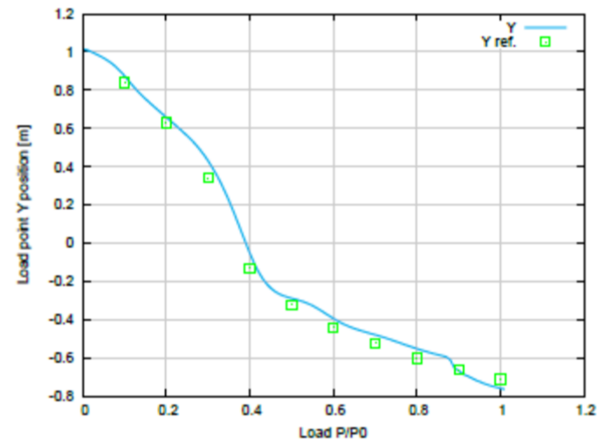
More info: Tasora, A. "Validation of Euler-Bernoulli corotational beams in Chrono::Engine", Chrono white paper



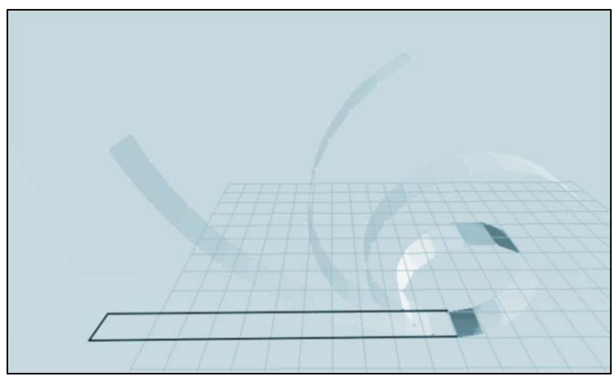
Kinematically exact Reissner shell element

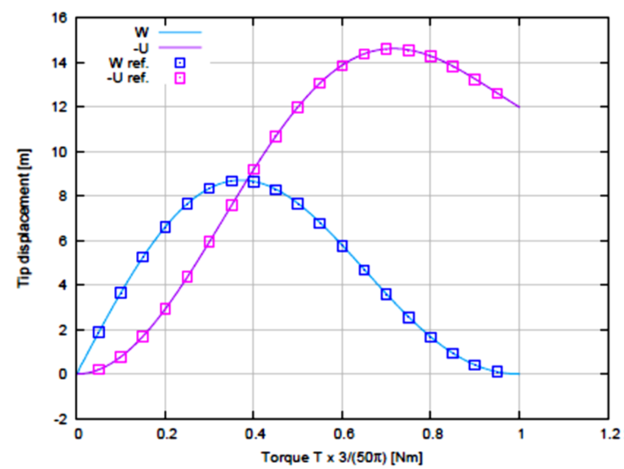
Clamped half cylinder with sliding constraints at the sides





Large bending in a rolled band





Comparison with results in literature and with analytical solutions