OptumG3

Verification of shell element with elastic properties

OPTUM COMPUTATIONAL ENGINEERING

Optum Computational Engineering | Hejrevej 37, 3. floor | 2400 Kbh. NV.
+45 30 11 63 55 | contact@optumce.com

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1 Introduction

1.1 Shell element

OptumG3 uses a triangular shell element with a quadratic displacement field. The stress and moment fields are linear and described by a total of 18 variables. The in-plane part of the shell element contributes to 7 nodes, whereas one is a centre node and the remaining 6 are corner nodes and edge (midpoint) nodes. The plate part of the shell element uses the same corner and edge nodes as well as two nodes along each edge for moment continuity.

1.2 Upper, lower and mixed

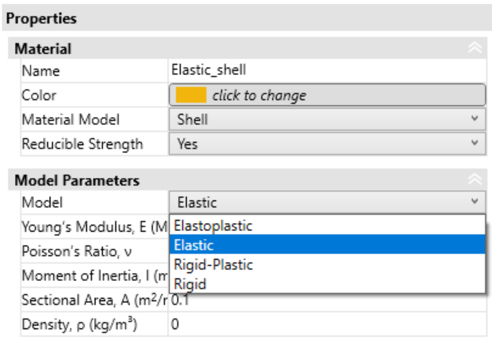
Currently in OptumG3 the shell element is based on a so-called mixed formulation which in essence is a hybrid, or mixed, formulation of an upper and lower bound formulation. The output results when using the shell element with a mixed formulation is guaranteed to be within the brackets of the upper (unsafe) and lower (safe) bounds. The hybrid formulation ensures an superb precision.

Currently in OptumG3 the mixed formulation is the only element available.

1.3 Material models and yield conditions

For the shell element 4 different material models can be selected namely

- Elastoplastic
- Elastic
- Rigid-Plastic
- Rigid



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In the present document verification of the **elastic material** model is considered

2 Square plate with simple supports – elastic material

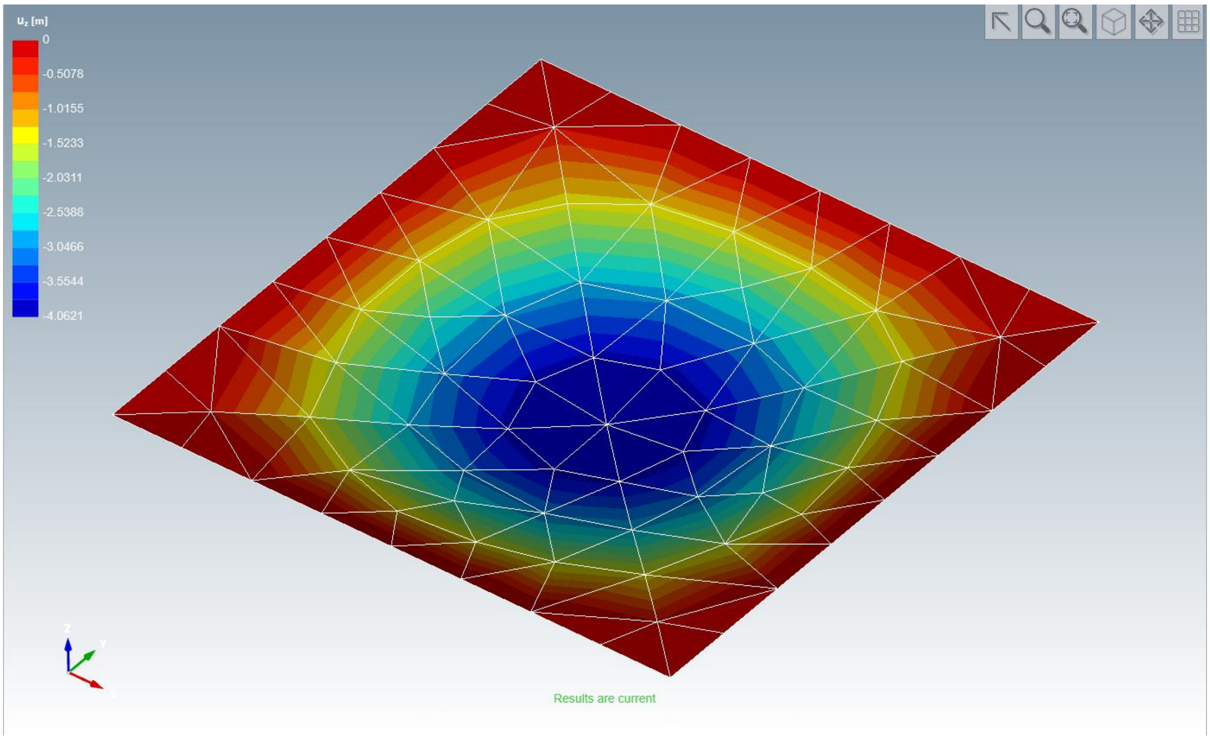

Figure **1: Square plate with simple supports – 120 elements**

Benchmark	**4.0624** (infinite series)
Results	4.0557 – 30 elements
	4.0602 – 60 elements
	4.0621 – 120 elements
Discrepancy	**0.01%** for 120 elements

General description:
Square 1x1m elastic plate. All edges with simple supports Loaded with unit area load of 1.0 kPa. E = 0.01125 MPa, Poisson ratio 0.25, plate thickness 0.1 m. Density 0.0 kg/m^3.

Material properties:

Properties	
Material	
Name	Elastic_shell
Color	click to change
Material Model	Shell
Reducible Strength	Yes
Model Parameters	
Model	Elastic
Young's Modulus, E (MPa)	0.01125
Poisson's Ratio, ν	0.25
Moment of Inertia, I (m^4/m)	8.333E-05
Sectional Area, A (m^2/m)	0.1
Density, ρ (kg/m^3)	0

Partial factors:
Unity

Reference:
S. Timoshenko, Theory of Plates and Shells, McGraw-Hill (1987)

3 Square plate with fixed supports – elastic material

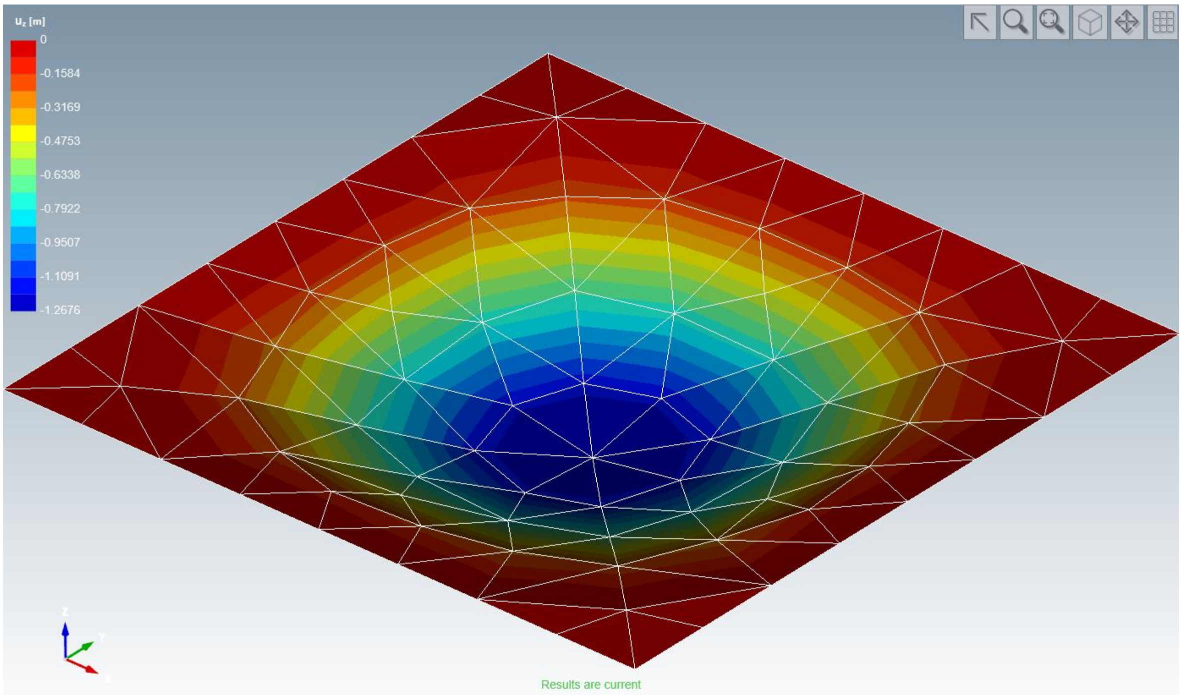

Figure **2: Square plate with fixed supports**

Benchmark	**1.2653** (infinite series)
Results	1.2997 – 30 elements
	1.2755 – 60 elements
	1.2676 – 120 elements
Discrepancy	**0.18%** for 120 elements

General description:
Square 1x1m elastic plate. All edges with simple supports Loaded with unit area load of 1.0 kPa. E = 0.01125 MPa, Poisson ratio 0.25, plate thickness 0.1 m. Density 0.0 kg/m^3.

Material properties:

Properties	
Material	
Name	Elastic_shell
Color	click to change
Material Model	Shell
Reducible Strength	Yes
Model Parameters	
Model	Elastic
Young's Modulus, E (MPa)	0.01125
Poisson's Ratio, ν	0.25
Moment of Inertia, I (m^4/m)	8.333E-05
Sectional Area, A (m^2/m)	0.1
Density, ρ (kg/m^3)	0

Partial factors:
Unity

Reference:
S. Timoshenko, Theory of Plates and Shells, McGraw-Hill (1987)