# OptumG3

Verification of shell element with elastic properties



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Verification of shell element - Elastic		0	p+um <sup>ce</sup>
	Date:	:	August 2019
	Rev. Date	:	-
	Page		2

# Table of content

1	Intro	oduction	. 3
	1.1	Shell element	. 3
	1.2	Upper, lower and mixed	. 3
	1.3	Material models and yield conditions	. 3
2	Squ	are plate with simple supports – elastic material	. 4
3	Squ	are plate with fixed supports – elastic material	. 5

Verification of shell element - Elastic		0	p+um <sup>ce</sup>
D	Date:	:	August 2019
R	Rev. Date	:	-
P	Page	:	3

# 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

Material		
Name	Elastic_shell	
Color	click to change	
Material Model	Shell	
Reducible Strength	Yes	
Andel Parameters		
Model Parameters	Flastic	
Model Parameters Model Young's Modulus, F. (	Elastic M Elastoplastic	
Vodel Parameters Model Young's Modulus, E ( Poisson's Ratio, v	Elastic M Elastoplastic Elastic	
<b>Nodel Parameters</b> Model Young's Modulus, E ( Poisson's Ratio, v Moment of Inertia, I (	Elastic M Elastoplastic Elastic Rigid-Plastic M Rigid	
Model Parameters Model Young's Modulus, E ( Poisson's Ratio, v Moment of Inertia, I ( Sectional Area, A (m <sup>2</sup>	Elastic M Elastoplastic Elastic Rigid-Plastic M Rigid /r 0.1	

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

Verification of shell element - Elastic		С	p+um <sup>ce</sup>
	Date:	:	August 2019
	Rev. Date	:	-
	Page	:	4

# 2 Square plate with simple supports – elastic material



Figure 1: Square plate with simple supports - 120 elements

Benchmark
Results

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

Discrepancy

#### **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<sup>3</sup>.

## Material properties:

Properties		
Material		
Name	Elastic_shell	
Color	click to change	
Material Model	Shell	Ý
Reducible Strength	Yes	Ý
Model Parameters		
moderrarameters		
Model	Elastic	Ý
Model Young's Modulus, E (MPa)	Elastic 0.01125	~
Model Young's Modulus, E (MPa) Poisson's Ratio, v	Elastic 0.01125 0.25	~
Model Young's Modulus, E (MPa) Poisson's Ratio, v Moment of Inertia, I (m <sup>4</sup> /m)	Elastic 0.01125 0.25 8.333E-05	~
Model Young's Modulus, E (MPa) Poisson's Ratio, v Moment of Inertia, I (m <sup>4</sup> /m) Sectional Area, A (m <sup>2</sup> /m)	Elastic 0.01125 0.25 8.333E-05 0.1	v

#### Partial factors: Unity

#### **Reference:**

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

Verification of shell element - Elastic		0	p+um <sup>CE</sup>
	Date:	:	August 2019
	Rev. Date	:	-
	Page	:	5

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# 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
	<b>1.2676</b> – 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<sup>3</sup>. Material properties:

material prope	FI LICS.	
Properties		
Material		
Name	Elastic_shell	
Color	click to change	
Material Model	Shell	Ŷ
Reducible Strength	Yes	Ŷ
Model Parameters		
Model	Elastic	v
Young's Modulus, E (MPa)	0.01125	
Poisson's Ratio, v	0.25	
Moment of Inertia, I (m4/m)	8.333E-05	
Sectional Area, A (m <sup>2</sup> /m)	0.1	
Density, ρ (kg/m³)	0	

#### **Partial factors:**

Unity

#### **Reference:**

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