A crane hook computation

Number
SP-XXX-001

Rev.
B

Date
15-Nov-2016

Hash
5d05b6e

Document type
Technical report

Pages
15

Author
John Doe gtheler@seamplex.com

Abstract

Quisquam ea sit provident rerum suscipit *earum*. Est officia incidunt molestiae **ab eius** facilis. Accusantium sint earum et. Perferendis incidunt odit ullam aliquid qui iste. Possimus nobis autem eum. Est quia minus omnis. Sed qui cum et. Et autem harum recusandae et. Quia distinctio omnis ea id ut dolores ea. At sit hic libero dolor optio error voluptatem. Qui dolor excepturi autem quas rerum similique autem. Corporis itaque ullam asperiores et qui at quia. Cumque rerum ratione aliquid.

Revision history

Rev.	Date	Author	
B	15-Nov-2016	John Doe	Mesh details and report body
A	15-Nov-2016	John Doe	First issue for comments

Contents

1 Introduction

This is an introduction. Our assumptions are

- one
- another one
- the last one

2 Conclusion

Everyhting works as *expected*.

A Project details

CAEplex[1] project settings	
Name	Test
Author email	gtheler@seamplex.com
Project ID	57e681e7ad1a4
Type	Linear structural analysis
Last modification	Tue, 15 Nov 2016 11:26:20 +0000 (UTC)

Figure 1: Project URL https://www.caeplex.com/demo/results.php?id=57e681e7ad1a4

[1]CAEplex is a web-based front-end for cloud-based open-source finite element analysis codes.

A.1 Geometry

Geometry file	
Name	`hook`
Format	STEP
MD5	`cbd6a2f1faf6d36d6b35f10544218fab`
Length units	Millimeters

Entitites	
Faces	12
Edges	34
Vertices	26
Wires	14
Solids	1
Shells	1
Compounds	0
Compsolids	0

Center of gravity	
x_{cog}	0 mm
y_{cog}	0 mm
z_{cog}	0 mm

Bounding box	
x_{min}	0 mm
x_{max}	72 mm
y_{min}	0 mm
y_{max}	23 mm
z_{min}	0 mm
z_{max}	79 mm

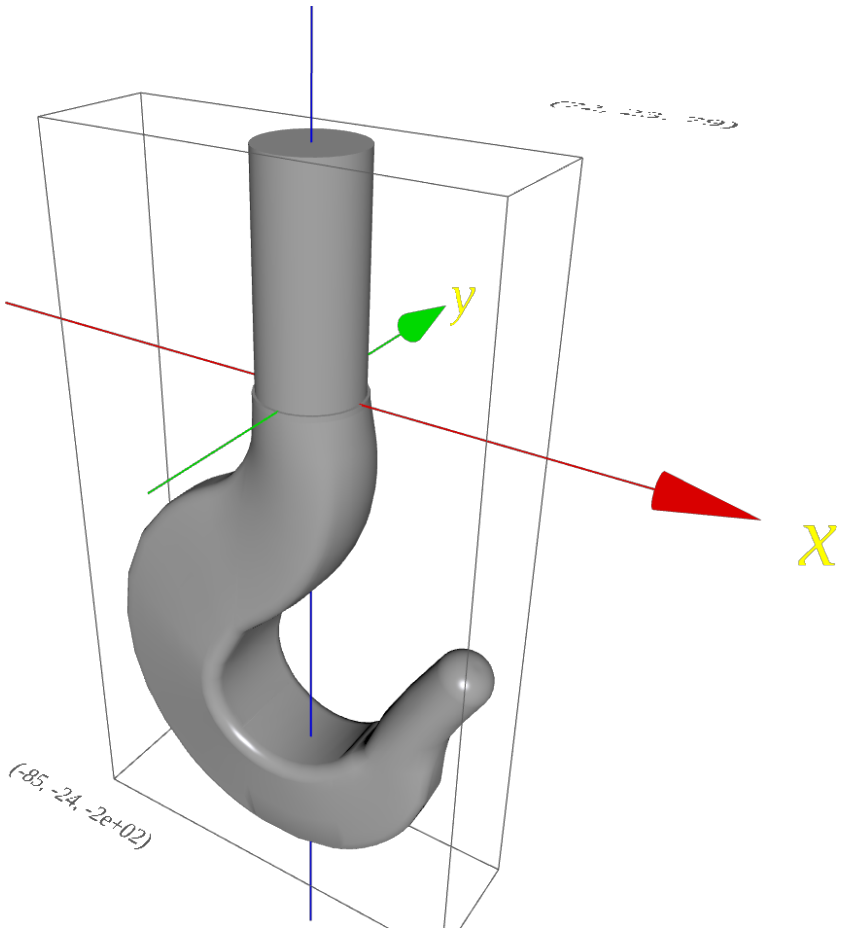


Figure 2

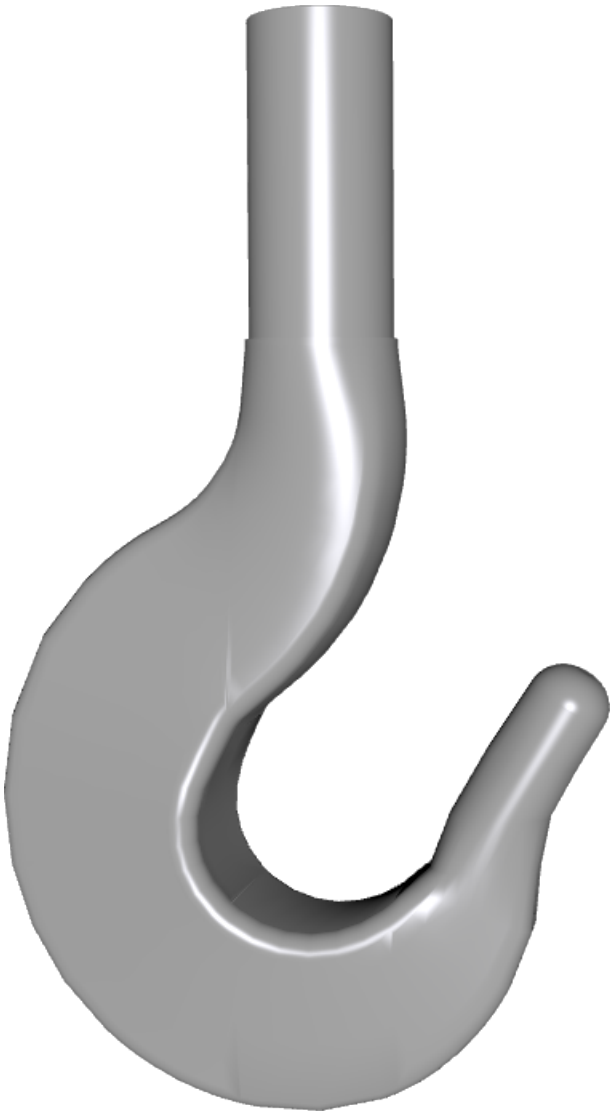


Figure 3

A.2 Problem

Material	
Name	Steel
Young modulus	E =200 000 MPa
Poisson ratio	ν =0.3
Yield strength	σ_y =400 MPa
Density ρ	7.8×10^{-6} kg/mm³

Volumetric forces	
Type	Self-weight
Density ρ	7.8×10^{-6} kg/mm³
Gravity g	9.806 mm/s²
Direction	$z-$

Condition 1	
Type	Displacement (Dirichlet)
Condition	Fixed

Condition 2	
Type	Load (Neumann)
Condition	Force
	$F_x = 0$ N
	$F_y = 0$ N
	$F_z = -30\,000$ N

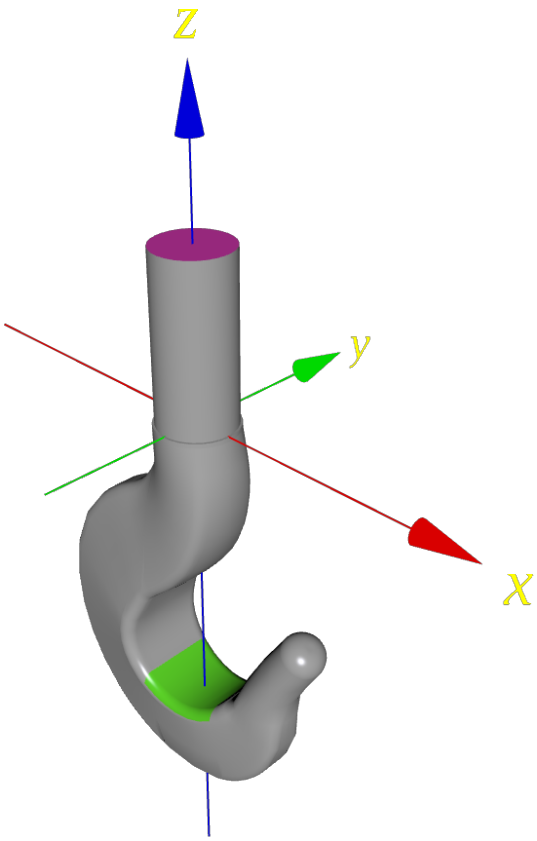


Figure 4

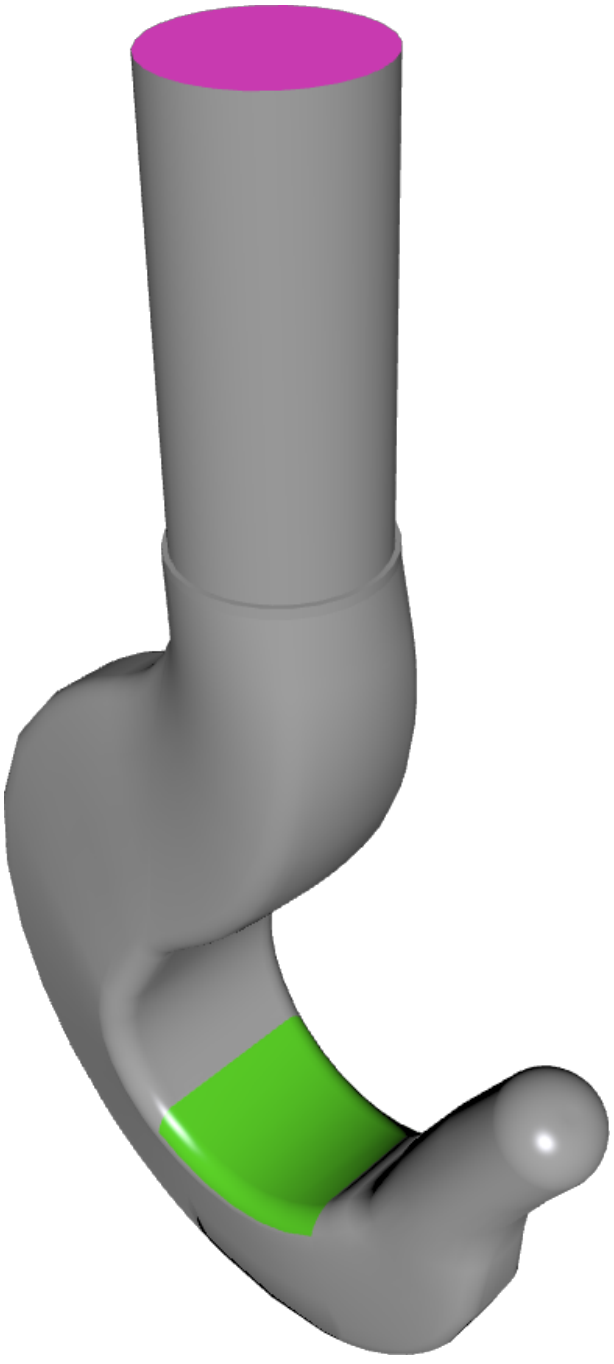


Figure 5

A.3 Mesh

Unstructured grid	
Granularity level	1/5
Nodes	8,700
Elements	48,211
Triangles	10,170
Tetrahedra	38,041

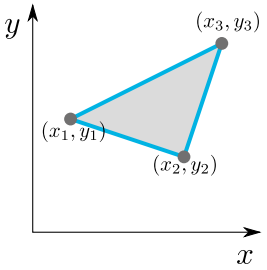
Back-end details	
Back-end version	Gmsh 2.13.1
2D algorithm	Delaunay
3D algorithm	Delaunay
Characteristic length factor	0.15

$$h_1(r,s) = 1 - r - s$$
$$h_2(r,s) = r$$
$$h_3(r,s) = s$$

(a) Shape functions

Index	Weight	r	s
1	1/3	1/6	1/6
2	1/3	2/3	1/6
3	1/3	1/6	2/3

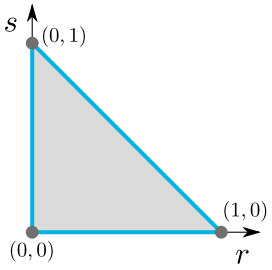
(b) Gauss points



(c) General coordinates

$$x(r,s) = \sum_{j=1}^{3} h_j(r,s) \cdot x_j$$
$$y(r,s) = \sum_{j=1}^{3} h_j(r,s) \cdot y_j$$

(d) Real ↔ Canonical



(e) Canonical coordinates

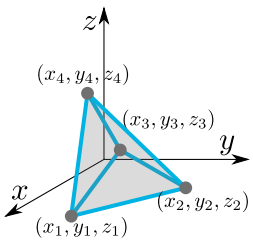
Figure 6: Mathematical details of the triangular isoparametric elements

$$h_1(r,s) = 1 - r - s - t$$
$$h_2(r,s) = r$$
$$h_3(r,s) = s$$
$$h_4(r,s) = t$$

(a) Shape functions

Index	Weight	r	s	t
1	1/4	1/6	1/6	1/6
2	1/4	2/3	1/6	1/6
3	1/4	1/6	2/3	1/6
4	1/4	1/6	1/6	2/3

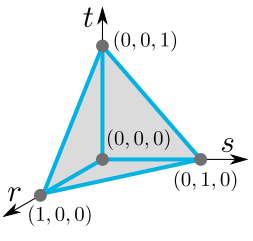
(b) Gauss points



(c) General coordinates

$$x(r,s) = \sum_{j=1}^{4} h_j(r,s) \cdot x_j$$
$$y(r,s) = \sum_{j=1}^{4} h_j(r,s) \cdot y_j$$

(d) Real ↔ Canonical



(e) Canonical coordinates

Figure 7: Mathematical details of the tetrahedral isoparametric elements

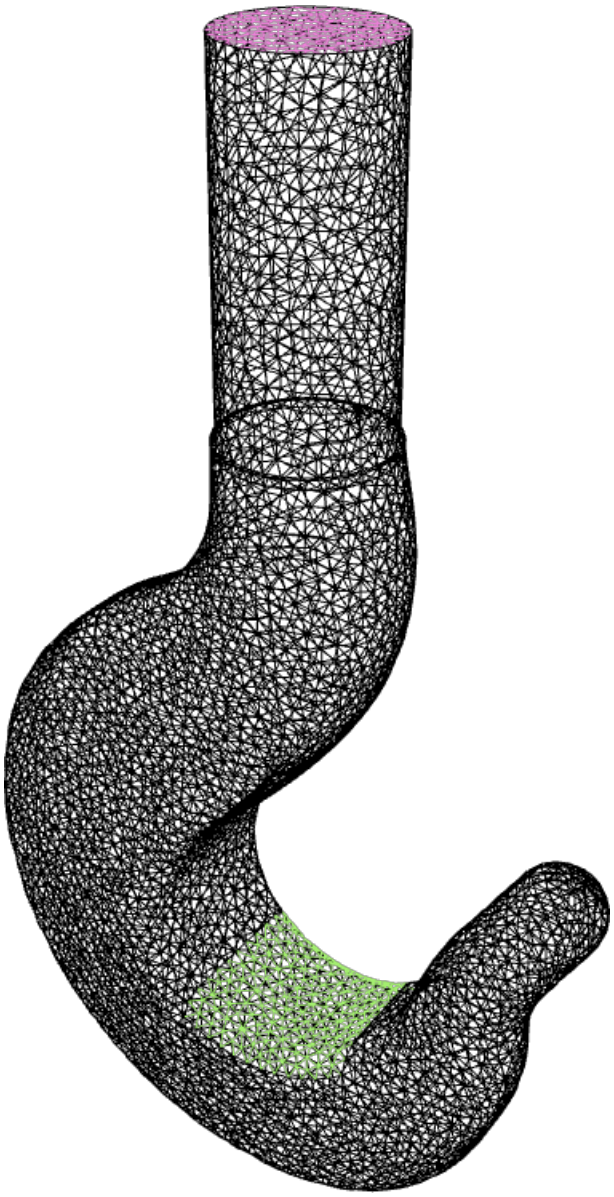


Figure 8

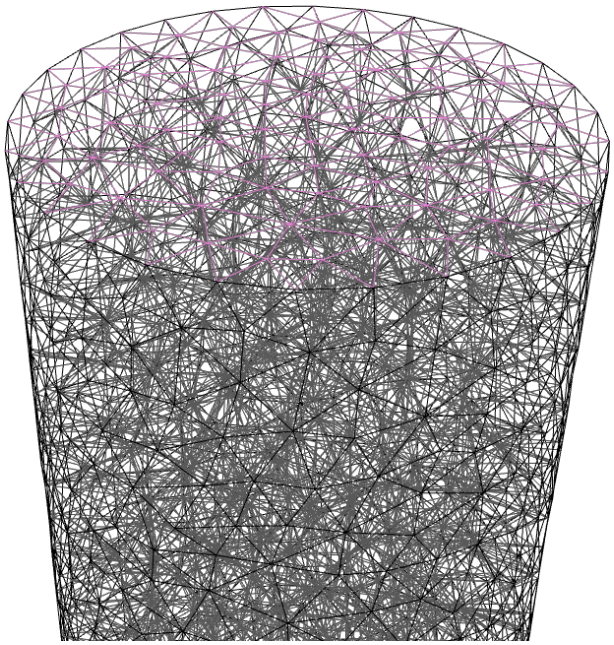


Figure 9: Mesh detail

A.4 Solution

Back-end details	
Back-end version	Fino 0.4.65
Formulation	Variational displacement-based linear elastic problem
Weighting	Galerkin
Problem size (unknowns)	26,100
Degree of freedom ordering	Node-based
Preconditioner	LU
Solver	Preconditioner only

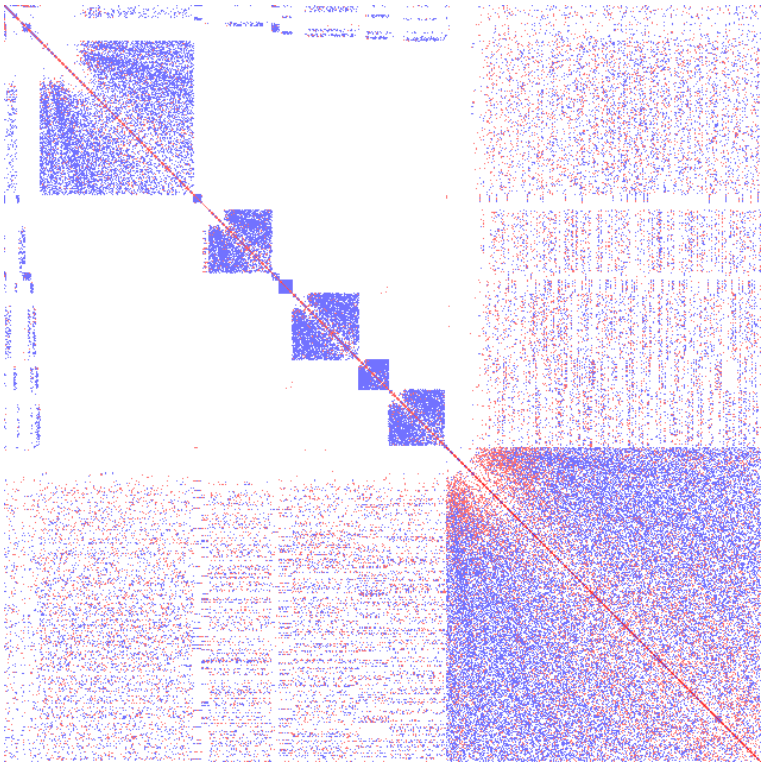


Figure 10: Problem stiffness matrix (26,100 × 26,100). Blue (red) dots represent positive (negative) values.

A.5 Results

Displacement	
Maximum value	$\lvert(u,v,w)\rvert_{\max}$ =0.281 mm
Location	$x = 71$ mm
	$y = -1.07$ mm
	$z = -88.4$ mm

Von Mises stress	
Maximum value	$\sigma_{\max} = 155.9$ MPa
Location	$x = -27.9$ mm
	$y = 6.78$ mm
	$z = -118$ mm

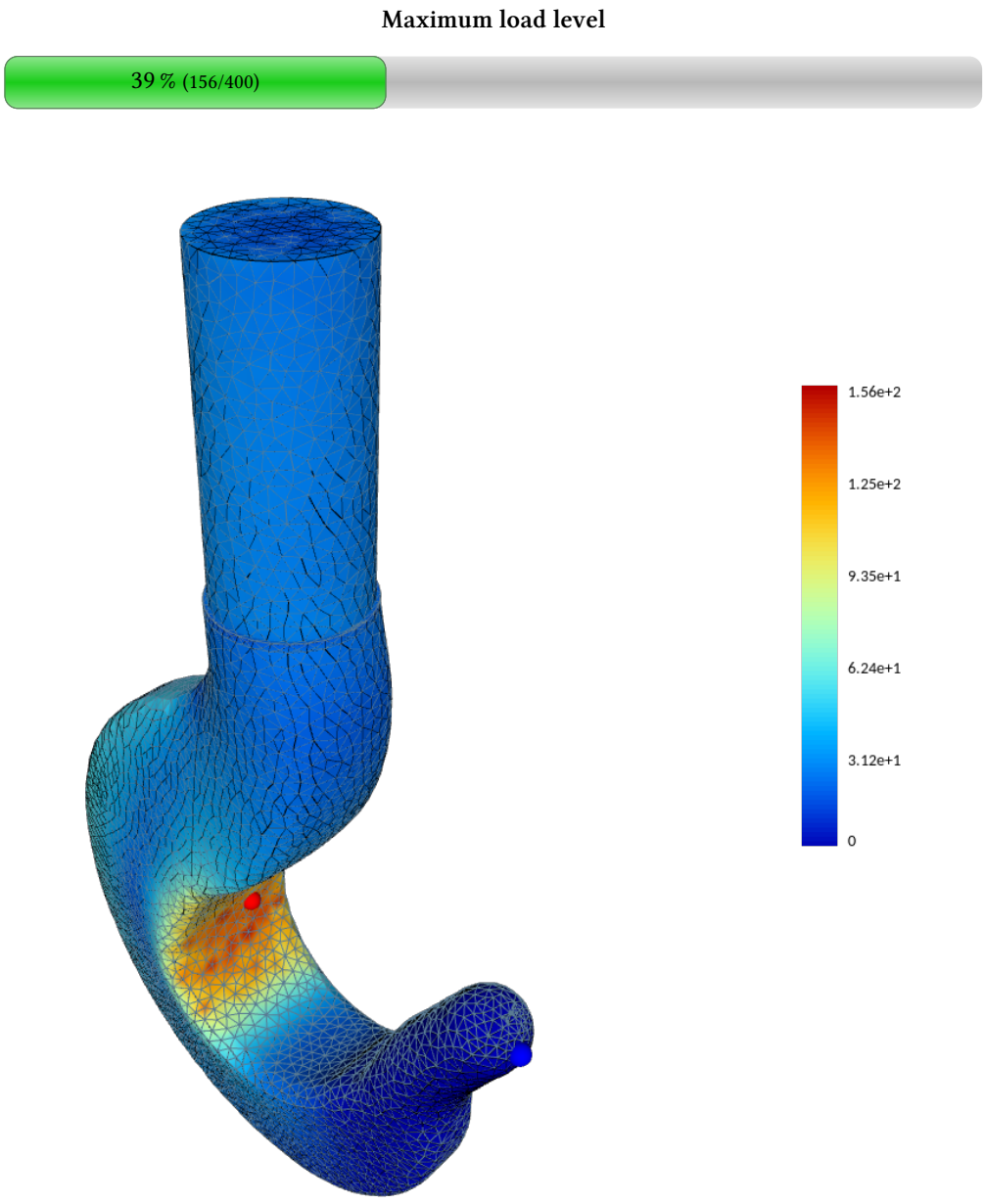


Figure 11

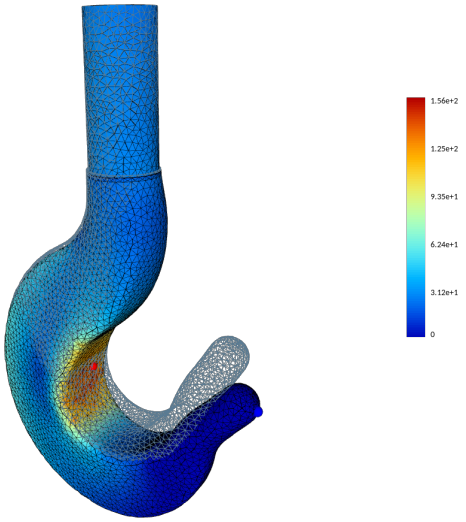


Figure 12

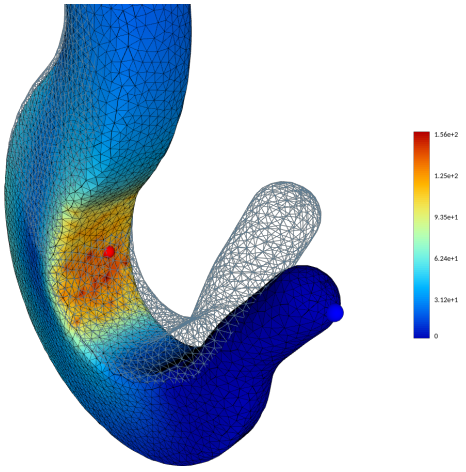


Figure 13