Universität Rostock
Traditio et Innovatio

Lehrstuhl Schiffstechnische Konstruktionen

ATENA ASSOCIAZIONE ITALIANA DI TECNICA NAVALE

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Investigations on Ultimate Strength for a Container Vessel under Combined Loads

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Overview

Various Types of Extreme Loads on Ship Structures

- Wave and Wind Loads
- Deadweight Loads
- Dynamic Pressure Loads
- Impact Loads
- Low Temperature
- Age – Related Degradation
- Initial Imperfection

Calculation of ultimate hull girder strength is required by CSR to ensure the safety of ship structures

Simplified method based on iterative-incremental approach (Smith's Method) is commonly used to determine bending moment-curvature curves

Idealized Structural Unit Method (ISUM) is a simplified method with reduced computational efforts to perform ultimate strength analysis

Finite Element Method (FEM) is very well suited to perform progressive collapse analyses of large structures

Collapse behavior of container vessel in pure vertical, horizontal and biaxial bending determined by Smith's method & nonlinear FEA

Overview

Dimensions and Properties of Container Vessel

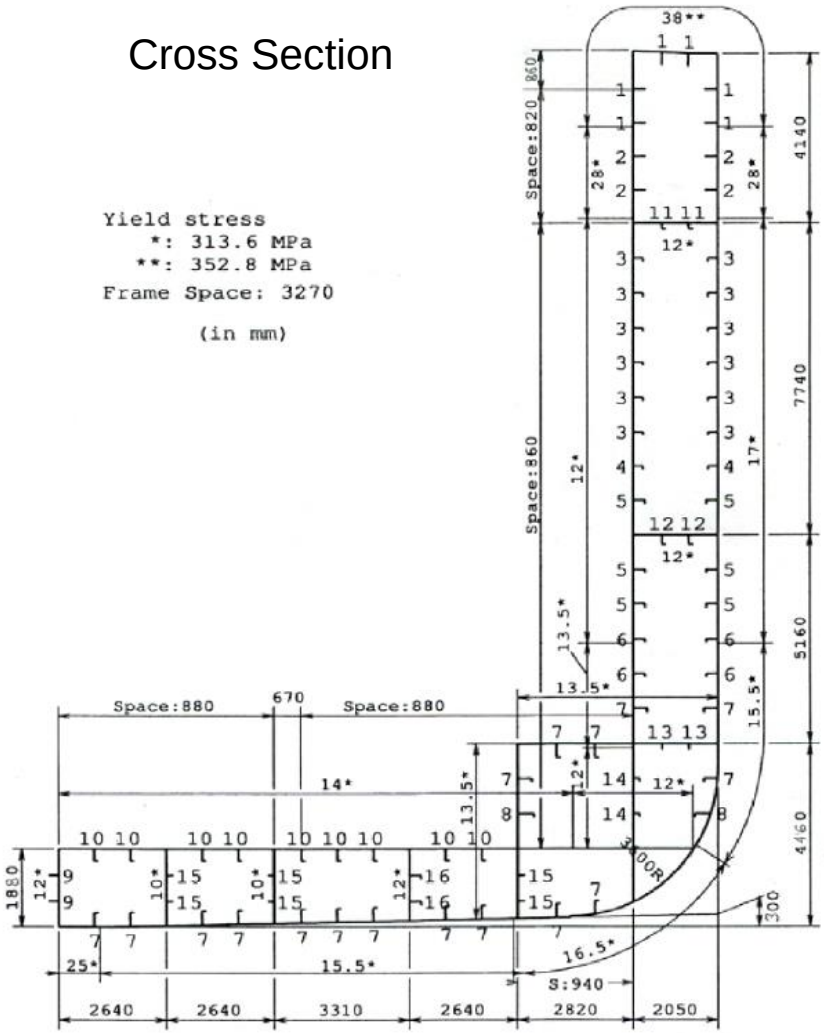
Principal Dimensions

Description	Symbol	Value	Unit
Length	L	230.0	m
Breadth	B	32.2	m
Depth	D	21.5	m

Material Properties

Description	Symbol	Value	Unit
Young's Modulus	E	210000	MPa
Poisson's Ratio	ν	0.3	-
Yield Stress *	σ_Y*	313.6	MPa
Yield Stress **	σ_Y**	352.8	MPa

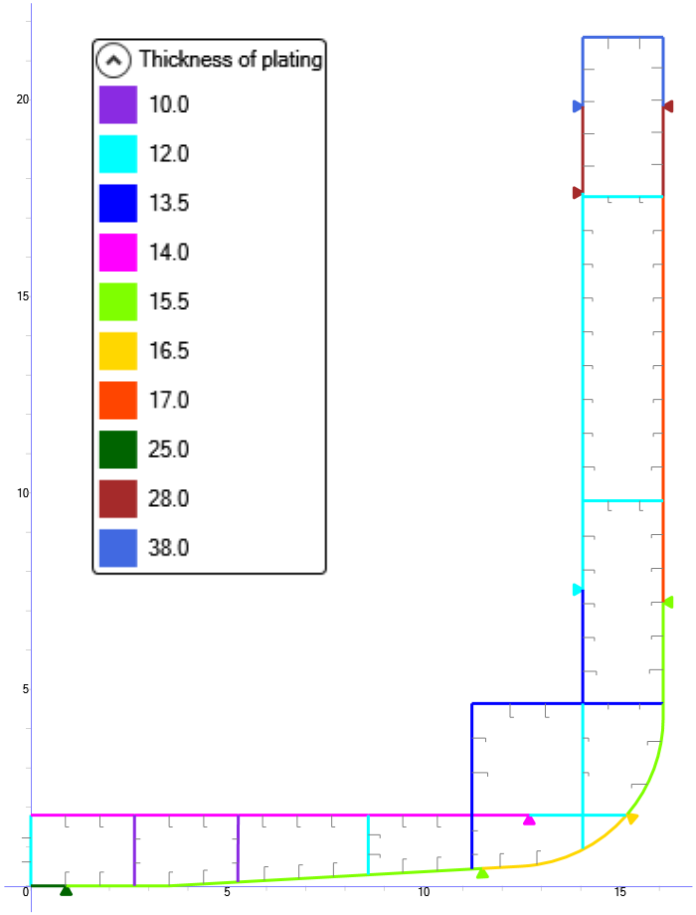
Cross Section



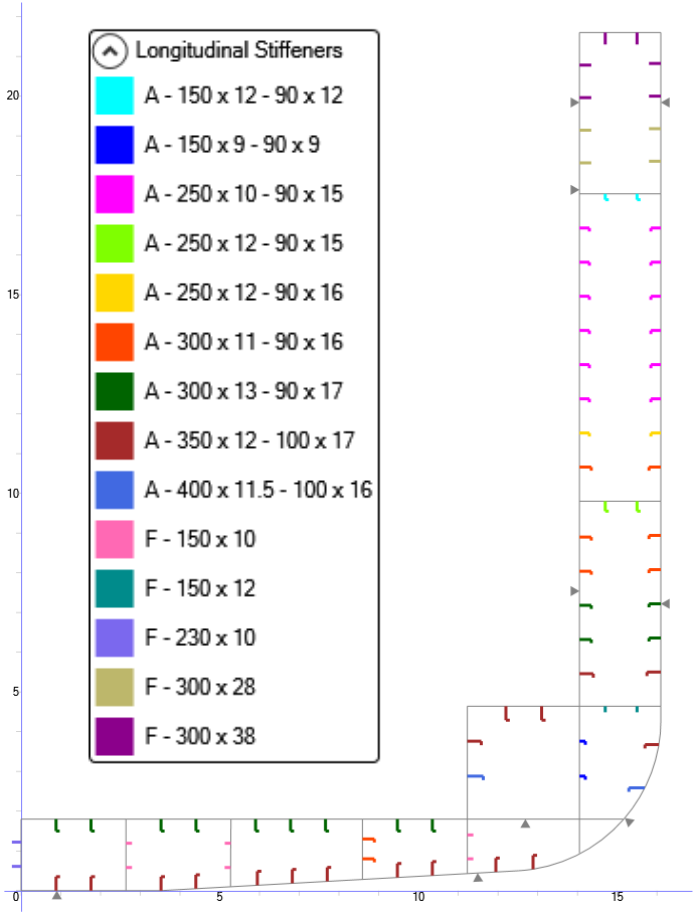
Reference:
ISSC Committee VI.2: Ultimate Hull Girder Strength. Proceedings of the 14th International Ship and Offshore Structure Congress, Vol 2: pp. 321-391, Nagasaki, Japan, 2000.

Smith's Method based Model

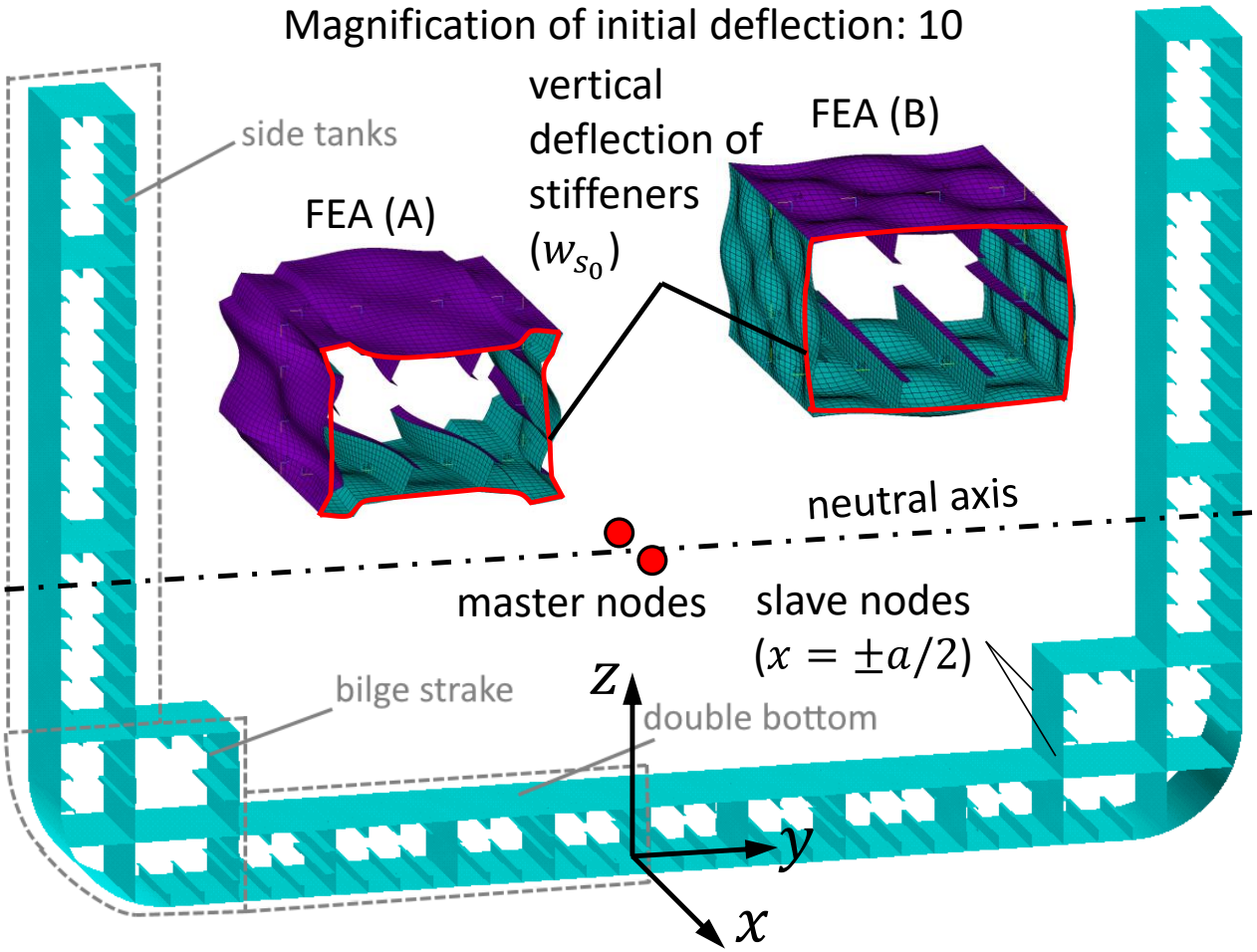
Plate Thickness Values



Stiffener Scantlings

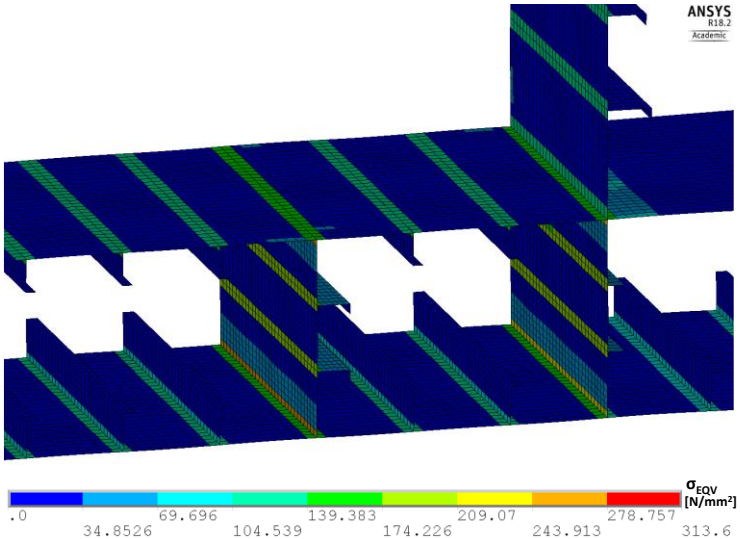


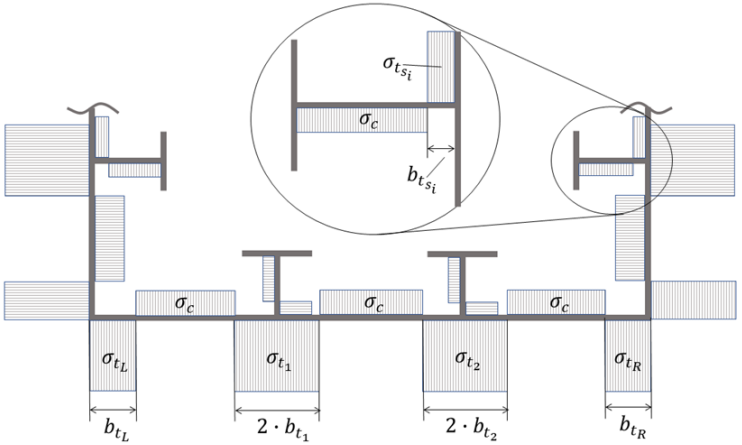
Finite Element Model



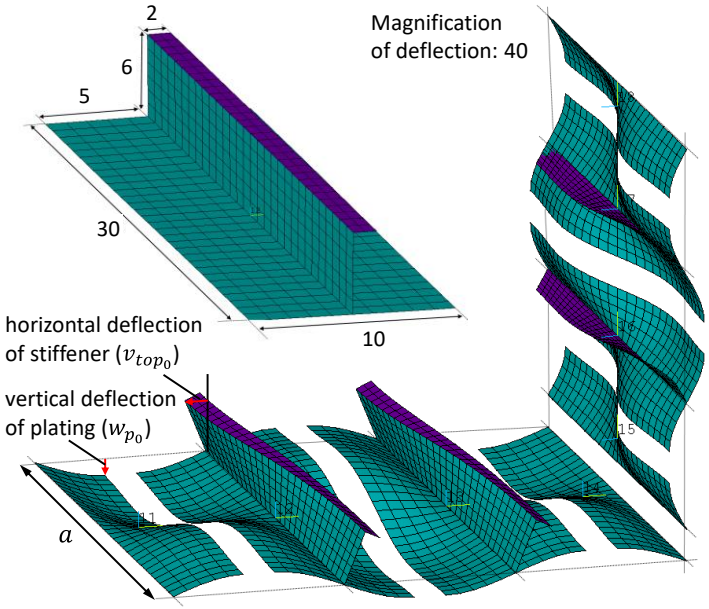
Finite Element Model

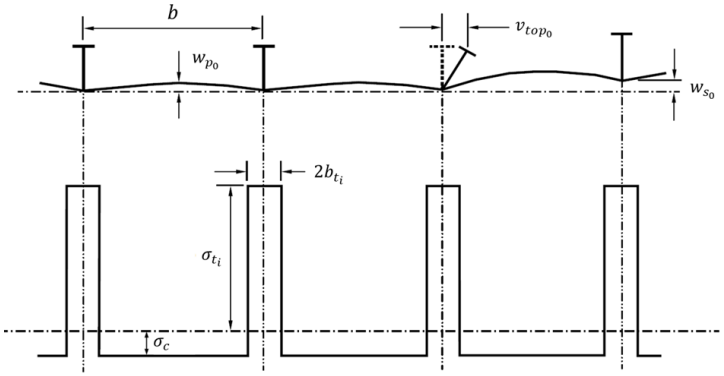
Residual Stress Distribution





Discretization and Initial Imperfections

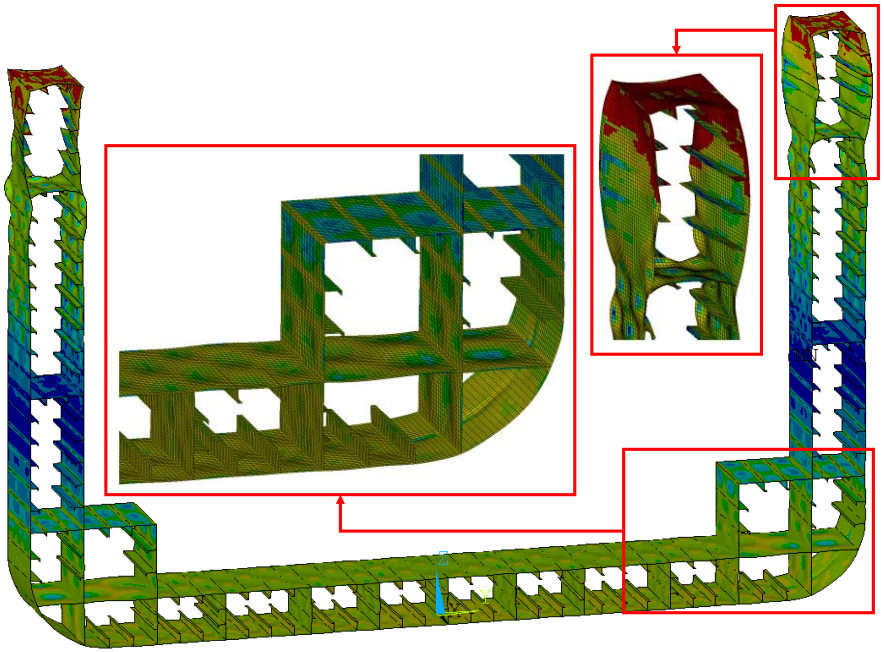




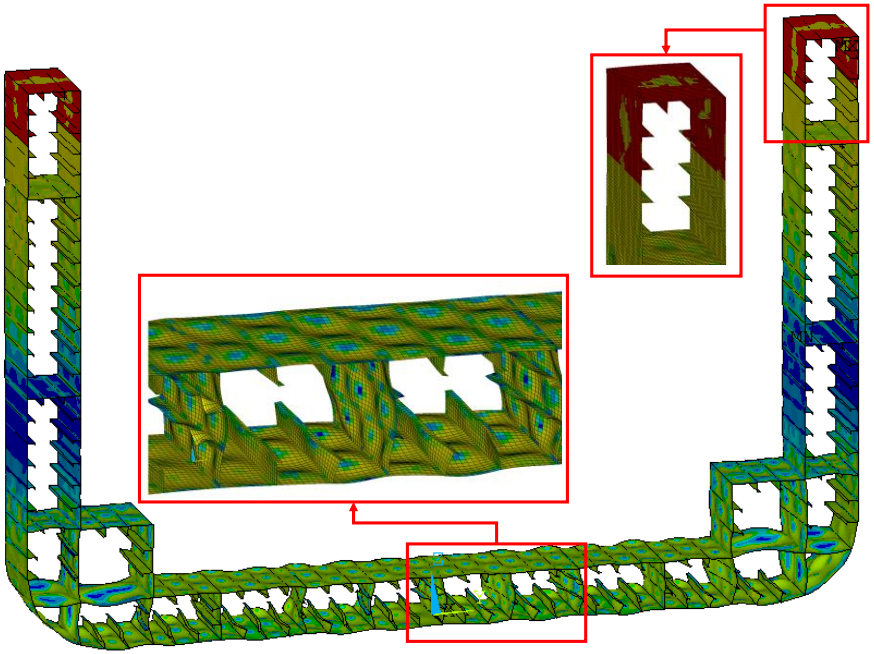
Overview

Finite Element Model (wrs) of Container Vessel in Vertical Bending

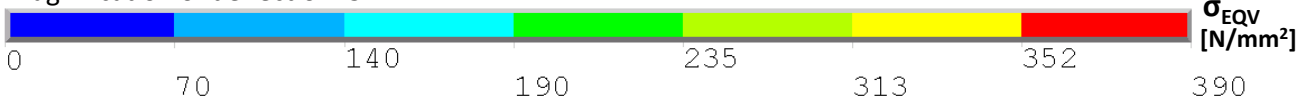
Ultimate Strength (Sagging)



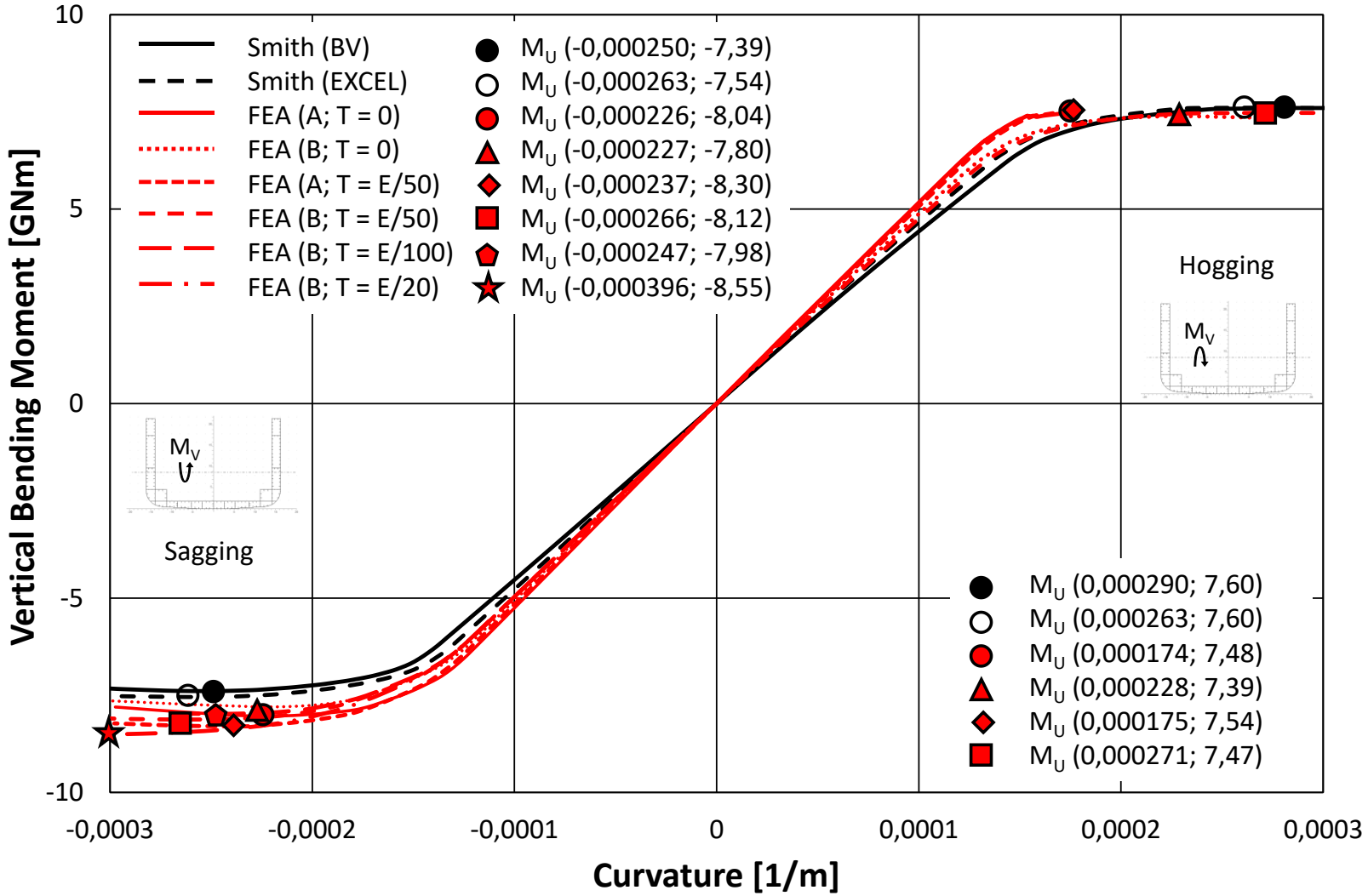
Ultimate Strength (Hogging)



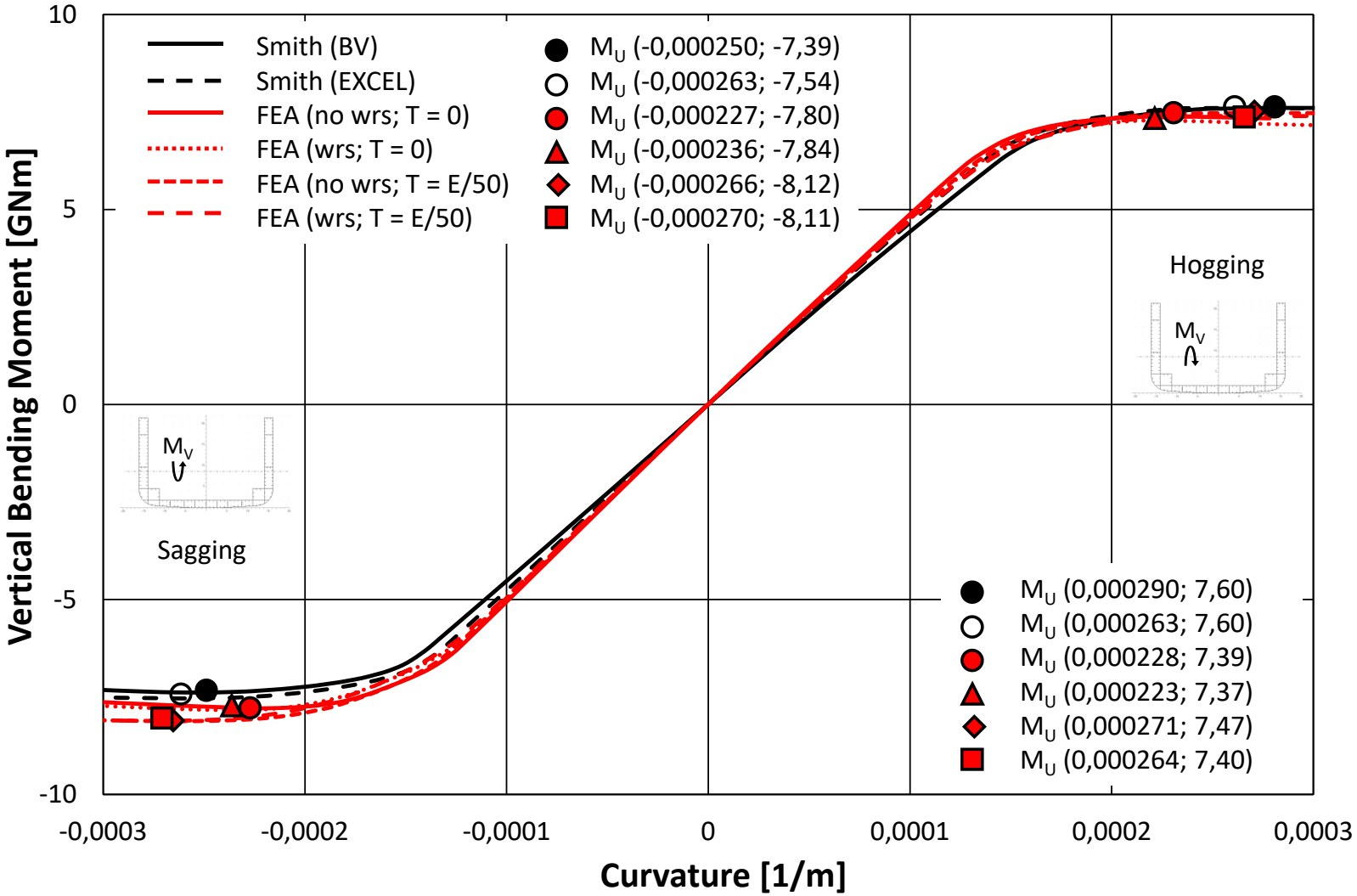
Magnification of deflection: 5



Initial Deflection and Material

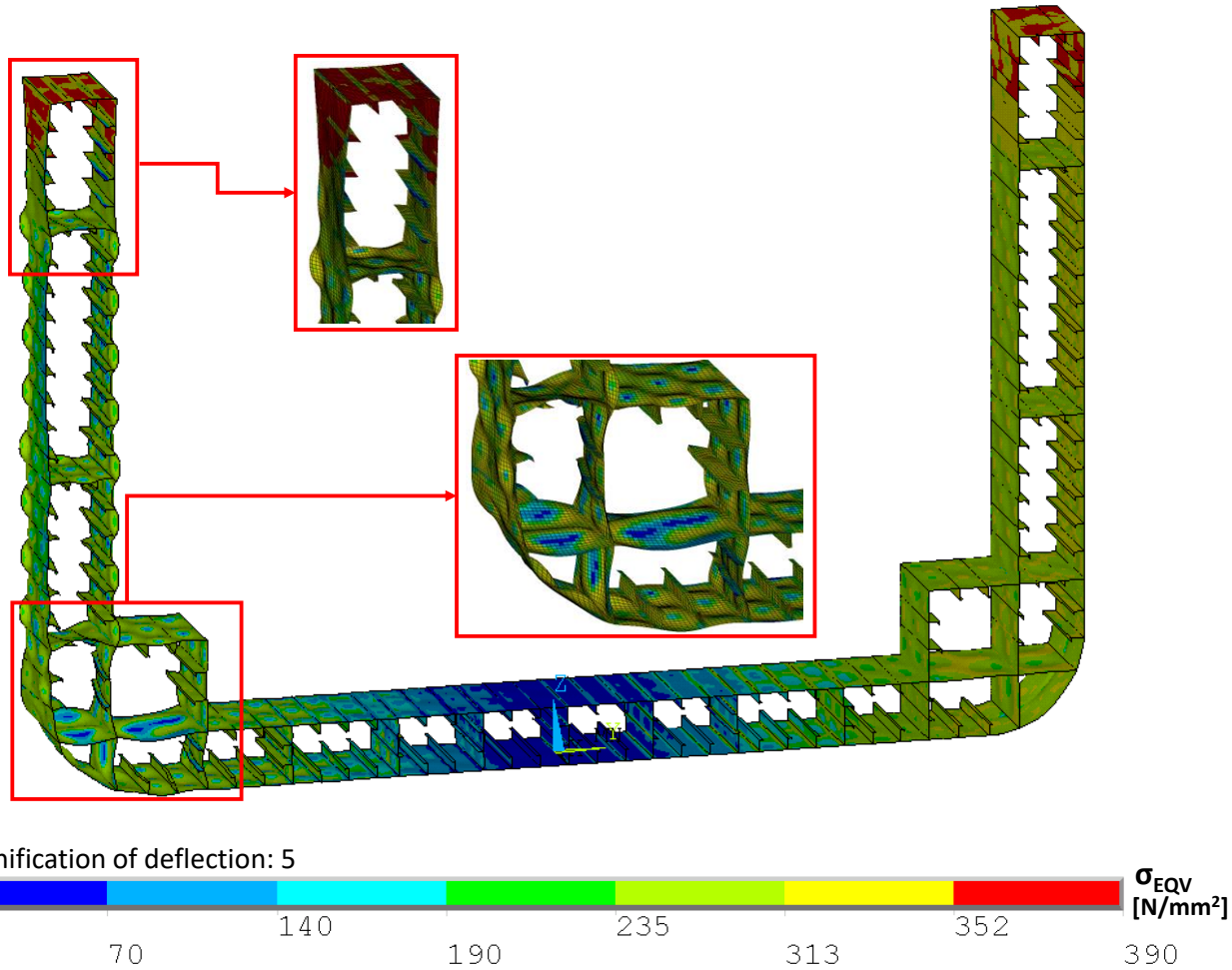


Welding Residual Stresses and Material

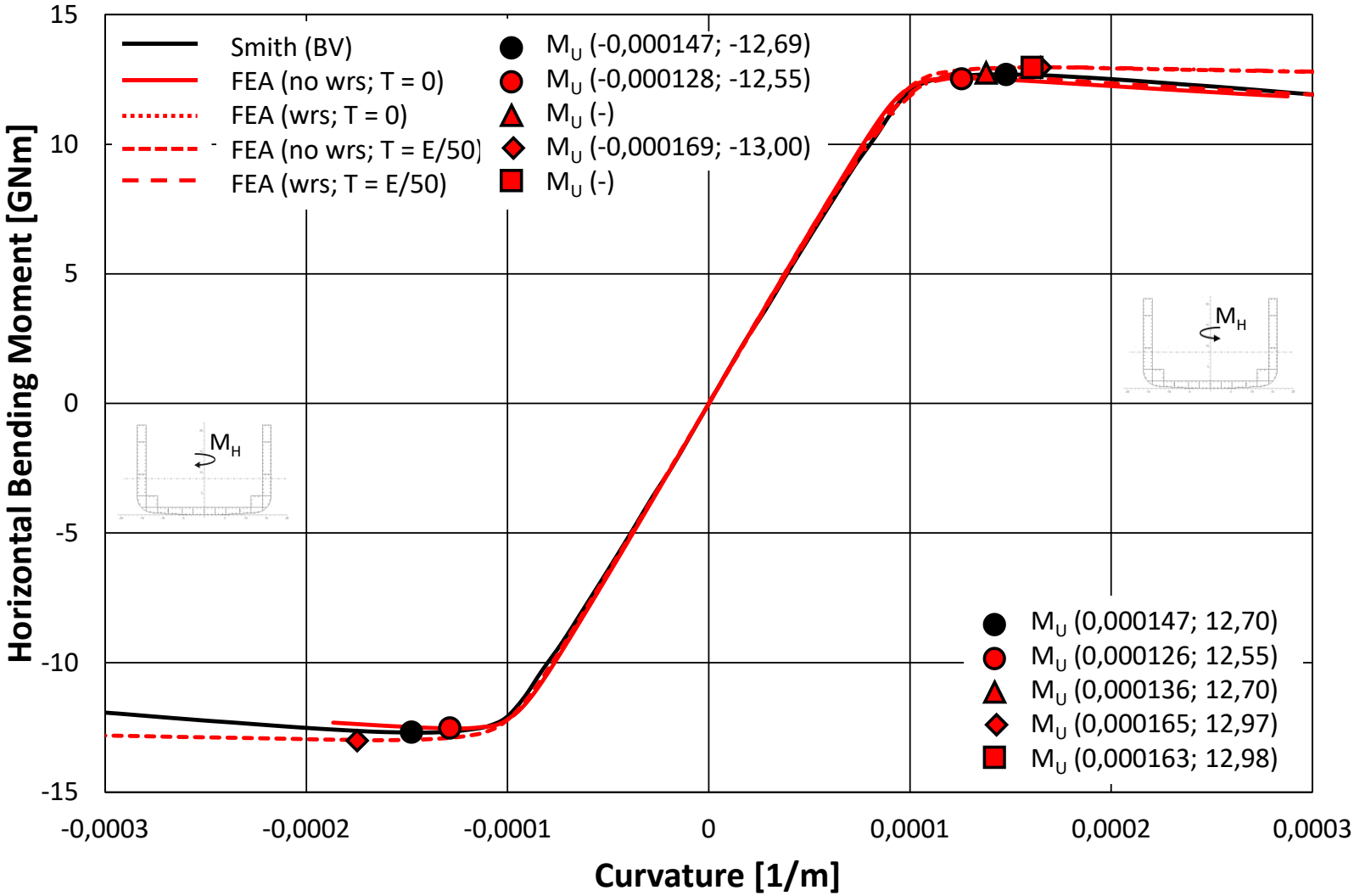


Overview

Finite Element Model (wrs) of Container Vessel in Horizontal Bending



Welding Residual Stresses and Material

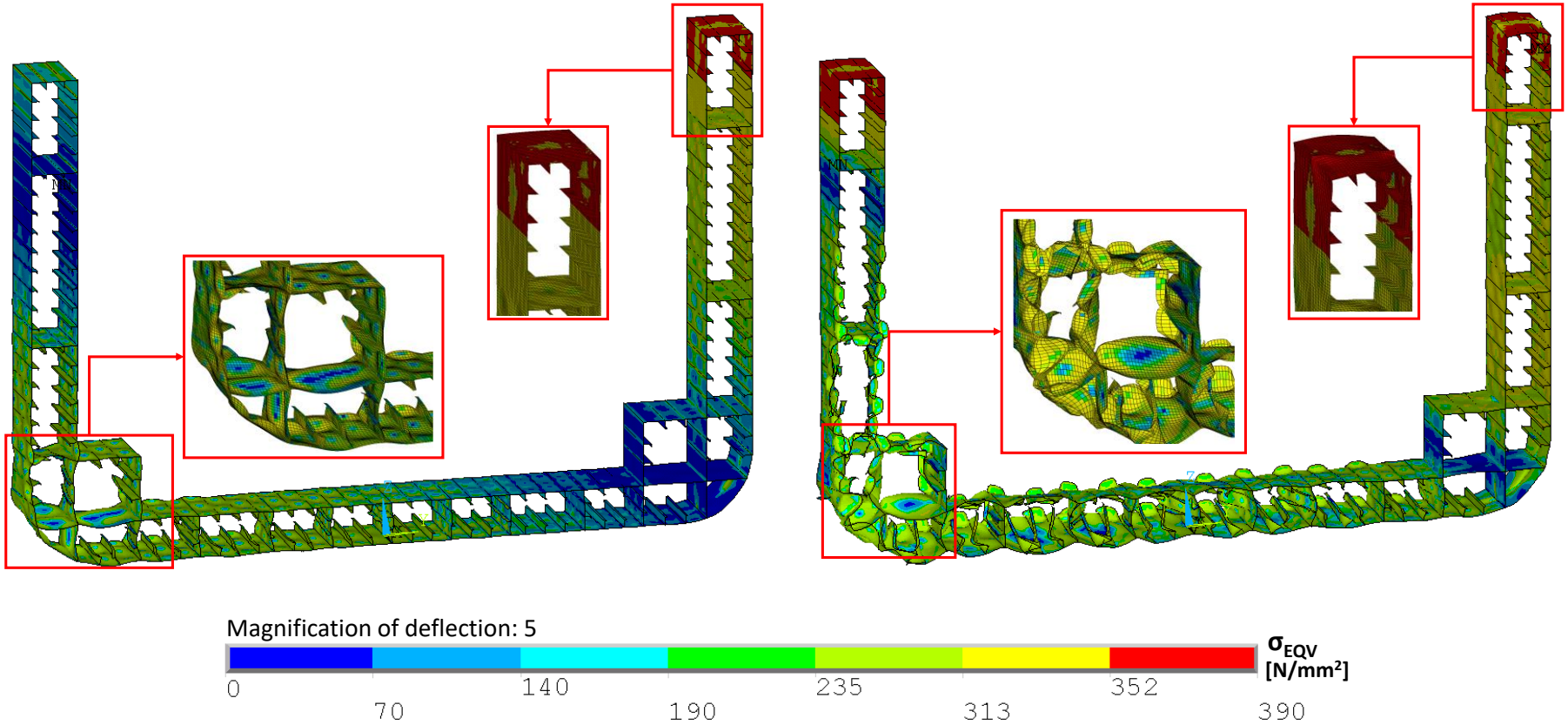


Overview

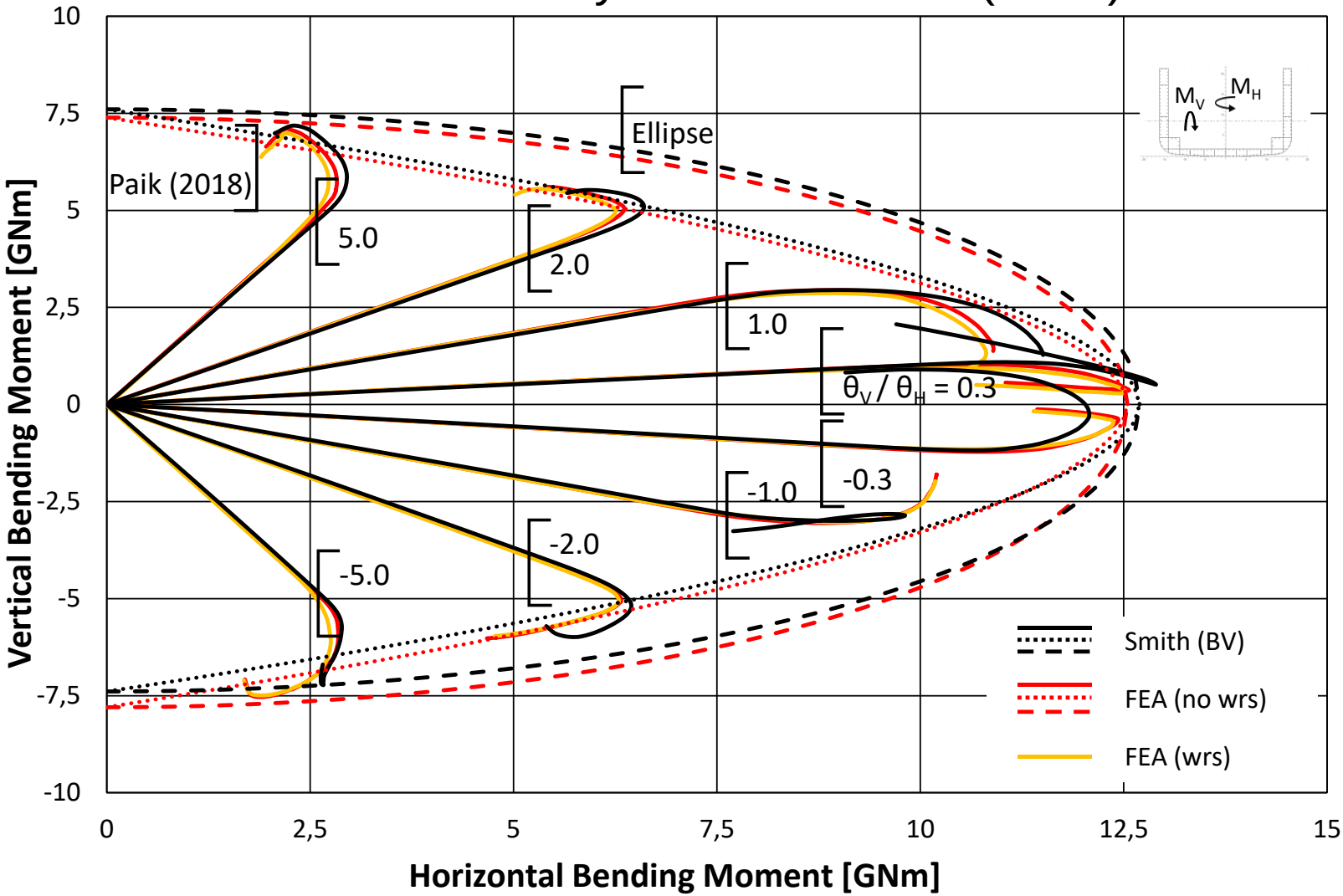
Finite Element Model (wrs) of Container Vessel in Horizontal Bending

Ultimate Strength (θ_V/θ_H = 2.0)

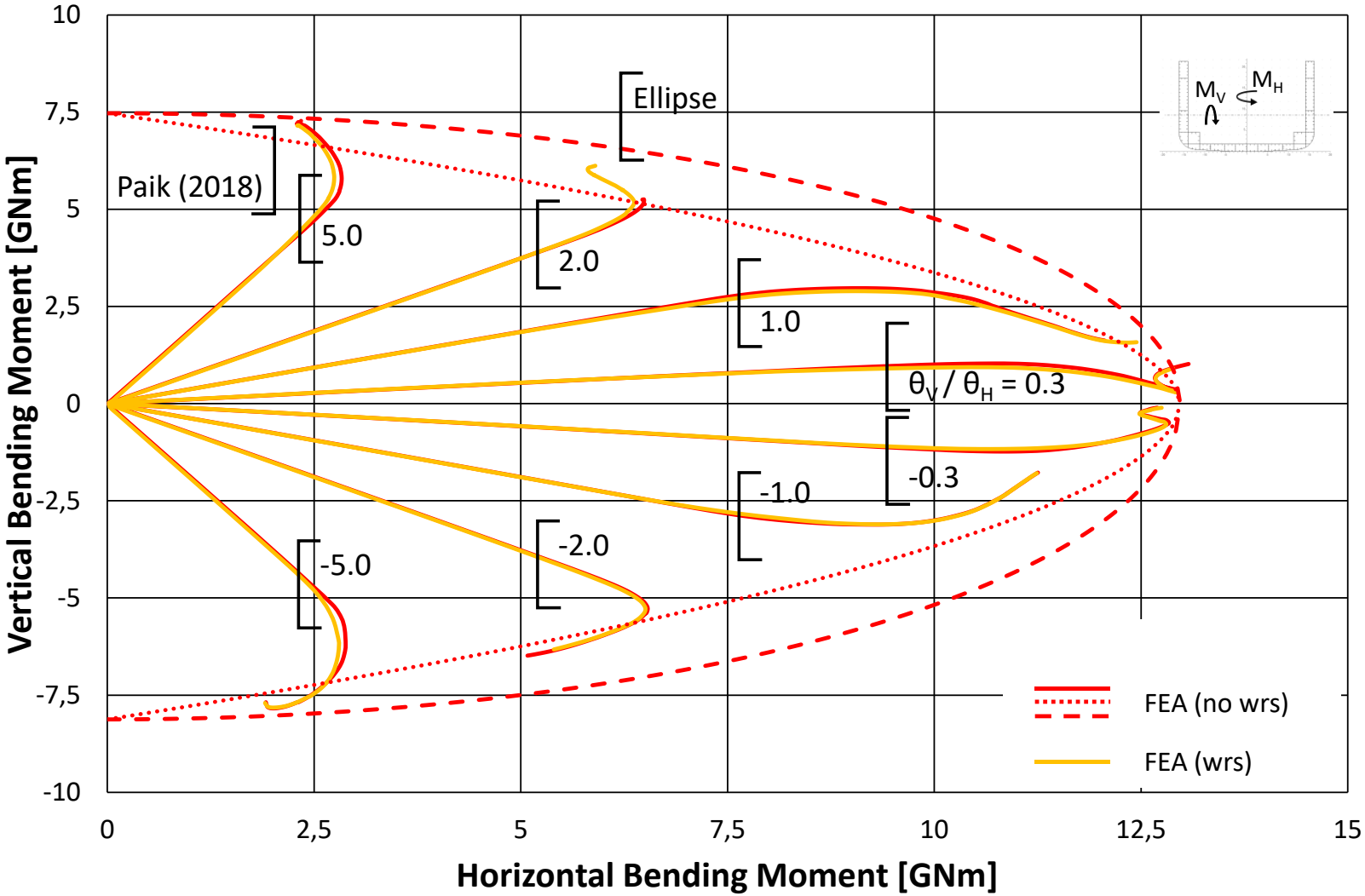
Post-Ultimate Strength (θ_V/θ_H = 2.0)



Elastic-Perfectly Plastic Material (T = 0)



Elastic-Plastic Material (T = E/50)



Overview

Conclusions

Ultimate strength of 3500 TEU container vessel under pure vertical, horizontal and biaxial bending successfully determined by nonlinear FEA (static implicit solver)

Depending on the initial deflection model good convergence behavior has been observed

Welding residual stresses only have a very small influence on the collapse behavior

Elastic-perfectly plastic material model delivers more conservative results instead of considering hardening effects

Nonlinear FEA results are slightly more conservative compared to Smith's method except in pure sagging condition

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Thank You for Your Attention!