LIÈGE université
School of Engineering

Resistance of the beam-to-column component « column web panel in shear »

NORDIC STEEL 2019

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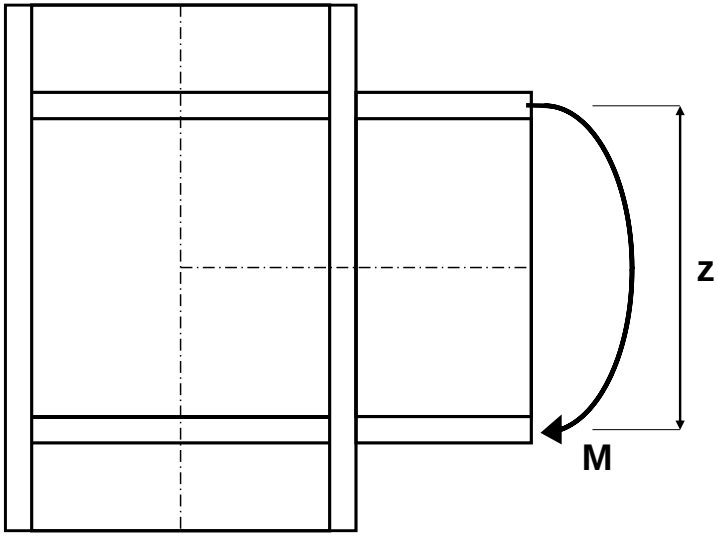
UEE
Urban & Environmental Engineering

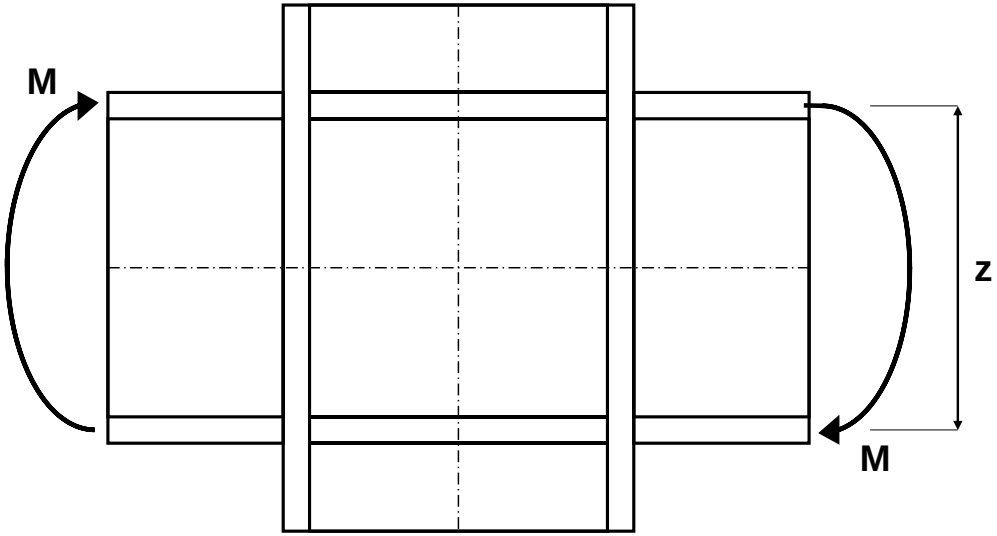
Outline

1. Introduction
2. Problem identification
3. Numerical investigations
4. Towards a mechanical model
5. Conclusions & further work

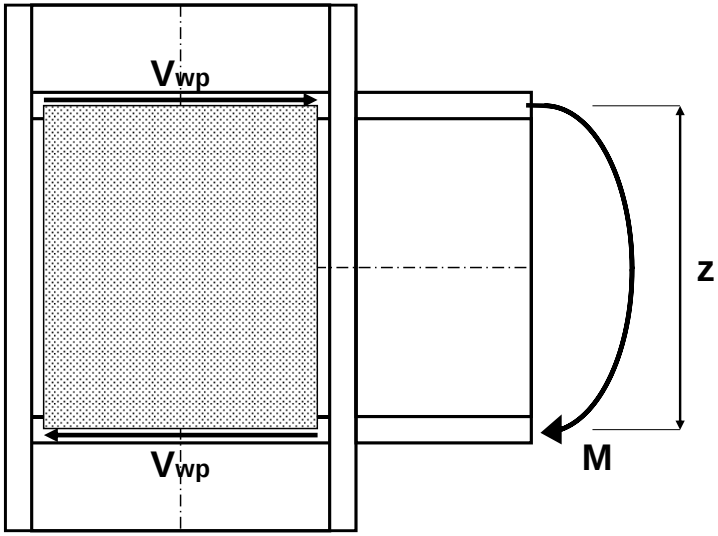
Outline

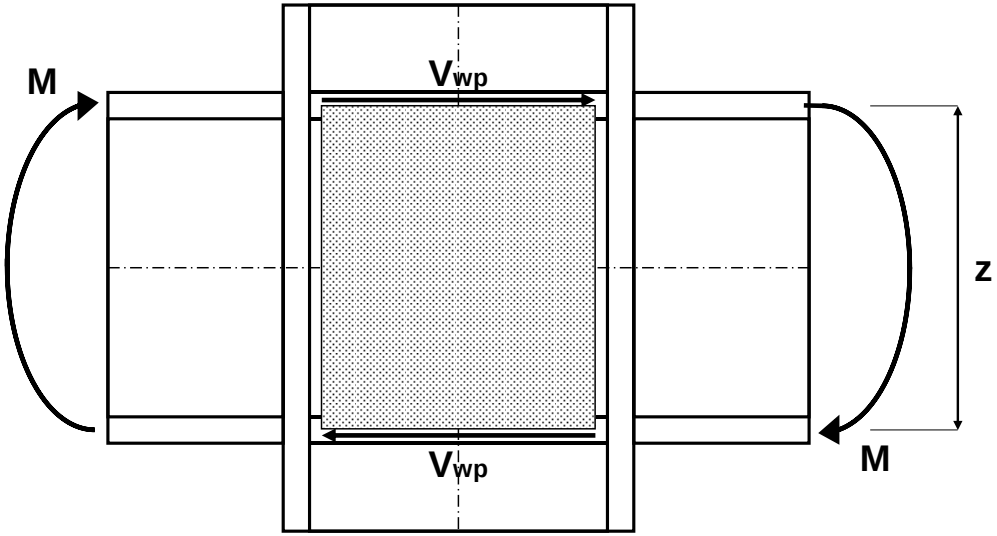
Column web panel in shear





Column web panel in shear





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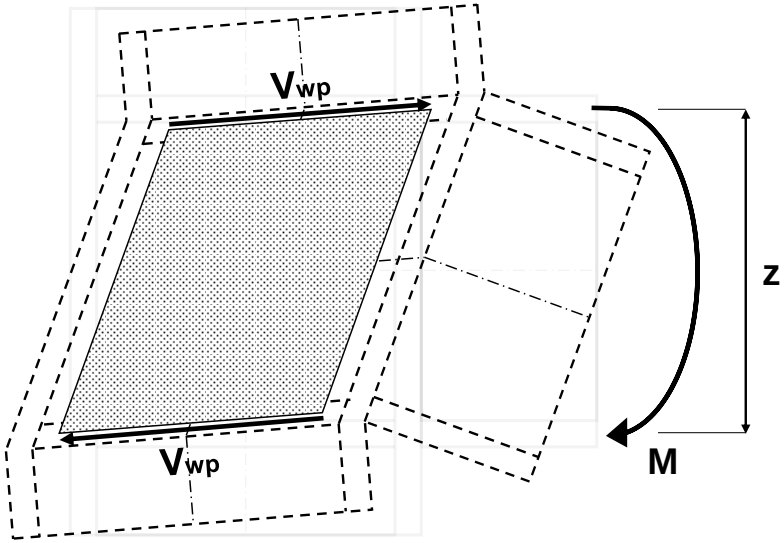

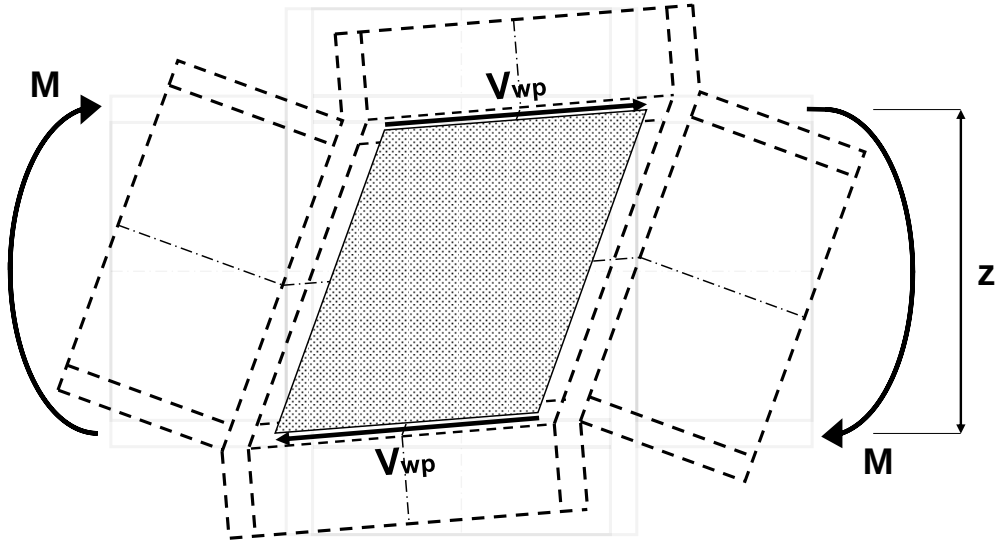

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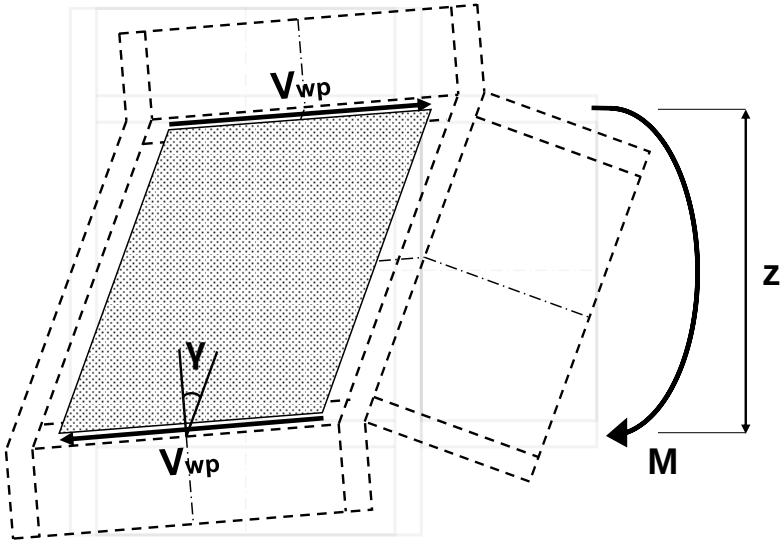

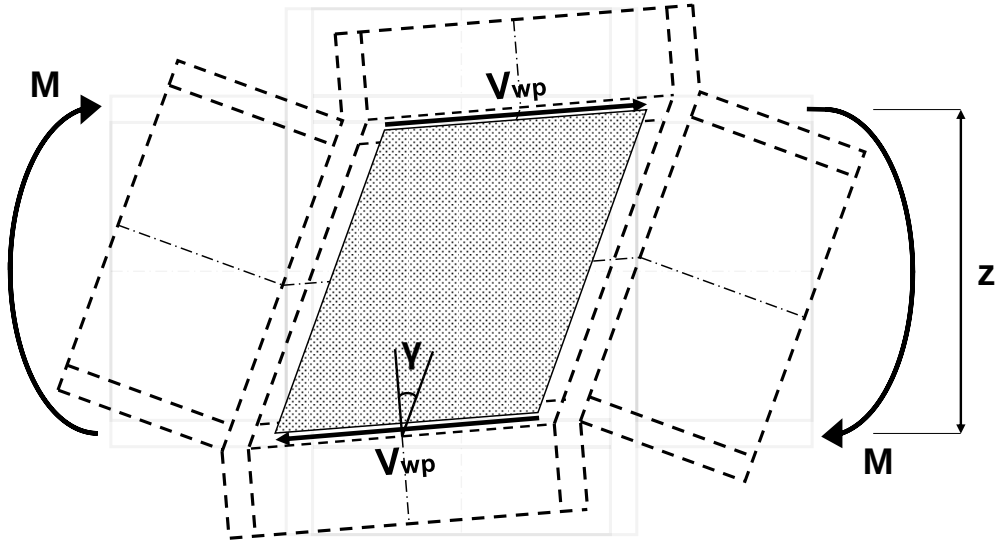

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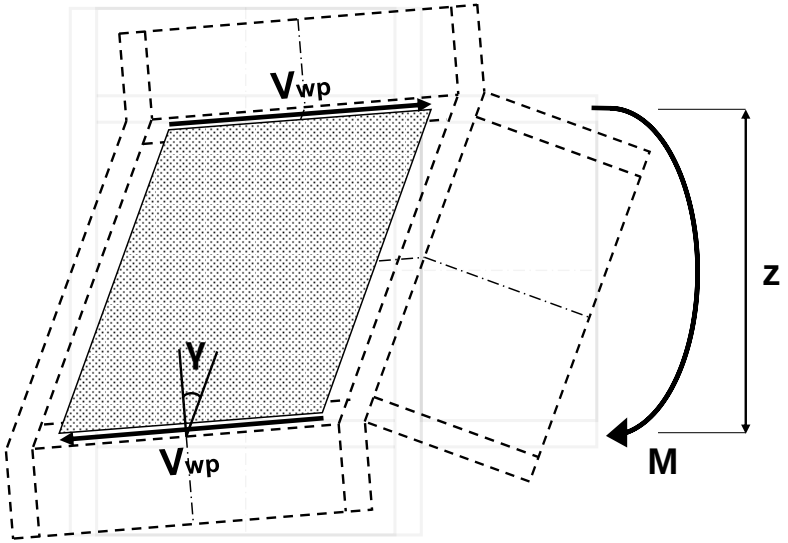
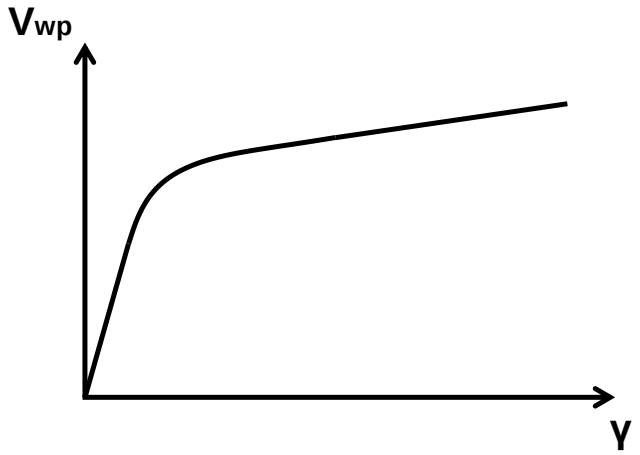
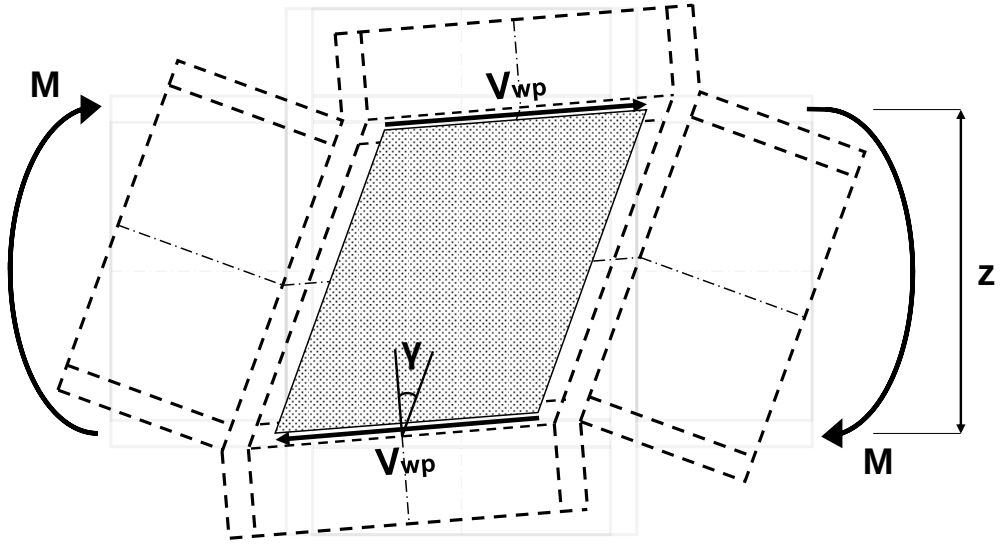
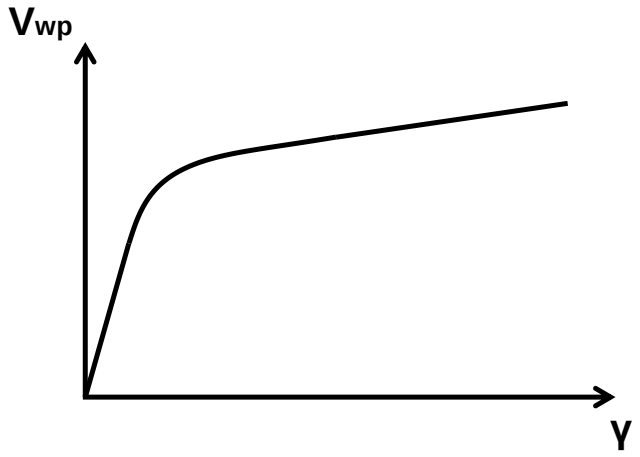
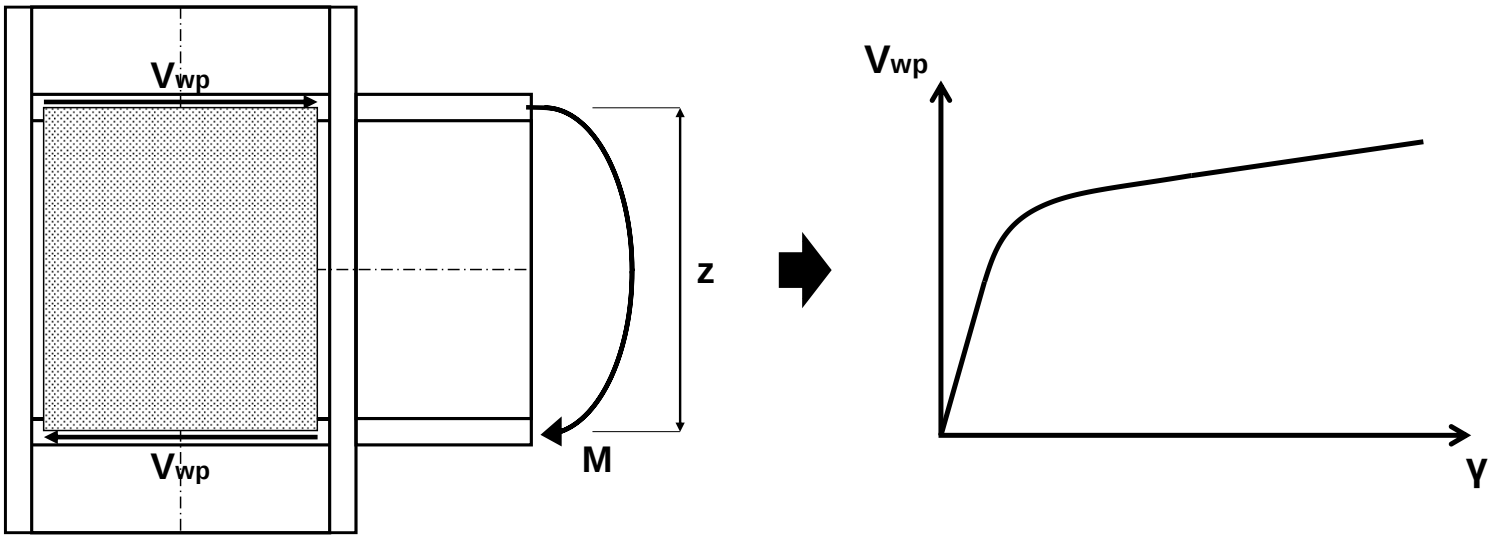








EC3-1-8 prediction



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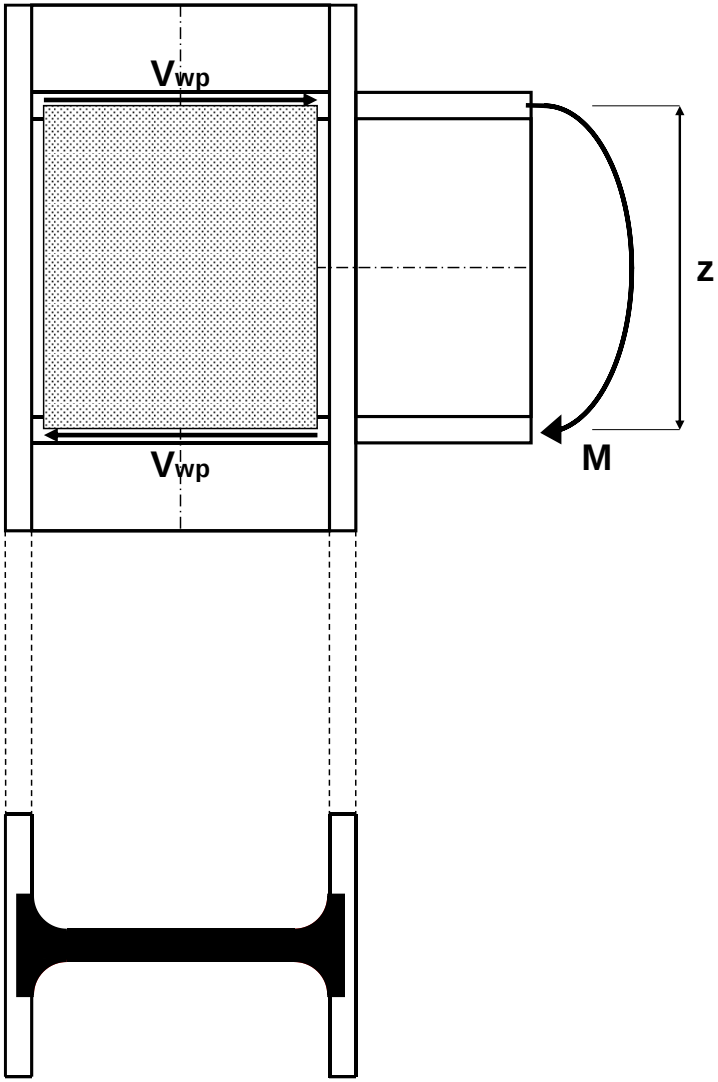

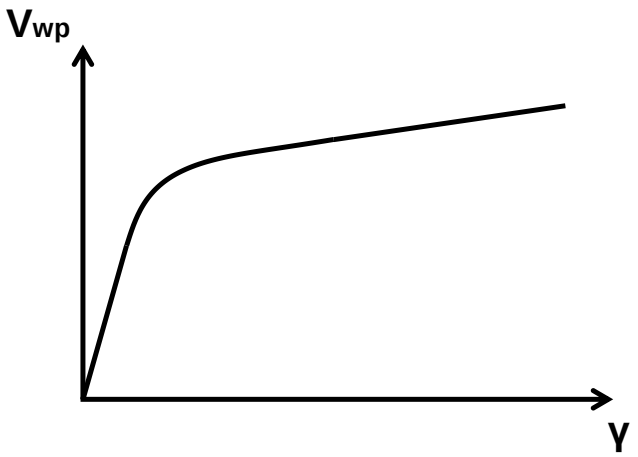

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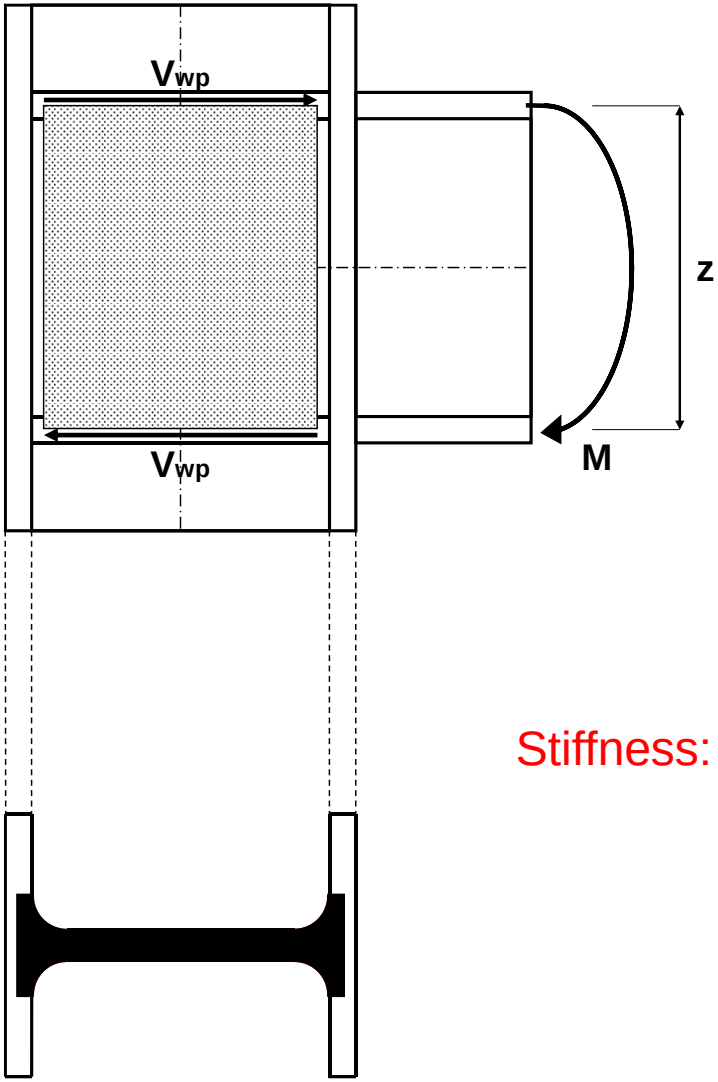
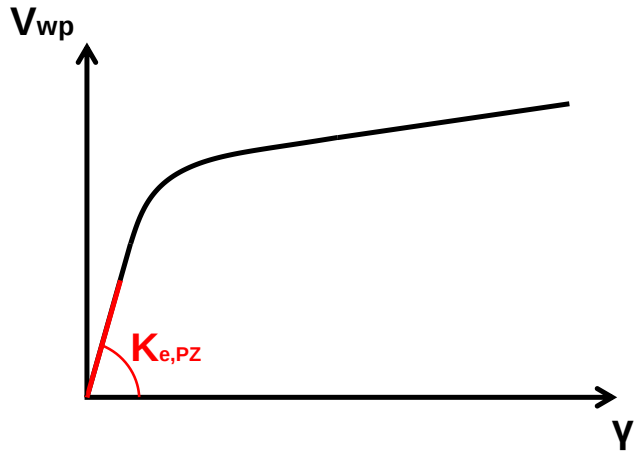
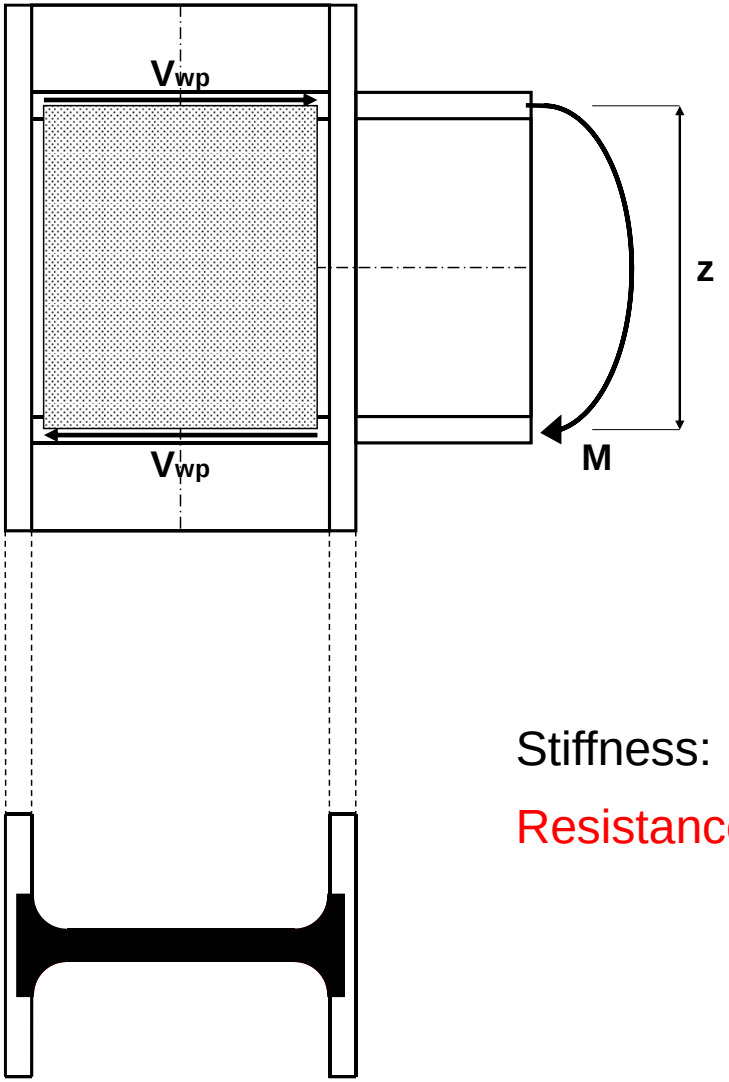
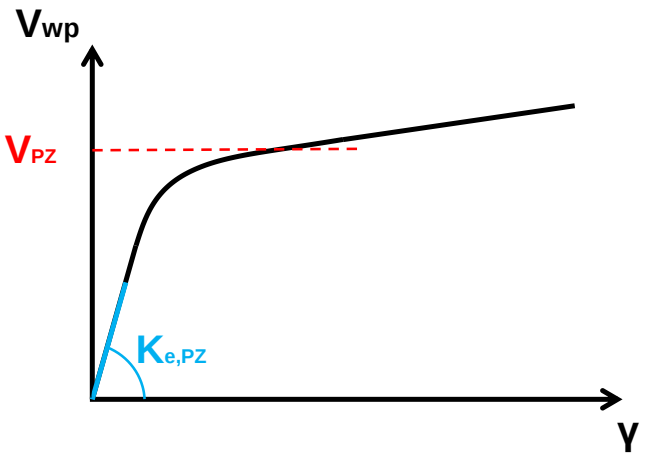




Stiffness: $K_{e,PZ} = G \cdot A_{VC}$

EC3-1-8 prediction





Stiffness: $K_{e,PZ} = G \cdot A_{VC}$

Resistance: $V_{PZ} = V_y + \Delta V_y$

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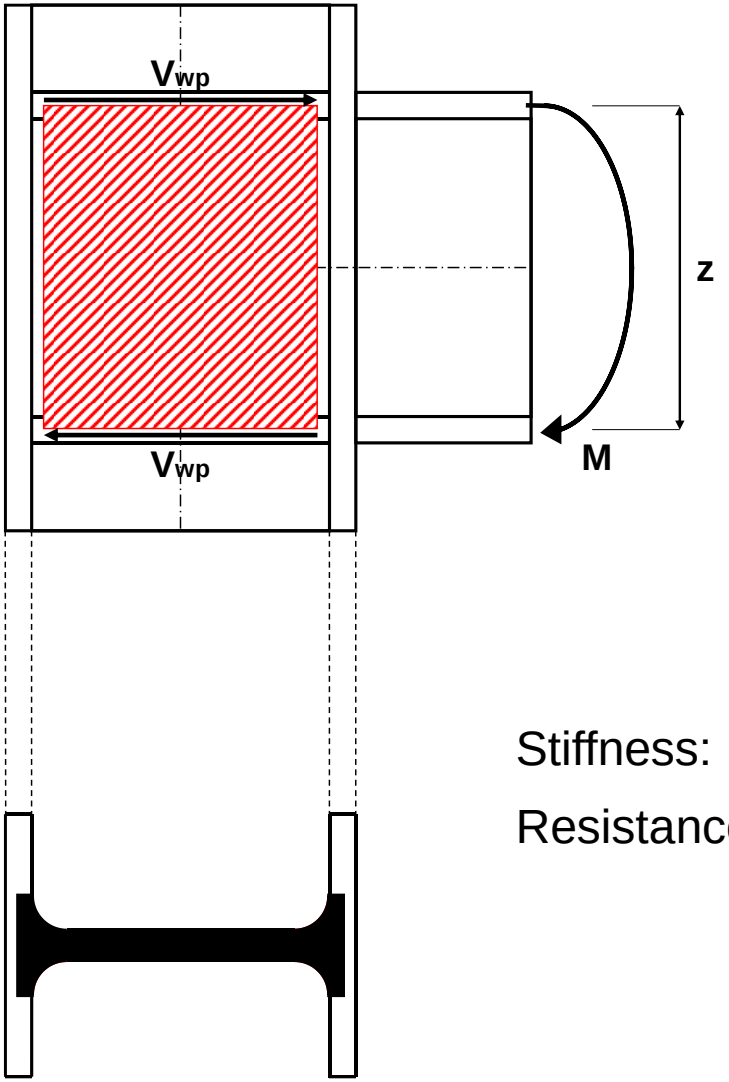

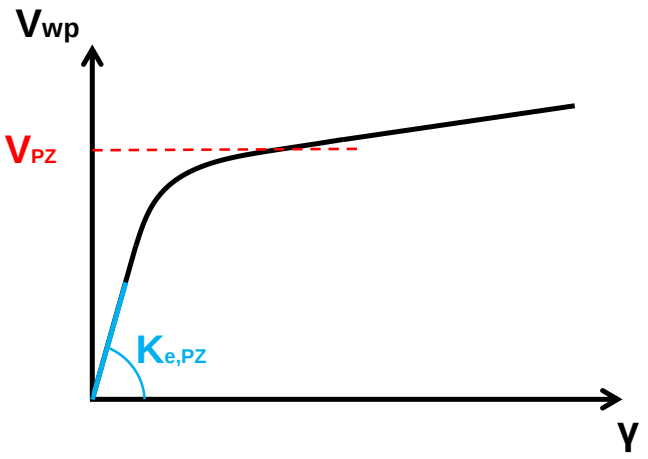

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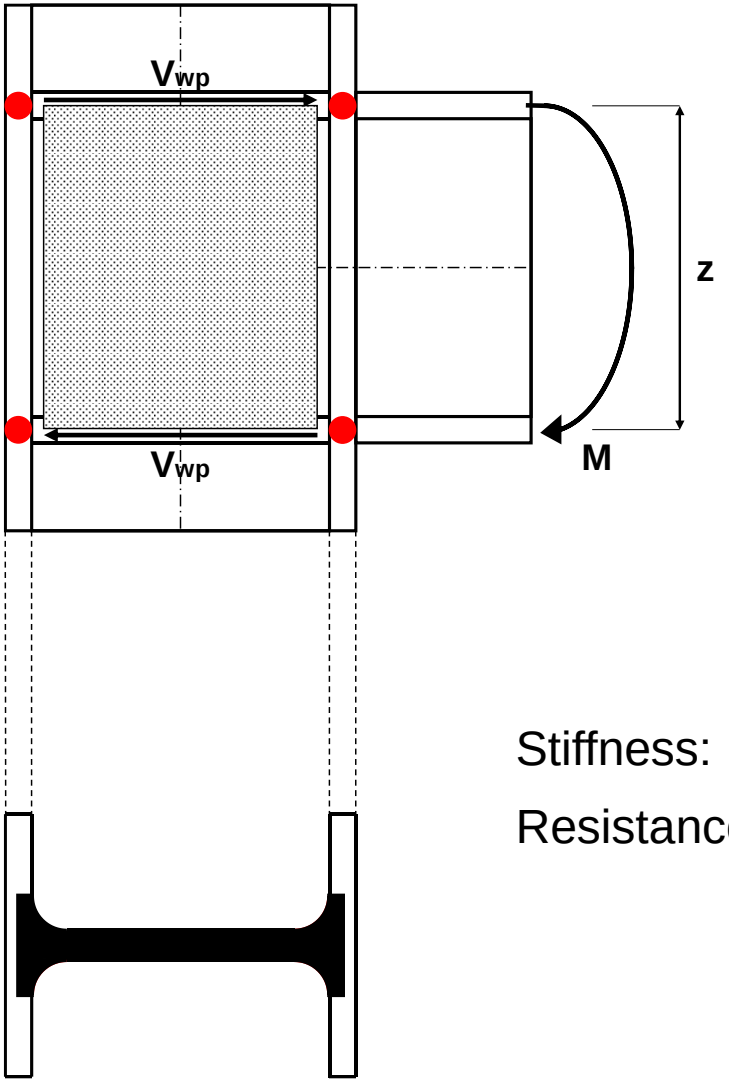
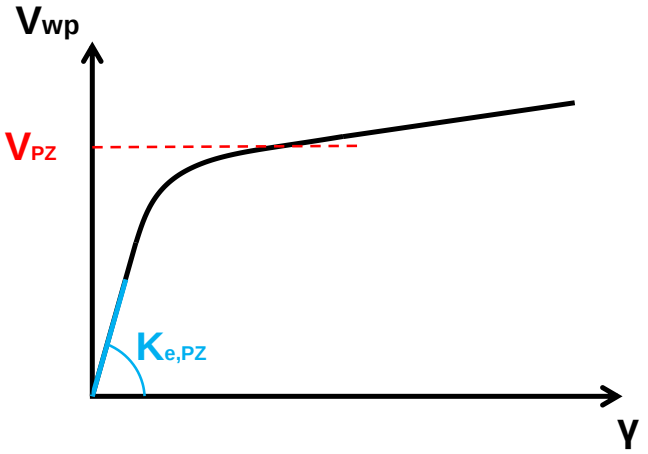
Resistance: $V_{PZ} = V_y + \Delta V_y$

$$\hookrightarrow \begin{cases} V_y = \rho \cdot \frac{f_{y,wc}}{\sqrt{3}} \cdot A_{VC} \\ \Delta V_y = 4 \cdot \frac{M_{pl,fc}}{d_s} \end{cases}$$

EC3-1-8 prediction





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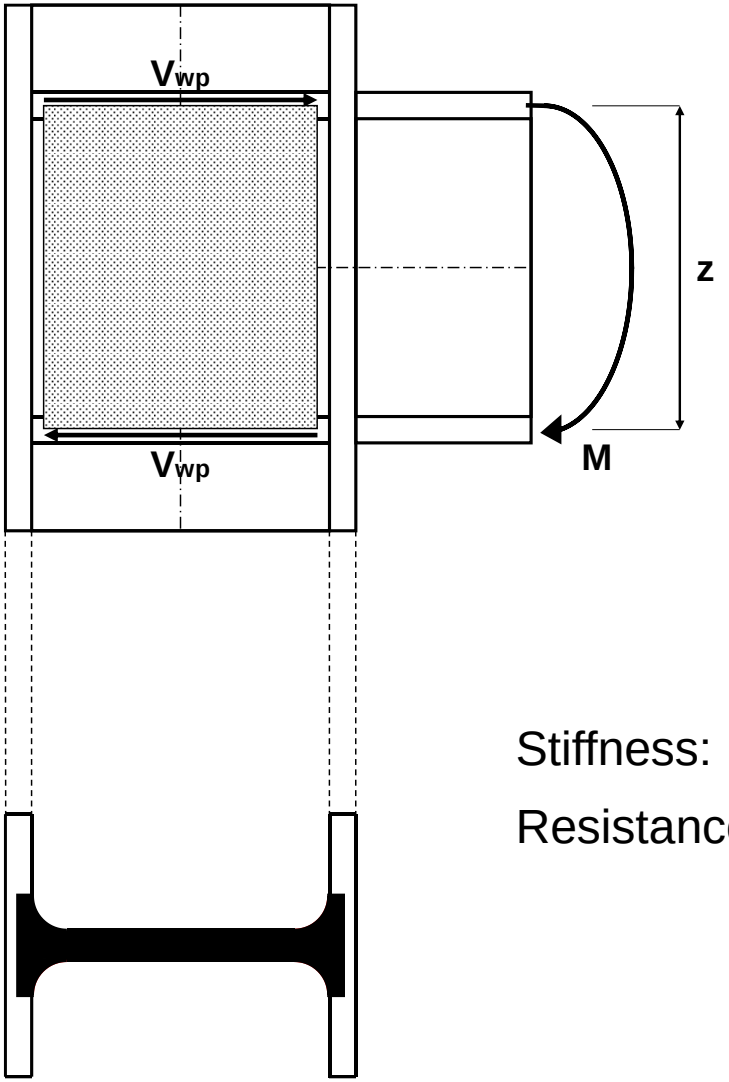

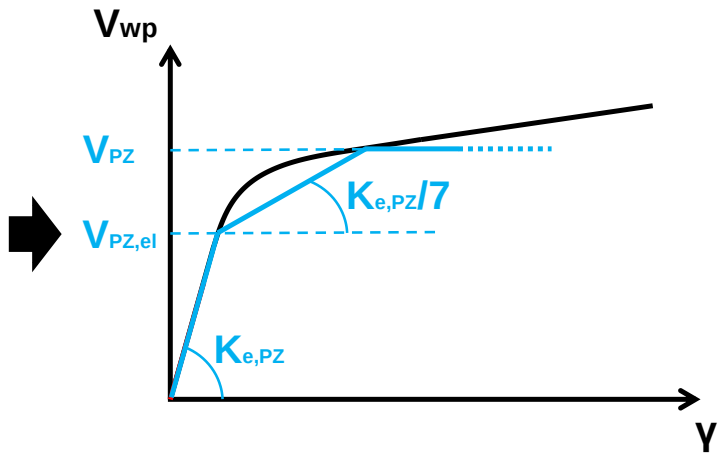

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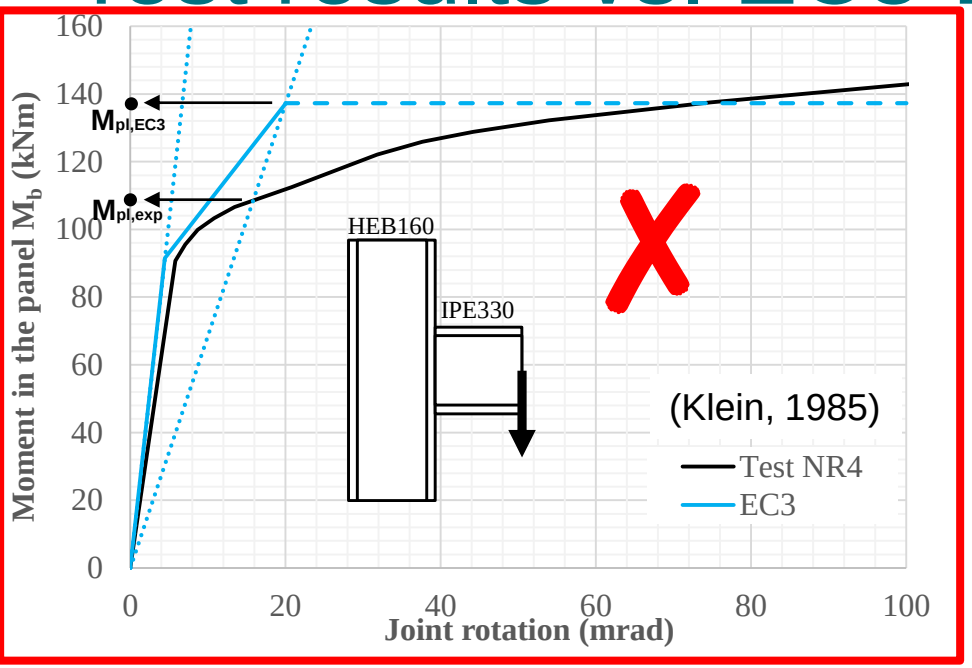
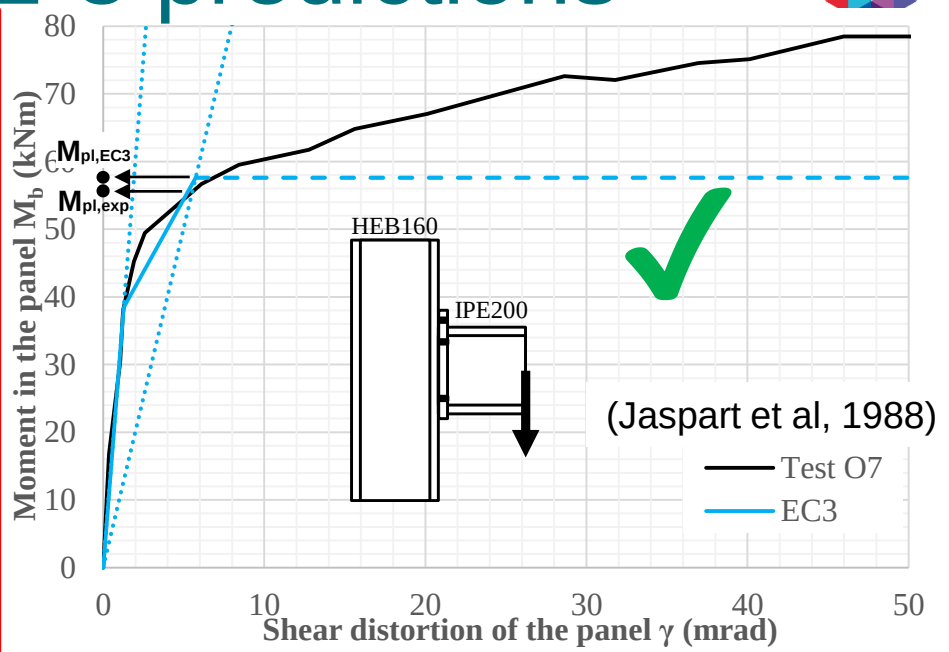
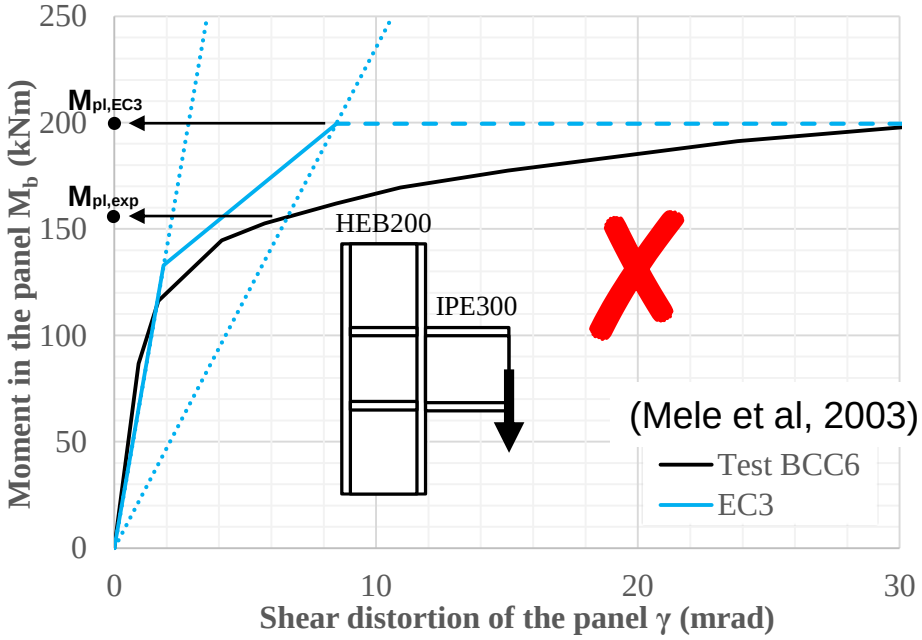
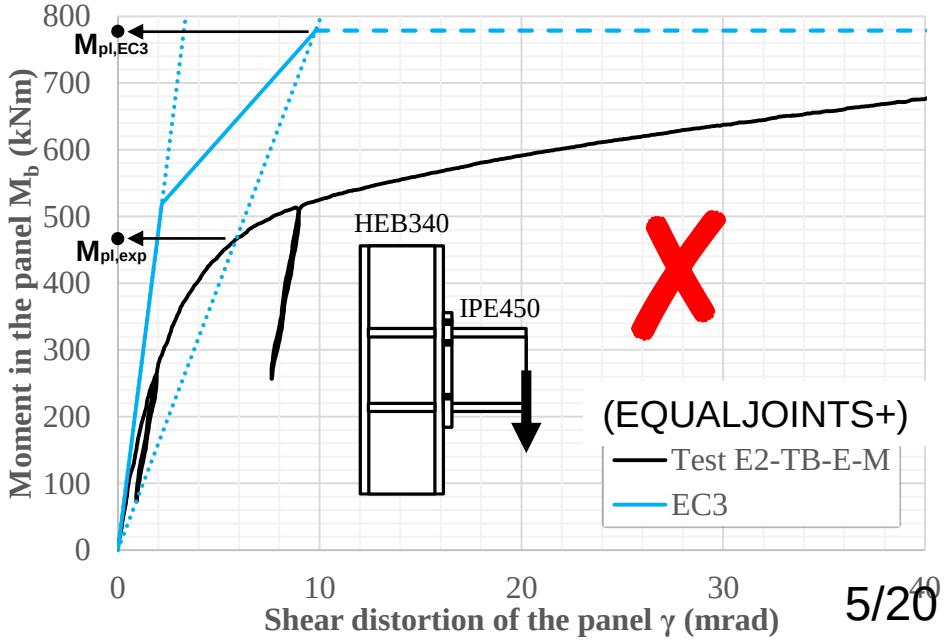
Outline

Test results vs. EC3-1-8 predictions



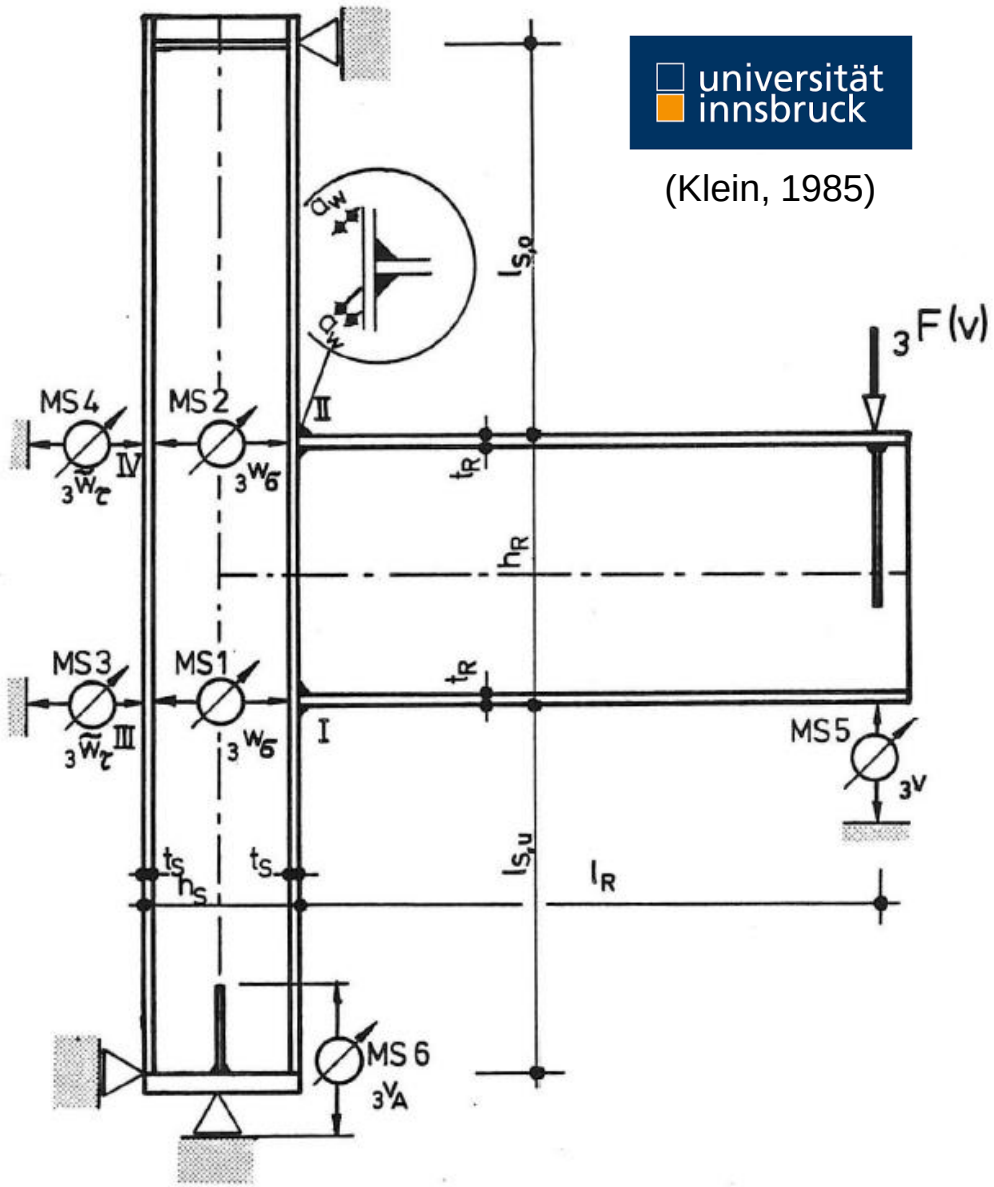






Outline

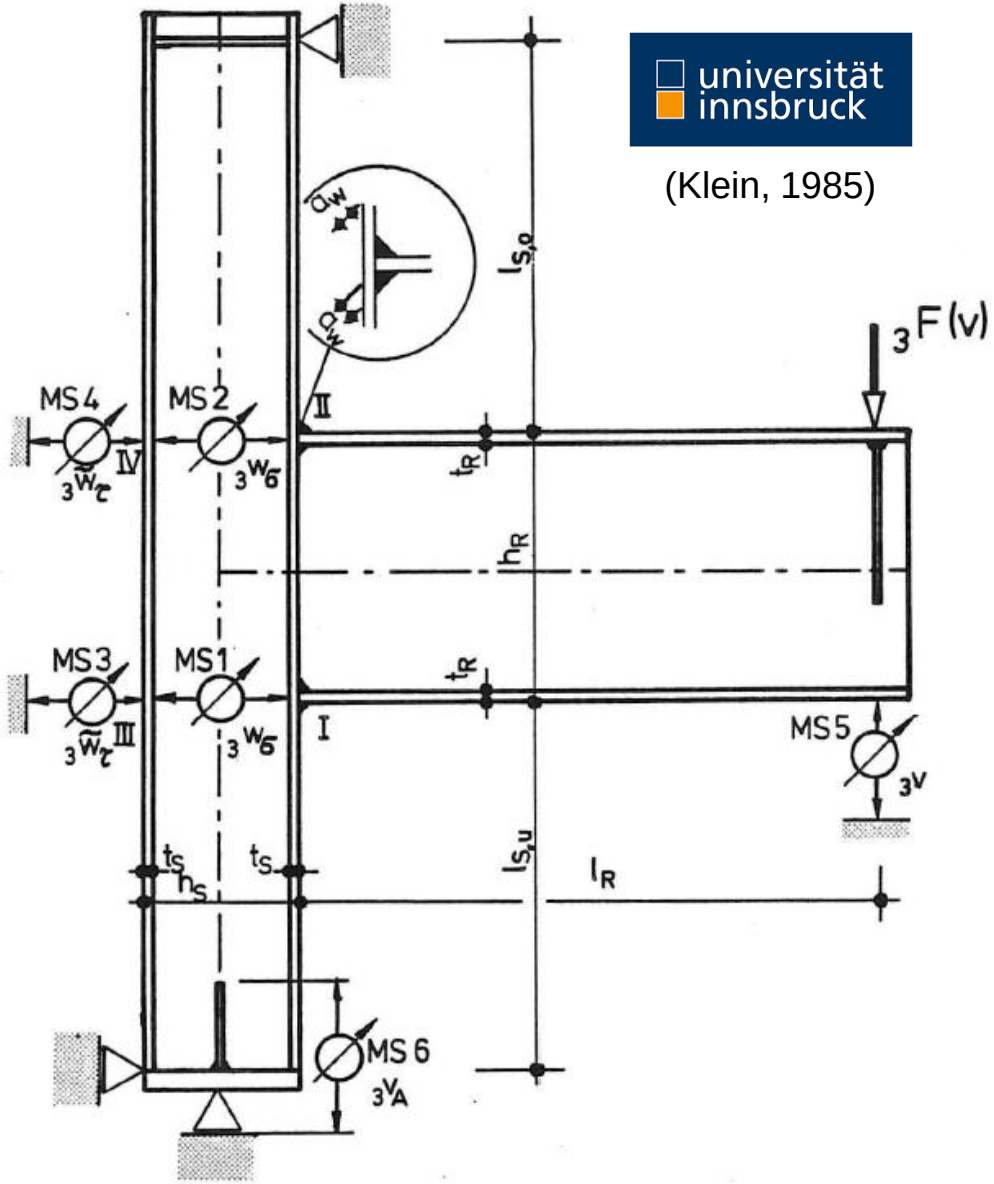
Reference experimental results

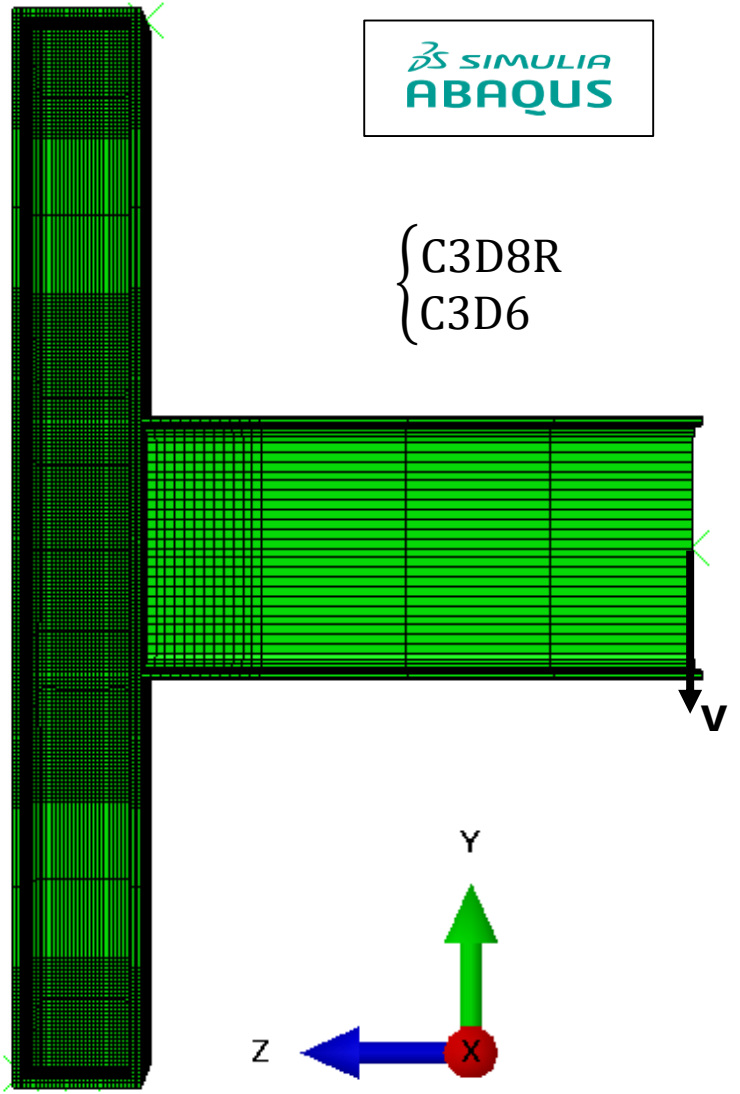


17 tests: NR1 → NR17

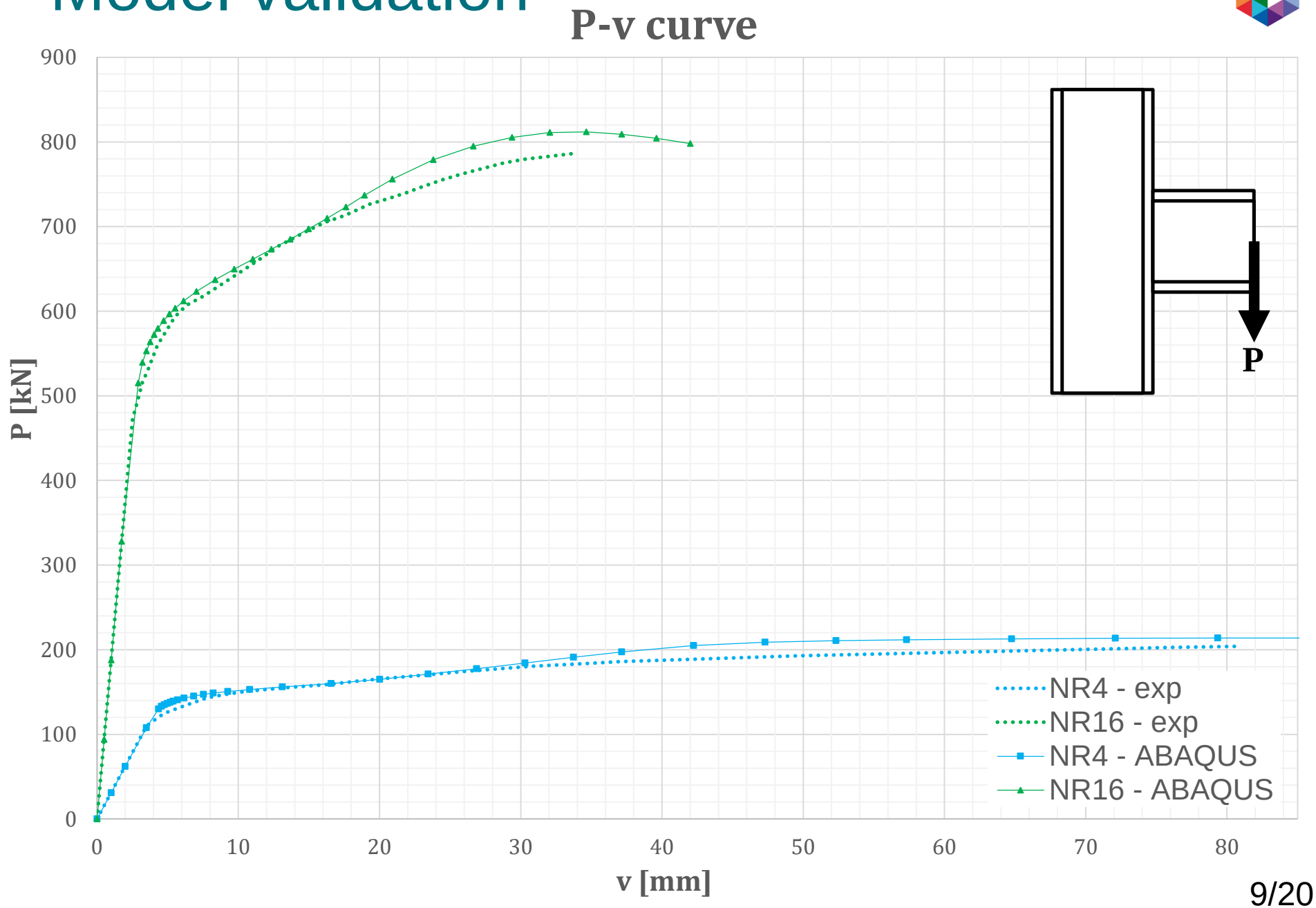
Tests	NR4	NR16
Beam	IPE 330	HEB 500
Column	HEB 160	HEB 300
l_R [mm]	698	580
$l_{S,u}$ [mm]	510	540
$l_{S,o}$ [mm]	510	550
a_w [mm]	7,1	12,7

Finite Element Model

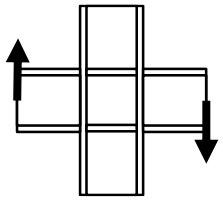
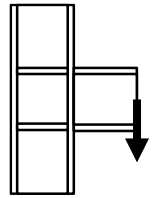
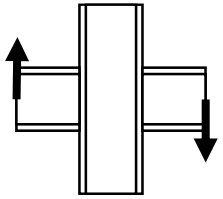
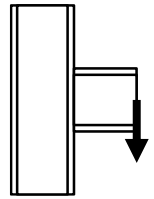




Model validation



Parametric study

Tests *X stands for 4/16*	Transverse column web stiffeners *Yes……..…..1* *No…….....…..0*	Root fillets in column *Yes……..…..1* *No…..……..…..0*	Type of joint *Single-sided…...s* *Double-sided.....d*	Test numbers	Loading situation
NRX	1	1	d	NRX-1-1-d	
		0		NRX-1-0-d	
		1	s	NRX-1-1-s	
		0		NRX-1-0-s	
	0	1	d	NRX-0-1-d	
		0		NRX-0-0-d	
		1	s	NRX-0-1-s	
		0		NRX-0-0-s	

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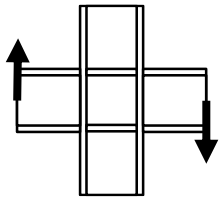
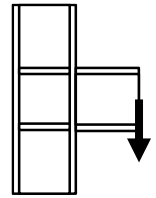
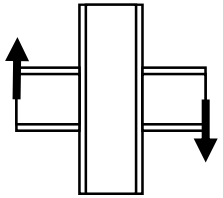
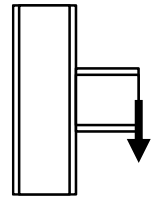
NRX	1	1	d	NRX-1-1-d	
		0		NRX-1-0-d	
		1	s	NRX-1-1-s	
		0		NRX-1-0-s	
	0	1	d	NRX-0-1-d	
		0		NRX-0-0-d	
		1	s	NRX-0-1-s	
		0		NRX-0-0-s	

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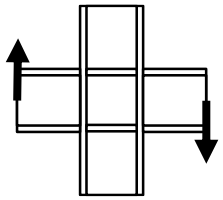
NRX	1	1	d	NRX-1-1-d	
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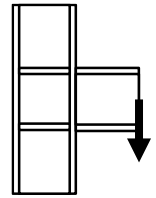
		1	s	NRX-1-1-s	
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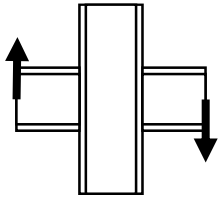
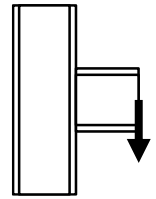
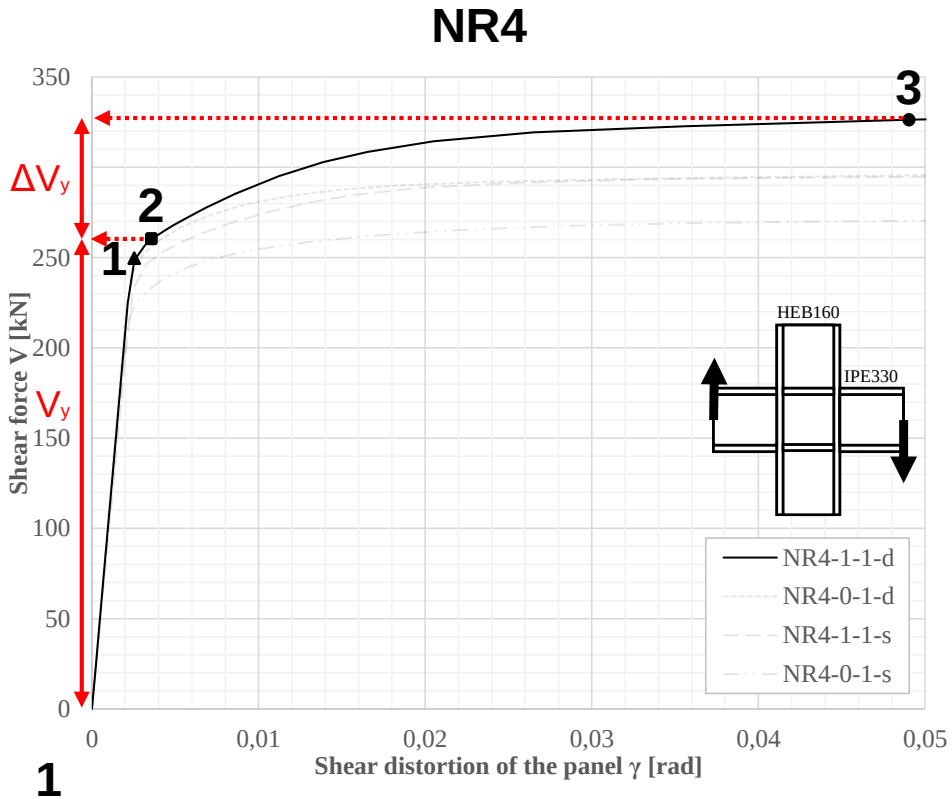
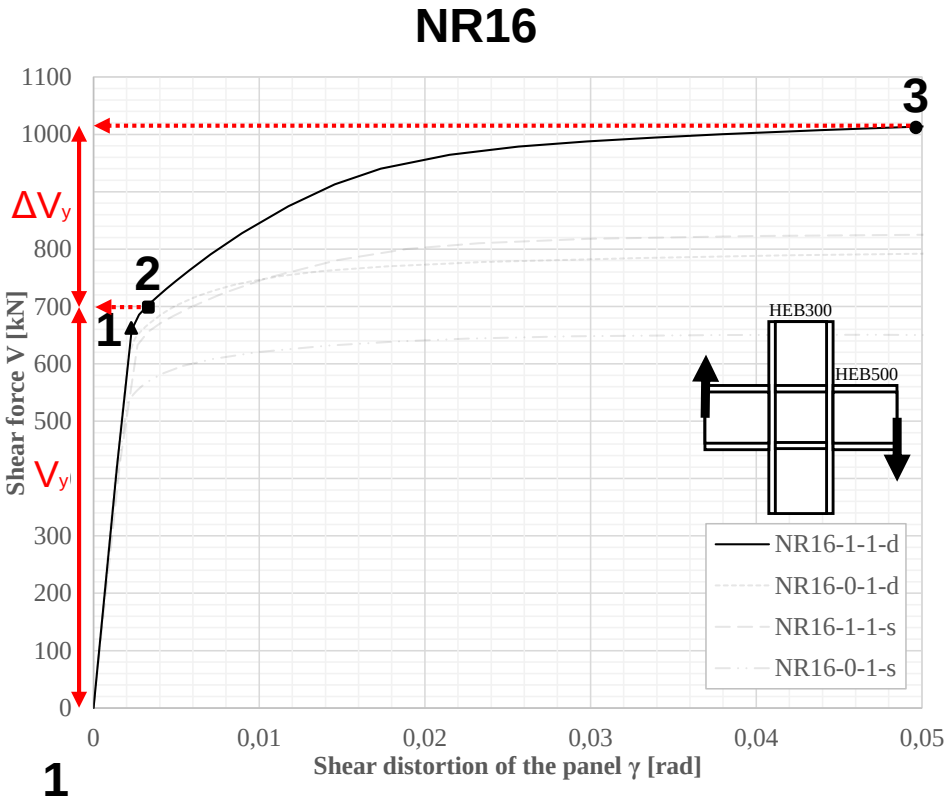
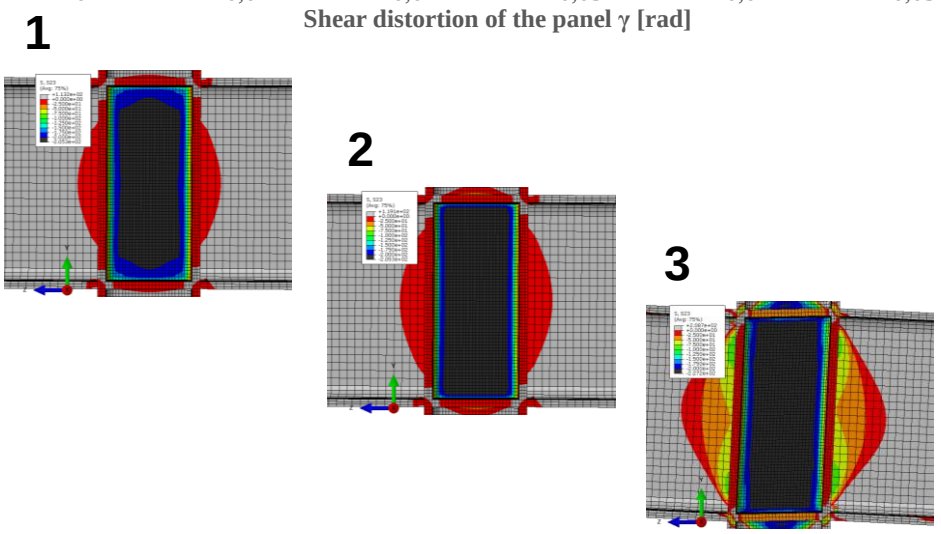
	0	1	d	NRX-0-1-d	
		0		NRX-0-0-d	
		1	s	NRX-0-1-s	
		0		NRX-0-0-s	

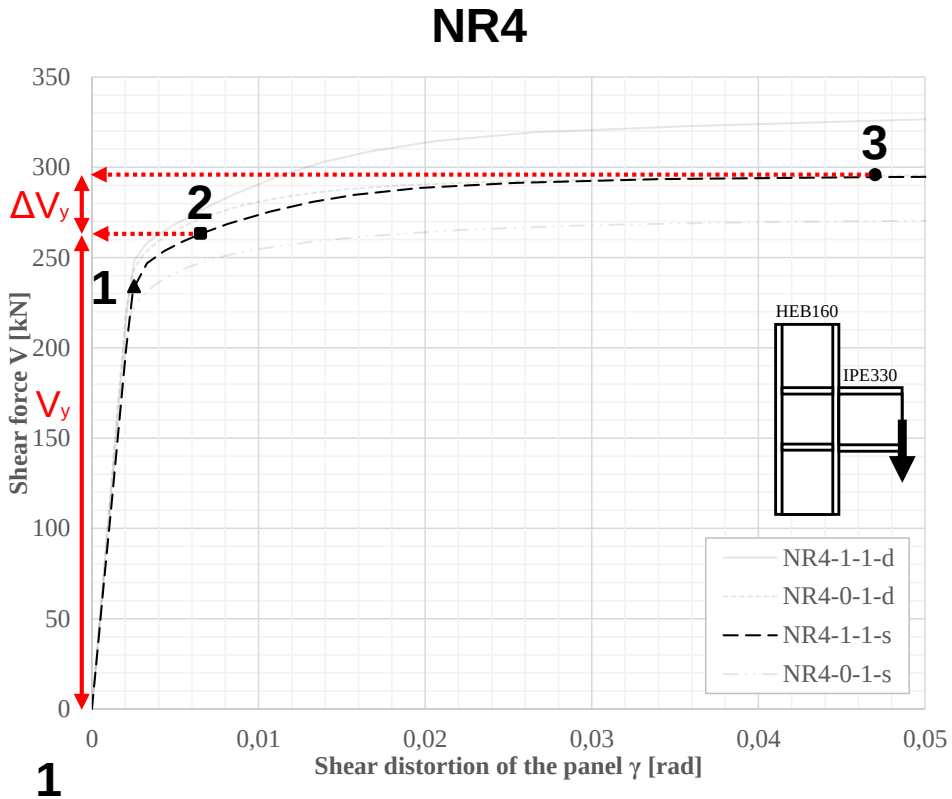
Stiffened double-sided

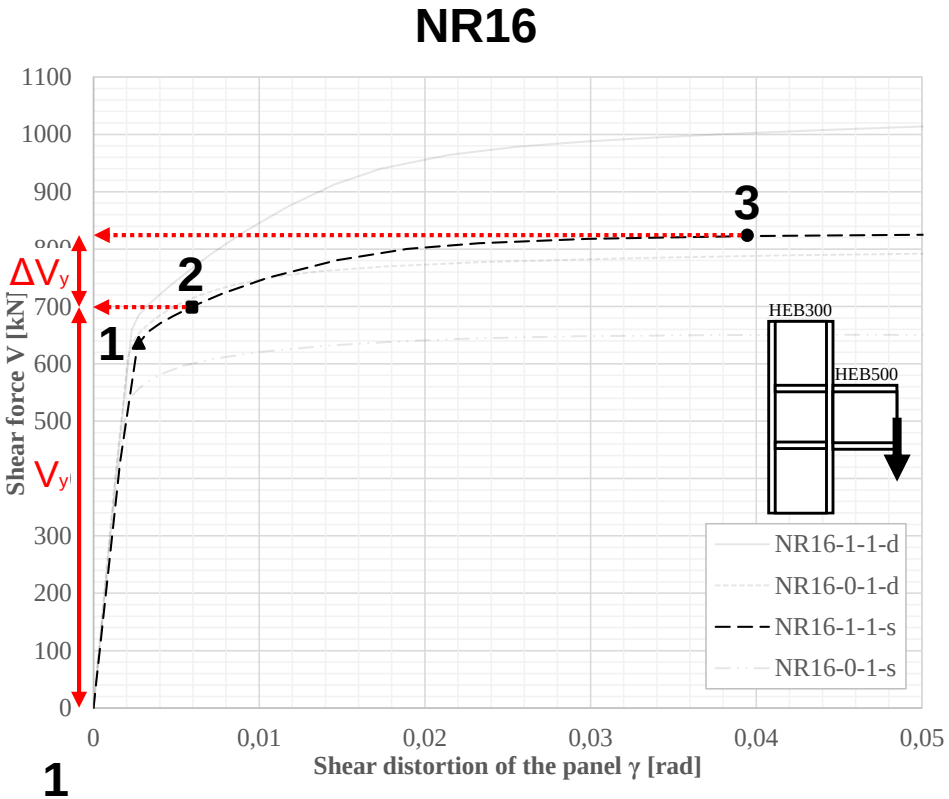






Stiffened single-sided





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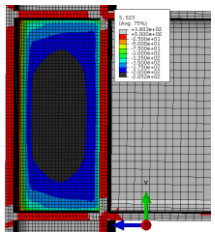

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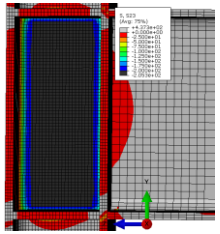

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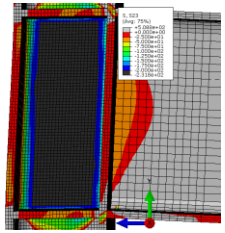

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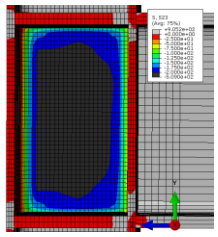

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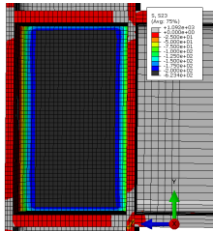

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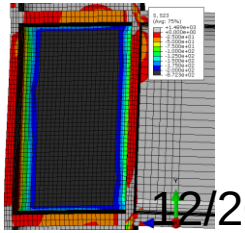
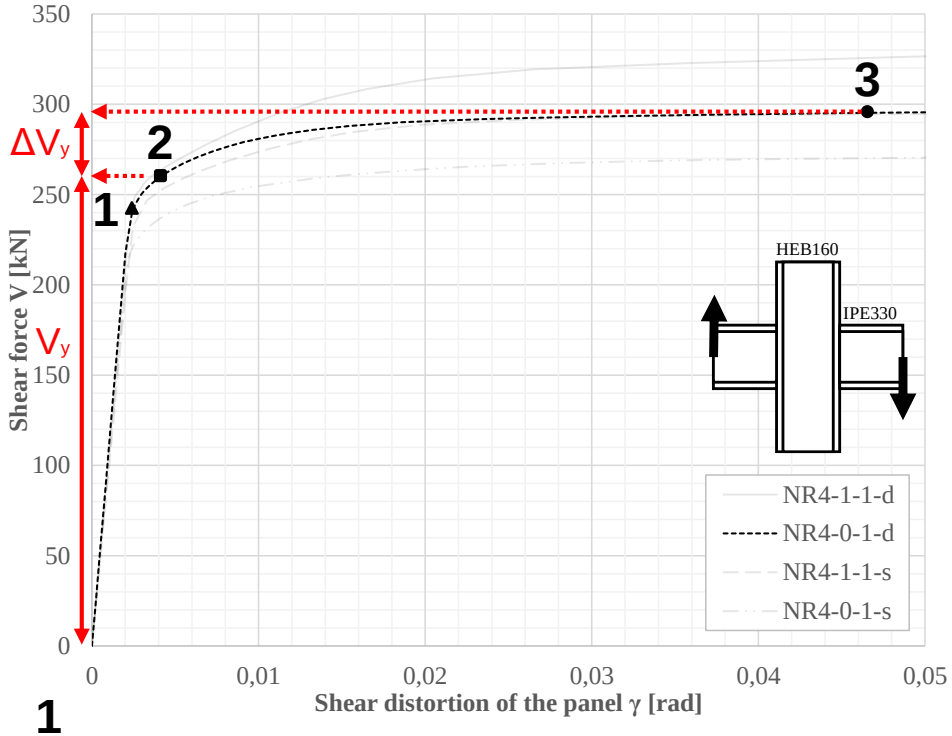
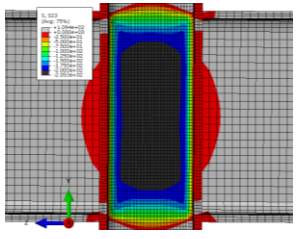
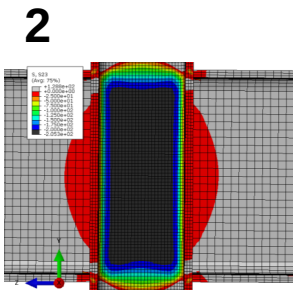


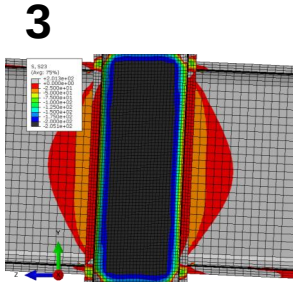
Unstiffened double-sided

NR4









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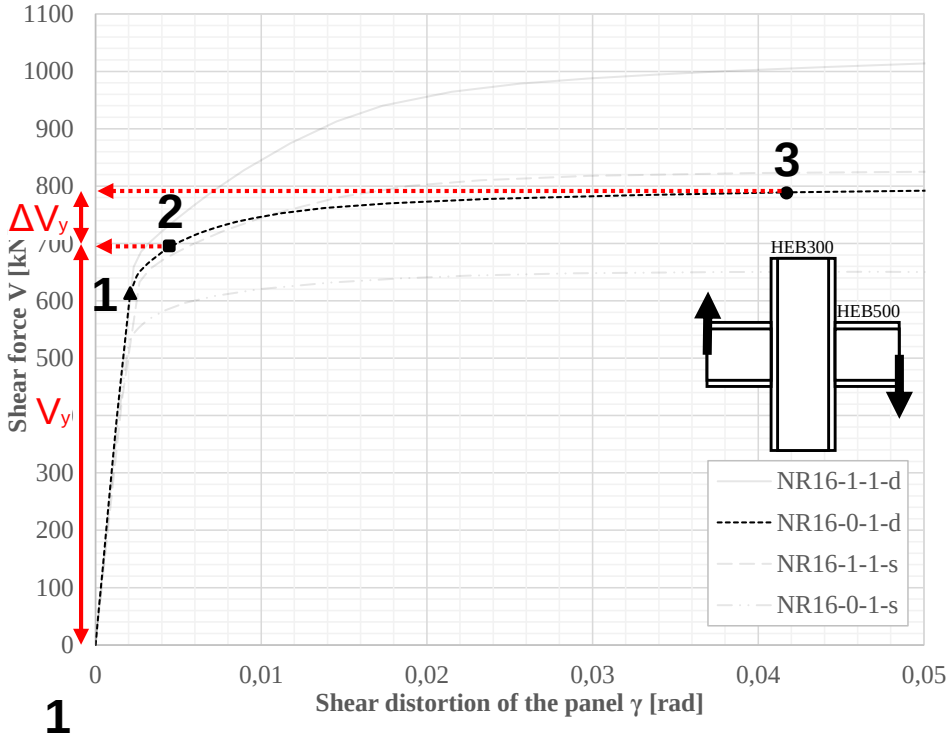
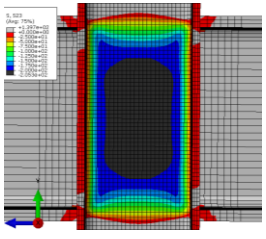
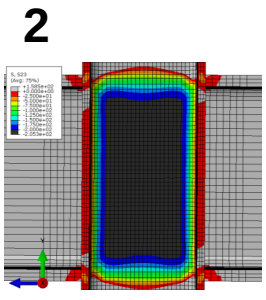
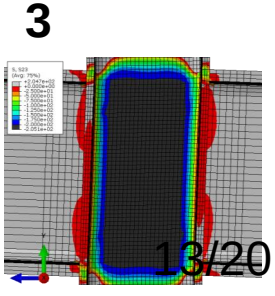


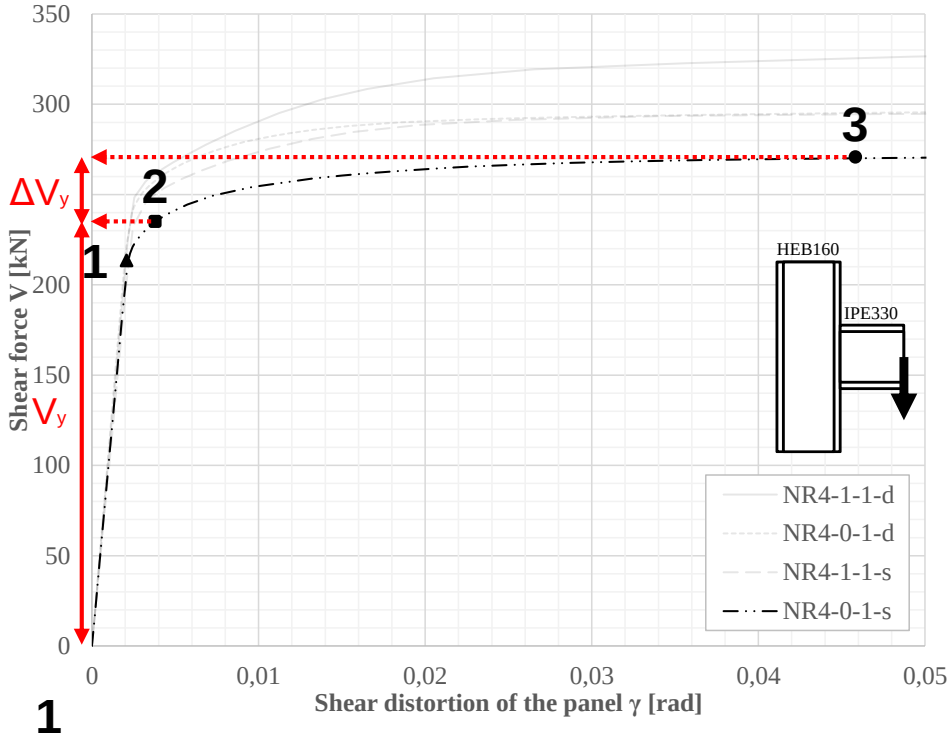






Unstiffened single-sided

NR4



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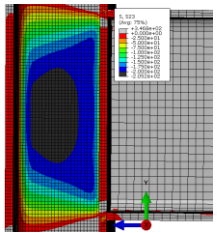

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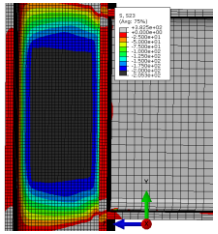

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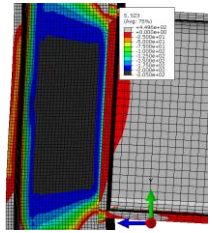

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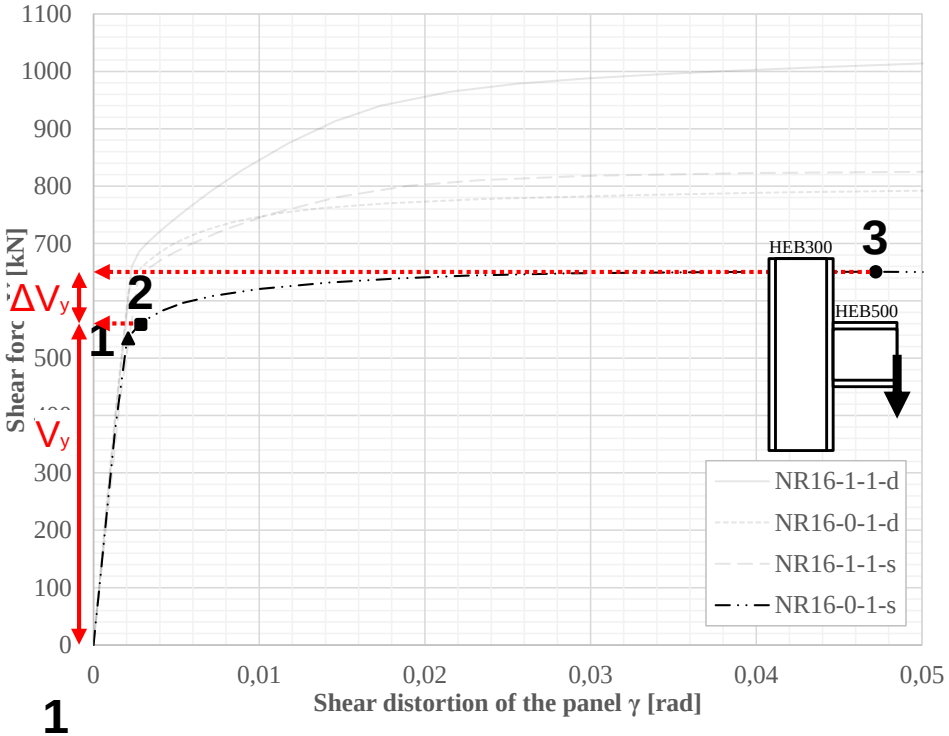

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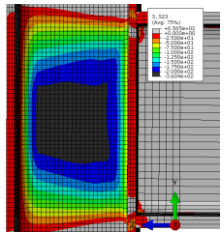

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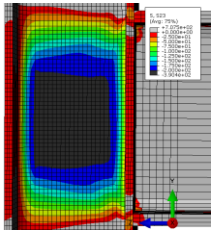

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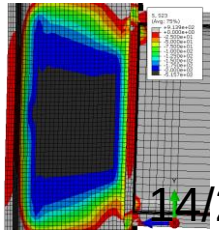
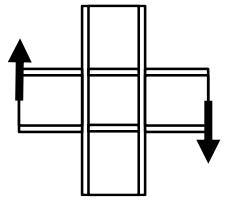
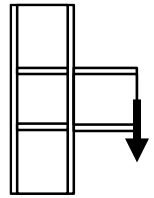
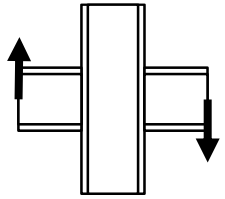
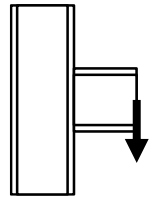


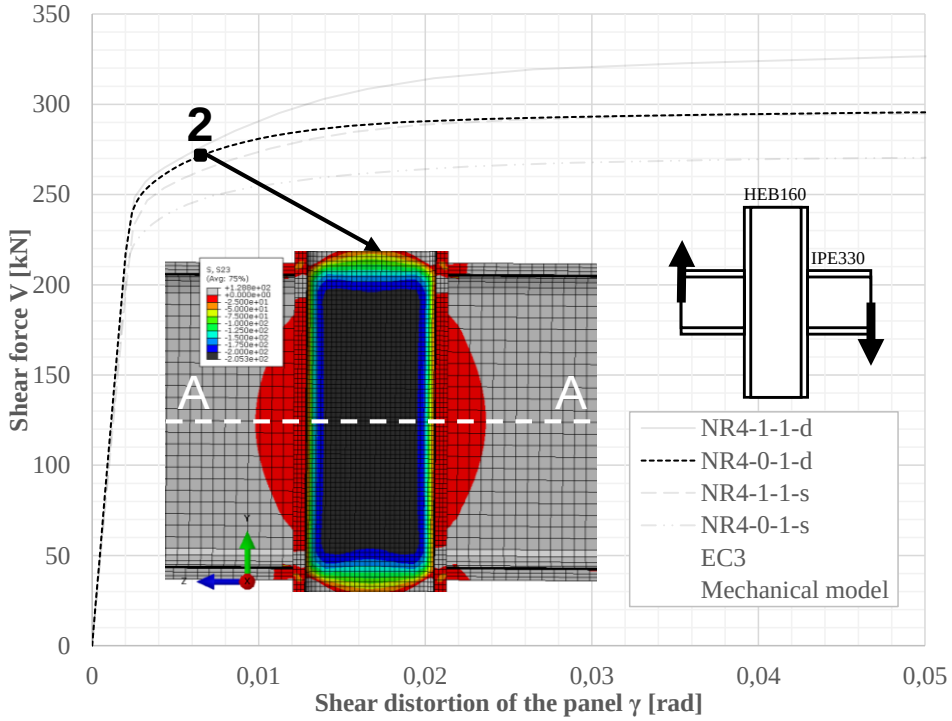
Outline

Parametric study

Tests *X stands for 4/16*	Transverse column web stiffeners *Yes……..…..1* *No…….....…..0*	Root fillets in column *Yes……..…..1* *No…..……..…..0*	Type of joint *Single-sided…...s* *Double-sided.....d*	Test numbers	Loading situation
NRX	1	1	d	NRX-1-1-d	
		0		NRX-1-0-d	
		1	s	NRX-1-1-s	
		0		NRX-1-0-s	
	0	1	d	NRX-0-1-d	
		0		NRX-0-0-d	
		1	s	NRX-0-1-s	
		0		NRX-0-0-s	

Assessment of V_y

NR4



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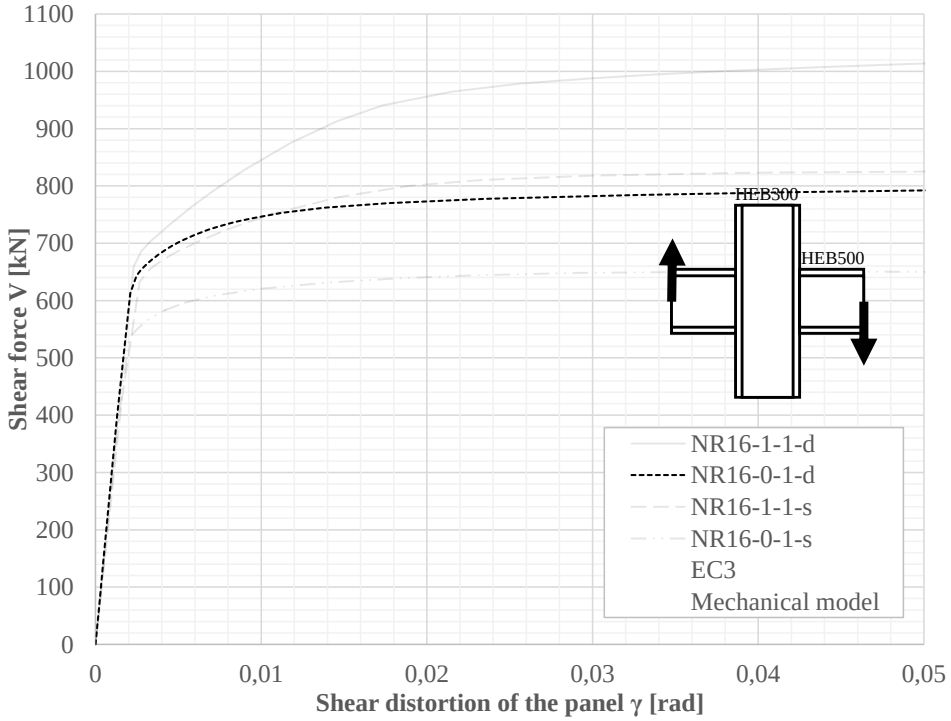

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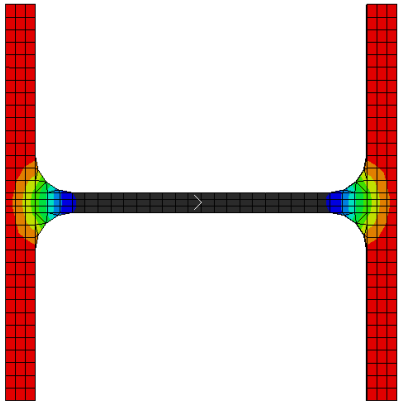

Assessment of V_y

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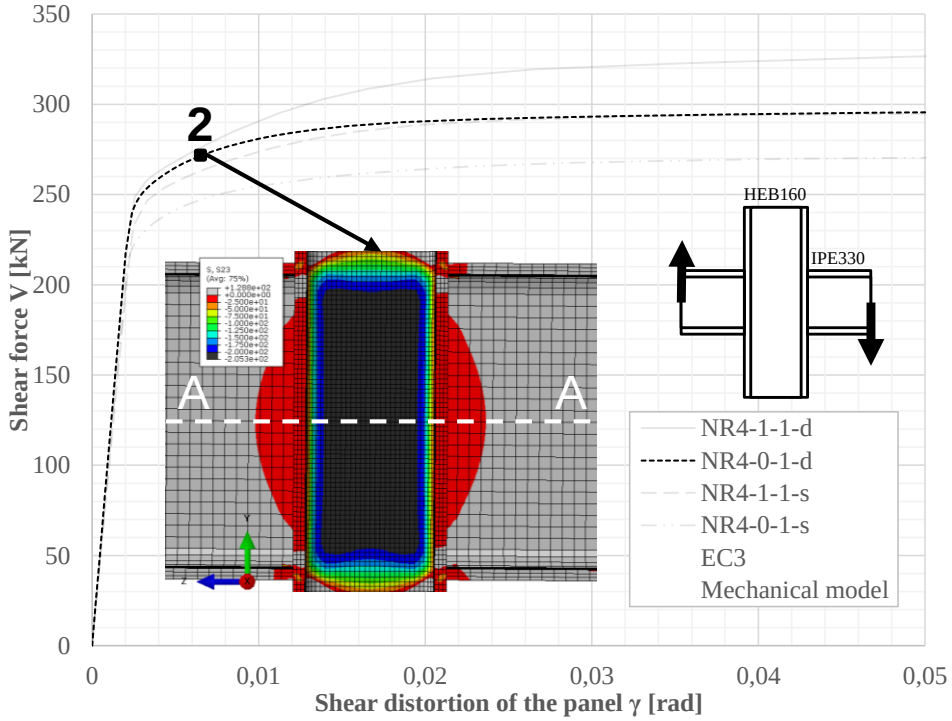

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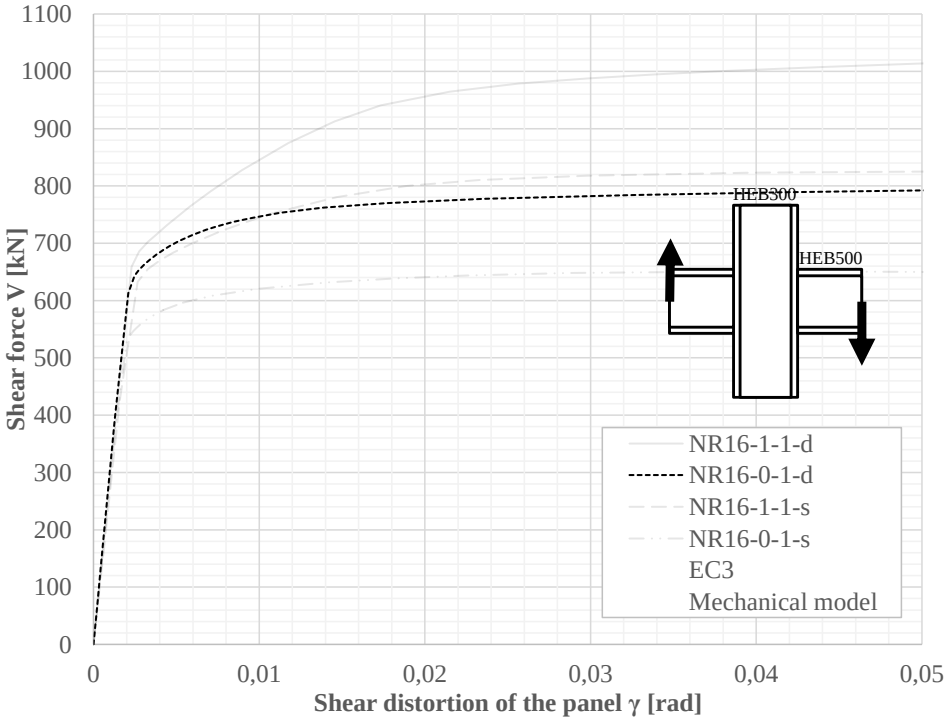

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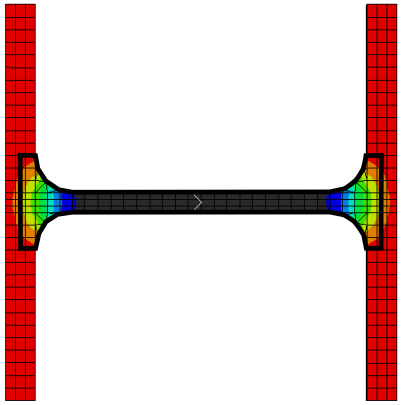

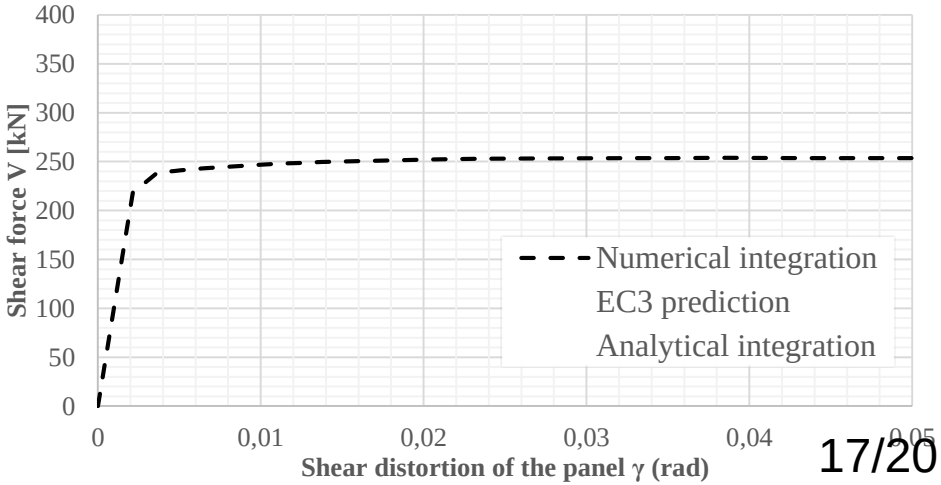

Assessment of V_y

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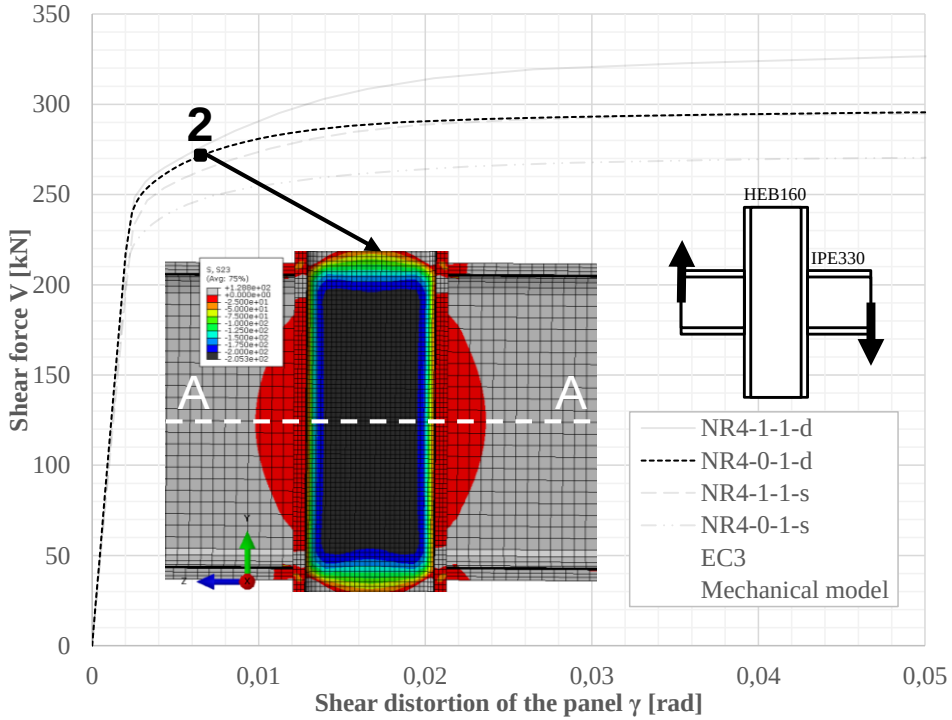

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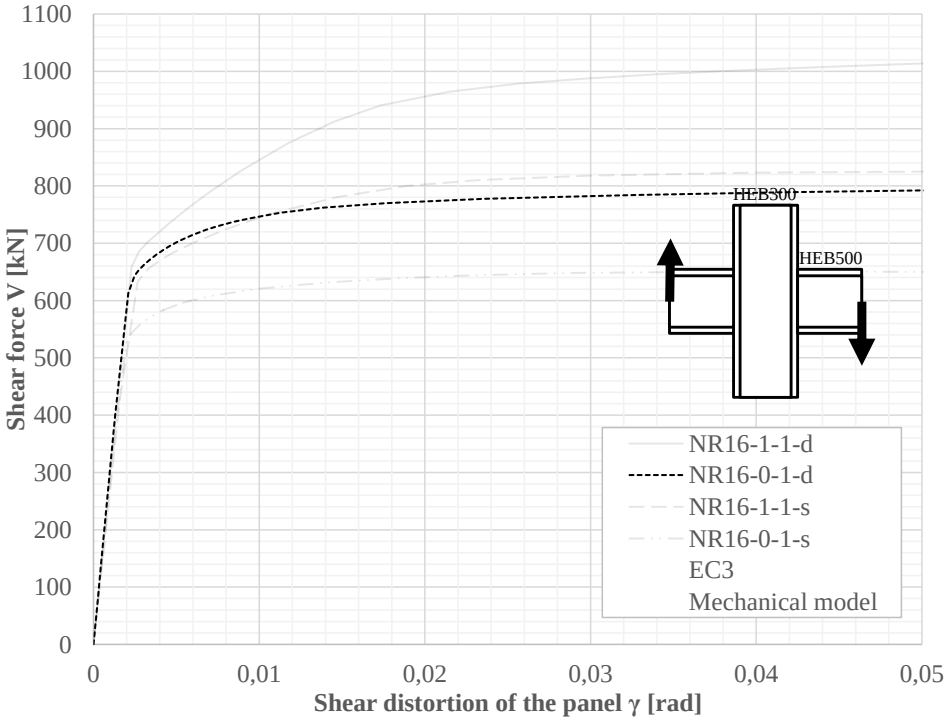

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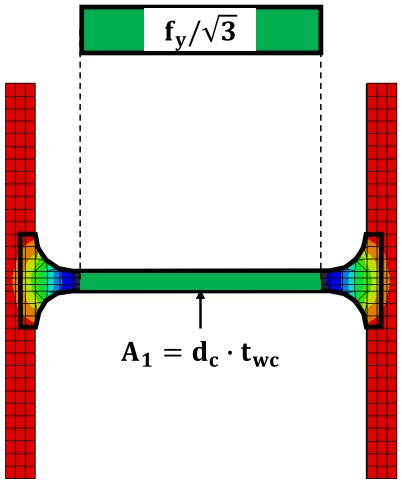

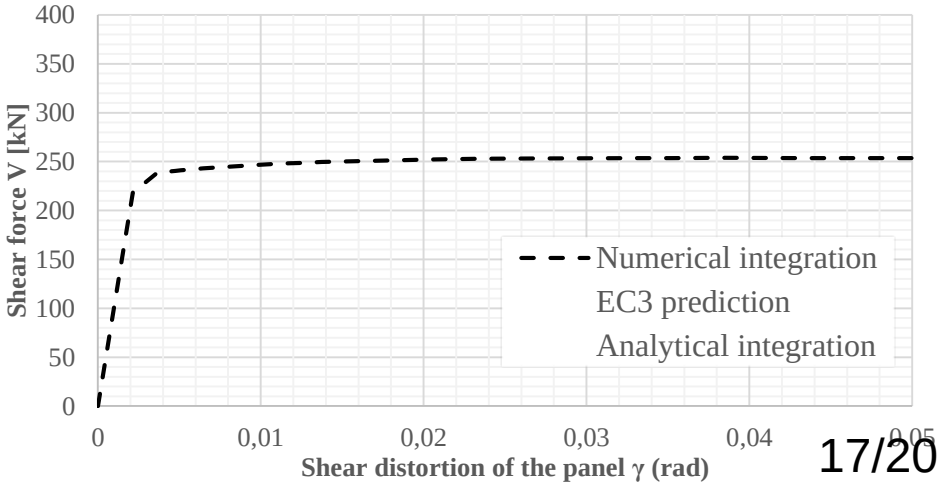

Assessment of V_y

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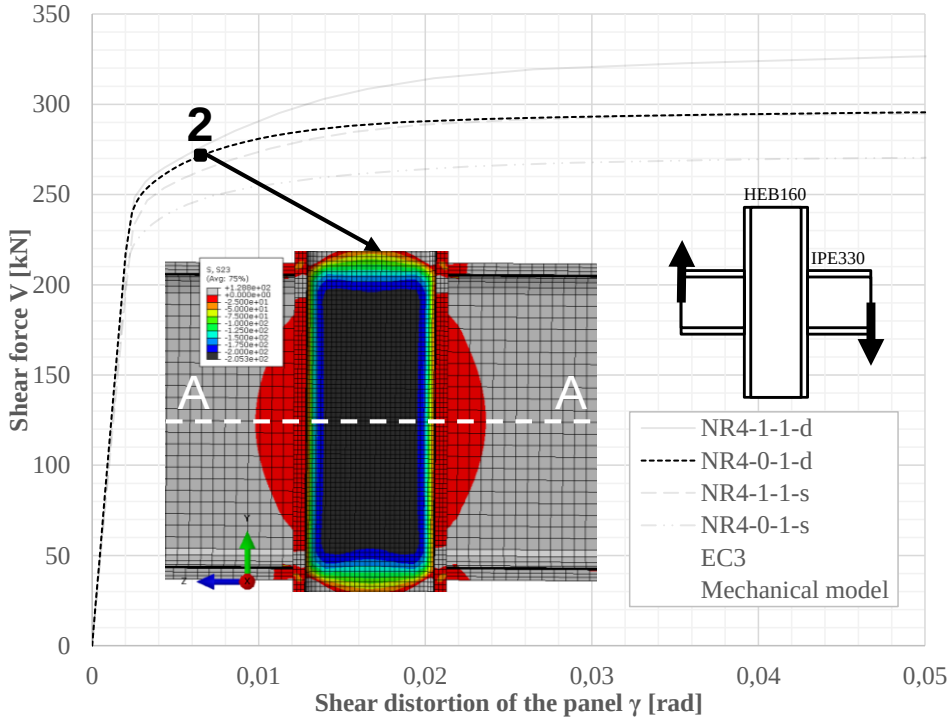

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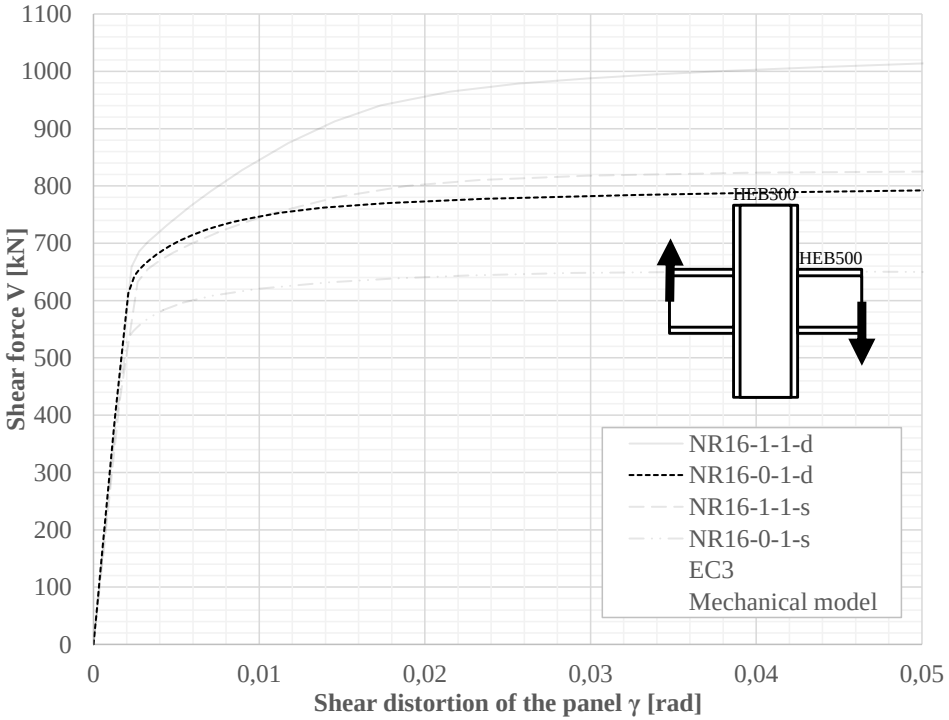

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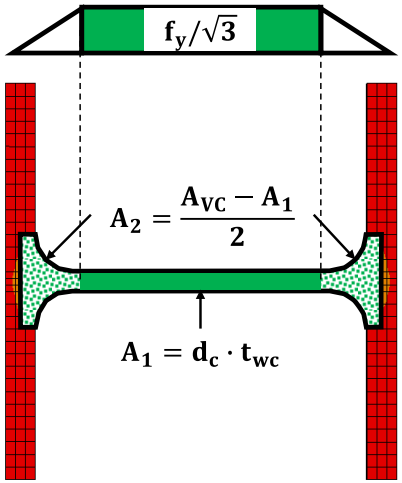

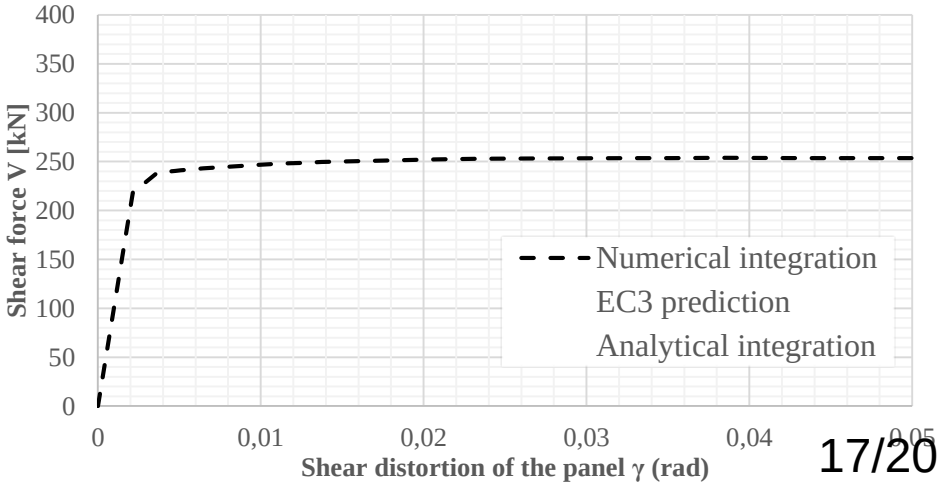

Assessment of V_y

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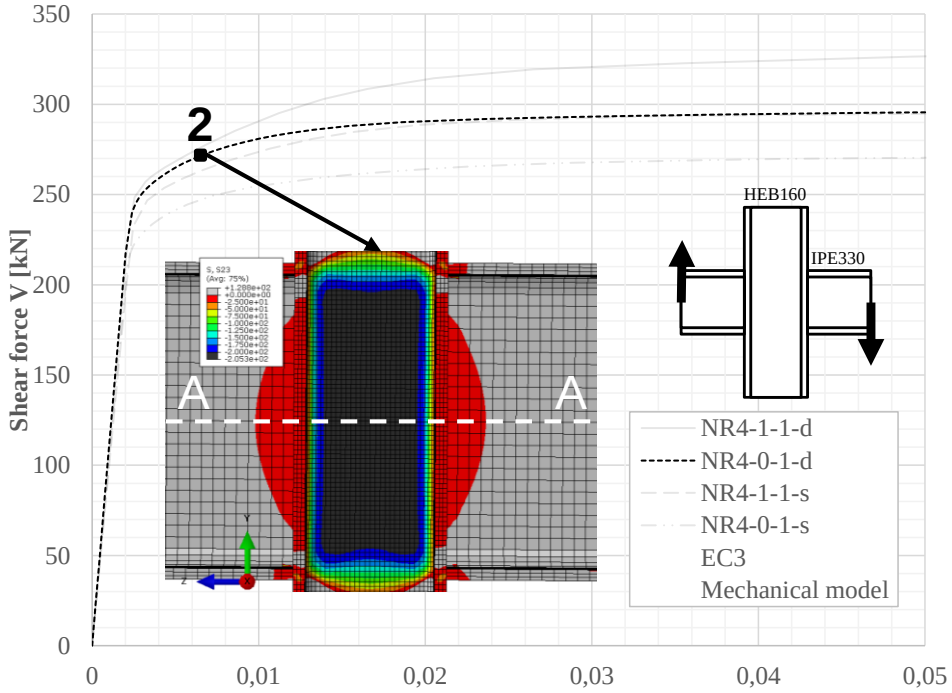

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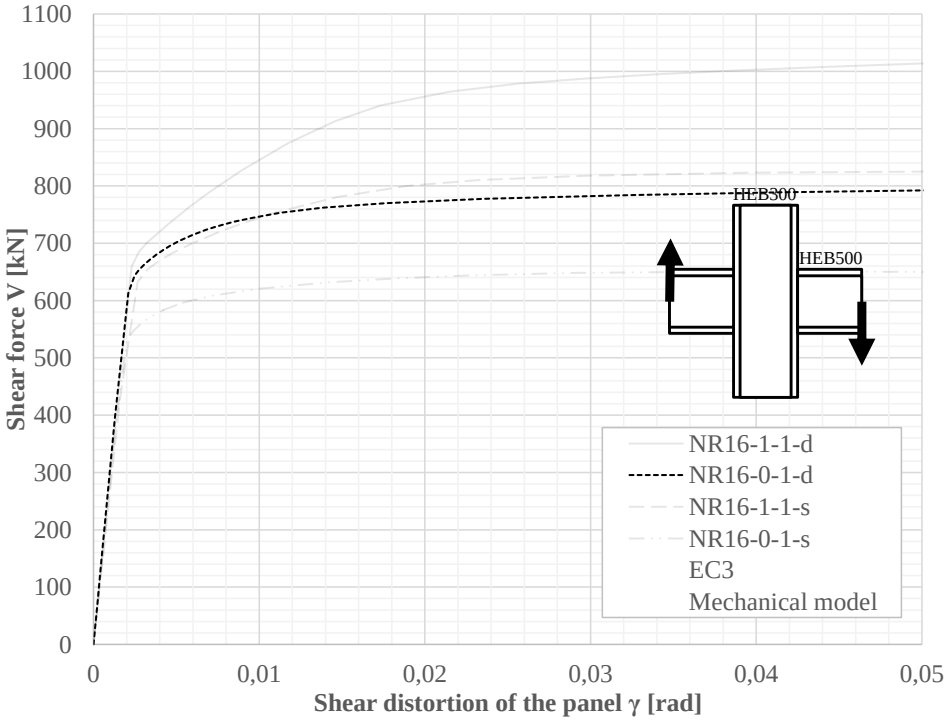

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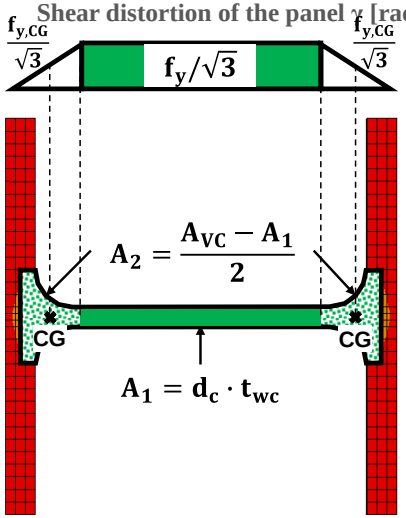
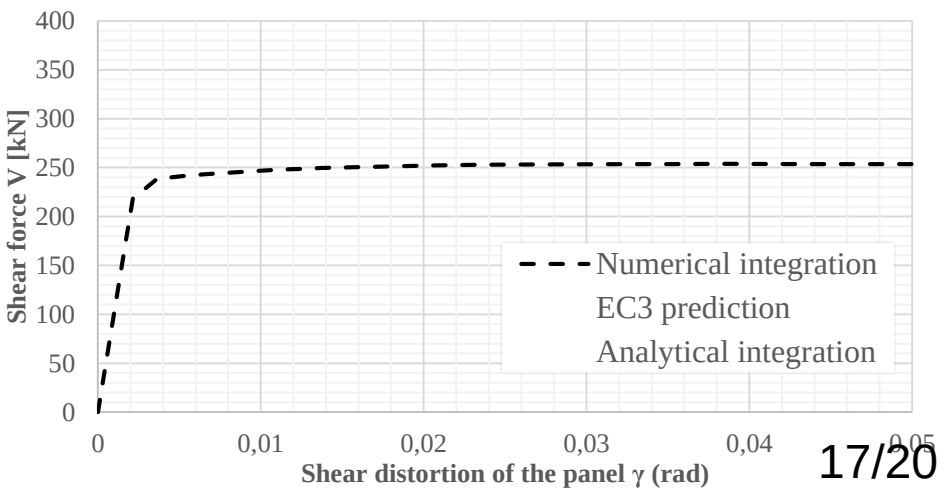
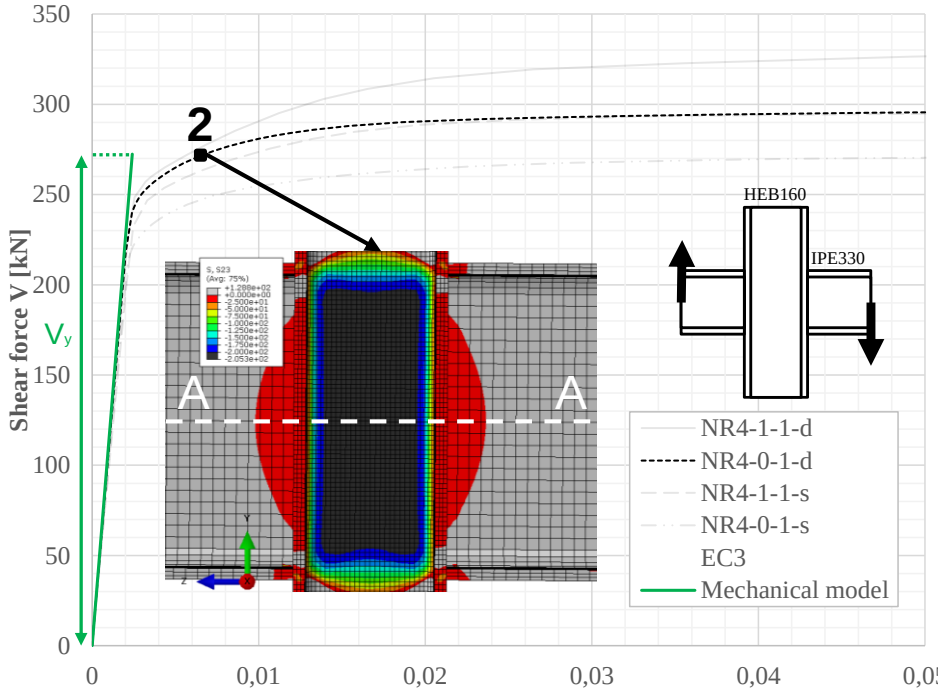




Assessment of V_y

NR4



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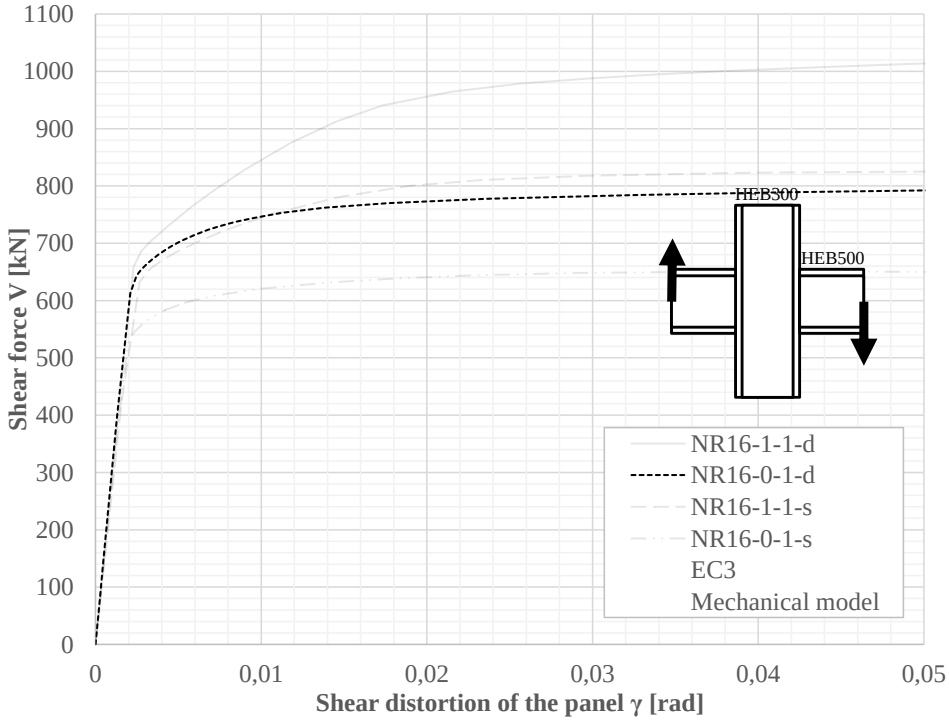

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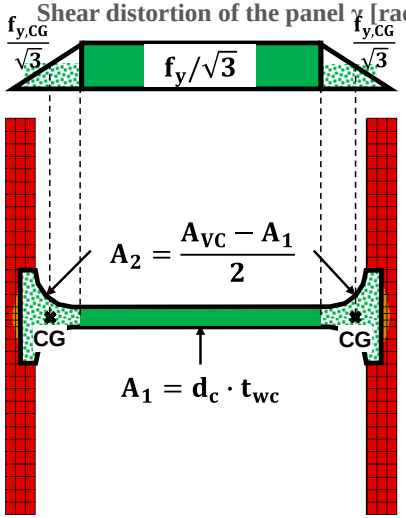
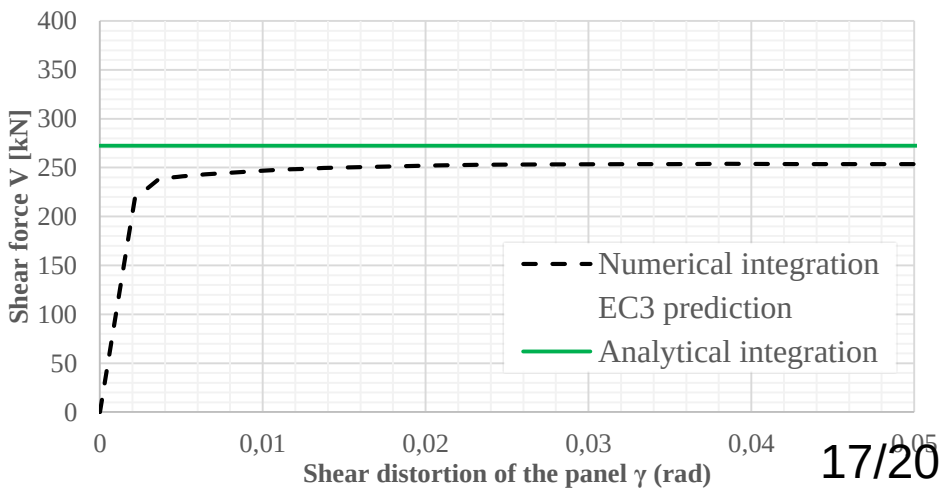
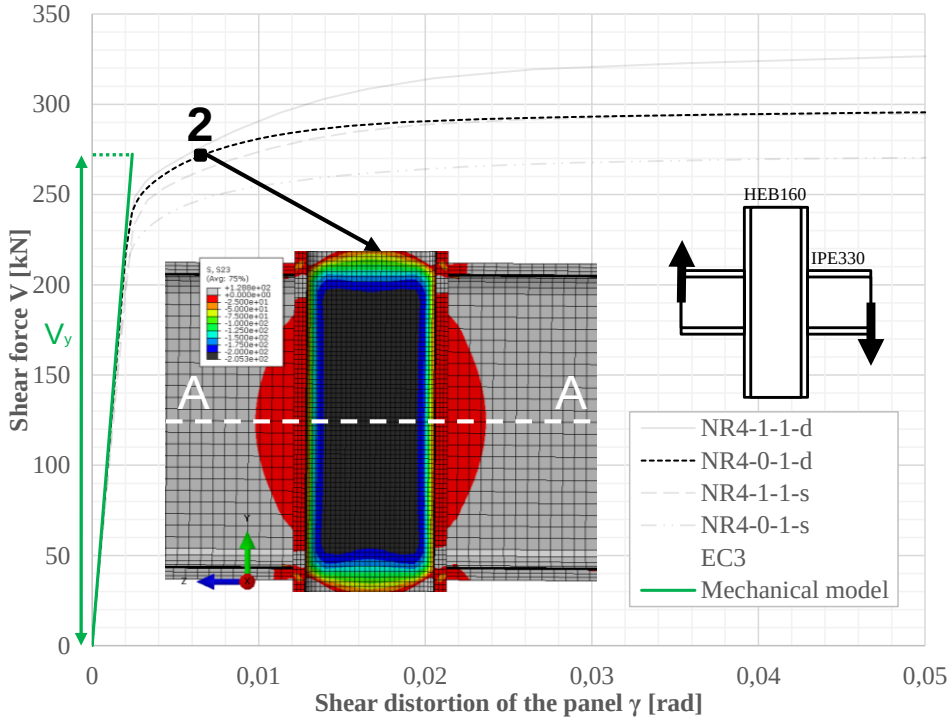




Assessment of V_y

NR4



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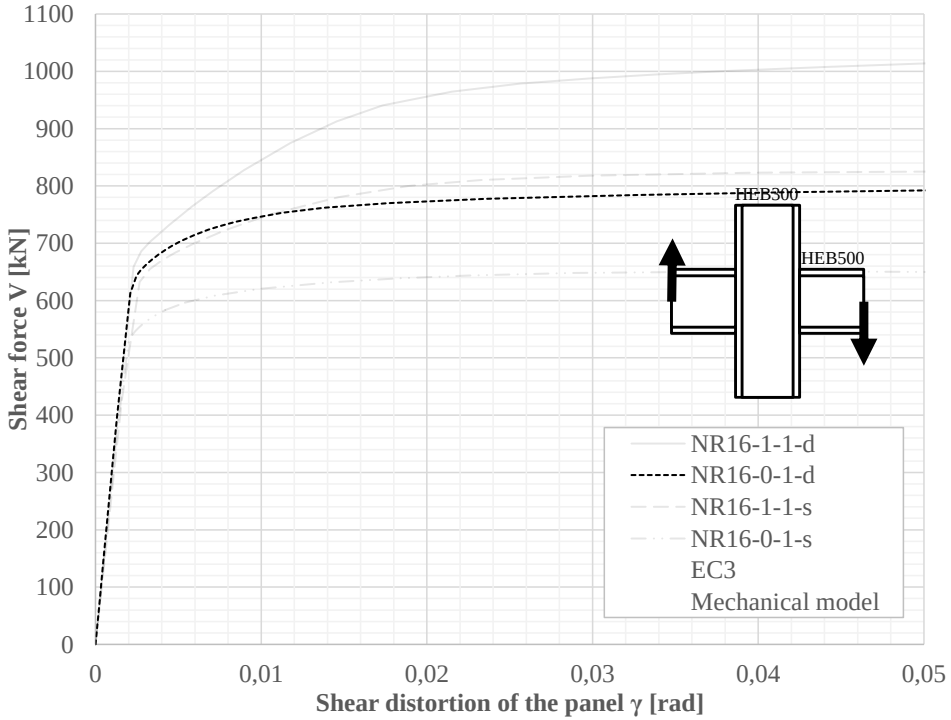

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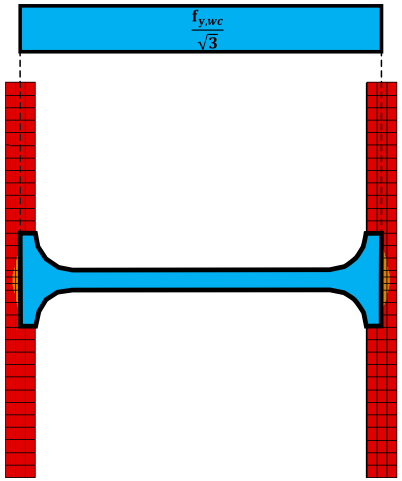
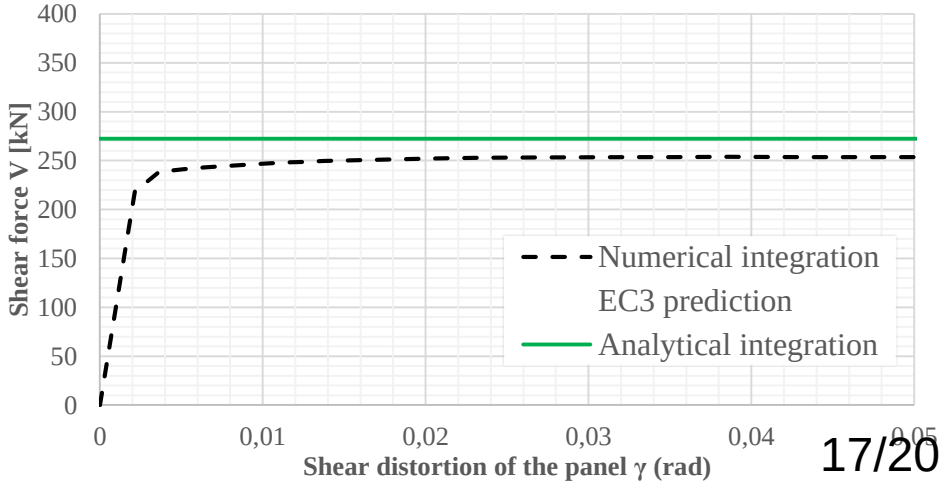
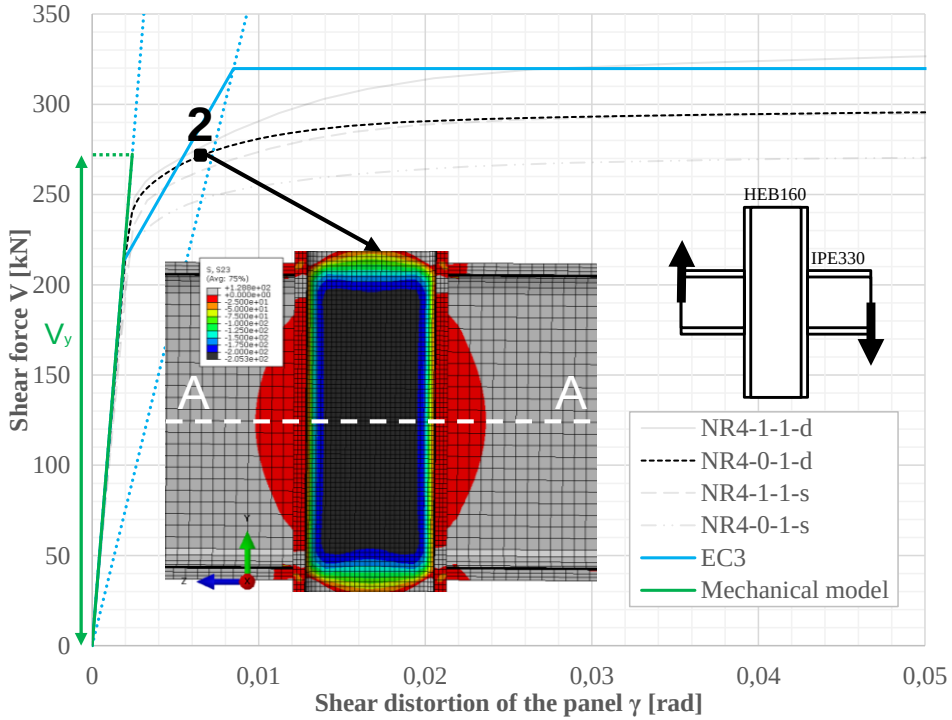




Assessment of V_y

NR4



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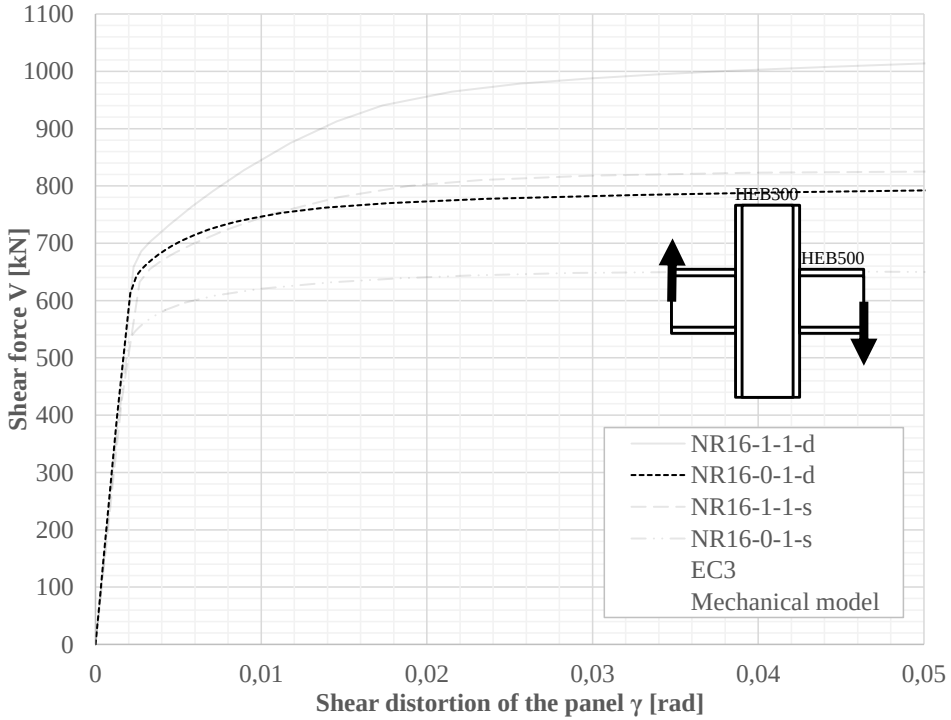

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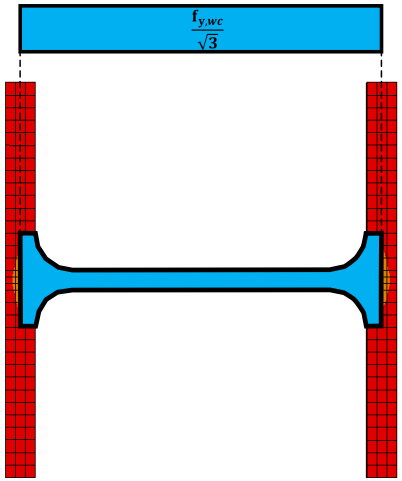
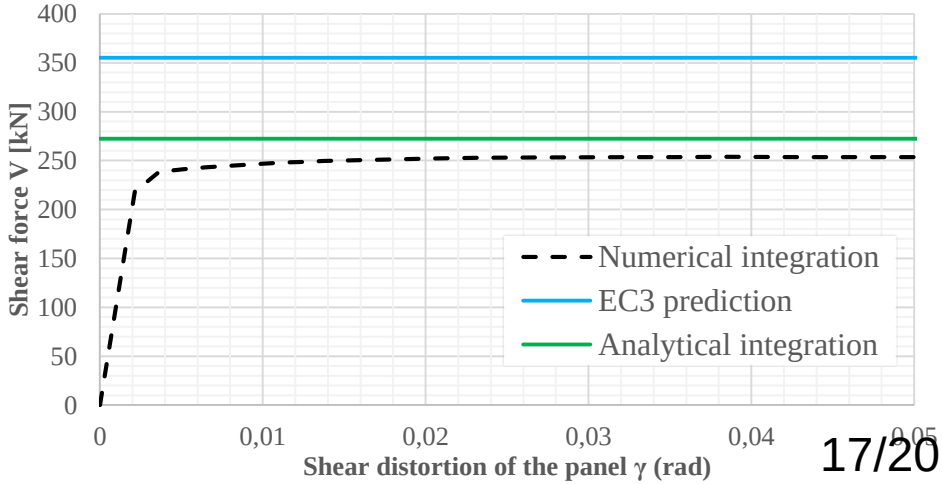
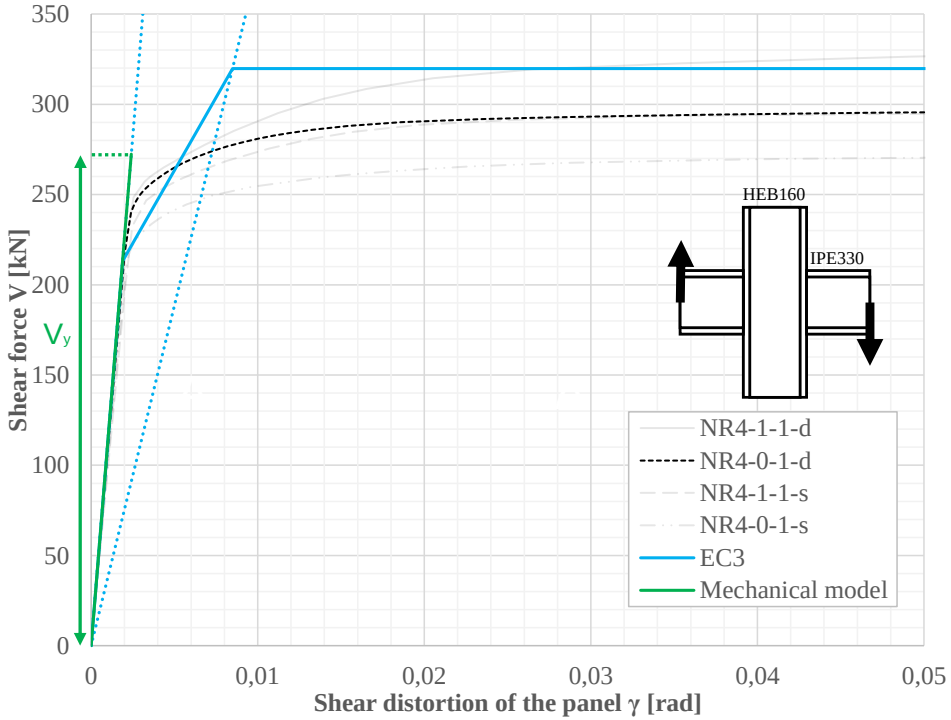


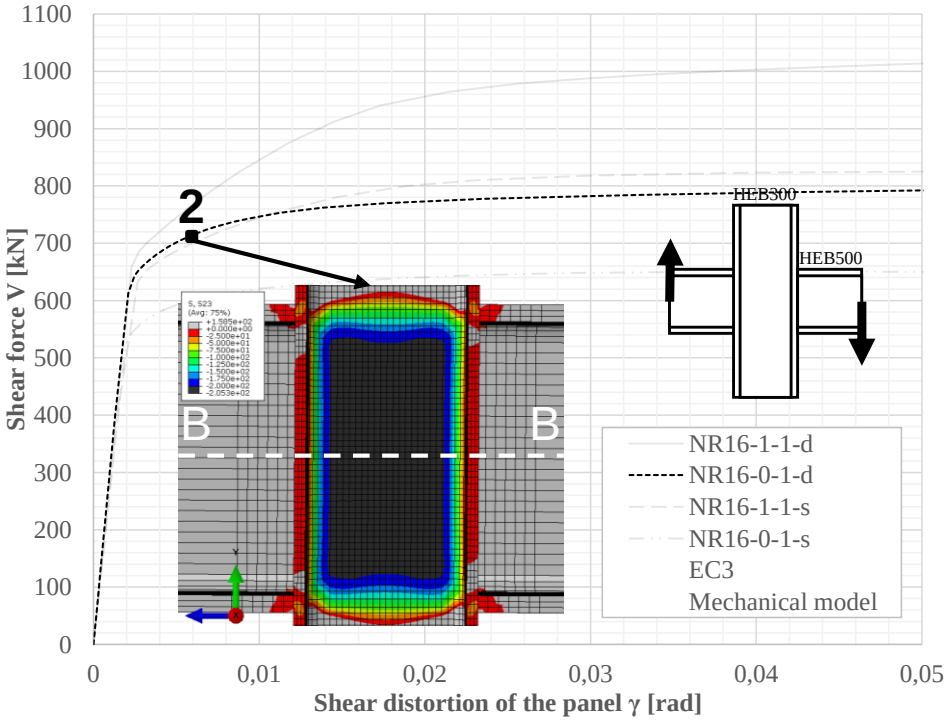


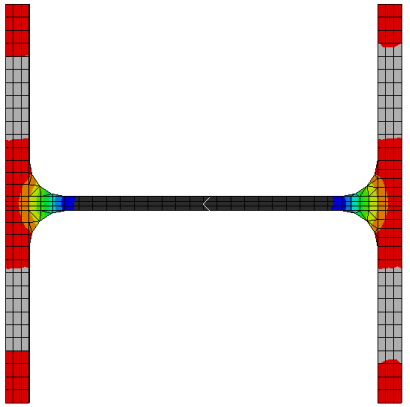
Assessment of V_y

NR4



NR16

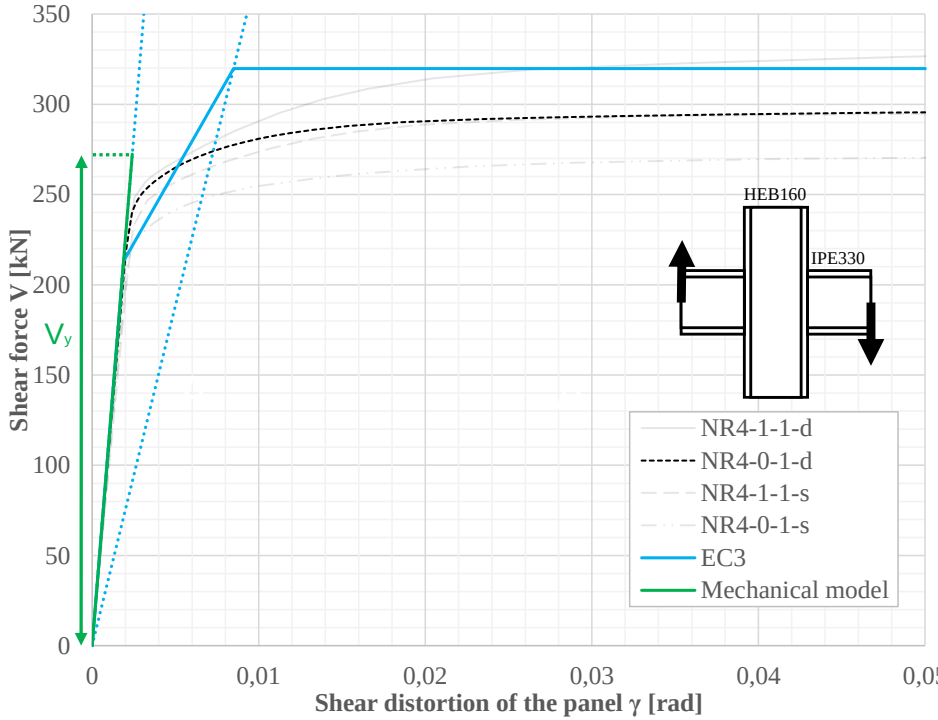




B-B

Assessment of V_y

NR4



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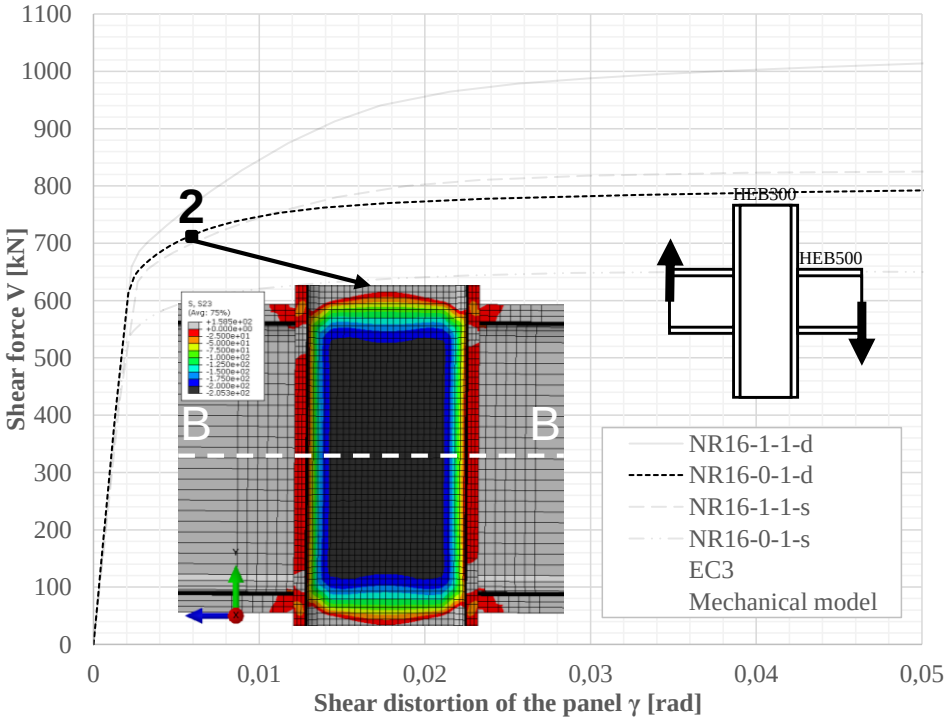
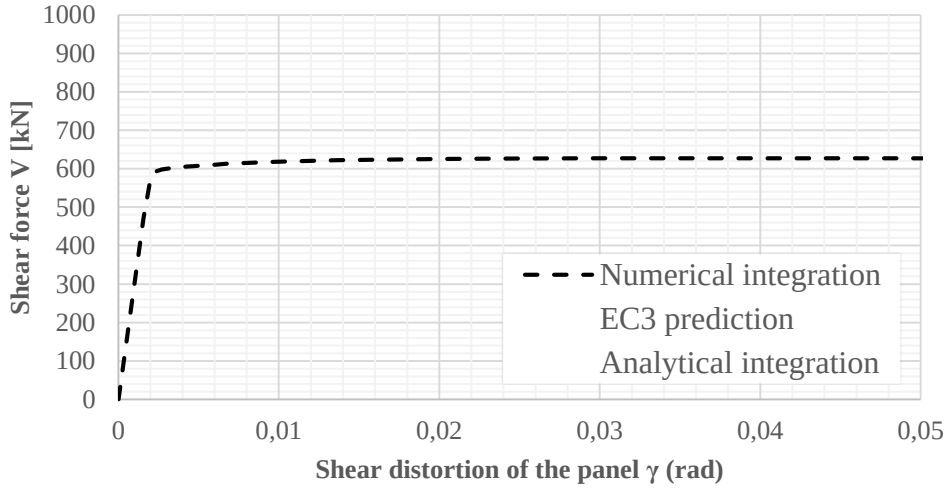
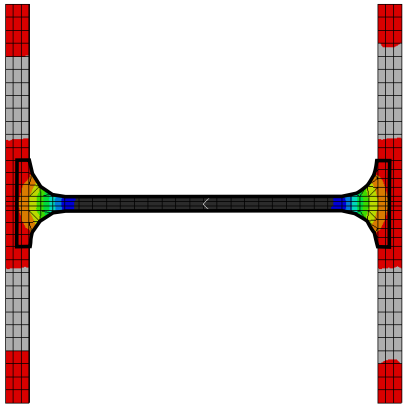


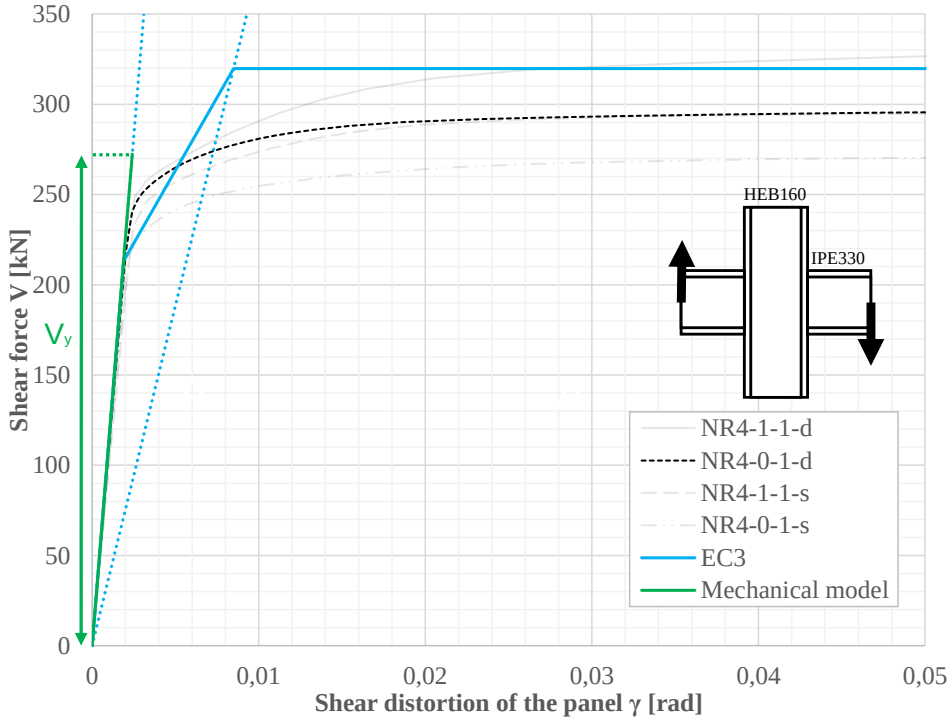




B-B

Assessment of V_y

NR4



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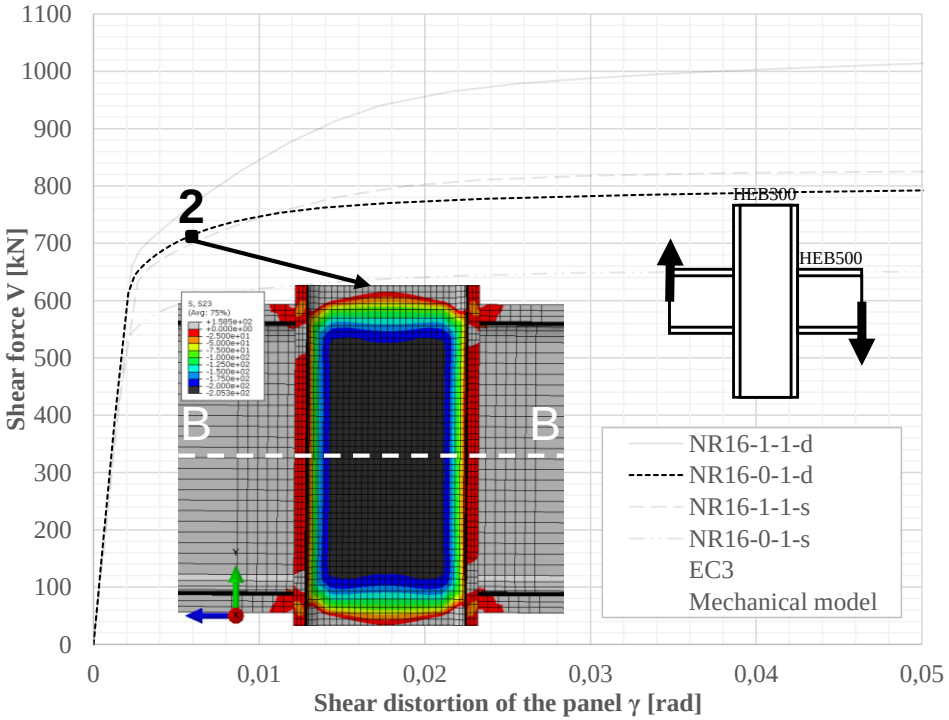

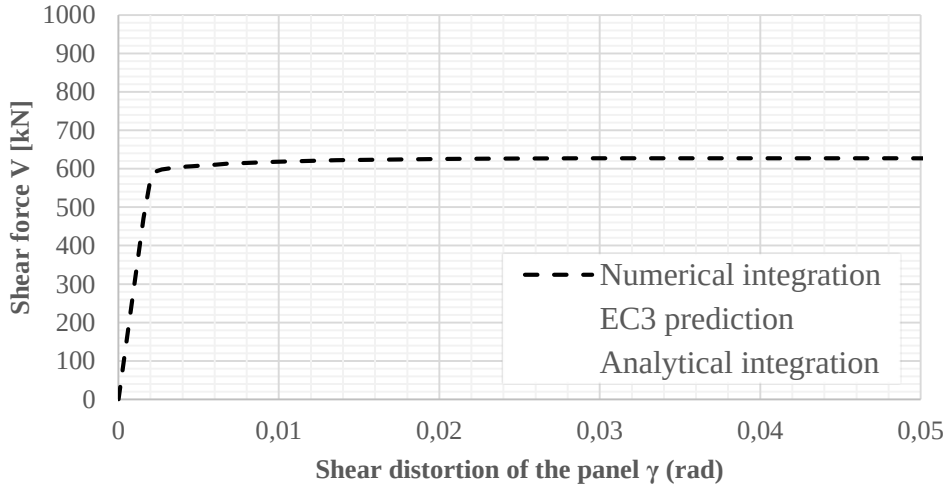

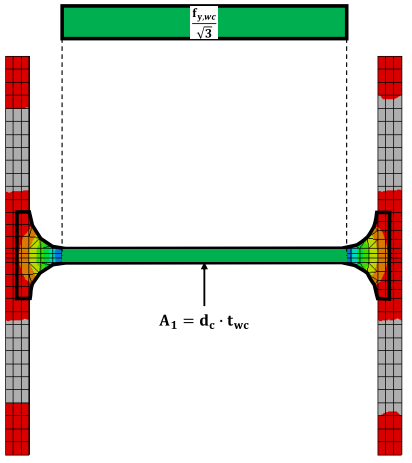

B-B

Assessment of V_y

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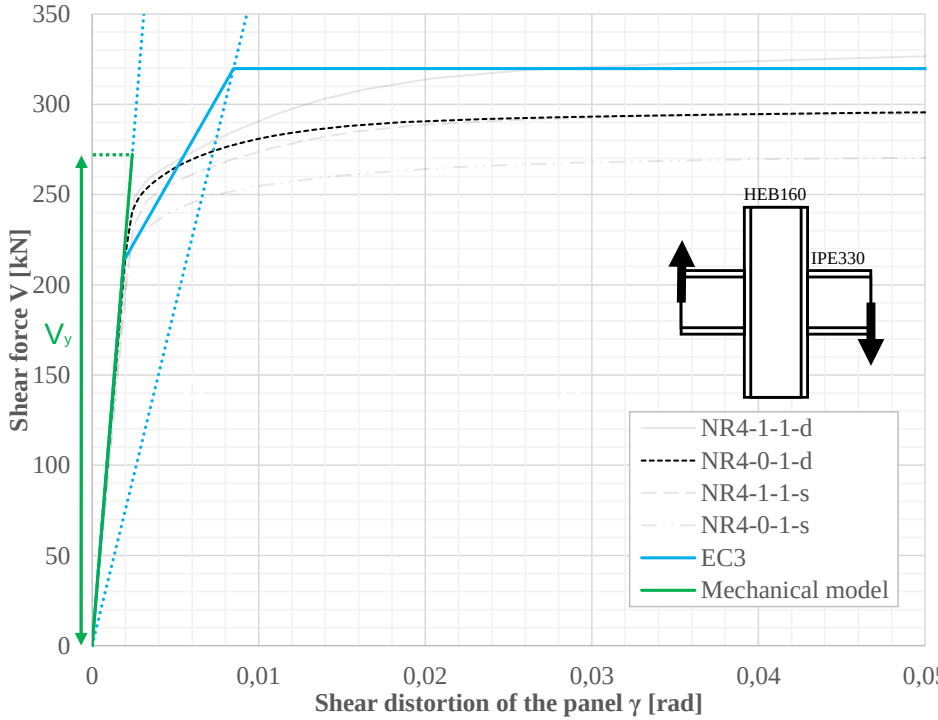

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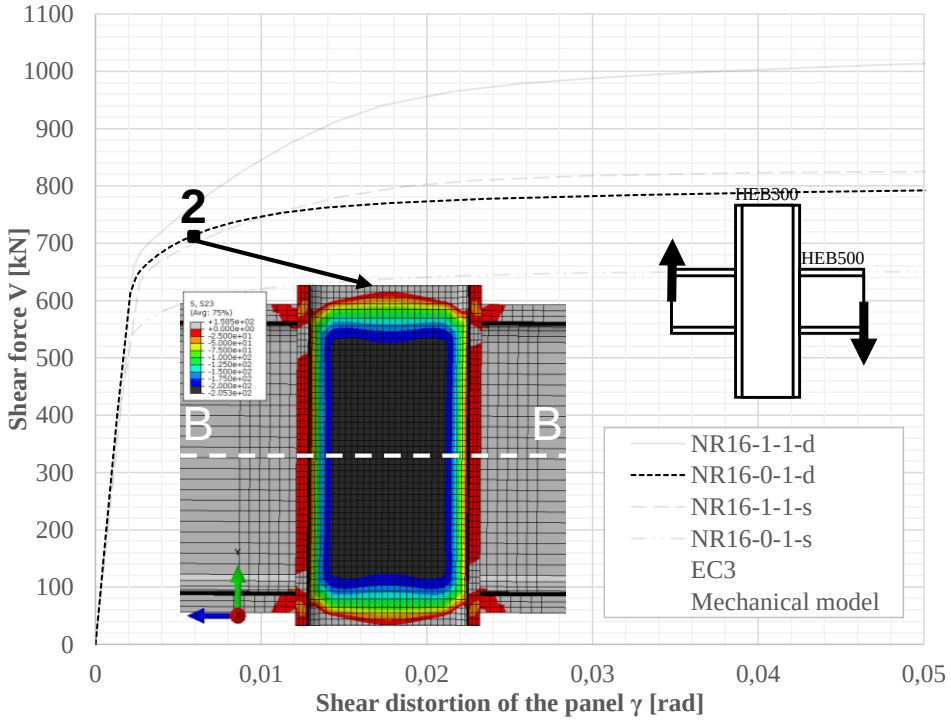
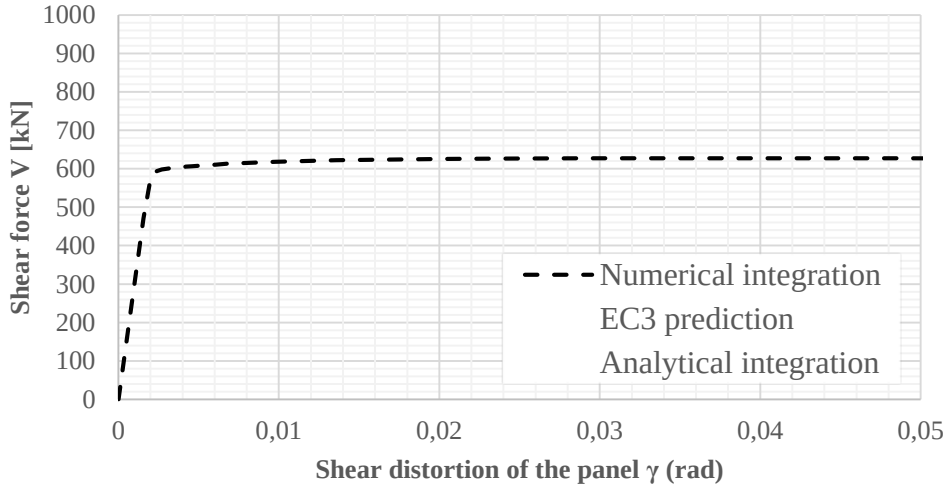
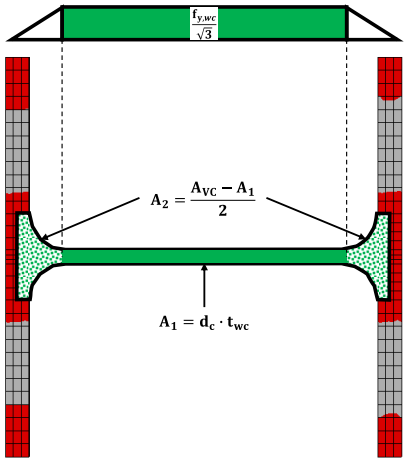


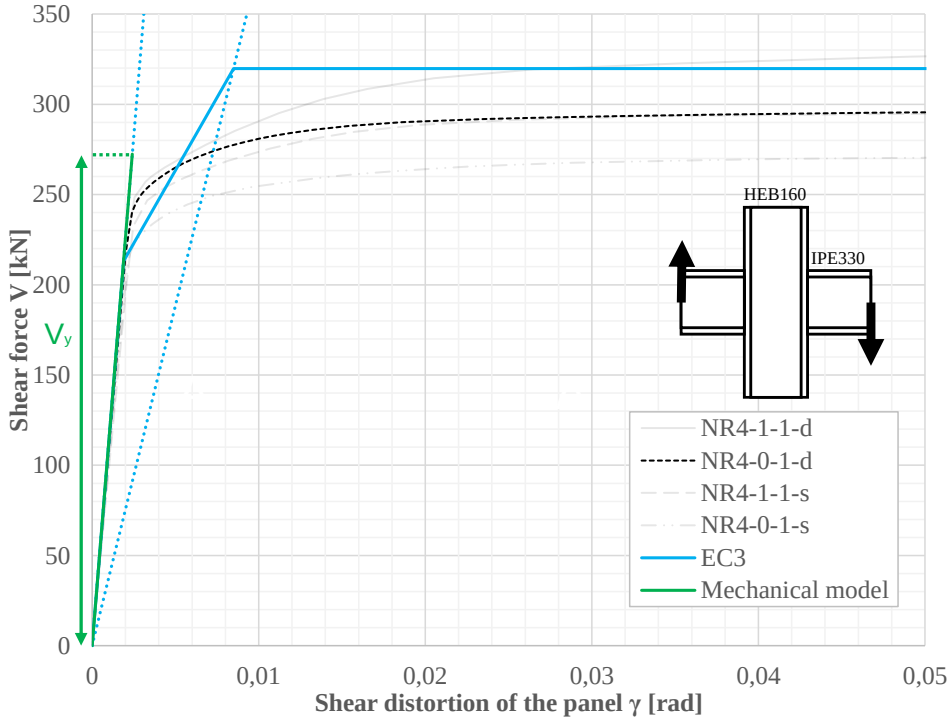




B-B

Assessment of V_y

NR4



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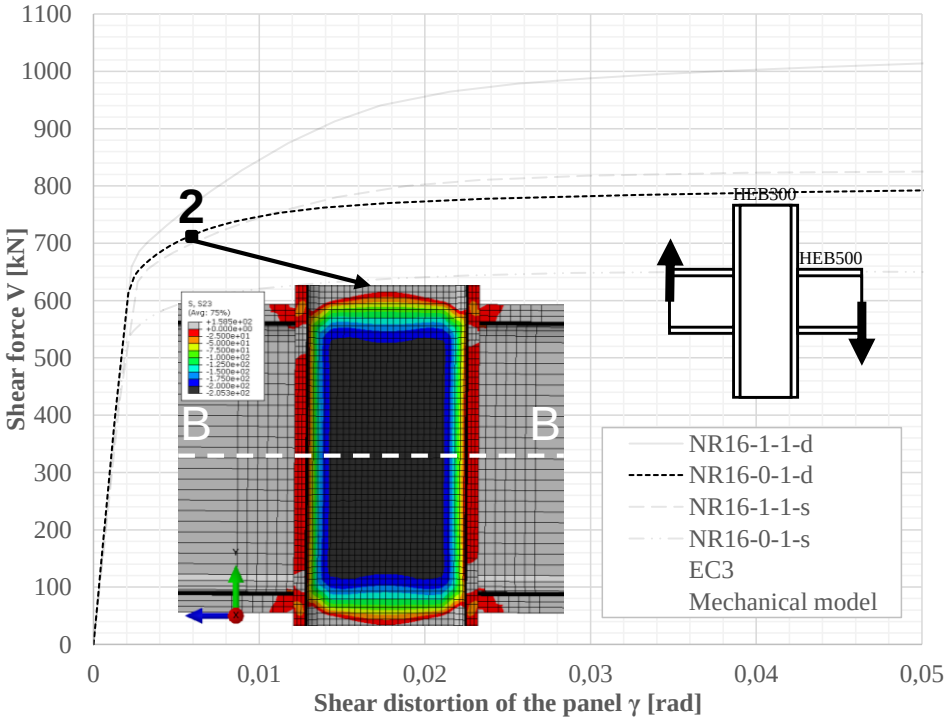
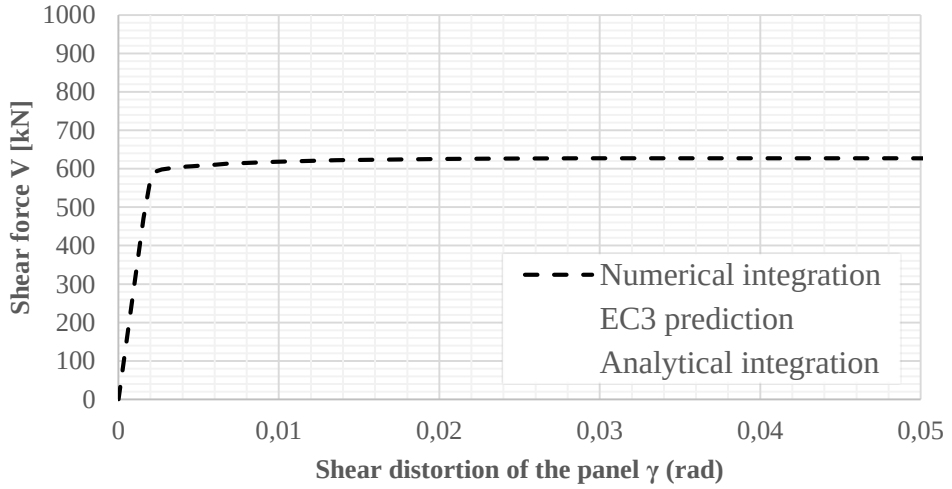
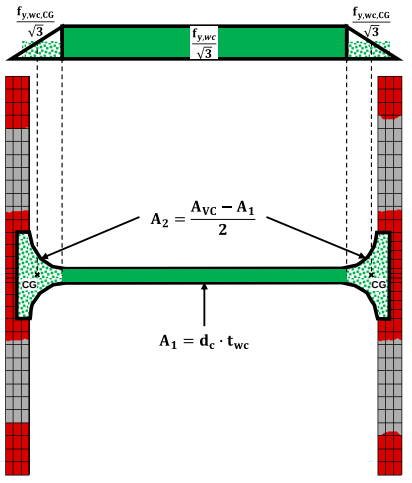


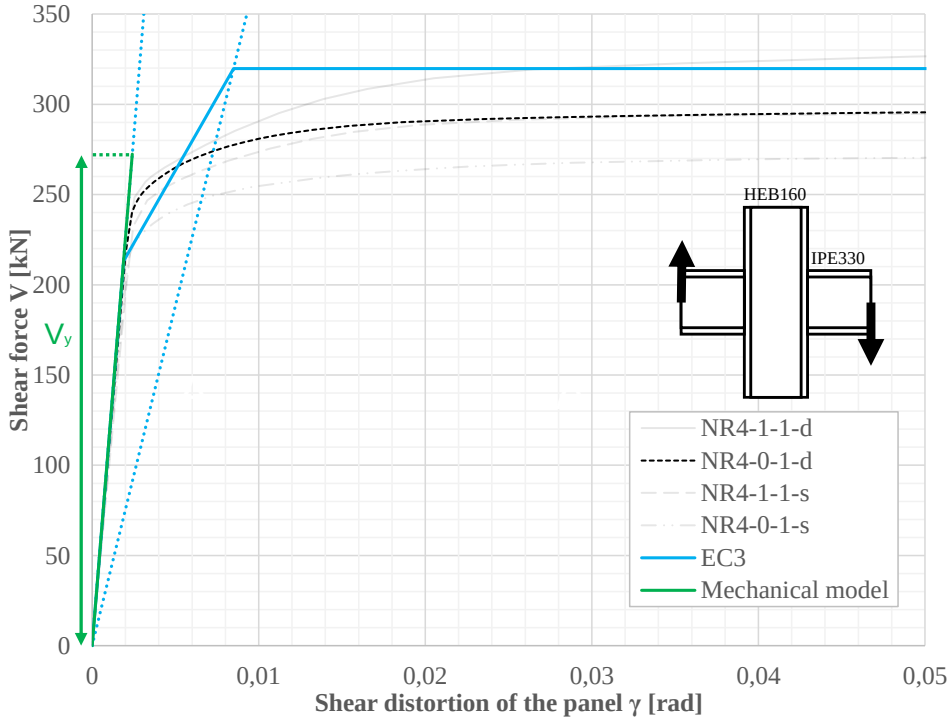




B-B

Assessment of V_y

NR4



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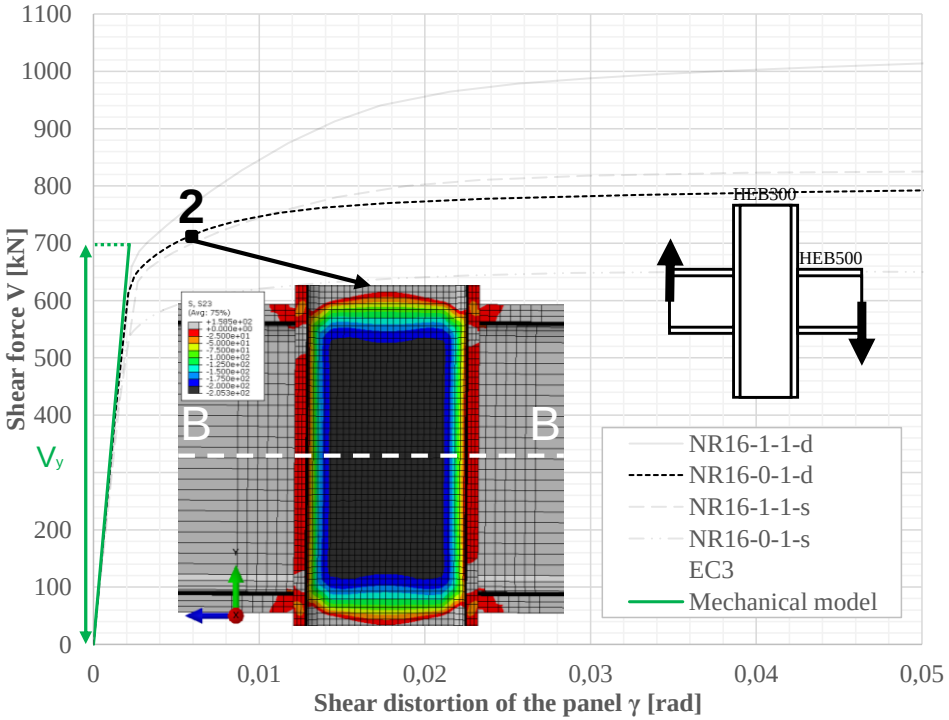
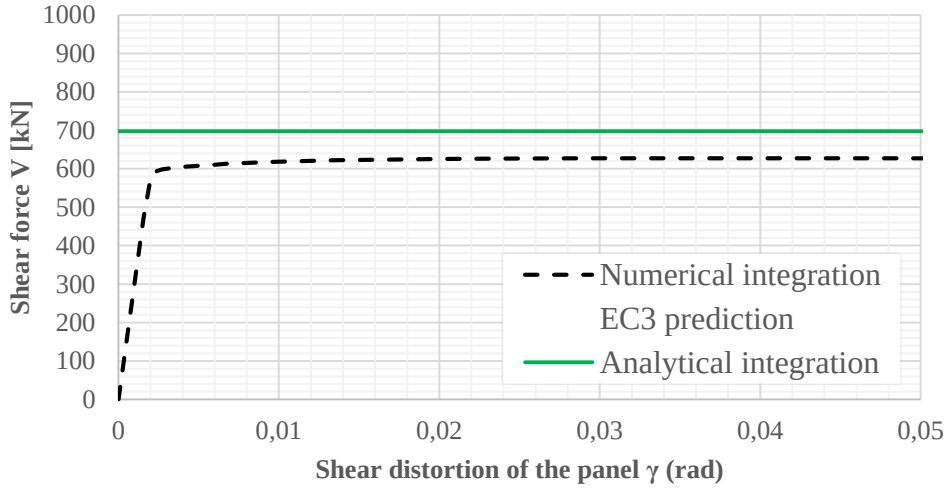
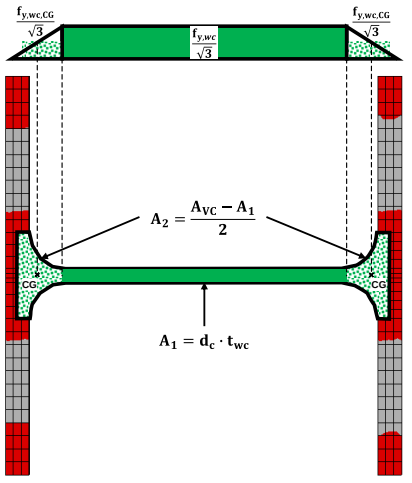


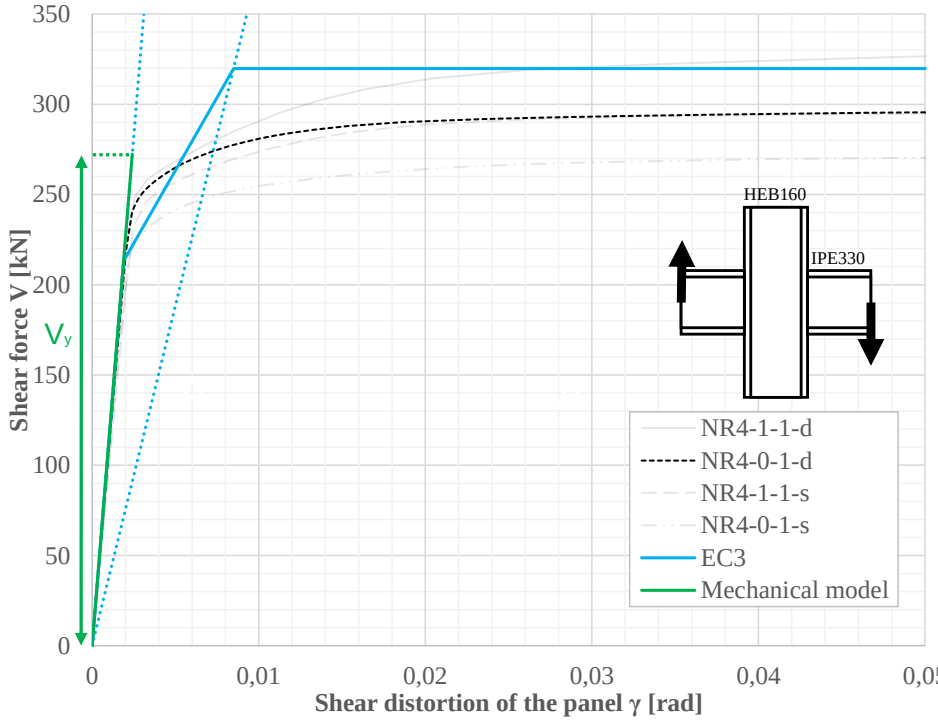




B-B

Assessment of V_y

NR4



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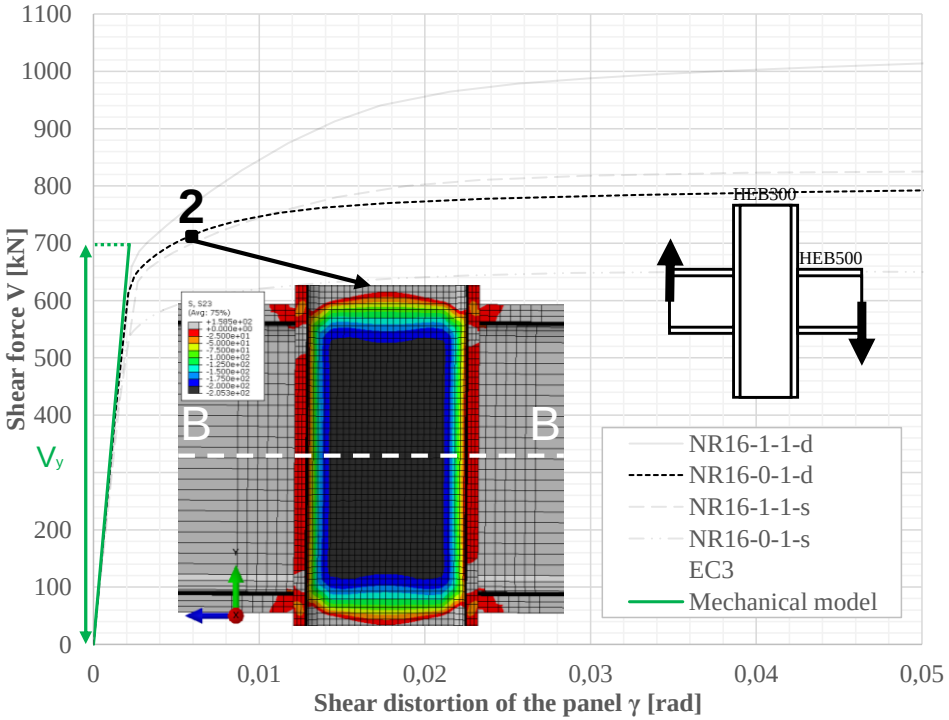
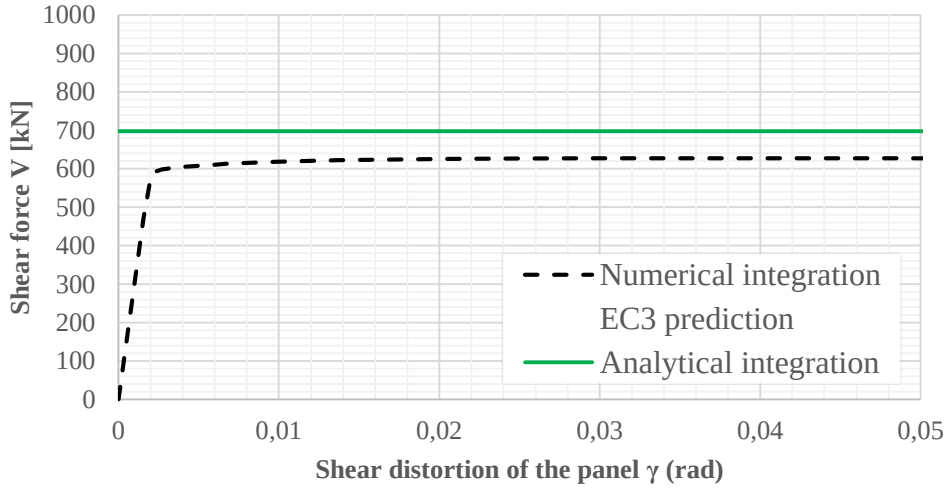
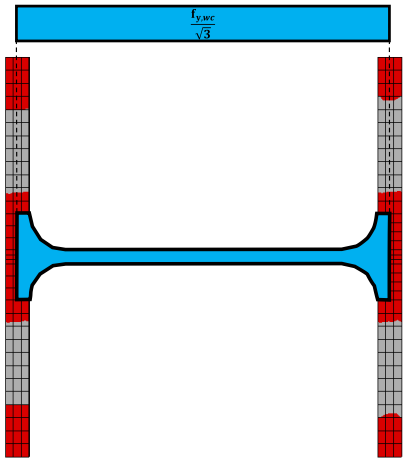


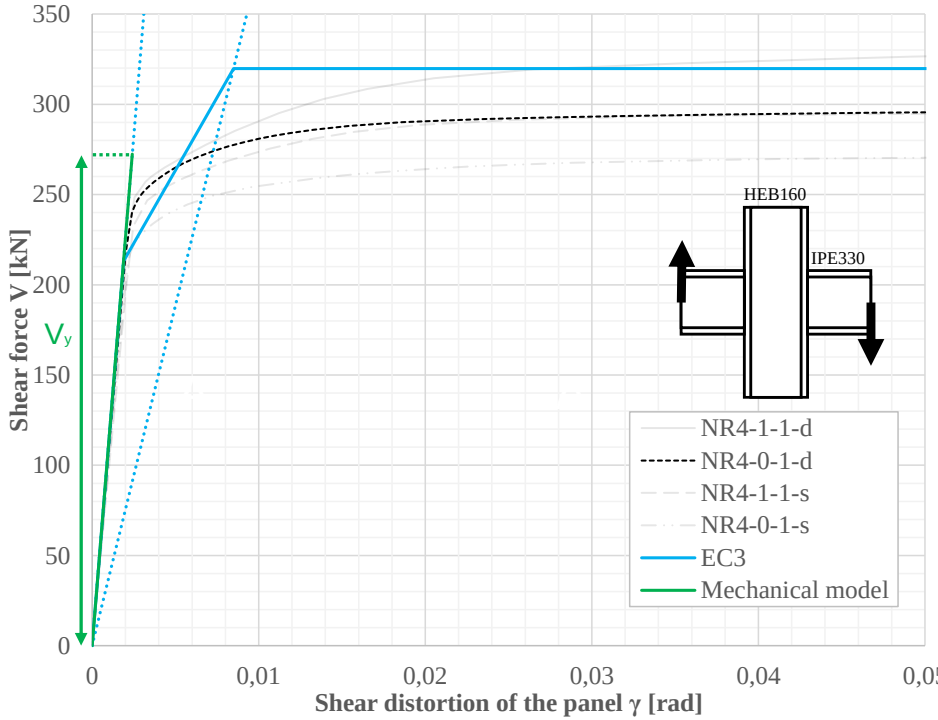




B-B

Assessment of V_y

NR4



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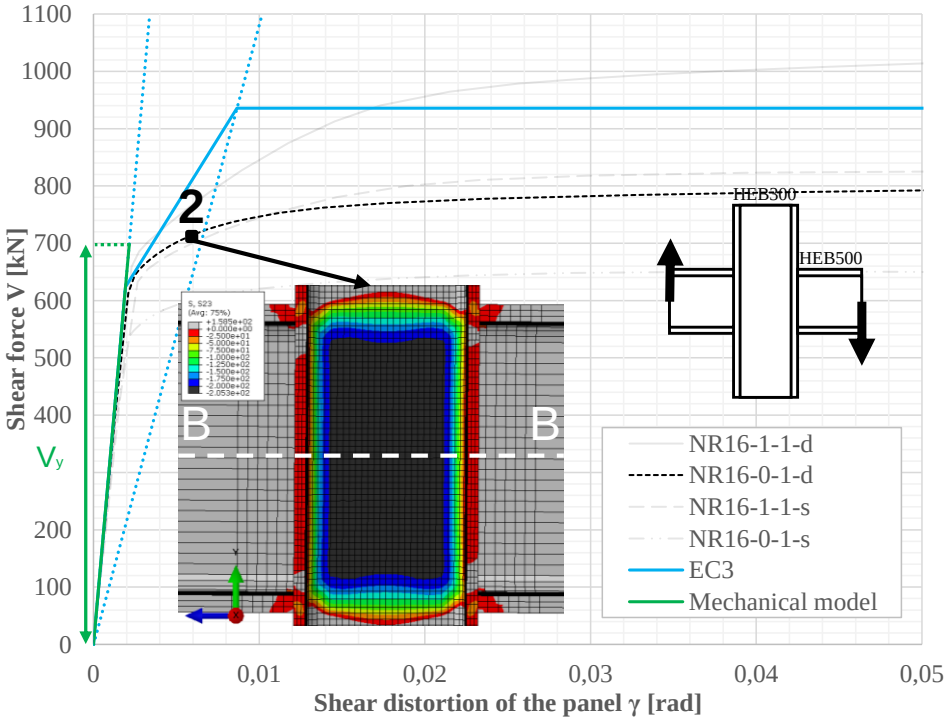
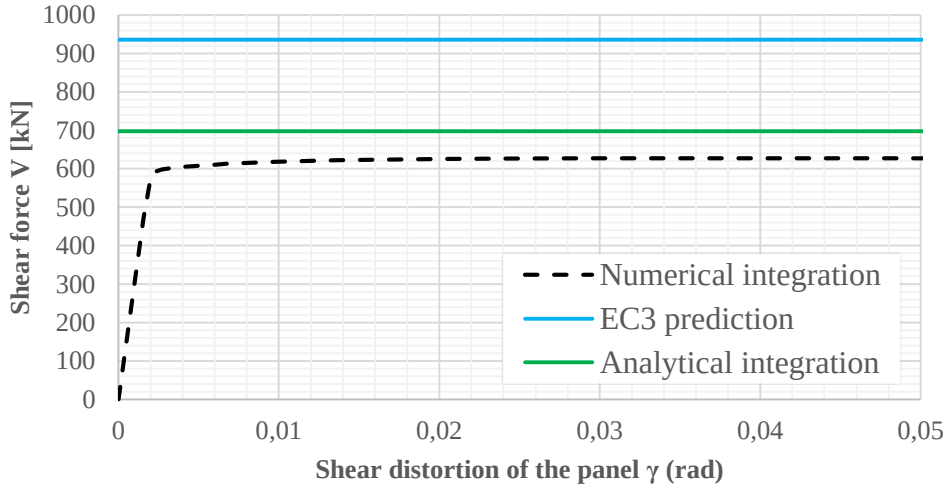
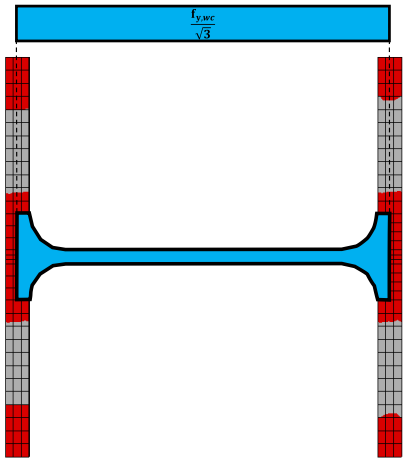


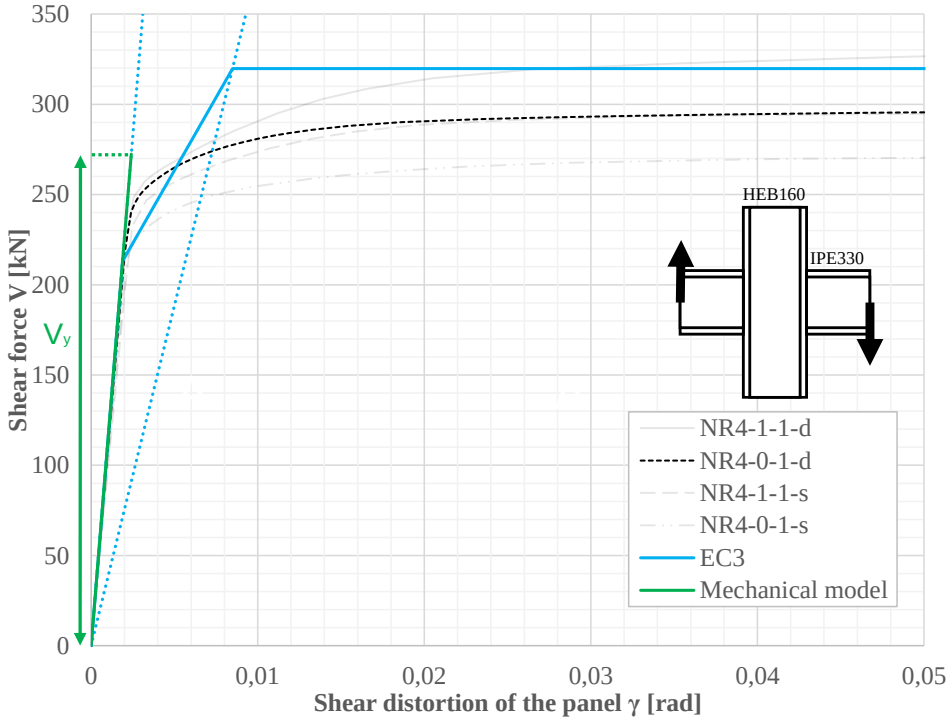




B-B

Assessment of V_y

NR4



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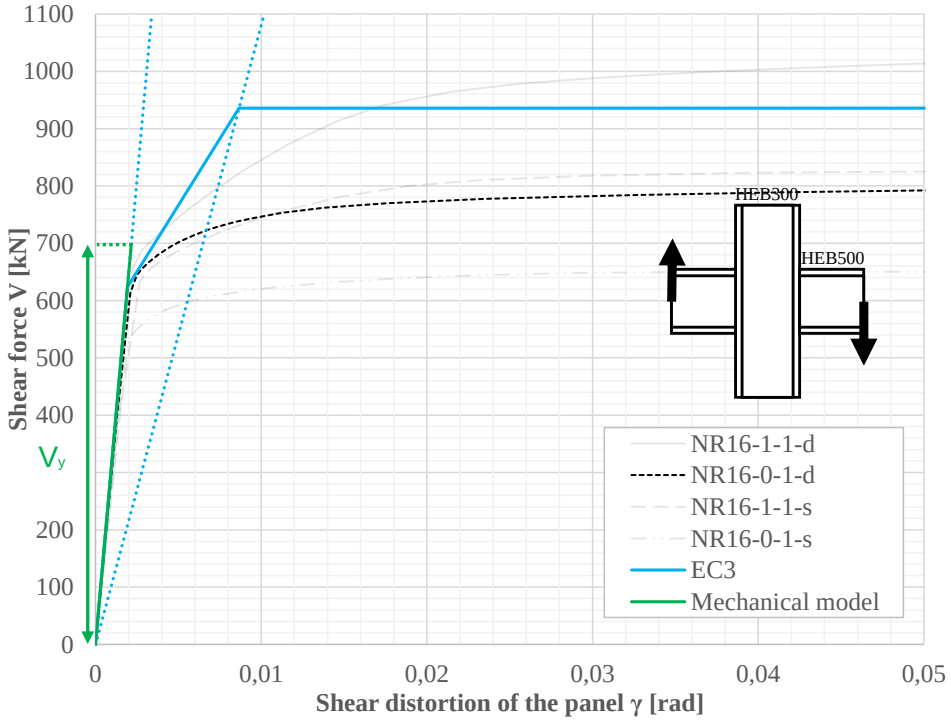
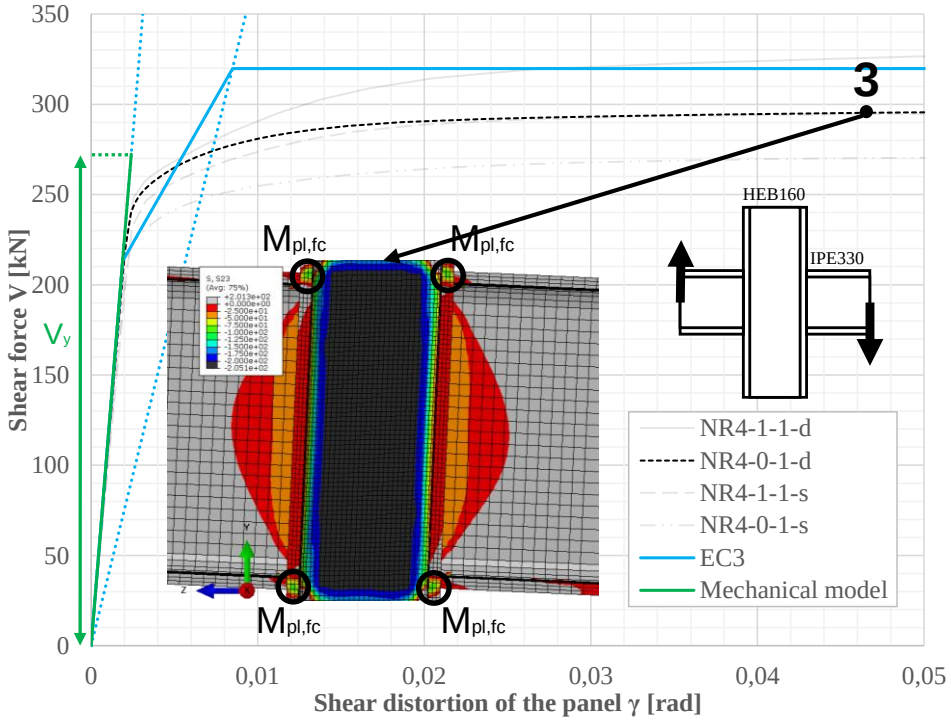


Assessment of ΔV_y

NR4



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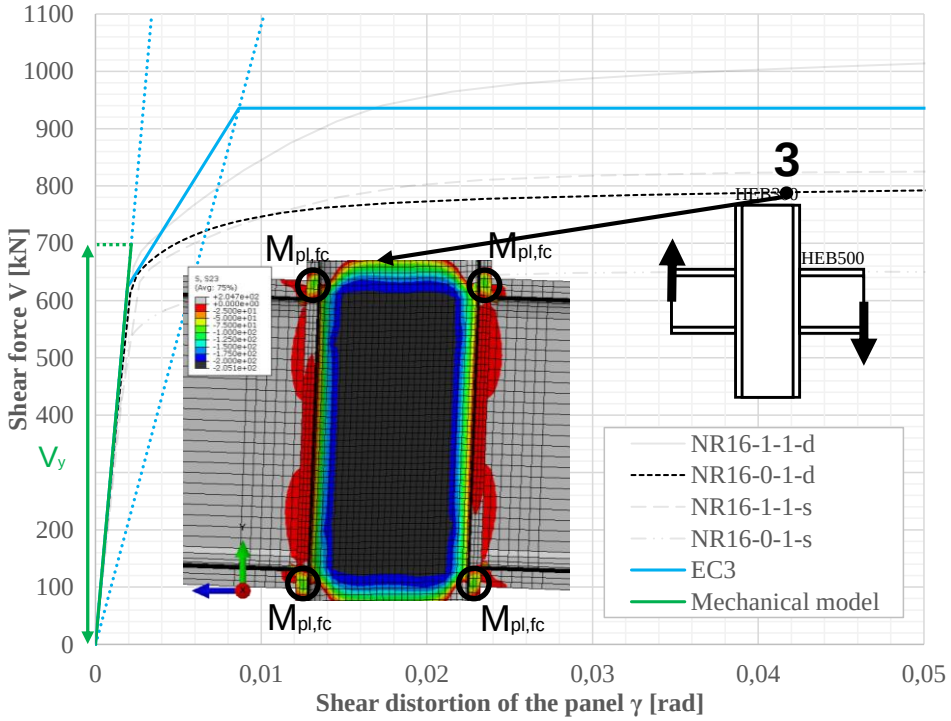
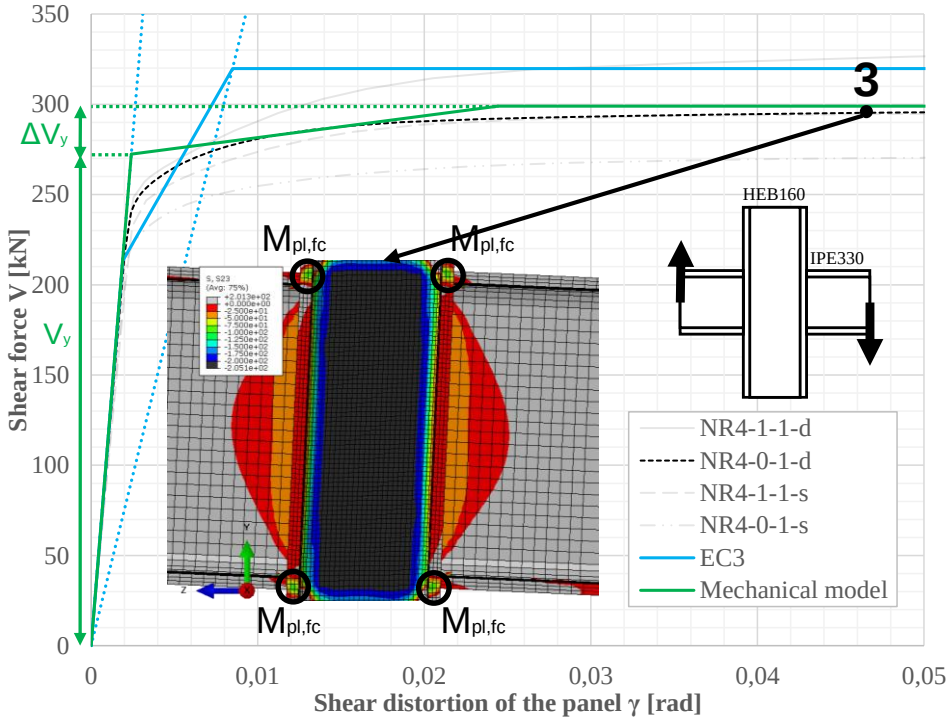


$$\Delta V_y = 4 \cdot \frac{M_{pl,fc}}{d_s}$$

Assessment of ΔV_y

NR4



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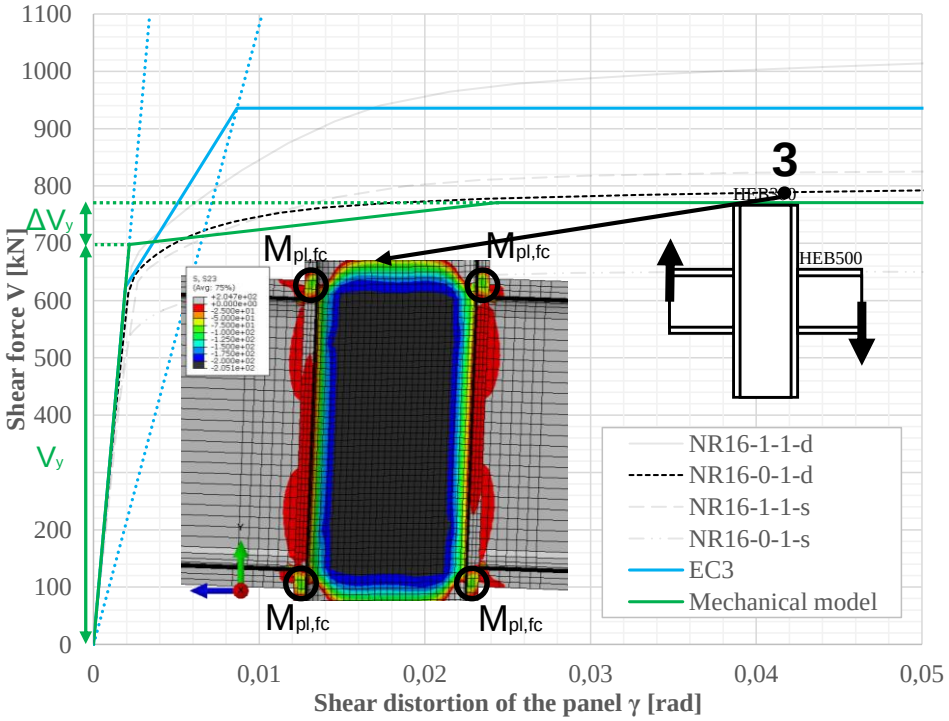

$$\Delta V_y = 4 \cdot \frac{M_{pl,fc}}{d_s}$$

$$K_{e,sur} = 2 \cdot \frac{12 \cdot E \cdot I_{fc}}{d_s^2} \qquad \text{(Jaspart, 1991)}$$

Conclusions & further work

Conclusions & further work

$$V_{PZ} = V_y + \Delta V_y$$

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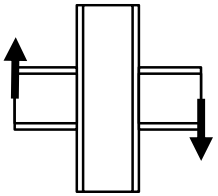
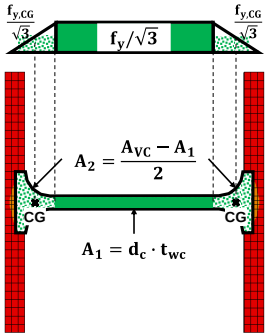
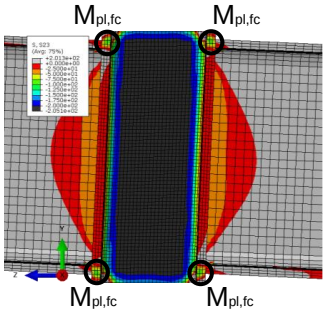
$$V_{PZ} = V_y + \Delta V_y$$

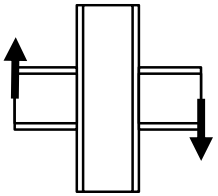
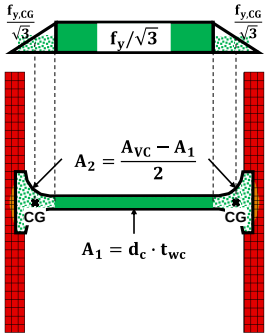
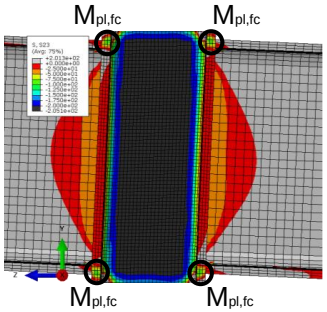
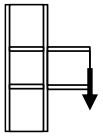
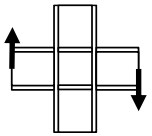
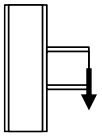
- Welded connections

	V_y	ΔV_y
	 $V_y = A_1 \cdot \frac{f_y}{\sqrt{3}} + 2 \cdot A_2 \cdot \frac{f_y}{\sqrt{3}}$	 $\Delta V_y = 4 \cdot \frac{M_{pl,fc}}{d_s^2}$

Conclusions & further work

$$V_{PZ} = V_y + \Delta V_y$$

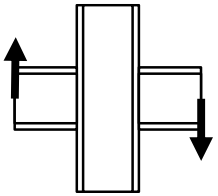
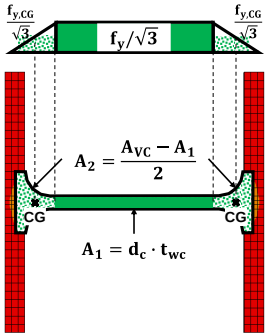
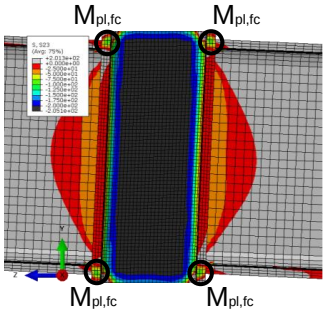
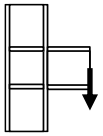
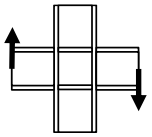
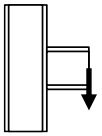
- Welded connections

	V_y	ΔV_y
	 $V_y = A_1 \cdot \frac{f_y}{\sqrt{3}} + 2 \cdot A_2 \cdot \frac{f_y}{\sqrt{3}}$	 $\Delta V_y = 4 \cdot \frac{M_{pl,fc}}{d_s^2}$
	✗	✗
	✗	✗
	✗	✗

Conclusions & further work

$$V_{PZ} = V_y + \Delta V_y$$

- Welded connections

	V_y	ΔV_y
	 $V_y = A_1 \cdot \frac{f_y}{\sqrt{3}} + 2 \cdot A_2 \cdot \frac{f_y}{\sqrt{3}}$	 $\Delta V_y = 4 \cdot \frac{M_{pl,fc}}{d_s^2}$
	✗	✗
	✗	✗
	✗	✗

- Bolted connections

LIÈGE université
School of Engineering

Thank you!
Questions?

NORDIC STEEL 2019

Adrien Corman
Jean-Pierre Jaspart
Jean-François Demonceau

18-20 September 2019, Copenhagen, Denmark
14th Nordic Steel Construction Conference

UEE
Urban & Environmental Engineering

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