

Educational version

Program : MDESIGN 2020 -
Module version : 18.0.3

User :
Date : 16.05.2024

Customer : Student
Project :

Beam

With the following program the static stress analysis of beams can be run.

The calculation results can be displayed graphically (resulting transverse forces, bending moments, bending stresses, shear stresses, deflection, tendency angle, static safety).

Groundwork Calculations

The groundwork of calculations for the calculation module 'Beam Calculation' is the Finite-Element Method.

Scope of the Program

- Loadings:

- Axial forces (centric, eccentric)	F_a	max. 20
- Radial forces	F_r	max. 20
- Distributed loads	q	max. 20
- Bending moments	M_b	max. 10
- Torsion moments	T	max. 10

For the calculation of the beam for the constrained torsion the following limitations are in force:

1. The beam must have a constant longitudinal cross-section.
2. The beam can not have more than one span.
3. Supports of a single beam can be two hinges or two restraints.
4. The calculation is made with according to "TM - Prof. Dr. Wandinger", the results are to be assessed as the first classification of the load. Due to local effects, curvature and the dependence of the load application, the results deviate considerably from a local view using the FEM calculation.

- Bearings

- Number of max. bearings: 10
- Rigid resp. elastic bearings (given bearing stiffness coefficients for degree of freedom)
- Rigid bearing, free bearing, support, rigid clamping

- Analysis of the maximum deflection

- Analysis of the tendency angle of the bearing points

- Optional consideration of own weight

- Determination of different results for any beam position (Moments, Bending, Deflection, Angle of Deflection)

- Static stress analysis σ_f

- max. 50 beam sections

- Available beam profiles:

- Strip steel, hot DIN EN 10058
- Equal leg angles DIN EN 10056-1
- I-beams, I-series DIN 1025-1
- I-beams, IPB-series DIN 1025-2
- I-beams, IPBI-series DIN 1025-3
- I-beams, IPBv-series DIN 1025-4
- I-beams, IPE-series DIN 1025-5
- Square, cold hollow sections DIN EN 10219-2
- Square, hot hollow sections DIN EN 10210-2*
- Rectangular, cold hollow sections DIN EN 10219-2
- Rectangular, hot hollow sections DIN EN 10210-2*
- Rounds, cold hollow sections DIN EN 10219-2
- Rounds, hot hollow sections DIN EN 10210-2*
- Rod, hot DIN EN 10060
- T-steel, circular DIN EN 10055
- Unequal leg angles DIN EN 10056-1

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- U-profile, incline shelf DIN 1026-1
- U-profile, direct shelf DIN 1026-2
- Square profile, hot DIN EN 10059
- Z-steel, hot DIN 1027

* Profiles, whose symbolic notations include the suffix „(1997)“, are no longer part of the present edition of the Norm DIN EN 10210-2.

Input data:

Beam Calculation

Geometry

Geometry scheme

General beam

Detailed calculation for position

x = 35 mm

Bearings

Nr.	Position x mm	Stiffness c_x N/mm	Stiffness c_y N/mm	Stiffness c_z N/mm	Tilt stiffness T_y N·m/°	Tilt stiffness T_z N·m/°
1	0	-1	-1	-1	-1	-1

Loading Data

Axial forces F_{ax}

Nr.	Position x mm	Amount F_{ax} N	Radius r mm	Angle α °
1	165	-700	0	0

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Bending moments M_b

Nr.	Position x mm	Amount M_b N·mm	Angle α °
1	165	-25500	0
2	165	183500	90

Torsion moments T

Nr.	Position x mm	Amount T N·mm	Length l mm
1	165	24000	0

Material Data

Material (strength values) according to

MDESIGN database

Material designation

S235JR

Material number

1.0038

Material group

Unalloyed structural steel

Heat treatment / State

none

Standard dimension

$d_{Nm} = 40$ mm

Standard dimension

$d_{Np} = 40$ mm

Ultimate strength for d_{Nm}

$R_{mN} = 360$ N/mm²

Yield point for d_{Np}

$R_{pN} = 235$ N/mm²

Temperature

T = 20 °C

Material, surface hardened

no

Loads mainly crosswise to the preferred direction of machining (rolling)

no

Results:

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Geometry

Total length of the beam l_g = 165 mm
Total mass of the beam m = 1.18 kg
Position of center of gravity (x-axis) x_s = 79.531 mm

Beam profiles

Cross section nr.	Beam profile	Symbolic notation	Width b mm	Height h mm	Diameter (Distance to axis) d mm	Beam flange t mm	Wall thickness s mm
1	Square, hot hollow sections	60x5	60	60	0	5	0
2	Square, hot hollow sections	50x5	50	50	0	5	0

Beam geometry

Nr	l_i mm	A cm ²	I_y cm ⁴	I_z cm ⁴	W_y cm ³	W_z cm ³	S_y cm ³	S_z cm ³
1	35	10.7	53.3	53.3	17.8	17.8	11.375	11.375
2	130	8.73	28.9	28.9	11.6	11.6	7.625	7.625

Loading Data

Bearing react. force

Nr	Type	Position x mm	R_y N	R_z N	R N	R_{ax} N	α °
1	Rigid clamping	0	-1500	-311.62	1532.03	700	0

Calculation results of maximum stresses and loadings

Max. bending moment

Max. bending moment around y-axis:

Position x = 0 mm
Amount $M_{y\max}$ = 75.924 N·m

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Max. bending moment around z-axis:

Position	x	=	0	mm
Amount	M_{zmax}	=	431	N·m

Resulting maximum bending moment:

Position	x	=	0	mm
Amount	M_{bmax}	=	437636.234	N·mm

Resulting maximum tension-pressure-stress:

Position	x	=	35	mm
Amount	σ_{zmax}	=	-0.802	N/mm ²

Maximum value of the normal stress

Salient point	Tension-pressure-stress σ_{zd} N/mm ²	Bending stress in consequence of M_{ymax} ($M_{\eta max}$) $\sigma_{\eta max}$ N/mm ²	Bending stress in consequence of M_{zmax} ($M_{\zeta max}$) $\sigma_{\zeta max}$ N/mm ²	Combined characteristic of normal stress σ_{res} N/mm ²
P1	0.8	32.74	5.63	39.17
P2	0.8	32.74	0	33.54
P3	0.8	32.74	-5.63	27.92
P3*	0.8	32.74	-5.63	27.92
P4	0.8	0	-5.63	-4.83
P5*	0.8	-32.74	-5.63	-37.57
P5	0.8	-32.74	-5.63	-37.57
P6	0.8	-32.74	0	-31.94
P7	0.8	-32.74	5.63	-26.31
P7*	0.8	-32.74	5.63	-26.31
P8	0.8	0	5.63	6.43
P1*	0.8	32.74	5.63	39.17

Maximum combined characteristic of the normal stress

Position	x	=	35	mm
Amount	σ_{resmax}	=	39.173	N/mm ²

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Maximum value of the shear stress

Salient point	Shear stress in consequence of F_z τ_{zmax} N/mm ²	Shear stress in consequence of F_y τ_{ymax} N/mm ²	Stress of torsion moment τ N/mm ²	Combined characteristic of shear stress τ_{res} N/mm ²
P1	-0.6	-2.92	0	-3.52
P2	-0.93	0	0	-0.93
P3	-0.6	-2.92	0	-3.52
P3*	-0.6	-2.92	0	-3.52
P4	0	-4.54	0	-4.54
P5*	-0.6	-2.92	0	-3.52
P5	-0.6	-2.92	0	-3.52
P6	-0.93	0	0	-0.93
P7	-0.6	-2.92	0	-3.52
P7*	-0.6	-2.92	0	-3.52
P8	0	-4.54	0	-4.54
P1*	-0.6	-2.92	0	-3.52

Maximum combined characteristic of
the shear stress

Position x = 35 mm
Amount τ_{resmax} = 4.542 N/mm²

Maximum equivalent stress:

Position x = 35 mm
Amount σ_{vxmax} = 39.644 N/mm²

Min. safety against yield point:

Position x = 35 mm
Amount S_{Fmin} = 5.928

Max. deflection

Resultant max. deflection

Position x = 165 mm
Amount v_{max} = 0.063 mm

Angle of the maximum deflection

Position x = 165 mm
Amount = 0.04229 °

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Calculation results for point

$x = 35$ mm

Bending moments around y-axis

$M_y = 378.5$ N·m

Bending moments around z-axis

$M_z = 65.068$ N·m

Result. max. bending moment

$M_b = 384.052$ N·m

Tension-pressure-stress

$\sigma_{zdx} = -0.802$ N/mm²

Normal stress

Salient point	Tension-pressure-stress σ_{zd} N/mm ²	Bending stress in consequence of M_y (M η) σ_η N/mm ²	Bending stress in consequence of M_z (M ζ) σ_ζ N/mm ²	Combined characteristic of normal stress σ_{res} N/mm ²
P1	-0.8	21.3	3.66	25.77
P2	-0.8	21.3	0	22.11
P3	-0.8	21.3	-3.66	18.44
P3*	-0.8	21.3	-3.66	18.44
P4	-0.8	0	-3.66	-2.86
P5*	-0.8	-21.3	-3.66	-24.16
P5	-0.8	-21.3	-3.66	-24.16
P6	-0.8	-21.3	0	-20.5
P7	-0.8	-21.3	3.66	-16.84
P7*	-0.8	-21.3	3.66	-16.84
P8	-0.8	0	3.66	4.46
P1*	-0.8	21.3	3.66	25.77

Maximum combined characteristic of
the normal stress

$\sigma_{res} = 25.768$ N/mm²

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Shear stresses

Salient point	Shear stress in consequence of F_z τ_z N/mm ²	Shear stress in consequence of F_y τ_y N/mm ²	Stress of torsion moment τ N/mm ²	Combined characteristic of shear stress τ_{res} N/mm ²
P1	-0.48	-2.32	0	-2.8
P2	-0.74	0	0	-0.74
P3	-0.48	-2.32	0	-2.8
P3*	-0.48	-2.32	0	-2.8
P4	0	-3.59	0	-3.59
P5*	-0.48	-2.32	0	-2.8
P5	-0.48	-2.32	0	-2.8
P6	-0.74	0	0	-0.74
P7	-0.48	-2.32	0	-2.8
P7*	-0.48	-2.32	0	-2.8
P8	0	-3.59	0	-3.59
P1*	-0.48	-2.32	0	-2.8

Maximum combined characteristic of the shear stress $\tau_{res} = 3.588$ N/mm²

Equivalent stress $\sigma_{vx} = 26.507$ N/mm²

Safety against yield point $S_F = 8.866$

Resulting maximum deflection $v = 0.002$ mm

Angle of the deflection $= 0.007361$ °

Material Data

Material data for $x = 35$ mm
Effective blank diameter $d_{eff} = 17.83$ mm
Ultimate strength $R_m = 360$ N/mm²
Yielding point $R_e = 235$ N/mm²

Notice:

For the calculation of the beam for the constrained torsion the following limitations are in force:

- the beam must have a constant longitudinal cross-section;
- the beam can not have more than one span;
- supports of a single beam can be two hinges or two restraint;

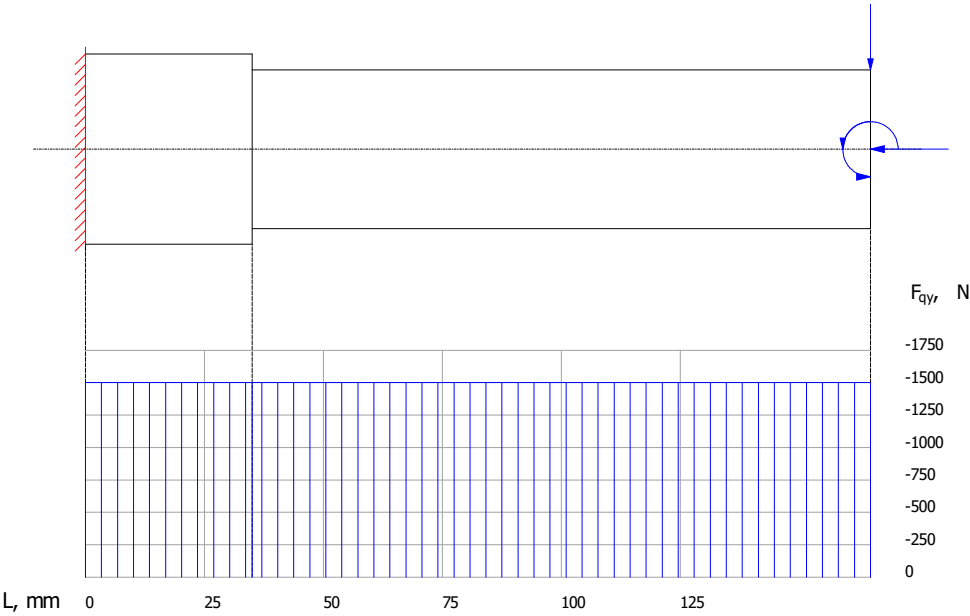
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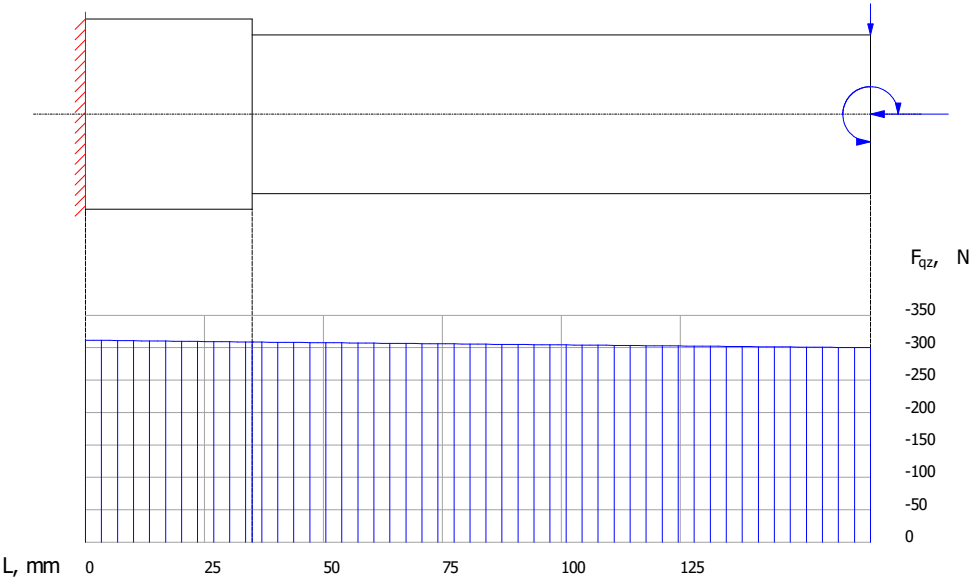
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- as beam profiles only standard profiles should be considered.

Transverse force development (X - Y - plane)



Transverse force development (X - Z - plane)

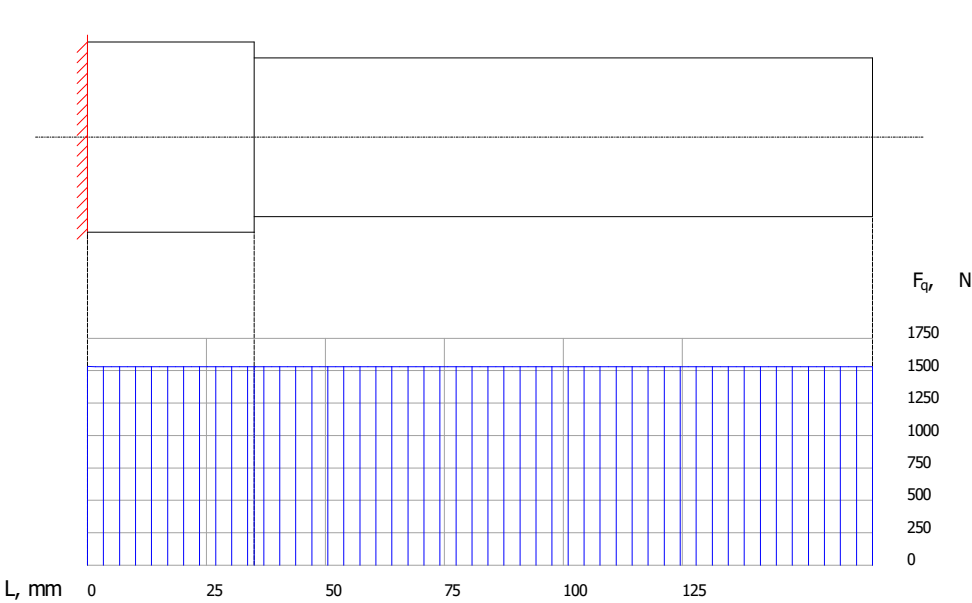


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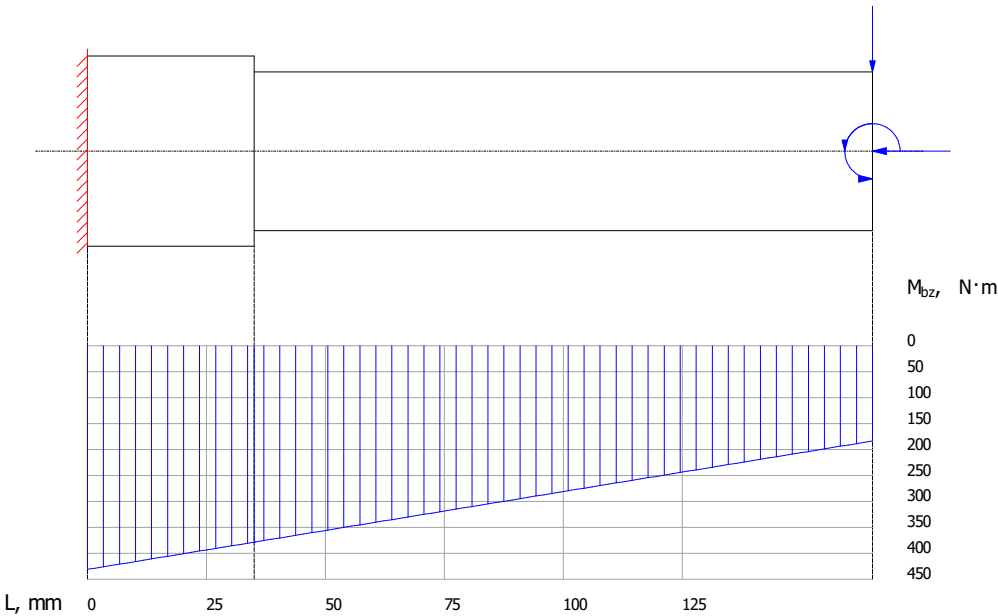
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Transverse force development (resultant)



Bending moment development (X - Y - plane)

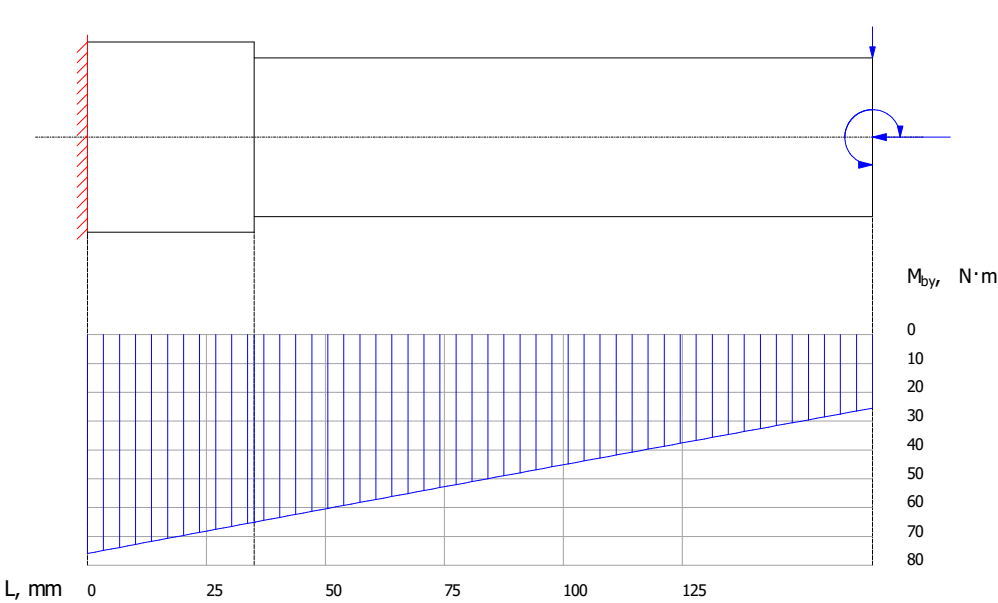


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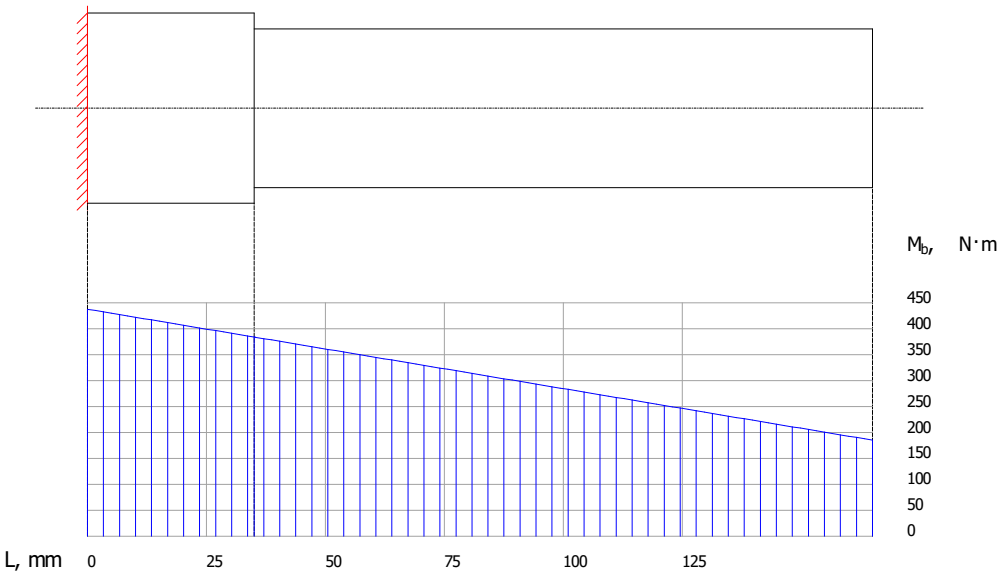
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Bending moment development (X - Z - plane)



Bending moment development (resultant)

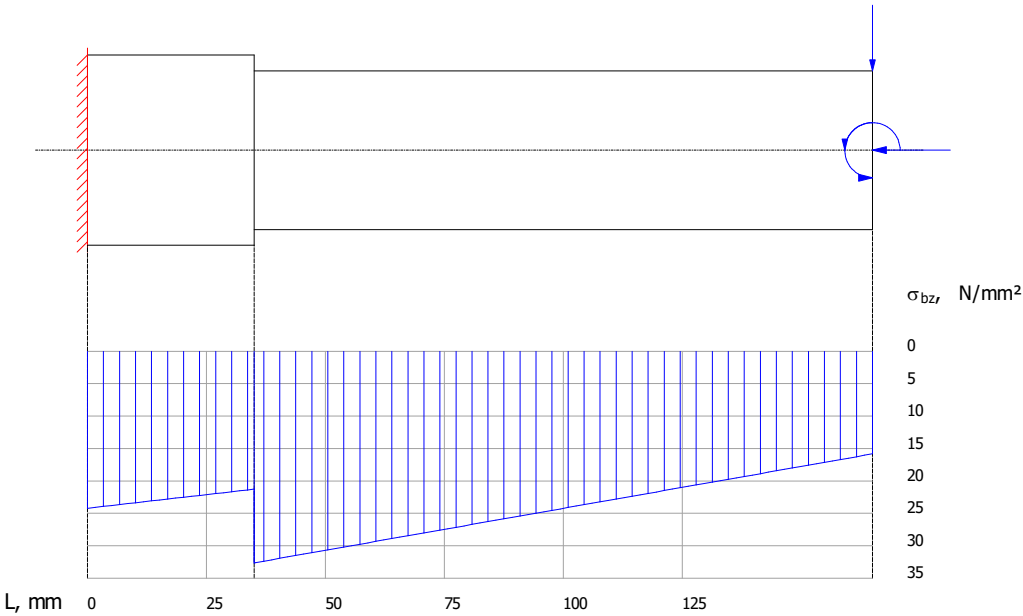


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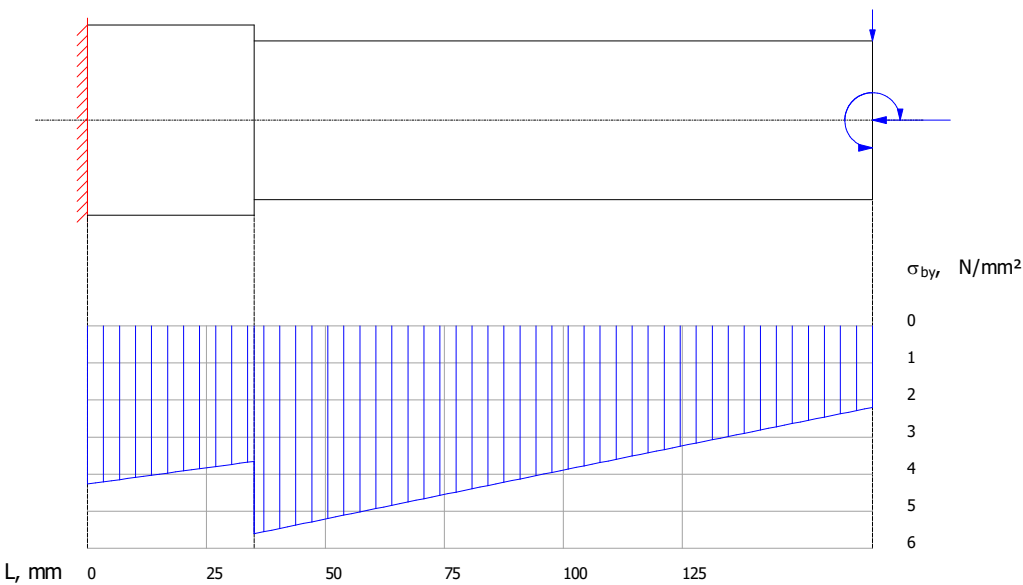
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Bending stress development (X - Y - plane)



Bending stress development (X - Z - plane)

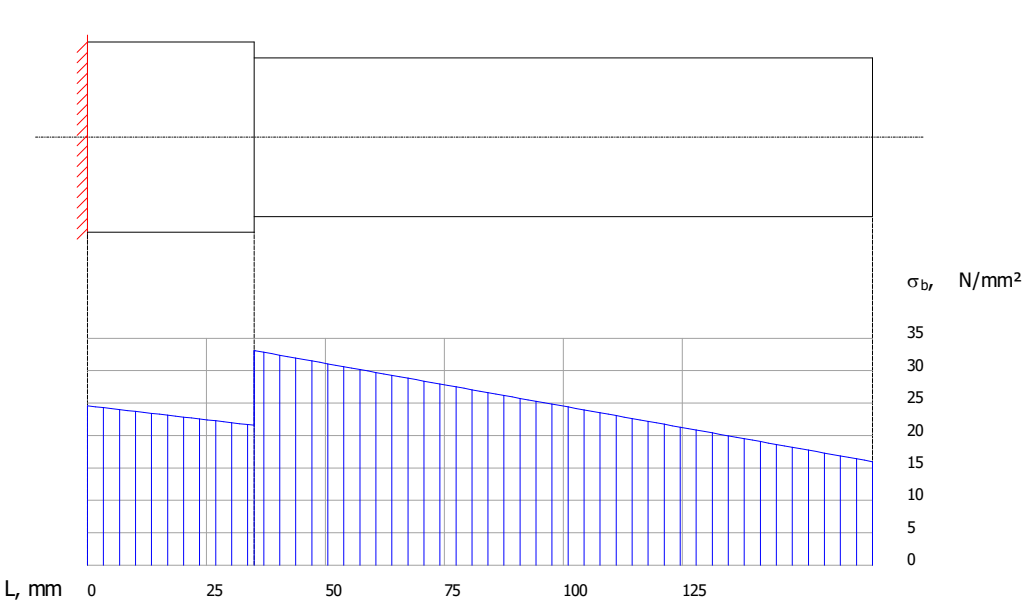


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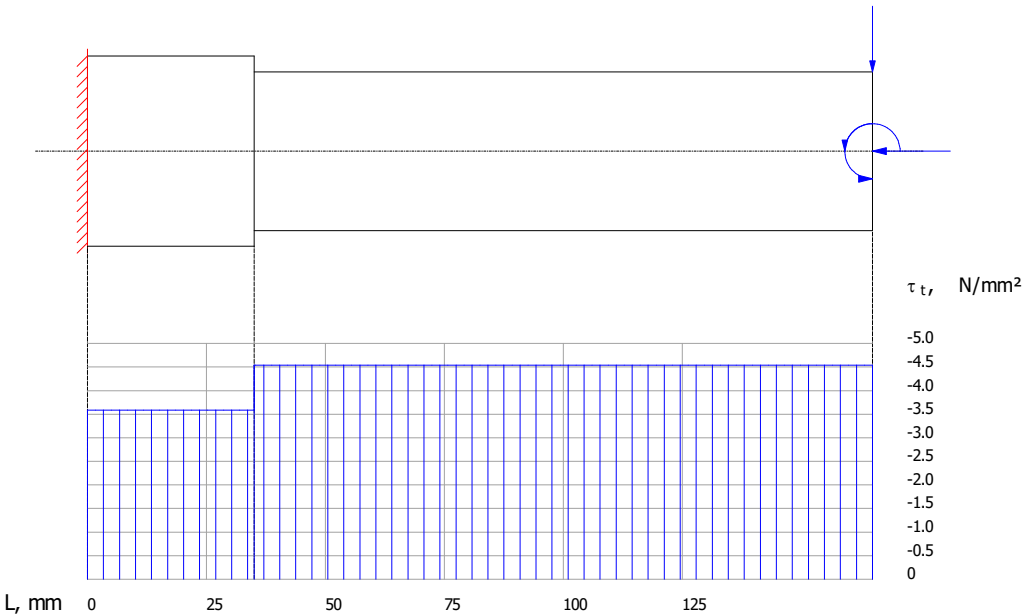
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Bending stress development (resultant)



Shear stress development (X - Y - plane)

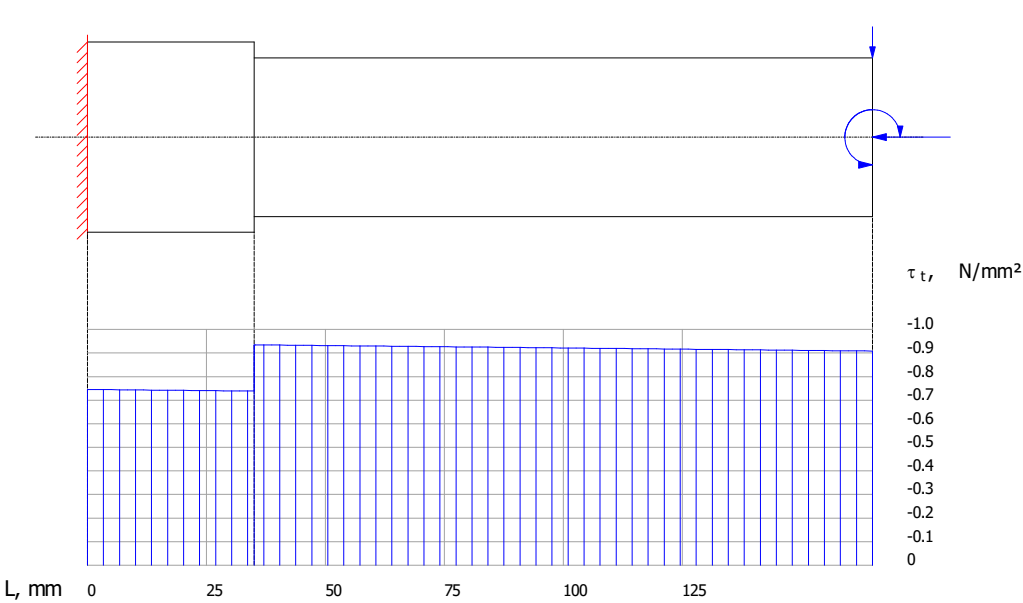


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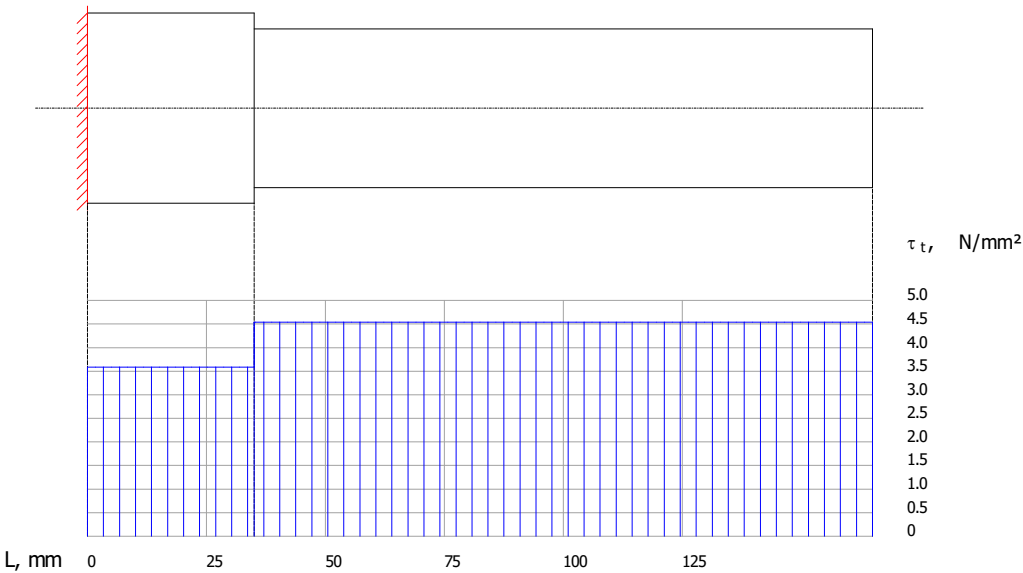
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Shear stress development (X - Z - plane)



Shear stress development (resultant)

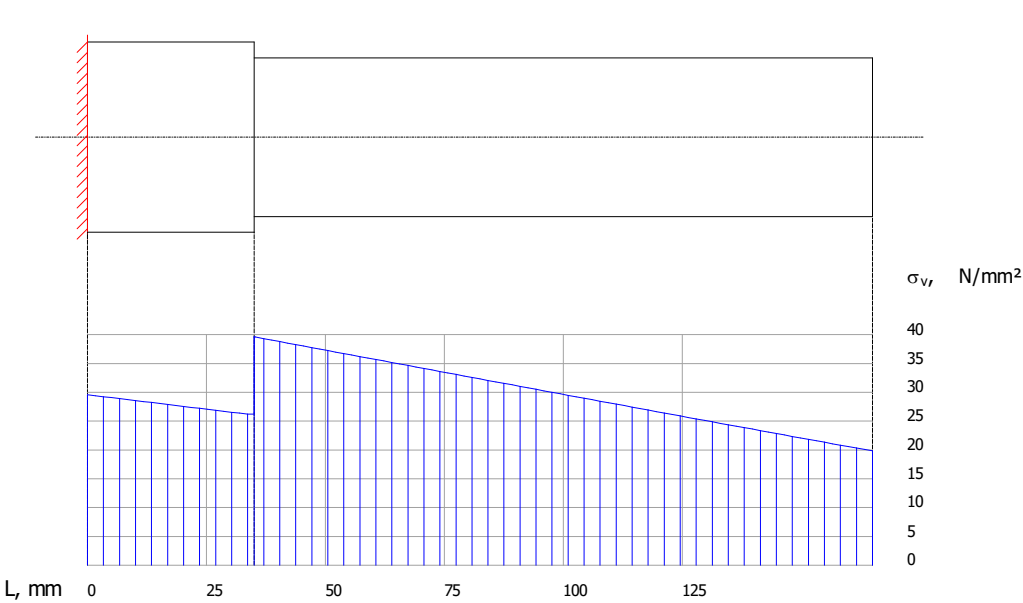


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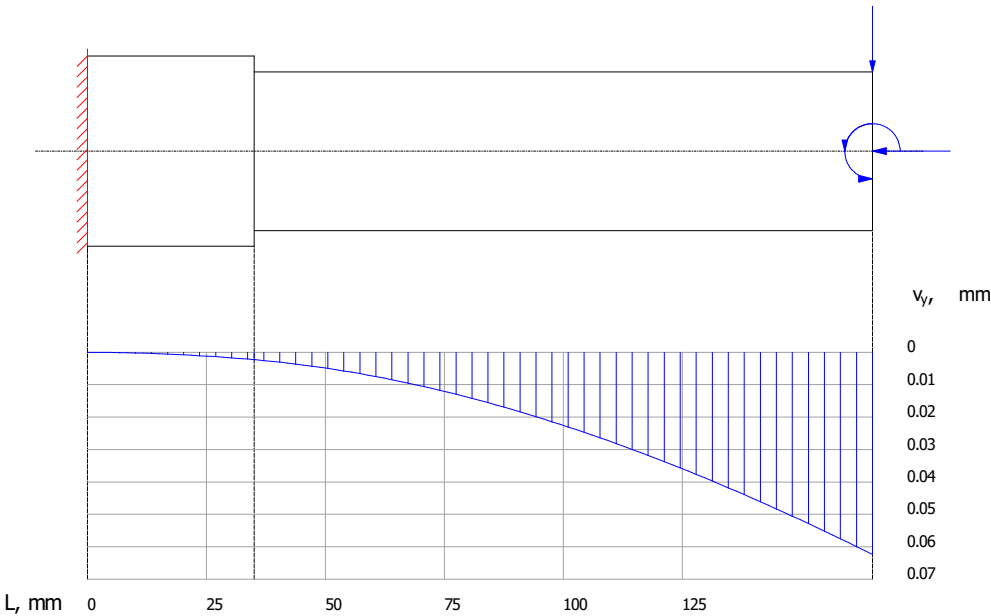
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Equivalent stress development (resultant)



Deflection (X - Y - plane)

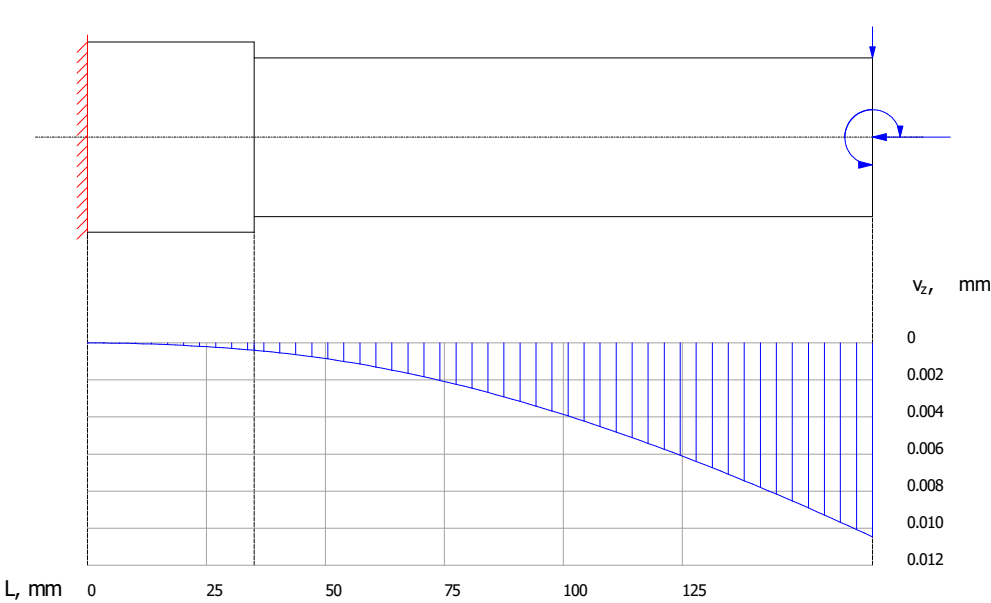


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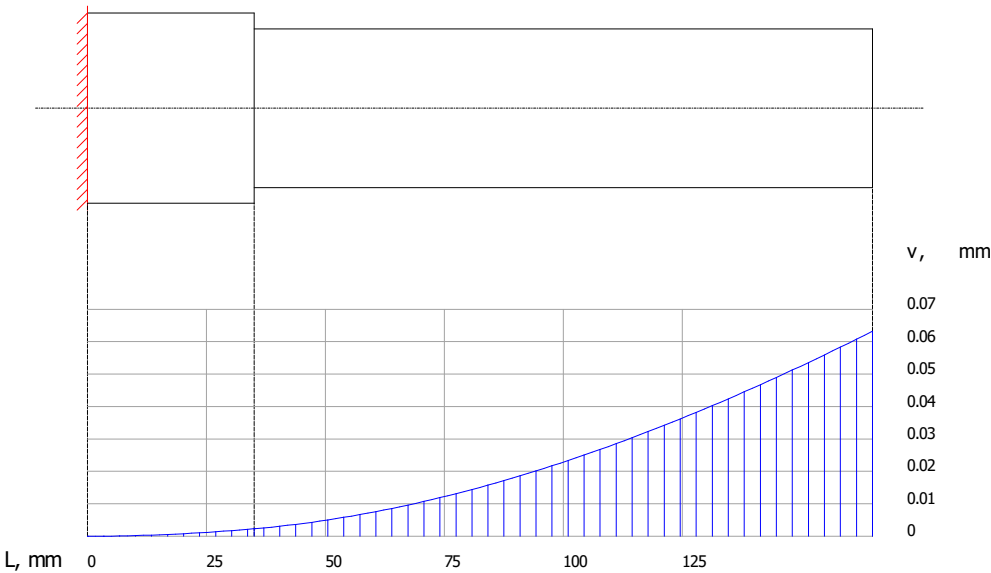
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Deflection (X - Z - plane)



Deflection (resultant)

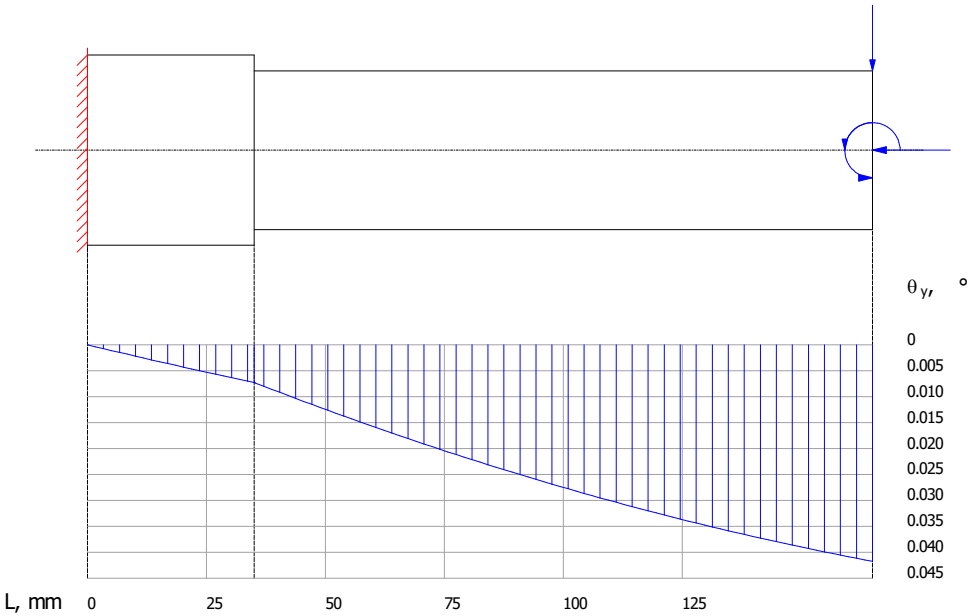


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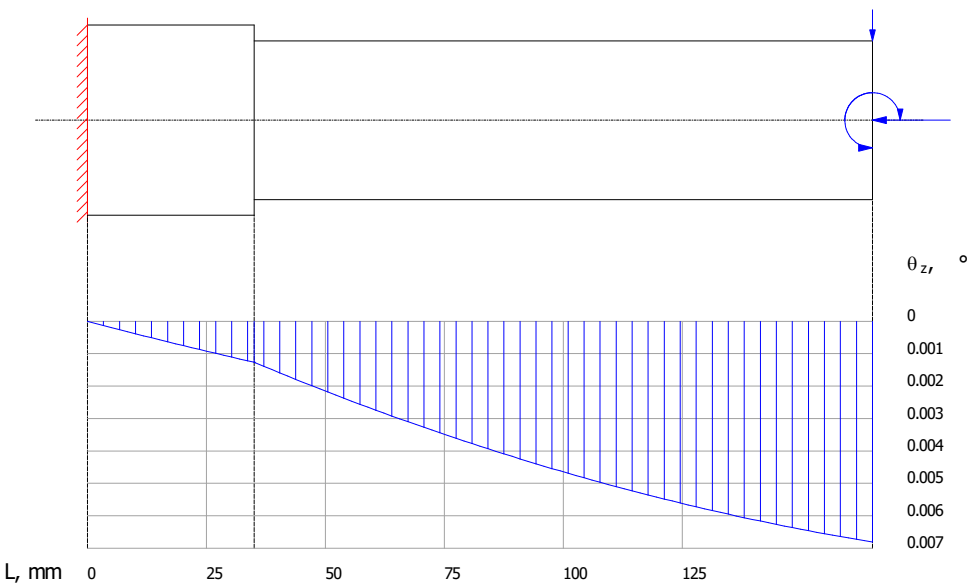
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Inclination (X - Y - plane)



Inclination (X - Z - plane)

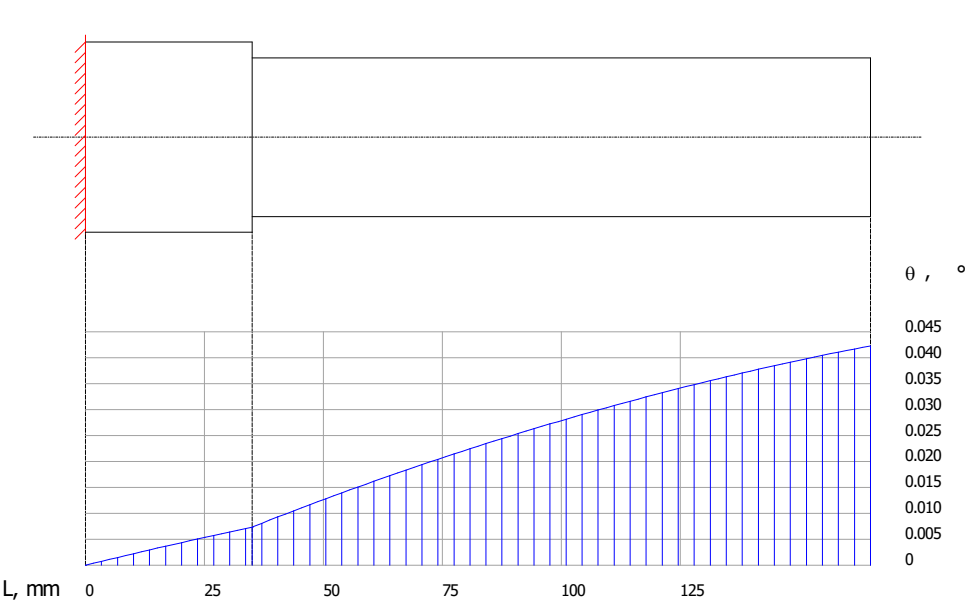


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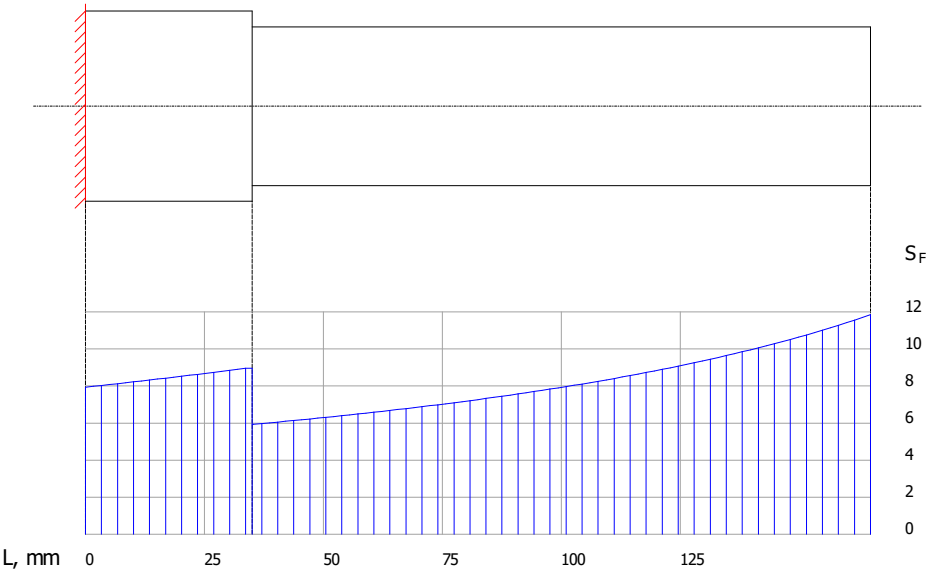
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Inclination (resultant)



Safety against yield point
(detail: S $f = 5 \cdot S$ f_m in)

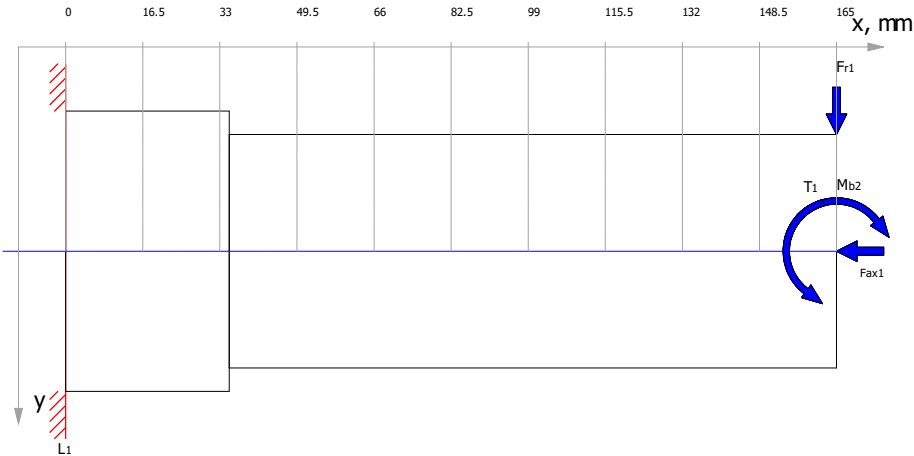


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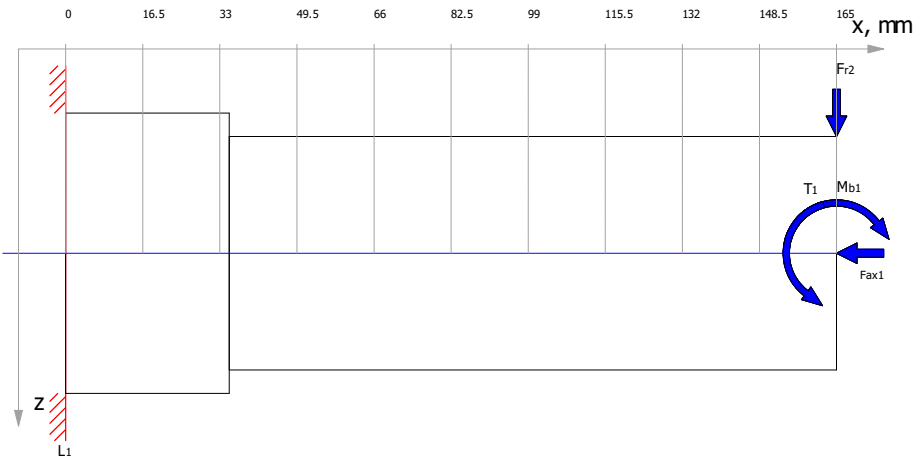
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Resultant graphic (X - Y - plane)



Resultant graphic (X - Z - plane)

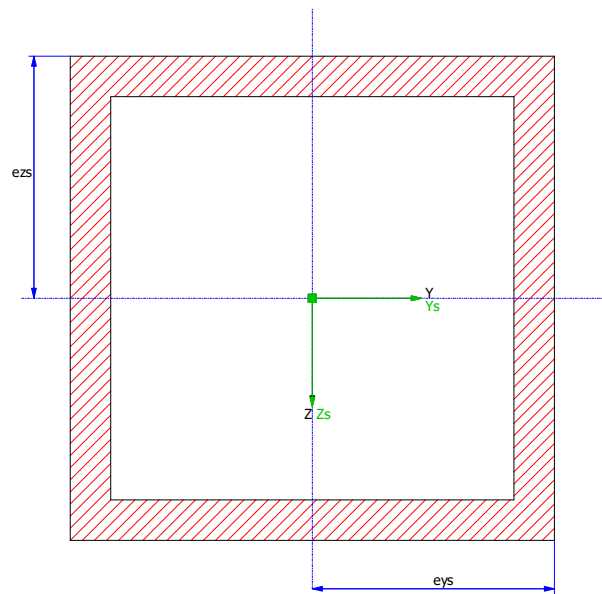


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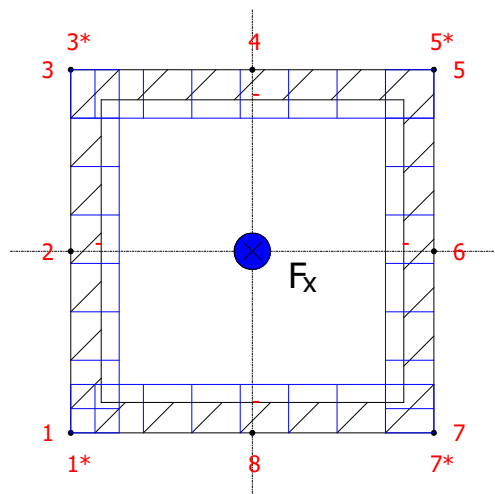
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Graphical presentation



Stress of axial force F_x

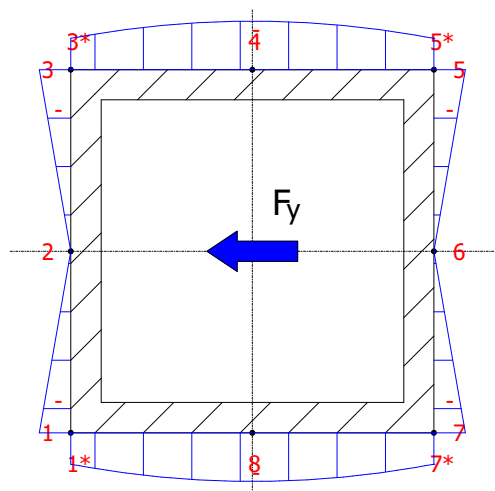


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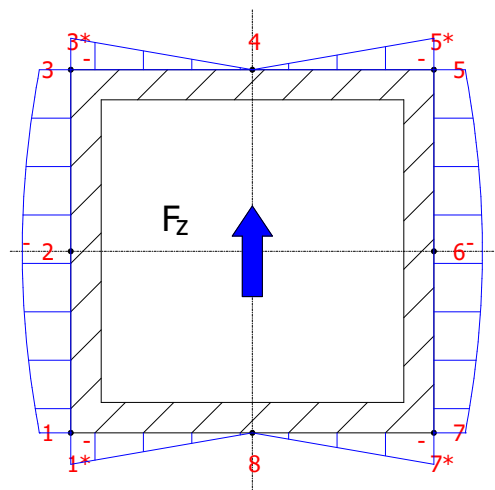
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Stress of radial force F_y



Stress of radial force F_z

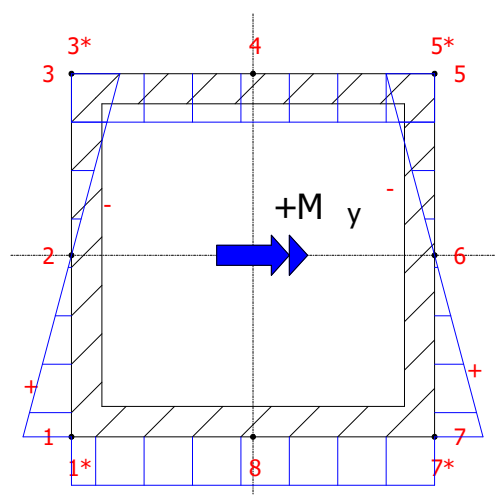


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Stress of bending moment M_y



Stress of bending moment M_z

