Wire Rope Tension and Bending Stress (Reuleaux)

Direct tensile stress, bending stress over a sheave by Reuleaux's formula and the static factor of safety of a wire rope from load, rope size and sheave diameter.

Method: Shigley's Mechanical Engineering Design (Budynas and Nisbett); ch. 17 (wire rope, bending stress σ_b = E_r d_w / D)

Factor of safety F_u/(W + F_b): use this one

3.3228

Input parameters

Unit system: SI

Parameter	Value	Unit
Load on the rope (including hook and rope weight)	50.000	kN
Rope diameter	20.000	mm
Metallic area as a share of the circle πd²/4 About 0.4 to 0.6 by construction; from the rope maker.	50.000	%
Outer wire diameter	1.3000	mm
Sheave pitch diameter	600.00	mm
Modulus of the rope	83.000	GPa
Minimum breaking force of the rope	260.00	kN

Calculated results

Parameter	Value	Unit
Metallic area	157.08	mm²
Direct tensile stress W/A	318.31	MPa
Bending stress E_r d_w/D	179.83	MPa
Equivalent bending load σ_b A	28.248	kN
Factor of safety F_u/(W + F_b): use this one	**3.3228**	
Shigley form (F_u − F_b)/W, only with Shigley's design factors	4.6350	

Notes for this case

- Use n = F_u/(W + F_b) for static and bending checks of stationary or general hoisting ropes. Shigley's n_s = (F_u − F_b)/W is higher and belongs with Shigley's fatigue-adjusted design factors for high-speed mine or elevator hoisting; do not judge it against the limits used for n.
- Lifting codes set minimum factors of safety and D/d ratios for each duty; this is a static check only.

Formula and method

$$\sigma_t = \frac{W}{A_m}, \quad \sigma_b = \frac{E_r d_w}{D}, \quad n = \frac{F_u}{W + \sigma_b A_m}, \quad n_s = \frac{F_u - F_b}{W}$$

Variables

W	Load on the rope (including hook and rope weight)	N
d_r	Rope diameter	m
A_m	Metallic area as a share of the circle πd²/4	-
d_w	Outer wire diameter	m
D	Sheave pitch diameter	m

E_r	Modulus of the rope	Pa
F_u	Minimum breaking force of the rope	N
A	Metallic area	m²
σ_t	Direct tensile stress W/A	Pa
σ_b	Bending stress E_r d_w/D	Pa
F_b	Equivalent bending load σ_b A	N
n	Factor of safety F_u/(W + F_b), the one to use	-
n_s	Shigley form (F_u − F_b)/W, only with Shigley's design factors	-

Method and standards

Reuleaux bending stress of wires over a sheave.

Assumptions and limits

- Shigley defines the static factor as n_s = (F_u − F_b)/F_t, with F_t the rope tension (W here); it is shown as n_s. The factor n = F_u/(W + F_b) adds the bending load to the tension instead of subtracting it from the strength, and gives a lower (more conservative) figure. Use n for static and bending checks of stationary or general hoisting ropes (50 kN on a 20 mm rope over a 600 mm sheave: n = 3.32). Use n_s (4.63 for the same case) only when working with Shigley's fatigue-adjusted design factors for dynamic, high-speed mine or elevator hoisting.
- Static load.

References

• Shigley's Mechanical Engineering Design (Budynas and Nisbett)
• ch. 17 (wire rope, bending stress σ_b = E_r d_w / D)

Report details

Report reference	FCC-WNEW-QAKP (the same inputs always give the same reference)
Generated	17 November 2026, 19:45 UTC
Calculator	Wire Rope Tension and Bending Stress (Reuleaux)
Method last reviewed	12 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/machine-design/wire-rope-stress

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