Tension Member: Gross, Net and Effective Area and Capacity

Gross area, net area on straight and staggered failure paths (s²/4g rule), effective net area with shear lag, and yield and rupture capacities of a plate or angle.

Method: Net-section rule with Cochrane s²/4g stagger term

Input parameters

Unit system: SI

Parameter	Value	Unit
Plate width (or developed angle width)	200.00	mm
Thickness	12.000	mm
Hole diameter	22.000	mm
Holes on the straight path	2.0000	
Holes on the staggered path	3.0000	
Stagger spaces on that path	2.0000	
Stagger pitch (along the force)	50.000	mm
Gauge (across the force)	60.000	mm
Shear lag factor	85.000	%
Yield stress	250.00	MPa
Ultimate stress	410.00	MPa
Yield resistance factor	90.000	%
Rupture resistance factor	75.000	%

Calculated results

Parameter	Value	Unit
Gross area	2,400.0	mm²
Net area, straight path	1,872.0	mm²
Net area, staggered path	1,858.0	mm²
Effective net area	1,579.3	mm²
Yield capacity on gross area	540.00	kN
Rupture capacity on effective net area	485.63	kN
Design tension capacity	485.63	kN

Notes for this case

• A_n = (b − n·d_h + Σs²/4g)·t on each candidate path; the smallest governs. A_e = U·A_n allows for shear lag when only part of the section is connected. Capacity = min(φ_y·A_g·f_y, φ_u·A_e·f_u). Enter the hole size, U and factors your steel code prescribes; also check block shear at the connection.

Formula and method

$$A_n = \left(b - n d_h + \sum \frac{s^2}{4g}\right) t, \quad A_e = U A_n, \quad T_d = \min(\phi_y A_g f_y,\ \phi_u A_e f_u)$$

Variables

b	Plate width (or developed angle width)	m
t	Thickness	m

d_h	Hole diameter	m
n_1	Holes on the straight path	-
n_2	Holes on the staggered path	-
n_s	Stagger spaces on that path	-
s	Stagger pitch (along the force)	m
g	Gauge (across the force)	m
U	Shear lag factor	-
f_y	Yield stress	Pa
f_u	Ultimate stress	Pa
ϕ_y	Yield resistance factor	-
ϕ_u	Rupture resistance factor	-
A_g	Gross area	m²
$A_{n,1}$	Net area, straight path	m²
$A_{n,2}$	Net area, staggered path	m²
A_e	Effective net area	m²
T_y	Yield capacity on gross area	N
T_u	Rupture capacity on effective net area	N
T_d	Design tension capacity	N

Method and standards

Tension member.

Assumptions and limits

- Static tension; holes of one size; no block shear check.

References

Net-section rule with Cochrane $s^2/4g$ stagger term

Report details

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

This calculator online

https://calc.firecad.com/civil/steel/tension-member-net-area

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.