Eccentrically Loaded Bolt Group (Circular Pattern) in Shear

Largest bolt force in a circular bolt group carrying an eccentric shear load: direct shear plus the torsional shear from the moment, and the bolt stress.

Method: Shigley's Mechanical Engineering Design (Budynas and Nisbett); ch. 8 (shear joints with eccentric loading, elastic method)

Input parameters

Unit system: SI

Parameter	Value	Unit
Shear load on the group	20.000	kN
Eccentricity of the load from the group centre	300.00	mm
Number of bolts on the circle	6.0000	
Radius of the bolt circle	100.00	mm
Bolt diameter in shear	16.000	mm

Calculated results

Parameter	Value	Unit
Direct (primary) shear per bolt F/n	3.3333	kN
Torsional (secondary) shear per bolt F e r/Σr²	10.0000	kN
Largest resultant bolt force	13.333	kN
Shear stress in that bolt	66.315	MPa

Notes for this case

- Elastic method: bolts equally stiff, plates rigid. The load is taken perpendicular to the line through the centre, with one bolt on the load line.

Formula and method

$$F' = \frac{F}{n}, \quad F'' = \frac{Fe\,r}{\sum r_i^2} = \frac{Fe}{nr}, \quad F_{max} = \left|\vec{F}' + \vec{F}''\right|_{max}$$

Variables

F	Shear load on the group	N
e	Eccentricity of the load from the group centre	m
n	Number of bolts on the circle	-
r	Radius of the bolt circle	m
d	Bolt diameter in shear	m
F'	Direct (primary) shear per bolt F/n	N
F''	Torsional (secondary) shear per bolt F e r/Σr²	N
F_{max}	Largest resultant bolt force	N
τ	Shear stress in that bolt	Pa

Method and standards

Elastic analysis of a bolt group.

Assumptions and limits

- Equal bolts, rigid plates.
- Shear stress on the nominal (shank) area: if the threads lie in the shear plane use the root area, which gives a higher stress. The stress is not compared with an allowable.

References

- Shigley's Mechanical Engineering Design (Budynas and Nisbett)
- ch. 8 (shear joints with eccentric loading, elastic method)

Report details

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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/eccentric-bolt-group

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.