Important Principal Stress Formulas PDF



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Important Principal Stress Formulas

Evaluate Formula 🕝

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1) Combined Bending and Torsion Condition Formulas

1.1) Angle of Twist in Combined Bending and Torsion Formula 🕝



Example with Units
$$30^{\circ} = \frac{\arctan\left(\frac{0.116913\,\text{MPa}}{67.5\,\text{kN}^{\circ}\text{m}}\right)}{2}$$

1.2) Angle of Twist in Combined Bending and Torsional Stress Formula C





1.3) Bending Moment given Combined Bending and Torsion Formula 🕝





1.4) Bending Stress given Combined Bending and Torsional Stress Formula 🕝



$$\sigma_b = \frac{T}{\frac{\tan{(2 \cdot \theta)}}{2}} \quad \boxed{0.135 \, \text{MPa} = \frac{0.116913 \, \text{MPa}}{\frac{\tan{(2 \cdot 30 \cdot)}}{2}}}$$

1.5) Torsional Moment when Member is subjected to both Bending and Torsion Formula 🕝

1.6) Torsional Stress given Combined Bending and Torsional Stress Formula 🕝



Example with Units
$$0.1169 \, \text{MPa} = 67.5 \, \text{kN*m} \cdot \left(\, \text{tan} \left(\, 2 \cdot 30^{\circ} \, \right) \, \right)$$



2) Complementary Induced Stress Formulas 🕝

2.1) Angle of Oblique Plane using Normal Stress when Complementary Shear Stresses Induced Formula 🕝



Formula Example with Units
$$\theta = \frac{a\sin\left(\frac{\sigma_{\theta}}{\tau}\right)}{2}$$

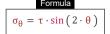
$$44.4537^{\circ} = \frac{a\sin\left(\frac{54.99 \, \text{MPa}}{55 \, \text{MPa}}\right)}{2}$$

2.2) Angle of Oblique Plane using Shear Stress when Complementary Shear Stresses Induced Formula (



$$\theta = 0.5 \cdot \arccos\left(\frac{\tau_{\theta}}{\tau}\right) \boxed{ 29.6105^{\circ} = 0.5 \cdot \arccos\left(\frac{28.145\,\text{MPa}}{55\,\text{MPa}}\right) }$$

2.3) Normal Stress when Complementary Shear Stresses Induced Formula 🕝



Formula Example with Units
$$\sigma_{\theta} = \tau \cdot \sin\left(2 \cdot \theta\right)$$

$$47.6314 \, \text{MPa} = 55 \, \text{MPa} \cdot \sin\left(2 \cdot 30^{\circ}\right)$$

2.4) Shear Stress along Oblique Plane when Complementary Shear Stresses Induced Formula 🕝

$$\tau_{\theta} = \tau \cdot \cos(2 \cdot \theta)$$

$$\tau_{\theta} = \tau \cdot \cos\left(2 \cdot \theta\right) \\ \hline \begin{bmatrix} 27.5 \, \text{MPa} & = 55 \, \text{MPa} \cdot \cos\left(2 \cdot 30^{\circ}\right) \end{bmatrix}$$

2.5) Shear Stress due to Effect of Complementary Shear Stresses and Shear Stress in Oblique Plane Formula 🕝

$$\tau = \frac{\tau_{\theta}}{\cos(2 \cdot \theta)}$$

Formula Example with Units
$$\tau = \frac{\tau_{\theta}}{\cos\left(2 \cdot \theta\right)} \qquad 56.29 \, \text{MPa} = \frac{28.145 \, \text{MPa}}{\cos\left(2 \cdot 30^{\circ}\right)}$$

2.6) Shear Stress due to Induced Complementary Shear Stresses and Normal Stress on Oblique Plane Formula 🖰

$$\tau = \frac{\sigma_{\theta}}{\sin(2 \cdot \theta)}$$

Formula Example with Units
$$\tau = \frac{\sigma_{\theta}}{\sin\left(2 \cdot \theta\right)} = \frac{54.99 \, \text{MPa}}{\sin\left(2 \cdot 30^{\circ}\right)}$$



3.1) Bending Stress of Circular Shaft given Equivalent Bending Moment Formula 🕝



Formula Example with Units
$$\sigma_b = \frac{32 \cdot M_e}{\pi \cdot \left(\phi^3 \right)} \quad \boxed{ 0.7243 \, \text{MPa} = \frac{32 \cdot 30 \, \text{kN}^* \text{m}}{3.1416 \cdot \left(750 \, \text{mm}^{\ 3} \right)} }$$

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3.2) Diameter of Circular Shaft for Equivalent Torque and Maximum Shear Stress Formula 🕝

Formula
$$\Phi = \left(\frac{16 \cdot T_e}{\pi \cdot \left(\tau_{\text{max}}\right)}\right)^{\frac{1}{3}}$$

Formula Example with Units
$$\Phi = \left(\frac{16 \cdot T_e}{\pi \cdot \left(\tau_{max}\right)}\right)^{\frac{1}{3}}$$

$$157.1413 \, \text{mm} = \left(\frac{16 \cdot 32 \, \text{kN*m}}{3.1416 \cdot \left(42 \, \text{MPa}\right)}\right)^{\frac{1}{3}}$$

Evaluate Formula

Evaluate Formula 🕝

3.3) Diameter of Circular Shaft given Equivalent Bending Stress Formula 🕝

Formula
$$\Phi = \left(\frac{32 \cdot M_e}{\pi \cdot \left(\sigma_b\right)}\right)^{\frac{1}{3}}$$

Formula Example with Units
$$\Phi = \left(\frac{32 \cdot M_e}{\pi \cdot \left(\sigma_b\right)}\right)^{\frac{1}{3}}$$

$$751.5011_{mm} = \left(\frac{32 \cdot 30_{\,\text{kN*m}}}{3.1416 \cdot \left(0.72_{\,\text{MPa}}\right)}\right)^{\frac{1}{3}}$$

3.4) Equivalent Bending Moment of Circular Shaft Formula 🕝

Formula
$$M_{e} = \frac{\sigma_{b}}{\frac{32}{\pi \cdot (\Phi^{3})}}$$

Evaluate Formula 🕝

Evaluate Formula 🕝

3.5) Equivalent Torque given Maximum Shear Stress Formula 🗂

Formula
$$T_{e} = \frac{\tau_{max}}{\frac{16}{\pi \cdot (\Phi^{3})}}$$

Formula Example with Units
$$T_{e} = \frac{\tau_{max}}{\frac{16}{\pi \cdot \left(\Phi^{3}\right)}} \quad \boxed{ 3479.0684 \, \text{kN*m} = \frac{42 \, \text{MPa}}{\frac{16}{3.1416 \cdot \left(750 \, \text{mm}^{3}\right)}} }$$

3.6) Location of Principal Planes Formula

Formula
$$\theta = \left(\left(\left(\frac{1}{2} \right) \cdot a tan \left(\frac{2 \cdot \tau_{xy}}{\sigma_y - \sigma_x} \right) \right) \right)$$

Formula Example with Units
$$\theta = \left(\left(\left(\frac{1}{2} \right) \cdot a tan \left(\frac{2 \cdot \tau_{xy}}{\sigma_y \cdot \sigma_x} \right) \right) \right)$$

$$6.2457^{\circ} = \left(\left(\left(\frac{1}{2} \right) \cdot a tan \left(\frac{2 \cdot 7.2 \, \text{MPa}}{110 \, \text{MPa} \cdot 45 \, \text{MPa}} \right) \right) \right)$$

3.7) Maximum Shear Stress due to Equivalent Torque Formula [7]

Formula
$$\tau_{\text{max}} = \frac{16 \cdot T_{\text{e}}}{\pi \cdot \left(\Phi^{3}\right)}$$

Formula Example with Units
$$\tau_{max} = \frac{16 \cdot T_e}{\pi \cdot \left(\Phi^3\right)} \quad \boxed{ 0.3863 \, \text{MPa} = \frac{16 \cdot 32 \, \text{kN*m}}{3.1416 \cdot \left(750 \, \text{mm}^{-3}\right)} }$$

Evaluate Formula 🕝

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4) Maximum Shear Stress on the Biaxial Loading Formulas (

4.1) Maximum Shear Stress when Member is Subjected to like Principal Stresses Formula 🕝



Example with Onlis
$$a = \frac{1}{2} \cdot \left(110 \, \text{MPa} - 45 \, \text{MPa} \right)$$

Evaluate Formula 🕝

4.2) Stress along X-Axis when Member is Subjected to like Principal Stresses and Max Shear Stress Formula 🕝

Example with Units

Evaluate Formula 🕝

 $\sigma_{x} = \sigma_{y} - \left(2 \cdot \tau_{max}\right)$ $26 \, \text{MPa} = 110 \, \text{MPa} - \left(2 \cdot 42 \, \text{MPa}\right)$

4.3) Stress along Y-Axis when Member is Subjected to like Principal Stresses and Max Shear Stress Formula (

Formula Example with Units $\sigma_y = 2 \cdot \tau_{max} + \sigma_x \qquad \boxed{129 \, {\rm MPa} \, = 2 \cdot 42 \, {\rm MPa} \, + 45 \, {\rm MPa}}$ Example with Units

Evaluate Formula 🕝

Evaluate Formula 🕝

Evaluate Formula

Evaluate Formula 🕝

5) Stresses in Bi-Axial Loading Formulas 🕝

5.1) Normal Stress Induced in Oblique Plane due to Biaxial Loading Formula 🕝

$$\sigma_{\theta} = \left(\frac{1}{2} \cdot \left(\sigma_{x} + \sigma_{y}\right)\right) + \left(\frac{1}{2} \cdot \left(\sigma_{x} - \sigma_{y}\right) \cdot \left(\cos\left(2 \cdot \theta\right)\right)\right) + \left(\tau_{xy} \cdot \sin\left(2 \cdot \theta\right)\right)$$

$$67.4854\,\text{MPa} \; = \left(\frac{1}{2}\cdot\left(\;45\,\text{MPa}\;+\;110\,\text{MPa}\;\right)\;\right) \; + \; \left(\frac{1}{2}\cdot\left(\;45\,\text{MPa}\;-\;110\,\text{MPa}\;\right) \; \cdot \; \left(\;\cos\left(\;2\cdot\;30^\circ\;\right)\;\right)\;\right) \; + \; \left(\;7.2\,\text{MPa}\;\cdot\sin\left(\;2\cdot\;30^\circ\;\right)\;\right) \; \right) \; + \; \left(\;7.2\,\text{MPa}\;\cdot\sin\left(\;2\cdot\;30^\circ\;\right)\;\right) \; + \; \left(\;7.2\,\text{MPa}\;\cdot\sin\left(\;20^\circ\;30^\circ\;\right)\;\right) \; + \; \left(\;7.2\,\text{MPa}\;\cdot\sin\left(\;20^\circ\;30^\circ\;30^\circ\;\right)\;\right) \; + \; \left(\;7.2\,\text{MPa}\;\cdot\sin\left(\;20^\circ\;30^\circ\;\right)\;\right) \; + \; \left(\;7.2\,\text{MPa}\;\cdot$$

5.2) Shear Stress Induced in Oblique Plane due to Biaxial Loading Formula 🗂

$$\tau_{\theta} = -\left(\frac{1}{2} \cdot \left(\sigma_{x} - \sigma_{y}\right) \cdot \sin\left(2 \cdot \theta\right)\right) + \left(\tau_{xy} \cdot \cos\left(2 \cdot \theta\right)\right)$$

Example with Units

$$31.7458 \, \text{MPa} = -\left(\frac{1}{2} \cdot \left(45 \, \text{MPa} - 110 \, \text{MPa}\right) \cdot \sin\left(2 \cdot 30^{\circ}\right)\right) + \left(7.2 \, \text{MPa} \cdot \cos\left(2 \cdot 30^{\circ}\right)\right)$$

5.3) Stress along X- Direction with known Shear Stress in Bi-Axial Loading Formula 🕝 Evaluate Formula

Formula

 $\sigma_{x} = \sigma_{y} - \left(\frac{\tau_{\theta} \cdot 2}{\sin\left(2 \cdot \theta\right)}\right) \left| 45.0019 \,_{\text{MPa}} = 110 \,_{\text{MPa}} - \left(\frac{28.145 \,_{\text{MPa}} \cdot 2}{\sin\left(2 \cdot 30^{\circ}\right)}\right) \right|$

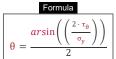
5.4) Stress along Y- Direction using Shear Stress in Bi-Axial Loading Formula 🗂

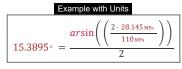
Formula

$$\sigma_y = \sigma_x + \left(\frac{\tau_\theta \cdot 2}{\sin\left(2 \cdot \theta\right)}\right) \boxed{109.9981 \text{MPa} = 45 \text{MPa} + \left(\frac{28.145 \text{MPa} \cdot 2}{\sin\left(2 \cdot 30^\circ\right)}\right)}$$

6) Stresses of Members Subjected to Axial Loading Formulas (

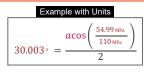
6.1) Angle of Oblique Plane using Shear Stress and Axial Load Formula 🕝





6.2) Angle of Oblique plane when Member Subjected to Axial Loading Formula

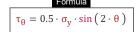




6.3) Normal Stress when Member Subjected to Axial Load Formula

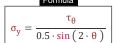
Formula
$$\sigma_{\theta} = \sigma_{y} \cdot \cos(2 \cdot \theta)$$

6.4) Shear Stress when Member Subjected to Axial Load Formula



$$\tau_{\theta} = 0.5 \cdot \sigma_{y} \cdot \sin\left(2 \cdot \theta\right) \qquad 47.6314 \,_{MPa} = 0.5 \cdot 110 \,_{MPa} \cdot \sin\left(2 \cdot 30^{\circ}\right)$$

6.5) Stress along Y-direction given Shear Stress in Member subjected to Axial Load Formula 🗂





6.6) Stress along Y-direction when Member Subjected to Axial Load Formula C



Formula Example with Units
$$\sigma_y = \frac{\sigma_\theta}{\cos\left(2 \cdot \theta\right)} \qquad 109.98 \, \text{MPa} \, = \frac{54.99 \, \text{MPa}}{\cos\left(2 \cdot 30^{\circ}\right)}$$

Evaluate Formula

Evaluate Formula 🕝

Evaluate Formula (

Evaluate Formula 🕝

Evaluate Formula 🕝

Evaluate Formula (

Variables used in list of Principal Stress Formulas above

- M Bending Moment (Kilonewton Meter)
- Me Equivalent Bending Moment (Kilonewton Meter)
- T Torsion (Megapascal)
- T_a Equivalent Torque (Kilonewton Meter)
- θ Theta (Degree)
- σ_b Bending Stress (Megapascal)
- σ_x Stress along x Direction (Megapascal)
- σ_v Stress along y Direction (Megapascal)
- σ_A Normal Stress on Oblique Plane (Megapascal)
- T Shear Stress (Megapascal)
- T_{max} Maximum Shear Stress (Megapascal)
- T_{XV} Shear Stress xy (Megapascal)
- TA Shear Stress on Oblique Plane (Megapascal)
- Φ Diameter of Circular Shaft (Millimeter)

Constants, Functions, Measurements used in list of Principal Stress Formulas above

- constant(s): pi,
 3.14159265358979323846264338327950288
 Archimedes' constant
- Functions: acos, acos(Number)
 The inverse cosine function, is the inverse function of the cosine function. It is the function that takes a ratio as an input and returns the angle whose cosine is equal to that ratio.
- Functions: arccos, arccos(Number)
 Arccosine function, is the inverse function of the cosine function. It is the function that takes a ratio as an input and returns the angle whose cosine is equal to that ratio.
- Functions: arctan, arctan(Number)
 Inverse trigonometric functions are usually accompanied by the prefix arc. Mathematically, we represent arctan or the inverse tangent function as tan-1 x or arctan(x).
- Functions: arsin, arsin(Number)
 Arcsine function, is a trigonometric function that takes a ratio of two sides of a right triangle and outputs the angle opposite the side with the given ratio.
- Functions: asin, asin(Number)
 The inverse sine function, is a trigonometric function that takes a ratio of two sides of a right triangle and outputs the angle opposite the side with the given ratio.
- Functions: atan, atan(Number)
 Inverse tan is used to calculate the angle by applying the tangent ratio of the angle, which is the opposite side divided by the adjacent side of the right triangle.
- Functions: cos, cos(Angle)

 Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- Functions: ctan, ctan(Angle)
 Cotangent is a trigonometric function that is defined as the ratio of the adjacent side to the opposite side in a right triangle.
- Functions: sin, sin(Angle)
 Sine is a trigonometric function that describes the ratio
 of the length of the opposite side of a right triangle to
 the length of the hypotenuse.
- Functions: tan, tan(Angle)
 The tangent of an angle is a trigonometric ratio of the length of the side opposite an angle to the length of the side adjacent to an angle in a right triangle.

- Measurement: Length in Millimeter (mm)
 Length Unit Conversion
- Measurement: Angle in Degree (°)

 Angle Unit Conversion
- Measurement: Torque in Kilonewton Meter (kN*m)

 Torque Unit Conversion
- Measurement: Moment of Force in Kilonewton Meter (kN*m)
 - Moment of Force Unit Conversion
- Measurement: Stress in Megapascal (MPa)
 Stress Unit Conversion

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- Important Bending Stress Formulas
- Important Combined Axial and Bending Loads Formulas (*)
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Multiply fraction

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