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Theories of Failure Formulas

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List of 20 Theories of Failure Formulas

Theories of Failure

Distortion Energy Theory

1) Distortion Strain Energy

Open Calculator

fx $$U_d = \frac{(1+\nu)}{6 \cdot E} \cdot \left((\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \right)$$

ex $$1.56\text{kJ/m}^3 = \frac{(1+0.3)}{6 \cdot 190\text{GPa}} \cdot \left((35\text{N/mm}^2 - 47\text{N/mm}^2)^2 + (47\text{N/mm}^2 - 65\text{N/mm}^2)^2 + (65\text{N/mm}^2 - 35\text{N/mm}$$

2) Distortion Strain Energy for Yielding

Open Calculator

fx $$U_d = \frac{(1+\nu)}{3 \cdot E} \cdot \sigma_y^2$$

ex $$16.47807\text{kJ/m}^3 = \frac{(1+0.3)}{3 \cdot 190\text{GPa}} \cdot (85\text{N/mm}^2)^2$$

3) Shear Yield Strength by Maximum Distortion Energy Theorem

Open Calculator

fx $$S_{sy} = 0.577 \cdot \sigma_y$$

ex $$49.045\text{N/mm}^2 = 0.577 \cdot 85\text{N/mm}^2$$

4) Shear Yield Strength by Maximum Distortion Energy Theory

Open Calculator

fx $$S_{sy} = 0.577 \cdot \sigma_{yt}$$

ex $$4.9\text{E}\hat{}\text{-6N/mm}^2 = 0.577 \cdot 8.5\text{N/m}^2$$

5) Strain Energy due to Change in Volume given Principal Stresses

Open Calculator

fx $$U_v = \frac{(1-2 \cdot \nu)}{6 \cdot E} \cdot (\sigma_1 + \sigma_2 + \sigma_3)^2$$

ex $$7.582105\text{kJ/m}^3 = \frac{(1-2 \cdot 0.3)}{6 \cdot 190\text{GPa}} \cdot (35\text{N/mm}^2 + 47\text{N/mm}^2 + 65\text{N/mm}^2)^2$$

6) Strain Energy due to Change in Volume given Volumetric Stress

Open Calculator

fx $$U_v = \frac{3}{2} \cdot \sigma_v \cdot \varepsilon_v$$

ex $$101.4\text{kJ/m}^3 = \frac{3}{2} \cdot 52\text{N/mm}^2 \cdot 0.0013$$

7) Strain Energy due to Change in Volume with No Distortion

Open Calculator

fx $$U_v = \frac{3}{2} \cdot \frac{(1 - 2 \cdot \nu) \cdot \sigma_v^2}{E}$$

ex $$8.538947\text{kJ/m}^3 = \frac{3}{2} \cdot \frac{(1 - 2 \cdot 0.3) \cdot (52\text{N/mm}^2)^2}{190\text{GPa}}$$

8) Stress due to Change in Volume with No Distortion

Open Calculator

fx $$\sigma_v = \frac{\sigma_1 + \sigma_2 + \sigma_3}{3}$$

ex $$49\text{N/mm}^2 = \frac{35\text{N/mm}^2 + 47\text{N/mm}^2 + 65\text{N/mm}^2}{3}$$

9) Tensile Yield Strength by Distortion Energy Theorem

Open Calculator

fx $$\sigma_y = \sqrt{\frac{1}{2} \cdot \left((\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right)}$$

ex $$26.15339\text{N/mm}^2 = \sqrt{\frac{1}{2} \cdot \left((35\text{N/mm}^2 - 47\text{N/mm}^2)^2 + (47\text{N/mm}^2 - 65\text{N/mm}^2)^2 + (65\text{N/mm}^2 - 35\text{N/mm}^2)\right.}$$

10) Tensile Yield Strength by Distortion Energy Theorem Considering Factor of Safety

Open Calculator

fx $$\sigma_y = f_s \cdot \sqrt{\frac{1}{2} \cdot \left((\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right)}$$

ex $$52.30679\text{N/mm}^2 = 2 \cdot \sqrt{\frac{1}{2} \cdot \left((35\text{N/mm}^2 - 47\text{N/mm}^2)^2 + (47\text{N/mm}^2 - 65\text{N/mm}^2)^2 + (65\text{N/mm}^2 - 35\text{N/m}\right.}$$

11) Tensile Yield Strength for Biaxial Stress by Distortion Energy Theorem Considering Factor of Safety

Open Calculator

$$\sigma_y = f_s \cdot \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1 \cdot \sigma_2}$$

$$84.59314\text{N/mm}^2 = 2 \cdot \sqrt{(35\text{N/mm}^2)^2 + (47\text{N/mm}^2)^2 - 35\text{N/mm}^2 \cdot 47\text{N/mm}^2}$$

12) Total Strain Energy per Unit Volume

Open Calculator

$$U_{Total} = U_d + U_v$$

$$31\text{kJ/m}^3 = 15\text{kJ/m}^3 + 16\text{kJ/m}^3$$

13) Volumetric Strain with No Distortion

Open Calculator

$$\varepsilon_v = \frac{(1 - 2 \cdot \nu) \cdot \sigma_v}{E}$$

$$0.000109 = \frac{(1 - 2 \cdot 0.3) \cdot 52\text{N/mm}^2}{190\text{GPa}}$$

Maximum Principal Stress Theory

14) Allowable Stress in Brittle Material under Compressive Loading

Open Calculator

$$\sigma_{al} = \frac{S_{uc}}{f_s}$$

$$62.5\text{N/mm}^2 = \frac{125\text{N/mm}^2}{2}$$

15) Allowable Stress in Brittle Material under Tensile Loading

Open Calculator

$$\sigma_{al} = \frac{S_{ut}}{f_s}$$

$$61\text{N/mm}^2 = \frac{122\text{N/mm}^2}{2}$$

16) Allowable Stress in Ductile Material under Compressive Loading

Open Calculator

$$\sigma_{al} = \frac{S_{yc}}{f_s}$$

$$52.5\text{N/mm}^2 = \frac{105\text{N/mm}^2}{2}$$

17) Allowable Stress in Ductile Material under Tensile Loading

Open Calculator

$$\sigma_{al} = \frac{\sigma_y}{f_s}$$

$$42.5\text{N/mm}^2 = \frac{85\text{N/mm}^2}{2}$$

Maximum Shear Stress Theory

18) Shear Yield Strength by Maximum Shear Stress Theory

Open Calculator

$$S_{sy} = \frac{\sigma_{yt}}{2}$$

$$4.3\text{E}\hat{}\text{-6N/mm}^2 = \frac{8.5\text{N/m}^2}{2}$$

19) Shear Yield Strength given Tensile Yield Strength

Open Calculator

$$S_{sy} = \frac{\sigma_y}{2}$$

$$42.5\text{N/mm}^2 = \frac{85\text{N/mm}^2}{2}$$

20) Tensile Yield Strength given Shear Yield Strength

Open Calculator

$$\sigma_y = 2 \cdot S_{sy}$$

$$85\text{N/mm}^2 = 2 \cdot 42.5\text{N/mm}^2$$

Variables Used

- **E** Young's Modulus of Specimen *(Gigapascal)*
- f_s Factor of Safety
- S_{sy} Shear Yield Strength *(Newton per Square Millimeter)*
- S_{sy} Shear Yield Strength *(Newton per Square Millimeter)*
- S_{uc} Ultimate Compressive Stress *(Newton per Square Millimeter)*
- S_{ut} Ultimate Tensile Strength *(Newton per Square Millimeter)*
- S_{yc} Compressive Yield Strength *(Newton per Square Millimeter)*
- U_d Strain Energy for Distortion *(Kilojoule per Cubic Meter)*
- U_{Total} Total Strain Energy per Unit Volume *(Kilojoule per Cubic Meter)*
- U_v Strain Energy for Volume Change *(Kilojoule per Cubic Meter)*
- ε_v Strain for Volume Change
- σ_1 First Principal Stress *(Newton per Square Millimeter)*
- σ_2 Second Principal Stress *(Newton per Square Millimeter)*
- σ_3 Third Principal Stress *(Newton per Square Millimeter)*
- σ_{al} Allowable Stress for Static Load *(Newton per Square Millimeter)*
- σ_v Stress for Volume Change *(Newton per Square Millimeter)*
- σ_y Tensile Yield Strength *(Newton per Square Millimeter)*
- σ_{yt} Tensile Yield Strength *(Newton per Square Meter)*
- ν Poisson's Ratio

Constants, Functions, Measurements used

- Function: **sqrt**, sqrt(Number)
  Square root function
- Measurement: **Pressure** in Gigapascal (GPa), Newton per Square Meter (N/m²)
  Pressure Unit Conversion
- Measurement: **Energy Density** in Kilojoule per Cubic Meter (kJ/m³)
  Energy Density Unit Conversion
- Measurement: **Stress** in Newton per Square Millimeter (N/mm²)
  Stress Unit Conversion

Check other formula lists

- **Design for Brittle and Ductile Material under Static Load Formulas**
- **Design of Curved Beams Formulas**
- **Design of Shaft for Torsional Moment Formulas**
- **Fracture Mechanics Formulas**
- **Stresses due to Bending Moment Formulas**
- **Theories of Failure Formulas**

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