Important Theories of Failure Formulas PDF

Formulas
Examples
with Units

List of 20
Important Theories of Failure Formulas

1) Maximum Principal Stress Theory Formulas

1.1) Allowable Stress in Brittle Material under Compressive Loading Formula

Evaluate Formula

Formula

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

Example with Units

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

1.2) Allowable Stress in Brittle Material under Tensile Loading Formula

Evaluate Formula

Formula

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

Example with Units

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

1.3) Allowable Stress in Ductile Material under Compressive Loading Formula

Evaluate Formula

Formula

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

Example with Units

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

1.4) Allowable Stress in Ductile Material under Tensile Loading Formula

Evaluate Formula

Formula

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

Example with Units

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

2) Maximum Shear Stress Theory Formulas

2.1) Shear Yield Strength by Maximum Shear Stress Theory Formula

Evaluate Formula

Formula

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

Example with Units

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

2.2) Shear Yield Strength given Tensile Yield Strength Formula

Evaluate Formula

Formula

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

Example with Units

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

2.3) Tensile Yield Strength given Shear Yield Strength Formula

Evaluate Formula

Formula

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

Example with Units

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

3) Distortion Energy Theory Formulas

3.1) Distortion Strain Energy Formula

Evaluate Formula

Formula

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

Example with Units

$$1.5409\,\text{kJ/m}^3 = \frac{(1+0.3)}{6 \cdot 190\,\text{GPa}} \cdot \left((35.2\,\text{N/mm}^2 - 47\,\text{N/mm}^2)^2 + (47\,\text{N/mm}^2 - 65\,\text{N/mm}^2)^2 + (65\,\text{N/mm}^2 - 35.2\,\text{N/mm}^2)^2 \right)$$

3.2) Distortion Strain Energy for Yielding Formula

Evaluate Formula

Formula

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

Example with Units

$$16.4781\,\text{kJ/m}^3 = \frac{(1+0.3)}{3 \cdot 190\,\text{GPa}} \cdot 85\,\text{N/mm}^2{}^2$$

3.3) Shear Yield Strength by Maximum Distortion Energy Theorem Formula

Evaluate Formula

Formula

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

Example with Units

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

3.4) Shear Yield Strength by Maximum Distortion Energy Theory Formula

Evaluate Formula

Formula

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

Example with Units

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

3.5) Strain Energy due to Change in Volume given Principal Stresses Formula

Evaluate Formula

Formula

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

Example with Units

$$7.6028\,\text{kJ/m}^3 = \frac{(1-2 \cdot 0.3)}{6 \cdot 190\,\text{GPa}} \cdot (35.2\,\text{N/mm}^2 + 47\,\text{N/mm}^2 + 65\,\text{N/mm}^2)^2$$

3.6) Strain Energy due to Change in Volume given Volumetric Stress Formula

Evaluate Formula

Formula

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

Example with Units

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

3.7) Strain Energy due to Change in Volume with No Distortion Formula

Evaluate Formula

Formula

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

Example with Units

$$8.5389\,\text{kJ/m}^3 = \frac{3}{2} \cdot \frac{(1 - 2 \cdot 0.3) \cdot 52\,\text{N/mm}^2{}^2}{190\,\text{GPa}}$$

3.8) Stress due to Change in Volume with No Distortion Formula

Evaluate Formula

Formula

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

Example with Units

$$49.0667\,\text{N/mm}^2 = \frac{35.2\,\text{N/mm}^2 + 47\,\text{N/mm}^2 + 65\,\text{N/mm}^2}{3}$$

3.9) Tensile Yield Strength by Distortion Energy Theorem Formula

Evaluate Formula

Formula

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

Example with Units

$$25.9931\,\text{N/mm}^2 = \sqrt{\frac{1}{2} \cdot \left((35.2\,\text{N/mm}^2 - 47\,\text{N/mm}^2)^2 + (47\,\text{N/mm}^2 - 65\,\text{N/mm}^2)^2 + (65\,\text{N/mm}^2 - 35.2\,\text{N/mm}^2)^2 \right)}$$

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

Evaluate Formula

Formula

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

Example with Units

$$51.9862\,\text{N/mm}^2 = 2 \cdot \sqrt{\frac{1}{2} \cdot \left((35.2\,\text{N/mm}^2 - 47\,\text{N/mm}^2)^2 + (47\,\text{N/mm}^2 - 65\,\text{N/mm}^2)^2 + (65\,\text{N/mm}^2 - 35.2\,\text{N/mm}^2)^2 \right)}$$

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

Evaluate Formula

Formula

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

Example with Units

$$84.7028\,\text{N/mm}^2 = 2 \cdot \sqrt{35.2\,\text{N/mm}^2{}^{\,2} + 47\,\text{N/mm}^2{}^{\,2} - 35.2\,\text{N/mm}^2 \cdot 47\,\text{N/mm}^2}$$

3.12) Total Strain Energy per Unit Volume Formula

Evaluate Formula

Formula

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

Example with Units

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

3.13) Volumetric Strain with No Distortion Formula

Evaluate Formula

Formula

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

Example with Units

$$0.0001 = \frac{\left(1 - 2 \cdot 0.3\right) \cdot 52\,\text{N/mm}^2}{190\,\text{GPa}}$$

Variables used in list of Theories of Failure Formulas above

- **E** Young's Modulus of Specimen *(Gigapascal)*
- f_s Factor of Safety
- 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 *(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)*
- ν Poisson's Ratio

Constants, Functions, Measurements used in list of Theories of Failure Formulas above

- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Measurement: **Pressure** in Gigapascal (GPa)
  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

Download other Important Design Against Static Load PDFs

- Important Fracture Mechanics Formulas
- Important Design of Curved Beams Formulas
- Important Radius of Fiber and Axis Formulas
- Important Theories of Failure Formulas

Try our Unique Visual Calculators

- Percentage increase
- HCF calculator
- Mixed fraction

Please SHARE this PDF with someone who needs it!

This PDF can be downloaded in these languages

English Spanish French German Russian Italian Portuguese Polish Dutch

12/5/2024 | 5:03:06 AM UTC