Theories of Failure Formulas

List of 20 Theories of Failure Formulas

Theories of Failure

Maximum Principal Stress Theory

1) Allowable Stress in Brittle Material under Compressive Loading

Open Calculator

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

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

2) Allowable Stress in Brittle Material under Tensile Loading

Open Calculator

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

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

3) Allowable Stress in Ductile Material under Compressive Loading

Open Calculator

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

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

4) Allowable Stress in Ductile Material under Tensile Loading

Open Calculator

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

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

Maximum Shear Stress Theory

5) Shear Yield Strength by Maximum Shear Stress Theory

Open Calculator

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

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

6) Shear Yield Strength given Tensile Yield Strength

Open Calculator

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

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

7) Tensile Yield Strength given Shear Yield Strength

Open Calculator

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

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

Distortion Energy Theory

8) 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

$1.540933\text{kJ/m}^3 = \frac{(1+0.3)}{6 \cdot 190\text{GPa}} \cdot \left((35.2\text{N/mm}^2 - 47\text{N/mm}^2)^2 + (47\text{N/mm}^2 - 65\text{N/mm}^2)^2 + (65\text{N/mm}^2 - 35.$

9) Distortion Strain Energy for Yielding

Open Calculator

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

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

10) Shear Yield Strength by Maximum Distortion Energy Theorem

Open Calculator

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

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

11) Shear Yield Strength by Maximum Distortion Energy Theory

Open Calculator

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

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

12) 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 $7.602751\text{kJ/m}^3 = \frac{(1 - 2 \cdot 0.3)}{6 \cdot 190\text{GPa}} \cdot (35.2\text{N/mm}^2 + 47\text{N/mm}^2 + 65\text{N/mm}^2)^2$

13) 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 $101.4\text{kJ/m}^3 = \frac{3}{2} \cdot 52\text{N/mm}^2 \cdot 0.0013$

14) 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 $8.538947\text{kJ/m}^3 = \frac{3}{2} \cdot \frac{(1 - 2 \cdot 0.3) \cdot (52\text{N/mm}^2)^2}{190\text{GPa}}$

15) Stress due to Change in Volume with No Distortion

Open Calculator

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

ex $49.06667\text{N/mm}^2 = \frac{35.2\text{N/mm}^2 + 47\text{N/mm}^2 + 65\text{N/mm}^2}{3}$

16) 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

$25.99308\text{N/mm}^2 = \sqrt{\frac{1}{2} \cdot \left((35.2\text{N/mm}^2 - 47\text{N/mm}^2)^2 + (47\text{N/mm}^2 - 65\text{N/mm}^2)^2 + (65\text{N/mm}^2 - 35.2\text{N/m}\right.}$

17) 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 $$51.98615\text{N/mm}^2 = 2 \cdot \sqrt{\frac{1}{2} \cdot \left((35.2\text{N/mm}^2 - 47\text{N/mm}^2)^2 + (47\text{N/mm}^2 - 65\text{N/mm}^2)^2 + (65\text{N/mm}^2 - 35.2\text{N}\right.}$$

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

Open Calculator

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

ex $$84.70277\text{N/mm}^2 = 2 \cdot \sqrt{(35.2\text{N/mm}^2)^2 + (47\text{N/mm}^2)^2 - 35.2\text{N/mm}^2 \cdot 47\text{N/mm}^2}$$

19) Total Strain Energy per Unit Volume

Open Calculator

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

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

20) Volumetric Strain with No Distortion

Open Calculator

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

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

Variables Used

- **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

- Function: **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

Check other formula lists

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

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