Important Eccentric Loading Formulas PDF

Formulas
Examples
with Units

List of 18
Important Eccentric Loading Formulas

1) Critical Buckling Load given Deflection in Eccentric Loading Formula

Evaluate Formula

Formula

$$P_c = \frac{P \cdot \left(4 \cdot e_{load} + \pi \cdot \delta\right)}{\delta \cdot \pi}$$

Example with Units

$$55.4174\,\text{kN} = \frac{9.99\,\text{kN} \cdot \left(4 \cdot 2.5\,\text{mm} + 3.1416 \cdot 0.7\,\text{mm}\right)}{0.7\,\text{mm} \cdot 3.1416}$$

2) Cross-Sectional Area given Radius of Gyration in Eccentric Loading Formula

Evaluate Formula

Formula

$$A_{cs} = \frac{I}{k_G^2}$$

Example with Units

$$13.3769\,\text{m}^2 = \frac{1.125\,\text{kg}\cdot\text{m}^2}{0.29\,\text{mm}^2}$$

3) Cross-Sectional Area given Total Stress is where Load doesn't lie on Plane Formula

Evaluate Formula

Formula

$$A_{cs} = \frac{P}{\sigma_{total} - \left(\left(\frac{e_x \cdot P \cdot c_x}{I_y}\right) + \left(\frac{e_y \cdot P \cdot c_y}{I_x}\right)\right)}$$

Example with Units

$$13.2277\,\text{m}^2 = \frac{9.99\,\text{kN}}{14.8\,\text{Pa} - \left(\left(\frac{4 \cdot 9.99\,\text{kN} \cdot 15\,\text{mm}}{50\,\text{kg}\cdot\text{m}^2}\right) + \left(\frac{0.75 \cdot 9.99\,\text{kN} \cdot 14\,\text{mm}}{51\,\text{kg}\cdot\text{m}^2}\right)\right)}$$

4) Cross-Sectional Area given Total Unit Stress in Eccentric Loading Formula

Evaluate Formula

Formula

$$A_{cs} = \frac{P}{f - \left(\left(P \cdot c \cdot \frac{e}{I_{neutral}}\right)\right)}$$

Example with Units

$$0.532\,\text{m}^2 = \frac{9.99\,\text{kN}}{100\,\text{Pa} - \left(\left(9.99\,\text{kN} \cdot 17\,\text{mm} \cdot \frac{11\,\text{mm}}{23\,\text{kg}\cdot\text{m}^2}\right)\right)}$$

5) Deflection in Eccentric Loading Formula

Evaluate Formula

Formula

$$\delta = \frac{4 \cdot e_{load} \cdot \frac{P}{P_c}}{\pi \cdot \left(1 - \frac{P}{P_c}\right)}$$

Example with Units

$$0.7393\,\text{mm} = \frac{4 \cdot 2.5\,\text{mm} \cdot \frac{9.99\,\text{kN}}{53\,\text{kN}}}{3.1416 \cdot \left(1 - \frac{9.99\,\text{kN}}{53\,\text{kN}}\right)}$$

6) Distance from XX to outermost fiber given Total Stress where Load doesn't lie on Plane Formula

Evaluate Formula

Formula

$$c_y = \frac{\left(\sigma_{total} - \left(\frac{P}{A_{cs}}\right) - \left(\frac{e_x \cdot P \cdot c_x}{I_y}\right)\right) \cdot I_x}{P \cdot e_y}$$

Example with Units

$$13.91\,\text{mm} = \frac{\left(14.8\,\text{Pa} - \left(\frac{9.99\,\text{kN}}{13\,\text{m}^2}\right) - \left(\frac{4 \cdot 9.99\,\text{kN} \cdot 15\,\text{mm}}{50\,\text{kg·m}^2}\right)\right) \cdot 51\,\text{kg·m}^2}{9.99\,\text{kN} \cdot 0.75}$$

7) Distance from YY to outermost fiber given Total Stress where Load doesn't lie on Plane Formula

Evaluate Formula

Formula

$$c_x = \left(\sigma_{total} - \left(\left(\frac{P}{A_{cs}}\right) + \left(\frac{e_y \cdot P \cdot c_y}{I_x}\right)\right)\right) \cdot \frac{I_y}{e_x \cdot P}$$

Example with Units

$$14.9835\,\text{mm} = \left(14.8\,\text{Pa} - \left(\left(\frac{9.99\,\text{kN}}{13\,\text{m}^2}\right) + \left(\frac{0.75 \cdot 9.99\,\text{kN} \cdot 14\,\text{mm}}{51\,\text{kg·m}^2}\right)\right)\right) \cdot \frac{50\,\text{kg·m}^2}{4 \cdot 9.99\,\text{kN}}$$

8) Eccentricity given Deflection in Eccentric Loading Formula

Evaluate Formula

Formula

$$e_{load} = \left(\pi \cdot \left(1 - \frac{P}{P_c}\right)\right) \cdot \frac{\delta}{4 \cdot \frac{P}{P_c}}$$

Example with Units

$$2.367\,\text{mm} = \left(3.1416 \cdot \left(1 - \frac{9.99\,\text{kN}}{53\,\text{kN}}\right)\right) \cdot \frac{0.7\,\text{mm}}{4 \cdot \frac{9.99\,\text{kN}}{53\,\text{kN}}}$$

9) Eccentricity w.r.t axis XX given Total Stress where Load doesn't lie on Plane Formula

Evaluate Formula

Formula

$$e_y = \frac{\left(\sigma_{total} - \left(\frac{P}{A_{cs}}\right) - \left(\frac{e_x \cdot P \cdot c_x}{I_y}\right)\right) \cdot I_x}{P \cdot c_y}$$

Example with Units

$$0.7452 = \frac{\left(14.8\,\text{Pa} - \left(\frac{9.99\,\text{kN}}{13\,\text{m}^2}\right) - \left(\frac{4 \cdot 9.99\,\text{kN} \cdot 15\,\text{mm}}{50\,\text{kg·m}^2}\right)\right) \cdot 51\,\text{kg·m}^2}{9.99\,\text{kN} \cdot 14\,\text{mm}}$$

10) Eccentricity wrt axis YY given Total Stress where Load doesn't lie on Plane Formula

Evaluate Formula

Formula

$$e_x = \frac{\left(\sigma_{total} - \left(\frac{P}{A_{cs}}\right) - \frac{e_y \cdot P \cdot c_y}{I_x}\right) \cdot I_y}{P \cdot c_x}$$

Example with Units

$$3.9956 = \frac{\left(14.8\,\text{Pa} - \left(\frac{9.99\,\text{kN}}{13\,\text{m}^2}\right) - \frac{0.75 \cdot 9.99\,\text{kN} \cdot 14\,\text{mm}}{51\,\text{kg·m}^2}\right) \cdot 50\,\text{kg·m}^2}{9.99\,\text{kN} \cdot 15\,\text{mm}}$$

11) Load for Deflection in Eccentric Loading Formula

Evaluate Formula

Formula

$$P = \frac{P_c \cdot \delta \cdot \pi}{4 \cdot e_{load} + \pi \cdot \delta}$$

Example with Units

$$9.5542\,\text{kN} = \frac{53\,\text{kN} \cdot 0.7\,\text{mm} \cdot 3.1416}{4 \cdot 2.5\,\text{mm} + 3.1416 \cdot 0.7\,\text{mm}}$$

12) Moment of Inertia about XX given Total Stress where Load doesn't lie on Plane Formula

Evaluate Formula

Formula

$$I_x = \frac{e_y \cdot P \cdot c_y}{\sigma_{total} - \left(\left(\frac{P}{A_{cs}}\right) + \left(\frac{e_x \cdot P \cdot c_x}{I_y}\right)\right)}$$

Example with Units

$$51.3301\,\text{kg·m}^2 = \frac{0.75 \cdot 9.99\,\text{kN} \cdot 14\,\text{mm}}{14.8\,\text{Pa} - \left(\left(\frac{9.99\,\text{kN}}{13\,\text{m}^2}\right) + \left(\frac{4 \cdot 9.99\,\text{kN} \cdot 15\,\text{mm}}{50\,\text{kg·m}^2}\right)\right)}$$

13) Moment of Inertia about YY given Total Stress where Load doesn't lie on Plane Formula

Evaluate Formula

Formula

$$I_y = \frac{e_x \cdot P \cdot c_x}{\sigma_{total} - \left(\left(\frac{P}{A_{cs}}\right) + \left(\frac{e_y \cdot P \cdot c_y}{I_x}\right)\right)}$$

Example with Units

$$50.0552\,\text{kg·m²} = \frac{4 \cdot 9.99\,\text{kN} \cdot 15\,\text{mm}}{14.8\,\text{Pa} - \left(\left(\frac{9.99\,\text{kN}}{13\,\text{m²}}\right) + \left(\frac{0.75 \cdot 9.99\,\text{kN} \cdot 14\,\text{mm}}{51\,\text{kg·m²}}\right)\right)}$$

14) Moment of Inertia given Radius of Gyration in Eccentric Loading Formula

Evaluate Formula

Formula

$$I = \left(k_G^{\,2}\right) \cdot A_{cs}$$

Example with Units

$$1.0933\,\text{kg·m²} = \left(0.29\,\text{mm}^{\,2}\right) \cdot 13\,\text{m²}$$

15) Moment of Inertia of Cross-Section given Total Unit Stress in Eccentric Loading Formula

Evaluate Formula

Formula

$$I_{neutral} = \frac{P \cdot c \cdot e}{f - \left(\frac{P}{A_{cs}}\right)}$$

Example with Units

$$18.826\,\text{kg·m²} = \frac{9.99\,\text{kN} \cdot 17\,\text{mm} \cdot 11\,\text{mm}}{100\,\text{Pa} - \left(\frac{9.99\,\text{kN}}{13\,\text{m²}}\right)}$$

16) Radius of Gyration in Eccentric Loading Formula

Evaluate Formula

Formula

$$k_G = \sqrt{\frac{I}{A_{cs}}}$$

Example with Units

$$0.2942\,\text{mm} = \sqrt{\frac{1.125\,\text{kg·m²}}{13\,\text{m²}}}$$

17) Total Stress in Eccentric Loading when Load doesn't lie on Plane Formula

Evaluate Formula

Formula

$$\sigma_{total} = \left(\frac{P}{A_{cs}}\right) + \left(\frac{e_x \cdot P \cdot c_x}{I_y}\right) + \left(\frac{e_y \cdot P \cdot c_y}{I_x}\right)$$

Example with Units

$$14.8132\,\text{Pa} = \left(\frac{9.99\,\text{kN}}{13\,\text{m²}}\right) + \left(\frac{4 \cdot 9.99\,\text{kN} \cdot 15\,\text{mm}}{50\,\text{kg·m²}}\right) + \left(\frac{0.75 \cdot 9.99\,\text{kN} \cdot 14\,\text{mm}}{51\,\text{kg·m²}}\right)$$

18) Total Unit Stress in Eccentric Loading Formula

Evaluate Formula

Formula

$$f = \left(\frac{P}{A_{cs}}\right) + \left(P \cdot c \cdot \frac{e}{I_{neutral}}\right)$$

Example with Units

$$81.9915\,\text{Pa} = \left(\frac{9.99\,\text{kN}}{13\,\text{m}^2}\right) + \left(9.99\,\text{kN} \cdot 17\,\text{mm} \cdot \frac{11\,\text{mm}}{23\,\text{kg·m}^2}\right)$$

Variables used in list of Eccentric Loading Formulas above

- A_{cs} Cross-Sectional Area *(Square Meter)*
- **c** Outermost Fiber Distance *(Millimeter)*
- c_x Distance from YY to Outermost Fiber *(Millimeter)*
- c_y Distance from XX to Outermost Fiber *(Millimeter)*
- **e** Distance from Load applied *(Millimeter)*
- e_{load} Eccentricity of Load *(Millimeter)*
- e_x Eccentricity with respect to Principal Axis YY
- e_y Eccentricity with respect to Principal Axis XX
- **f** Total Unit Stress *(Pascal)*
- **I** Moment of Inertia *(Kilogram Square Meter)*
- $I_{neutral}$ Moment of Inertia about Neutral Axis *(Kilogram Square Meter)*
- I_x Moment of Inertia about X-Axis *(Kilogram Square Meter)*
- I_y Moment of Inertia about Y-Axis *(Kilogram Square Meter)*
- k_G Radius of Gyration *(Millimeter)*
- **P** Axial Load *(Kilonewton)*
- P_c Critical Buckling Load *(Kilonewton)*
- **δ** Deflection in Eccentric Loading *(Millimeter)*
- σ_{total} Total Stress *(Pascal)*

Constants, Functions, Measurements used in list of Eccentric Loading Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- 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: **Length** in Millimeter (mm) *Length Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area Unit Conversion*
- Measurement: **Pressure** in Pascal (Pa) *Pressure Unit Conversion*
- Measurement: **Force** in Kilonewton (kN) *Force Unit Conversion*
- Measurement: **Moment of Inertia** in Kilogram Square Meter (kg·m²) *Moment of Inertia Unit Conversion*

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