Important Expressions For Crippling Load Formulas PDF

Formulas
Examples
with Units

List of 32
Important Expressions For Crippling Load Formulas

1) Both Ends of Column are Fixed Formulas

1.1) Crippling Load given Moment of Section if Both Ends of Column are Fixed Formula

Evaluate Formula

Formula

$$P = \frac{M_{Fixed} - M_t}{\delta}$$

Example with Units

$$1.6625\,\text{kN} = \frac{20000\,\text{N*mm} - 50\,\text{N*mm}}{12\,\text{mm}}$$

1.2) Crippling Load if Both Ends of Column are Fixed Formula

Evaluate Formula

Formula

$$P = \frac{\pi^2 \cdot E \cdot I}{l^2}$$

Example with Units

$$0.2335\,\text{kN} = \frac{3.1416^2 \cdot 10.56\,\text{MPa} \cdot 5600\,\text{cm}^4}{5000\,\text{mm}^2}$$

1.3) Deflection at Section given Moment of Section if Both Ends of Column are Fixed Formula

Evaluate Formula

Formula

$$\delta = \frac{M_{Fixed} - M_t}{P}$$

Example with Units

$$6.65\,\text{mm} = \frac{20000\,\text{N*mm} - 50\,\text{N*mm}}{3\,\text{kN}}$$

1.4) Length of Column given Crippling Load if Both Ends of Column are Fixed Formula

Evaluate Formula

Formula

$$l = \sqrt{\frac{\pi^2 \cdot E \cdot I}{P}}$$

Example with Units

$$1394.8105\,\text{mm} = \sqrt{\frac{3.1416^2 \cdot 10.56\,\text{MPa} \cdot 5600\,\text{cm}^4}{3\,\text{kN}}}$$

1.5) Modulus of Elasticity given Crippling Load if Both Ends of Column are Fixed Formula

Evaluate Formula

Formula

$$E = \frac{P \cdot l^2}{\pi^2 \cdot I}$$

Example with Units

$$135.698\,\text{MPa} = \frac{3\,\text{kN} \cdot 5000\,\text{mm}^2}{3.1416^2 \cdot 5600\,\text{cm}^4}$$

1.6) Moment of Fixed Ends given Moment of Section if Both Ends of Column are Fixed Formula

Evaluate Formula

Formula

$$M_{Fixed} = M_t + P \cdot \delta$$

Example with Units

$$36050\,\text{N*mm} = 50\,\text{N*mm} + 3\,\text{kN} \cdot 12\,\text{mm}$$

1.7) Moment of Inertia given Crippling Load if Both Ends of Column are Fixed Formula

Evaluate Formula

Formula

$$I = \frac{P \cdot l^2}{\pi^2 \cdot E}$$

Example with Units

$$71961.0679\,\text{cm}^4 = \frac{3\,\text{kN} \cdot 5000\,\text{mm}^2}{3.1416^2 \cdot 10.56\,\text{MPa}}$$

1.8) Moment of Section if Both Ends of Column are Fixed Formula

Evaluate Formula

Formula

$$M_t = M_{Fixed} - P \cdot \delta$$

Example with Units

$$-16000\,\text{N*mm} = 20000\,\text{N*mm} - 3\,\text{kN} \cdot 12\,\text{mm}$$

2) Both Ends of Columns are Hinged Formulas

2.1) Crippling Load given Moment at Section if Both Ends of Column are Hinged Formula

Evaluate Formula

Formula

$$P = -\frac{M_t}{\delta}$$

Example with Units

$$-0.0042\,\text{kN} = -\frac{50\,\text{N*mm}}{12\,\text{mm}}$$

2.2) Crippling Load when Both Ends of Column are Hinged Formula

Evaluate Formula

Formula

$$P = \frac{\pi^2 \cdot E \cdot I}{l^2}$$

Example with Units

$$0.2335\,\text{kN} = \frac{3.1416^2 \cdot 10.56\,\text{MPa} \cdot 5600\,\text{cm}^4}{5000\,\text{mm}^2}$$

2.3) Deflection at Section given Moment at Section if Both Ends of Column are Hinged Formula

Evaluate Formula

Formula

$$\delta = -\frac{M_t}{P}$$

Example with Units

$$-0.0167\,\text{mm} = -\frac{50\,\text{N*mm}}{3\,\text{kN}}$$

2.4) Length of Column given Crippling Load with Both Ends of Column Hinged Formula

Evaluate Formula

Formula

$$l = \sqrt{\frac{\pi^2 \cdot E \cdot I}{P}}$$

Example with Units

$$1394.8105\,\text{mm} = \sqrt{\frac{3.1416^2 \cdot 10.56\,\text{MPa} \cdot 5600\,\text{cm}^4}{3\,\text{kN}}}$$

2.5) Modulus of Elasticity given Crippling Load with Both Ends of Column Hinged Formula

Evaluate Formula

Formula

$$E = \frac{P \cdot l^2}{\pi^2 \cdot I}$$

Example with Units

$$135.698\,\text{MPa} = \frac{3\,\text{kN} \cdot 5000\,\text{mm}^2}{3.1416^2 \cdot 5600\,\text{cm}^4}$$

2.6) Moment due to Crippling Load at Section if Both Ends of Column are Hinged Formula

Evaluate Formula

Formula

$$M_t = -P \cdot \delta$$

Example with Units

$$-36000\,\text{N*mm} = -3\,\text{kN} \cdot 12\,\text{mm}$$

2.7) Moment of Inertia given Crippling Load with Both Ends of Column Hinged Formula

Evaluate Formula

Formula

$$I = \frac{P \cdot l^2}{\pi^2 \cdot E}$$

Example with Units

$$71961.0679\,\text{cm}^4 = \frac{3\,\text{kN} \cdot 5000\,\text{mm}^2}{3.1416^2 \cdot 10.56\,\text{MPa}}$$

3) One End of Column is Fixed and Other is Free Formulas

3.1) Crippling Load given Moment of Section if One End of Column is Fixed and Other is Free Formula

Evaluate Formula

Formula

$$P = \frac{M_t}{a - \delta}$$

Example with Units

$$0.025\,\text{kN} = \frac{50\,\text{N*mm}}{14\,\text{mm} - 12\,\text{mm}}$$

3.2) Crippling Load if One End of Column is Fixed and Other is Free Formula

Evaluate Formula

Formula

$$P = \frac{\pi^2 \cdot E \cdot I}{4 \cdot l^2}$$

Example with Units

$$0.0584\,\text{kN} = \frac{3.1416^2 \cdot 10.56\,\text{MPa} \cdot 5600\,\text{cm}^4}{4 \cdot 5000\,\text{mm}^2}$$

3.3) Deflection at Free End given Moment of Section if One End of Column is Fixed and Other is Free Formula

Evaluate Formula

Formula

$$a = \frac{M_t}{P} + \delta$$

Example with Units

$$12.0167\,\text{mm} = \frac{50\,\text{N*mm}}{3\,\text{kN}} + 12\,\text{mm}$$

3.4) Deflection of Section given Moment of Section if One End of Column is Fixed and Other is Free Formula

Evaluate Formula

Formula

$$\delta = a - \frac{M_t}{P}$$

Example with Units

$$13.9833\,\text{mm} = 14\,\text{mm} - \frac{50\,\text{N*mm}}{3\,\text{kN}}$$

3.5) Length of Column given Crippling Load if One End of Column is Fixed and Other is Free Formula

Evaluate Formula

Formula

$$l = \sqrt{\frac{\pi^2 \cdot E \cdot I}{4 \cdot P}}$$

Example with Units

$$697.4053\,\text{mm} = \sqrt{\frac{3.1416^2 \cdot 10.56\,\text{MPa} \cdot 5600\,\text{cm}^4}{4 \cdot 3\,\text{kN}}}$$

3.6) Modulus of Elasticity given Crippling Load if One End of Column is Fixed and Other is Free Formula

Evaluate Formula

Formula

$$E = \frac{4 \cdot l^2 \cdot P}{\pi^2 \cdot I}$$

Example with Units

$$542.7921\,\text{MPa} = \frac{4 \cdot 5000\,\text{mm}^2 \cdot 3\,\text{kN}}{3.1416^2 \cdot 5600\,\text{cm}^4}$$

3.7) Moment of Inertia given Crippling Load if One End of Column is Fixed and Other is Free Formula

Evaluate Formula

Formula

$$I = \frac{4 \cdot l^2 \cdot P}{\pi^2 \cdot E}$$

Example with Units

$$287844.2717\,\text{cm}^4 = \frac{4 \cdot 5000\,\text{mm}^2 \cdot 3\,\text{kN}}{3.1416^2 \cdot 10.56\,\text{MPa}}$$

3.8) Moment of Section due to Crippling Load if One End of Column is Fixed and Other is Free Formula

Evaluate Formula

Formula

$$M_t = P \cdot (a - \delta)$$

Example with Units

$$6000\,\text{N*mm} = 3\,\text{kN} \cdot (14\,\text{mm} - 12\,\text{mm})$$

4) One End of Column is Fixed and Other is Hinged Formulas

4.1) Crippling Load given Moment at Section if One End of Column is Fixed and Other is Hinged Formula

Evaluate Formula

Formula

$$P = \frac{-M_t + H \cdot (l - x)}{\delta}$$

Example with Units

$$333.3292\,\text{kN} = \frac{-50\,\text{N*mm} + 2\,\text{kN} \cdot (5000\,\text{mm} - 3000\,\text{mm})}{12\,\text{mm}}$$

4.2) Crippling Load if One End of Column is Fixed and Other is Hinged Formula

Evaluate Formula

Formula

$$P = \frac{2 \cdot \pi^2 \cdot E \cdot I}{l^2}$$

Example with Units

$$0.4669\,\text{kN} = \frac{2 \cdot 3.1416^2 \cdot 10.56\,\text{MPa} \cdot 5600\,\text{cm}^4}{5000\,\text{mm}^2}$$

4.3) Deflection at Section given Moment at Section if One End of Column is Fixed and Other is Hinged Formula

Evaluate Formula

Formula

$$\delta = \frac{-M_t + H \cdot (l - x)}{P}$$

Example with Units

$$1333.3167\,\text{mm} = \frac{-50\,\text{N*mm} + 2\,\text{kN} \cdot (5000\,\text{mm} - 3000\,\text{mm})}{3\,\text{kN}}$$

4.4) Horizontal Reaction given Moment at Section if One End of Column is Fixed and Other is Hinged Formula

Evaluate Formula

Formula

$$H = \frac{M_t + P \cdot \delta}{l - x}$$

Example with Units

$$0.018\,\text{kN} = \frac{50\,\text{N*mm} + 3\,\text{kN} \cdot 12\,\text{mm}}{5000\,\text{mm} - 3000\,\text{mm}}$$

4.5) Length of Column given Crippling Load if One End of Column is Fixed and Other is Hinged Formula

Evaluate Formula

Formula

$$l = \sqrt{\frac{2 \cdot \pi^2 \cdot E \cdot I}{P}}$$

Example with Units

$$1972.56\,\text{mm} = \sqrt{\frac{2 \cdot 3.1416^2 \cdot 10.56\,\text{MPa} \cdot 5600\,\text{cm}^4}{3\,\text{kN}}}$$

4.6) Length of Column given Moment at Section if One End of Column is Fixed and Other is Hinged Formula

Evaluate Formula

Formula

$$l = \frac{M_t + P \cdot \delta}{H} + x$$

Example with Units

$$3018.025\,\text{mm} = \frac{50\,\text{N*mm} + 3\,\text{kN} \cdot 12\,\text{mm}}{2\,\text{kN}} + 3000\,\text{mm}$$

4.7) Modulus of Elasticity given Crippling Load if One End of Column is Fixed and Other is Hinged Formula

Evaluate Formula

Formula

$$E = \frac{P \cdot l^2}{2 \cdot \pi^2 \cdot I}$$

Example with Units

$$67.849\,\text{MPa} = \frac{3\,\text{kN} \cdot 5000\,\text{mm}^2}{2 \cdot 3.1416^2 \cdot 5600\,\text{cm}^4}$$

4.8) Moment at Section if One End of Column is Fixed and Other is Hinged Formula

Evaluate Formula

Formula

$$M_t = -P \cdot \delta + H \cdot (l - x)$$

Example with Units

$$4E{+}6\,\text{N*mm} = -3\,\text{kN} \cdot 12\,\text{mm} + 2\,\text{kN} \cdot (5000\,\text{mm} - 3000\,\text{mm})$$

4.9) Moment of Inertia given Crippling Load if One End of Column is Fixed and Other is Hinged Formula

Evaluate Formula

Formula

$$I = \frac{P \cdot l^2}{2 \cdot \pi^2 \cdot E}$$

Example with Units

$$35980.534\,\text{cm}^4 = \frac{3\,\text{kN} \cdot 5000\,\text{mm}^2}{2 \cdot 3.1416^2 \cdot 10.56\,\text{MPa}}$$

Variables used in list of Expressions For Crippling Load Formulas above

- **a** Deflection of Free End *(Millimeter)*
- **E** Modulus of Elasticity of Column *(Megapascal)*
- **H** Horizontal Reaction *(Kilonewton)*
- **I** Moment of Inertia Column *(Centimeter⁴)*
- **l** Column Length *(Millimeter)*
- M_{Fixed} Fixed End Moment *(Newton Millimeter)*
- M_t Moment of Section *(Newton Millimeter)*
- **P** Column Crippling Load *(Kilonewton)*
- **x** Distance b/w Fixed End and Deflection Point *(Millimeter)*
- **δ** Deflection at Section *(Millimeter)*

Constants, Functions, Measurements used in list of Expressions For Crippling Load 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: **Pressure** in Megapascal (MPa) *Pressure Unit Conversion*
- Measurement: **Force** in Kilonewton (kN) *Force Unit Conversion*
- Measurement: **Moment of Force** in Newton Millimeter (N*mm) *Moment of Force Unit Conversion*
- Measurement: **Second Moment of Area** in Centimeter⁴ (cm⁴) *Second Moment of Area Unit Conversion*

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