

Important Pile Foundations Formulas PDF



Formulas
Examples
with Units

List of 25 Important Pile Foundations Formulas

1) Allowable Load on Piles Formulas

1.1) Allowable Load for Drop Hammer Driven Piles Formula

Formula

$$P_a = \frac{2 \cdot W_h \cdot H_d}{p + 1}$$

Example with Units

$$12.0898 \text{ kg} = \frac{2 \cdot 20.19 \text{ kg} \cdot 0.3 \text{ m}}{2.00 \text{ mm} + 1}$$

Evaluate Formula 

1.2) Height of Drop given Allowable Load for Drop Hammer Driven Piles Formula

Formula

$$H_d = \frac{P_a \cdot (p + 1)}{2 \cdot W_h}$$

Example with Units

$$0.3 \text{ m} = \frac{12.09 \text{ kg} \cdot (2.00 \text{ mm} + 1)}{2 \cdot 20.19 \text{ kg}}$$

Evaluate Formula 

1.3) Height of Drop given Allowable Load for Steam Hammer Driven Piles Formula

Formula

$$H_d = \frac{P_a \cdot (p + 0.1)}{2 \cdot W_h}$$

Example with Units

$$0.0305 \text{ m} = \frac{12.09 \text{ kg} \cdot (2.00 \text{ mm} + 0.1)}{2 \cdot 20.19 \text{ kg}}$$

Evaluate Formula 

1.4) Weight of Hammer given Allowable Load for Drop Hammer Driven Piles Formula

Formula

$$W_h = \frac{P_a \cdot (p + 1)}{2 \cdot H_d}$$

Example with Units

$$20.1903 \text{ kg} = \frac{12.09 \text{ kg} \cdot (2.00 \text{ mm} + 1)}{2 \cdot 0.3 \text{ m}}$$

Evaluate Formula 

1.5) Weight of Hammer given Allowable Load for Steam Hammer Driven Piles Formula

Formula

$$W_h = \frac{P_a \cdot (p + 0.1)}{2 \cdot H_d}$$

Example with Units

$$2.0553 \text{ kg} = \frac{12.09 \text{ kg} \cdot (2.00 \text{ mm} + 0.1)}{2 \cdot 0.3 \text{ m}}$$

Evaluate Formula 



2) Axial Load Capacity of Single Piles Formulas

2.1) Allowable Load for given Safety Factor Formula

Formula

$$P_{\text{allow}} = \frac{Q_{\text{su}} + Q_{\text{bu}}}{F_s}$$

Example with Units

$$10 \text{ kN} = \frac{17.77 \text{ kN} + 10.23 \text{ kN}}{2.8}$$

Evaluate Formula 

2.2) Allowable Load using Safety Factors Formula

Formula

$$P_{\text{allow}} = \left(\frac{Q_{\text{su}}}{F_1} \right) + \left(\frac{Q_{\text{bu}}}{F_2} \right)$$

Example with Units

$$12.5207 \text{ kN} = \left(\frac{17.77 \text{ kN}}{2.5} \right) + \left(\frac{10.23 \text{ kN}}{1.89} \right)$$

Evaluate Formula 

2.3) Pile Capacity Formula

Formula

$$Q_u = Q_{\text{su}} + Q_{\text{bu}}$$

Example with Units

$$28 \text{ kN} = 17.77 \text{ kN} + 10.23 \text{ kN}$$

Evaluate Formula 

2.4) Shaft Resistance using Allowable Load and Safety Factor Formula

Formula

$$Q_{\text{su}} = (F_s \cdot P_{\text{allow}}) - Q_{\text{bu}}$$

Example with Units

$$17.77 \text{ kN} = (2.8 \cdot 10 \text{ kN}) - 10.23 \text{ kN}$$

Evaluate Formula 

2.5) Toe Resistance using Allowable Load and Safety Factor Formula

Formula

$$Q_{\text{bu}} = (P_{\text{allow}} \cdot F_s) - Q_{\text{su}}$$

Example with Units

$$10.23 \text{ kN} = (10 \text{ kN} \cdot 2.8) - 17.77 \text{ kN}$$

Evaluate Formula 

3) Group of Piles Formulas

3.1) Allowable Bearing Pressure on Rock given Allowable Design Load Formula

Formula

$$q_a = \frac{Q_d - \left(\frac{\pi \cdot d_s \cdot L_s \cdot f_g}{4} \right)}{\frac{\pi \cdot (d_s^2)}{4}}$$

Example with Units

$$18.9296 \text{ MPa} = \frac{10.0 \text{ MPa} - \left(\frac{3.1416 \cdot 0.5 \text{ m} \cdot 2.0 \text{ m} \cdot 2 \text{ MPa}}{4} \right)}{\frac{3.1416 \cdot (0.5 \text{ m}^2)}{4}}$$

Evaluate Formula 

3.2) Allowable Concrete-Rock Bond Stress given Allowable Design Load Formula

Formula

$$f_g = \frac{Q_d - \left(\frac{\pi \cdot (d_s^2) \cdot q_a}{4} \right)}{\pi \cdot d_s \cdot L_s}$$

Example with Units

$$2.0006 \text{ MPa} = \frac{10.0 \text{ MPa} - \left(\frac{3.1416 \cdot (0.5 \text{ m}^2) \cdot 18.92 \text{ MPa}}{4} \right)}{3.1416 \cdot 0.5 \text{ m} \cdot 2.0 \text{ m}}$$

Evaluate Formula 



3.3) Allowable Design Load on Rock Socket Formula

Formula

Evaluate Formula 

$$Q_d = \left(\pi \cdot d_s \cdot L_s \cdot f_g \right) + \left(\frac{\pi \cdot (d_s^2) \cdot q_a}{4} \right)$$

Example with Units

$$9.9981 \text{ MPa} = \left(3.1416 \cdot 0.5 \text{ m} \cdot 2.0 \text{ m} \cdot 2 \text{ MPa} \right) + \left(\frac{3.1416 \cdot (0.5 \text{ m}^2) \cdot 18.92 \text{ MPa}}{4} \right)$$

3.4) Efficiency Factor for Group of Piles Formula

Formula

Evaluate Formula 

$$E_g = \frac{\left(2 \cdot f_s \cdot (b \cdot L + w \cdot L) \right) + (b \cdot W_g)}{n \cdot Q_u}$$

Example with Units

$$1.7194 = \frac{\left(2 \cdot 15 \text{ N/m}^2 \cdot (2.2 \text{ m} \cdot 0.52 \text{ m} + 2.921 \text{ m} \cdot 0.52 \text{ m}) \right) + (2.2 \text{ m} \cdot 8 \text{ m})}{6.0 \cdot 9.45}$$

3.5) Group Drag Load in Pile Group Analysis Formula

Formula

Evaluate Formula 

$$Q_{gd} = A_F \cdot Y_F \cdot H_F + C_g \cdot H \cdot c_u$$

Example with Units

$$17.192 \text{ MPa} = 1024 \text{ m}^2 \cdot 2000 \text{ kg/m}^3 \cdot 4 \text{ m} + 80 \text{ m} \cdot 1.5 \text{ m} \cdot 0.075 \text{ MPa}$$

3.6) Socket Length given Allowable Design Load on Rock Socket Formula

Formula

Example with Units

Evaluate Formula 

$$L_s = \frac{Q_d - \left(\frac{\pi \cdot (d_s^2) \cdot q_a}{4} \right)}{\pi \cdot d_s \cdot f_g}$$

$$2.0006 \text{ m} = \frac{10.0 \text{ MPa} - \left(\frac{3.1416 \cdot (0.5 \text{ m}^2) \cdot 18.92 \text{ MPa}}{4} \right)}{3.1416 \cdot 0.5 \text{ m} \cdot 2 \text{ MPa}}$$

4) Laterally Loaded Vertical Piles Formulas

4.1) Characteristic Pile Length for Laterally Loaded Vertical Piles Formula

Formula

Example with Units

Evaluate Formula 

$$T = \left(\frac{EI}{n_h} \right)^{0.5}$$

$$1.7496 \text{ m} = \left(\frac{12.0 \text{ N/m}}{3.92} \right)^{0.5}$$



4.2) Horizontal Subgrade Reaction Coefficient given Characteristic Pile Length Formula

Formula

$$n_h = \frac{EI}{(T)^2}$$

Example with Units

$$3.9363 = \frac{12.0 \text{ N/m}}{(1.746 \text{ m})^2}$$

Evaluate Formula 

4.3) Lateral Deflection for Fixed Head Pile Case Formula

Formula

$$\delta = \left(\frac{P_h \cdot (T)^3}{EI} \right) \cdot \left(A_y - \left(\frac{A_\theta \cdot B_y}{B_\theta} \right) \right)$$

Example with Units

$$5.8306 \text{ m} = \left(\frac{9.32 \text{ N} \cdot (1.746 \text{ m})^3}{12.0 \text{ N/m}} \right) \cdot \left(2.01 - \left(\frac{0.60 \cdot 1.50}{1.501} \right) \right)$$

Evaluate Formula 

4.4) Lateral Deflection of Pile with Head Free to Move Formula

Formula

$$y = \left(\frac{A_y \cdot P_h \cdot (T)^3}{EI} \right) + \left(\frac{B_y \cdot M_t \cdot (T)^2}{EI} \right)$$

Example with Units

$$30.7921 = \left(\frac{2.01 \cdot 9.32 \text{ N} \cdot (1.746 \text{ m})^3}{12.0 \text{ N/m}} \right) + \left(\frac{1.50 \cdot 59 \text{ N} \cdot \text{m} \cdot (1.746 \text{ m})^2}{12.0 \text{ N/m}} \right)$$

Evaluate Formula 

4.5) Negative Moment Imposed on Pile Formula

Formula

$$M_n = \left(\frac{A_\theta \cdot P_t \cdot T}{B_\theta} \right) - \left(\frac{\theta_s \cdot EI}{B_\theta \cdot T} \right)$$

Example with Units

$$690.7459 \text{ N} \cdot \text{m} = \left(\frac{0.60 \cdot 1000 \text{ N} \cdot 1.746 \text{ m}}{1.501} \right) - \left(\frac{1.57 \text{ rad} \cdot 12.0 \text{ N/m}}{1.501 \cdot 1.746 \text{ m}} \right)$$

Evaluate Formula 

4.6) Pile Stiffness given Characteristic Pile Length for Laterally Loaded Piles Formula

Formula

$$EI = ((T)^2) \cdot n_h$$

Example with Units

$$11.9502 \text{ N/m} = ((1.746 \text{ m})^2) \cdot 3.92$$

Evaluate Formula 



4.7) Positive Moment Imposed on Pile Formula

Evaluate Formula 

Formula

$$M_p = (A_m \cdot P_h \cdot T) + (B_m \cdot M_t)$$

Example with Units

$$293.0563 \text{ N}\cdot\text{m} = (3.47 \cdot 9.32 \text{ N} \cdot 1.746 \text{ m}) + (4.01 \cdot 59 \text{ N}\cdot\text{m})$$

5) Toe Capacity Load Formulas

5.1) Quasi Constant Value for Piles in Sands Formula

Formula

$$q_l = 0.5 \cdot N_q \cdot \tan(\Phi_i)$$

Example with Units

$$12.0315 = 0.5 \cdot 3.01 \cdot \tan(82.87^\circ)$$

Evaluate Formula 

5.2) Ultimate Tip Load for Piles Installed in Cohesive Soils Formula

Formula

$$Q_b = A_b \cdot N_c \cdot C_u$$

Example with Units

$$798.12 \text{ N} = 7.39 \text{ m}^2 \cdot 9 \cdot 12.00 \text{ Pa}$$










Evaluate Formula 



Variables used in list of Pile Foundations Formulas above

- **A_b** Base Area of Pile (Square Meter)
- **A_F** Area of Fill (Square Meter)
- **A_m** Coefficient of Lateral Load in Positive Moment
- **A_y** Coefficient A_y
- **A_g** Coefficient A_g
- **b** Thickness of Dam (Meter)
- **B_m** Coefficient of Moment Term in Positive Moment
- **B_y** Coefficient B_y
- **B_g** Coefficient B_g
- **C_g** Circumference of Group in Foundation (Meter)
- **c_u** Undrained Shear Strength of Soil (Megapascal)
- **C_u** Undrained Strength in Shear (Pascal)
- **d_s** Socket Diameter (Meter)
- **E_g** Efficiency Factor
- **EI** Stiffness of Pile (Newton per Meter)
- **f_g** Allowable Concrete-Rock Bond Stress (Megapascal)
- **f_s** Average Peripheral Friction Stress of Block (Newton per Square Meter)
- **F_s** Factor of Safety in Pile Foundation
- **F1** Factor of Safety F1
- **F2** Factor of Safety F2
- **H** Thickness of Consolidating Soil Layers (Meter)
- **H_d** Height of Drop (Meter)
- **H_F** Thickness of Fill (Meter)
- **H_{sd}** Height of Drop for Steam Hammer (Meter)
- **L** Length of Soil Section (Meter)
- **L_s** Socket Length (Meter)
- **M_n** Moment Negative (Newton Meter)
- **M_p** Moment Positive (Newton Meter)

Constants, Functions, Measurements used in list of Pile Foundations Formulas above

- **constant(s):** pi, 3.14159265358979323846264338327950288
Archimedes' constant
- **Functions:** tan, tan(Angle)
The tangent of an angle is a trigonometric ratio of the length of the side opposite an angle to the length of the side adjacent to an angle in a right triangle.
- **Measurement: Length** in Meter (m), Millimeter (mm)
Length Unit Conversion 
- **Measurement: Weight** in Kilogram (kg)
Weight Unit Conversion 
- **Measurement: Area** in Square Meter (m²)
Area Unit Conversion 
- **Measurement: Pressure** in Megapascal (MPa), Newton per Square Meter (N/m²), Pascal (Pa)
Pressure Unit Conversion 
- **Measurement: Energy** in Newton Meter (N*m)
Energy Unit Conversion 
- **Measurement: Force** in Kilonewton (kN), Newton (N)
Force Unit Conversion 
- **Measurement: Angle** in Radian (rad), Degree (°)
Angle Unit Conversion 
- **Measurement: Surface Tension** in Newton per Meter (N/m)
Surface Tension Unit Conversion 
- **Measurement: Density** in Kilogram per Cubic Meter (kg/m³)
Density Unit Conversion 



- M_t Moment in Soil (*Newton Meter*)
- n Number of Piles
- N_c Bearing Capacity Factor dependent on Cohesion
- n_h Coefficient of Horizontal Subgrade
- N_q Bearing Capacity Factor
- p Penetration per Blow (*Millimeter*)
- P_a Allowable Pile Load (*Kilogram*)
- P_{allow} Allowable Load (*Kilonewton*)
- P_h Laterally Applied Load (*Newton*)
- P_t Lateral Load (*Newton*)
- Q_{bu} Toe Resistance (*Kilonewton*)
- Q_{su} Shaft Resistance (*Kilonewton*)
- Q_u Pile Capacity (*Kilonewton*)
- q_a Allowable Bearing Pressure on Rock (*Megapascal*)
- Q_b Ultimate Point Load (*Newton*)
- Q_d Allowable Design Load on Rock Socket (*Megapascal*)
- Q_{gd} Group Drag Load (*Megapascal*)
- q_l Quasi Constant Value
- Q_u Single Pile Capacity
- T Characteristic Pile Length (*Meter*)
- w Width of Soil Section (*Meter*)
- W_g Width of Group (*Meter*)
- W_h Hammer Weight (*Kilogram*)
- W_s Steam Hammer Weight (*Kilogram*)
- y Lateral Deflection
- Y_F Unit Weight of Fill (*Kilogram per Cubic Meter*)
- δ Lateral Deflection Fixed Head (*Meter*)
- ϑ_s Angle of Rotation (*Radian*)
- Φ_i Angle of Internal Friction of Soil (*Degree*)



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