Important Mix Design, Modulus of Elasticity and Tensile Strength of Concrete Formulas PDF

Formulas
Examples
with Units

List of 21
Important Mix Design, Modulus of Elasticity and Tensile Strength of Concrete Formulas

1) Job Mix Concrete Volume Formulas

1.1) Absolute Volume of Component Formula

Evaluate Formula

Formula

$$V_a = \frac{W_L}{SG \cdot \rho_{water}}$$

Example with Units

$$0.375\,\text{m}^3 = \frac{900\,\text{kg}}{2.4 \cdot 1000.001\,\text{kg/m}^3}$$

1.2) Gel-Space Ratio for Complete Hydration Formula

Evaluate Formula

Formula

$$GS = \frac{0.657 \cdot C}{(0.319 \cdot C) + Wo}$$

Example with Units

$$1.568 = \frac{0.657 \cdot 10\,\text{kg}}{(0.319 \cdot 10\,\text{kg}) + 1000\,\text{mL}}$$

1.3) Specific Gravity of Material given its Absolute Volume Formula

Evaluate Formula

Formula

$$SG = \frac{W_L}{V_a \cdot \rho_{water}}$$

Example with Units

$$2.4 = \frac{900\,\text{kg}}{0.375\,\text{m}^3 \cdot 1000.001\,\text{kg/m}^3}$$

1.4) Target Mean Strength for Mix Design Formula

Evaluate Formula

Formula

$$f'_{ck} = f_{ck} + (1.65 \cdot \sigma)$$

Example with Units

$$20.01\,\text{MPa} = 20.01\,\text{MPa} + (1.65 \cdot 4)$$

1.5) Volume of Empty Capillary Pores Formula

Evaluate Formula

Formula

$$Vec = (V_{cp} - V_{wcp})$$

Example with Units

$$3.5\,\text{mL} = (8\,\text{mL} - 4.5\,\text{mL})$$

1.6) Volume of Products of Hydration Per Unit of Dry Cement Formula

Evaluate Formula

Formula

$$Vp = \left(\frac{V_{hc}}{V_{cah}}\right)$$

Example with Units

$$22.2222\,\text{mm}^3 = \left(\frac{70\,\text{mL}}{3.15\,\text{g/mL}}\right)$$

1.7) Water Cement Ratio Formula

Evaluate Formula

Formula

$$CW = \frac{w_m}{w_c}$$

Example with Units

$$0.45 = \frac{9\,\text{kg}}{20\,\text{kg}}$$

1.8) Weight of Cementitious Materials in Concrete Batch Formula

Evaluate Formula

Formula

$$w_c = \frac{w_m}{CW}$$

Example with Units

$$20\,\text{kg} = \frac{9\,\text{kg}}{0.45}$$

1.9) Weight of Material given its Absolute Volume Formula

Evaluate Formula

Formula

$$W_L = V_a \cdot SG \cdot \rho_{water}$$

Example with Units

$$900.0009\,\text{kg} = 0.375\,\text{m}^3 \cdot 2.4 \cdot 1000.001\,\text{kg/m}^3$$

1.10) Weight of Mixing Water in Batch Formula

Evaluate Formula

Formula

$$w_m = CW \cdot w_c$$

Example with Units

$$9\,\text{kg} = 0.45 \cdot 20\,\text{kg}$$

2) Modulus of Elasticity of Concrete Formulas

2.1) Modulus of Elasticity of Concrete Formula

Evaluate Formula

Formula

$$E_{cmd} = 5000 \cdot \left(f_{ck} \right)^{0.5}$$

Example with Units

$$22.3663\,\text{MPa} = 5000 \cdot \left(20.01\,\text{MPa} \right)^{0.5}$$

2.2) ACI Code Formulas

2.2.1) Modulus of Elasticity of Concrete in SI Units Formula

Evaluate Formula

Formula

$$E_c = 0.043 \cdot w_c^{1.5} \cdot \sqrt{f'_c}$$

Example with Units

$$0.0272\,\text{MPa} = 0.043 \cdot 20\,\text{kg}^{1.5} \cdot \sqrt{50\,\text{MPa}}$$

2.2.2) Modulus of Elasticity of Concrete in USCS Units Formula

Evaluate Formula

Formula

$$E_c = 33 \cdot w_c^{1.5} \cdot \sqrt{f'_c}$$

Example with Units

$$20.871\,\text{MPa} = 33 \cdot 20\,\text{kg}^{1.5} \cdot \sqrt{50\,\text{MPa}}$$

2.3) Normal-Weight, Normal-Density Concrete Formulas

2.3.1) Modulus of Elasticity for Normal Weight Concrete in UCSC Units Formula

Evaluate Formula

Formula

$$E_c = 57000 \cdot \sqrt{f'_c}$$

Example with Units

$$403.0509\,\text{MPa} = 57000 \cdot \sqrt{50\,\text{MPa}}$$

2.3.2) Modulus of Elasticity of Normal Weight and Density Concrete in SI Units Formula

Evaluate Formula

Formula

$$E_c = 4700 \cdot \sqrt{f'_c}$$

Example with Units

$$33.234\,\text{MPa} = 4700 \cdot \sqrt{50\,\text{MPa}}$$

3) Modulus of Rupture Formulas

3.1) Modulus of Rupture of Rectangular Sample in Four-Point Bending Formula

Evaluate Formula

Formula

$$f_{4ptr} = \frac{F_f \cdot L}{B \cdot \left(T^2\right)}$$

Example with Units

$$56.25\,\text{MPa} = \frac{80\,\text{N} \cdot 180\,\text{mm}}{100\,\text{mm} \cdot \left(1.6\,\text{mm}^2\right)}$$

3.2) Modulus of Rupture of Rectangular Sample in Three-Point Bending Formula

Evaluate Formula

Formula

$$f_{3ptr} = \frac{3 \cdot F_f \cdot L}{2 \cdot B \cdot \left(T^2\right)}$$

Example with Units

$$84.375\,\text{MPa} = \frac{3 \cdot 80\,\text{N} \cdot 180\,\text{mm}}{2 \cdot 100\,\text{mm} \cdot \left(1.6\,\text{mm}^2\right)}$$

4) Tensile Strength of Concrete Formulas

4.1) Maximum Load Applied during Splitting Tensile Strength of Concrete Formula

Evaluate Formula

Formula

$$W_{load} = \frac{\sigma sp \cdot \pi \cdot D_1 \cdot L_c}{2}$$

Example with Units

$$3.7699\,\text{kN} = \frac{40\,\text{N/m}^2 \cdot 3.1416 \cdot 5\,\text{m} \cdot 12\,\text{m}}{2}$$

4.2) Splitting Tensile Strength of Concrete Formula

Evaluate Formula

Formula

$$\sigma sp = \frac{2 \cdot W_{load}}{\pi \cdot D_1 \cdot L_c}$$

Example with Units

$$38.1972\,\text{N/m}^2 = \frac{2 \cdot 3.6\,\text{kN}}{3.1416 \cdot 5\,\text{m} \cdot 12\,\text{m}}$$

4.3) Tensile Strength of Concrete in Combined Stress Design Formula

Evaluate Formula

Formula

$$f_r = 7.5 \cdot \sqrt{f'_c}$$

Example with Units

$$53.033\,\text{MPa} = 7.5 \cdot \sqrt{50\,\text{MPa}}$$

4.4) Tensile Strength of Normal Weight and Density Concrete in SI Units Formula

Evaluate Formula

Formula

$$f_r = 0.7 \cdot \sqrt{f'_c}$$

Example with Units

$$0.0049\,\text{MPa} = 0.7 \cdot \sqrt{50\,\text{MPa}}$$

Variables used in list of Mix Design, Modulus of Elasticity and Tensile Strength of Concrete Formulas above

- **B** Width of Section *(Millimeter)*
- **C** Mass Of Cement *(Kilogram)*
- **CW** Water Cement Ratio
- D_1 Diameter of Cylinder 1 *(Meter)*
- E_c Modulus of Elasticity of Concrete *(Megapascal)*
- E_{cmd} Elastic Modulus of Concrete for Mix Design *(Megapascal)*
- f_{3ptr} Modulus of Rupture of Concrete Threepoint bending *(Megapascal)*
- f_{4ptr} Modulus of Rupture of Concrete Fourpoint bending *(Megapascal)*
- f'_c Specified 28-Day Compressive Strength of Concrete *(Megapascal)*
- f_{ck} Characteristic Compressive Strength *(Megapascal)*
- f'_{ck} Target Average Compressive Strength *(Megapascal)*
- F_f Load at Fracture Point *(Newton)*
- f_r Tensile Strength of Concrete *(Megapascal)*
- **GS** Gel Space Ratio
- **L** Length of Section *(Millimeter)*
- L_c Length of Cylinder *(Meter)*
- **SG** Specific Gravity of Material
- **T** Average Section Thickness *(Millimeter)*
- V_a Absolute Volume *(Cubic Meter)*
- V_{cah} Absolute Volume of Dry Cement actually Hydrated *(Gram per Milliliter)*
- V_{cp} Volume of Capillary Pores *(Milliliter)*
- V_{hc} Volume of Hydrated Cement *(Milliliter)*
- V_{wcp} Volume of Water Filled Capillary Pores *(Milliliter)*
- **Vec** Volume of Empty Capillary Pores *(Milliliter)*

Constants, Functions, Measurements used in list of Mix Design, Modulus of Elasticity and Tensile Strength of Concrete 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), Meter (m) *Length Unit Conversion*
- Measurement: **Weight** in Kilogram (kg) *Weight Unit Conversion*
- Measurement: **Volume** in Cubic Meter (m^3), Milliliter (mL), Cubic Millimeter (mm^3) *Volume Unit Conversion*
- Measurement: **Pressure** in Megapascal (MPa) *Pressure Unit Conversion*
- Measurement: **Force** in Newton (N), Kilonewton (kN) *Force Unit Conversion*
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m^3), Gram per Milliliter (g/mL) *Density Unit Conversion*
- Measurement: **Stress** in Megapascal (MPa), Newton per Square Meter (N/m^2) *Stress Unit Conversion*

- **Vp** Volume of Solid Products of Hydration *(Cubic Millimeter)*
- w_c Weight of Cementitious Materials *(Kilogram)*
- W_L Weight of Material *(Kilogram)*
- W_{load} Maximum Load Applied *(Kilonewton)*
- w_m Weight of Mixing Water *(Kilogram)*
- **Wo** Volume of Mixing Water *(Milliliter)*
- ρ_{water} Water Density *(Kilogram per Cubic Meter)*
- **σ** Standard Deviation of Distribution
- **σsp** Splitting Tensile Strength of Concrete *(Newton per Square Meter)*

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