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Earth Dam and Gravity Dam Formulas

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List of 34 Earth Dam and Gravity Dam Formulas

Earth Dam and Gravity Dam

Earth dam

Coefficient of permeability of earth dam

1) Coefficient of Permeability given Maximum and Minimum Permeability for Earth Dam

$$fx \quad k = \sqrt{K_o \cdot \mu_r}$$

Open Calculator 

$$ex \quad 11.3274\text{cm/s} = \sqrt{0.00987\text{m}^2 \cdot 1.3\text{H/m}}$$

2) Coefficient of Permeability given Quantity of Seepage in Length of Dam

$$fx \quad k = \frac{Q_t \cdot N}{B \cdot H_L \cdot L}$$

Open Calculator 

$$ex \quad 4.646465\text{cm/s} = \frac{0.46\text{m}^3/\text{s} \cdot 4}{2 \cdot 6.6\text{m} \cdot 3\text{m}}$$



3) Coefficient of Permeability Given Seepage Discharge in Earth Dam

$$fx \quad k = \frac{Q_t}{i \cdot A_{cs} \cdot t}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$ex \quad 0.291952 \text{cm/s} = \frac{0.46 \text{m}^3/\text{s}}{2.02 \cdot 13 \text{m}^2 \cdot 6 \text{s}}$$

4) Maximum Permeability given Coefficient of Permeability for Earth Dam

$$fx \quad K_o = \frac{k^2}{\mu_r}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$ex \quad 0.007692 \text{m}^2 = \frac{(10 \text{cm/s})^2}{1.3 \text{H/m}}$$

5) Minimum Permeability given Coefficient of Permeability for Earth Dam

$$fx \quad \mu_r = \frac{k^2}{K_o}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 1.013171 \text{H/m} = \frac{(10 \text{cm/s})^2}{0.00987 \text{m}^2}$$



Quantity of seepage

6) Head difference between Headwater and Tail Water given Quantity of Seepage in Length of Dam

$$\text{fx } H_L = \frac{Q \cdot N}{B \cdot k \cdot L}$$

[Open Calculator !\[\]\(23d9fc146e83b5c3013cfa32c784f8d5_img.jpg\)](#)

$$\text{ex } 6.333333\text{m} = \frac{0.95\text{m}^3/\text{s} \cdot 4}{2 \cdot 10\text{cm}/\text{s} \cdot 3\text{m}}$$

7) Length of Dam to which Flow Net applies given Quantity of Seepage in Length of Dam

$$\text{fx } L = \frac{Q \cdot N}{B \cdot H_L \cdot k}$$

[Open Calculator !\[\]\(aa53ad6fea213b8b2226d3077e30533a_img.jpg\)](#)

$$\text{ex } 2.878788\text{m} = \frac{0.95\text{m}^3/\text{s} \cdot 4}{2 \cdot 6.6\text{m} \cdot 10\text{cm}/\text{s}}$$

8) Number of Equipotential Drops of Net given Quantity of Seepage in Length of Dam

$$\text{fx } N = \frac{k \cdot B \cdot H_L \cdot L}{Q}$$

[Open Calculator !\[\]\(626ce8ac21792b9405bfddfea8e0c96a_img.jpg\)](#)

$$\text{ex } 4.168421 = \frac{10\text{cm}/\text{s} \cdot 2 \cdot 6.6\text{m} \cdot 3\text{m}}{0.95\text{m}^3/\text{s}}$$



9) Number of Flow Channels of Net Water given Quantity of Seepage in Length of Dam

$$fx \quad B = \frac{Q \cdot N}{H_L \cdot k \cdot L}$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$ex \quad 1.919192 = \frac{0.95m^3/s \cdot 4}{6.6m \cdot 10cm/s \cdot 3m}$$

10) Quantity of Seepage in Length of Dam under Consideration

$$fx \quad Q = \frac{k \cdot B \cdot H_L \cdot L}{N}$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$ex \quad 0.99m^3/s = \frac{10cm/s \cdot 2 \cdot 6.6m \cdot 3m}{4}$$

11) Seepage Discharge in Earth Dam

$$fx \quad Q_s = k \cdot i \cdot A_{cs} \cdot t$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

$$ex \quad 15.756m^3/s = 10cm/s \cdot 2.02 \cdot 13m^2 \cdot 6s$$



Slope protection

12) Fetch given Height of Waves for Fetch more than 20 miles

Open Calculator 

$$\text{fx } F = \frac{\left(\frac{h_a}{0.17}\right)^2}{V_w}$$

$$\text{ex } 257.5087\text{m} = \frac{\left(\frac{12.2\text{m}}{0.17}\right)^2}{20\text{m/s}}$$

13) Height of Wave from Trough to Crest given Velocity between 1 and 7 feet

Open Calculator 

$$\text{fx } h_a = \frac{V_w - 7}{2}$$

$$\text{ex } 6.5\text{m} = \frac{20\text{m/s} - 7}{2}$$

14) Molitor-Stevenson equation for Height of Waves for Fetch less than 20 miles

Open Calculator 

$$\text{fx } h_a = 0.17 \cdot (V_w \cdot F)^{0.5} + 2.5 - F^{0.25}$$

$$\text{ex } 4.967505\text{m} = 0.17 \cdot (20\text{m/s} \cdot 44\text{m})^{0.5} + 2.5 - (44\text{m})^{0.25}$$



15) Molitor-Stevenson equation for Height of Waves for Fetch more than 20 miles

$$fx \quad h_a = 0.17 \cdot (V_w \cdot F)^{0.5}$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5_img.jpg\)](#)

$$ex \quad 5.043015m = 0.17 \cdot (20m/s \cdot 44m)^{0.5}$$

16) Velocity when Wave Heights between 1 and 7 feet

$$fx \quad V_w = 7 + 2 \cdot h_a$$

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5_img.jpg\)](#)

$$ex \quad 31.4m/s = 7 + 2 \cdot 12.2m$$

Wind velocity

17) Wind Velocity given Height of Waves for Fetch less than 20 miles

$$fx \quad V_w = \frac{\left(\frac{h_a}{0.17}\right)^2}{F}$$

[Open Calculator !\[\]\(0d7ca0919e6c47bbd874bfa0189fe22e_img.jpg\)](#)

$$ex \quad 117.0494m/s = \frac{\left(\frac{12.2m}{0.17}\right)^2}{44m}$$



18) Wind Velocity given Height of Waves for Fetch more than 20 miles 

$$\text{fx } V_w = \frac{\left(\frac{h_a - (2.5 - F^{0.25})}{0.17} \right)^2}{F}$$

Open Calculator 

$$\text{ex } 118.5028\text{m/s} = \frac{\left(\frac{12.2\text{m} - (2.5 - (44\text{m})^{0.25})}{0.17} \right)^2}{44\text{m}}$$

19) Zuider Zee Formula for Wind Velocity given Height of Wave Action 

$$\text{fx } V_w = \left(\left(\left(\frac{\frac{h_a}{H}}{1.5} - 0.75 \right) \cdot (2 \cdot [g]) \right) \right)^{0.5}$$

Open Calculator 

$$\text{ex } 19.72301\text{m/s} = \left(\left(\left(\frac{\frac{12.2\text{m}}{0.4\text{m}}}{1.5} - 0.75 \right) \cdot (2 \cdot [g]) \right) \right)^{0.5}$$

20) Zuider Zee Formula for Wind Velocity given Setup above Pool Level 

$$\text{fx } V_w = \left(\frac{h_a}{\frac{F \cdot \cos(\theta)}{1400 \cdot d}} \right)^{\frac{1}{2}}$$

Open Calculator 

$$\text{ex } 20.95875\text{m/s} = \left(\frac{12.2\text{m}}{\frac{44\text{m} \cdot \cos(30^\circ)}{1400 \cdot 0.98\text{m}}} \right)^{\frac{1}{2}}$$



Zuider zee formula

21) Angle of Incidence of Waves by Zuider Zee formula

$$\text{fx } \theta = a \cos \left(\frac{h \cdot (1400 \cdot d)}{(V^2) \cdot F} \right)$$

[Open Calculator !\[\]\(d66ff64371a51729ac8c1cdaa685ba6f_img.jpg\)](#)

$$\text{ex } 69.30904^\circ = a \cos \left(\frac{15.6\text{m} \cdot (1400 \cdot 0.98\text{m})}{((83\text{mi/h})^2) \cdot 44\text{m}} \right)$$

22) Height of Wave Action using Zuider Zee Formula

$$\text{fx } h_a = H \cdot \left(0.75 + 1.5 \cdot \frac{V_w^2}{2 \cdot [g]} \right)$$

[Open Calculator !\[\]\(faf942dc3e59ce8eb64b4ac481eca7e0_img.jpg\)](#)

$$\text{ex } 12.53659\text{m} = 0.4\text{m} \cdot \left(0.75 + 1.5 \cdot \frac{(20\text{m/s})^2}{2 \cdot [g]} \right)$$

23) Height of Wave from Trough to Crest given Height of Wave Action by Zuider Zee Formula

$$\text{fx } H = \frac{h_a}{0.75 + 1.5 \cdot \frac{V_w^2}{2 \cdot [g]}}$$

[Open Calculator !\[\]\(95b425611cbd2b8716a140cf67c81822_img.jpg\)](#)

$$\text{ex } 0.38926\text{m} = \frac{12.2\text{m}}{0.75 + 1.5 \cdot \frac{(20\text{m/s})^2}{2 \cdot [g]}}$$



24) Setup above Pool Level using Zuider Zee Formula

$$\text{fx } h_a = \frac{(V_w \cdot V_w) \cdot F \cdot \cos(\theta)}{1400 \cdot d}$$

[Open Calculator !\[\]\(0f848bbd71cef6b345273b16f905912a_img.jpg\)](#)

$$\text{ex } 11.10936\text{m} = \frac{(20\text{m/s} \cdot 20\text{m/s}) \cdot 44\text{m} \cdot \cos(30^\circ)}{1400 \cdot 0.98\text{m}}$$

25) Zuider Zee formula for Average depth of Water given Setup above Pool level

$$\text{fx } d = \frac{(V_w \cdot V_w) \cdot F \cdot \cos(\theta)}{1400 \cdot h_a}$$

[Open Calculator !\[\]\(3211b5d1d968fc1665909b34f9f16010_img.jpg\)](#)

$$\text{ex } 0.892392\text{m} = \frac{(20\text{m/s} \cdot 20\text{m/s}) \cdot 44\text{m} \cdot \cos(30^\circ)}{1400 \cdot 12.2\text{m}}$$

26) Zuider Zee Formula for Fetch Length given Setup above Pool Level

$$\text{fx } F = \frac{h_a}{\frac{(V_w \cdot V_w) \cdot \cos(\theta)}{1400 \cdot d}}$$

[Open Calculator !\[\]\(9c2e8d1b5bd77cb5c9f83b7a9cff79fd_img.jpg\)](#)

$$\text{ex } 48.3196\text{m} = \frac{12.2\text{m}}{\frac{(20\text{m/s} \cdot 20\text{m/s}) \cdot \cos(30^\circ)}{1400 \cdot 0.98\text{m}}}$$



Gravity Dam

27) Density of Water given Water Pressure in Gravity Dam

$$\text{fx } \rho_{\text{Water}} = \frac{P_{\text{W}}}{0.5} \cdot (H_{\text{S}}^2)$$

[Open Calculator !\[\]\(a03a7eb2f4046e1d3c76772003e549ea_img.jpg\)](#)

$$\text{ex } 729\text{kg/m}^3 = \frac{450\text{Pa}}{0.5} \cdot ((0.9\text{m})^2)$$

28) Eccentricity for Vertical Normal Stress at Downstream Face

$$\text{fx } e_{\text{d}} = \left(1 + \left(\frac{\sigma_{\text{z}}}{\frac{F_{\text{v}}}{144 \cdot T}} \right) \right) \cdot \frac{T}{6}$$

[Open Calculator !\[\]\(5361750c22c4e047a52f4eac1ec2d4cc_img.jpg\)](#)

$$\text{ex } 19.72667 = \left(1 + \left(\frac{2.5\text{Pa}}{\frac{15\text{N}}{144 \cdot 2.2\text{m}}} \right) \right) \cdot \frac{2.2\text{m}}{6}$$

29) Eccentricity given Vertical Normal Stress at Upstream Face

$$\text{fx } e_{\text{u}} = \left(1 - \left(\frac{\sigma_{\text{z}}}{\frac{F_{\text{v}}}{144 \cdot T}} \right) \right) \cdot \frac{T}{6}$$

[Open Calculator !\[\]\(b792654f2cef9719eabeb6c5be00811e_img.jpg\)](#)


$$\text{ex } -18.993333 = \left(1 - \left(\frac{2.5\text{Pa}}{\frac{15\text{N}}{144 \cdot 2.2\text{m}}} \right) \right) \cdot \frac{2.2\text{m}}{6}$$



30) Total Vertical Force for Vertical Normal Stress at Upstream Face [Open Calculator](#) 

$$fx \quad F_v = \frac{\sigma_z}{\left(\frac{1}{144 \cdot T}\right) \cdot \left(1 - \left(\frac{6 \cdot e_u}{T}\right)\right)}$$

$$ex \quad 14.99484N = \frac{2.5Pa}{\left(\frac{1}{144 \cdot 2.2m}\right) \cdot \left(1 - \left(\frac{6 \cdot 19}{2.2m}\right)\right)}$$

31) Total Vertical Force given Vertical Normal Stress at Downstream Face [Open Calculator](#) 

$$fx \quad F_v = \frac{\sigma_z}{\left(\frac{1}{144 \cdot T}\right) \cdot \left(1 + \left(\frac{6 \cdot e_d}{T}\right)\right)}$$

$$ex \quad 14.99484N = \frac{2.5Pa}{\left(\frac{1}{144 \cdot 2.2m}\right) \cdot \left(1 + \left(\frac{6 \cdot 19}{2.2m}\right)\right)}$$

32) Vertical Normal Stress at Downstream Face [Open Calculator](#) 

$$fx \quad \sigma_z = \left(\frac{F_v}{144 \cdot T}\right) \cdot \left(1 + \left(\frac{6 \cdot e_d}{T}\right)\right)$$

$$ex \quad 2.500861Pa = \left(\frac{15N}{144 \cdot 2.2m}\right) \cdot \left(1 + \left(\frac{6 \cdot 19}{2.2m}\right)\right)$$



33) Vertical Normal Stress at Upstream Face

$$\text{fx } \sigma_z = \left(\frac{F_v}{144 \cdot T} \right) \cdot \left(1 - \left(\frac{6 \cdot e_u}{T} \right) \right)$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$\text{ex } 2.500861\text{Pa} = \left(\frac{15\text{N}}{144 \cdot 2.2\text{m}} \right) \cdot \left(1 - \left(\frac{6 \cdot -19}{2.2\text{m}} \right) \right)$$

34) Water Pressure in Gravity Dam

$$\text{fx } P_W = 0.5 \cdot \rho_{\text{Water}} \cdot (H_S^2)$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$\text{ex } 405\text{Pa} = 0.5 \cdot 1000\text{kg/m}^3 \cdot ((0.9\text{m})^2)$$



Variables Used









- **A_{CS}** Cross-Sectional Area of Base (*Square Meter*)
- **B** Number of Beds
- **d** Water Depth (*Meter*)
- **e_d** Eccentricity at Downstream
- **e_u** Eccentricity at Upstream
- **F** Fetch length (*Meter*)
- **F_v** Vertical Component of Force (*Newton*)
- **h** Height of Dam (*Meter*)
- **H** Wave Height (*Meter*)
- **h_a** Height of Wave (*Meter*)
- **H_L** Loss of Head (*Meter*)
- **H_S** Height of Section (*Meter*)
- **i** Hydraulic Gradient to Head Loss
- **k** Coefficient of Permeability of Soil (*Centimeter per Second*)
- **K_o** Intrinsic Permeability (*Square Meter*)
- **L** Length of Dam (*Meter*)
- **N** Equipotential Lines
- **P_W** Water Pressure in Gravity Dam (*Pascal*)
- **Q** Quantity of Seepage (*Cubic Meter per Second*)
- **Q_s** Seepage Discharge (*Cubic Meter per Second*)
- **Q_t** Discharge from Dam (*Cubic Meter per Second*)
- **t** Time Taken to Travel (*Second*)





- **T** Thickness of Dam (Meter)
- **V** Wind Velocity for Freeboard (Mile per Hour)
- **V_w** Wind Velocity (Meter per Second)
- **θ** Theta (Degree)
- **μ_r** Relative Permeability (Henry per Meter)
- **ρ_{Water}** Water Density (Kilogram per Cubic Meter)
- **σ_z** Vertical Stress at a Point (Pascal)



Constants, Functions, Measurements used

- **Constant:** **[g]**, 9.80665 Meter/Second²
Gravitational acceleration on Earth
- **Function:** **acos**, `acos(Number)`
Inverse trigonometric cosine function
- **Function:** **cos**, `cos(Angle)`
Trigonometric cosine function
- **Function:** **sqrt**, `sqrt(Number)`
Square root function
- **Measurement:** **Length** in Meter (m)
Length Unit Conversion 
- **Measurement:** **Time** in Second (s)
Time Unit Conversion 
- **Measurement:** **Area** in Square Meter (m²)
Area Unit Conversion 
- **Measurement:** **Pressure** in Pascal (Pa)
Pressure Unit Conversion 
- **Measurement:** **Speed** in Centimeter per Second (cm/s), Meter per Second (m/s), Mile per Hour (mi/h)
Speed Unit Conversion 
- **Measurement:** **Force** in Newton (N)
Force Unit Conversion 
- **Measurement:** **Angle** in Degree (°)
Angle Unit Conversion 
- **Measurement:** **Volumetric Flow Rate** in Cubic Meter per Second (m³/s)
Volumetric Flow Rate Unit Conversion 



- **Measurement: Density** in Kilogram per Cubic Meter (kg/m^3)
Density Unit Conversion 
- **Measurement: Magnetic Permeability** in Henry per Meter (H/m)
Magnetic Permeability Unit Conversion 



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- [Arch Dams Formulas](#) 
- [Buttress Dams Formulas](#) 
- [Earth Dam and Gravity Dam Formulas](#) 

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