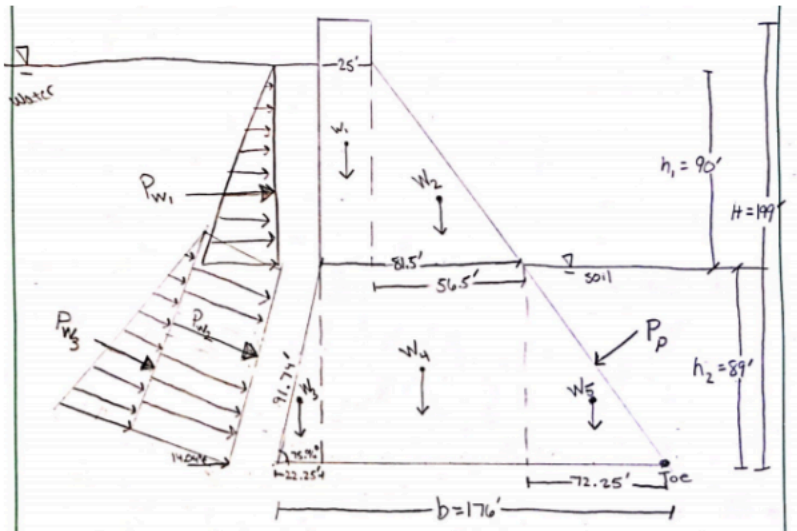
Wachusett Dam Statics Analysis



Materials Used & Amount & Density ($\rho = \frac{lb}{ft^3}$)

Granite: 7,402,671 ft^3 $\rho = 172\ lb/ft^3$

Portland Cement: 2,189,781 ft^3 $\rho = 89.90\ lb/ft^3$

Natural Cement: 4,926,960 ft^3 $\rho = 196.65\ lb/ft^3$

Total = 14,519,412 ft^3

Weight

Granite: 172 (7,402,671) = 1,273,259,412 lb

P. Cement: 89.90 (2,189,781) = 196,861,311.9 lb

N. Cement: 196.65 (4,926,960) = 968,886,684 lb

Total = 2,439,007,408 lb

Average Density

$$\rho_{avg} = \frac{2,439,007,408\ lb}{14,519,412\ ft^3} = 167.98\ lb/ft^3$$

• assume ℓ 1' into page

$W_1 = 167.98\ ^{lb}/_{ft^3} \times (25' \times 110') \times 1' = 461{,}945\ lb$

$W_2 = 167.98\ ^{lb}/_{ft^3} \times (\frac{1}{2} \times 56.5' \times 90') \times 1' = 427{,}089.15\ lb$

$W_3 = 167.98\ ^{lb}/_{ft^3} \times (\frac{1}{2} \times 22.25' \times 89') \times 1' = 166{,}321.20\ lb$

$W_4 = 167.98\ ^{lb}/_{ft^3} \times (81.5' \times 89') \times 1' = 1{,}218{,}442.93\ lb$

$W_5 = 167.98\ ^{lb}/_{ft^3} \times (\frac{1}{2} \times 72.25' \times 89') \times 1' = 540{,}076.70\ lb$

Pressure from Water

$P_{w_1} = \frac{1}{2} K_a \gamma_w (h_1)^2$ * $K_a = 1$ for water

$= \frac{1}{2}(1)\, 62.4\ ^{lb}/_{ft^3}\, (90')^2$

$P_{w_1} = 252{,}720\ lb$

$P_{w_2} = K_a \gamma_w (h_2)^2$

$= 1\, (62.4\ ^{lb}/_{ft^3})\, (89')^2$

$= 494{,}270.4\ lb$

$P_{w_{2H}} = 494{,}270.4\ lb \cos(14.04°) = 479{,}504.86\ lb$

$P_{w_{2V}} = 494{,}270.4\ lb \sin(14.04°) = 119{,}909.62\ lb$

$P_{w_3} = \frac{1}{2} K_a \gamma_w (h_2)^2$

$= \frac{1}{2}(1)\, 62.4\ ^{lb}/_{ft^3}\, (89')^2$

$P_{w_3} = 247{,}135.2\ lb$

$P_{w_{3H}} = 247{,}135.2\ lb \cos(14.04°) = 239{,}752.43\ lb$

$P_{w_{3V}} = 247{,}135.2\ lb \sin(14.04°) = 59{,}954.81\ lb$

	Load (lb)	Moment Arm (ft)	Moment about Toe (lb-ft)
P_{W_1}	252,720	$89' + \frac{90'}{3} = 119'$	30,073,680
$P_{W_{2H}}$	479,504.86	$89'/2 = 44.5'$	21,337,966.27
$P_{W_{3H}}$	239,752.43	$89'/3 = 29.67'$	7,113,454.60
	$\Sigma H = 971,977.29$		$\Sigma M_o = 58,525,100.87$ ✓2
W_1	461,945	$176' - 22.25' - \frac{25'}{2} = 141.25'$	65,249,731.25
W_2	427,089.15	$72.25' + \frac{56.5'}{2} = 100.5'$	42,922,459.58
W_3	166,321.20	$176' - \frac{22.25'}{2} = 164.88'$	27,423,039.46
W_4	1,218,442.93	$72.25' + \frac{81.5'}{2} = 113'$	137,684,051.1
W_5	540,076.70	$72.25'/2 = 36.13'$	19,512,971.17
$P_{W_{1V}}$	119,909.62	$176' - \frac{(89'+2)}{\tan(75.96°)} = 164.87'$	19,769,499.05
$P_{W_{3V}}$	59,954.81	$176' - \frac{(89'+3)}{\tan(75.96°)} = 168.58'$	10,107,181.87
	$\Sigma V = 2,993,739.41$		$\Sigma M_R = 322,668,933.5$

Factor of Safety Against Overturning:

$$FS_o = \Sigma M_R / \Sigma M_o$$

$$= 322,668,933.5 / 58,525,100.87$$

$FS_o = 5.51 > 2$ OK

Factor of Safety Against Sliding:

$$FS_s = \frac{[\Sigma V \tan(\frac{2}{3}\phi_2') + \frac{2}{3}C_2'](b) + P_p}{\Sigma H}$$

*[Ignore P_p]

Assume Rock:
$C_2' = 208,854.34 \frac{lb}{ft^2}$
$\phi_2' = 30°$

$$= \frac{[2,993,739.41 \tan(\frac{2}{3} \cdot 30°) + \frac{2}{3}(208,854.34)](176')}{971,977.29}$$

$FS_s = 222.5 > 2$ OK