WHITCHURCH ENGINEERING
610 9th Street
Fortuna, CA 95540
Phone: (707) 725-6926

Aquadam Stability Calculation

Perry's Victory and International Peace Memorial Seawall Retrofit Project, Put-in Bay, Ohio

Whitchurch engineering job no.	ESW2301
Date	March 22 2003
Calculated by	P.Michael Gent
	California Lic no. C71604

Purpose: Evaluate the stability of a 14' high Aquadam, backed up with a 10' high Aquadam, to protect reconstruction of the breakwater at the Perry's Victory and International Peace Memorial, Put-In-Bay, Ohio.

Assumptions: The maximum depth of retained water will be 8'. The soils which the Aquadam rests upon are stable clayey sands. A coefficient of friction of 0.30 has been chosen for this interface. The Aquadam is not expected to settle in these soils. This calculation assumes the Aqua Dam flotational forces act across 1/3 the dam contact width.

Sources of information: Perry's Victory and International Peace Memorial, Drawing no. 370/152968 shows the maximum still water elevation as 576.2'. The drawing by ES Wagner Co. shows the water elevation as 573.4'. Both drawings show the low point at the lake bed where the dam will be placed is shown as 565.9'. This calculation uses the still water height from the ES Wagner drawing. A retained water height of 8' is used in this calculation. Wave impact has been calculated per ASCE7-16 chapter 5. The coefficient of friction for geotextile fabric against sands, from a study by Bosto Geosynthetics, is .84. As the contact soils are submerged clayey sands the coeficient of friction chosen for this calculation is 0.30.

Exclusions: This calculation is based on information presented to us by E.S. Wagner. Whitchurch Engineering has not inspected the site and accepts no responsibility for conditions differing from those represented herein. Whitchurch Engineering does not hold a license to practice civil engineering in Ohio and expects review and approval of this calculation by an Ohio licensed civil engineer.

Conclusions: The Aquadams as presented here offer a 2.1:1 factor of safety against sliding and a 3.2:1 factor of safety against overturn.

Single dam

h, Dam height	14	feet
d, height of retained water	8	feet
Temp of water in dam and being retained assumed similar	55	deg F
g, Density of liquid 62.4pcf for fresh water 64.0pcf for salt water	62.4	lbs/cuft
α, angle to horizontal for predicting wave force	30	deg
Cp, from ASCE7-16 table 5.4-1	1.6	
v, flow rate normal to dam	0	feet/second
m, Estimated coeficient of friction	0.3	
w, Estimated contact width across bottom of dam	26	feet
V, estimated dam volume	332	cuft/ft

Calculation of lateral force acting on dam

Ff, Lateral force from flow = dgv^2/(2*Gc)	0	lbs/ft dam length
Fs, lateral force from static water height $=gd^2/2$	1,997	lbs/ft dam length
Ft, Total lateral force from static height and flow	1,997	lbs/ft dam length
F_{tw}, combined lateral force from wave action from ASCE7-16 equ 5.4-6 , $F_{tw}=1.1C_p g_w d_s^2+2.4g_w d_s^2$	16,613	lbs/ft dam length
Fnv due to angle of dam surface above the water line ASCE7-16 equ 5.4-8 $Fnv=Ftsin^2\alpha$	4,153	lbs/ft dam length
Ft, Total lateral force for this calculation	4,153	lbs/ft dam length

Resistance to sliding

ground pressure exerted by dam P=Vg/w	797	psf
Total pressure acting on interior dam membrane contact width, = Pw	20,717	lbs/ft dam length
Flotation force from static height = gdw/6	2,163	lbs/ft dam length
Net gravitational force creating friction = Pw – gdw/6	18,554	lbs/ft dam length
F_1, Frictional force resisting lateral movement = m (Pw-gdw/6)	5,566	lbs/ft dam length
Factor of safety against lateral displacement = lat. force/frict. force	1.34	

Resistance to overturn

Md, Moment imparted by static depth = .3333*d*gd^2/2	5,324	ftlbs/ft dam length
Mf, Moment imparted by flow = .5*d*dgv^2/2	0	ftlbs/ft dam length
Mw, Or moment imparted by wave action =dFnv	33,227	ftlbs/ft dam length
Mb, Moment imparted by flotation = .888*w*gdw/6	49,944	ftlbs/ft dam length
Sum Mw and Mb	83,171	ftlbs/ft dam length
Mr, Resisting vertical moment dam width water weight = .5w*gV	269,318	ftlbs/ft dam length
Factor of safety against overturn = resisting moment/overturn moment	3.2	

Lateral force resistance with second dam as back up

h_2, Second dam height	10	feet
w_2, Second dam contact width across bottom of dam	18	feet
V_2, Second dam estimated volume	166	cuft/ft
F2, Frictional force resisting lateral movement = gV_2m	3370	lbs/ft dam length
Combined frictional force resisting lateral force = F_1+F_2	8936	lbs/ft dam length
Combined factor of safety against sliding	2.15	

WHITCHURCH ENGINEERING
610 9th Street
Fortuna, CA 95540
Phone: (707) 725-6926

Diagram of forces in Aquadam calculation