VOLUME I

PHASE I

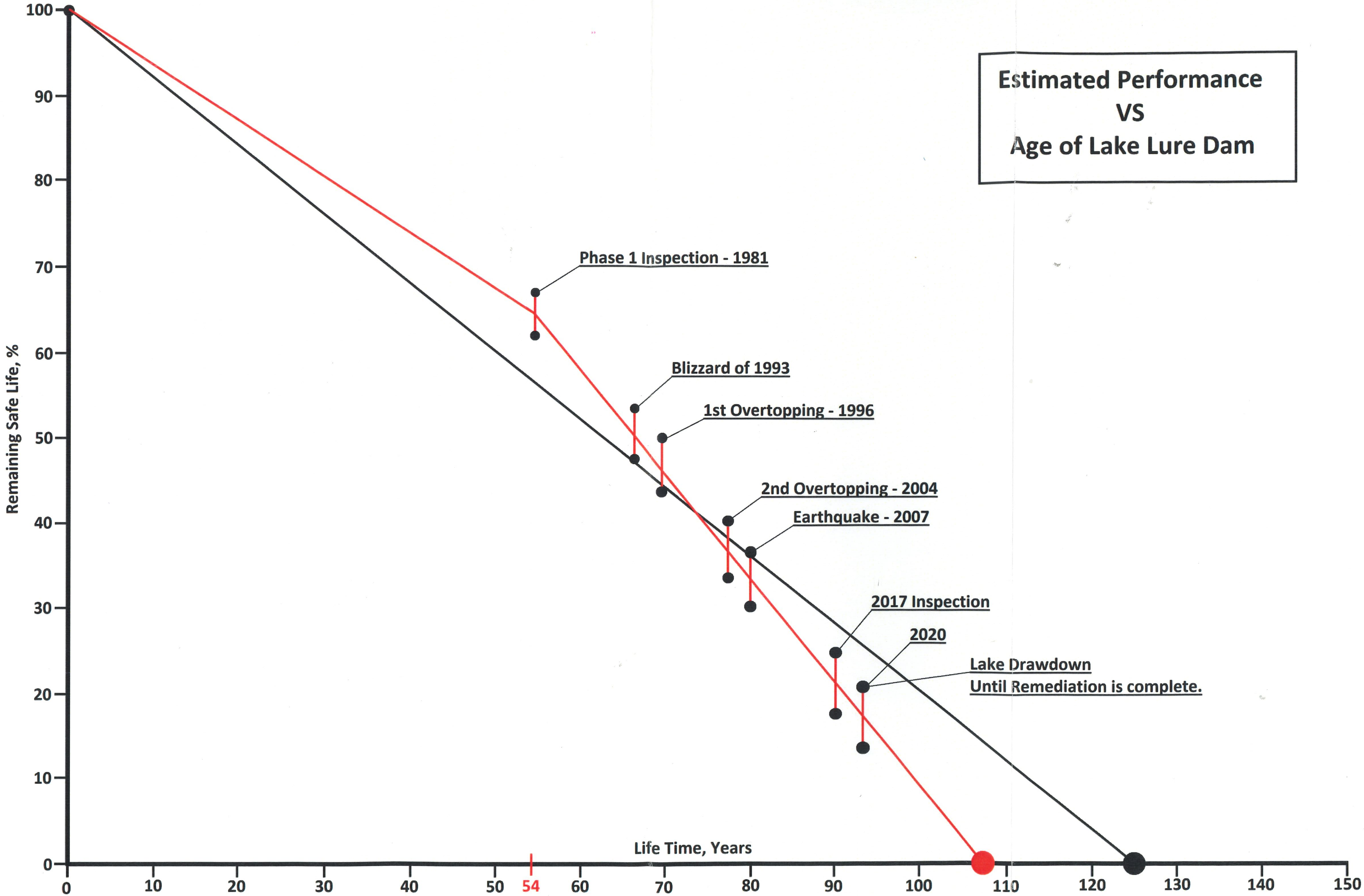
DAM SAFETY INSPECTION REPORT

APPENDIX C

TABLE I – 1 PERFORMANCE INVENTORY

TABLE I-1
PERFORMANCE INVENTORY

BAY No.	COMMENT	LEAKAGE	JOINTS	RATING
1	OGEE S/W	MOD.	FAIR	60
	Lt. Abut. Wall	SEV.	FAIR	50
2	OGEE S/W	MIN.	GOOD	70
3	OGEE S/W	END SCOUR	FAIR	55
	TRASH GATE	MOD.		50
4		MOD.	FAIR	65
5	SEWER LINE	MOD.	FAIR	50
6		SEV.	POOR	40
7	P. HOUSE	MOD.	FAIR	60
8		MOD.	FAIR	55
9		EXT.	SEVERE	40
10		EXT.	SEVERE	30
11		SEV.	POOR	35
12		MOD.	FAIR	55
13		MIN.	FAIR	65
			OVERALL	52


Estimated Performance
VS
Age of Lake Lure Dam
Remaining Safe Life, %
100
90
80
70
60
50
40
30
20
10
0
Phase 1 Inspection - 1981
Blizzard of 1993
1st Overtopping - 1996
2nd Overtopping - 2004
Earthquake - 2007
2017 Inspection
2020
Lake Drawdown
Until Remediation is complete.
Life Time, Years
0
10
20
30
40
50
54
60
70
80
90
100
110
120
130
140
150

STABILITY ANALYSES
SECTION C-C; BUTTRESS NO. 11
REFERENCE SHEET 2 of F

ACTING AND RESISTING FORCES ON SECTION C-C:

WEIGHT OF ROADWAY BRIDGE: SPAN LENGTH = 41 FEET

1. GUARD RAIL WALLS:
$W_{BW} = 2 \cdot 41' \cdot [1' \cdot 4' \cdot 135\ pcf] = 44,280\ lbs$
VERTICAL FORCE @ ℄ OF BUTTRESS

2. BRIDGE DECK: WIDTH = 21 FEET; THICKNESS = 6 IN.
$W_{BD} = [41' \times 21' \times 0.5' \times 135\ pcf] = 58,117.5\#$
VERTICAL FORCE @ ℄ BUTTRESS & COG of BRIDGE

3. BRIDGE GIRDERS:
THREE (3) EQUALLY-SPACED CONCRETE BEAMS: 2' x 3'
$W_{BG} = 3 \cdot [2' \times 3' \times 41' \times 135\ pcf] = 99,630\#$
THREE (3) EQUAL LOADS of 33,210# @ ℄ BUTTRESS

4. BRIDGE BENT ON TOP of BUTTRESS No. 11:
$W_{BB} = [3' \times 6' \times 21' \times 135\ pcf] = 51,030\#$
VERTICAL LOAD @ COG of BUTTRESS CAP

TOTAL WEIGHT of BRIDGE = 253,057.5#

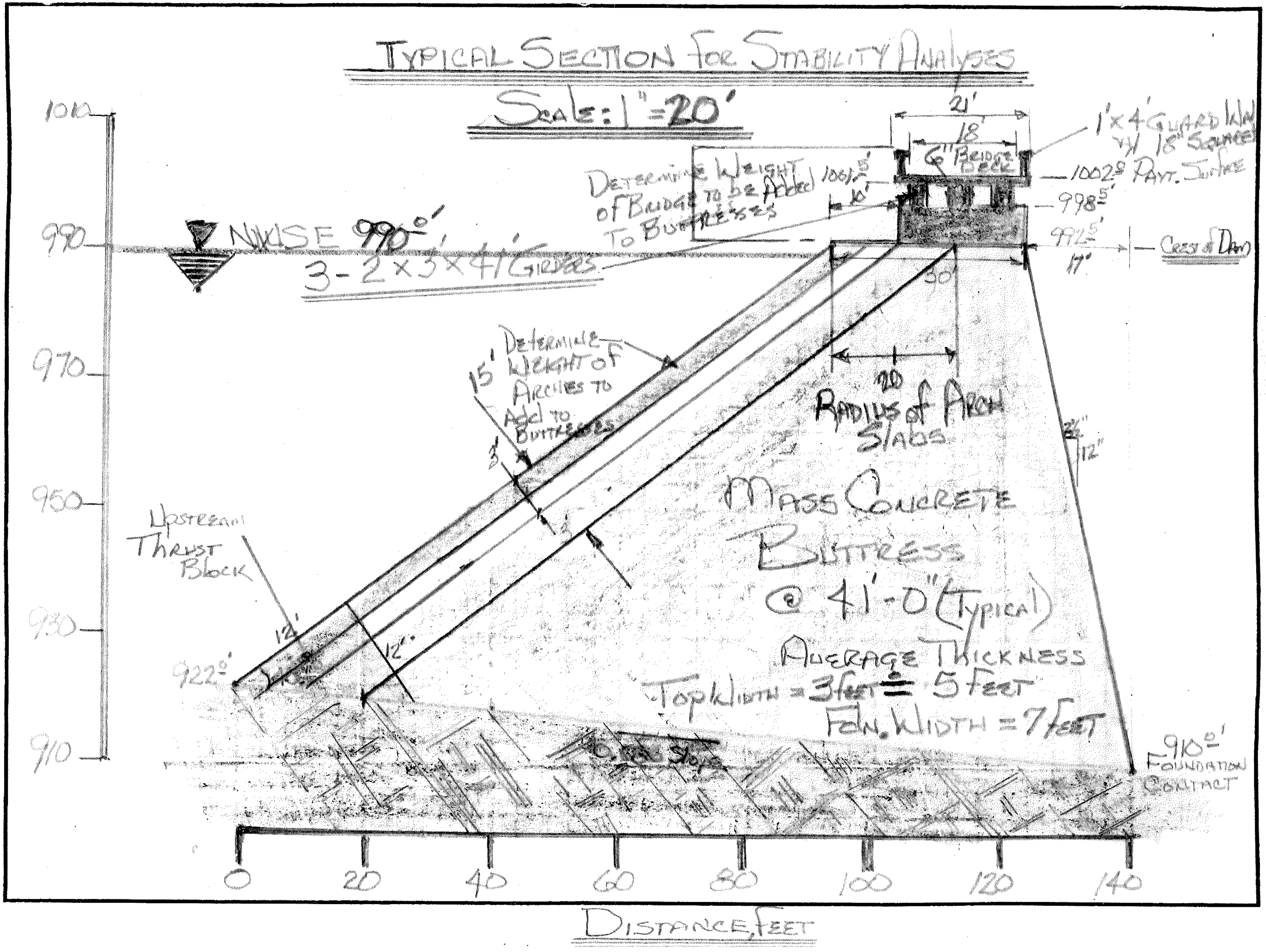
REQ'D F. ADDITIONAL LOADING:

F.S. = 3.0	– NORMAL LOADING – ADD ONE (1) VEHICLE = 5,000#
F.S. = 2.0	– UNUSUAL LOADING – ADD TWO (2) VEHICLES = 10,000#
F.S. = 1.0	– EXTREME LOADING – ADD THREE (3) VEHICLES = 15,000#

MARKS ENTERPRISES OF NC, PLLC

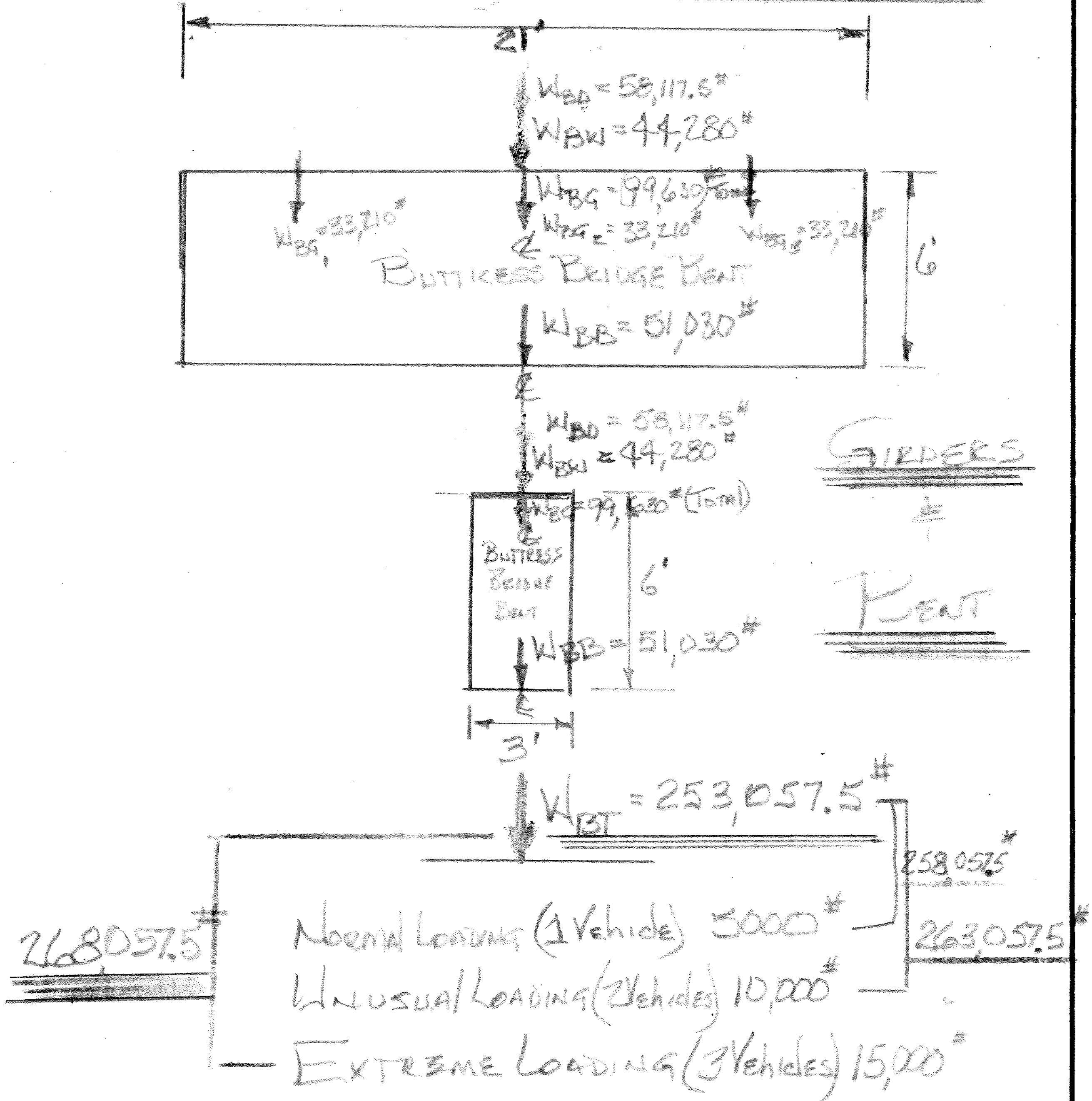
BY: BDM DATE: 03-11-2017 SHEET No. 2 of 7

PROJECT: Stability Analyses Section PROJECT No. TYE-16-006



Roadway Bridge Loading Diagrams:

Guard Rail Walls & Bridge Deck:



ACTING & RESISTING FORCES ON SECTION C-C (CONT'D):

WEIGHT of SEMI-CIRCULAR UPSTREAM SLAB:

REFERENCE SHEET 2 of

$W_{TOTAL\,(NORMAL)} = 1,352,400^{\#}$

$W_{VERTICAL} = 956,147^{\#}$ ACTING @ 84' FROM HEEL

$W_{LATERAL} = 956,147^{\#}$ ACTING @ 50' ABOVE HEEL

WEIGHT of BUTTRESS No. 11 w/ BUTTRESS CAP:

REFERENCE SECTION C-C ON SHEET 2 of

$W_{cap} = [2.5' \cdot 3' \cdot 21'] \times 135\,pcf = 21,262.5^{\#}$

FORCE ACTING @ ℄ of CAP; $\bar{X} = 10.5'$; $\bar{Y} = 1.5'$

WEIGHT COMPONENTS:

$W_1 = 1/2(B \cdot H \cdot t) \times \gamma_{CONCRETE} = 1/2 \cdot 20' \cdot 80' \cdot 5' \cdot 135\,pcf$

$W_1 = 540,000^{\#}$ ACTING @ 13.33' FROM HEEL

$W_2 = (21' \times 80' \times 5') \cdot 135\,pcf = 1,134,000^{\#}$

ACTING @ 30.5' FROM HEEL

$W_3 = W_{CAP} \longrightarrow$ SEE ABOVE

$W_4 = 1/2(72' \cdot 80' \cdot 5') \cdot 135\,pcf$

$W_4 = 1,944,000^{\#}$ ACTING @ 65' FROM HEEL

$W_5 = W_{THRUST\,BLOCK} = 1/2(27' \cdot 14' \cdot 41') \cdot 135\,pcf$

$W_5 = 1,046,115^{\#}$ ACTING @ 131' FROM HEEL

Acting & Resisting Forces on Section C-C: (Cont'd)

Hydrostatic Loading:

Weight of H_2O over U/S Slab:

$$W_W (P_W) = \tfrac{1}{2}(B \cdot H \cdot L \cdot \gamma_0) = \tfrac{1}{2} \cdot (70' \cdot 70' \cdot 41' \cdot 62.4\,pcf)$$

$$P_W = 6,268,080\ lbs$$

$\bar{X}$ = 115 feet U/S of Heel of Buttress

Lateral Force of Water on U/S Slab:

$$P_1 = P_W = 6,268,080\ lbs$$

$\bar{Y}$ = 57 feet Above the Heel of Buttress

Hydrostatic Uplift:

Hydrostatic Pressure @ Heel = $P_{u_1} = 70' \cdot 62.4\,pcf$

$P_{u_1} = 4368\,psf$

Hydrostatic Pressure @ D/S End of Slab Thrust Block:

$$P_{u_2} = (70' - 2') \cdot 62.4\,pcf = 4243.2\,psf$$

$$P_{U_1} = \left(\frac{4368 + 4243.2}{2}\right) \cdot 28' \cdot 41' = 4,942,828.8\,\#$$

$\bar{X}$ = 126.5' from Heel of Buttress

Hydrostatic Pressure @ U/S End of Buttress

$$P_{u_3} = P_{u_2} = 4243.2\,psf$$

Hydrostatic Pressure @ Heel of Buttress

$$P_{u_4} = 0.0 + \Delta \cdot \gamma_0 = 10 \cdot 62.4 = 624\,psf$$

P_{u_4} acts @ 67.4' from Heel of Buttress

$$P_{U_2} = \left(\frac{4243.2 + 624.0}{2}\right) \cdot 7' \cdot 112' = 1,907,942.4\,\#$$

SLIDING RESISTANCE, F_R:

$$F_R = C_a \cdot A_{Fdn} + (\Sigma W - \Sigma P_u)\tan\phi_f$$

C_a = Cohesion/Adhesion Concrete to Bedrock

For 90-Year Old Concrete $C_a \Rightarrow \cancel{0}$

Trial 1 Stability Analysis

Use C_a = 15,000 psf

$A_{Fdn} = 140' \cdot 7' = 980 \text{ ft}^2$

$\Sigma W = W_B + W_{Buttress} + W_{Slab} = 7,498,357\#$

$W_{Water} = 6,268,080\#$

$\Sigma W_{Structure} + W_{Water} = 13,766,437\#$

$\Sigma P_u = P_{u_1} + P_{u_2} = 4,942,828.8\# + 1,907,942.4\#$

$\Sigma P_u = 6,850,771.2\#$

$(\Sigma W - \Sigma P_u) = 6,915,665.8\#$

$\tan\phi_{Concrete} = 0.36; \phi = 20°$

$\tan\phi_{Bedrock} = 1.70; \phi = 59.5°$

Trial 1 Stability Analysis

Use $\phi_{Concrete} = 20$

SLIDING RESISTANCE, F_R: (CONT'D)

$$F_R = C_a \cdot A_{FDN} + [\Sigma W - \Sigma P_u] \tan \phi_{f_{CONCRETE}}$$

$$F_R = \boxed{15{,}000 \cdot 980^{\#}} + 6{,}915{,}665.8^{\#} \cdot 0.36$$

$$F_R = (14{,}700{,}000) + (2{,}489{,}639.7^{\#})$$

$$F_R = 17{,}189{,}639.7^{\#}$$

FACTOR of SAFETY UNDER NORMAL CONDITIONS:

$$F.S._{SLIDING} = \frac{F_R}{P_w} = \frac{17{,}189{,}639.7^{\#}}{6{,}268{,}080^{\#}}$$

$$F.S._{SLIDING} = 2.74 < 3.00$$

NOT GOOD

IF $\phi_{CONCRETE}$ IS REDUCED FURTHER BY WEATHERING SO THAT C_a = 7,500 psf & $\phi_f = 15°$ ($\tan\phi = 0.27$) THE FACTOR of SAFETY AGAINST SLIDING IS REDUCED TO **1.47** WHICH IS UNACCEPTABLE

CONSEQUENTLY, THE UPLIFT FORCE & CONDITION of the CONCRETE to BEDROCK CONTACT ARE VITAL TO THE SAFETY.

Factor of Safety Against Overturning:

$$F.S._{O.T.} = \frac{M_{RESISTING}}{M_{OVERTURNING}} = \frac{\Sigma(P_{VERTICAL} \cdot L_{VERTICAL})}{\Sigma[P_{LATERAL} \cdot L_{LAT} + P_{UPLIFT} \cdot L_{U}]}$$

$$M_O = [P_{L_{slab}} \cdot L_{slab} + P_{L_{WATER}} \cdot L_{WATER} + P_{UPLIFT} \cdot L_{UPLIFT}]$$

$$P_{L_S} \cdot L_{slab} = 956,147^{\#} \cdot 50' = 47,807,350 \text{ ft-lbs}$$

$$P_{L_{WATER}} \cdot L_{WATER} = 6,268,080^{\#} \cdot 57' = 357,280,560 \text{ ft-lbs}$$

$$\Sigma P_{UPLIFT} \cdot L_{UPLIFT} = P_{U_1} \cdot L_1 + P_{U_2} \cdot L_2 = 4,942,828.8^{\#} \cdot 126' +$$
$$1,907942.4^{\#} \cdot 67.4' = 622,796,428.8 +$$
$$128,595,317.8 = 751,391,746.6$$

$$M_O = 47,807,350 + 357,280,560 + 751,391,746.6$$

$$M_O = 1,156,479,656.6 \text{ ft-lbs}$$

$$M_R = M_{BRIDGE} + M_{BUTTRESS} + M_{slab} + M_{WATER} + M_{THRUST\ BLOCK}$$

$$M_{BRIDGE} = 258,057.5^{\#} \cdot 30.0' = 7,741,725.0 \text{ ft-lbs}$$

80316398 $M_{SLAB} = 1,229,512^{\#} \cdot 84.0' = 103,279,450.8 \text{ ft-lbs}$

$$M_{WATER} = 6,268,080.0 \cdot 115' = 720,829,200 \text{ ft-lbs}$$

Factor of Safety Against Overturning: (Cont'd)

$$M_{BUTTRESS} = W_1 L_1 + W_2 L_2 + W_3 L_3 + W_4 \cdot L_4 + W_5 \cdot L_5$$

$$M_{BUTTRESS} = (540{,}000 \cdot 13.33) + (1{,}134{,}000 \cdot 30.5') + (21{,}262.5^{\#} \cdot 29.5') + (1{,}944{,}000^{\#} \cdot 65') + (89{,}302.5^{\#} \cdot 131')$$

$$M_{BUTTRESS} = [7{,}199{,}820 + 34{,}587{,}000 + 627{,}243.75 + 126{,}360{,}000 + 11{,}698{,}627.5] \text{ ft-lbs}$$

$$\underline{\underline{M_{R_{BUTTRESS}} = 180{,}472{,}691.25 \text{ ft-lbs}}}$$

$$M_{THRUST\ BLOCK} = 1{,}046{,}115^{\#} \times 131'$$
$$\underline{\underline{= 137{,}041{,}065 \text{ ft-lbs}}}$$

$$\underline{\underline{\Sigma M_R = 1{,}229{,}680{,}480.1 \text{ ft-lbs}}}$$

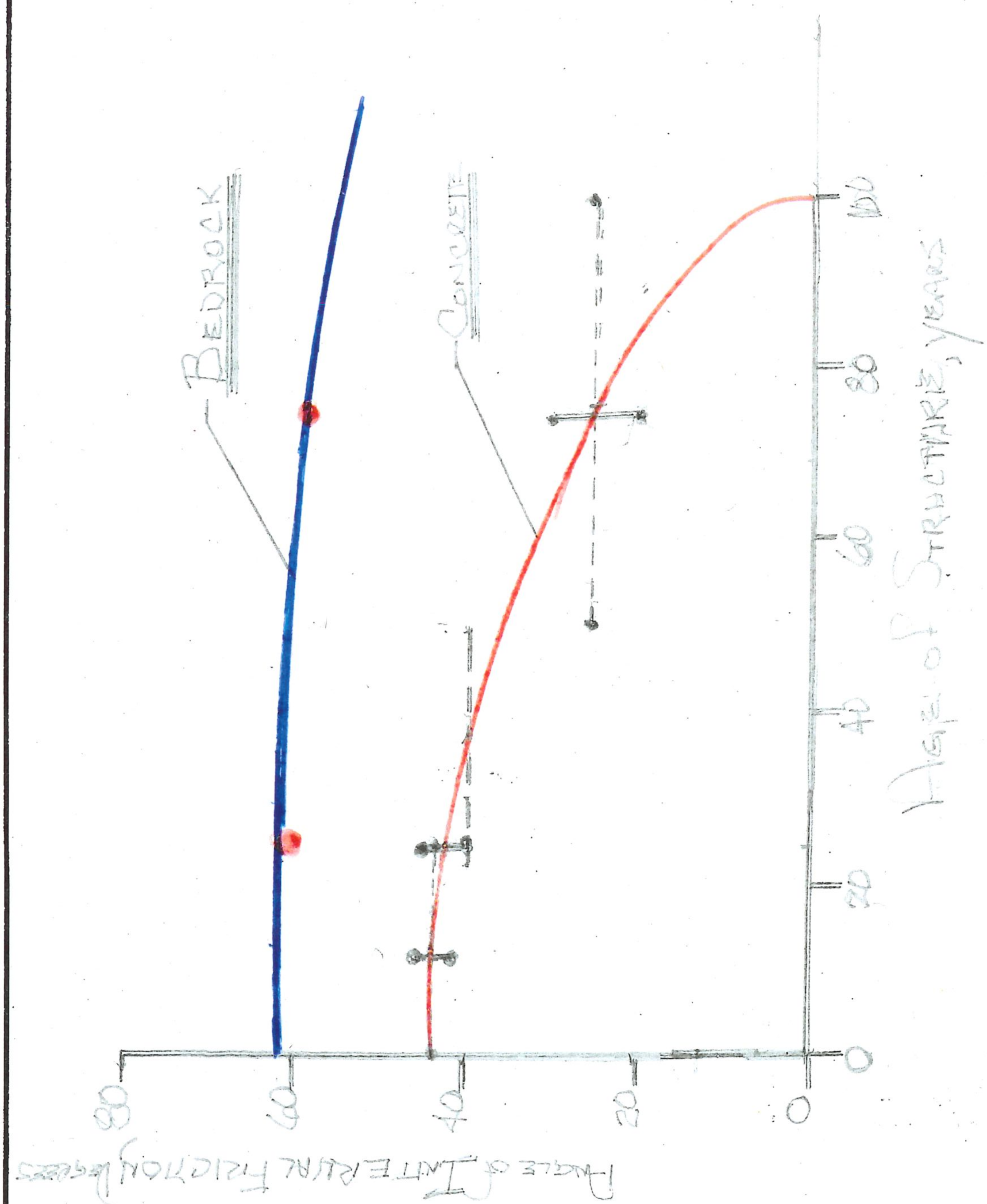
$$F.S._{OT} = \frac{M_R}{M_O} \quad \frac{1{,}229{,}680{,}480}{1{,}156{,}479{,}657}$$

$$\underline{\underline{F.S._{OVERTURNING} = 1.06}}$$

Extremely Marginal!

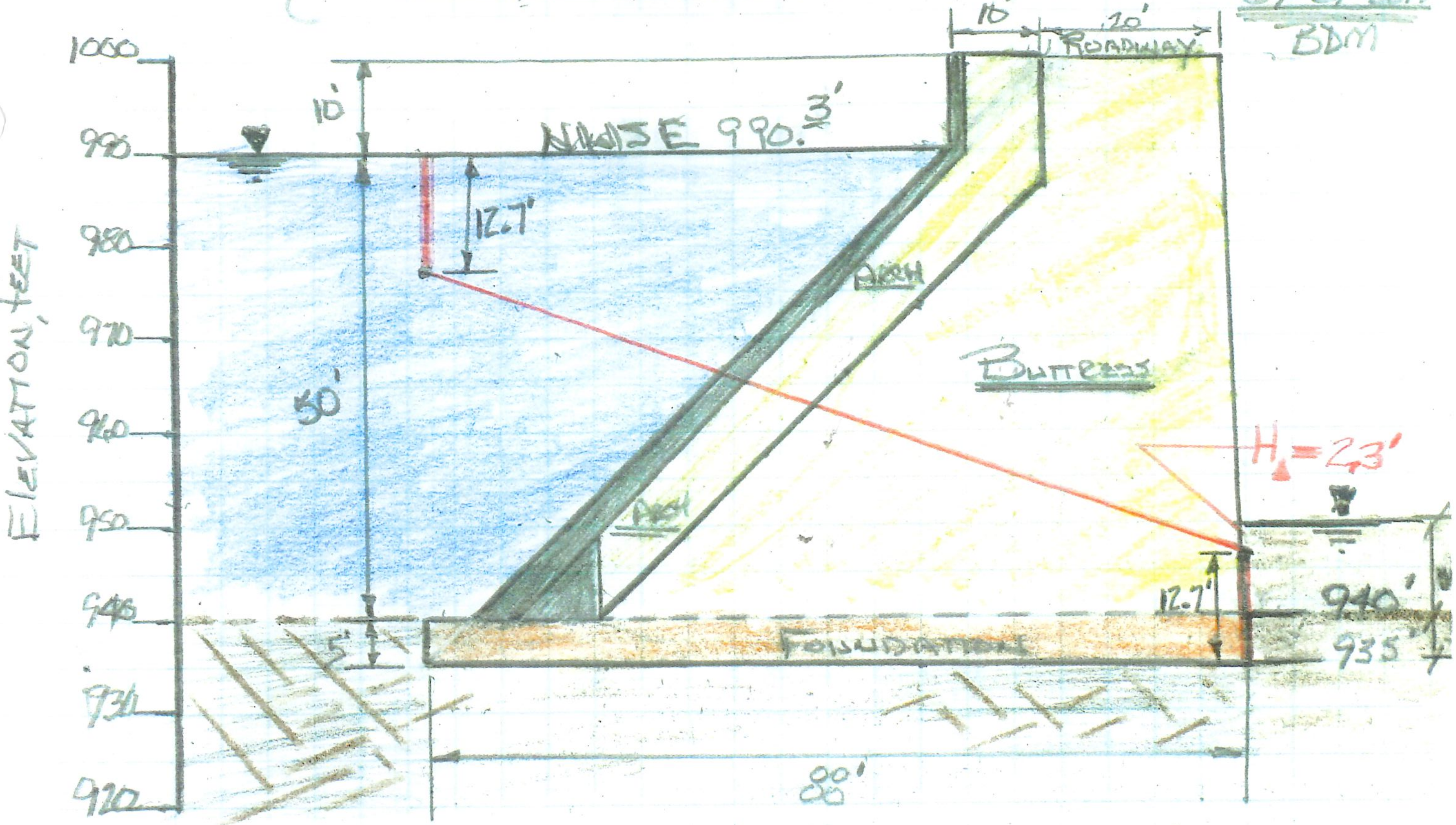
$\therefore$ Must Conduct Detailed Stability Analyses with Piezometer Data.

BY: BDM DATE: 03-20-2017 SHEET No. N/A of N/A
PROJECT: Inspection of Lake Lure Dam PROJECT No. ME-16-008



LANE' WEIGHTED CREEP THEORY

09-01-2017
BDM



$$L_L = d_1 + d_2 + \tfrac{1}{3}(L_1) = 5' + 5' + \tfrac{1}{3}(88') = \underline{39.33'}$$

$$H_L = H_W = 50' \;;\; \frac{H_L}{L_L} = \frac{50'}{39.33'} = \underline{1.27}$$

$$\frac{H_L}{L_L}\cdot 2d_1 = 1.27 \cdot 10' = \underline{12.7'}\;;\; \frac{H_L}{L_L}\cdot 2d_3 = 1.27\cdot 10' = \underline{12.7'}$$

Excess Hydrostatic Head, $H_\Delta = H_T - \frac{H_L}{L_L}\cdot d_2$

$C_{L_{MIN}}$ FOR PWR = 1.0 TO 2.0

$H_\Delta = 15' - 12.7' = 2.3$ Feet

Excess Hydrostatic Pressure, $P_W = H_\Delta \cdot \gamma_0$

C_L (Partially Weathered Rock) 1.0 TO 2.0 > 0.79

$P_W = 2.3$ feet $\cdot$ 62.4 pcf

$P_W = 143.5$ psf

LANE'S WEIGHTED CREEP THEORY:

NOT GOOD

$$L_L \geq C_L \cdot H_L \;:\; 39.33' \geq C_L \cdot 50'$$

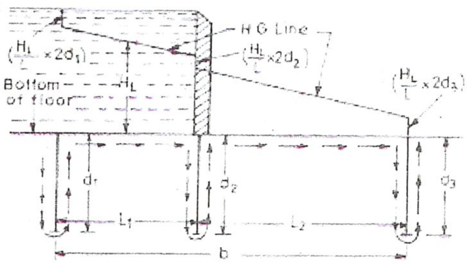
$$C_L \leq \frac{39.33'}{50.0'} = 0.79$$

Lane's Weighted Creep Theory

8/31/2015 No comments

Bligh, in his theory, had calculated the length of the creep, by simply adding the horizontal creep length and the vertical creep length, thereby making no distinction between the two creeps. However, Lane, on the basis of his analysis carried out on about 200 dams all over the world, stipulated that the horizontal creep is less effective in reducing uplift (or in causing loss of head) than the vertical creep. He, therefore, suggested a weightage factor of 1/3 for the horizontal creep, as against 1.0 for the vertical creep.

Thus in Fig–1,



the total Lane's creep length (L_l) is given by

$$L_l = (d_1 + d_1) + (1/3)\,L_1 + (d_2 + d_2) + (1/3)\,L_2 + (d_3 + d_3)$$
$$= (1/3)\,(L_1 + L_2) + 2(d_1 + d_2 + d_3)$$
$$= (1/3)\,b + 2(d_1 + d_2 + d_3)$$

To ensure safety against piping, according to this theory, the creep length Ll must no be less than C_1H_L, where H_L is the head causing flow, and C_1 is Lane's creep coefficient given in table –2

Table – 2: Values of Lane's Safe Hydraulic Gradient for different types of Soils

SL. No.	Type of Soil	Value of Lane's Coefficient C_1	Safe Lane's Hydraulic gradier should be less than
1	Very fine sand or silt	8.5	1/8.5
2	Fine sand	7.0	1/7
3	Coarse sand	5.0	1/5
4	Gravel and sand	3.5 to 3.0	1/3.5 to 1/3
5	Boulders, gravels and sand	2.5 to 3.0	1/2.5 to 1/3
6	Clayey soils	3.0 to 1.6	1/3 to 1/1.6

G+

Reactions: funny (0) interesting (1) cool (1)

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0 comments:

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