

ROLLINS, BROWN AND GUNNELL, INC.

PROFESSIONAL ENGINEERS

July 14, 1982

Larry Bowen
Horrocks Engineers
1 West Main
American Fork, UT 84003

Dear Larry:

A stability analysis has been completed for the Crandall Canyon Pond proposed by Price River Coal Company. In order to define the characteristics of the embankment material, laboratory tests were performed on a representative sample of the soil furnished us by Horrocks Engineers.

Atterberg and grain-size distribution tests show the soil to be a gravelly, sandy clay with low plasticity characteristics. The modified proctor performed on the material indicated a maximum density of 127 pounds per cubic foot with a moisture content of 10.2 percent (see Figure 1).

The strength parameters for use in the stability analysis were defined by performing both triaxial and direct shear tests on the minus No. 4 material. The results of both tests indicate a friction angle of approximately 34 degrees with a cohesion of around 1 psi (see Figures 2 and 3).

The maximum section investigated in the analysis was 16 feet high with a crest width of 20 feet. The high water surface was placed 7 feet below the crest, and the piezometric line was sloped from the upstream water surface to the downstream toe of the embankment. This, of course, represents the downstream steady-state case. The upstream sudden drawdown case was not considered.

The stability analysis was performed on the DEC 10 computers at BYU using a program developed by Stephen Wright at the University of Texas. This program is based on Spencer's method for stability analysis and satisfies both force and moment equilibrium.

It is our understanding that the foundation material underlying the embankment is composed of a soil type similar to that in the embankment; however, since no laboratory tests were performed on the foundation material, lower values for the density and strength parameters were assumed.

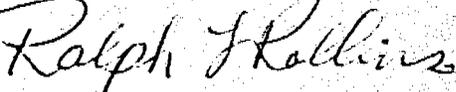
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The embankment was assigned a total unit weight of 132 pounds per cubic foot and a friction angle of 34 degrees, and the foundation was assigned a density of 124 pounds per cubic foot and a friction angle of 32 degrees in all cases. With a cohesion of 100 pounds per square foot in the embankment and none in the foundation, sideslopes of 1.5 horizontal to 1 vertical were required for a factor of safety of 1.5. However, if the cohesion in both the foundation and the embankment is assumed as 150 pounds per square foot, a factor of safety of 1.5 could be obtained for sideslopes of 1 horizontal to 1 vertical.

It is our opinion that a cohesion of 150 pounds per square foot is justified, based upon the laboratory tests performed and that the steeper sideslopes should perform satisfactorily. If you have any questions regarding the information contained herein, please advise us.

Yours truly,

ROLLINS, BROWN AND GUNNELL, INC.



Ralph L. Rollins

KR/lw

enc.



SOIL MOISTURE DENSITY RELATIONSHIP

ASTM D 1557-78

Maximum Density 127.0 lbs. per cubic foot

Optimum Moisture 10.2 %

DRY UNIT WEIGHT IN LBS. PER CUBIC FOOT

128

126

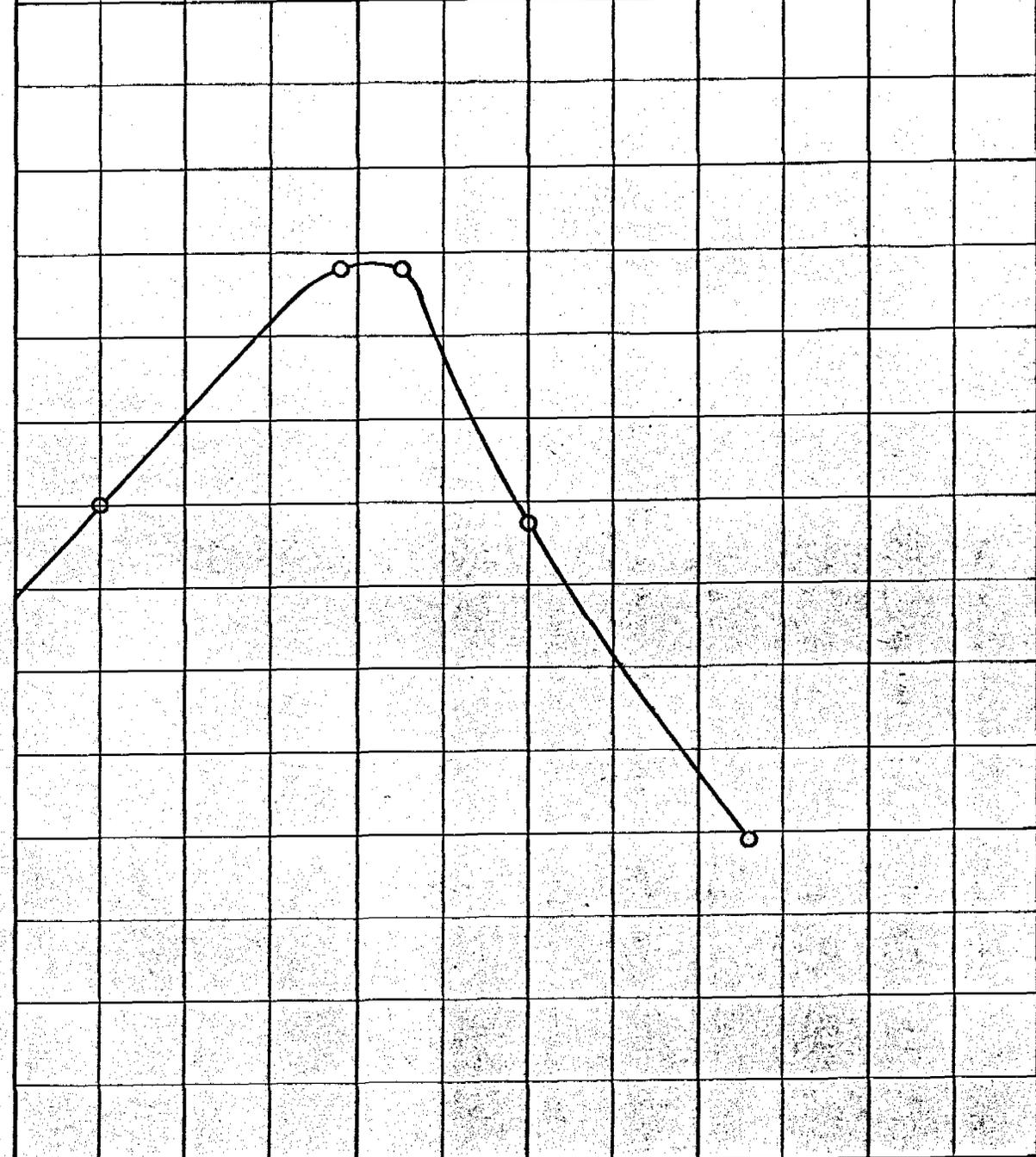
124

122

120

118

116



MOISTURE IN PERCENT



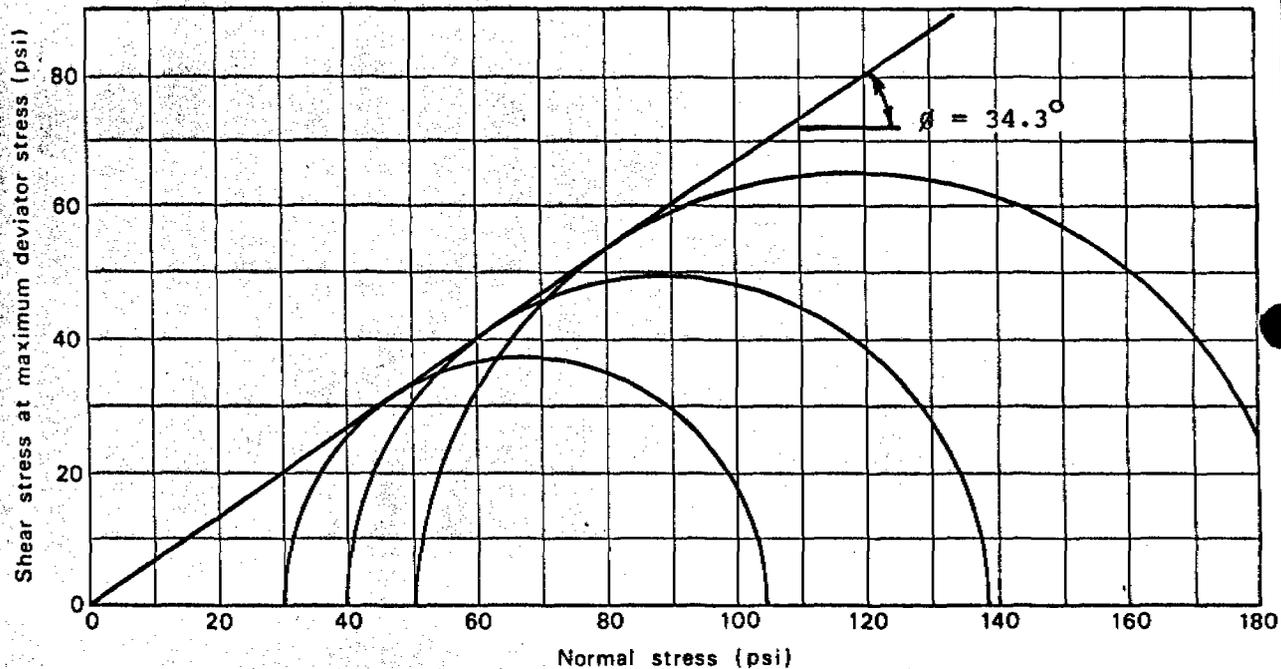
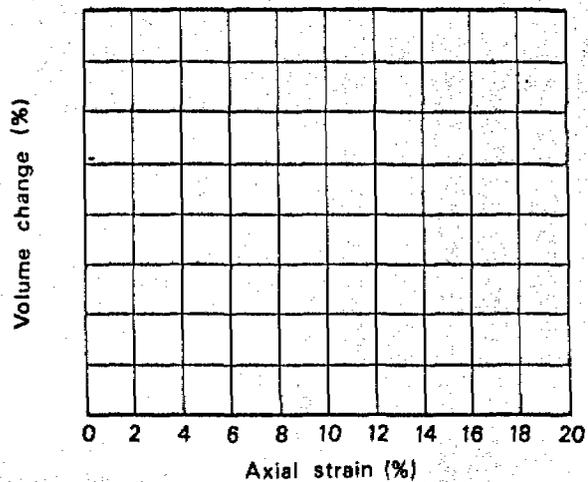
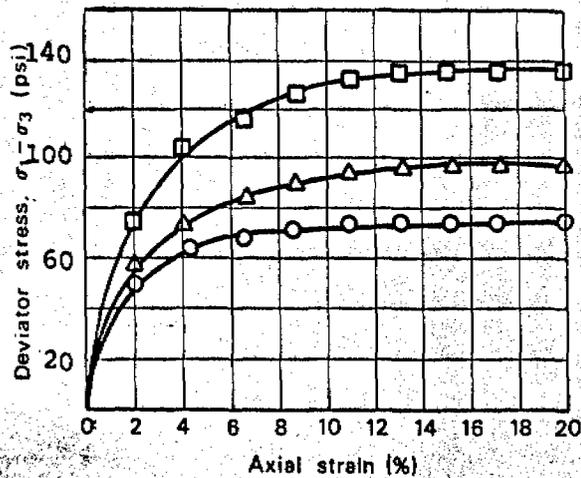
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Project: Crandall Canyon Pond
Price River Coal Company

Location:

Figure No. 1



Test no. or symbol	Boring no. or depth	Sample data		Degree of saturation (%)	Confining pressure (psi)	Maximum deviator stress (psi)	Strength values at failure		Sample size, L/D (inches)	Strain rate (inches/minute)
		Dry density (pcf)	Moisture content (%)				Friction angle ϕ (degrees)	Cohesion (c/psi)		
○		119.1	10.0	100.0	30	74.4	34.3	0	2.8	1.32 .0006
△		120.8	10.5	100.0	40	97.8	34.3	0	2.8	1.32 .0006
□		121.4	11.0	100.0	50	134.8	34.3	0	2.8	1.32 .0006



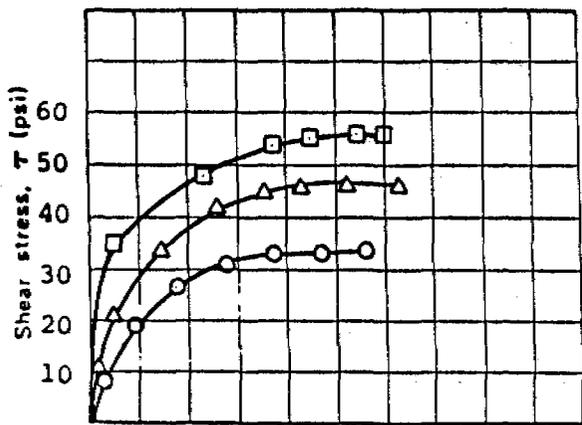
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TRIAxIAL SHEAR TEST

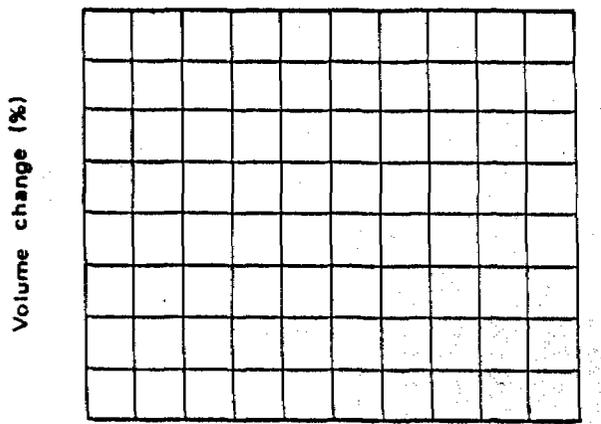
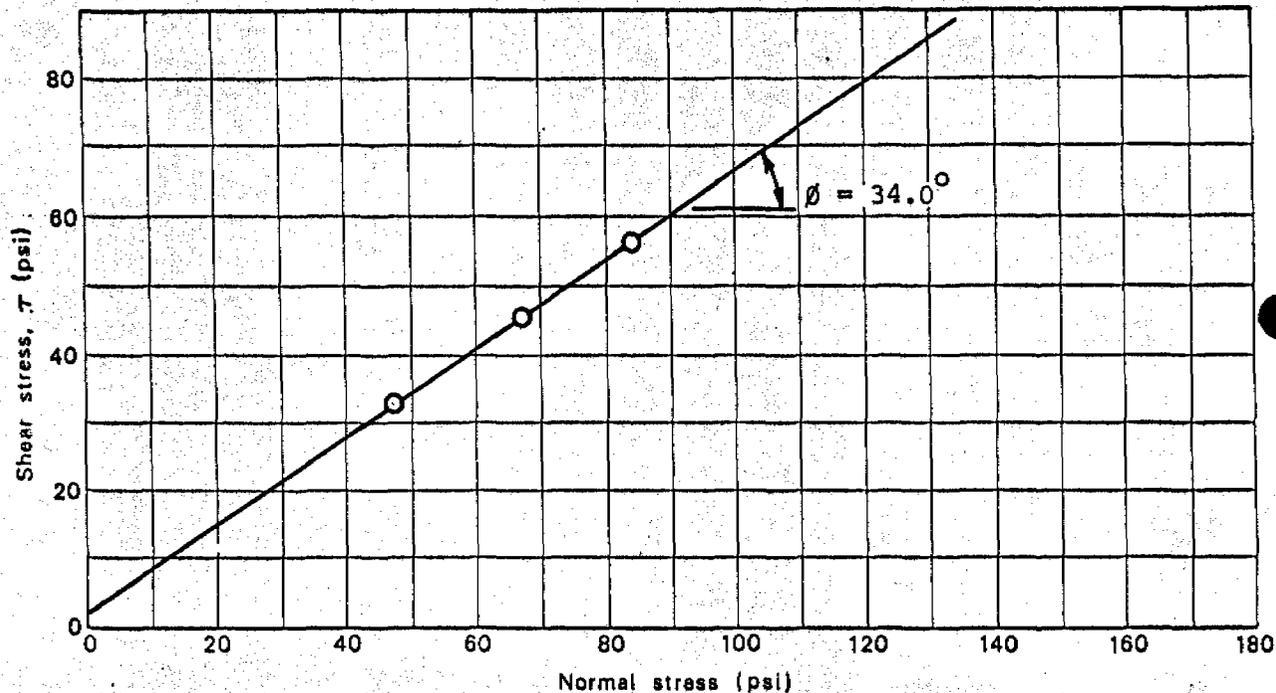
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HOLE NO.
DEPTH:

FIGURE
NO. 2



Horizontal displacement, δ_h (in. $\times 10^{-2}$)



Axial strain (%)

Test no. or symbol	Boring no. or depth	Sample data		Degree of saturation (%)	Normal stress, σ_n (psi)	Maximum shear stress, τ (psi)	Strength values at failure		Sample size (inches)	Strain rate (inches/minute)
		Dry density (pcf)	Moisture content (%)				Friction angle ϕ (degrees)	Cohesion (c/psi)		
○		121	10.0	100.0	47.4	33.0	34	1.0	2.5	.0024
△		121	10.0	100.0	68.6	46.4	34	1.0	2.5	.0024
□		121	10.0	100.0	83.8	56.7	34	1.0	2.5	.0032



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DIRECT SHEAR TEST

Project: Crandall Canyon Pond
Price River Coal Company

HOLE NO.
DEPTH:

FIGURE
NO. 3