TVA 64 (OS-9-65)

UNITED STATES GOVERNMENT

Memorandum

TENNESSEE VALLEY AUTHORITY

TO : G. L. Buchanan, Chief, Civil Engineering and Design Branch, 401 UB-K (2)

FROM : Gene Farmer, Chief, Construction Services Branch, 305 NB-K

DATE : May 2, 1975

SUBJECT: ALLEN STEAM PLANT - ASH DISPOSAL AREAS DIKES - SOIL INVESTIGATION

At your request of January 31, 1975, our laboratory has completed the field exploration and laboratory testing for the proposed ash dikes. The field portion of the investigation was done from March 2 to 26, 1975, under adverse weather conditions. Drilling was slowed by heavy rainfall and flooding of the Mississippi River. The work was carried out with a CME drill and hollow stem augers, a Minuteman mobile drill, 4-in. diam. hand augers, a 2-in. o.d. split spoon, and a 3-in. diam. thin-walled tube sampler.

East Dike

Exploration of the east dike foundation included one undisturbed and eight standard penetration borings as shown on laboratory drawing 604K582. Boring SS-2 could not be drilled as this location was inundated by about 4 feet of water. All borings drilled were extended to the required depth.

In detail, the soil profile established in the dike area consists primarily of lean clay, CL, and silt, ML, along with lesser amounts of silty sand, SM, and poorly-graded silty sand, SP and SP-SM. Fill varying in depth from 8 to about 12 feet was encountered between stations 22+00 and 40+00. Fill was not present between stations 44+00 and 51+50. Boring SS-8 at station 15+90 was atypical in that the profile consisted of about 11 feet of ash and slag underlain by 13 feet of hydraulic fill and classifying poorly-graded sand, SP. During the investigation, the water table varied with the river level, from el. 212 at station 22+00 to el. 216 at station 44+00.

Standard penetration resistance reveals nearly all soils are of medium to soft consistencies. However, fill is generally of greater strength than the upper foundation soils. Zones of particular weakness, N<3, are present between stations 22+00 and 44+00 comprising a major portion of the foundation.

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ALLEN STEAM PLANT - ASH DISPOSAL AREAS DIKES - SOIL INVESTIGATION

Laboratory classification testing disclosed fill generally has lower natural moisture contents than the underlying foundation soils which have moisture contents approaching or exceeding the liquid limit. At station 33+90, undisturbed samples were obtained for detailed evaluation. These soils, consisting of lean clay and silt, CL and ML, are characterized by medium dry densities and void ratios and high natural moisture contents. Triaxial Q tests performed on representative samples at natural moisture content and saturated triaxial R tests indicated a wide range of shear strength as shown on the attached tabulation. Samples from el. 210.5 and el. 200.5 were too soft for trimming and would not support their own weight. In lieu of triaxial tests, vane shear tests were performed on these soils with values of 0.03 to 0.1 tsf reflecting the weakness.

West Dike

Five standard penetration borings were drilled in the west dike foundation shown on drawing 604K583. All borings except SS-5 at station 28+00 extended to the required depth. At this location, sand flowing under hydrostatic head into the hollow stem auger prevented sampling below el. 193.0.

The soil profile in the area between stations 16+00 and 28+00 consists of 7 to 9 feet of fill comprising silt, ML, and silty sand, SM, overlying original ground. In-situ foundation soils comprise stratified lean clay,CL; silt, ML; silty sand, SM; and well- to poorly-graded silty sands, SW-SM and SP-SM. In boring SS-1 at station 12+00, a 22 foot layer of ash overlies original ground. The water table varied from el. 207.0 to 209.5 during the initial phase of drilling. Later observations indicated a rapid rise in the water table caused by flooding of the Mississippi.

Standard penetration test results show the fill materials to be of medium to hard consistencies with "N" values varying from 5 to 30. Foundation soils are considerably weaker, particularly between el. 197 and el. 210 where soft to medium consistencies are prevalent.

A particularly weak zone, N<3, was established at station 24+00. As in the east dike, laboratory testing indicated the fill to be of lower natural moisture content than foundation soils. Subsoils have in-place moisture contents at or exceeding the liquid limit.

For detailed testing, undisturbed samples were obtained in boring US-4 at station 24+05. In general, foundation soils at this location exhibit slightly higher dry densities and lower void ratios than the east dike foundation. Triaxial Q and R test results shown in the attached tabulation reflect variable foundation strength. One vane shear test resulted in 0.06 tsf on a sample from el. 203 after a triaxial specimen deformed under its own weight.

Borrow

As shown on drawing 604K581, a total of 24 auger borings was drilled in the northwest borrow area. Although the total area is larger than the one explored, floodwaters prevented further sampling. Drawings 604K584 and 604K585 show borrow soils to include primarily silty sand, SM, and silt, ML, with lesser amounts of lean clay, CL, and poorly-graded silty sand, SP-SM.

Classification testing established the percent fines in soils from each boring. Borrow soils with fines in excess of 35 percent are considered suitable as core material, and material with less than 35 percent fines are designated random materials as shown on drawings 604K584 and 604K585. The area including borings PAH-4 through 10 and 17 and 18 can supply sufficient quantities of core material. Random fill materials can be obtained from the remainder of the borrow area. High water tables and high natural moisture contents in the area were caused by floodwaters.

As shown on the attached tabulation, Summary of Laboratory Test Data - Borrow Soil Classes, characteristics were established for six soil classes.

Core Fill

Permeability tests performed on specimens remolded at 95 percent compaction indicated coefficients for the core materials averaging

from 7.4×10^{-6} to 8.4×10^{-7} cm/sec. The average natural moisture content of these soils represented by classes I, II, and III was 26 percent or about 11 percent above optimum. Thus, aeration during and after excavation is essential prior to placement. Class IV may be excessively wet for use where encountered below the natural ground surface.

Randon Fill

Random soils represented by class V have a natural moisture content about 5 percent above optimum. Class VI which is low in fines was tested for minimum-maximum density.

Shear tests including triaxial Q and R were performed on classes I through V at moisture contents 3 percent above optimum and at 95 percent compaction.

The direct shear strength of class VI soils was determined at 85 percent relative density and 12 percent moisture. See the attached tabulation for the detailed test results.

Summary

This investigation has shown the foundations for the east and west ash dikes to be composed of fill and an alluvium of widely varying consistency. Silts, lean clays, and silty sands are randomly stratified to the depths explored. Significant weakness was often established near the top of original ground below the fill and extending to a maximum depth of 13 feet. Some of the weak soils were too soft to permit conventional shear testing.

The borrow exploration in an area northwest of the plant determined the availability of approximately 150,000 cu. yd. of core material comprising silt and silty sand with a fines content in excess of 35 percent. For selective excavating, suitable core materials are identified in the borrow profiles. Very high natural moisture contents in the borrow will require major drying efforts prior to placement of the fill. Random fill material, silty sand, and poorly-graded silty sand, will be available for the dike shall construction. Typical random soil contains less than 20 percent fines.

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ALLEN STEAM PLANT - ASH DISPOSAL AREAS DIKES - SOIL INVESTIGATION

For design purposes, the following values are recommended:

		Q		R		S		Coeff. of Perm.
	γ_w	ϕ deg.	c tsf	ϕ deg.	c tsf	ϕ deg.	c tsf	cm/sec
Foundation	115	15	0.1	10	0.3	--		--
Core	125	30	0.1	12	1.0	--		8×10^{-6}
Random	120	--	--	20	1.0	30	0	5×10^{-4}

Gene Farmer

WHC:PO
Attachments
CC (Attachments):
R. G. Domer, 519 MIB-K
R. O. Lane, SMW-K
H. H. Mull, 707 UB-K

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CC: R. G. Domer, 519 MIB-K
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ALLEN STEAM PLANT

ASH DIKES

FOUNDATION INVESTIGAT

SUMMARY OF LABORATORY TE

Elevation	Soil Symbol	Soil Type	Nat. Moist. %	Nat. Moist. % Sat.	Std. Penetr.	Grain-Size Analysis Gravel %	Sand %	Silt %	Clay %	D_{10} mm	Att Li Lim %
East Dike											
Boring US-5, Surface El. 215.5											
215.5-214.0	CL	A	22.6	84.1	--	0	8	58	34	--	32
212.5-210.4	CL	A	29.1	94.4	--	0	19	58	23	--	33
209.5-207.1	CL	A	38.5	92.6	6	0	5	63	32	--	42
206.5-204.7	CL	A	28.0	83.8	3	0	20	63	17	--	31
203.5-201.2	CL	A	31.9	90.8	1	0	18	59	23	--	31
200.5-198.6	ML-CL	B	30.3	81.0	1	0	31	54	15	--	26
197.5-195.1	ML	C	31.9	93.0	1	0	4	82	14	--	32
194.5-192.5	ML	D	28.1	96.8	3	0	25	68	7	0.012	N.
191.4-190.2	ML	d	23.9	93.9	6	0	26	68	6	0.019	N.
West Dike											
Boring US-4, Surface El. 217.8											
215.8-214.8	CL	b	18.8	88.0	18	0	16	64	20	--	28
212.8-212.0	ML	C	20.0	78.2	18	3	35	50	12	--	26
209.8-208.3	SM	E	16.6	63.8	6	0	59	33	8	0.0079	N.
206.8-206.2	CL	a	27.0	89.7	1	0	39	48	13	--	27
203.8-202.6	CL	B	31.8	94.5	2	0	18	64	18	--	30
202.6-201.4	CL	A	35.2	93.5	2	0	3	60	37	--	36
200.8-200.0	ML	C	26.9	82.4	1	0	19	69	12	--	28
197.8-195.4	CL	a	35.4	97.0	6	0	1	59	40	--	47
194.8-194.0	CL	a	32.1	94.0	3	0	8	71	21	--	31
194.0-192.8	ML	D	26.6	92.4	9	0	36	57	7	0.015	N.
191.8-189.7	SM	e	23.5	90.2	23	0	53	40	7	0.013	N.

ALLEN STEAM PLANT

ASH DIKES

SUMMARY OF LABORATORY TEST DATA

BORROW SOIL CLASSES

Class	I	II	III	IV	V	VI
Symbol	ML	SM	ML	CL	SM	SP-SM
Mechanical and Hydrometer Analysis						
Gravel, percent	0	0	0	0	0	0
Sand, percent	46	53	41	8	81	91
Silt, percent	46	38	50	57	16	9
Clay, percent	8	9	9	35	3	0
Atterberg Limits						
Liquid Limit, percent	NP	NP	22.5	41.4	NP	NP
Plastic Limit, percent	NP	NP	21.8	22.6	NP	NP
Plasticity Index, percent	NP	NP	0.7	18.8	NP	NP
Standard Proctor Compaction						
Optimum Moisture, percent	13.5	14.8	16.7	23.8	14.5	86.4*
Maximum Density, pcf	113.2	110.8	107.0	93.3	107.6	112.0**
Penetration Resistance, psi	1040	850	730	540	--	
Shear Strength at 3% Above Optimum Moisture						
Triaxial Q: ϕ, degrees	34.5	34.0	34.5	8.2	35.0	
c, tsf	0.10	0.12	0.10	0.90	0.30	
Triaxial R: ϕ, degrees	13.0	17.5	12.0	16.0	21.0	
c, tsf	1.30	1.65	1.55	0.15	2.80	
Shear Strength at 85% Relative Density and 12% Moisture						
Direct Shear S: ϕ, degrees						34.2
c, tsf						0.00
Submerged: ϕ, degrees						29.3
c, tsf						0.03
Permeability, cm/sec	7.4×10^{-6}	8.3×10^{-6}	8.6×10^{-6}	8.4×10^{-7}	--	--

*Minimum Density
**Maximum Density