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Full Length Research Paper

Investigations into the Suitability of Soil Samples for Dam Embankment Construction (Soil Deposits around Proposed Earth Dam Site in Faskari)

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This paper presents the result of a research work conducted on some soil samples collected around Faskari town to determine the suitability or otherwise of such samples to Earth Dam construction. Five different undisturbed soil samples were collected from different pits, these samples were tested in the laboratory for five different investigations upon which the results were compared to the specifications provided under the Guidelines on Dam design and construction. A Reasonable percentage of the results obtained agrees with the specification of Earth Dam design and construction as such the studied soils are recommended for such purposes.

Keywords: Earth dam, soil investigations, laboratory test, soil suitability

INTRODUCTION

The design and construction for the Dam Embankment requires some investigations on the soil samples in order to avoid the occurrences of basic failures (Stephens, 1987). The general concept of Dam failure described some patterns as possibilities if not properly designed. The occurrence of Dam failure may be of various characteristics and dimensions depending on the type of the Dam and nature of the materials used in its construction. The failures may either be in form of bearing capacity, overturning, sliding or water leakages/cuts. Some soil samples are prone to failures whereas others are resistant to such. The chemical composition of a particular soil sample is what governs its tendency to failures and most of the soil samples obtainable from the southern part of Katsina are mostly clayed-lateritic soils at the surface but may exhibit other properties when it reaches certain depth. There are some Earth-Dam proposals around Faskari town but the major concern is how to construct it and stand the taste of time. One proposed area was selected for this research and it happens there is an existing Dam that failed on some extreme end around the spill way. A repair work was undertaken to restore the Dam to its normal function/capacity. The above laid down background formed the basis of this research. Earth Dam construction is similar to that of the Road in terms of compaction and other operations but different in materials specifications (Federal Highway Design Manual of Nigeria 2006; Stephens, 1987).

METHODOLOGY

Soil samples were collected from the study area and transported to the soil test laboratory of Hassan Usman Katsina Polytechnic Katsina state. The tests conducted are those covered under soil investigations for Earth Dam construction of British Standard BS1377 specifications on Soils. Five undisturbed soil samples were collected around the proposed barrow pit area for laboratory

Table 1. Soil test results for all the samples.

Label	Sample Type	NMC (%)	CBR (%)	K (cm/sec)	Compaction		Atterbergs Limit				Sieve Analysis			Remarks
					OMC (%)	MDD (gm/m3)	L.L. (%)	P.L (%)	P.I. (%)	L.S. (%)	2mm	0.425mm	0.075mm	
BPR	Disturbed	6.15	27	-	16	2.3	33	25	7.9	7.9	85.5	60.8	33.3	
BP1	Disturbed	4.98	-	2.579×10^{-6}	15.5	2.154	27	22.6	3.9	6	84.6	68.2	42.5	pervious clay
BP2	Disturbed	-	-	5.987×10^{-7}	-	-	41	29.6	11	11	71.7	48.8	41.8	pervious clay
A-H	undisturbed	-	-	8.656×10^{-6}	-	-	-	-	-	-	-	-	-	pervious clay
B-H	undisturbed	-	-	1.065×10^{-6}	-	-	-	-	-	-	-	-	-	pervious clay
C-V	undisturbed	-	-	8.942×10^{-7}	-	-	-	-	-	-	-	-	-	pervious clay
D-H	undisturbed	-	-	1.661×10^{-5}	-	-	-	-	-	-	-	-	-	semi pervious silt
E-H	undisturbed	-	-	7.169×10^{-5}	-	-	-	-	-	-	-	-	-	semi pervious silt

investigation of their properties. These samples were labeled as shown in (Table 1). Secondly, three (3) disturbed soil samples were collected (that is from one existing embankment located around the area), in which samples BPR and BP1 were collected from stock-piled materials within the reservoir section and sample BP2 was collected from stock-piled cut-off materials. These samples were taken to laboratory and tested for the purpose of determining their suitability or otherwise. The tests conducted include Atterberg Limit, Particle size Distribution, Standard Proctor Compaction, California Bearing Ratio, Natural Moisture Content and Permeability test. The experiments for all the parameters mentioned were conducted based on the procedures as presented in various literatures of soil behaviors researches (Omange *et al*., 1988; Ola, 1987; Ola, 1983; Madedor, and Adekale, 1987). The result is shown in the attached result sheets.

RESULTS AND DISCUSSION

Analysis of the obtained results was carried out with reference to standard specifications for judgment purposes and it was referred to the work conducted by (Adesunloye, 1987; Abolarinwa, 2010). Experimental results were summarized and shown in (Table 1). It presents the summary of the entire soil test results for the various parameters examined. Analysis and discussions are as follows.

Material grading (particle size distribution)

Based on the material grading envelopes provided in the small earth dam design manual, the particle size distribution of the tested samples plotted in the zoned dam material envelopes indicates that the entire samples falls within the range specified for shell materials (Figure 1), similarly from homogenous dam material envelopes (Figure 2), the whole samples plotted falls within the homogenous range, from (Figure 3) of the filter and drain material envelope, samples were not collected for filter sand and drain gravels.

Permeability

Based on the permeability test result as presented in (Table 1), it shows that all the samples are pervious clay with the exception of un-disturbed samples D-H and E-H which are semi pervious silt and they not suitable for any portion of the embankment due to lack of cohesion, poor structure, fine material and difficulty in compaction.

Atterberg limit

The result shows that the plasticity index of the entire samples are within the acceptable range that lies between 3 and 11 %, similarly the linear shrinkage result lies between the range of 6 and 11 % which is also within the range accepted for dam construction.

Standard proctor compaction

The optimum moisture content lies between 15 and 16 % for both samples and their maximum dry densities indicates that, the soils have very high unit weight up to a value of $21kN/m^3$. Therefore, it would help in structural stability.

Natural moisture content

Samples BPR and BP1 have a range of natural moisture content between 4 and 6% for the disturbed samples.

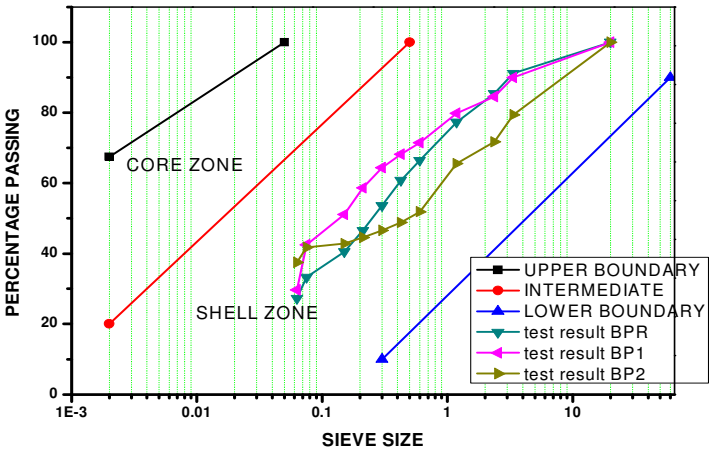

Figure 1. Zoned dam material envelopes.

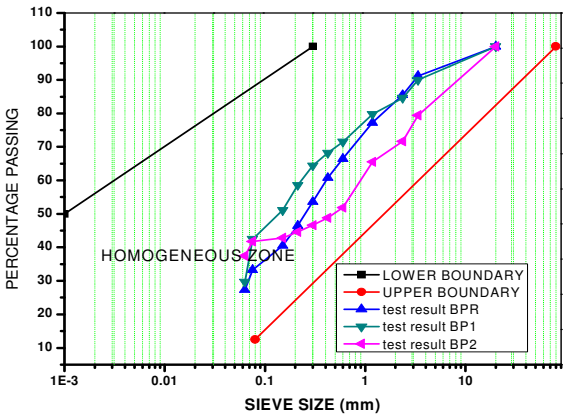

Figure 2. Homogenous dam material envelopes.

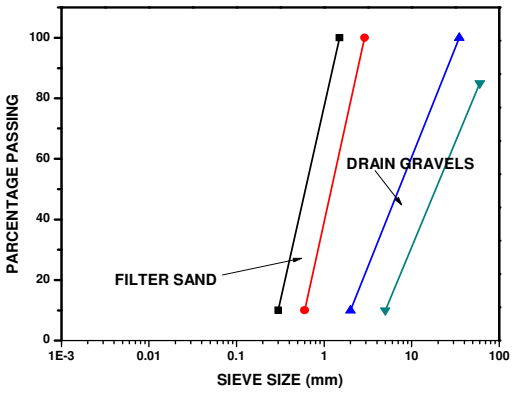

Figure 3. Filter and drain materials envelopes.

California bearing ratio

The obtained California bearing ratio of 27 for BPR sample shows that the borrow pit can be used for light traffic as a sub-base materials without any further stabilization; this is in conformity with the standard of a Federal Highway Design Manual of Nigeria.

Conclusion

Based on the obtained results for the tested samples, the following conclusions can be drawn:

(i) All the borrow pits samples can be used as homogenous embankment since the results show that the material grading falls within the homogenous and shell envelopes.
(ii) The California bearing ratio (CBR) of 27 obtained from BPR sample is adequate enough to be used as a sub-base material.
(iii) The optimum moisture content and maximum dry density obtained shows the ability of the material to be used because of its high unit weight.
(iv) The provision of toe filter and drain should be made.
(v) Generally, the soils deposit around the area is suitable for dam and road constructions therefore the likely causes of Dam failure if at all happens after construction should not be associated to the materials nature of the area.

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