Engineering Properties of Bauxite Residue

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Key words : road, waste, construction, strength, property, bauxite residue.

Bauxite residue (also called red mud) is the solid remainder of the bauxite industrial treatment by the Bayer process. Estimates raise the annual production of bauxite residue worldwide to 150 million tons. Reuse and recycling attempts include production of ceramics, use as an additive in cement, extraction of metals. Significantly less known and investigated is the potential use of this by-product in road engineering projects, which engage big volumes of earthwork and are likely to absorb large quantities of the by-product.

The Highway Engineering Laboratory of the Aristotle University of Thessaloniki started exploring the properties of bauxite residue and possible engineering applications in the 90's. Research was orientated to physical and to strength properties of the by-product and its mixtures with natural soils and aggregates. Research findings over time and, especially, the installation of an industrial filter press, used to separate the solid fraction of bauxite residue, unveiled a material of high engineering performance, appropriate for use in road construction. Laboratory and site experience on its engineering properties indicate a high strength material, far beyond the respective findings of other researchers worldwide.

In fact, physical characteristics, reported by different researchers, vary substantially in terms of plasticity, permeability and specific density but also in terms of Proctor characteristics (optimum moisture and dry density). However, the dispersion of laboratory test results for strength properties is much more significant: CBR values varying from 2 to 55 and unconfined compression from 1,4 to 5,6 kg/cm2. Is this variation exclusively due to the heterogeneity of the material or are there other reasons related to the conditions of laboratory testing in each case? In the present paper, the reasons of this dispersion are investigated and an approach to correct interpretation of test results is outlined.

Table : Strength characteristics of bauxite residue from laboratory testing

INSTITUTE / COMPANY	COUNTRY	MATERIAL	UNIAXIAL		TRIAXIAL		REMARKS
			CBR	qu (kg/cm^2)	c (cohesion) (kg/cm^2)	φ (friction) (^{o})	
CURTIN UNIVERCITY / ALCOA	AUSTRALIA	COARSE BR	55 (soaked) 48 (unsoaked)				
National Institute of Technology Bhopal / HINDALCO	INDIA	BR	2 (soaked) 5 (unsoaked)				
UWD-University of Dundee-Jacobs Babtic /	CANADA/ SCONTLAND	BR			c'=0.26	42°	
ANDHRA UNIVERSITY/ NALCO	INDIA	BR		1.49			
GENERS GEOTECHNIC/	INDIA	BR			0.1÷0.2	26°÷28°	
SOA UNIVERSITY/ NALCO	INDIA	BR				38°÷42°	
Aristotle University of Thesssaloniki (AUTH)/ AoG	GREECE	BR+FA	19 (unsoaked)	5.6			FA=3% Fly Ash

The present paper aims to present the testing procedure to determine the engineering characteristics of bauxite residue from "Aluminum of Greece", as well as, some strength improvement recipes which classify the by-product as a very solid and resistant material, suitable for use in road construction.

Fig. : Local road constructed from bauxite residue

The paper also presents the pilot engineering projects in Boetia, Greece, designed by the AUTH team and introducing bauxite residue as the main construction material. After several years under operation and real traffic conditions, the road structures exhibit excellent performance and this may be considered as a real engineering achievement in the field of recycling of waste materials and industrial by-products.

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