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Comparative compact and strength characteristics of loess-cement mixtures with various additives

Сравнителни уплътнителни и якостни характеристики на циментольосови смеси с различни добавки

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Абстракт. Определят се уплътнителните характеристики и якостните показатели: якост на едноосен натиск на заздравен с портландцимент льос от района на АЕЦ „Козлодуй“ и с добавка на природни вещества: серпентинит, зеолит (клиноптилолит) и бентонит, съответно 10% и 20%. Сравнява се якостта на смеси от песъчлив льос със 7% и 12% цимент, формовани при стандартна плътност ρ_{ds} и оптимално водно съдържание w_{opt}, след едномесечно отлежаване с цел отчитане на влиянието на добавките.

Key words: loess-cement mixtures, strengthening, highly adsorptive additives.

Introduction

There are thorough researches and scientific facts that the Bulgarian loess soils can be easily stabilized with hydraulic binders and it can be transformed in impermeable and strong material with long term strengthening properties (Angelova, 2007; Evstatiev, Karastanev, 2013). On such material, used as soil cement cushion, were build up all the Kozloduy NPP facilities. In addition, the terrain in the Kozloduy region is selected to host the National radioactive waste repository. From the other hand, there are investigations in the world radioactive waste management and disposal practice considering the use of compositions made on the base of cement with sorbent substance as engineered barriers (Gradev et al., 1978; Trivedi et al., 1992; Kansouh, 2012). In Bulgaria, similar investigations were performed for plastic soil-cement mixtures (Tchakalova, Todorov, 2008). In the report the authors present results for the determination of compaction (Proctor test) characteristics and of the strength characteristics as unconfined compressive strength of mixtures made on the base of loess with a serpentinite, zeolite and bentonite additives, stabilized by ordinary Portland cement.

Materials and methods

Sandy loess from the region of the Kozloduy NPP, zeolite (clinoptilolite) from the Beli Plast deposit, serpentinite from a representative outcrop in the Rhodopes and bentonite from the BENTONITE Ltd plant were being used for the tests. All additives were initially or before test ground under 0.05 mm fraction. First, series of Proctor tests with loess and a distinct additive of 10% and 20% were performed in order to evaluate the specific maximum dry density ρ_{ds} at the optimal moisture content w_{opt}. Then a series of samples were prepared as a mixture of disturbed sand loess and of additives, with 7 and 12 percentage of ordinary Portland cement (OPC) all compacted at the optimal moisture content w_{opt} till attainment of maximum dry density ρ_{ds}. The cylindrical samples, with dimensions of h/d 5/5 cm were aged 1 month in hermetic glass tanks with approximately 100% humidity at room temperature. Then unconfined compressive strength (UCS) tests of all mixture variations were performed in order to observe the strength development characteristics in time.

Results and discussion

The Proctor tests results of samples with and without additives are presented in Table 1. The UCS results after the tests of samples with and without additives prepared at optimal moisture content and aged one month are presented in Table 2. Based on the results the following relationships could be observed. The addition of the zeolite of the both percentages strictly decreases the value of the maximum dry density but in the same time increases the optimal water content. Serpentinite additive of 10% almost no impacts the

Table 1. Composition percentages and compaction indices of the investigated mixtures

Loess type	Zeolite* [%]	Serpentinite [%]	Bentonite* [%]	Maximum dry density, ρ_{ds} [g/cm^3]	Moisture content, w_{opt} [%]
Sandy loess	–	–	–	1.63	18.24
	10	–	–	1.58	19.34
Sandy loess		10	–	1.64	18.40
			10	1.63	21.10
	20			1.56	20.80
Sandy loess		20		1.66	17.50
			20	1.54	22.30

* Note: after Antonov, 2013

Table 2. Unconfined compressive strength (UCS) of the loess-cement-additive samples

Mixture type	Additive [%]			UCS after 1 month aging, *Rc*, [MPa]
	zeolite*	serpentinite	bentonite*	
	–	–	–	1.36
Loess with 7%	10/20	–	–	3.31/3.52
cement“		10/20	–	1.12/1.34
	–	–	10/20	2.25/1.92
	–	–	–	2.23
Loess with 12%	10/20	–	–	4.91/6.03
cement	–	10/20	–	2.08/2.26
	–	–	10/20	3.22/3.25

* Note: after Antonov, 2013

parameters of the Proctor curve while there is a small increase of the ρ_{ds} and a decrease of the w_{opt}. The bentonite samples show much higher optimal water content with decreased maximum dry density especially at 20% one (Table 1). The UCS values of the zeolite samples show unambiguous increase for the both additive and cement percentages. The serpentinite 10% samples at the both cement percentages show a small decrease of the referent UCS while those with 20% reach same values. The bentonite samples of all variations present an increase in the strength but not as much as the zeolite ones (Table 2). In general, the investigated mixtures possess the basic mechanical properties to serve in their future role for utilization in the foundation work screens against radionuclide and heavy metal migration. The future usage of the additives in the soil-cement should be connected to the specific case of the retardation properties requirements. The variations of the Proctor tests parameters give flexibility in the construction options of the soil-cement screens. A further detailed investigation of the structure properties is needed in order to evaluate the nature of the strength characteristics.

References

Angelova, R. 2007. Loess-cement long-term strength – a facilitating factor for loess improvement applications. – *Geologica Balc., 36,* 3–4, 21–24.

Antonov, D. 2013. Static and dynamic strength parameters of stabilized loess soils from Kozloduy town area. – *Engineering Geology and Hydrogeology, 27,* 3–12.

Evstatiev, D., D. Karastanev. 2013. Investigation and applications of loess-cement in Bulgaria. – *Engineering Geology and Hydrogeology, 27*, 85–112.

Gradev, G., M. Milanov, V. Prodanov, G. Stefanov. 1978. A study of the sorption properties of natural calcium clinoptilolite by using radioactive indicators. – *J. Radioactive Chem., 45*, 103–114.

Kansouh, W.A. 2012. Radiation distribution through serpentine concrete using local materials and its application as a reactor biological shield. – *Annals of Nuclear Energy, 47,* 258–263.

Tchakalova, B., K. Todorov, 2008. Plastic soil-cement mixtures for isolation barriers. – *Geologica Balc., 37*, 1–2, 91–96.

Trivedi, D., R. Holmes, D. Brown. 1992. Monitoring the in-situ performance of a cement/bentonite cut-off wall at a low level waste disposal site. – In: *Proceedings of Symposium D of the E-MRS Fall Meeting 1991. Cement and Concrete Research, 22*, 339–349.