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Full-scale Evaluation in a Fatigue Track of a Base Course Treated with Geopolymers

Javier Camacho-Tauta[1], Oscar Reyes-Ortiz[1], António Viana da Fonseca[2], Sara Rios[2], Nuno Cruz[3] and Carlos Rodrigues[4]

[1]*Universidad Militar Nueva Granada, Colombia*
javier.camacho@unimilitar.edu.co, oscar.reyes@unimilitar.edu.co
[2]*Universidade do Porto, Portugal*
viana@fe.up.pt, sara.rios@fe.up.pt
[3]*Mota-Engil, Portugal*
nunocruz@mota-engil.pt
[4]*Instituto Politécnico de Guarda, Portugal*
cord@ipg.pt

Abstract

Usually, optimal percentages of additives used to improve the characteristics of soils, are determined by laboratory tests of different complexity. Then, these optimal combinations are used directly in the pavement structures, without analysis of time or scale differences between laboratory and field conditions. This paper presents the results of a full-scale accelerated pavement test on a base course that has been improved by using fly ash and an alkali activator. Initially, the main characteristics of the testing equipment are presented. The optimal amount of the different components was previously obtained by laboratory tests. The components were mixed, the material was extended and compacted in layers and a curing time was permitted. After that, a wheel loaded with a vertical hydraulic actuator, simulating a rear half-axis of a truck, passed on the top layer repeated times. During the test, vertical deformations of the surface were measured in several points along the track. Results after around 10000 loading repetitions were compared against simultaneous measurements on a non-treated material subjected to identical loading application, showing the advantages of the alkali activation in reducing deformability of base courses and the effect of variable natural wheatear conditions on both type of pavement structures.

Keywords: alkali activation, fatigue test, rutting

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1 Introduction

Tertiary roads in remote areas need low-cost construction materials, which usually should be obtained locally. This restriction sometimes imposes the condition of using materials that do not meet technical specifications for such use. In the particular case of granular materials, mechanical or chemical stabilization are alternatives to improve their quality. The main purposes of soil stabilization are to: modify the soil, expedite construction and improve the strength and durability of the soil (Das, 1995). In the chemical stabilization, the soil is mixed with other substances that react with the minerals or water present in the soil mass, producing a decrease in void ratio, reduction of water content, joining of fissures or cementation of particles. Cement and lime are commonly used as chemical stabilizers. However, production of these materials involves consumption of natural resources and it is recognized as an activity of high environmental impact (Chen, Hong, & Xu, 2015).

Coal burning fly ash is an industrial waste of rising interest as alternative component in production of materials for the civil and infrastructure construction industry. For example, the use of geopolymers resulting from the alkaline activation of fly ash has been used for different application such as to replace the ordinary Portland cement concrete (Kupwade-Patil & Allouche, 2013). While the chemical reactions are described in detail by Duxson *et al.* (2007), an explanation of the use of geopolymers for soil improvement can be found in Rios *et al.* (2015).

The mechanical characterization in laboratory of soils stabilized by alkaline-activated fly ash is necessary to obtain the optimum percentages of activators and fly ash to be used in field. However, the actual performance of the stabilized soil should be tested in full scale by either in a short section of a road in service or in a prototype built in a fatigue track with simulated traffic. Full-scale testing reduces the necessity of extrapolation in scale, time or environmental condition (Powell, 2012). Apart of the scale similarities, the advantages of the full-scale test include the application of a loading regime comparable with the future traffic and exposition of the structure to the real weather conditions. The economic benefits of accelerated pavement testing (APT) in design are discussed by du Plessis *et al.* (2012). There are many works on APT on pavement roads, but few reports of using this facility to study unpaved roads as for example Yang et al. (2012). This paper shows the results of an unpaved base course treated with activated fly ash subjected to moving loading in a fatigue track. Variations of climatic conditions during curing and testing periods were measured by using a portable climatic station. The length of the track allowed the simultaneous test of a section of non-treated material under identical loading and environmental conditions, making possible direct comparisons between results.

2 Equipment and Experimental Procedure

2.1 Description of the Fatigue Track

The full-scale accelerated fatigue track is located in the Nueva Granada Military University at Cajicá (Colombia). The equipment is composed by three main parts: two boxes of concrete (each one 3m wide, 12m length and 1.5m depth) to contain the pavement structures to be tested; a steel structure to support the mechanical components and provide the reaction to vertical loading; and the mechanic/hydraulic components that generate the moving load (Vargas-Fonseca, Reyes-Ortiz, & Camacho-Tauta, 2014). Figure 1 shows a picture of the fatigue track anchored over one of the concrete boxes, which is filled with the soil structure. The deep of the concrete box allows a prototype with the complete layers of a conventional pavement structure from subgrade to surface course. The maximum speed of the wheel is 18 km/hour due to the length of the track in combination with a high-precision controlled servomotor. The second box can be used to construct a second pavement structure, while the test is running on the first box.