Coal tar, material used in soil improvement for use in road engineering

R Ochoa Díaz1, A Montañez1 and J Cuentas1
1 Universidad Pedagógica y Tecnológica de Colombia, Tunja, Colombia.

E-mail: ricardo.ochoa@uptc.edu.co

Abstract. Coal tar is a by-product of coal distillation in the absence of oxygen to obtain metallurgical coke; its colour varies from dark coffee to black, slightly viscous and its density is greater than that of water. Taking into account the previous characteristics, this document presents a study of the feasibility of using coal tar for the improvement of physical properties, mechanics and dynamics of materials used in road engineering. In this way, the origin, characteristics, and properties of tar are first described. Next, its combination with which granular-based material is evaluated through the CBR test procedure to determine its resistance and to compare it with the non-stabilized material. Finally, the behaviour of the material when subjected to dead loads by means of resistant modules found with the NAT (Nottingham Asphalt Tester) is explored. As a result, the option of using coal tar as a stabilizer was identified due to its use under specific conditions.

1. Introduction

Upon seeing the current state of roads in the country, in which high investments are made and the pavement structures do not support the period of time for which they are constructed, it becomes necessary to search for new construction and stabilization methods for pavement which comply with construction specifications.

The fulfilment of granular layer specifications is not always obtained through available sources; this has led to the continuous search for and development of methodologies of improvement based on the amendment of an external agent such as stabilizing treatments with lime, cement and asphalt, among others [1].

Is for that reason that this document shows the study of an alternative in granular bases stabilization, as the coal tar, it is a bituminous product semisolid or liquid that is obtained as a distillation remainder of coal [2], in lack of air. The coal tar is a binder in cold, water resistant, insoluble in lubricant oils and fuels derivatives from petroleum [3]. The coal tar used in this study is produced in the steel Acerías Paz del Río S.A., at the coker, that process is made to 1000°C [4]. The material to be stabilized should be product from the mechanical grinding and must meet with specifications for a granular-based material type; to make that test were performed based in the testing standards for material cart of the INVIAS [5].

2. Materials and methodology

They made some tests to coat tar, there were tending to stablish physical-chemical characteristics, the results were: moisture: 7%, specific gravity: 1.18g/cm³, calorific value: 8.9Kcal/Kg, melting point: 80°C. The granular-based material corresponds to BG-40 from a quarry that belongs to the company CSS Tunja.

The method used to develop the research was proposed in three stages: the first one was the making of the tests needed to know the characteristics of the materials. The second one was about making the mix of the granular-base type material with the coal tar, to establish the resistance characteristics (CBR) [6] and to determine the optimal percentage of coal tar. And the third one is about to make the
comparison with the parameters of material resistance without alter with the mixed material with the optimal percentage and the analysis of the convenience of using the tar as a stabilizer.

3. Experimental design

For this study material with the granular base type BG-40, article 330 of the general specifications for INVIAS road construction [7] was used, and mixed with a material of four different percentages of tar (1, 3, 5 y 7%), and through the CBR laboratory test (rule INVE-148-13) the resistance of each mix was determined in order to obtain the optimal percentage of tar to obtain the best characteristics of the material. A mix was made with this optimal percentage and the mechanical and dynamic processes of the material were determined and verified with the parameters of the non-modified material.

4. Results

4.1. Optimal percentages of coal tar

With the CBR from each percentage of tar we made a graphic of CBR Vs. tar percentage with which we determine the optimal percentage to stabilize the granular-base material, the optimal percentage selected 3%, with which we obtained the most material resistance.

4.2. Parameters of mechanical behaviour

In the lineal elastic analysis, one sole value of the elastic modular value and a Poisson relation representative of the material were considered. To conduct the statistical analysis of the mechanical behaviour of the coal tar as a stabilizer in granular bases the CBR test, the index used to grade the quality of materials in accordance with INVIAS, was used.

As Figure 1 show, the stabilized material with optimal percentage coal tar improved by 19 units of CBR corresponding with an increment of 32% in respect to the unstabilized material. It demonstrates that coal tar is effective in the stabilization of granular bases.

Figure 2 shows the averages of the three cylinder expansions for each case, unchanged and stabilized material with the optimal percentage, in which it is evident that one of the main properties of coal tar is in to reduce the spread, reducing by approximately 80 %.

4.3. Parameters of dynamic behaviour

In Figure 3, an increasing tendency is observed: as the state of force grows the resilient modulus of the material grows. For the case of the specimens with an unstabilized base, the modulus of the material diminishes when the percentage of humidity in the specimen grows.
5. Conclusions
The optimal percentage to stabilize the granular-base material is 3% in weight. Although at the moment of stabilize the granular-base we do not reached to meet the minimum specifications stipulated by the INVÍAS 2013 standards, for a granular- base type A, for a transit level NT3, we can to increase the resistance by approximately 35% getting a CBR of 79%, which we conclude  that coal tar from the company Acerías Paz del Río has effectiveness as a stabilizer of granular - bases, improving their resistance.

It was determined that one of the main improvements of stabilizing base material with coal tar is expansion, achieving an 80% reduction for which the expansion percentage is 0.02. The expansion percentage found in the material is considered low or non-critical according to the specifications of INVIAS, in which the minimum percentage of a material is 2%.

The resilient modulus test is considered the most accurate way to characterize the resistance of a material. In the case of the tests made in the chamber triaxial, it is observed that the moisture content in the specimen affects directly the resistance of the material; in that way, to higher humidity less resilient modulus or less resistance.

Coal tar is classified as a physical-chemical stabilizing agent, where its main support is due to the coating of fine particles, considered noxious when they are sandy silt, and with the presence of water it varies volumetrically.

References
[1] Márquez S 2005 Estabilización de suelos (Argentina: Universidad Nacional de la Patagonia San Juan Bosco)
[2] Ochoa R 2013 *IOP Publishing Journal of Physics Conference Series* 466
[3] Acerías Paz del Río SA 2014 Alquitrán (Tar Crude) (http://www.pazdelrio.com.co/es-es/Productos /coproductos/Paginas/ alquitran. aspx)
[4] Gómez A 2002. *Proceso siderúrgico planta belencito* (Colombia: Acerías Paz del Río S.A.)
[5] Instituto Nacional de Vías 2013 Normas de ensayos de materiales para carreteras (Bogotá: INVIAS)
[6] Higuera C 2011 Nociones sobre métodos de diseño de estructuras de pavimento para carreteras (Colombia: Universidad Pedagógica y Tecnológica de Colombia)
[7] Instituto Nacional de Vías 2013 Especificaciones generales de construcción de carreteras (Bogotá: INVIAS)