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USING ENZYMATIC EMULSIONS TO REINFORCE ROAD LAYERS

C. STAN[1] **V. CIOBANU[1]**

Abstract: *In the last period, a lot of new concept soil stabilizers appeared on the market, acting differently in the stabilization process due to their bonding and catalytic properties. In comparison with traditional stabilizing agents, enzymatic emulsions present the advantage of an easier transportation due to their reduced volumetric masses. Also, by comparison with traditional stabilizers, the applied technology in earth layers stabilization may differ. In this context, in the present paper are presented the key steps in stabilization applied technology using Alphasoil®06 enzymatic emulsion.*

Key words: *road, layer, stabilization, enzyme, emulsion.*

1. Introduction

Enzymatic emulsions are widely known as enzymes or enzymatic emulsions. In the last period, practically the production of such stabilizing agents exploded. There are a lot of commercial denominations, and some of them have been tested including in our country. The following commercial brands can be mentioned: Alphasoil06, Bio Cat 300-1, EMC SQUARED, Earth Zyme, Perma-Zyme 11X, Terrazyme, UBIX No. 0010 etc.

Many of the dust suppression and earth stabilizing emulsions do not publish their exact composition and action mechanism, these being considered the producer's property. As a consequence, their grouping by considering well delimited characteristics (traits) is difficult to realize or is realized with little accuracy.

Enzymatic emulsions contain enzymes (protein molecules) which react with soil particles, generating a cemented bond which stabilizes the soil structure and reduces its affinity for water.

Enzymatic emulsions work (are applied) on a wide variety of soils on condition of a minimum clay content presence. Applied in small dosages, in the surface road layers, enzymatic emulsions provide good results in dust suppression by bonding the dust particles and reducing dust generation. When applied in greater dosages, they are used for stabilization purposes. If the application is adequate, and soil compaction follows the normal parameters, the stabilized soils form a dense layer, waterproofed which can be used as cover layer for roads.

Most information regarding enzymatic emulsions is provided by producers' literature and only small scale independent research has been realized in order to prove their suitability. Also, the performances in their stabilizing applications may vary between different products. Some products may be the subject of composition reformulation and the studied cases may not be of actuality at a certain point.

In order to overcome this inconvenience, specific testing of the products and

[1] Dept. of Forest Engineering, Forest Management and Terrestrial Measurements, *Transilvania* University of Braşov.

performance verifying when a product is chosen are recommended [1], [2].

Usually, enzymatic emulsions are used for two applications: dust suppressing and soil stabilization. Also, other applications types were tested: building materials - earth stabilized bricks [4].

This kind of stabilizing agent is used for low volume roads, and the application frequency will increase according to the traffic increment and road designed speed. According to soil or stabilized material, supplementary restrictions regarding vehicles loading may appear [1].

Road layers stabilization using this kind of agent is applicable in any climatic regions, without restrictions regarding terrain topography. The resulted surfaces may become slippery when wet, especially in case of high clay content soils (greater than 20…30%). In these conditions, minor reconfiguring work may be needed especially after high intensity rains [1].

The minimum clay content has to be in common conditions of at least 10%, and the soil to be stabilized has to present a plasticity index greater than 8%. Best results are obtained in soils having a clay content between 12 and 24% (even 25…30% in some products case), presenting plasticity indexes between 8 and 35%. Also, enzymatic emulsions provide best results when the moisture content is smaller by 2…3% than optimum moisture content (O.M.C.). Enzymatic emulsions can increase soil resistance by 30…300% if the surface water is well drained [1].

This kind of stabilizing agents presents a smaller application in comparison with other types, reason for which the experience accumulation is reduced especially in our country conditions.

Enzymatic emulsions are usually provided in liquid concentrated form. Certain water quantities are required for their dilution on the site.

The required work equipment is usually composed of a cistern with spraying devices, grading equipment, scarification equipment, milling equipment and compaction equipment.

Diluted solution realization comprises the enzymatic concentrate solution mixing by adding water. The usual mixing rapports are those between 1:100 and 1:500 [1].

The application process can be different according to product nature: pulverization or mixing method. The recommended depths for mixing depend on the stabilization purpose. In dust suppression applications, depths between 25…59 mm are usually used and in soil stabilization applications the usual depths are between 100…200 mm.

Special measures have to be taken in order to assure that the soil moisture content before stabilization is situated under the optimum moisture content, which is usually realized only after solution application (water provided by enzymatic emulsion is taken into consideration). If the material is too dry or wet, special correction measures are taken in order to provide best working conditions. In dust suppression applications, surface scarifying permits an equal and uniform impregnation of the enzymatic emulsion. In case of soil stabilization applications, the soil is scarified on depths required by the application.

After the attaining of necessary conditions, the enzymatic emulsion is applied, by mixing with soil. Usually, this operation is realized in several phases, by successive passing, in order to provide a good mixture. The next operation refers to surface grading, followed by compaction [1].

Several construction restrictions may be involved in stabilization applications using enzymatic emulsions: the stabilization applications are forbidden if any kind of rain is forecasted in 24 hours, or if the

temperature is under 4…16 °C (in function of applied product). Site productivity varies between 2.000…5.000 m^2/hour. The construction road or lane is closed during stabilization process, but it can be opened for small traffic after construction realization. The stabilized surfaces are left for a 2…3 days curing period before regular traffic opening [1].

Life expectancy of the stabilized materials varies according to traffic and climatic conditions. Usually, it is of 5…7 years in stabilization applications case (with some exceptions - 12 or more years) [2]. Life expectancy and best performances are provided in optimum dosage application conditions, as well as maintenance realization [1]. Additional grading and enzymatic emulsion adding may be required in order to preserve the quality of stabilized layers [1].

2. Stabilization Mechanisms

By definition, an enzyme is an organic catalyst, which provides the conditions for a reaction acceleration (which in enzyme absence is slower developed), without becoming a part of the final product. Enzymes combine with organic molecules in order to achieve an intermediary reactive which changes ions with clayly structures, by breaking their reticular network and causing the coverage effect which blocks water absortion and density losses. Enzymes are regenerated by reaction and participate again in the reaction. Due the fact that the ions are elevated, an osmotic migration occurs, and a good mixing process is required [2].

Enzymes are natural materials which are fabricated of natural materials obtained from bio-products resulted from food or other industries. They present the advantage of a good transportation rapport due to the fact that they are delivered in concentrated form.

The concept of soil stabilization process using enzymes is demonstrated also by natural processes. In Latin America and Asian regions, the stabilization capacities are demonstrated by ants which build earth structures having the consistency of a rock and several meters in height. These structures resist in heavy rains and are realized by mixing ant saliva by soil [3].

The idea of enzymatic stabilization for roads was developed departing from enzymatic products used in horticulture. The modification of a process produced a material which is adequate for weak terrains.

Enzymes are absorbed by the reticular structure of the clay, and then are released for cationic exchange. They present an important effect on the reticular structure of the clay, generating its expansion, then its reduction. If absorbed by cations, the enzymes are transported in the electrolyte system of the soil, and they facilitate hydrogen ions release by bacteria, increasing the pH values of clay particles surface which contribute to clayey structures' breaking [2].

Added to soils, enzymes increase the mixing and bonding capacity of particles, permiting their easier compaction. Also, enzymes improve chemical bonds which participate in soil particle binding thus generating tresistant and permanent structures [2].

3. A Technology Overview Using Alphasoil®06 Product

Alphasoil®06 is a homogeneous, brown-yellow liquid which is identified by the following characteristics: specific density - 0.95 g/cm^3, pH at 20 ºC - 7.0, boiling point - 100 ºC, partially soluble in water, without volatile compounds. It is delivered in 200 L canes, along with a quality certificate and technical specifications provided by its label.

4. Road Construction Phases Using Alphasoil®06

4.1. Analysis, planning, testing and execution

Before any road construction using Alphasoil enzymatic emulsion, it is necessary to obtain some basic information, gathered through a rigorous soil analysis by an experienced laboratory. The key indicators to be analysed are: natural and optimum moisture content (Proctor value), soil classification and granularity (soil composition curve), soil pH, density and compression (CBR test), water retention test.

4.2. Roadbed preparation

In order to provide best results, the local soil may be the object of supplementary material mixing in order to obtain an ideal granularity curve. For this purpose an 1/3 gravel, 1/3 sand and 1/3 clay composition is suitable for road stabilization. When pure clay is used, the dried fractions have to be between 15 and 30%, the rest being composed of gravel (35%) and sand (35%). Dried clay is indicated due to its state, the wet one being difficult to use in the mixing process. The used materials have to be dried and without great particles. The external material, added in order to improve the mechanical properties of the soil has to be mixed with local soil prior to enzymatic emulsion mixing. Gravel dimension in the stabilized layer has to be smaller than 8...10 cm, placed at 1/3 depth from the exterior surface.

In order to realize a good stabilization process, the roadbed has to be prepared by compaction. The compaction is realized in order to provide a better stability which would undertake traffic loads. If compaction is not properly realized, the roadbed may be instable and the stabilization process may fail.

If the roadbed is too wet for compaction, one of the following procedures may be applied:

- Direct mixing and soil drying;
- Soil mixing with lime in order to eliminate the water surplus. Lime addition does not affect the stabilization process.

All the surface water must be evacuated. In this order of ideas, a slope must be provided for the roadbed during compaction. Water evacuation is made using a 1:3 ratio slope. Another technique comprises the introduction of some tubes in the road body in order to evacuate the water. Special care must be granted to the mixing machine which must not come in contact with these tubes. In flat zones, the road is realized at 40...50 cm above soil in order to prevent water flow from lateral ditches over the road surface.

In order to prepare the stabilized layer shape, a grader is usually used. The stabilized layers will lose up to 35% of their thickness due to the compaction process.

In cases in which the local material is mixed with external materials in order to optimize local properties, their mixing is realized before enzyme application. The material will be processed on a 30 cm depth using PTH scarifying equipment (Figure 1). After that, all the material will be milled using PTH milling equipment (Figure 2).



Fig. 1. *Roadbed preparing using a scarificator*



Fig. 2. *Layer grinding using a crusher machine*

If the soil to be stabilized is too wet, the PTH milling machine will not provide best results, therefore an amount of 2...3% quicklime will be added.

Due to the width of active milling devices mounted on the base machine, the milling-mixing operations are realized in several passes thus covering the entire lane.

3.3. Alphasoil® 06 emulsion application

The working amount of enzymatic emulsion results from concentrate mixing with water in order to provide an optimum moisture content (OMC), is around 10...14%.

The correlation between the necessary quantity of emulsion and the stabilized quantity is provided by geotechnical engineering. Thus, in order to stabilize a quantity of 1 m^3 soil, 0.12 L of enzyme are necessary. Generally, this amount is diluted in 1:4 ratios in order to obtain the base liquid, resulting (1 + 4 = 5) 0.6 L/m^3.

Weather conditions represent an important component and they have to be carefully analysed before starting work. The moderate climate zones are generally associated with 1...2% water evaporation in 24 hours.

The necessary enzymatic emulsion quantity is calculated considering the total area and the necessary of emulsion per m^2, or the total volume and the necessary of emulsion per m^3, by considering the cistern volume. For emulsion dispersion usually special cisterns endowed with spraying devices are used (Figure 3).



Fig. 3. *Enzymatic emulsion dispersion using a cistern*

Soil mixing has to begin immediately after its treatment with enzymatic emulsion (Figure 4). The best solution for mixing purposes is represented by PTH milling machine, equipped with electronic dispersion system, realizing emulsion dispersion and mixing at the same time.



Fig. 4. *Mixing operation using a milling machine*

Once the mixing operation is finished, a layer configuration may be necessary in order to realize the final stabilized road. The road shape is realized using a grader for mixed layer configuration (Figure 5).

In order to provide best circulation surfaces, after all the above mentioned operations, there is necessary to stabilize

layer compaction. Layer compaction is realized using a compactor machine (Figure 6).



Fig. 5. *Road shape configuring using a grader*



Fig. 6. *Layer compaction using a compaction machine*

After all the mentioned operations, a cover layer may be provided in order to protect the road against mechanical stress provoked by traffic as well as weather conditions.

Cover layer can be built of rock (35...50 mm), before final drying (Figure 7). Another solution is represented by gravel and rock mixing in the structure.



Fig. 7. *Adding rock as cover layer*

If bituminous binders are used, these are applied at a 3...7 days interval after the all structure had been dried.

References

1. Kestler, M.A.: *Stabilization Selection Guide for Aggregate and Native-Surfaced Low-Volume Roads*. U.S. Department of Agriculture, Forest Service, National Technology and Development Program, 2009.
2. Scholen, D.E.: *Non-Standard Stabilizers.* FHWA-FLP-92-011, U.S. Department of Transportation, Washington D.C., 1992.
3. Velasquez, R., et al.: *Preliminary Laboratory Investigation of Enzyme Solutions as a Soil Stabilizer*. In: Final Report, Minessota Department of Transportation, 2005.
4. *** *Enzyme Stabilized Mud* (*Earthen*) *Construction using Borozyne-R "DZ-1X"*. Available at: http://2.imimg.com/data2/WL/WT/MY-3941391/mud-construction.pdf. Accessed: 11.03.2012.