MARBLE TREATMENT WASTE FOR SLOPE STABILISATION

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SUMMARY

The problem of slope stabilisation is very important during the construction and performance of roads and highways, and, therefore, many kinds of methodologies have been developed. In the present research work, slope stabilisation was performed on the national highway Kavala-Xanthi (Xerias site) by mulching with simple hydro-seeding (A) and marble treatment waste (B), a combination of hydro-seeding (two kinds of bitumen emulsion (anionic and cationic). After two years of application, soil erosion occurred only in the area where simple hydro-seeding was used, whereas in that with combination (B) there was a large amount of plant covering. When using a bitumen cationic emulsion, the amount of plant coverage was more than 60 %. This application results not only in slope stabilisation but, in a parallel manner, in minimizing the environmental problem of huge quantities of marble treatment waste deposits found in Greece.

KEYWORDS: slope, environment, stabilisation, bitumen emulsion, marble, waste.

INTRODUCTION

The phenomena of soil erosion may occur during the construction of roads and highways and their use [1]. Depending on the special cases, many kinds of treatments are used for the protection of the environment. These examples include:

- Area modification – earth-covering
- Fencing e.g. by wire net or by other means
- Seeding in different ways, such as in drainage basins [2], hydro-seeding [3], or in combination with bitumen materials [4-6].

Treatment with seeding is advantageous, compared to technical treatment, because its performance improves with time, its materials are not destroyed, and it is environment-friendly.

In this research, the materials, methods and the results refer to the treatment of slope stabilisation in the national highway Kavala-Xanthi at the Xerias site. The treatment was done by using hydro-seeding containing a suitable mixture of seeds, fertilizers etc., two kinds of bitumen emulsion (anionic and cationic), and marble treatment waste in dry form.

The aim was to discover the possibility of using wastes from marble treatment, which are in big quantities creating a huge environmental problem in the area of Thessaloniki.

TRIAL SITE

The Xerias site in the national highway Kavala-Xanthi was chosen, because soil erosion had been observed due to bad climatic conditions and a big depth of embankment. At the trial site, the mean annual rainfall is 510 mm with two maximum values in November and May. The mean daily temperature is 14 ^{o}C, the average annual relative humidity is 61 %, and the main kind of vegetation is *Quercus coccifera*. Mulching and use of bitumen emulsion and marble treatment waste was carried out in March 2002. The slope of embankment at the trial site was more than 60 %.

Analysis of the subsoil showed it to have a limestone base (SC-CL), with a pH value of 8.1. The surface soil contained more than 30 % clay with a pH value of 7.7.

Three areas of research were selected, with a surface of 100 m^2 each:

Area I: The treatment was done only with hydro-seeding with a specific seeding mixture.

Area II: The treatment was done with hydro-seeding as above, and the use of Bitumen Anionic Emulsion (BAE) and Marble Treatment Waste (MTW) in dry form.

Area III: The treatment was done with hydro-seeding, but also the use of Bitumen Cationic Emulsion (BCE) and Marble Treatment Waste (MTW) in dry form.

MATERIALS AND METHODS

Seeding mixture

The seeding mixture [7] contained *Lolium rigidum* (15 %), *Festuca aruddinacea* and *ovina* (28 %), *Cinodon*

dactylon L. (15 %), as well a mixture of *Trifolium, Lotus, Fachelia* and *Thymus* (27 %). Additionally, fertilizers, adhesives and tyrph were used for better adhesion.

Bitumen emulsions

Two types of bitumen emulsion were used, an anionic slow setting BAE (SS-1, according to ASTM) [8], and a cationic slow setting BCE (CSS-1, according to ASTM) [9]. Both emulsions were produced by BITOUMINA S.A., Thessaloniki. The emulsions had the properties shown in Table 1.

TABLE 1 - Properties of mulching bitumen emulsions.

Characteristics	Bitumen Anionic Emulsion	Bitumen Cationic Emulsion
a. Tests on emulsion		
Viscosity, Saybolt Furol at 25°C, (sec)	32	28
Storage stability test, 24 h (%)	<1	<1
Cement mixing sieve test (%)	<2	<2
Sieve test	<0.1	<0.1
Residue by distillation (%)	59	61
Particle charge test	negative	positive
b. Tests on residue from distillation test (%)		
Penetration, 25°C, 100 g, 5 sec, 0.1mm	112	107
Ductility, 25 °C, 5 cm/min (cm)	>40	>40
Solubility in trichloroethylene (%)	99	98.5

Marble treatment waste

Marble treatment waste consisted of marble dust (80%) and water (20%). Marble dust was pure $CaCO_3$ (> 98%). There are 25 factories treating marble in the Thessaloniki area, and producing annually more than 5.000 MT of waste causing huge environmental problems.

Application

Figure 1 shows the modified equipment of the Greek company (AKTIS S.A.) that was used for application of the materials.

The mixture of seeds, fertilisers, tyrph and adhesive material was first applied to all research areas (I, II, III). After that, bitumen emulsion and marble treatment waste (dried) were applied to areas II and III. The quantities applied are shown in Table 2.

TABLE 2 - Applied materials for slope stabilisation (g/m2).

MATERIALS \ AREAS	I	II	III
Hydro-seeding mixture	50	50	50
Bitumen Anionic Emulsion	-	500	-
Bitumen Cationic Emulsion	-	-	500
Marble Treatment Waste (dry)	-	500	500

RESULTS

After two years (March 2002-March 2004), the following was observed:

A: Great soil erosion has occurred in Area I, because only hydro-seeding was applied (Fig. 2, left side).

B: No soil erosion has occurred in Areas II and III, because of the positive combination of hydro-seeding, bitumen emulsion and marble treatment waste (Fig. 2, right side).

C: The 60-70 % plant coverage with BCE, and 50-60 %.with BAE.

FIGURE 1 - Mulching application equipment.

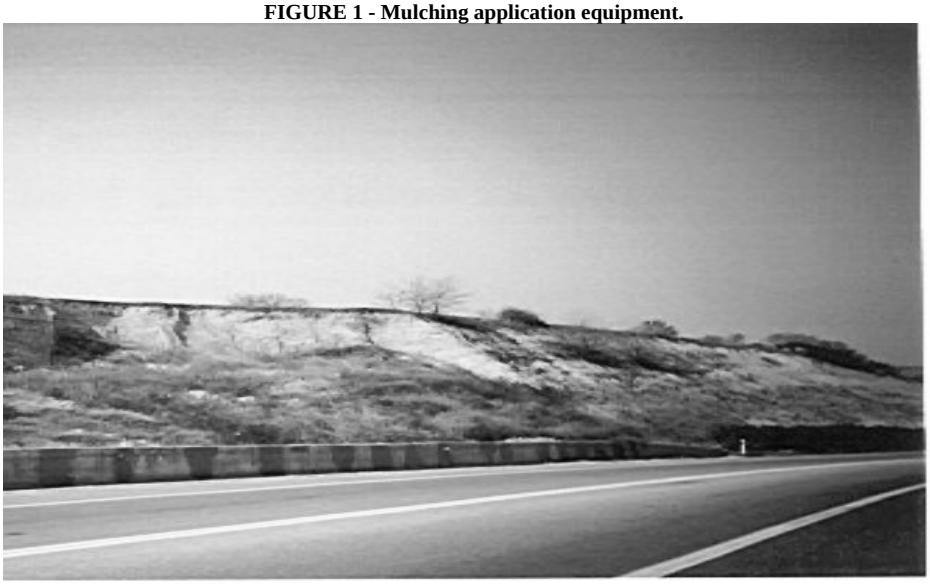

FIGURE 2 - Great soil erosion observed in Area I (left side).

DISCUSSION AND CONCLUSION

The use of hydro-seeding in combination with bitumen emulsion (especially the cationic type) and marble treatment waste gave very satisfactory results, increasing the road`s safety and environmental protection. The additional use of marble treatment waste by this soil stabilisation method can help to decrease the environmental problem of huge deposits in the area of Thessaloniki.

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