Increase of strength and compaction efficacy by insertion of a geogrid in a granular base layer

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ABSTRACT: The paper presents a discussion about the increasing of the compaction efficacy of a granular base material compacted over a soft soil provided by a synthetic layer reinforcement element introduced into the base material. Tests results and the methodology to verify the improvement are presented.

1 INTRODUCTION

In the last decades, the road construction on sites whose soil has poor engineering properties, is being done with geosynthetics in order to improve their bearing capacity and decrease the granular base thickness required for these cases.

Usually, a geosynthetic is used in a separation/reinforcement function and directly applied onto soft soil layer. When the first fill layer is spread and compacted, the geosynthetic deformation mobilize tensile forces, providing a reinforced effect.

Since this layer still allows larger deformations under construction traffic, the compacted base material over this layer usually shows mechanical properties inferior than if this material was compacted upon a rigid platform.

The paper proposes to introduce a new synthetic layer acting as a reinforcement element to control this phenomena: a geogrid, with the main function of increasing the compaction efficacy and improve the bearing capacity of the granular base.

The pavement cross section shown in Figure 1 considers this proposition. The material spread over the geotextile could be any soil whose function is only to provide a platform to support the traffic of compaction equipment. The geogrid aperture size should allow the interlocking of the base material as a system in order to improve the geogrid confining effect.

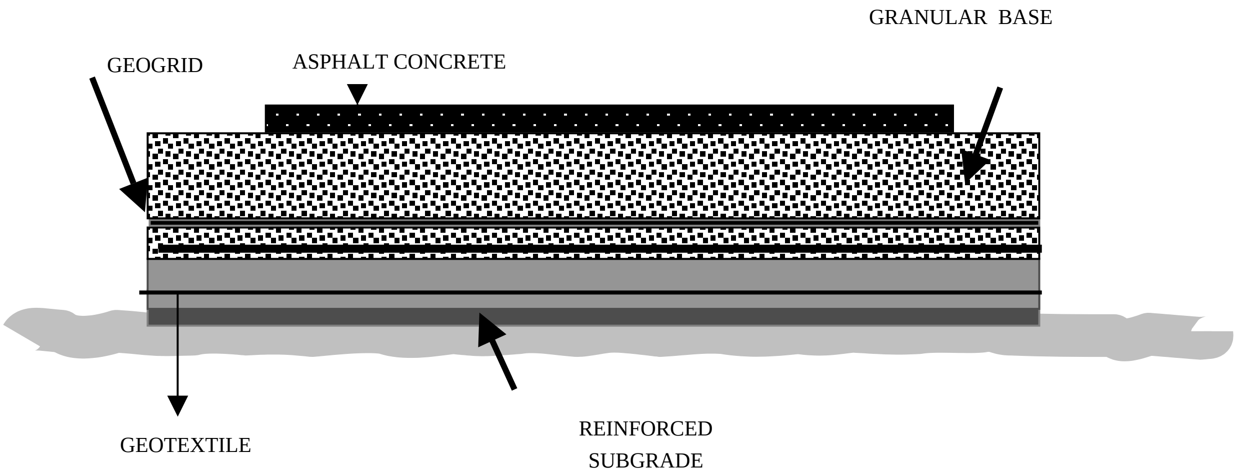

Figure 1 Typical pavement cross section.

2 TESTS

To analyze the possibility of increasing the compaction efficacy introduced by geogrid layer, laboratory tests were carried on 120 x 60 cm box as shown on Figure 2.

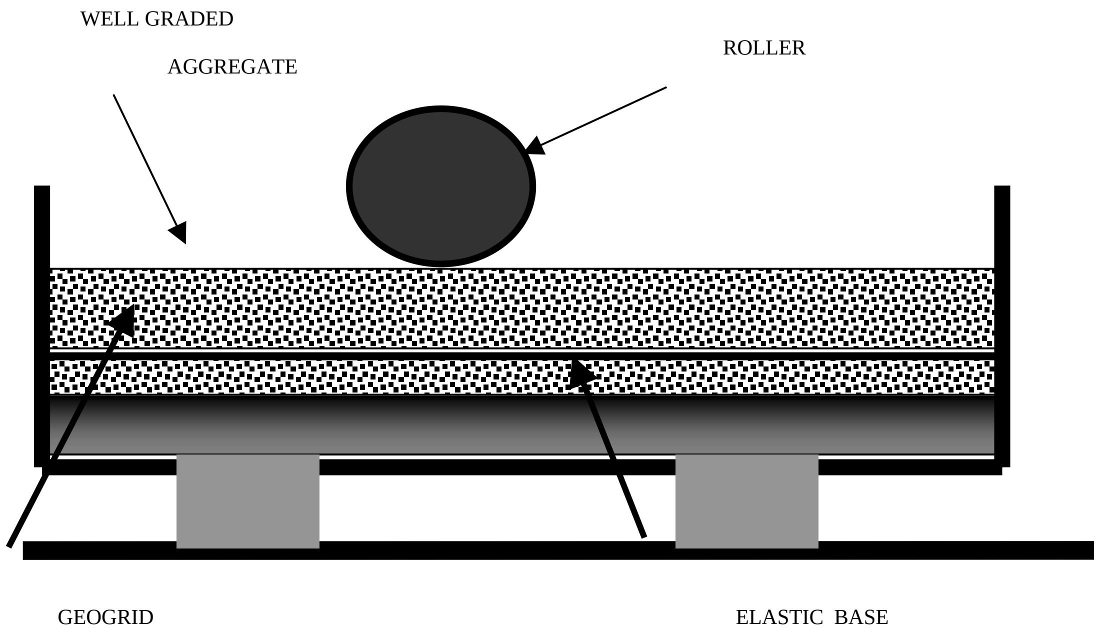

Figure 2. Tests apparatus.

In these tests, an artificial subgrade was simulated using a rubber material. The granular material adopted was a well-graded crushed stone rock, and the reinforcing layer was a woven biaxial geogrid. The granular material was compacted by a smooth wheel roller weighting 83 kgf, passed 40 times at a 1.8 km/h speed . The roll width is 40 cm.

The tests considered the following situation: without reinforcement, with geogrid placed at 2 cm and 7 cm above the subgrade surface. The geogrid was clamped during the compaction.

With the purpose of checking the increase of base strength, the compacted specimens were loaded with static loads applied by a hydraulic jack, until a 27 mm penetration of a piston was recorded as illustrated by Figure 3.

3 MATERIALS

The granular material explored was a well graded crushed stone, which the granulometric distribution presented in Figure 4, commonly used as a base course material presenting a maximum dry weight of 21.4 kN/m^3 to an optimum water content of 4,8%.

The reinforcement was provided by a polyester woven biaxial geogrid with 80 kN/m tensile strength and 2 cm aperture size.

The soft soil was simulated by an elastic layer 8 cm thick. A geotextile was inserted as a separating layer between the granular and the elastic layers, in order to avoid grain embedment on the elastic layer..

4 ANALYSIS OF THE LOAD TEST

It is believed that such kind of reinforcement could produce two beneficial effects:

- an increase on granular layer compaction efficiency;
- an increase on bearing capacity due to the presence of the geogrid.

The first phenomena can be analyzed by load test only if the ratio between the load piston diameter (D) and the granular layer thickness above the geogrid (h) is small enough such as the reinforcing effect will not be significant.

A literature survey on foundation reinforcement showed that:

- tests performed by Binquet and Lee (1975 a, b) indicate that failure occurs above reinforcement level if B/h < 1.5, where B is the foundation width;
- Khing et al (1993) did not observe on their tests any strength or bearing capacity gain for ratios B/h <1;
- Fabrin (1999) concluded from numerical analysis that reinforcement depths given by B/h <1 will not lead to any benefits.

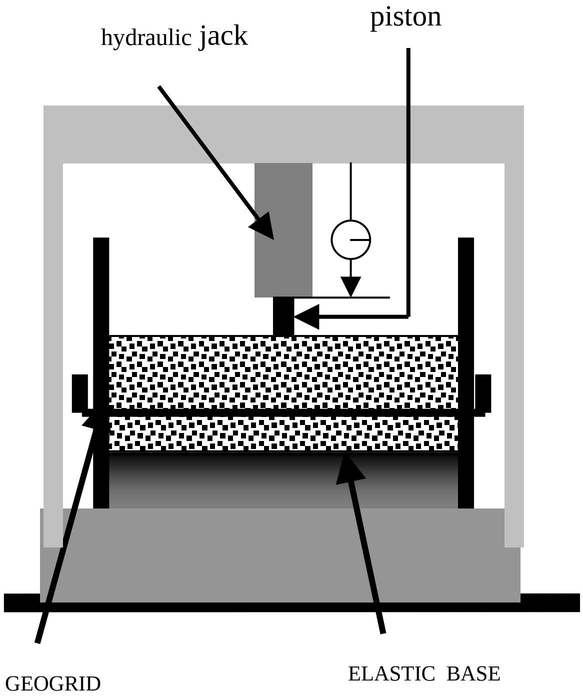

Figure 3. Load tests.

Figure 4. Particle size distribution of the base material

These studies indicate that load tests results with a 50 mm diameter load piston penetrating 27 mm would not be influenced by the presence of the geogrid on the tests here performed.

5 RESULTS

Table 1 presents tests characteristics and compaction control results. Figure 5 shows a comparison between the results of the load tests performed on the granular material compacted with the geogrid and the ones performed on the material compacted without the geogrid, represented by Bg/Bs. The values presented are averages over at least two measurements.

The base material layer thickness after compaction was approximately 14 cm height.

Table 1. Tests characteristics and compaction control

	reinforcement position	water content (%)	total weight (kN/m^3)
BM	-	5.6	22.3
GR2	+2 cm	5.2	21.4
GR7	+7 cm	4.7	22.2

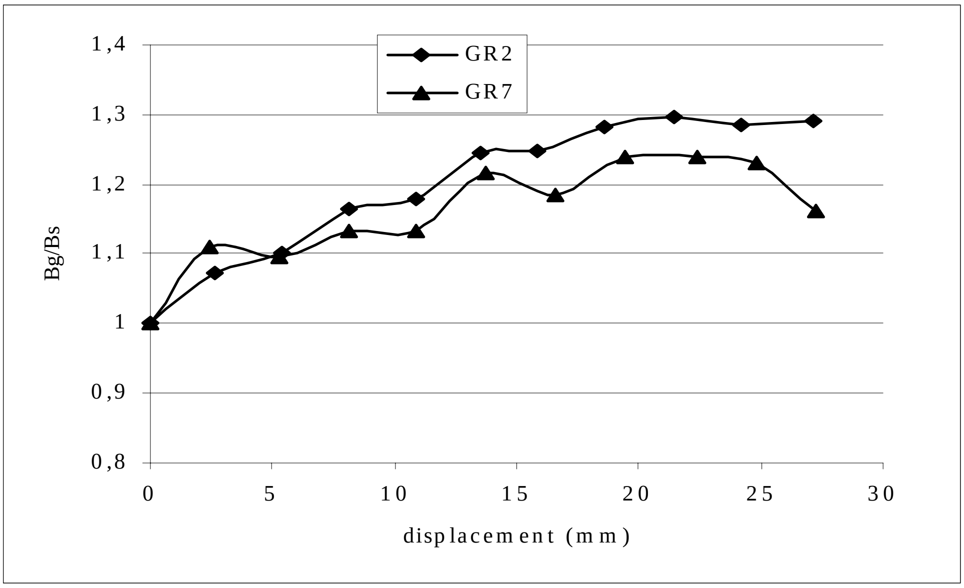

Figure 5. Bearing capacity ratio observed on the tests.

6 COMMENTS

The observed increases on bearing capacity with the geogrid located at 2 cm or at 7 cm above the interface indicate an improvement on granular material properties.

It is interesting to note that test GR2 showed the best performance, in spite of the small differences among all the tests. The 30% increase on bearing capacity represents the average over 3 close values. Maybe, this is the best condition, since it will benefit bottom layer compaction, leading to a better behavior under repeated loads.

The geogrid located at the interface has proved its efficacy for the increase on system bearing capacity under full scale loads. In terms of compaction efficiency improvement, a small effect is expected in this case, due to a lack of interlocking helps from the geogrid at this position. The elastic properties of the subgrade layer and the presence of the separation element avoided the intrusion of the base material between the geogrid and the separating geotextile, as it observed in preliminary tests.

It is interesting to performed tests with soft soil instead the elastic base, presenting different behavior parameters.

The final conclusions of this research will be reached only after the completion of tests that will be performed on granular layers compacted with conventional construction equipment on full-scale conditions. This additional effort is justified by the promising results there presented.

REFERENCES

Blinquet, J and Lee, K. L. (1975a) Bearing capacity tests on reinforced earth slabs, *Journal of Geotechnical Engineering Division*, ASCE, vol. 101, n.12, pp. 1241-1255.

Blinquet, J and Lee, K. L. (1975b) Bearing capacity tests on reinforced earth slabs, *Journal of Geotechnical Engineering Division*, ASCE, vol. 101, n.12, pp.1257-1276.

Fabrin, T.W (1999) O uso de geossintéticos no reforço de fundações – aplicação ao caso de tubulações enterradas, *Master Thesis*, Aeronautical Technological Institute, S.José dos Campos, Brazil, 219 pg.

Khing, K H, Das, B M, Puri, V K, Cook, E E, Yen, S C (1993) The bearing capacity of a strip foundation on geogrid reinforced sand, *Geotextiles and Geomembranes*, vol.13. pp 199-206.