Geogrid construction damage resistance

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ABSTRACT: When soil, especially crushed gravel, is spread on geogrids and is compacted, geogrids suffer damage due to local punctures and abrasions by the aggregate. Every type of geogrid suffers a different degree of damage which can be assessed by tensile tests performed on both damaged and undamaged products. On this subject extensive independent test programs have been performed in the U.K. for evaluating the residual tensile strength of different geosynthetics after a full scale compaction damage procedure. The full scale compaction damage trials were performed by the TRRL (Transport Road Research Lab) following the procedure set by Watts and Brady (1990) and tensile tests were performed both on the original and damaged specimens by independent laboratories. In addition other tests, in agreement with the laboratory construction test procedure (ENV ISO10722-1) have been performed to verify current laboratory standard practices versus in-situ results. Finally also the possible interaction between installation damage and long term behavior was verified.

1 INTRODUCTION

When soil, especially crushed gravel, is spread on geogrids and is compacted, geogrids suffer damage due to local punctures and abrasions by the aggregate. Every type of geogrid suffers a different degree of damage which can be assessed visually and/or by comparing tensile tests performed on both damaged and undamaged (control) products.

From a more general approach it could be stated that the kind and the level of damage can be extremely varying, thus depending on soil characteristics (grain size distribution, angularity, sharpness, hardness etc.), compaction (level of compaction, type of compactor etc.) and geogrids characteristics (polymer, construction technology, mass weight, geometry etc.). Some of the typical geogrid installation damage are reported in Fig. 1, 2, and 3).

Such a large number of different influencing factors is clearly responsible of large spread of testing results, that in many cases are difficult to compare between each other.

For this reason the necessity of disposing of a strictly Standardized reference procedure is nowadays a major problem.

In the present paper the testing results from two different procedures are reported, commented and reciprocally compared in order to allow a better understanding of the damaging measurement problem on geogrids. Moreover the possible influence of installation damage on long term mechanical properties has been also considered.

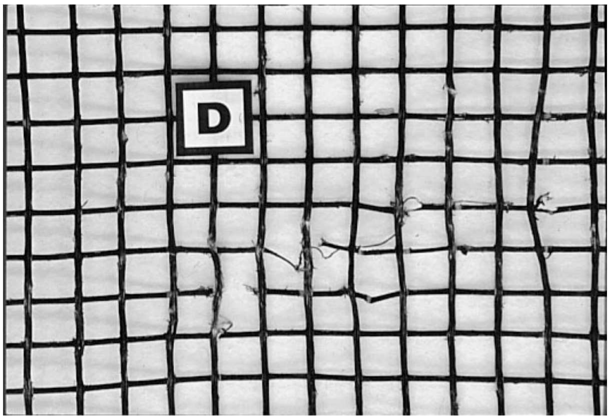

Figure 1. Typical PET geogrid damage (Type C)

1.1 *Tested geogrids*

Basically three different families of geogrids have been chosen for every family different tensile strength classes were considered:

Type A: Integral Extruded Geogrids
Type B: Integral Punched Geogrids
Type C: Woven PET geogrids

Note: the suffix 1 is for uniaxial the suffix 2 is for biaxial geogrids: i.e.: Type A2: Biaxial Integral Extruded Geogrid

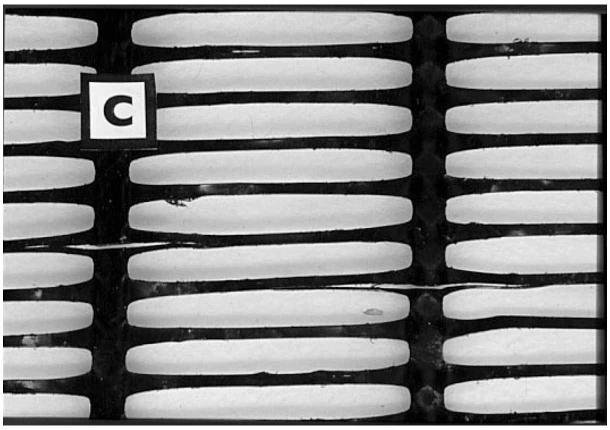

Figure 2. Typical damage in “punched” PE geogrid (Type B)

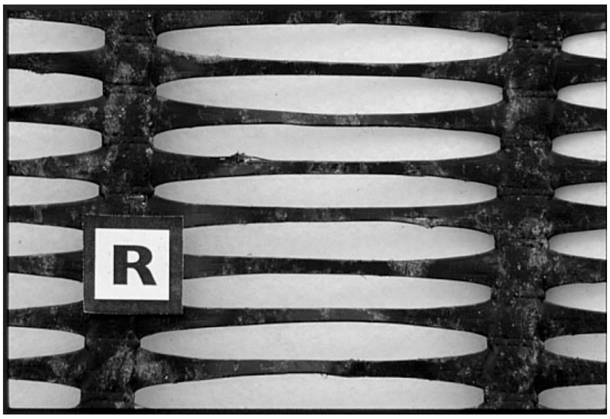

Figure 3. Typical damage in "extruded" PE geogrid (Type A)

2 FULL SCALE COMPACTION TESTS

Extensive independent test programs have been performed in the UK for evaluating the residual tensile strength of different geosynthetics after a full scale compaction damage trial. In example, full scale compaction damage trials were performed by the TRRL (Transport Road Research Lab) following the procedure set by Watts and Brady (1990) and tensile tests were performed both on the original and damaged specimens by independent laboratories. The results of these tests for several geogrids are summarised in the following figure 3 and 4 that contains some results of the tests performed at TRRL, as reported by Wright and Greenwood (1993), Watts and Brady (1994) and Watts and Greene (1995).

2.1 *The damaging procedure*

All the results reported in chapter 2 have been determined always in agreement with the procedure defined by Watts and Brady (1990) and the tensile tests carried out in agreement with either BS6906 Part 1 or ISO 10319 Wide Width Tensile Test Methods and GRI-GG1 Single Rib Tensile Test Method.

The aim of the procedure is to reproduce the site damage. The procedure is reported below accordingly to the original:

- place 2.1 m wide, 2.0 m long, 6 mm thick steel plate on concrete floor;
- compact base layer of backfill over and around plate, using a thickness of backfill and intensity of compaction as required;
- place specimens of geotextile (geogrid) on top of the compacted layer; in these trials two number 1.0 m wide, 3.0 m long specimens of the geotextile (geogrid) were installed side by side;
- compact upper layer of backfill over and around specimens; for ease of recovery one end of the geotextile (geogrid) was first covered by a 5 mm thick sheet of plywood;
- the backfill was removed from the end of the plate nearest the plywood, and chains from an overhead crane were attached to lifting eyes on the plate;
- the plate was raised about 0.5 m to expose the full width of the plate and geotextile (geogrid);
- the geotextile (geogrid) was clamped between blocks of wood and fixed to the edge of the steel plate;

– the plate was then raised and moved horizontally to allow the backfill to fall away or to be easily removed from the geotextile (geogrid).

2.2 *The Test Results*

The results are presented in graphical form showing the behavior and the trend of different geogrid types under full scale installation damage testing. The results are plotted Vs the two main indexes for geogrid classification.

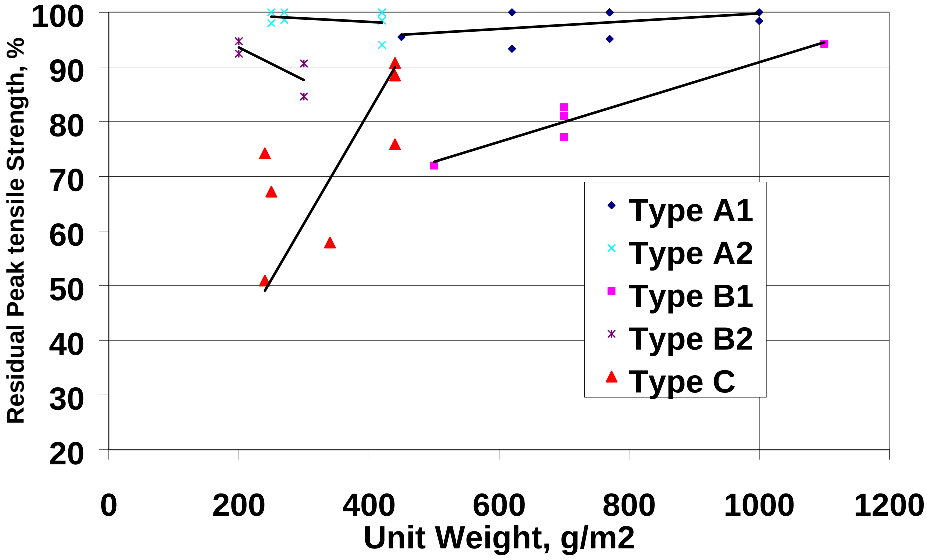

Figure 4: Residual Tensile strength Vs geogrid Unit Weight

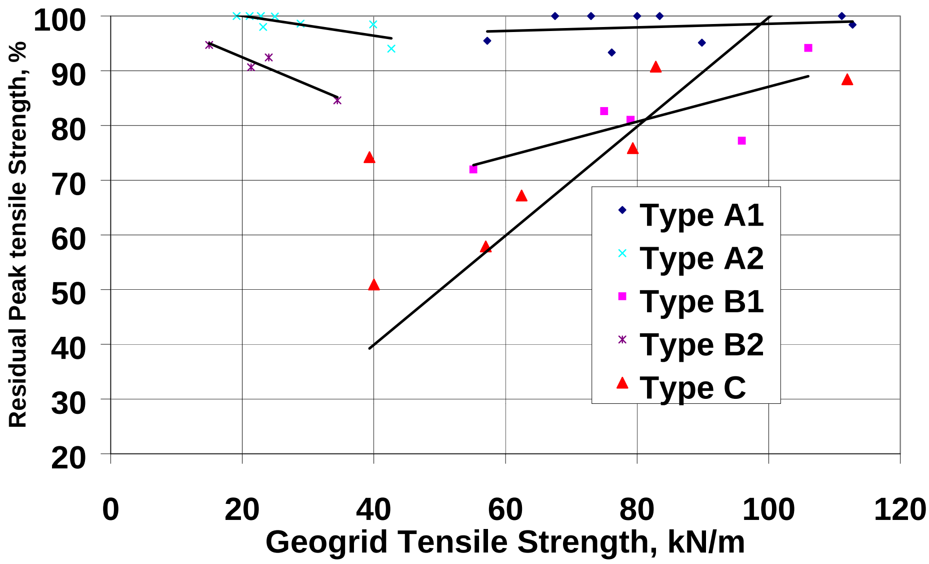

Figure 5: Residual Tensile strength Vs geogrid Tensile Strength

3 LABORATORY COMPACTION TESTS

A series of tests have been performed during spring 1999 (Cancelli 1999) in order to evaluate the installation damage on a range of geogrids accordingly to ENV ISO 10722-1.

Specimens were prepared in accordance with EN963 and were dimensioned as required by EN ISO 10319 wide width tensile test method, while standard atmosphere conditions were realized according to ISO 554 (20° ± 1).

3.1 *The damaging procedure*

A compression device, which met the ENV ISO 10722-1 test method requirements, was used. The sinusoidal cycle loading has been applied through a servo hydraulic actuator controlled by an Instron 8580 digital multi-axis closed-loop controller and the applied load were measured and

The test container was a rigid steel box, measuring 670 x 470 x 200 mm. A steel loading plate was used (measuring 350 x 460) but, in order to guarantee a higher stiffness, it was coupled with a second steel plate measuring 200 x 300, with an overall thickness of 40 mm (Fig. 6).

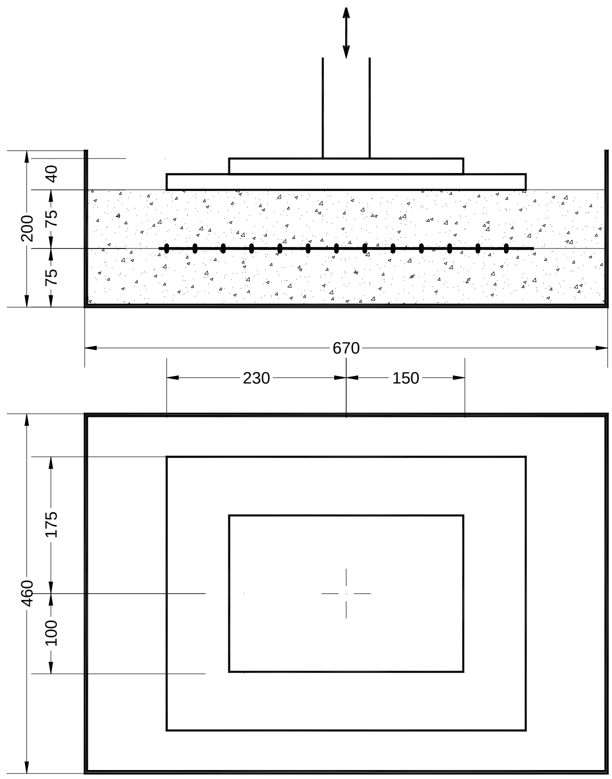

Figure 6. Test apparatus according to ISO 10722-1.

Different materials were used in the damage procedure: namely a sintered aluminum oxide (*Corindon SD 5-10 mm*), a sandy Gravel and a Sand (*Ticino sand*).

The properties of the sintered aluminum oxide were complying the requirements stated by ENV ISO 10722-1. Both the sandy Gravel and the Sand were provided from northern Italy. The grain size curves of the aggregates are reported in fig. 7.

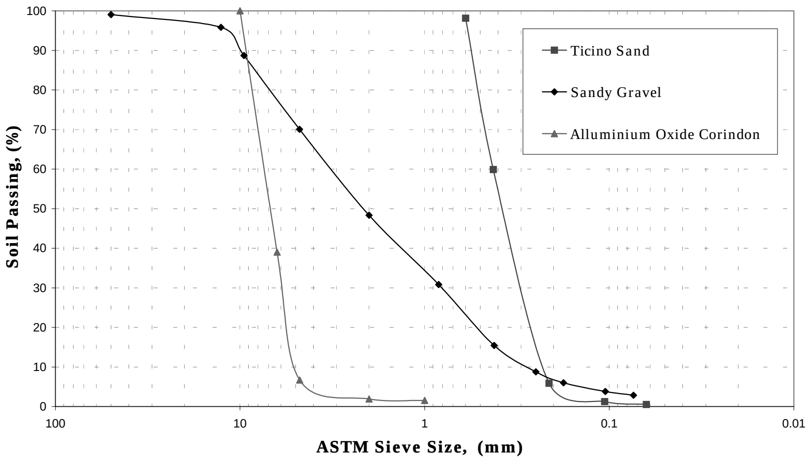

Figure 7. Aggregates grain size distribution.

A sinusoidal cyclic loading was applied at a frequency of either 1 Hz and the load was ranging from 5 to 900 kPa for 200 loading cycles. The pressure was determined using the area of loading plate according to ENV ISO 10722-1.

3.2 *Damage assessment*

The assessment of the damage was made by comparing the undamaged specimen and the damaged specimen at the same reference tensile test. The reference test was a wide width tensile test according to EN ISO 10319. The change in the reference property was calculated as follows:

$$\Delta R = (R_d / R_0) \times 100 \qquad (1)$$

being: R_d = the reference value of damaged specimen
R_0 = the reference value of undamaged specimen
ΔR = the percentage change in the reference value (damage index)

3.3 *ENV ISO 10722-1 Test Results*

The test results have shown, generally speaking, a lower loss of tensile properties in comparison to full scale data. This is due to both the usage of less severe aggregate and to the fact that this test does not allow shearing effects on the geogrid itself. Thus only puncturing forces are applied to the geogrid products. Thus open and light structures are less damaged than in reality.

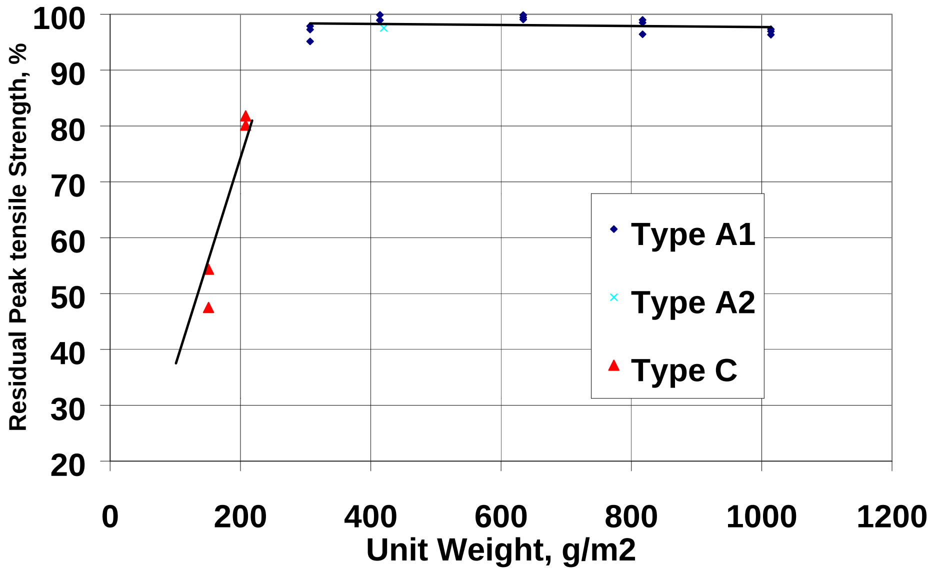

Figure 8: Residual Tensile strength Vs Geogrid Unit Weight

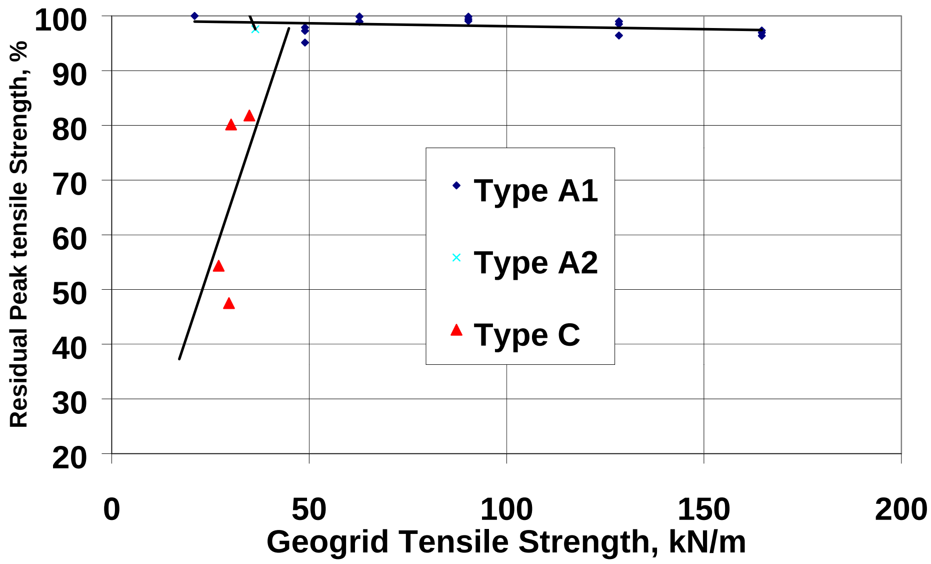

Figure 9: Residual Tensile strength Vs Geogrid Tensile Strength

4 CONCLUSIONS

The test results have shown a consistent relationship between tensile strength and unit weight versus residual peak tensile strength. The woven PET and PP geogrids suffers much greater tensile loss than extruded geogrids. At the same time punched geogrids type B1 suffer, when exposed to full scale construction damages, a loss of tensile strength due to splitting and cracking of its brittle structure.

REFERENCES

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Watts, G.R.A., and Brady, K.C., (1990), “Site Damage Trials on Geotextiles”, Proc. IV Int. Conf. on Geotextiles, Geomembranes and Related Products, The Hague, The Netherlands.