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Abrasion damage of geogrids induced by turbid flow

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Abstract

A cylindrical chamber generating a forced circular turbid flow is developed to study the abrasion damage of three woven geogrids. It is shown that this chamber creates consistent turbid flow velocities and particle concentrations, and is potentially useful as an accelerated abrasion damage test based on the results of laboratory tests and pilot seashore protection tests. Two types of damage on the strands of woven geogrids are identified: one is abrasion against the surface of strands in the flow direction; the other is the cutting of strands normal to the flow direction. Test results also show that the strength reductions increase with test duration, while the strength reduction rates decrease as the test duration increases. The change in particle angularity may account for the decreasing strength reduction rates observed in the tests. An epoxy-coated geogrid (GRID 6) appeared to have higher resistance against abrasion than a polyvinylchloride-coated geogrid (GRID 2) indicating that the use of new coating materials to increase the durability of woven geogrids in turbid flow environments is possible. This also suggests a need for establishing cost-effectiveness and robustness evaluation systems for coating materials.

Keywords: Abrasion damage; Geogrids; Turbid flow

1. Introduction

There is increasing demand for geosynthetic containers for underwater breakwaters (Pilarczyk, 1998; Yee, 2002), river dyke improvement (Fowler, 1997), streambank erosion control (Freeman and Fischenich, 2000) and erosion control of seashores (dasNeves et al., 2004). In such applications abrasion of geogrids caused by the sandy and/or grave particles in turbid flow may be a major source of the damage to geogrids. Abrasion damage in turbid flow is a mechanical process which occurs typically during 'in-service' conditions, in contrast to 'installation damage' which occurs during compaction stages of earthwork-related projects. For decades, installation damage of geogrids has been studied via full-scale trials (e.g. Bush, 1988; Sandri, 1993; Hufenus et al., 2005) and laboratory tests (e.g., Paula et al., 2004; Huang and Chiou, 2006; Huang, 2006). The combined effect of installation damage and creep of damaged geogrids has been investigated (Allen and Bathurst, 1994; Pinho-Lopes et al., 2002), and guidelines for determining reduction factors due to installation damage have also been developed (e.g., Elias, 2001; Hufenus et al., 2005). To the best of knowledge of the writers, no study on the abrasion damage caused by the movement of sands or gravels on the surface of geosynthetics has been performed. Fig. 1 shows a pilot test using geogrid-sewn bags for a gravelly seashore protection. The geogrid bags were made by sewing pieces of high-strength geogrid manufactured from woven polyester (PET) yarns coated with polyvinylchloride (PVC). On-site gravels were used as in-fill material to maximize the effective use of in situ material. One month after placing the gravel-filled geogrid bags, some geogrids facing the sea suffered various degrees of damage (Fig. 2). The possible mechanisms for these damages were visually investigated. Signs of movement of small to large sized gravel particles on the top of

Abbreviation: Al_2O_3; Aluminum dioxide; CMD; Cross-machine direction; GRID 2; GRID 4; GRID 6; Three different types of woven geogrids investigated; MD; Machine direction; PET; Polyester; PVC; Polyvinylchloride; RPM; Revolutions per minute

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Nomenclature

ε_f	strain at breakage of geogrids (%)
P_c	volumetric particle concentration (%)
PSR	percentage of ultimate tensile strength reduction (%)
T	flow duration (h)
T_f	wide-width ultimate strength for intact geogrids (kN/m)
T_d	wide-width ultimate strength for damaged geogrids (kN/m)
V_m	average flow velocity along the full-height of the specimen (m/s)
V–M ratio	volume of coating material and the mass of yarns (cm^3/g)

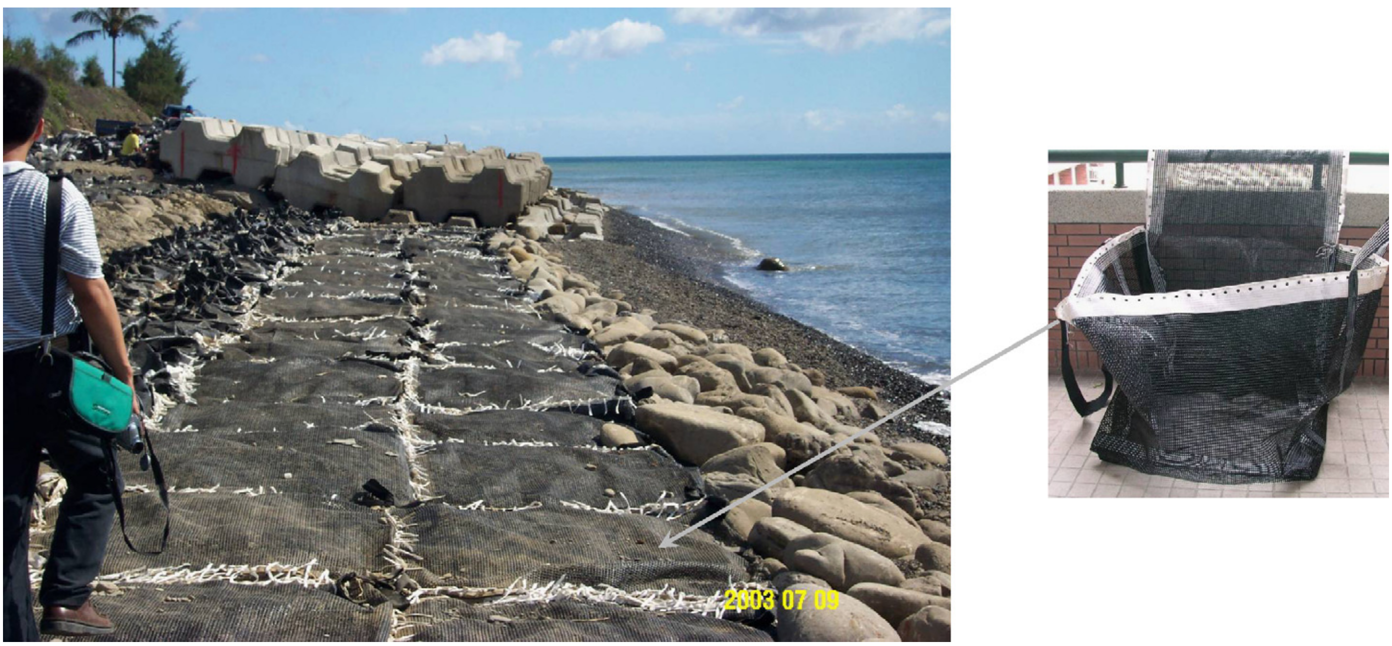

Fig. 1. Geogrid containers used in a pilot test on seashore protection.

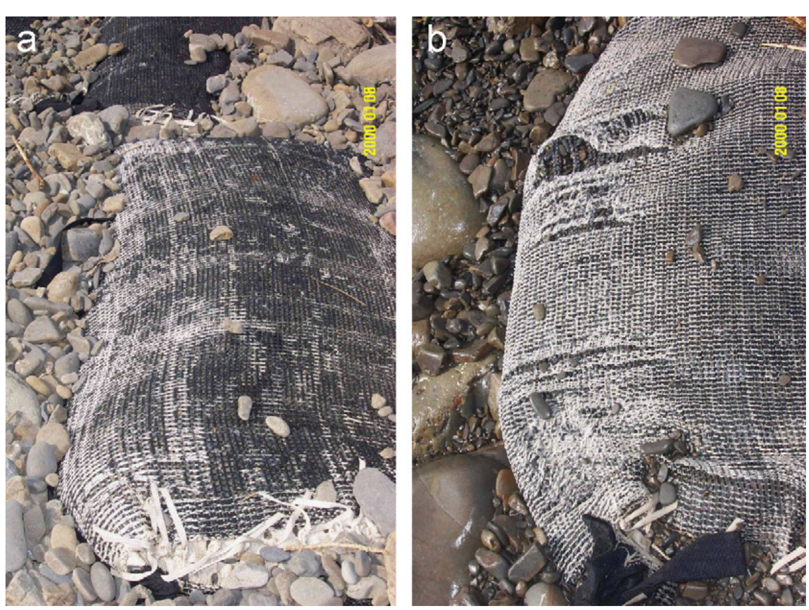

Fig. 2. Various degrees of damage to the geogrid containers observed 1 month after completion: (a) example of moderate damage and (b) example of serious damage.