TEST STUDY ON THE CONFINED CREEP FEATURES OF HDPE GEOGRID IN SAND

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Abstract: Creep is an important property of geogrid for its application in any permanent reinforced structure. At the present time, most of creep experiments were carried out under unconfined conditions that are obviously different from the actual status of geogrid used in geotechnical engineering structures. A series of confined creep tests on HDPE geogrid in sand have been conducted. The relationship between creep strain and time was obtained under different vertical pressures. The tests indicate that effect of confined condition on creep features of geogrids is striking, the effects of creep load and cover load on creep is also not insignificant.

Keywords: geogrid, HDPE, creep, sand

INTRODUCTION

The feature of geosynthetic deformation that is increased continually with time under a sustained load action is referred to as creep. Creep is the key factor to decide whether reinforced earth technique can be used to permanent works or not. It may cause the stress state within the internal structure of reinforced earth to be changed, resulting in stability loss or excessive deformation. Thus, to predict the long-term creep of reinforcement materials for geosynthetics is of crucial importance to the safety and economy of the structure. So, researches on the creep features of geosynthetics is being continuously increased at present, but these researches are basically directed towards geotextile or geomembrane, and relevant creep test standards from majority of countries (e.g. ISO 13431, ASTMD 5262, BS 6906-1991 and Chinese standard GB/T 17637-1998, etc.) provide that creep test of geosynthetics should be carried out under an unconfined condition, so, creep properties obtained by this test method is much stronger than that of geosynthetics embedded in soil mass in actual works, this leads to adoption of a large creep reduction coefficient when designing a project, too much strength reduction limits the application of some geosynthetic materials in permanent reinforced earth. Consequently, considering the effect of confined constraint condition on creep is very necessary and more conforms to the actual engineering application condition.

There are a great deal of factors affecting the confined creep features of geosynthetics, except for nature of geosynthetic material itself, filling soil (e.g. sandy soil or clay), cover load, sample size and creep load etc. have to be also taken into account, so testing is quite difficult, and time during which creep test lasts usually is very long, thus, relevant research results are seldom obtained. Chinese scholar Wang Xiequn et. al. (2004) analyzed the change in creep property of geotextile under different load levels and cover earth pressure limit through confined creep test of two typical geotextile in sandy soil. Brazil scholar L.D.B. Becker et al. (2002) conducted large-scale tests to study the long-term tensile creep property of nonwoven geotextile embedded in sandy soil. Gao Chuanming et al. (2005) combined a loess highway embankment project to observe the strain of reinforced geogrids for two years and obtain the deformation development law of geogrids during its construction and operation periods. In this paper, pullout friction test apparatus of geosynthetics is used to conduct confined creep test of geogrids with two kinds of strengths in dense sandy soil and compare them with creep test results under the unconstraint tensile condition and gain the creep deformation law under different creep loads.

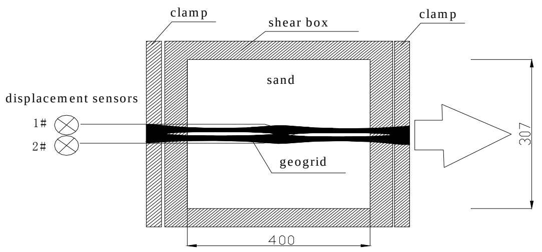
GENERAL DESCRIPTION OF TEST

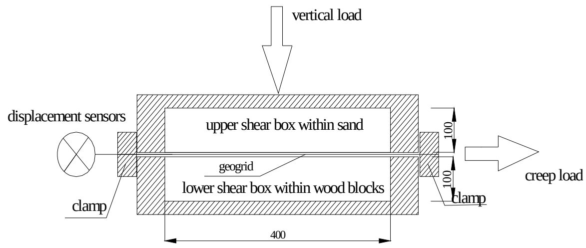
Test apparatus

A pull-out apparatus of geosynthetics is utilized to conduct confined creep test, the apparatus mainly includes vertical and horizontal loading systems, shear box and acquisition system of displacement etc, of which, vertical load is applied through a lever, horizontal load is applied right through weights; upper and lower sides of shear box with a length and width of 43cm and 30.7cm are fixed. In order to ensure that geogrids are always at a horizontal state during the tensile process, wooden blocks are placed within the lower shear box; standard sands are filled in the upper shear box, geogrids are located between wooden blocks and sands to simulate the confined condition. The schematic diagram of the pull-out apparatus used for the confined creep test is shown in Figure 1.

Two non-extendible string wires are fixed at two transverse ribs of geogrids embedded in sand and are extended out of the shear box to connect to displacement sensors to measure the creep deformation of geogrids. Data acquisition device can conduct automatic acquisition through setting acquisition time interval; during the initial period of test, acquisition interval is shorter (1 times/min); during the later period, it is gradually prolonged to in range of 30min to 60min.

Unconfined creep test is carried out by using microcomputer-controlled electronic creep test apparatus including an environment chamber that can control temperature and humidity of creep test.





(a) Plane Schematic diagram (b) Section diagram

Figure 1. Schematic diagram of the pull-out apparatus for the confined creep test

Sand and geogrid

Basic mechanical properties of two kinds of HDPE uniaxial oriented geogrids in the test are shown in Table 1 with their representative tensile stress-strain curves shown in Figure 2.

Table 1. Basic mechanical properties of two geogrids

Geogrid	Elongation (%)	Tensile strength (kN/m)	Strength corresponding to Elon. 2% (kN/m)	Strength corresponding to Elon. 5%(kN/m)
HDPE50	12.0	52.3	15.8	29.8
HDPE80	10.6	85.1	30.4	55.2

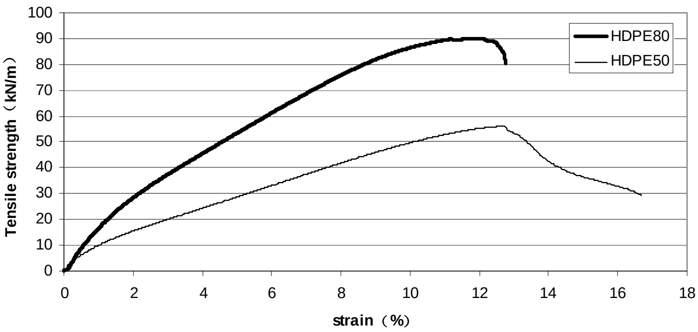


Figure 2. Basic tensile characteristic curve of tested geogrids

Standard sands with a diameter of 0.25 to 0.5mm are used as fills, creep tests for three sets of standard sands and PE50 geogrid are carried out under the temperature condition (12℃ to 18℃), the vertical load 15kPa and creep loads are 39%, 51%, 58% of the unconfined tensile strength. For one creep test on a set of standard sand and PE80 geogrid, the vertical load is 5kPa and creep load is 26% of the unconfined tensile strength. In addition, in order to compare the effect of confined condition on the creep, unconstraint tensile creep tests for PE50 geogrid were undertaken under the same temperature conditions.

ANALYSIS OF TEST RESULTS

Unconfined creep test

Unconfined creep tests was carried out under the condition of 20℃ temperature with a creep load of 50% of the limit tensile strength. At the time of writing this paper, the test has lasted for about 270h and is currently still under way. Figure 3 is the time-history curve of creep deformation. It follows from this figure that at the early period of loading, deformation develops so rapidly that the strain within 1h is as large as 10.4%, around 16.2% within 120h and 19.1% within 260h. It is seen from the curve that creep deformation still trends to increase continuously.

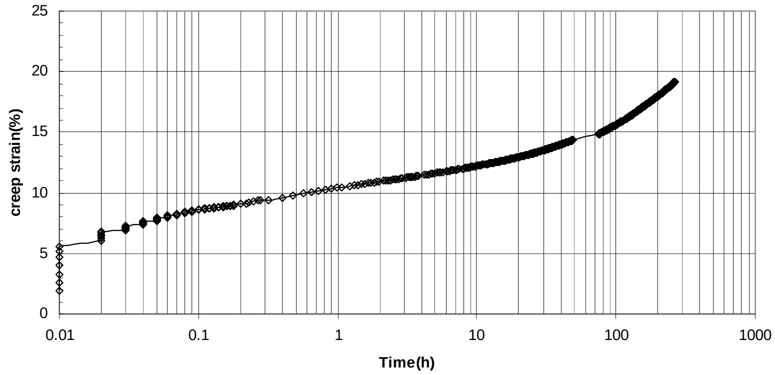


Figure 3. Time-history curve for unconstraint tensile creep of HDPE50 geogrid (50% creep load, 20℃)

Confined creep test in sand

Figure 4 shows the time-history curve of strain for HDPE50 geogrid under different creep load conditions. Because the horizontal creep load is applied through weights, the nonuniform load application means that the deformation law at the early loading stage (in first 0.1h) under different creep load is affected. But it can be seen from the figure that when geogrid acts under a confined condition, its creep deformation are much less than that under unconfined conditions. When creep load level is 58% of the limit tensile strength (above the unconfined creep test of 50% tensile strength detailed above), the creep elongation rate after 120h is only about 3.8%, and its main creep deformation occurs within about 1h of loading, which is above 80% total creep deformation. In addition, creep strain has a tendency to grow with an increase in creep load but its increase amplitude is not large. When creep load level is increased from 39% to 58%, creep strain is only raised from about 2.7% to 3.8%.

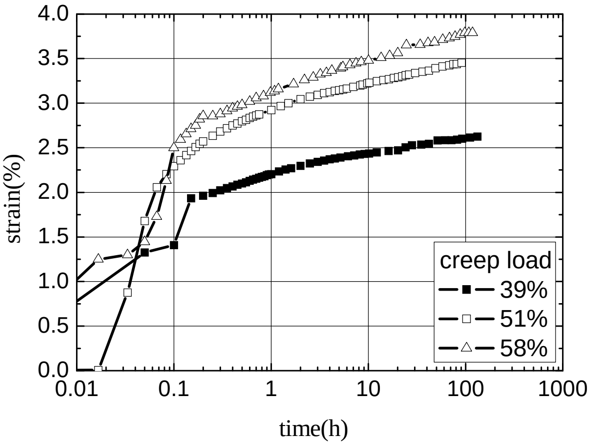


Figure 4. Creep curves of HDPE50 geogrid interacted with standard sand (vertical load is 15kPa)

Creep test for HDPE80 geogrid is carried out with a vertical load of 5 kPa and a creep load of 26 % of the limit tensile strength, time-history curves of relevant creep deformation are shown in Figure 5. It follows that the effect of vertical load reduction on creep is very obvious, even a small creep load can produce a large creep deformation. When creep load level is 26%, creep strain for HDPE 80 geogrid has reached approx. 3.9 %, more than 2.7% of creep for HDPE50 geogrid when load level is 39%.

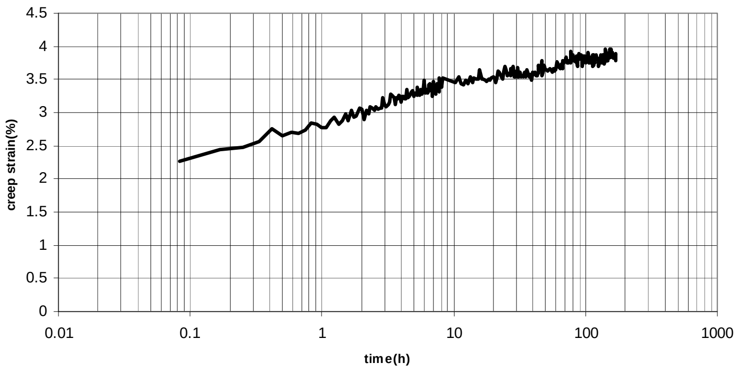


Figure 5. Creep curves of HDPE80 geogrids interacted with standard sand (creep load is 26% tensile strength)

Discussion

Limited by test apparatus, the limit tensile strength of geogrids under confined conditions in sand has not been obtained, thus the load level adopted for the creep tests is only a comparison with unconstraint tensile strength, its actual load level may be small, so the resulting creep deformation is not large. There is still a need to properly modify the test apparatus to obtain more exact basic mechanical property indices of geogrids interacting with sand.

CONCLUSIONS

- Laboratory tests indicate that effect of confined condition on creep features of geogrids is striking, with the creep deformation of geogrids in sand reduced greatly in comparison with conventional unconfined condition.
- The greater the creep load is, the larger the resulting creep deformation is; but when the load level is higher than 50%, its effect on creep deformation tends to become small.
- The effect of cover load on creep is also not insignificant, with the greater the cover load is, the less creep deformation is obtained.

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