

LARGE SCALE BIAXIAL CREEP TESTS ON A POLYPROPYLENE GEOGRID

GROSSFORMATIGE KRIECHVERSUCHE AN EINEM POLYPROPYLEN-GEOGITTER

ESSAIS DE FLUAGE A GRANDE ECHELLE SUR DES GRILLES GEOTEXTILES EN POLYPROPYLENE

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Summary: Geogrids are been used more and more in the construction of roads and railways, if the required bearing capacity of the base soil can not be reached. The loading of the products used is of a biaxial nature. A biaxial creep-test on a polypropylene grid is reported.

Zusammenfassung: Geokunststoffe werden zunehmend im Verkehrswegebau eingesetzt, wenn die erforderliche Tragfähigkeit des Planums nicht erreicht wird. Die Beanspruchung der eingesetzten Produkte erfolgt zweiachsig. Es wird über einen biaxialen Kriechversuch mit einem Geogitter aus Polypropylen berichtet.

Résumé: Des grilles géotextiles sont de plus en plus utilisées dans la construction de routes et voies ferrées si la capacité de portance du palier n'est pas suffisante. Les produits utilisés étaient chargés d'une manière biaxiale. Un rapport est donné sur un essai de fluage biaxial avec une grille géotextile.

1) Introduction

In the construction of roads the bearing capacity of the base soil is tested using loadplates-testings. The stiffmodulus E_{V2} is determined during several loadingcycles. The value of the stiffness-modulus E_{V2} required has to be at least 45 MN/m². If this value is not

reached, the procedure up to the present was to remove the weak soil and replace it with a stronger one. With the increasing sensibility for the environment and because of the limited stock of good materials recently geosynthetics (wovens, nonwovens or grids) were laid on the soft ground and then the bearing coarse was put on top of this. The geosynthetics prevented penetration of the grains of the bearing coarse into the soft ground. The loading of the products used occurs in a longitudinal and a transverse direction [Fig.1]. The actual value of the loading is still unknown and has to be investigated. Independent of the value of the real loading the behaviour of the products long term loading have been investigated up to now separate for each direction. To take into consideration the real loading a grid was stretched in a special frame which is able to produce forces simultaneously in two directions. The loading was carried out in steps. At the different loadings the deformations were been measured until equilibrium was attained.

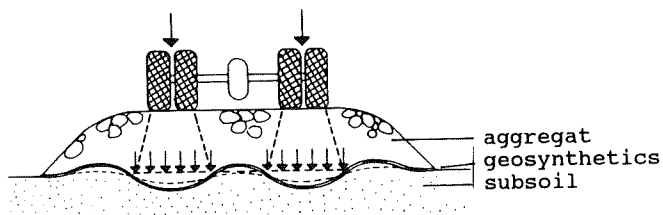


Fig. 1 Road construction with geosynthetics [1]

2) Polymers under long term loadings

Under permanent tensile forces it is known, that plastic deformations occur in polymer materials. The magnitude of these deformations depend on the type of the polymer material, on the loading and on the temperature. The behaviour of different polymer materials (Polyethylene PE, Polypropylene PP, Polyamid PA and Polyester PETP) at normal room temperature (20 °C) are shown in Fig.2 and Fig.3. In the semilogarithmic graphs (time axis logarithmic) the strain dependence on time is shown (In Fig. 2 for 60% and in Fig. 3 for 20% of the short-time-tensile-strength of the products). With the higher loading only the polymer material Polyester (PETP) shows a linear increase of the deformation with logarithmic time. At the lower load level (20% of the tensile strength) all products except the polypropylene-grid have a linear development of strain with logarithmic time. Grids of this material have proved themselves to be very satisfactory in practice. The stiffness of the products produce a contact with the soil without slippage. On the other hand these types of grids can be produced very cheaply, what is important, because in the practice normally several thousand squaremeters are needed.

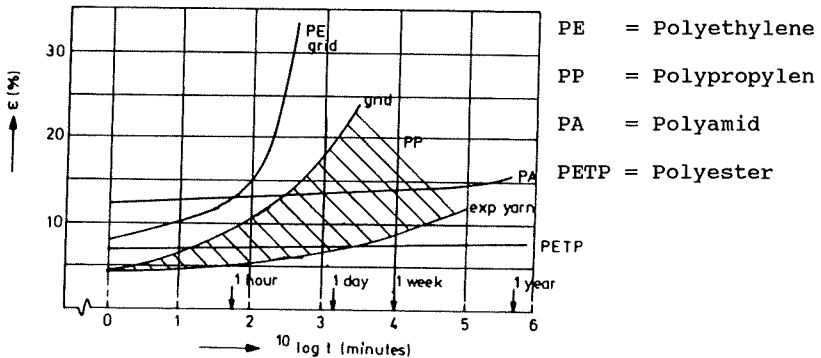


Fig. 2 Creep test at 60 % load [1]

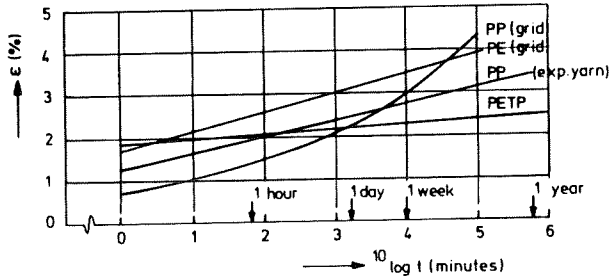


Fig. 3 Creep test at 20 % load [1]

3) Test equipment

At the Otto-Graf-Institut (FMIPA), there is a special test equipment with which it is possible to apply permanent loadings in two directions. The dimension of the sample is 1x1 m. Therefore it is possible to minimize the production tolerances. The equipment is shown in Fig.4. The sample is fixed with 10 cm wide vices, which are connected to wires with vertical suspended weights. Where the wires change direction precision ball-bearings are placed to exclude the wire friction. To measure the deformations two measuring gauges with a accuracy of 1/100 mm were placed in the middle of the sample.

4) Examined product

The test was carried out using a grid taken from a polymer sheet. The name of the product was TENSAR SS 35, the material was polypropylene. First of all the sheet was stamped with holes (see Fig. 5). With a special temperature control an uniaxial grid structure was produced by stretching. In a further step stretching in

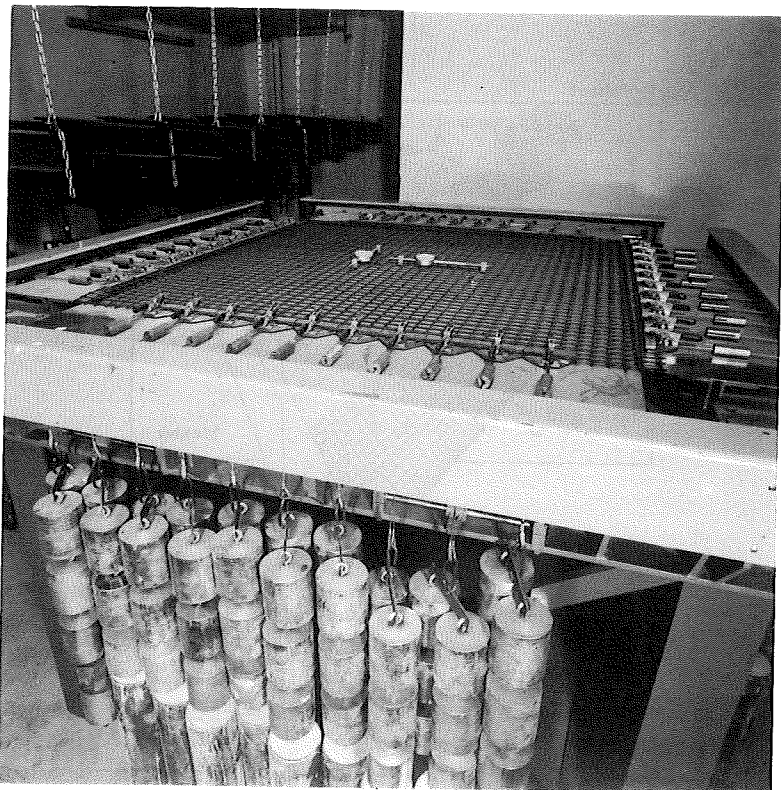


Fig. 4 Test equipment

the other direction produces biaxial grid with a width of 3,5 m, which shows a different mechanical behaviour in both directions (see Fig. 5).

Direction	Short-time Tensile Strength [kN/m]	Failure Strain [%]
Transverse	42	14
Longitudinal	34	15

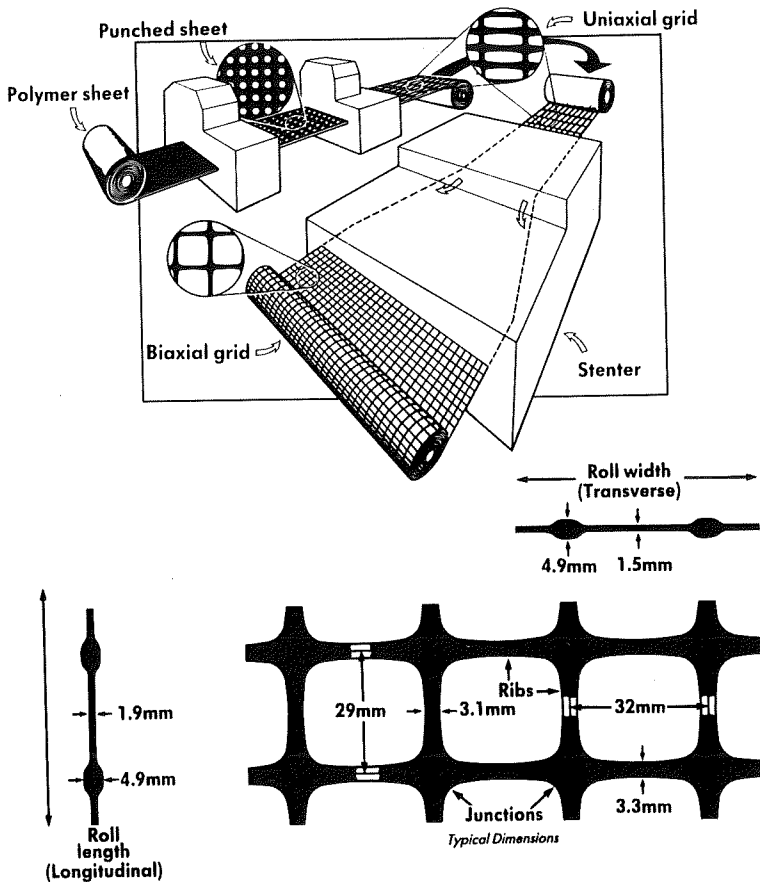


Fig. 5 The used product "TENSAR SS 35"

The strength was determined at room temperature. The behaviour in long term creep tests has been investigated by the producer of the grid, but only in the transverse direction [2]. Five samples with a width of 170mm (5 longi-tudinal ribs) were fixed in a creep frame. Four

loading steps (9.5, 13.5, 16.2 and 20.1 kN/m) were used, which correspond loadings between 20 and 50 % of the short-time tensile strength. The test were carried out for about 1000 hours (41 days). The test results are shown in a time-deformation-plot with a logarithmic time axis in Fig. 6 . It can be seen, that even with small loadings the creep deformations of the polymer had not finished within the duration of the test time. Only the two lowest loading steps show a linear time-strain-relationship, which permit an extrapolation after the test time.

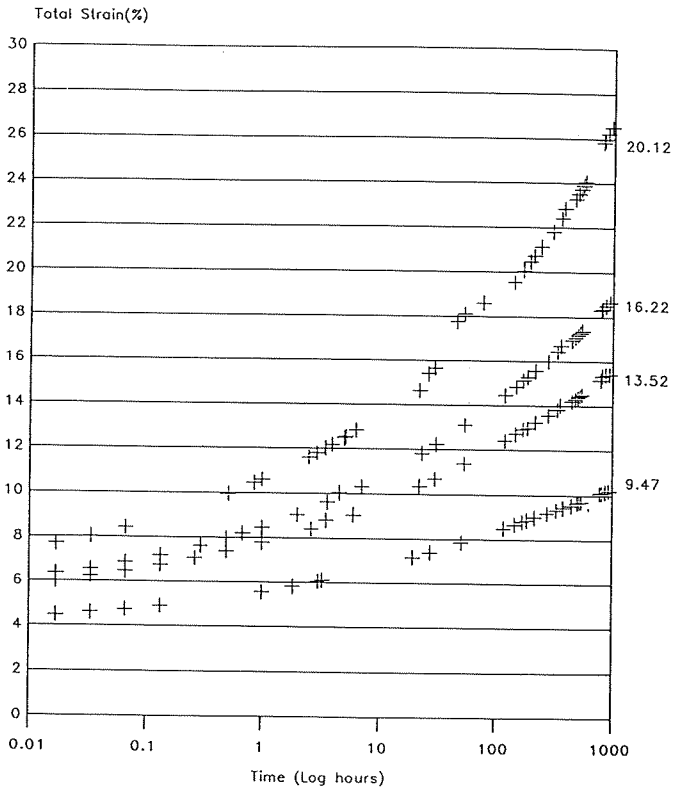


Fig. 6 Strain-time curves in the transverse direction [2]

By the evaluation of the test results, it must be remembered, that the creep tests were carried out in one direction only, and the transverse-contraction of the sample was not obstructed. Therefore the measured deformation is relatively high.

6) Own tests

With the above described test equipment a 1x1 m² large grid sample was installed. The different loading steps and their observation times are shown in the following table. The loading was equal in both directions.

Loading Steps [kN/m]	Short-time Tensile Strength		Duration	
	Transverse [%]	Longitudinal [%]	[Days]	Total [Days]
2.0	4.8	5.9	76	76
4.0	9.5	11.8	20	96
6.0	14.3	17.6	121	217
6.8	16.2	20.0	256	473

The results of the biaxial creep test are shown in Fig. 7 for the individual load steps and in Fig. 8 for the total test sequence.

The individual loading steps were observed until all deformations ceased. Under the highest loading step (6.8 kN/m) the deformations appeared at first to cease but after 32 days the deformation started to increase again.

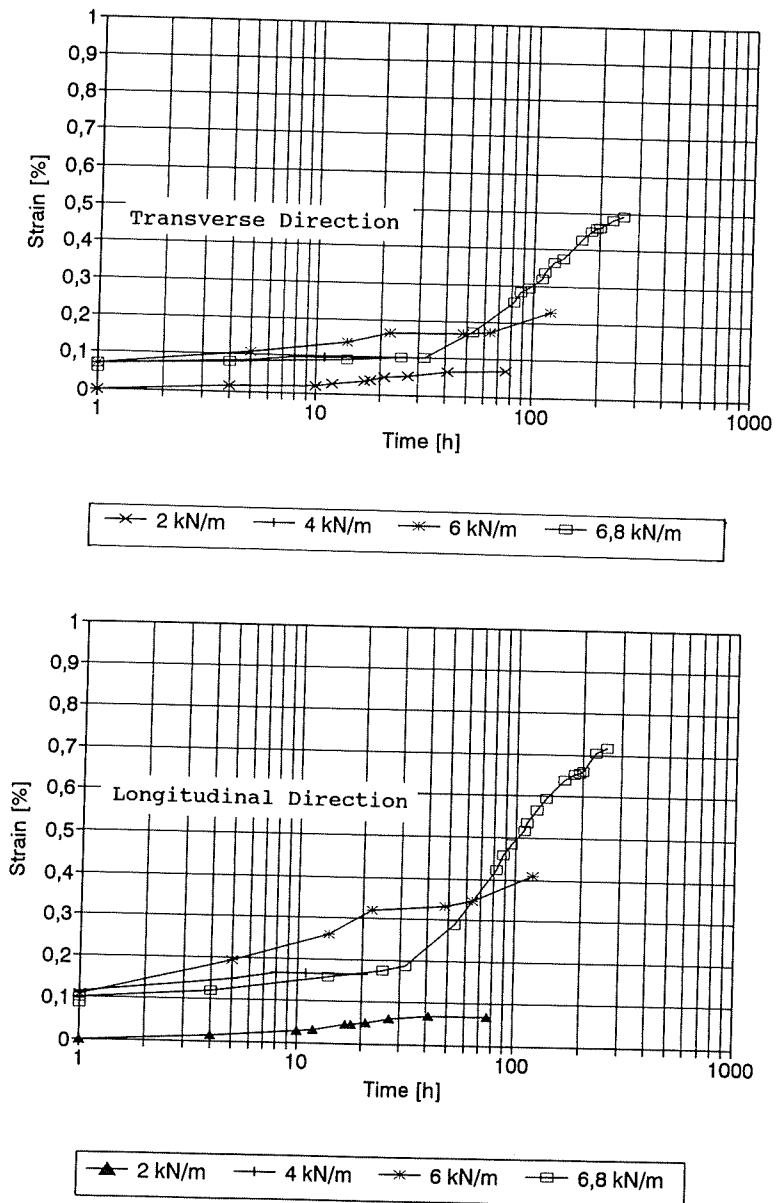


Fig. 7 Strain-time curves of the biaxial test

Up to now these deformations have not come to rest. The measured deformations with these test conditions are distinct less than the deformations in the unidirectional tests. This behaviour can probably be attributed to the hindrance of the transverse contraction. In the practice the transverse contraction is hindered by the embedding in the soil.

The deformations of the several loading steps are shown in the following table:

Loading Steps [kN/m]	Maximum Strain		Percent of Failure Strain	
	Transverse [%]	Longitudi- nal [%]	Transverse [%]	Longitudi- nal [%]
2.0	0.07	0.07	0.5	0.5
4.0	0.17	0.24	1.2	1.6
6.0	0.40	0.65	2.9	4.3
6.8	0.90	1.36	6.4	8.9

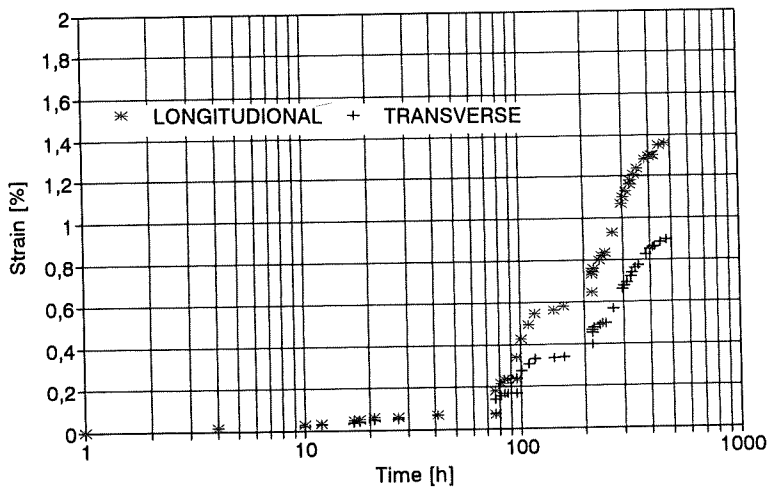


Fig. 8 Total strain-time curves of the biaxial test

6) Discussion

Creep tests were carried out in a biaxial creep frame on a grid, which was constructed from a perforated polypropylene-sheet under thermal controlled stretching. This test was carried out without contact with soil. In accordance with the real conditions it was possible, to hinder the transverse contraction. The measured deformations are therefore much smaller compared with tests carried out in only one direction. However it was observed that even at low loadings (maximal 16 % of the short-time tensile strength in the transverse direction) the deformations had not ceased even after an observation time of 256 days under this loading. Most likely molecular shear strengths were overstepped, and an equilibrium situation is not yet been reached.

Should the results be transferred on the real condition in practice, it must be remembered, that the real tensile force is still unknown today, because the dimensioning is carried out using empirical methods.

7) Literature

[1] Veldhuijzen van Zanten, R., geotextiles and geomembranes in civil engineering, A.A. Balkema, Rotterdam, 1986

[2] Austin, R., Dickinson, J., sustained load tests of Tensar SS 35 geogrid, report of Netlon, Blackburn (UK), unpublished

[3] Tensar SS 35, product information