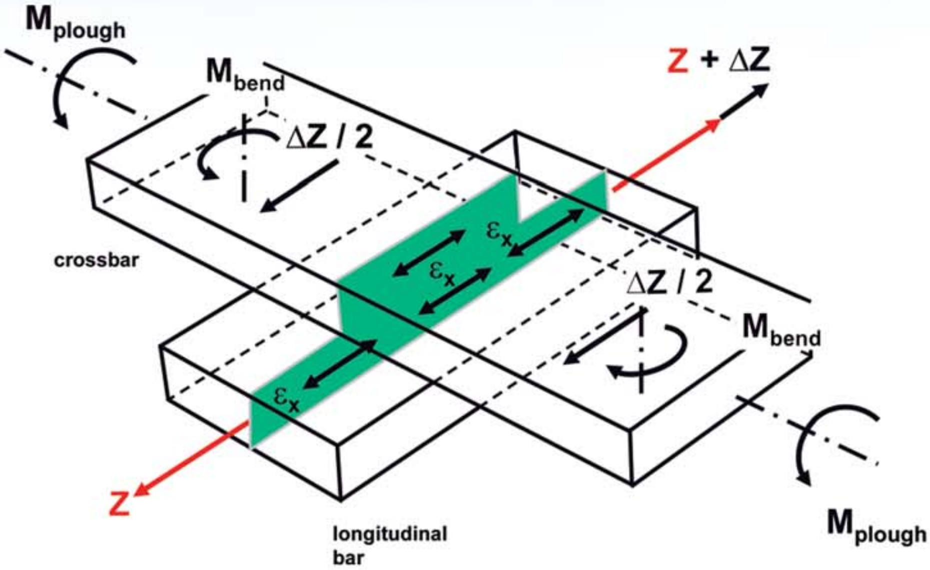
TECHNICAL NOTE

Secugrid® - Radial stiffness

TN-SG 1



NAUE

Figure 1
Shear interaction between base aggregate and Secugrid® geogrid

Load distribution in geogrid reinforced base courses

The use of geogrids to reinforce soft or compressible foundation soils for unpaved aggregate roads is one of the major application areas for geogrids. Traffic loads which are applied to aggregate road surfaces create lateral movements inside the base aggregate. When a geogrid is installed between the subgrade and the base aggregate, shear interaction develops (Figure 1). This shear interaction is also known as the "interlocking effect".

The interlocking effect restrains the aggregate laterally (Figure 2) and transmits tensile forces from the aggregate to the geogrid. As the geogrid is much stiffer in tension than the base aggregate, lateral stresses and strains in the reinforced base aggregate are reduced and less vertical deformation (rut depth) in the road surface can be expected.

Figure 2
Efficiency of Secugrid® geogrids

The interaction between geogrid and base aggregate increases the elastic modulus and thus the stiffness or load distribution capacity of the base course. This correlation enables the reduction of reinforced aggregate thicknesses in comparison to un-reinforced aggregate layers (Figure 3) or longer service lives of the reinforced section with comparable base course thicknesses.

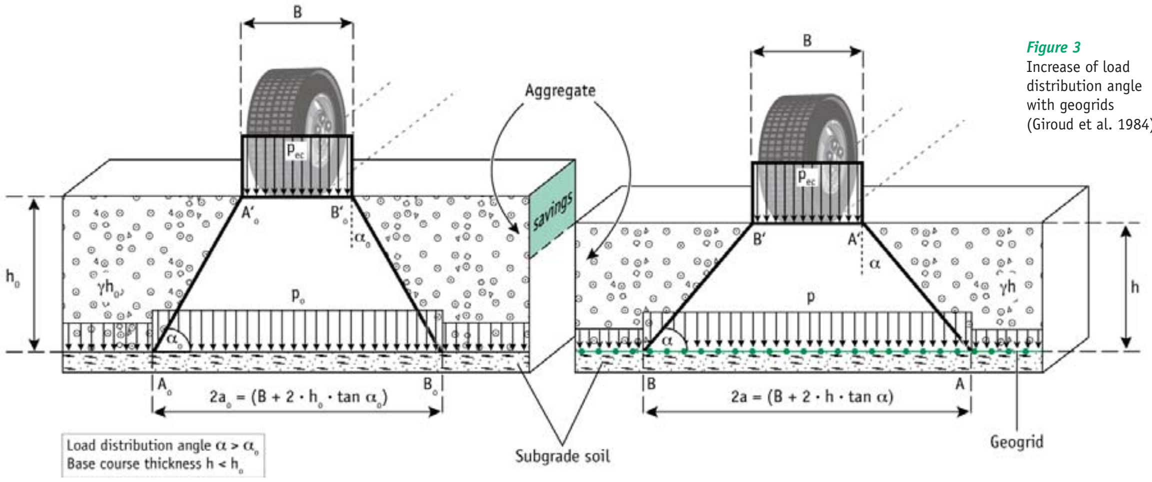


Figure 3
Increase of load distribution angle with geogrids (Giroud et al. 1984)

Stresses from traffic loads, which are transferred to the base aggregate, lead to an outward motion of the aggregate from the wheel, mainly in the direction of the traffic flow and perpendicular to it. Due to the shear interaction (interlocking) that is generated between the base aggregate and the reinforcement, the geogrid is mainly stressed in longitudinal and transverse directions.

Biaxial load distribution typically takes place where the traffic flow is guided in defined directions across the installed geogrid reinforcement, such as in roads and railway applications (Figure 4, bottom).

In applications where a defined direction of traffic flow does not exist, such as in large traffic areas like parking lots and container terminals (Figure 4, right), the geogrid reinforcement might also be stressed diagonally to the longitudinal and transverse (biaxial) direction.

Regardless of which of these two different stress conditions becomes decisive, one of the main reinforcement factors is the ability of the geogrid to absorb the mobilised stresses at potentially low deformations.

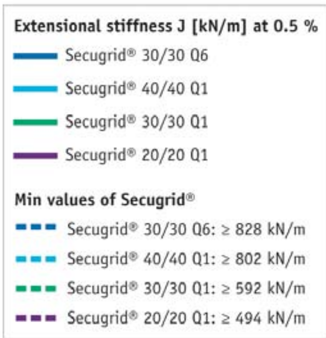
This key reinforcement characteristic of a geogrid is also known as the "tensile modulus" or "secant stiffness".

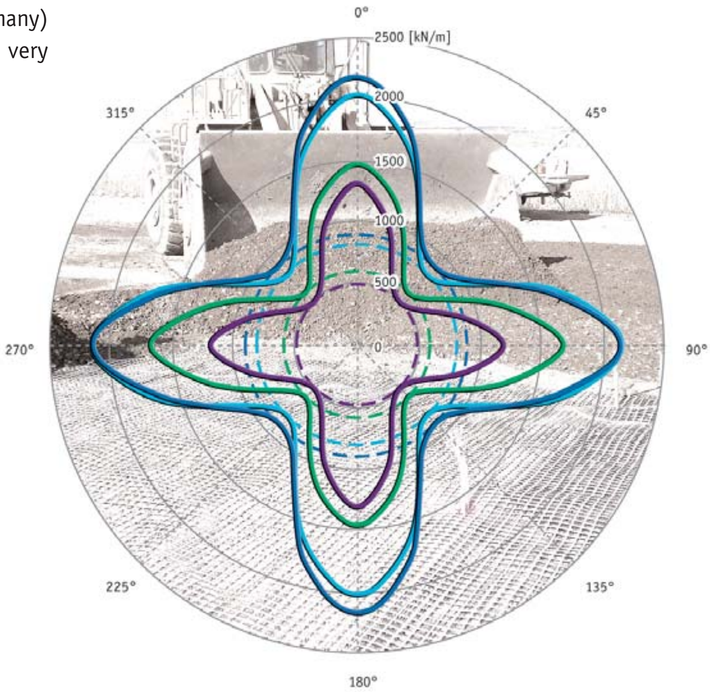
Figure 4
Potential stress directions in geogrid reinforcement layers

Evaluation of geogrid stiffness

To examine the tensile modulus or secant stiffness values of Secugrid® geogrids in the conventional biaxial directions as well as diagonally to the longitudinal and transverse direction, tensile tests according to EN ISO 10319 have been carried out at tBU Institut für textile Bau- und Umwelttechnik, Greven (Germany) that determined the radial geogrid stiffness at very low deformations of 0.5% (Figure 5).

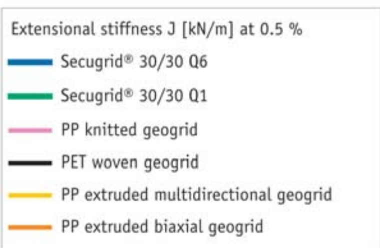
Figure 5
Radial Secant Stiffness of Secugrid® geogrids at 0.5% elongation





The test results show extremely high secant stiffness values of ≥ 1,500 kN/m for Secugrid® 30/30 Q1 and values of ≥ 2,000 kN/m for Secugrid® 30/30 Q6 in both biaxial directions. Importantly, high secant stiffness values of ≥ 592 kN/m for Secugrid® 30/30 Q1 and ≥ 828 kN/m for Secugrid® 30/30 Q6 have also been achieved diagonally to the longitudinal and transverse directions.

To be able to compare the performance of Secugrid® geogrids to other reinforcement products, the same tests were carried out for woven and knitted geogrids as well as for a multidirectional extruded polypropylene/PP geogrid with triangular apertures. All test results of the measured radial secant stiffness values at 0.5% strain for the tested geogrids are shown in Figure 6. The values show that the tested Secugrid® geogrids provide the highest radial stiffness values of all materials tested.



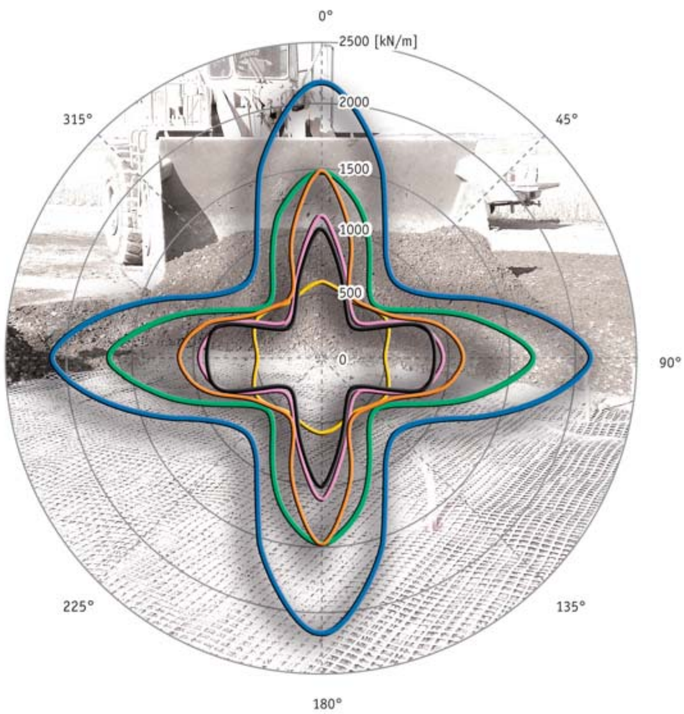


Figure 6
Radial Secant Stiffness of different geogrids at 0.5% elongation

In Table 1 the minimum Radial Secant Stiffness values at 0.5% elongation of the examined geogrids are summarized:

Geogrid	Radial Stiffness $J_{0.5\%}$ [kN/m]	
Secugrid® 20/20 Q1 (PP)	≥ 494	
Secugrid® 30/30 Q6 (PP)	≥ 828	
Secugrid® 30/30 Q1 (PP)	≥ 592	
Secugrid® 40/40 Q1 (PP)	≥ 802	
Knitted multifilament geogrid (PP)	≥ 394	
Woven multifilament geogrid (PET)	≥ 344	
Extruded biaxial geogrid (PP)	≥ 550	
Extruded multidirectional geogrid (PP) – Type 160*	UK datasheet ≥ 505	US datasheet ≥ 300
Extruded multidirectional geogrid (PP) – Type 170*	≥ 580	≥ 475

Table 1
Secant stiffness values $J_{0.5\%}$ of different geogrids

* according to manufacturer's product information

Based on the special manufacturing technique for Secugrid® geogrids, the flat, welded, pre-stressed polymer bars provide the desired high tensile modulus values (high tensile forces are absorbed at low strain levels) in longitudinal, transverse and diagonal directions, especially at the typically low strain rates which develop inside geogrid reinforced aggregate base courses.

NAUE
NAUE GmbH & Co. KG
Gewerbestrasse 2
32339 Espelkamp-Fiestel
Germany

Phone +49 5743 41-0
Fax +49 5743 41-240
E-Mail info@naue.com
Internet www.naue.com