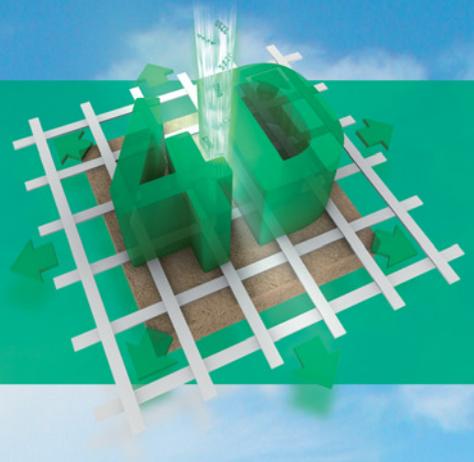
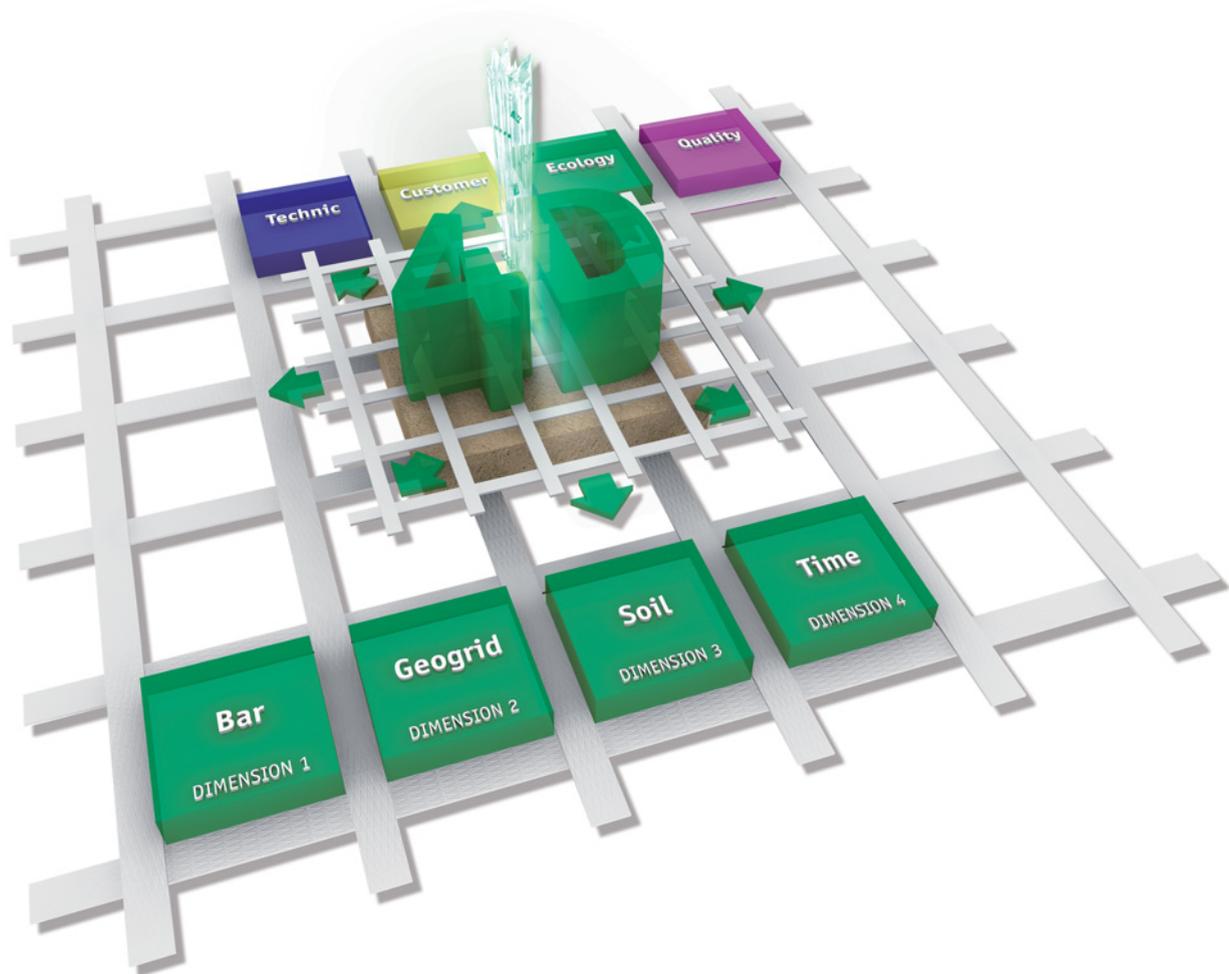


**Secugrid®**  
**FOURDIMENSIONS**  
QUALITY



QUALITY





The four dimensions of length (the bar), width (the geogrid), depth (the soil) and time (durability) greatly influence construction project scope, design, product selection and expected service life. Today, NAUE introduces you to a new four-dimensional way of understanding reinforcement applications: the Four Dimensions of Secugrid®.



# DIMENSION 1

## Superior Bars



A geogrid's quality can be defined in many ways, such as long-term design strength and cost. But one of the first places one should look is at the individual bars of a geogrid. It is in these bars that the success of a project's many goals rest: strength transfer, elongation, installation and degradation resistance and sustainability.

In NAUE's manufacturing process, rollers uniformly stretch the ribs and uniformly orient the polymers into high-tensile flat bars. Additionally, these high tensile strength bars are embossed, a process which creates a frictional surface that improves the frictional performance of the geogrid bars in soils.

Prior to the manufacturing, intensive raw material tests are carried out to investigate the

resin properties, such as the moisture content of the polyester resin, the melt flow index or the differential scanning calorimetry (DSC). The DSC is a

*»There is no need to compromise with quality.«*

technique in which energy input into a resin is measured as a function of temperature, while the resin subjected to a controlled temperature program.

To further ensure uniform and constant product quality the bars are continuously tested in the manufacturing quality control lab after the extrusion and stretching process. Tests carried out are mass of the bar, dimensions of the bar and strength/strain characteristics. The superior stress/strain cha-

racteristics of the Secugrid® bars, especially in the key elongation range - less than 2% - are the characteristics to which many projects must be

designed and by which geogrids are often judged. The tensile strength of Secugrid® is excellent at low elongation.

To meet the varied specification and site-specific needs of a project, Secugrid® bars are offered in many different mass levels, ensuring you a stiff, durable, effective reinforcement that maximises your design's potential.

Testing in accordance with national and international standards provides these necessary, very strong tensile modulus values. When installed in a roadway base course, NAUE Secugrid® vastly increases that base course strength, thus reducing the need for as much gravel. This can equate to significant project savings. For MSE walls, steeper designs are enabled through Secugrid®, thus optimising the use of land space while minimising disturbance.

Road life is extended. Walls last longer. Maintenance needs are reduced. Installation is faster without sacrificing safety. And it all starts with the manufacturing process and the bars.

- Technical advantages:** High-strength, high-modulus, robust geogrid bars for sustainable performance
- Customer advantages:** Safe and long-lasting stress transfer in the design
- Quality advantages:** Superior manufacturing method for ensuring reinforcement strength
- Ecological advantages:** Roads hold up better with less aggregate; steeper walls can be built.

## DIMENSION 2

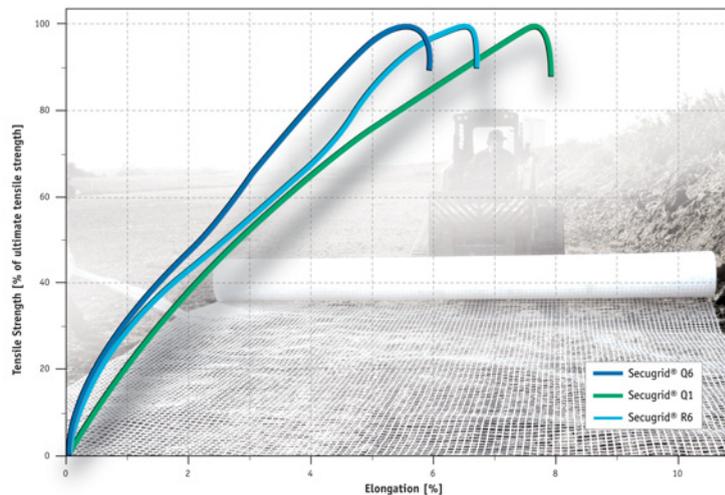
# Quality Testing in All Directions



Geogrids are used wherever high-strength reinforcement at low elongation is required. The stress/strain behavior of the reinforcement is a decisive factor in the selection of the proper geogrid to be installed.

course in place under repeated loads, and geogrid robustness to protect against damage during installation and provide long-term site performance.

NAUE's manufacturing process



To ensure the specified quality, Secugrid® products are undertaken a strict manufacturing quality control program including the strength of the junctions, the Secugrid® tensile strength and elongation pro-

geogrid. Geogrids with high torsional stiffness and a good interlocking of the aggregate (e.g., aggregate is restrained laterally) provide greater resistance against the described twisting stresses. Again, a high strength at design elongations combined with a high torsional rigidity value are important.

*»Plus potest qui plus valet.  
The stronger always succeeds.«*

Geogrids typically have an elongation of up to 15%. However, elongation under realistic design conditions is generally less than 2%. The stress/strain behavior of an installed geogrid must match the uniaxial elongation behavior of the soil. The one-dimensional bar characteristics form a structurally sound and stable geogrid, creating a rigid, high-performing, two-dimensional Secugrid® structure. The joining of these bars provides excellent torsional rigidity, the interlocking effect that holds base

secures the quality of Secugrid's junction strength. The point of intersection of the machine direction and cross machine direction ribs, which defines a geogrid's shape, is referred to as the geogrid junction. NAUE's process feeds the one-dimensional bars into welding equipment. Cross-machine direction bars are introduced and firmly welded\* together (creating the two-dimensioned apertures - the openings - in the geogrid.)

erties as well as other country specific properties.

To understand how these junctions impact performance, consider the effect of a wheel passing over a granular base course, within which a geogrid has been installed for reinforcement. Shear stress develops in the aggregate on the plane of the grid. This shear stress changes in magnitude and direction as the wheel passes. The direction is important because the change in direction causes a twisting motion in the

Also, the Secugrid® product line offers many different tensile strength levels to best match your installation's performance and specification needs. With PET and PP geogrid options, Secugrid® gives you flexibility in design and installation approaches with rigid, robust geogrids - stabilised by their superior junction strength - for long-term, sustainably-engineered sites.

**Technical advantages:** True biaxial strength and radial stress transfer and interlocking

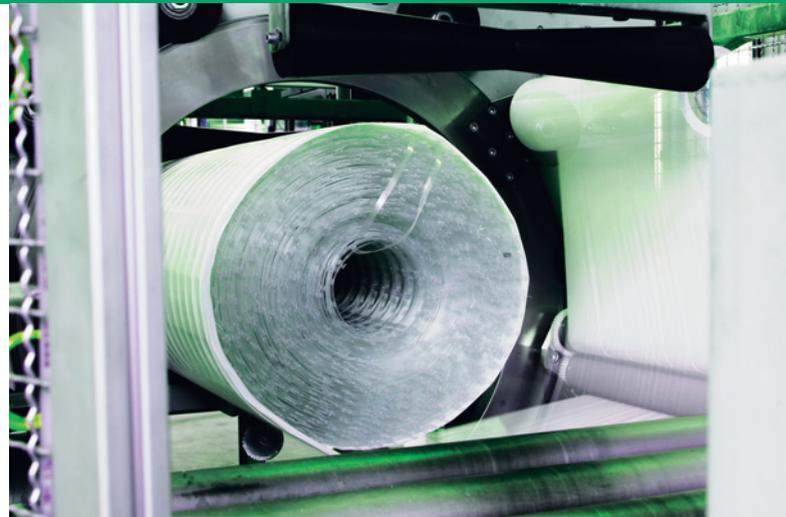
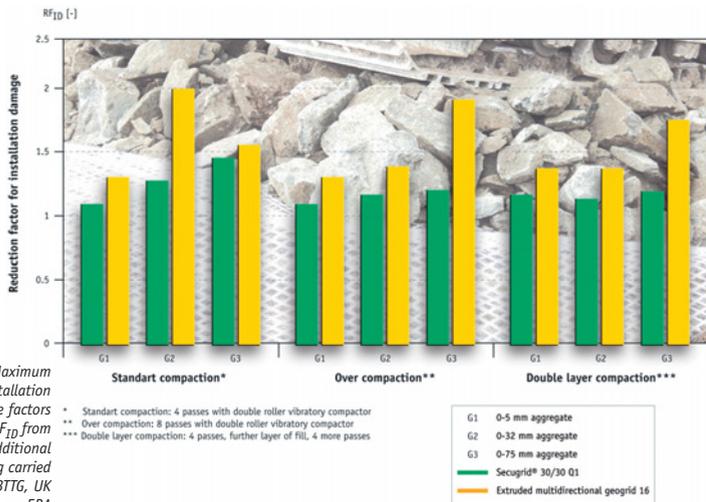
**Customer advantages:** Reduced long-term maintenance issues. Ease of installation

**Quality advantages:** Round the clock quality control, ISO 9001 audited, CE marking

**Ecological advantages:** Optimised Secugrid® for soil reinforcement reduces transport needs (and costs) to site

# DIMENSION 3

## Stabilisation for soils



Maximum Installation Damage factors  $RF_{IP}$  from additional testing carried out by BTTG, UK on ERA Installation Damage Samples

While one always designs with the long-term goals of a project in mind, protecting the project during installation is very important - and not just on site. This protection is found first in geogrid product selection. Robustness plays a key role.

Damage during installation process by equipment, poor handling or lack of proper site preparation are issues to look at.

*»Quality is not an accident; it is the result of planning, skill and execution.«*

The subtle imperfections that installation damage can cause may be the difference between success and failure in the long-term, since a weakened grid may yield to later stresses. Secugrid® is very robust.

Numerous tests have revealed the durability of Secugrid®.

Pull-out tests, for example, permit the calculation of the coefficient of interaction. This helps investigate the differing behavior between a geosynthetic and a soil.

In pull-out tests, the pull-out resistance of a geogrid is largely dependent on the product's structure. Despite the same tensile strength and aperture size, other geogrids may exhibit a re-

latively small soil contact surface in comparison to Secugrid® products. The surface friction for Secugrid® products is proven to be high and therefore ideal for such applications where high pull-forces are required. If the soil is also fully mobilised between the ribs then only the soil's residual shear strength in

its loosened state remains. The geogrid "ploughs" through the soil. The Secugrid® product's "ploughing" action causes a considerably large soil area to become involved in the absorption of force because its transverse ribs torque/twist slightly on their axes toward their mid-points between junctions. Secugrid's strong junction shear strength prevents torquing/twisting under soil coverage from taking place at the junctions.

Additionally the interlocking effect restrains the aggregate laterally 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.

Software specific to capitalising on these product advantages and utilising them in your projects is available. NAUE's long-running series of SecuSlope and SecuCalc software are readily available.

SecuSlope is an interactive, design-orientated program for Secugrid® geogrid-reinforced slopes, walls and abutments (according to US Federal Highway Administration (FHWA) or BS 8006).

SecuCalc, which is based on the Giroud-Han design method, allows for a generic calculation of aggregate base course material in unreinforced and Secugrid®-reinforced applications.

Secugrid® geogrid reinforced applications extend the service life of the design, improve the overall performance, reduce excavation and lower overall costs.

**Technical advantages:** High stress/strain characteristic provides multiple benefits - better distribution of tensile forces, longer service lives, improved long-term project economy, and much more

**Customer advantages:** Reduced dependency on aggregate, less long-term maintenance, maximised site use

**Quality advantages:** The wide range of quality products made of polypropylene or polyester with strengths up to 400 kN/m

**Ecological advantages:** Maximising space use is a project characteristic that improves sustainability. Reducing material shipments (e.g., heavy aggregate) is also an important environmental benefit

# DIMENSION 4

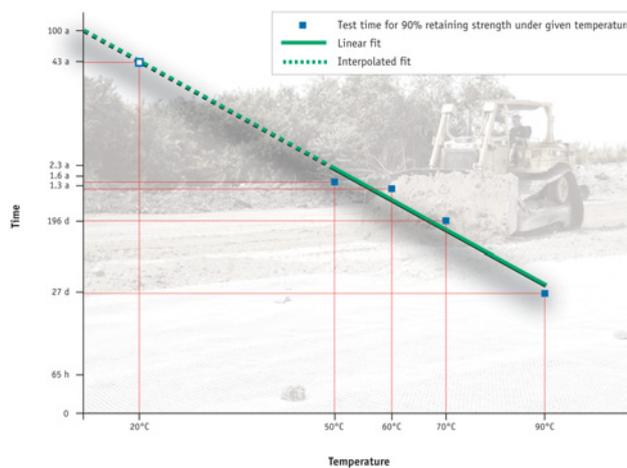
## Long-Term Durable Solutions



Creep is a major concern for the survivability of walls. Even reinforced walls have historically been built on a smaller scale or softer angle to defuse creep concerns. But the hyper-modern manufacturing technique, strength and resin stability of Secugrid® allow for steeper, more economical, environmentally sustainable walls.

These are not only cost-effective solutions for development, but environmentally re-

Arrhenius plot for Secugrid R6 expressing the time to 90 % residual tensile strength



Source: EuroGeot. 2008: Assessment of the Alkaline Hydrolysis of PET: Sothen Müller-Rochholz, Trnsand Erdmann, Henning Ehsenbert, Adrian Dobrat & Jan Retzlaff

A test example: Secugrid® (PET) geogrids and a typical bar have been immersed in saturated  $\text{Ca}(\text{OH})_2$  to achieve a pH-value of 12.5. They've been stored at temperatures of 50 to 90 °C. The test duration at 50 °C has been more than 4 years. The test series shows that the chemical properties of the raw material and the geometry of the elements together are decisive for the hydrolysis resistance of PET-geosynthetics.

»Get the job done with quality.«

sponsible. Polyester Secugrid® types stand for low creep rates, high strength, high modulus, high pull-out resistance and excellent interlocking effect and make it the best candidate for such an application.

The combination of excellent stress/strain characteristics and the very good long-term creep-resistance values of these Secugrid® geogrids allows for an economical, high-strength selection in critical applications such as mechanically stabilised earth (MSE) wall designs.

Steeper walls offer numerous advantages. Notably, the use of space is maximised while site disturbance is minimised. In building steeper walls through the installation of Secugrid® - which can make mountain roads possible, promote sustainable urban development, and increase landfill air space and profitability - one also realises valuable environmental benefits.

One of the chief elements behind Secugrid's long-term strength is the outstanding

qualities of polyester (PET) used in the manufacture of Secugrid®.

Alkaline hydrolysis is a chemical reaction which attacks the surface of the elements and for long-term applications a high resistance is needed. Secugrid® PET product types have been tested against this chemical reaction and due to the proper selection of resin show a very good resistance against degradation.

While the performance of Secugrid® is appreciated over time, the immediate readiness of Secugrid® in terms of project qualification must also be recognised. Secugrid® is manufactured under the ISO 9001 regime, ensuring its uniformity and high quality. With the aid of this integrated quality management system, the requirements of the customer and/or the projects are fully understood and fulfilled.

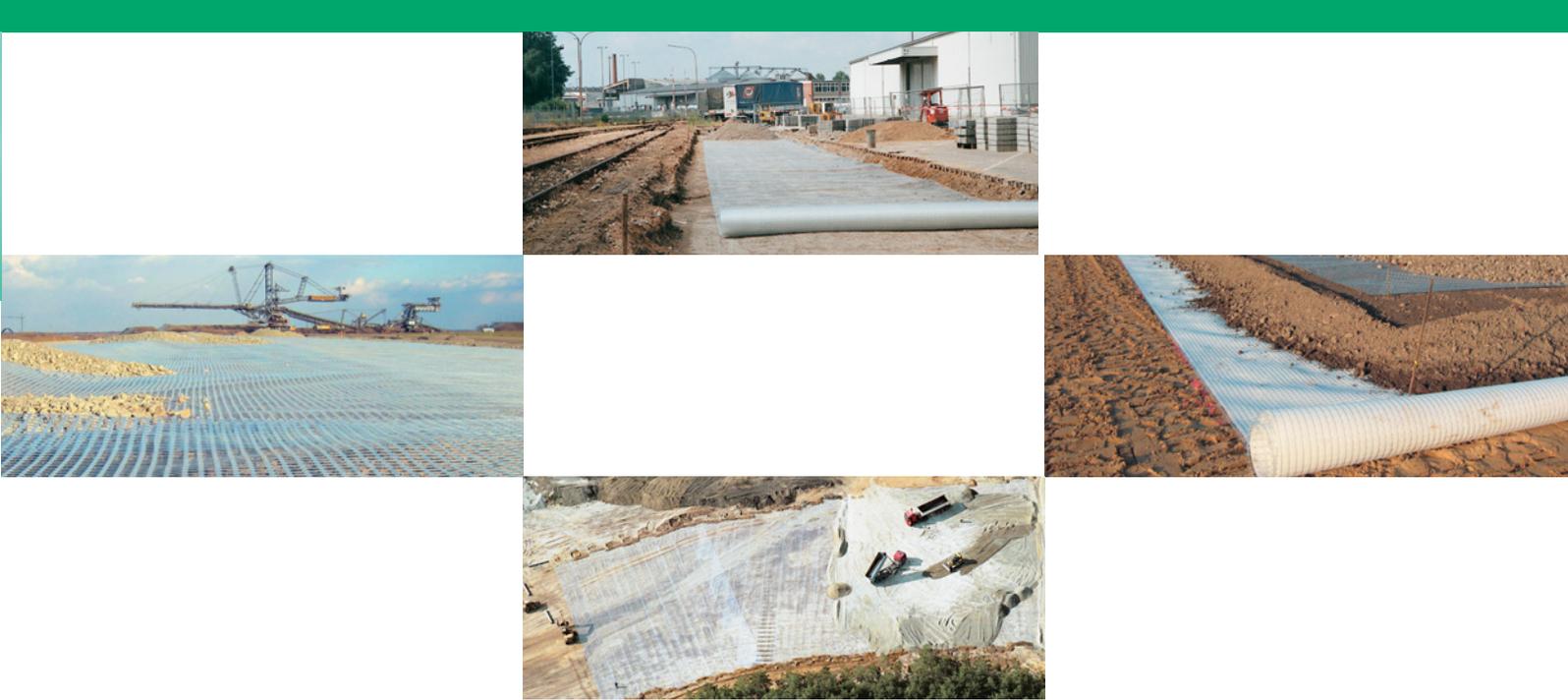
Among its many international approval ratings, Secugrid® has received the coveted CE Mark for use in Europe.

**Technical advantages:** Long-term resistance and performance of Secugrid® soil reinforcement geogrids

**Customer advantages:** Quicker installation in the project, longer lasting design

**Quality advantages:** Excellent and durable long-term creep performance

**Ecological advantages:** Long-lasting designs, reducing carbon footprint and minimising use of finite resources



Secugrid® geogrids are produced with a new dimension of manufacturing technology. The reinforcement element is a highly-oriented polypropylene or polyester bar that is uniformly extruded and drawn to achieve a high modulus and high strength at low elongations. This is combined with the NAUE-patented welding technology to provide a structurally sound and stable geogrid. Secugrid® is used mainly for base reinforcement, mechanically stabilised earth (MSE) wall construction including veneer stabilisation, the segmental retaining wall (SRW) market, embankment reinforcement, load transfer platforms over pile caps and other soil reinforcement applications. Biaxial geogrids are primarily used in base reinforcement applications, while uniaxial geogrids are often used in the other markets.





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