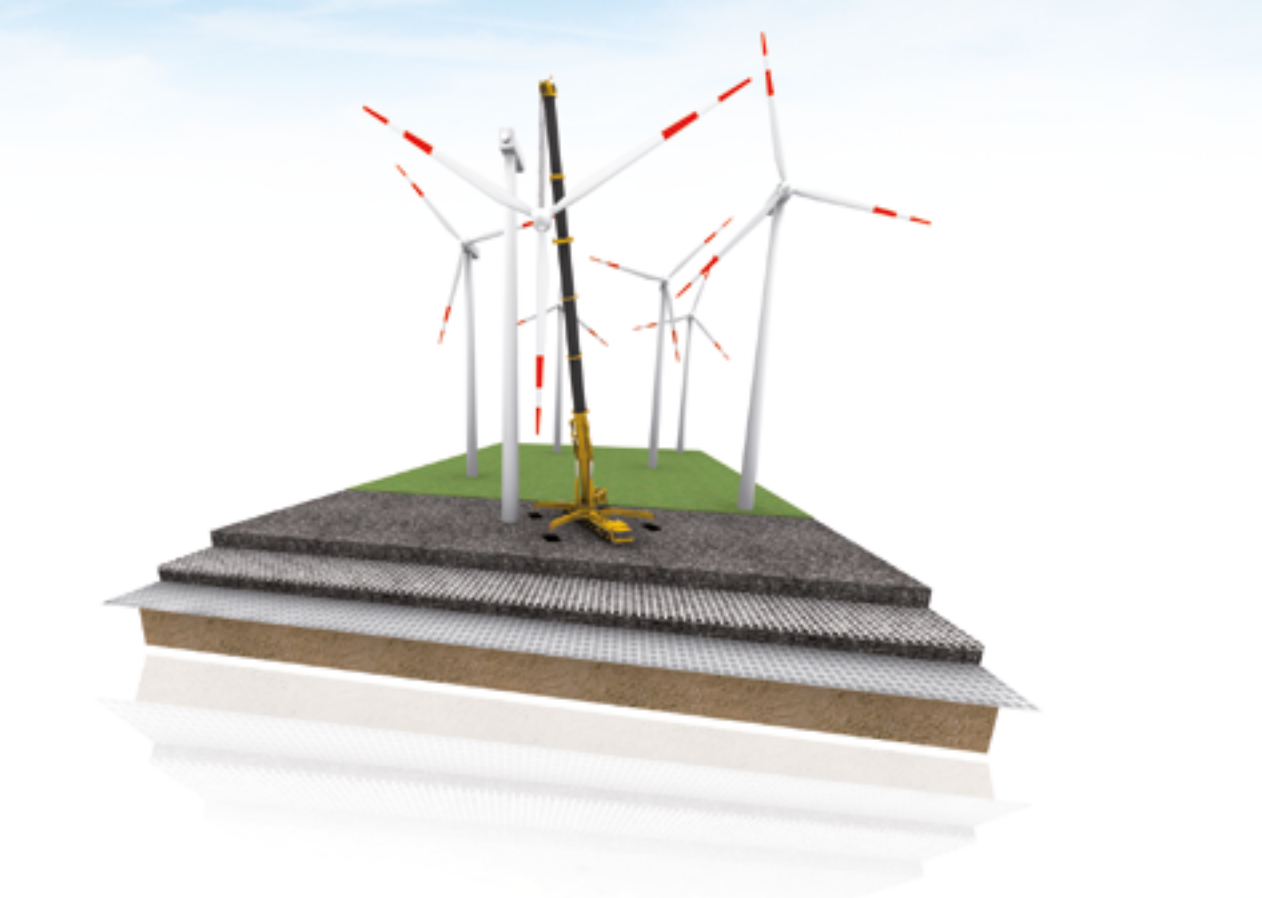
RENEWABLE WIND ENERGY AND GEOSYNTHETICS

Naue



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Building on sustainable ground.

Naue **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 pre-stressed 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. Combigrid®, a composite product where a nonwoven Secutex® geotextile is firmly bonded between Secugrid® reinforcing bars, is mainly used for designs with soft and low CBR soils where reinforcement, combined with filtration and separation, is needed.

Summary of renewable wind energy and geosynthetics

From wind farms to biomass, methane conversion to hydro, geosynthetics are providing environmental protection and cost and operational efficiencies to help realize sustainable goals and responsible development around the world. Global new investment in renewable energy increased during 2008 to 2010 dramatically from USD $130 billion to $211 billion [1]. Wind energy is the fastest growing renewables sector, adding nearly 40 GW in 2010 alone. With leading adopters including India, China, Spain, Germany, the United States, and others, it is a true, global success story. Many of these projects are being made possible, technically and economically, through the utilisation of geosynthetics in their construction. In particular, wind farms are succeeding upon geogrid reinforcement.

Accessing renewable energy: Wind power

Greenhouse gas-emitting sources of energy, such as our steadily depleting fossil fuel sources, share an interesting engineering challenge with clean, renewable energy resources: both are generally found in areas and environments that complicate tapping into these sources. Wind energy, which is one of the oldest and most dependable sources of renewable power, typifies this problem of access.

Modern wind farms require a great deal of operating space. Further, they often require significant, additional open space across which those powerful winds can develop. Many of the most ideal wind farm sites have become the way they are - less developed - because of soil characteristics that complicate construction in those areas.

The key to wind farm development often becomes one of access and soil stability. Roads must be built to the giant wind turbine pads, and both the roads and pads must be strong enough to support transportation and long-term siting of those giant turbines.

Naue geosynthetic reinforcement is frequently utilised to bring these projects online.

Strength in the geogrid

Typically, the base course under these roadways is made of crushed aggregate that must provide efficient load distribution of the stresses transferred from traffic. In all cases it is important that the shear strength of the subsoil, which in general can be very low, is exceeded by the base course material.

To achieve a long-term, safe solution for these low strength subsoils, geogrid reinforcement is installed between the subsoil and the overlaying base course (Fig. 1). Naue Secugrid® and Combigrid® geogrids provide high strength at low strains - an absolute necessity for this type of application. These geogrids possess uniform strength in all of their high-tenacity, flat, welded bars, which creates a rigid, stable, two-dimensional grid that is as strong in its longitudinal direction as in its tranverse direction. Additionally, the embossed bars provide frictional performance-improving surface.

The end result is superior stress-strain characteristics, especially in the key elongation range (less than 2%).

Roadway aggregate interlocks with this high-strength geogrid (Fig. 2). Naue Secugrid®, with its extraordinary torsional rigidity, prevents lateral movement of the aggregate. When stresses are induced from above, the Secugrid® bars redistribute the load throughout the interlocked system. Not only is lateral movement of aggregate restrained, the risk of vertical movement is also greatly reduced. This is crucial to maintaining roadway integrity.

Case study: Sălbatica Wind Farm, Romania

The Sălbatica Wind Farm is located in one of Europe's best locations for a wind park: Romania's Dobrogea region. Its open lands are characterised by strong, dependable winds. The site operator, an Italy-based firm with successful installations around the world, foresees developing 500MW of renewable energy in Romania.

In its first stage, Sălbatica involved the construction of 35 turbines. Another 35 followed in stage two, with each turbine generating 2MW of power. Currently, the annual production of the site is 85.5 million kWh/year, which is enough to power 29,000 households. From an environmental standpoint, the carbon footprint reduction is impressive: Sălbatica's turbines produce power that if produced by traditional means would have released 48,000 metric tons of CO_2 per year.

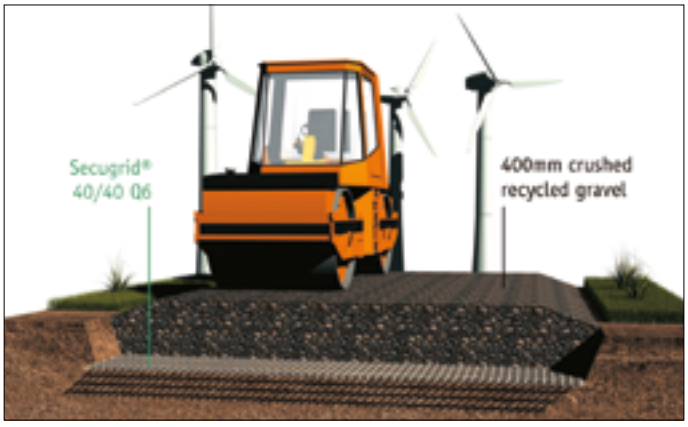

Fig. 1
Typical cross section of an access road to a windfarm

Fig. 2
Demonstration of the interlocking effect under a 2.2t van

[1] Global Wind Report Annual Market Update 2010 [published April 2011 by the Global Wind Energy Council; Global Status Report, published by the Renewable Energy Policy Network for the 21st Century (REN21)].

Case Study: Whitelee Wind Farm, Eaglesham Moor, Scotland

Situated just 17km outside of Scotland's second largest city, Glasgow, the 5.5ha Whitelee Wind Farm at Eaglesham Moor has emerged as one of the most important renewable power sites in the United Kingdom. With 140 turbines, the site is capable of providing 322MW, which is enough to power 180,000 homes.

The region's soils are extremely challenging for this type of construction, however, with depths of up to 7m and overlying 2 - 3m of glacial till. Roughly two-thirds of the site is set upon these types of soils and unable to support conventional concrete gravity foundations for the pads.

The soils in some zones were so difficult that the peat was collapsing as base foundations for pads were being dug. As the geotechnical issues of the turbine pads were being managed through varying concrete base sizes, pile work and other methods, the access roads were being constructed with a combination of geosynthetics.

The volume of peat required floating road constructions with geotextile and geogrid separation. On-site personnel reported that some zones were so significantly soft that after breaking through the crust they found 2.5m of settlement occurring.

The geosynthetic reinforcement was imperative if these roads were to be realised in an economical manner.

In the construction, Naue Secugrid® 40/40 Q1 geogrids were installed in the 600mm thick base course at 200mm intervals (Fig. 3).

Fig. 3
Placement of aggregate on Naue Secugrid®

Above this, Secugrid® 30/30 Q1 geogrids were installed. Both types of Naue Secugrid® are designed for high strength, high modulus, excellent interlocking with aggregate, and long-term performance. Delivered in easy-to-install rolls and highly durable (so that installation and other construction activities and handling procedures do not damage the grids before they are placed to function as designed), the Secugrid® helped site workers complete more than 1.5km of road per week. Within a month, the site was ready for large-scale installation of the turbines (Fig. 4).

»Whatever the wind brings is converted to energy.«

Fig. 4
Finalised windfarm with Secugrid® soil reinforced areas

In total, more than 1.4 million m² of geosynthetics were installed. The Eaglesham Moor site has also become an attractive nature escape. A visitor centre has been constructed, entry to the land is free and visitors may take part in an interactive exhibition. More than 70km of trails have been opened at this exemplary wind farm.

Economics & Environmental Benefits

Close to 40% of the world's energy consumption and greenhouse gas emissions are related to construction. This provides the construction industry an enormous opportunity to improve and provide more sustainable solutions.

Our engineering solutions are designed to provide economical benefits for our clients, for example by reducing the amount of aggregate required and the number of truck deliveries to site.

Naue Secugrid® and Combigrid® products are the latest generation of geogrids, and their utilisation can significantly reduce the demand on natural resources such as aggregate in construction.

For example, for a soft subgrade (CBR 0.5%) and an expected bearing capacity of CBR 15% on top of the road surface, 90cm of crushed rock would be required to achieve the required strength without geogrid reinforcement (Fig. 5).

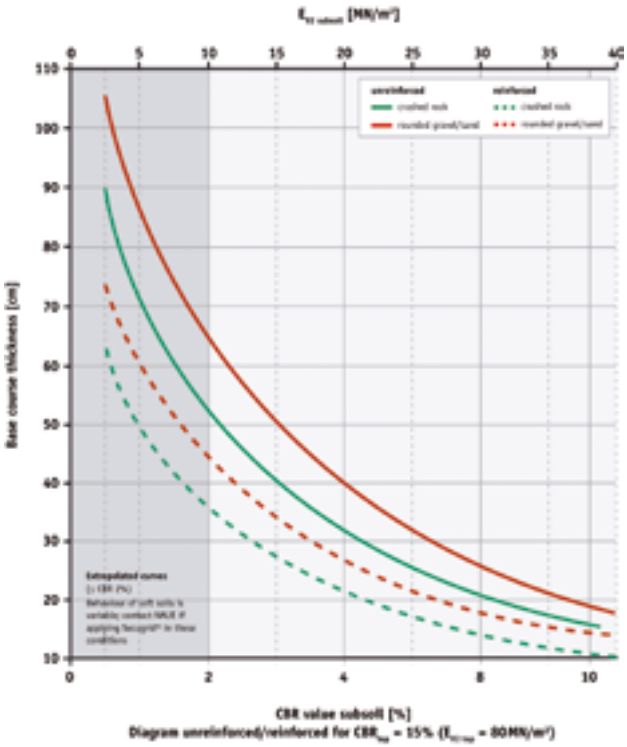

Fig. 5
Design chart for crushed rock and gravel subbase - unreinforced and Secugrid® reinforced

With a Naue Secugrid® 30/30 Q1 geogrid installed on top of the soft subgrade as soil reinforcement, only 63cm of crushed rock would be needed to achieve the same strength (Fig. 5). Applied under the entire 30,000m² road project, it amounts to a huge reduction in cost and subbase fill materials. Further the entire Secugrid® geogrid material can be delivered in just one truckload.

The aggregate volume demand saved on this project by using that layer of geogrid is equal to 8,100m³ (14,580t) - approximately 608 truckloads of aggregate. Cost saving estimations are very much project-dependent but in a case like this the potential cost saving with the Secugrid® subbase reinforcement can be several 100,000€.

The choice to use Naue Secugrid® saves a considerable amount on aggregate delivery and reduces the amount of time needed for construction, which also reduces cost. By reducing the need for aggregate extraction, processing and transport by heavy trucks, geogrid-reinforced construction can reduce the associated energy demand and CO_2 emissions compared with conventional alternatives such as lime stabilisation (Fig. 6).

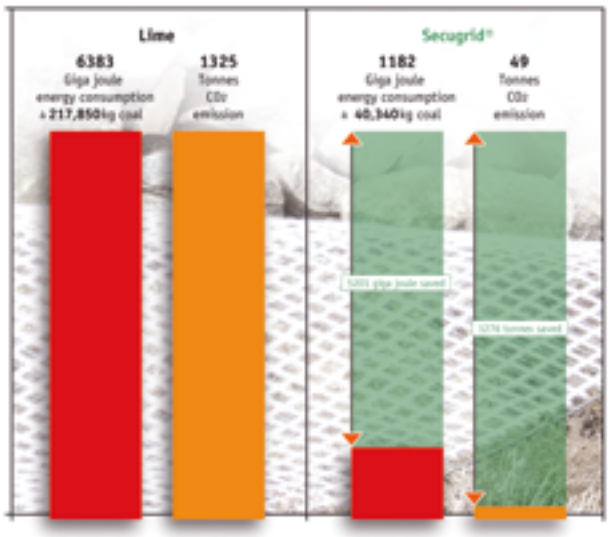

Fig. 6
Environmental savings based on accumulated energy and CO_2 consumption, when comparing Secugrid® soil reinforcement with lime stabilisation (project: district road K34, Aachen, Germany)

For wind farms, which require large amounts of land and are often constructed on weak soils or soils that need to be reinforced in order to accommodate heavy turbines, the savings can be considerable.

Additional expensive and extensive measures like establishing pile foundations for safe crane working platforms can be replaced by geogrid-reinforced working platforms in most cases. Geosynthetic reinforcement allows for more efficient land use through less land disturbance and a reduced need for aggregate. Naue Secugrid® reinforced roads and crane platforms are stronger and installations provide longer service lives with decreased maintenance intervals.

Secugrid®
Soil Reinforcement - Technical Back-up

Secugrid®

Naue Secugrid® geogrids are manufactured from high-quality polypropylene (PP) or polyester (PET) bars which are welded firmly together, providing a structurally sound and stable geogrid.

Highly orientated bars of Secugrid® that are uniformly extruded and pre-stressed, enable high tensile strength at low strains. And the roughened surface of these individual bars increases frictional properties, which allows fine-grained materials to transfer loads to the Secugrid® reinforcement.

This exceptional stress-strain behaviour at low elongation is vital to reduce road deformation, which improves long-term performance, such as in roadway subgrades (Fig. 7).

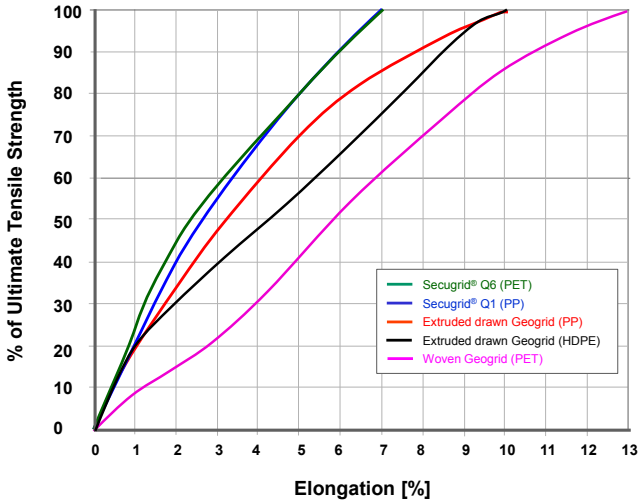

Fig. 7
Typical stress-strain curves for Secugrid® and market available geogrids

As loads are applied to the road surface, the aggregate interlocks with the Secugrid® geogrid layer.

The superior stiffness of Secugrid® creates excellent aperture stability to support an aggregate layer with high lateral restraint.

The high torsional stiffness of Naue Secugrid® provides greater resistance against twisting motions, so the interlocked aggregate layer remains confined not only laterally but also vertically. The radial tensile strength at low elongations prevents deformations in the subgrade and preserves the reinforced roadway's surface.

The bearing capacity of the road is increased. The maintenance needs are greatly reduced and the service life of the road is extended.

Independent testing has shown the beneficial impact of Secugrid®'s high radial stiffness (Fig. 8) when compared to similar available products in base course structures.

Naue manufactures Secugrid® in various common and project-specific tensile strengths to meet individual project design and specification requirements. Easy installation on the jobsite and a high resistance to installation damage complete the high performance quality of Naue Secugrid® geogrids.

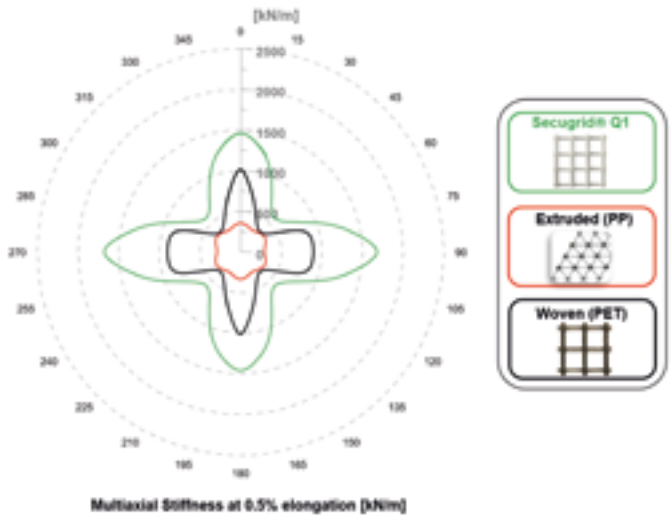

Fig. 8
Radial secant stiffness of Secugrid® and other geogrids at 0.5% elongation

Combigrid®
The Solution on Soft Soils

Combigrid®

Reinforcement alone is not always enough. Additional engineering functions may be required in the reinforcement layer, such as separation, filtration and drainage. Naue Combigrid® combines all of these requirements in a single product. This composite product combines a Secugrid® geogrid with a needle-punched Secutex® nonwoven geotextile.

Fig. 9
Base course reinforcement with Secugrid® and Combigrid® (bottom)

The geotextile is firmly welded between the reinforcement bars, providing exceptional support for soil stabilisation, separation and filtration applications in addition to the geogrid's reinforcement strength.

The unique manufacturing process leads to an interlocking behaviour equivalent to that of Secugrid®. The unique combination of separation, filtration and drainage characteristics means that Naue Combigrid® is typically used on top of subsoils with a CBR value of less than 3%. Typical areas of application include reinforcement of base courses, working platforms, temporary access roads, paved roads and pipeline trenches.

Larg-scale lab tests in the U.S. to simulate the traffic passages on an unreinforced base course resulted in 75mm deep traffic ruts after 20 load cycles, and it took 540 load cycles when Secugrid® reinforcement was used. However, when Naue Combigrid® (Fig. 10) was used, the corresponding traffic rut depth was not reached even after 100,000 load cycles.

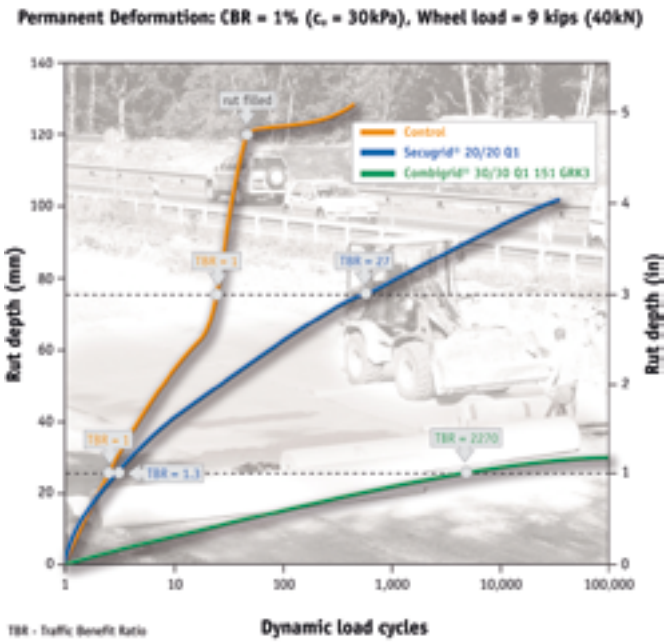

Fig. 10
Combigrid® and Secugrid® traffic benefit ratio over a very weak subsoil, compared to an unreinforced design in a large-scale lab test

Advantages of Secugrid® and Combigrid®

- Very high strength at low strains
- Immediate interlocking effect
- Good frictional bond to fine-grained soils due to textured geogrid surfaces
- High aperture stability
- High radial stiffness
- Uniaxial geogrid strengths up to 400kN/m
- Available with combined Naue Secutex® nonwoven (Combigrid®)
- Quick and easy to install
- High resistance to installation damage
- Made from uniformly extruded solid PET or PP bars
- High resistance against biological and chemical attack
- ISO 9001 certified

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