Dear Mr. Cracknell,

Referring to your inquiry concerning above mentioned project, please find enclosed our preliminary design of Secugrid®/Combigrd® reinforced base courses, to increase the low bearing capacity of the existing subgrade of the above mentioned project.

Introduction

Often the required bearing capacity on subgrades can not be achieved, so that additional measures have to be taken. As an economic solution to improve the subgrade strength, the installation of geosynthetics for reinforcement, filtration and separation has successfully been carried out.

Fig. 1: Shear interaction between base aggregate and Secugrid® geogrid

Vehicular loads applied to the road surface create a lateral spreading motion of the aggregate. Tensile lateral strains are created at the interface subgrade/geogrid as the aggregate moves down and sideways due to the applied load.
Through shear interaction of the base aggregate with the geogrid (see Figure 1), the aggregate is laterally restrained (see Figure 2) and tensile forces are transmitted from the aggregate to the geogrid. As the geogrid is much stiffer in tension as the aggregate, the lateral stress is reduced in the reinforced base aggregate and less vertical deformation at the road surface can be expected.

Fig. 2: Efficiency of Secugrid® geogrids

The interaction between geogrid and base aggregate increases the shear strength and thus the load distribution capacity of the used base course material. This correlation enables the reduction of reinforced aggregate thicknesses in comparison to un-reinforced aggregate layers (see Figure 3).

Fig. 3: Increase of load distribution angle with Secugrid® geogrids
Present situation

According to the given information it is planned to increase the low bearing capacity of the in-situ subgrade for the Niagara Region Windfarm at Grimsby/Wainfleet in Canada. According to the given information [1] the subgrade consists of soft to very soft clayey soil layers. The undrained shear strength of the upper layers is documented in the range of approx. 10-30 kPa, which can be correlated to an $E_{v2} \geq 2.5$ MN/m².

According to the given information [1] ENERCON E-101 turbines are planned to be used for this windfarm. Thus the required bearing capacity on top of the base course is defined with 100 MN/m² for the access roads as well as for the crane hardstandings (values defined as $E_{v2}$-value). If a different specification is required a revised design can be carried out.

In the following the required base course thicknesses for both constructions are given.

**Design of Secugrid®/Combigrd® reinforced base course**

The increase of the subgrade bearing capacity given by Secugrid® geogrids taking the height of the construction and the base course material into consideration is shown in the design charts in [3]. With the given $E_{v2,sub}$-values of min. 2.5 MN/m² and taking a well graded crushed aggregate into consideration, the required base course thickness is determined as given in the following tables 1.

**Table 1: Access roads base course thickness requirements depending on in-situ CBR**

<table>
<thead>
<tr>
<th>In-situ $E_{v2}$</th>
<th>≥ 2.5 MN/m²</th>
<th>≥ 5.0 MN/m²</th>
<th>≥ 7.5 MN/m²</th>
<th>≥ 10.0 MN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness d (mm)</td>
<td>800 mm</td>
<td>650 mm</td>
<td>550 mm</td>
<td>460 mm</td>
</tr>
<tr>
<td>Type of construction</td>
<td>Double-layered</td>
<td>Double-layered</td>
<td>Double-layered</td>
<td>Single-layered</td>
</tr>
</tbody>
</table>

The given base course thicknesses cover the specified requirement concerning a sufficient bearing capacity. More economic solutions focus on the serviceability criteria of those constructions. In case that the requirements during construction stage can be reduced the base course thickness can be reduced based on axle passes for individual road sections. This requires a separate / revised design which can be carried out in addition if requested.
Required geogrid types

Cohesive subgrades often provide the risk of pumping or squeezing of fine particles into the good quality base course material. The result of this effect is a lower serviceability of the base course layer and probably lower performance of the whole construction. For this case it is recommended to install a geotextile (e.g. Secutex® 151 GRK 3C) or a much better product Combigrd® which consists of a geogrid Secugrid® combined with Secutex® 151 GRK 3C, which is directly welded between the longitudinal and transverse bars of the geogrid.

For this project we recommend the use of Combigrd® 30/30 Q1 151 GRK 3. For base courses of access roads with thicknesses greater than 500 mm as well as for all crane hardstandings a secondary reinforcement layer is recommended. Therefore the cross section in Figure 4 becomes decisive while the single layered construction (only access roads d < 500 mm) is shown in Figure 5.

![Diagram](image)

**Fig. 4: Typical Cross Section for double-layered Combigrd® reinforced constructions**

![Diagram](image)

**Fig. 5: Typical Cross Section for single-layered Combigrd® reinforced constructions**
Final recommendations and comments

The serviceability of the construction essentially depends on the installation, the degree of compaction and the soil-mechanical values of the fill material including the resistance against demolition. It has to be guaranteed that the specified materials will be able to provide the required bearing capacities. Poor graded materials are probably not able to reach the required strength also using the optimal moisture content.

Please note that the recommended base course constructions have neither been proven with regard to their resistance against bearing failure nor a settlement analysis has been carried out. It is absolutely recommended to carry out such analysis when details for the crane loadings are available.

We hope that the provided information leads to an economic and safe construction. Please note that this recommendation is only valid for Secugrid®/Combigrd® geogrids and cannot be transferred to other products.

If the boundary conditions which have been considered in this design will change, a new design of the geosynthetic reinforced base course will become necessary.

With best regards,

BBG - Bauberatung Geokunststoffe GmbH & Co. KG

i. V. Dipl.-Ing. J. Klompmaker

i. A. Dipl.-Ing. C. Psiorz
Project related information and standards

[1] Email from Mr. Andy Cracknell (NAUE) with project related information, May 2nd 2014
[2] NAUE GmbH & Co. KG: Design chart for Secugrid® geogrids reinforced base courses, 05/2012

Enclosures

[E1] Technical data sheet: Combigrid® 30/30 Q1 151 GRK 3 (NAUE GmbH & Co. KG)
[E2] Installation guide: Base course reinforcement (NAUE GmbH & Co. KG)

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