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6 pages + Enclosure

August 2nd 2013

Project: IPEX Plant Expansion in Edmonton, Alberta, Canada
Here: Secugrid®/Combigrid® reinforced flexible pavement system

Dear Mr Lilley,

With regard to your enquiry concerning above mentioned project, please find following our project specific preliminary design for a Secugrid®/Combigrid® reinforced flexible pavement system at the "*IPEX Plant Expansion*" project located in Edmonton, Alberta, Canada.
The carried out design follows the principles of the AASHTO '93 Pavement Design Guide [3].
NAUE GmbH & Co. KG agreed to take over the costs for working out this design, subject to placement of order for all the materials specified.

INTRODUCTION

Often the required bearing capacity on subgrades cannot 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.
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.

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Figure 1: Shear interaction between base aggregate and Secugrid® 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.

Figure 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).

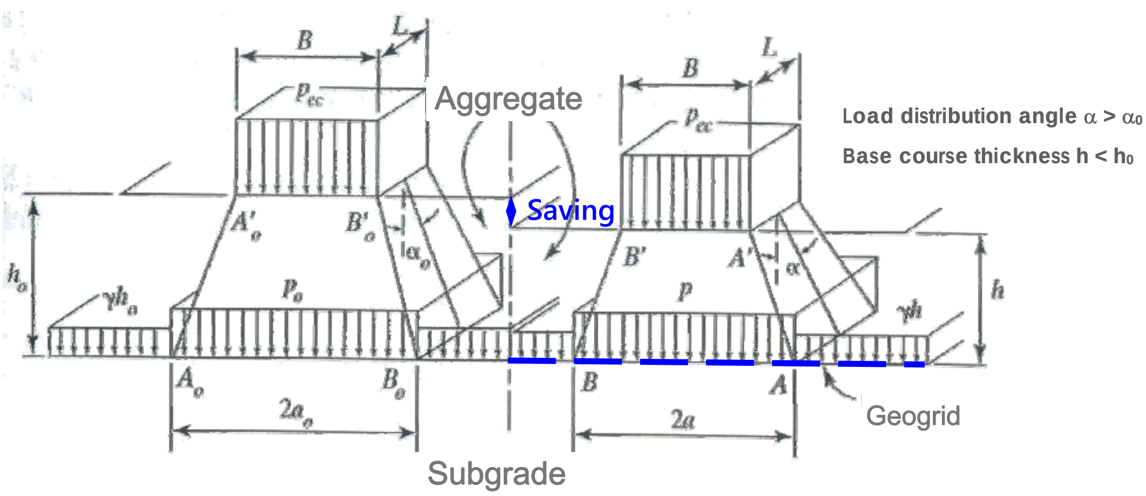

Figure 3: Increase of load distribution angle with Secugrid® geogrids

DESIGN OF FLEXIBLE PAVEMENT SYSTEM

The design of flexible pavements with geosynthetic reinforcement in the base course layer is typically accomplished via empirical techniques involving the construction of pavement test sections similar in cross section and materials to the expected design and observation of the improvement in pavement performance [4].
The results of these tests are often expressed in terms of an improvement in the structural layer coefficient of the base course layer, which is done within the context of the AASHTO '93 Pavement Design Guide [3].
The AASHTO '93 method utilizes an index termed the "Structural Number" (SN) to indicate the required combined structural capacity of all pavement layers overlying the subgrade. The required SN is a function of several influencing factors, like e.g. reliability, serviceability, subgrade resilient modulus and expected traffic intensities. The actual SN must be greater than the required SN to ensure long term pavement performance.
The actual SN value for a unreinforced pavement section is calculated as follows:

$$SN = a_1 \cdot d_1 + a_2 \cdot d_2 \cdot m_2 \qquad \text{Eq. (1)}$$

Where a_1 and a_2 are the layer coefficients characterizing the structural quality of the asphaltic concrete layer and the aggregate base course in a pavement system.
A subbase layer can be included in equation (1) if desired, d_1 and d_2 are their thickness and m_2 is the drainage coefficient for the granular subbase.
A modification to equation (1) is introduced to account for the structural contribution of a geogrid reinforcement (here: Secugrid®/Combigrid®) to flexible pavements

$$SN = a_1 \cdot d_1 + LCR \cdot a_2 \cdot d_2 \cdot m_2 \qquad \text{Eq. (2)}$$

where LCR is the layer coefficient ratio. Equation (2) can be used to calculate the base course thickness for geogrid reinforced pavements by rearranging its terms:

$$d_2 = \frac{SN - a_1 \cdot d_1}{LCR \cdot a_2 \cdot m_2} \qquad \text{Eq. (3)}$$

When the layer coefficient ratio LCR is greater than 1 the thickness of the geogrid reinforced base course is reduced compared to unreinforced sections, similarly, if the base course thickness is held constant, the structural number of the reinforced section increases. An increased structural number implies and extended service life of the pavement for the same traffic level. Several mechanistic-empirical models for analysis and design of reinforced flexible pavements have recently been reported [5] / [6]. These models have been calibrated against the type of pavement test sections suggested by [4]. These methods have the potential to analytically generate benefit values for a given set of pavement design conditions.

In the framework of the carried out research work [8] the referenced mechanistic-empirical models [5] / [6] were used to determine the Layer Coefficient Ratios for Secugrid® 30/30 Q1 from NAUE. The results of Secugrid® 30/30 Q1 can be transferred to the product Combigrid® 30/30 Q1 151 GRK3. This product consists of the same reinforcement component as the examined Secugrid® product and has in addition a separation and filtration geotextile component integrated between the longitudinal and transverse bars of the geogrid.

PROJECT SITUATION

In the framework of expansion works at the IPEX plant in Edmonton, Alberta, a new access route through the southern region of the yard area is constructed. In the following preliminary design the reinforced granular base course thickness of the planned asphalt pavement system will be designed based on the given/assumed information [2] as summarized below:

Design Input Parameters:

Design life:	20 years
Subgrade CBR:	2.5%
Traffic frequency:	$2.5 \cdot 10^5$ ESALS
Reliability level:	R = 85%
Layer coefficient:	$a_1 = 0.40$ (asphalt)
	$a_2 = 0.140$ (base course)
Drainage coefficient:	$m_2 = 0.8$ (base course)
Layer Coefficient Ratio (Geogrid):	LCR = 1.45 (Secugrid® 30/30 Q1 @ 2.5% CBR)

DESIGN PROPOSAL

According to the described boundary conditions the following typical cross section for the roadway structure, as shown in Figure 4, is proposed based on the carried out design.

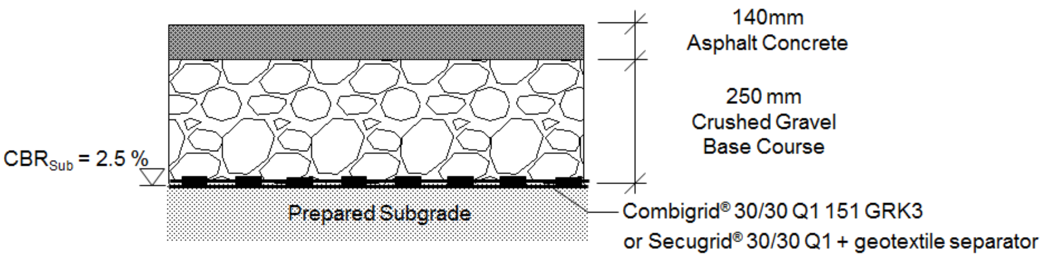

Figure 4: Typical Cross Section of reinforced roadway structure

On top of the prepared subgrade the installation of a geogrid type Secugrid® 30/30 Q1 is recommended. As far as the mechanical and hydraulic filter stability cannot be assumed in the transition zone between the subgrade and the reinforced base course, a geotextile separation and filter layer (recommendation: Secutex® 151 GRK 3 C) is recommended to be placed between the clay subsoil and the geogrid to prevent squeezing or pumping of fines into the base course. This is essential to ensure the internal shear strength and therefore the long-term bearing capacity during the lifetime of the construction.

It is also possible to use Combigrid® 30/30 Q1 151 GRK3 (see data sheet in Enclosure [E1]) on the bottom of the reinforced base course. This composite product consists of a separation and filter layer Secutex® 151 GRK 3 C and a geogrid Secugrid® 30/30 Q1.

With best regards,

BBG - Bauberatung Geokunststoffe
GmbH & Co. KG

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

Related information & literature

[1] Email from Mr. Nigel J. Lilley (Brock White Canada) to Mr. Chris Quirk (NAUE Geosynthetics Ltd.) with project related information, July 31st, 2013

[2] Shelby Engineering Ltd. – Geotechnical Evaluation Addendum, IPEX Plant Expansion, 4225-92nd Avenue, Edmonton, AB, May 23, 2013

[3] AASHTO (1993). AASHTO Guide for Design of Pavement Structures. American Association of State Highway and Transportation Officials, Washington, DC.

[4] AASHTO (2009). Standard Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures. Publication R50-09. American Association of State Highway and Transportation Officials, Washington, DC.

[5] Perkins, S.W., Christopher, B.R., Cuelho, E.V., Eiksund, G.R., Schwartz, C.S. and Svanø, G. (2009). A Mechanistic-Empirical Model for Base-Reinforced Flexible Pavements. International Journal of Pavement Engineering, Vol. 10, No. 2, pp. 101-114.

[6] Perkins, S.W. and Edens, M.Q. (2003). A Design Model for Geosynthetic-Reinforced Pavements. International Journal of Pavement Engineering, 4:1, 37-50.

[7] Perkins, S.W., Christopher, B.R., Klompmaker, J. (2012): *"Reinforced Flexible Pavement Layer Coefficients Determined by Mechanistic-Empirical Modeling"*, 5th European Geosynthetic Congress, EuroGeo5, Valencia, Spain

[8] Perkins, S.W., Christopher, B. (2012): "Evaluation of AASHTO '93 Layer Coefficients for pavements reinforced with NAUE geogrids", Final Project Report

Enclosure

[E1] Data sheet for Combigrid® 30/30 Q1 151 GRK3 (NAUE GmbH & Co. KG)