Case history of a noise barrier in Almere, Netherlands

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ABSTRACT:
The use of geosynthetics in road construction is a well-known technology and represents an economical and reliable building method. Especially in construction of noise barriers geosynthetics help to deliver creative architectural designs. Common materials are steel, concrete or glas elements. In this paper the use of geogrids and nonwoven in a noise barrier in Almere, the Netherlands is described. The main issue is to deliver an extrem low settlement. This is achieved by a three-element system: pile foundation, reinforced mattress and gabions anchored with geogrids. Therefore geogrids in different tensile strengths are required. Furthermore laboratory tests are presented that evaluate the connection between geogrid and steel elements.

1 INTRODUCTION

In the municipality of Almere, Netherlands a new residential area has been established. The location near the A6 motorway means high levels of noise. For this reason the Almere Local Authority decided to construct a noise protection system. The architectural design scheme provides an effective and visual acceptable solution with the appearance of a "city gate".

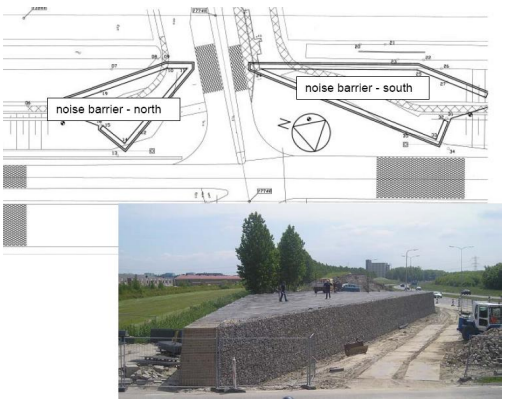

Figure 1. Noise protection barrier

2 PROJECT DESCRIPTION

Along the major road an existing embankment protects the new residential area near Almere from noise pollution due to the A6 motorway. This existing earth bank was breached by the approach road to the residential area.

Reflecting the weak soil conditions and the need for a settlement-free gabion construction a pile foundation was specified by the architect. The piles have a depth up to 8 meters with a pile spacing of 1.2m x 1.2m. On the top of the pile head a geogrid reinforced mattress with crushed rock was installed. The mattress was reinforced using three layers of geogrid with a tensile strength of 180kN/m. It has a total thickness of 60cm.

A Gabion wall in two variants formed the front wall. The front wall near the road was built with the appearance of stone chippings. The east side of the barrier is filled with masonry work.

To prevent damage or horizontal imperfections in the gabion wall geogrids were used to anchor the gabions in the earth structure.

The front inclination is almost vertical with a backside angle of 90°. In the earth structure, sand is used in combination with geogrids as reinforcing material.

Figure 2. Weak soil conditions

The geogrid reinforcement was analysed using special design software for reinforced earth structures. The cross section was calculated with two different geogrids for an efficient solution. A geogrid with 60kN/m tensile strength is used every 1.0m continuously in the superstructure. Between these layers a geogrid with 40kN/m tensile strength is used with an anchorage length of 2.0m.

3 THREE-ELEMENT SYSTEM

To meet the requirement of no visible deformations in a noise barriere of up to 6m in height built on weak soil, a special system was needed.

Therefore three elements were used:

- pile foundation
- geogrid reinforced mattress
- reinforced earth construction with anchored gabions

As shown in Figure 3, there are different kinds of loads: area load, point load and skin friction.

The piles distribute the load from the soil structure and mattress by skin friction into the weak subsoil. The reinforced mattress distributes the area loads into point loads on the pile foundation.

The construction above the mattress uses geogrids to prevent settlement and to anchor the gabions that are used as the visual design feature.

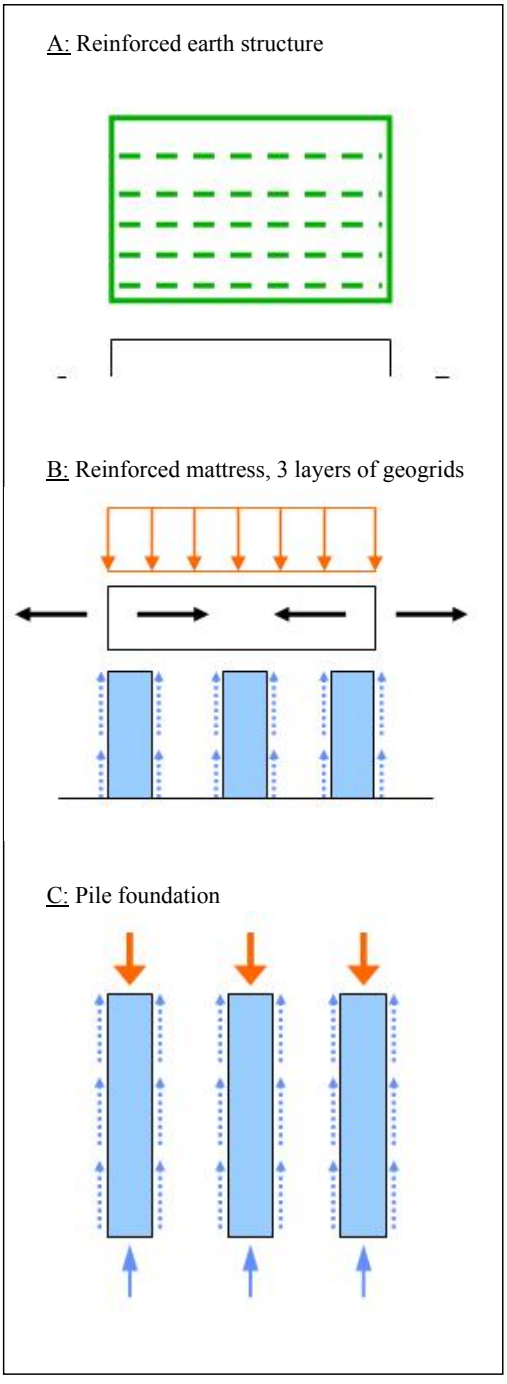

Figure 3. Three-element system (reinforced soil structure, reinforced mattress and pile foundation)

4 MATERIALS USED

The settlement of the structure is highly dependent on the reinforcement properties. In consideration of the settlement requirements, a geogrid is needed with high strength and low creep.

Therefore geogrids made of polyester are used with tensile strength from 40 kN/m to 180 kN/m.

4.1 *Earth structure*

In the earth structure two types of geogrids are used: uniaxial geogrids with tensile strength of 40kN/m (geogrid type A) and 60kN/m (geogrid type B). The design with a primary and secondary reinforcement layer was chosen for an efficient and economical solution.

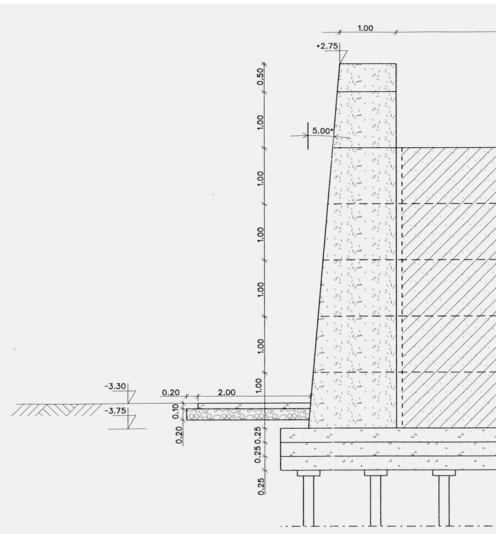

Figure 4. Cross section of the earth structure

In the cross section shown on Figure 4 the two types of geogrides are installed alternately. The type B geogrid functions as the primary reinforecement layer with higher strength and an embedded length of 4m. The type A geogrid is positioned as the secondary reinforcement layer with a length of 2m. Both are anchoring the gabions with a wraparound length of 1.5m. To avoid erosion effects a nonwoven is used between the gabions and the backfill soil.

The connenction between the geogrid and steel elements is tested according to EN ISO 10321. The test results show that the strength of the geogrid led to a deformation of the steel bar and a failure in a welded steel connection. This shows a high force transmission from the steel to the geosynthetic.

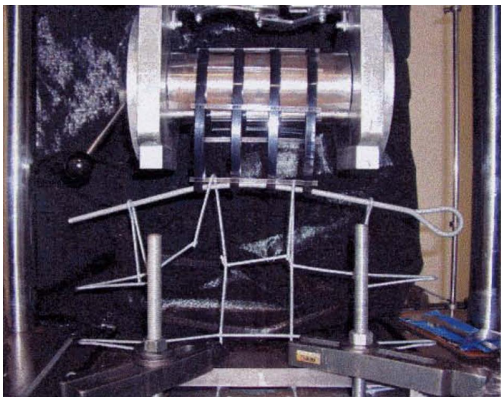

Figure 5. Steel/geogrid connection testing

The principal method to evaluate the force F transfered from soil to geogrid is shown in the following equation:

$$F = \frac{\sigma \cdot l \cdot \mu \cdot \tan\varphi'}{\gamma} \quad (1)$$

F: connection force
σ: vertical load
l: reinforcement length
μ: coefficient of friction
φ′: angle of friction
γ: safety factor

Figure 6. Reinforced mattress

4.2 *Reinforced mattress*

The reinforced mattress as a layer between the pile foundation and the soil structure needs to be a stiff construction to prevent deformation. Therefore three layers of a 180 kN/m geogrid are used.

The most important property influencing long term behaviour is the creep resistance. This is shown for the chosen product in Figure 7 where the residual tensile strength can be extrapolated to a life time of over 120 years.

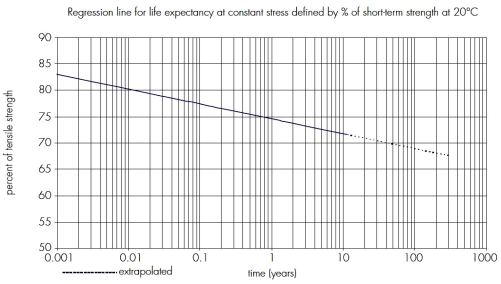

Figure 7. Creep behavior (BBA Certificate No 03/R133)

Figure 8. Pile foundation

Figure 9. Anchored gabions

5 CONCLUSION

The Almere noise barrier project shows how geogrids helped to create a unique construction with the architecture of a "city gate". Furthermore this variant of a noise reduction system needs less soil in comparison to conventional earth walls of the same height.

Figure 10. View of the two earth structures

REFERENCES

Roads and Bridges Agreement Certificate No 03/R133, British Board of Agrement March 2008