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Innovative design and construction technique

for the bridge abutments of the temporary construction road along Viaduct 3 of the Gautrain Rapid Rail Link

BOMBELA CIVILS JOINT Venture (BCJV) approached Kaytech Engineered Fabrics to offer an alternative design for the abutment walls of a temporary road bridge crossing Allandale Road. The temporary bridge runs parallel to Viaduct 3 of the Gautrain Rapid Rail Link (GRRL) route and will carry construction traffic during the construction of the viaduct. Kaytech approached ARQ Consulting Engineers to prepare a design for the abutment walls consisting of a geosynthetic-reinforced backfill, dry-stacked, concrete block retaining wall system. As far as the authors are aware, this is one of the few applications in South Africa of this type of retaining system used as bridge abutments directly carrying the weight of the bridge deck and applied traffic loadings.

PROJECT DESCRIPTION

Viaduct 3 of the Gautrain Rapid Rail Link crosses Allandale Road south-east of the Pretoria Main Road (R101). A temporary access road has been constructed parallel and to the immediate west of the GRRL route. The temporary access road crosses Allandale Road via a three-span steel-girder bridge supported by two median piers, the total span of the bridge structure being around 69 m. The abutments and wing walls are required to limit the encroachment of the approach fills onto Allandale Road and the nearby electrical pylons. The placement of the bridge structure and the natural fall of the ground require

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1. *First placement of RockGrid PC reinforcement*
2. *Stepped concrete foundation with base block*
3. *Southern abutment wall nearing full height*
4. *Southern abutment wall*

abutment heights of 6,3 m and 6,9 m for the northern and southern abutments respectively.

ARQ prepared a conceptual design based on a dry-stacked, concrete block facing using Concor's Enviro wall segmental blocks. The solid concrete blocks are well suited to carry the imposed loads without cracking, provide a good structural interface with the geogrid reinforcement and additionally are shaped to facilitate construction of the retaining wall at the specified final angle of 85 degrees.

The approximately 9 000 m^3 of weathered granite backfill within the reinforced zone were strengthened with Kaytech's RockGrid PC product. RockGrid PC is a new-generation high-strength composite geotextile that offers the reinforcement characteristics of geogrids and wovens in conjunction with the favourable hydraulic qualities of nonwoven geotextiles. The material exhibits a high-tensile modulus (high tensile strength at low elongation) of 18 kN/m, 45 kN/m and 100 kN/m at 2%, 5% and 10% strain (ISO 10319) respectively, providing excellent reinforcement characteristics and minimum deformation. RockGrid PC furthermore demonstrates a very low creep tendency. As a composite reinforcing geotextile, RockGrid PC provides sufficient drainage capacity within its plane, that is, transmissivity is high, enabling it to reduce pore pressure build-up in the reinforced soil thereby improving the shear resistance and stability of the overall structure.

DESIGN METHODOLOGY

The design methodology was largely influenced by the temporary nature of the abutment structures. The abutments and wing walls were designed for a 'serviceability' life not exceeding five years. The design considered the concrete block facing as a lining to contain backfill and not actively contributing to resisting lateral forces. The geogrid reinforcing within the backfill serves the dual purpose of anchoring the facing units as well as restraining movement of the wall through the frictional stresses mobilised between the geogrid and the backfill material. The backfill material and applied loads thus both create lateral pressure and interact with the imbedded geogrid layers to resist it. The overall stability of the wall against sliding and overturning was calculated by considering the reinforced soil block as a rigid mass.

FINITE ELEMENT METHODS

An interesting aspect of the design was the use of finite element methods to assess the internal stability of the reinforced backfill and the expected movements under the applied vehicle loads. An overall 'factor of safety' was calculated by means of a 'strength reduction factor' (SRF) method. This method also facilitates the prediction of the tensile forces that are generated within each layer of the imbedded geogrid.

PROJECT STATUS

Construction on the northern and southern abutment walls started concurrently in February 2007 and was practically completed by end April 2007. Kalode Construction completed the work in the allotted time to land the deck on the required date. The abutment and wing walls are monitored for movement and regularly inspected for signs of distress. The temporary bridge structure has been carrying traffic for approximately one month and appears to be functioning as designed.

CONCLUSION

The use of a dry-stacked concrete block facing in conjunction with a geogrid-reinforced backfill zone provided a cost and time-effective solution to the requirements for the temporary abutment walls required to cross Allandale Road. □

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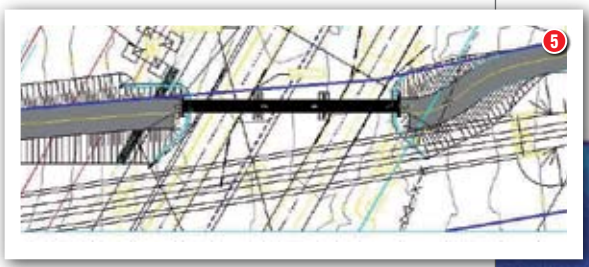
5 *General layout of Viaduct 3 and the temporary bridge structure*
6 *Contour plot of maximum shear strains and graphical depiction of tensile forces generated within the geogrid reinforcement*
7 *Typical cross section of the northern and southern abutment walls*
8 *Northern abutment wall nearing full height*
9 *Steel girder units in place*
10 *Southern abutment wall supporting the bridge*

PROJECT TEAM

- **Client** Bombela Civils Joint Venture
- **Designers** ARQ Consulting Engineers
- **Suppliers** Kaytech Engineered Fabrics; Concor
- **Contractor** Kalode Construction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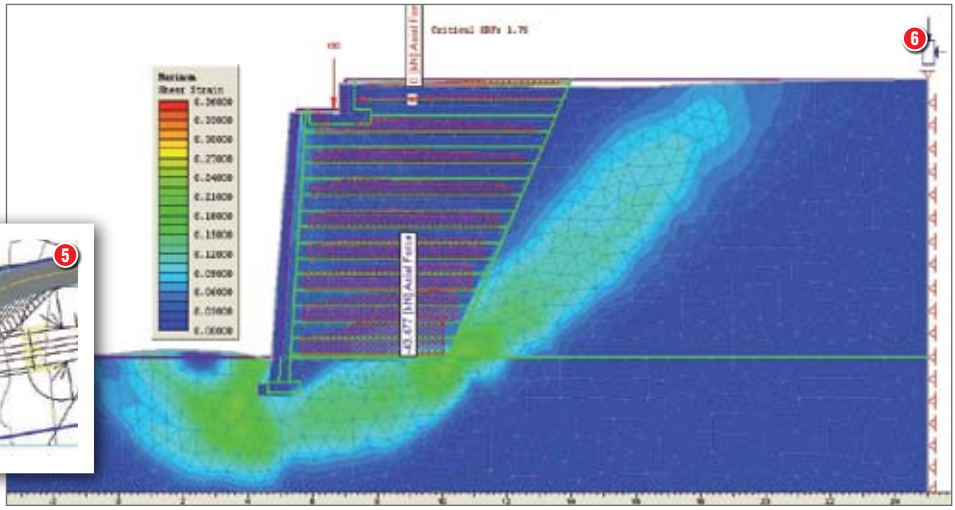
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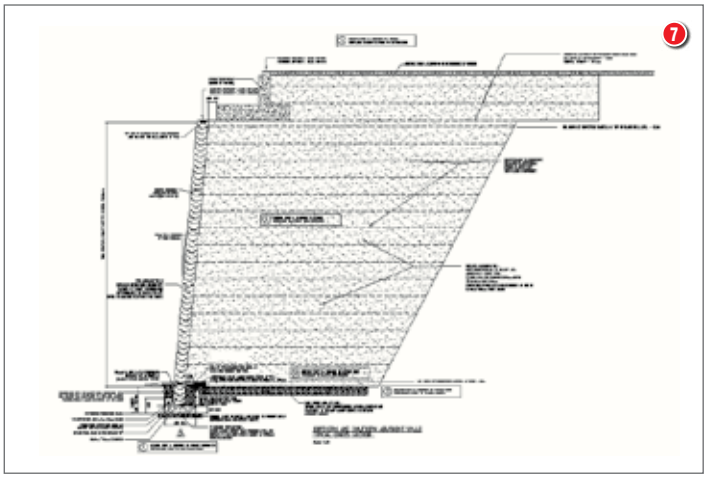
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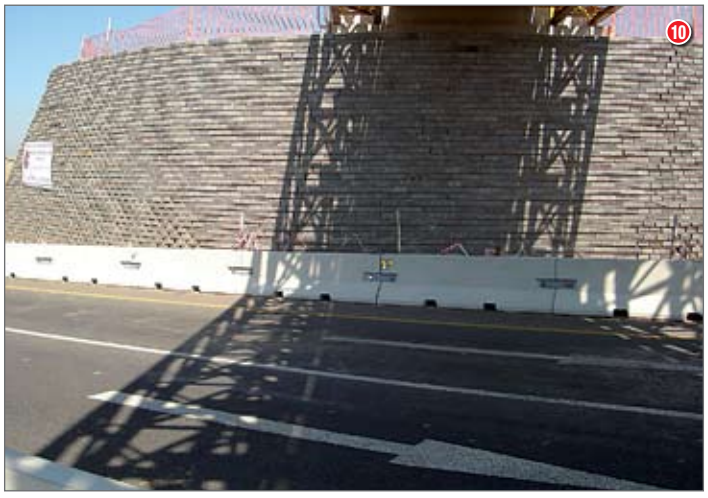
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