Geosynthetics, J. Kuwano & J. Koseki (eds)

Newport southern distributor road: Uses of geosynthetics

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ABSTRACT: Newport City Council, using a Design Build Finance and Operate (DBFO) method of procurement, commissioned the Newport Southern Distributor Road. The contract was awarded to a consortium of Morgan Est and Vinci Construction. Faber Maunsell was appointed as the designer for the civil works. The route crosses several areas underlain by soft ground, domestic and industrial wastes. The paper examines the applications of geosynthetics within the project to overcome the various problems encountered.

1 INTRODUCTION

Newport Southern Distributor Road is a 9.3 km, on-line and off-line road improvement scheme to dual carriageway. It has a 40-year concession and maintenance period with a specified 10-year residual life at hand-back. With a contract value of £55M, it is the most prestigious local authority Private Finance Initiative highway scheme in Wales to date.

The road runs from Junction 24 of the M4 around the south of Newport to an interchange connected to Junction 28 of the M4 by the A48 at Maesglas, allowing traffic to access the old docks redevelopment areas without entering the town. A major feature of the route is a new bowstring girder bridge over the River Usk. Figure 1 shows the route.

The road passes through a number of areas that are underlain by soft alluvial clay soils, contaminated soils and domestic refuse disposals. Engineering the support for the new road in these areas included: geosynthetics in load transfer platforms for distributing embankment and bridge structure loads through to arrays of pile elements termed ‘Controlled Modulus Columns’; band drains installed to speed up time dependent consolidation of embankment foundation soils; capping and venting systems for prevention of water ingress through the new road into the refuse, and collection of gas egress along a venting layer

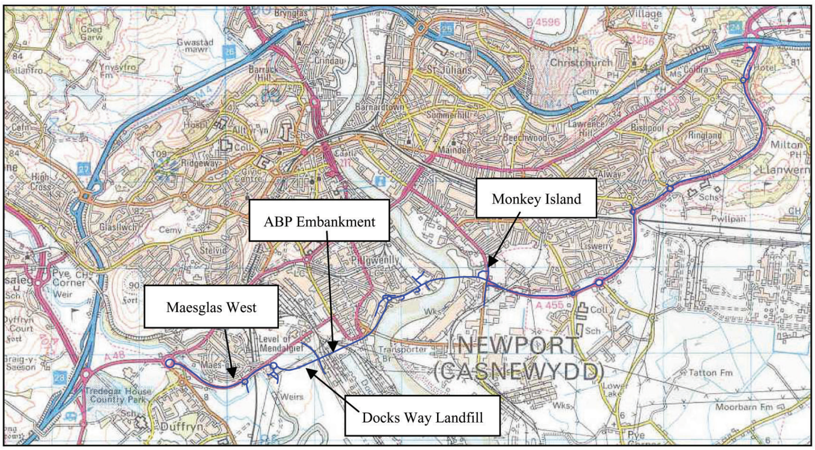

Figure 1. Plan showing the route of the Southern Distributor Road.

placed beneath the new capping system; and a geocell mattress for the promotion of uniform settlement of the road where constructed over refuse of varying deformation characteristics.

2 THE LOAD TRANSFER PLATFORMS

The main embankments south of the River Usk cross an area of very soft moderately contaminated silty organic clay which extends to about 18 m below ground level.

The load transfer platforms had two forms; the first was at Church Street where driven H piles were used to support fill placed in a narrow creek. A surface water pipe was extended beneath the fill and the load transfer platform was designed to avoid loading the pipe. The load transfer platform was reinforced with a single layer of Paralink 300s with a single layer of Paralink 900s over the pipe for additional support. Figure 2 shows a section through the load transfer platform at Church Road.

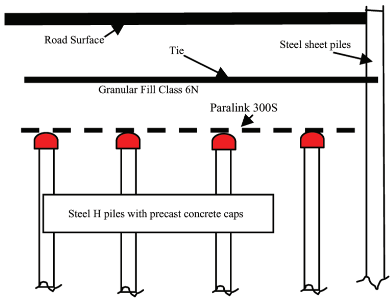

Figure 2. Section through the Church Road Load Transfer Platform.

The embankments which support the route on the approaches to the bridges at Westway Road and the ABP bridge are supported on controlled modulus columns (CMCs).

The CMC process was carried out by Menard Soltraitment, the CMCs are unreinforced concrete columns which are formed using a displacement auger. The advantages of the CMC process is that virtually no soil is brought to the surface, and as the soil in this part of the site is moderately contaminated, it would be expensive to remove any spoil from site. The soft or loose soils are 'improved' by the CMC process by the lateral displacement of the soils by the auger and the injection of the concrete which fills the void formed by the auger.

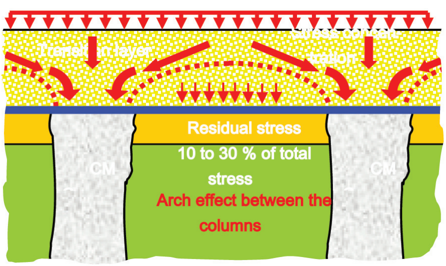

Figure 3. Design Mechanism used for Load Transfer Platform and CMC columns.

A granular fill load transfer platform reinforced with two layers of a polyester 80 kN/m width woven geotextile with the layers laid orthogonally. The design of the geotextile was carried out using the finite element computer program, Plaxis running in a 2D mode with the CMC columns modeled as walls. The forces from Plaxis were checked using the methods described in BS8006.

The specification of the geotextile was simplistic with the only requirement to be satisfied being the short term tensile strength, BSENISO 10318, the stain at failure and basic survivability during installation (max cone drop hole size, BSENISO 918). The properties of the geotextile were to be verified prior to delivery and continuously throughout the works by the manufacturer. All rolls were to be CE marked and the manufacturer was required to provide the accompanying documents. After some initial difficulties the accompanying documents were provided and a grade of geotextile satisfying the specification was provided, all be it a stronger than intended by the manufacturer. The minimum tensile strength was specified as being the value declared by the manufacturer in his CE documentation minus the declared negative tolerance.

The performance of the load transfer platform supporting the embankments has been as intended with little or no settlement being experienced at the road surface.

3 THE DOCKS WAY LANDFILL

The Docks Way landfill is crossed by the route over a length of about 500 m. During the preparation of the conceptual design it was intended that the road construction would be supported on a piled load transfer platform. The municipal waste was in two layers an older ashy waste, 3 to 4 m thick about 70 years old overlain by more recent waste 3 m thick and about 6 years old and a clay capping layer about 1m thick. As the design was being developed the Environment Agency imposed two restrictions which made the use of the piled load transfer platform impossible. The restrictions were first: that no piles or supports would be allowed to penetrate the soft clay sealing layer below the waste and second: that the waste could not be moved to other parts of the landfill.

Large settlements of the landfill were predicted 300 to 400 mm, based on the guidance given in the

BRE Report 'Building on Fills' for the settlement factors. An engineering solution was need which would eliminate or minimize the settlement, and which would accommodate any residual settlements with minimal differential settlement.

The solution developed was a two staged construction. A 3 m high, bund of fill covering the footprint of the road was placed as a preconstruction surcharge for 3 to 4 months. After the 3 to 4 month period settlement of the waste had virtually stopped. Due to the site engineers placing the plate settlement gauges after the fill rather than before filling, the initial settlement and early parts of the consolidation settlement was not recorded.

The solution to accommodate the residual settlements was to support the road pavement on a geocell mattress. The geocell mattress was designed with help from Tensar International Ltd., using Tensar geogrids. The geocell mattress was 1.0 m thick and the road construction above the mattress was 0.8 m. The thickness of the construction was such that the capping layer above the waste was removed along most of the southern edge of the road. Building on the waste was considered by the Environment Agency to be a variation to the waste tip license and any new construction would need to provide a fully engineered capping and make provision for gas management. To satisfy these conditions a fully welded HDPE membrane was installed with a thick needle punched protection layer on each side, a gas venting composite was included in the lower geotextile (Protexia from Geofabrics Ltd.). The gas vent was connected to a venting trench on the south side of the road and any water which seeps through the road construction into the granular fill in the mattress is drained to a pipe at the northern side of the road. Figure 4 shows a typical section through the road and Figure 5 a detail of the geosynthetic capping, gas venting layer.

Soon after construction several areas of the road over the tip showed signs of excessive differential settlement. Investigations of the areas where settlement had occurred showed that defects noted during construction had not been corrected and that the geogrids forming mattress had in some areas been completely folded over. Therefore instead of the granular fill being confined within the vertical geogrid cells, the mattress was a 200 mm thick layer of squashed geogrid and a 0.8 m thick layer of unreinforced granular fill. The stiffness of the mattress was therefore not as intended. To restore the stiffness of the road construction the whole of the road pavement was removed and a lightly reinforced concrete slab was constructed over the mattress.

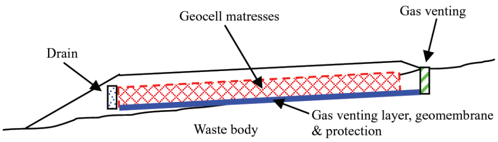

Figure 4. Typical section through road over Docks Way Landfill.

Figure 5 Detail of the geosynthetic capping.

Figure 6 shows the defects noted during construction and Figure 7 shows the exposed top of the geocell mattress.

Figure 6. Geocell mattresses during construction.

4 MAESGLAS WEST LANDFILL AREA

A second area of landfill was found when the site clearance for the pavement construction was carried out. A large amount of mixed industrial and domestic waste was found at formation level. After further investigations and gas monitoring in the area an HDPE membrane with geotextile protection layers was placed

Figure 7. Uneven top of geogrid mattress.

beneath the pavement to restrict inflows of water into the waste and to direct any gas to venting trenches in a controlled manner.

Figure 8 shows a typical view of the exposed wastes being capped and sealed with the geosynthetic materials.

Figure 8. Maesglas West Landfill Area.

5 MONKEY ISLAND EMBANKMENT

The embankments at Monkey Island are built over soft alluvial clay of about 7 m thickness. To increase the rate of consolidation and to ensure that there was no long term settlement after construction geocomposite band drains (100 mm wide Mebra drains) were installed at 3.0 m centres through the foundation soils and a gravel drainage blanket was placed on the ground surface before the fill was placed.

The analysis of the consolidation settlement predicted a total settlement of 350 mm, after 3 months 300 mm settlement had been recorded. The observations suggested that the rate of settlement was negligible after 3 months and the road pavement and drainage work was allowed to follow on. No significant further settlements have been observed in this area.

6 CONCLUSIONS

- The uses made of geosynthetics have allowed construction in difficult conditions.
- The high strength geotextiles used in the load transfer platforms have performed as designed with no unexpected settlements of movements.
- The use of geomembranes to cap the areas of landfill has made it possible to build over these areas with minimal excavations of contaminated ground.
- The geocell mattress was constructed without sufficient care, had the mattress been built as shown by the manufacturer the design concept would have been satisfied. The failure of the system was entirely due to poor supervision of the works and a failure to correct problems as they developed.

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