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SLOPE ENGINEERING

GREAT HEAP FORWARD

A 16ha former quarry is being infilled to provide a platform for a new housing scheme

Recycling, sustainability and regeneration is providing Nuneaton with a monster embankment, explains Peter Assinder.

A disused quarry in Tuttle Hill, Nuneaton, East Midlands, is being regenerated to provide a new housing site for Redrow Homes (Midlands).

The former quartzite and diorite quarry, covering an area of about 16ha, ceased operation in the late 1990s. Midland Quarry consists of a main void, which is flooded, and a smaller partially in-filled shallow void. To regenerate the site for housing, the shallow void is being in-filled to provide a stable development platform, while the main void is to be left as an open body of water.

Warwickshire County Council (WCC) has played a major role in facilitating, promoting, technically approving and eventually taking ownership of this retaining structure.

The fill material was previously placed within the shallow void in two separate operations. The lower fill was compacted, verified by soil testing. However, subsequent infilling was not and this has been excavated, modified with lime if overly wet, and re-compacted.

The reclamation works include:

- Excavation of loose fill from the shallow void
- Removal by blasting of overhanging / excess rock
- Preparation and processing of materials on site for placement
- Building a 35m high geogrid reinforced soil slope between the shallow and main voids
- Placement of engineered fill behind the reinforced soil block to provide a stable housing development platform.

Redrow awarded the design and build contract to CA Blackwell (Contracts) and, together with its geogrid subcontractor Kerbline Civil Engineering, is building a 35m high reinforced soil embankment with a 1:1 slope face. The reinforced element comprises 75,000m³ of either 75mm down crushed rock or a typically three-to-one blend of this type of crushed rock and imported foundry sand.

The 20,000m³ of foundry sand has been supplied from another Redrow site in nearby Rugby. The Class 6F1/6F2 fill will produce a maximum 5% air voids at a moisture content between optimum and optimum -2%.

About 55,000m³ of site won rock is being used within the reinforced soil block. The quarry was formerly used to win two main rock types: a hard quartzite of Hartshill Sandstone Formation and a Greenstone Diorite (Spessartite Lamprophyre), which formed an igneous intrusion within the quarry.

Blackwell subcontracted out specialist blasting services to obtain the site-won hard rock fill. Peak particle velocities were not allowed to be over 6mm/s due to the presence of an old engineering works on the edge of the site, which was still occupied. Consequently, Blasting Services carried out a series of blasts using about 50 "hot-shot" detonations per blast, set to 5millisec firing intervals.

Blackwell's site workers are supported by a Pegson XR400 crusher and a Stehr SBF 24/6 stabiliser pulled by a John Deere tractor. The earthmoving fleet comprises Bell B30D dump-trucks, Komatsu D85EX dozer, Komatsu WA 380 loading shovel, 30t and 45t excavators, and a Cat CS663 vibratory roller with a mass-per-metre width of roller of 5.4t.

The stabiliser plant is being used on the clay backfill being placed behind the reinforced soil block where the moisture contents are occasionally elevated. An application of lime is used to produce a compactable material.

Redrow proposes to build about 270 units, all founded on the cohesive backfill constructed behind the reinforced soil block. The 270,000m³ of clay backfill is a Class 7A-selected cohesive fill. During construction, the quarry lake level had to be lowered by about 3m, from 58m AOD (Above Ordnance Datum) to 55m AOD. This was to remove water from the founding level and allow Blackwell to prepare the in-situ rock foundation in the floor of the shallow void.

However, the design of the slope structure allows for a water level rise to 82m AOD so future water level rises are taken into consideration at design stage. The finished level of the reinforced slope crest will be

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92m AOD, with a 5m wide berm constructed at 82m AOD. A 3m high unreinforced capping will give a finished level of 95m AOD.

An outline design for the reinforced soil embankment was produced by Arup / JMP Consulting in the form of an AIP (approval in principle) document in the pre-tender stages. Huesker provided assistance and advice to Arup / JMP about the design of such a high embankment and the selection of a certified geogrid.

WCC accepted the AIP and the adoption of the roads running throughout the residential housing development behind the reinforced soil embankment. But Blackwell's design and build contract with Redrow required, as a subcontract appointment, a specialist reinforced soil designer to develop and execute the design of the embankment, including the interface with the existing rock faces.

Blackwell employed P&S Consulting Engineers (Pascoe) as its geotechnical designer for the embankment. Pascoe used the Arup / JMP pre-tender design information, together with the site reclamation specification, to produce a rationalised layout using Fortrac reinforcement geogrids.

The analysis of the reinforced soil embankment had to satisfy a number of temporary and permanent conditions: during construction, during filling of the lake and the inundation of the engineered fills, and allowing for a rapid lowering of the water in the lake.

A particular concern was the post-construction movement of the embankment materials. Pascoe satisfied this condition by designing the embankment based on limiting the mobilised strains within the Fortrac geogrid reinforcement. Following a detailed survey of the quarry rock faces, Pascoe modified the layout of the embankment to work better with the rock contours, where practical, and modify the tie-in detail between the reinforced soil embankment and the north rock face to practically eliminate any rock excavation.

A short linear length of embankment was increased in inclination from 45° to 51° and rotated off axis by 35° to intersect the rock face in a near perpendicular alignment. This design change allowed a substantial reduction to the quantity of rock that would otherwise have been blasted from the northern face of the shallow void, which was close to an old brick-built engineering workshop with a weak roof.

A number of building constraints have been overcome by allowing the construction of a temporary ramp over one edge of the reinforced soil embankment to enable rock to be won from the sides of the main void. This allowed Blackwell to continue to win rock over the winter months while the building of the reinforced soil slope itself was in abeyance until the beginning of the traditional earthworks season in April.

Pascoe modified the layout of the embankment to work better with the rock contours

The temporary climbing shutter system used to support the face ensures a tight wrap construction

The design of the reinforced soil slope comprises layers of high strength polyester geogrid. A range of Huesker Fortrac geogrids are being used within the slope with ultimate tensile strengths ranging between 400kN/m and 55kN/m. The tail lengths at the base of the slope are 35m long decreasing proportionally to 8m near the top of the slope. A 3m high unreinforced 1:2 slope will sit on top of the reinforced soil block to allow easier installation of utilities.

The slope face is formed using a wraparound type structure. At Midland Quarry, due to the presence of the quarry lake, the risk of wave action on the slope face required the use of gabion stone, installed within the front section of the slope face for the lower two-thirds of the slope height. The upper third of the slope will comprise a topsoil face to aid vegetation above the water line.

A filter geotextile was placed between the gabion stone and compacted backfill, to reduce the risk of fines being washed through the gabion stone during wave action or fluctuations in the water level.

The wraparound face construction is being formed using a temporary climbing shutter system. This allows easy installation of safety rails on top of the shutter. As each lift is completed, the shutters are pulled out and placed on top of the completed lift. The shutters are kept in place using angle supports every few metres. There was initial concern that the relatively shallow face angle would not allow sufficient compaction of the gabion stone within the face. However, with careful placement, the gabion stone has so far been installed to a high standard.

Following completion of the reclamation earthworks, there will be a settlement period of two years, during which surface and internal settlement, pore pressures and deformation of the face of the wall will be monitored as part of the overall contract.

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