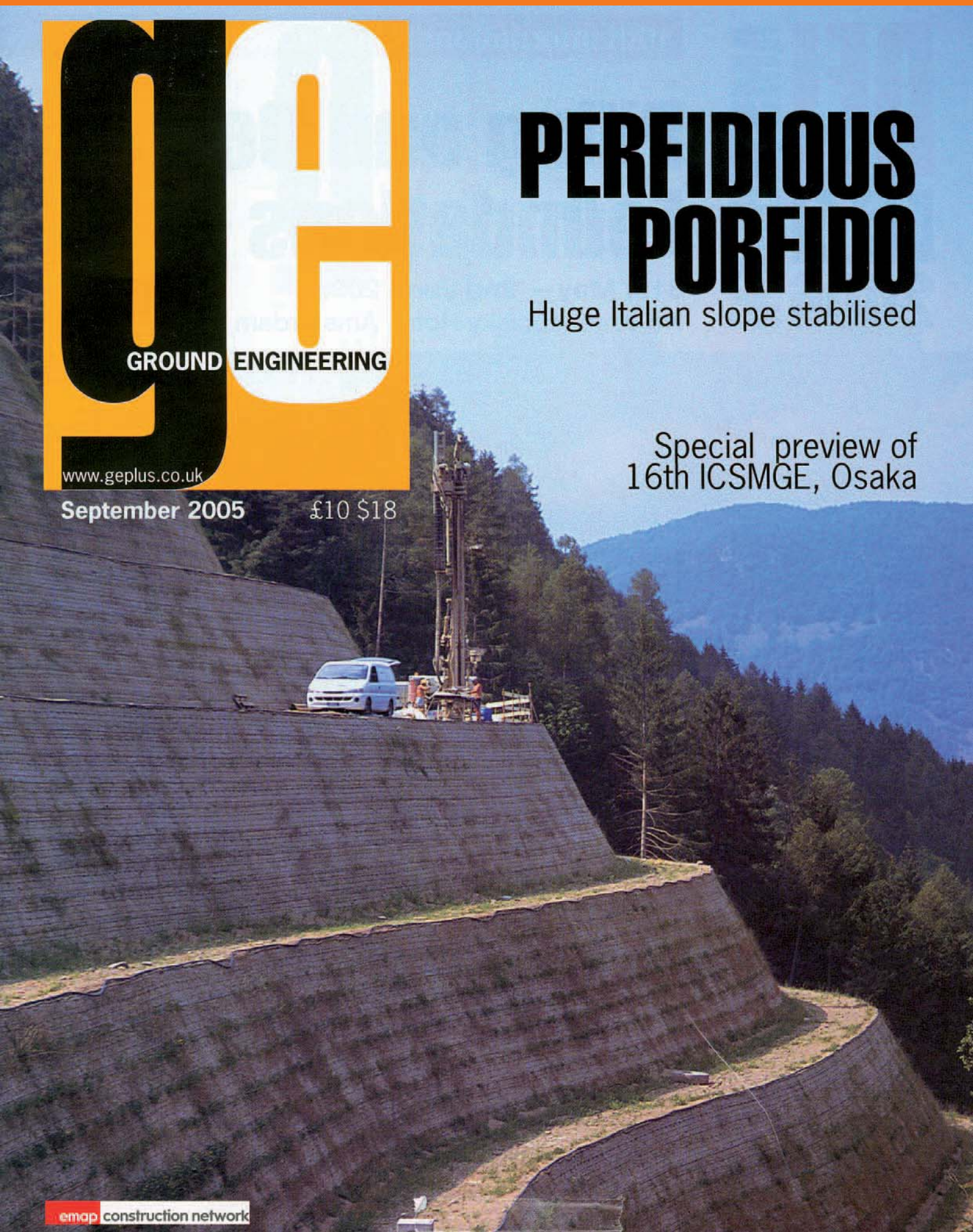
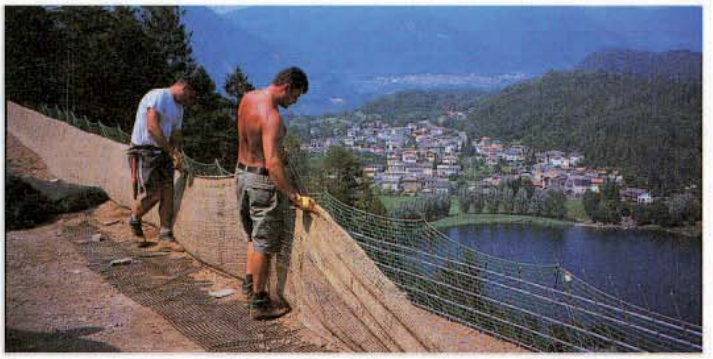
Fonte: Ground Engineering, September 2005

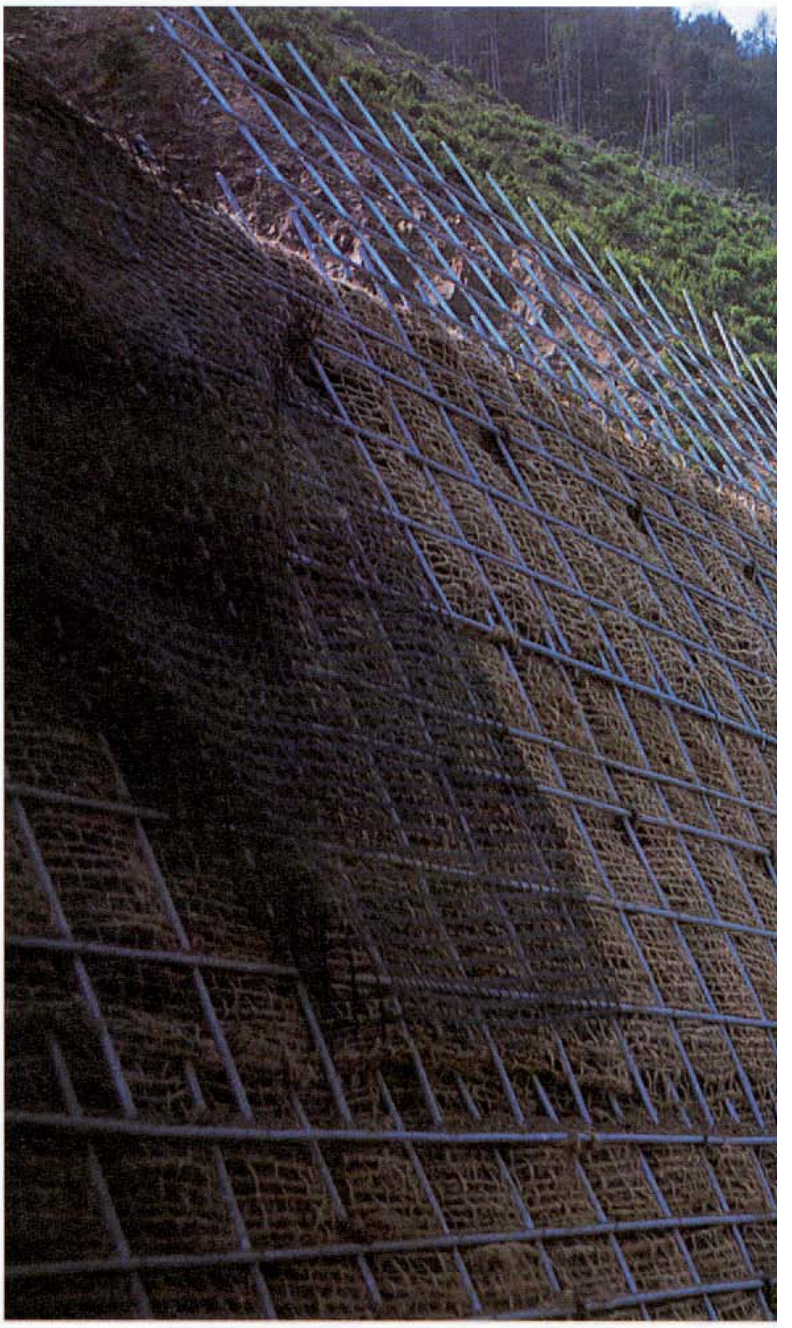


SLOPE ENGINEERING

BACK FROM THE BRINK

A huge stabilised slope is being built in northern Italy to prevent an "inland tsunami". Damon Schünmann investigates.





The province of Trento in north east Italy boasts some truly spectacular scenery. The landscape is broken up by the jagged peaks of the pre-Alps with winding mountain roads threading their way through a series of tunnels and valleys. Alongside the roads are apple orchards, vineyards and fields of maize.

On reaching the village of Lases, located by the beautiful lake which bears the same name, it is hard to picture a more peaceful and atmospheric landscape. Until recently however, behind the picturesque scenery lurked a grim, not to say spectacular threat. This was because the porfido (granite) slopes, which have been quarried for years to supply the red-brown pavement stone used in the region, had become perilously unstable.

Although frequent signposts warn of rock falls, and there are stabilisation schemes dotted along both road and rail routes, Lases' particular threat stems from the location of a quarry directly above the lake. Add to this a rock mass that engineers say had been destabilised by the quarrying, throw in a fault plane running directly underneath and a good dose of groundwater, and the full horror emerges.

Millions of cubic metres of porfido were in danger of cascading up to 200m down the slope into the lake, and that would have made a very big splash indeed. Perhaps so large, that worst case scenarios envisaged the resulting wave leading to the evacuation of shoreline inhabitants.

By the mid 1990s, monitoring showed movement on the slopes and the Province of Trento had to act.

Alfonso Dalla Torre, IGT Tecnostudio supervisor and the designer working on behalf of the province, says: "Monitoring of the slope started in 1996 and at that time there was movement of about 100mm to 200mm of about 1M.m^3 [of mate-

The 60m high slope at Lases has been benched and reinforced with geotextile to prevent a potentially catastrophic failure.

rial]. But there might have been five times more. Everything is due to the presence of water; water is the engine."

The first data was gained from a site investigation and it was clear something was wrong at a specific depth. Fortunately, a geologist noticed a "weakness plane" at the surface. Although this was not exactly at the area of movement, boreholes confirmed it was up to 20m thick, and went under an area that could become a slip plane if groundwater reached trigger levels.

In 2000, heavy rains caused a temporary acceleration of slide movement and investigators from Politecnico di Torino (the Polytechnic University of Turin) were called in. They produced an analysis of existing data to interpret the sliding phenomena and guidelines for a final design to stabilise to slope.

They also gave possible scenarios for slope failure and consequent cascading of material into the lake. The highest level of alert would have called for an evacuation of local inhabitants.

The resulting project is designed to reprofile the slope, removing the load from the top while reducing groundwater levels. To address the latter, site workers are installing about 3.5km of drainage system including 48 micro drains to prevent the increase of neutral pore pressure along the sliding plane.

This parcel of work includes 25 monitoring benchmarks and a network of five inclinometers, six piezometric tubes, three strain gauges and two magnetic settlement devices.

The work is part of the £5M (€7.4M) project won by a temporary association of contractors Profacta and Vezzola, although there was a significant rebate on this figure.

At the same time, a precarious 770,000m^3 porfido load is being removed from the top of the slope. And, crucially, the foot is being stabilised with 300,000m^3 of crushed porfido fill stabilised in a benched profile reinforced with geotextile.

The £276,000 (€407,000) worth of geotextile was supplied by Huesker and managing director Pierpaolo Fantini explains: "We are compressing the rock to increase friction and prevent sliding. The natural angle of the slope would not have been enough and the only way to make it steeper was with a stabilised slope solution."

Although the reinforcement structure is fairly typical, what makes it stand out is its sheer size: 60m high. Fantini says he has not heard of a taller one in Europe. The impressive height is reached in 12.5m benches, "a sophisticated design in terms of stability, prediction of movement and deformation", he says.

The primary reinforcement material for the slope is Huesker's 110kN Fortrac 110/30-20 with 45kN Fortrac 45/20-20 as secondary reinforcement for the benches. Both are supplied in 5m wide rolls.

The 60° sloping face of each bench is hydro-seeded with a mixture of seeds, water, fertiliser and glue. This will allow erosion-resisting vegetation to take hold among the Geojute degradable matting Lago is laying over the front of the slope, which will also retain smaller fragments of porfido within the benches.

Pierpaolo says slopes of this kind cannot be steeper than 65° as vegetation does not grow easily thereafter.

For speed, the front faces are profiled using zinc-coated steel wire mesh rather than temporary wooden formwork to give an accurate profile, with all the stabilisation work being done by the Fortrac geotextile.

Lago began work in January and was due to complete in August, by which time 200,000m^2 of geotextile will have been laid, creating a front surface of 12,000m^2.