Performance of High-Strength Geogrid In Reinforced Soil Slope and the Yeager Airport

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The extension of Runway 5 at Yeager Airport in Charleston, WV required the construction of a 74-m tall, 1 horizontal to 1 vertical (1H:1V) reinforced soil slope (RSS). The RSS was needed due to lack of the requisite contiguous land necessary to extend the length of the runway to meet Federal Aviation Administration (FAA) safety requirements. The RSS alternative was selected as a technically feasible and cost-effective strategy to lengthen the runway and allow installation of an innovative engineered materials arresting system (EMAS) at the end of the runway. Erosion control geosynthetic materials were used at the face of the RSS to provide an aesthetic "green" slope face to allow the RSS to blend into the natural hillside. The project was completed in 2007, and at the time of completion, it represented the tallest RSS in the world. A photograph of the project nearing completion is presented in Figure 1a to show the embankment being constructed; the geogrid being installed, and the erosion control facing.

(a) (b)

Figure 1: Photograph of RSS Nearing Completion (a) and During Construction (b)

In March 2015, nearly eight years after completion of the project, portions of the RSS failed. Forensic investigations and analyses were performed to assess the potential causes of failure. These investigations allowed an evaluation of the performance of the various engineered systems for the project. Two of the critical components related to the RSS were: (i) the soils used for the construction of the embankment; and (ii) the high-strength geogrid used as primary reinforcement. A photograph showing installation of the geogrid during construction of the embankment is presented in Figure 1b.

The backfill materials used for construction of the embankment included excavated native materials comprised predominantly of durable crushed sandstone. Materials immediately above and below the geogrid were to exhibit a maximum particle size of 15 cm. Other materials in the embankment between the geogrid reinforcement spaced at nearly 1 m vertical intervals could have particles as large as 61 cm. Because of these relatively aggressive conditions, construction-induced damage testing utilizing the selected geogrid reinforcement were performed prior to final material acceptance.

The project specifications identified the minimum ultimate tensile strength of the two geosynthetic reinforcements selected for design: (i) P-1 = 160 kN/m and (ii) P-3 = 123 kN/m. The selected high-strength geogrid for the project was a PVC-coated, high-tenacity polyester manufactured by TenCate Geosynthetics. The actual ultimate tensile strength (i.e., minimum average roll value or MARV) for both types geogrid exceeded the minimum project specifications. The minimum long-term design strength (T_a) after application of the relevant strength reduction factors was: (i) P-1 = 56 kN/m; and (ii) P-3 = 43 kN/m. Samples of both types of geogrid were carefully exhumed as part of the forensic investigation program. The results of wide-width tensile strength tests on the recovered specimens are presented in Figure 1. Results indicate that there was only minor strength loss in the geogrid despite the anticipated installation damage, nearly eight years of service in contact with the aggressive (i.e., large particle size) backfill soils and exhumation of the geogrid. In fact, the average tested strength values after exhumation were only slightly reduced from the original MARV and both high-strength geogrid materials still significantly exceeded the project design values for long-term design strength (T_a) and the calculated maximum mobilized tension (T_{actual}) in the geogrid, which was about 10kN/m. These results indicate that these flexible types of geogrid reinforcement products are extremely durable and retain tensile strength after installation stresses/damage and nearly eight years of service in an aggressive backfill.

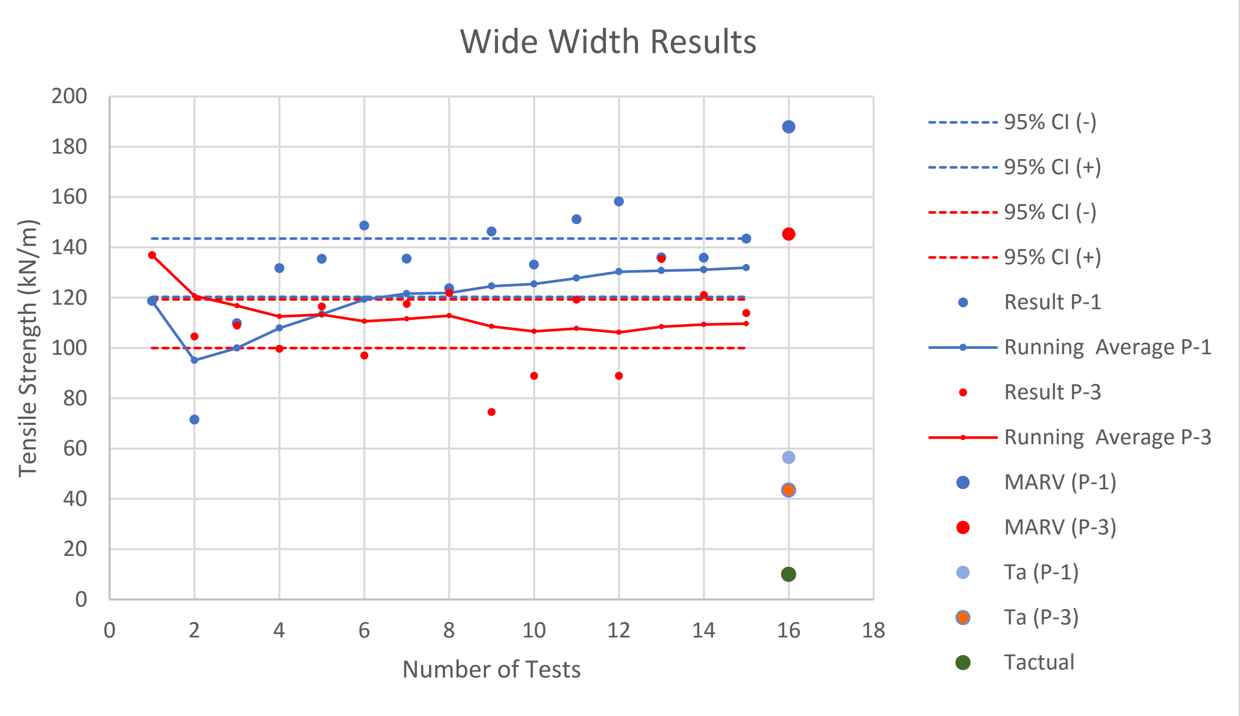

Figure 1: Results of Geogrid Testing of Exhumed Specimens