Good design hunting

Australian expressway poses geotechnical and environmental challenges

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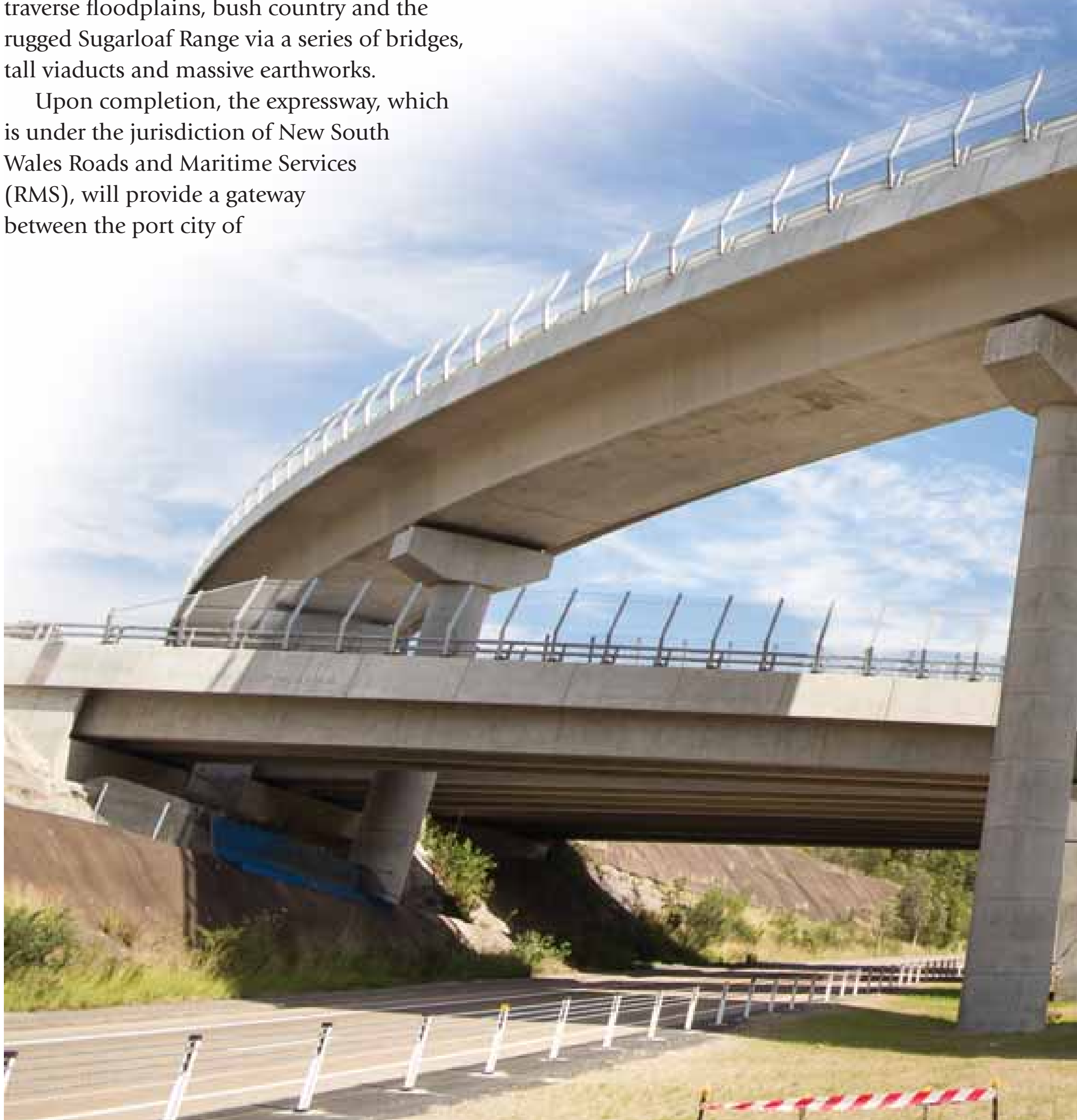
Contributing Author

The Hunter Expressway in New South Wales, Australia—the biggest single road construction project under construction in that state at $1.7 billion (AUS)—has met many milestones in 2013 and is heading toward completion by the end of December 2013, weather permitting.

A 25-mile, four-lane highway, the Hunter Expressway includes major interchanges that traverse floodplains, bush country and the rugged Sugarloaf Range via a series of bridges, tall viaducts and massive earthworks.

Upon completion, the expressway, which is under the jurisdiction of New South Wales Roads and Maritime Services (RMS), will provide a gateway between the port city of Newcastle and the Lower and Upper Hunter Valley mining and agricultural regions, reducing travel time between Braxton and Newcastle by about 25 minutes and reducing traffic on congested local roadways.

The Hunter Expressway Alliance—comprising RMS, Parsons Brinckerhoff, Thiess and Hyder Consulting—is responsible for designing and constructing the eastern 8-mile section of expressway from the Newcastle interchange on the M1 Pacific Motorway to just east of Kurri Kurri. The segment includes



two major interchanges and three viaducts up to 131 ft high and totaling 2,756 ft in length, as well as 16 other bridges.

The project team faced a number of challenges. Below ground, former mining activities and variable geotechnical conditions presented exceptional engineering and construction challenges. Further, a commitment to minimizing the disruption of natural and cultural resources required special techniques for nearly every aspect of the design and construction.

Respecting the project surroundings

While any major highway project significantly affects its surroundings, the project team on the Hunter Expressway was determined to keep impacts to an absolute minimum, especially because the highway passes through forested areas with protected flora species and historic sites. The alignment was shifted through the Sugarloaf Range and the highway elevated over deep

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gullies to tread more lightly on the landscape and enable wildlife to cross beneath. Changes were planned for area roadways to consolidate traffic onto the expressway, reducing net impacts. Strict clearing limits were imposed as part of the planning approval process. The total area cleared for construction on the alliance's section—including the highway elements, embankments, drainage basins and channels, precasting yard and construction access roads—has not exceeded 168 acres.

To ensure that construction followed strict guidelines, minimum offsets were developed to allow safe and practical working zones, and then a clearing limit was set around the road footprint. Three-dimensional modeling and geographic information systems were used to precisely map and monitor the area required for the design while ensuring the work was done within the environmentally approved limits.

Stabilizing former mines

Two coal seams at different depths directly below the viaducts and the Newcastle interchange had been mined using the "bord and pillar" method, which leaves underground tunnels and caverns supported—in theory—by pillars of unmined material. The oldest mines had been worked more than 120 years ago.

Mine areas were stabilized by drilling a series of boreholes into the voids and filling them with fly ash-cement grout. In all, more than 1,600 boreholes representing 155,000 drill meters were drilled and more than 7 million cu ft of ground was placed.

The boreholes were drilled from platforms to protect vegetation. Because the ground had to be stabilized well beyond the clearing boundary, a majority of the boreholes were drilled at an angle, increasing the length and complexity of the bore. Despite extensive geotechnical investigation, exact subsurface conditions at each location could only be determined after construction drilling. A video camera was lowered into each borehole to record the condition of the hole and the mine void. The observed conditions were compared to expected conditions, and adjustments to the treatment were developed as needed. More than 6,400 videos were assessed and more than 130 validation holes were drilled as part of the in-depth mine-void-fill validation process.

Strong solutions for weak soils

While mine stabilization addressed potential vertical movement of the ground, there was also a weak subsurface layer in the corridor that could cause horizontal movement if mines beyond the construction footprint were to collapse. Considerable effort went into identifying the zones vulnerable to movement. Where possible, viaduct piles were founded above the zone. Where piles had to be deeper, a double-cased eccentric piling design was used, with the center portion of the pile extending below the weak zone. Within the weak zone a ring of space between the pile and an outer sleeve allows horizontal movement up to 1 ft without damaging the viaduct formation.

In general, the soil and rock materials in the corridor have poor engineering properties. The formation at the east of the project corridor is dominated by tuffaceous material—essentially solidified ash from an ancient volcano—and coal/carbonaceous sedimentary rock. These rocks are moisture-sensitive, expansive, erodible and low-strength. Other areas are alluvial sediments: soft soils prone to settling. Much of the geotechnical investigation was focused on characterizing these areas, and in turn, much of the design effort went into developing solutions.

The terrain required numerous cuts through elevated areas. The steeper the walls of a cutting, the less the ground surface needed to be disturbed. The project therefore incorporated many retaining structures, such as reinforced soil walls and bored-pile walls, to reduce the construction footprint. In areas of weak or expansive soils, zoned embankments with stronger materials were used on the outer edges to limit volume change.

Milestones achieved

In June, the Hunter Expressway Alliance completed all structures at two major interchanges. At the Newcastle interchange, the

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completed structures include three super-T-girder bridges, a cut-and-cover underpass and a 492-ft-long incrementally launched flyover bridge across both arterial roads. The opening of the Pacific Motorway (formerly the F3 Freeway) southbound on-ramp was completed ahead of schedule in May 2013. Completion of the twin expressway overbridges and Buchanan Road bridges allowed the Buchanan interchange to open to traffic in March 2013. The signature exposed-aggregate ribbed wall panels are a feature on all the expressway overbridges.

All 30 new major bridges have been completed, with the installation of the modular expansion joints on the viaducts in June. There are myriad bridge types throughout the project, all chosen to suit the varied topographical conditions for their respective purposes.

A variety of pavement types was necessary to suit differing ground conditions. Concrete paving was completed on the mainline in March, with the successful implementation of stringless slipform paving on more than 2.5 million cu ft of roadway. Various surface finishes also were trialed for noise assessment, such as transverse and longitudinal tyning and the low-noise diamond-grinding trial in the vicinity of a populated area near Averys Lane.

Placement of 135,000 metric tons of dense-grade asphalt was completed in June. Placement of the deformation-resistant stone-mastic asphalt wearing surface was completed in August, despite the shorter days and colder weather.

In early July, high-voltage power was commissioned successfully from the M1 Pacific Motorway to Averys Lane. The communications/power installation includes an 11-kV backbone and an intelligent transportation system route throughout the corridor, which included more than 72 miles of underground conduit, 28 miles of underground power and fiber-optic cables, six large variable-message signs, infrared tracker loggers and three CCTV cameras mounted at the interchanges.

The Hunter Expressway presented a host of challenges, requiring complex design and construction solutions. Completion of the highway in a four-year time frame represents a significant achievement, providing the citizens of New South Wales with a transportation resource that will provide numerous benefits for years to come. **R&B**

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