

Gold Mine Stockpile Cover

Advantic Delivers 20 Years in 12 Days

Challenge

In a world's first application, Advantic engineers delivered a remedial structural system that enabled the safe and cost effective operation of a gold mine in Kalgoorlie, Western Australia by combining multi-material structural analysis, high tolerance manufacturing of structural polymer materials, focused "design for constructability" expertise, and construction installation support.

Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM), a joint venture between Barrick Gold Corporation and Newmont Mining Corporation, had determined that a 258 foot (78.5 meter) suspended conical roof structure (stockpile cover) required structural remediation works to critical steel members in order to meet business objectives of safe and sustainable production until the end of the life of the mine, currently projected for 2029. Site conditions included aggressive chemical attack coupled with damaging impacts by heavy earth-moving equipment.

The result was substantially reduced load carrying capacity of 80 foot (24 meter) long primary structural steel members undergoing compression and bending. Prior to Advantic's involvement, KCGM engineers undertook substantial engineering investigation and analysis of the structure to understand critical loads, member forces and the subsequent risks to the business, via the assistance of traditional external engineering consultants. A number of conventional material solutions incorporating steel, concrete, and grout had been proposed with costs ranging from \$8 million to \$13 million AUD, each requiring an extensive shutdown period to complete the remedial construction effort, which would dramatically impact the operation of the plant and its ability to meet its yearly production targets. The large capital expense, coupled with the impact to production and operations amid volatile mineral prices, required the client to re-think the path forward.

KCGM looked to Advantic for an alternative solution.



Figure 1 | Stockpile Cover Undergoing Jacket Installation

Conventional Material Solution: \$8 to \$13 million AUD

Advantic Structural Jacket Installation: \$3 million AUD

Cost Savings: \$5 million AUD 63% less than the conventional

Solution

Recognizing that little guidance exists in the successful design and integration of advanced material solutions in infrastructure applications, Advantic provided a staged engineering approach as an integral activity within the project delivery program.

Engineering Design

After reviewing all existing documentation and studies on the structure, Advantic formulated conceptual solution approaches including analytical design methodologies, preliminary first principle analyses, and basic material selection and characterization.

Preliminary design, however, does not end at the drafting table. A site visit enabled the Advantic team to meet with KCGM project

management team as well as potential installation contractors. A concise agenda enabled the rapid extraction of information concerning critical construction opportunities and limitations as well as to build relationships with key personnel.

Finite element analyses were performed on each critical structural member to investigate the optimized design geometries necessary to achieve minimum material performance requirements.

Each member was modeled independently, including an accounting of all field-surveyed damage and cross section reduction due to corrosion. Leveraging strong relationships with global adhesives manufacturers, Advantic performed a further experimental program to identify and characterize performance for the design geometries and load paths. The final design solution involved a system-level approach incorporating multiple material interactions: stainless steel, thin bond line structural adhesive, Advantic polymer core material, and field-installed thick bond line structural adhesive. The solution took the form of hundreds of Advantic ‘jackets’ installed to provide continuous reinforcement of the existing structural members. Due to the criticality of the work and nature of the design solution, being a world first, KCGM requested third party engineering peer review of the design effort and outcomes, which was undertaken by two independent design firms.

Advanced Manufacturing

Given that this was a first production run of a new product, Advantic rapidly developed the constituent material supply chain, manufacturing methods of multi-material assembly, and quality control program necessary for such a critical structural work. KCGM engaged a third party to oversee manufacturing quality control throughout the effort by reviewing the production processes and records by Advantic, as well as Advantic’s suppliers.

An aggressive delivery schedule was required for the project, which Advantic accommodated by internally expediting manufacturing through use of additional specialist tooling and drawing on flexibility in human resources to ramp up production. A total of 648 Advantic jackets were manufactured in less than eight weeks.

System Integration

KCGM desired to install the remedial jackets during a planned maintenance shutdown of the facility. Construction delays would result in production loss to the operation which would consequently add to the overall ‘total’ project cost, and as such the methods and speed of installation were critical to project success.

The jackets were designed to be structurally bonded to the prepared surface of the existing steel members with an advanced structural adhesive. Complicating efforts, the environmental conditions were anticipated to be extremely hot, dry, and dusty, requiring substantial forethought on adhesive application due to potential for shortened cure time and surface contamination detrimental to bond strength. Further to this, the client required the installation solution to be as simple as possible to enable traditional construction resources to undertake the works, without any specialist knowledge or



Figure 2 | Corroded and Damaged Steel

Why Advantic Core?



- Provides 4,000 lb/in² (27 MPa) compressive strength at 35 lb/ft³ (560 kg/m³) density
- High shear strength transfers load around damaged areas
- Impermeable to moisture
- Will not corrode
- Strong interface with structural adhesives
- Readily machined to tolerance
- Accommodates rough handling in the field during construction

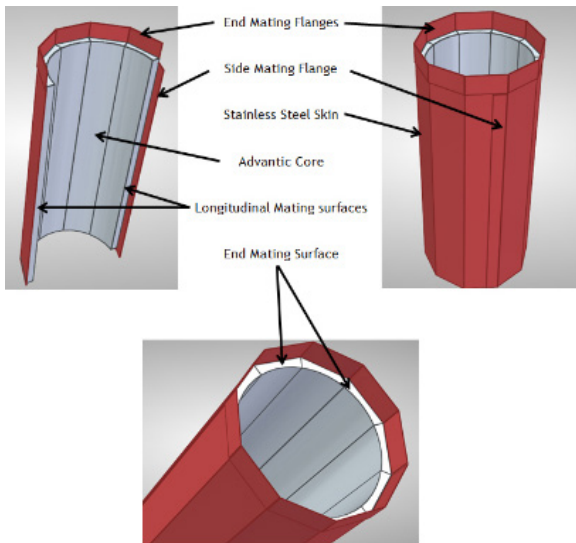


Figure 3 | Advantic Jacket Schematic



Figure 4 | Advantic Jacket Ready for Installation

training in adhesives and polymers.

Advantic sought to overcome these challenges via the development of an extensive installation Work Methodology document complete with step-by-step instructions with three-dimensional CAD renderings and photographs for each step. As part of the Work Method preparation, Advantic fabricated a full scale model section of the existing structure on their manufacturing floor and prototyped the installation method.

The Work Method document became part of the tender package for the works, and was a source of constant reference during installation and facilitated in briefing of the contractor's staff.

Installation

Construction management during processing plant shutdowns is often a complicated dance of competing priorities, and requires leadership to provide rapid on-the-fly response to real-time challenges and work flow conflicts across multiple trades and activities. Advantic personnel, with significant experience in construction project management and large works installation, provided support to KCGM's project management team as well as the contractor's leadership to ensure the project and design objectives were delivered in accordance with the client's requirements and design intent.

Prior to commencement of work activities, Advantic responded to contractor inquiries and alternatives requests. Onsite meetings prior to the shutdown allowed Advantic to provide training for the contractor's leadership team, and to work through project scheduling, logistics of personnel and equipment, and trial installations at the project site.

During the shutdown Advantic worked closely with the KCGM's project management team as well as the contractor to prioritize, train, appropriately resource the round-the-clock installation work crews, and to ensure the documented quality of installation.

Advantic reviewed and recommended modifications to the work method, improvements in environmental sealing techniques, and instructions for hot work remediation of severely damaged steel sections prior to jacket installation as required.

With Advantic's holistic project support, the critical installation was completed on time and on budget, enabling KCGM to remediate, strengthen, and safely manage a critical asset for sustainable and safe production over the coming 20 years.



Figure 5 | Empty Stockpile Cover Ready for Jacket Installation

Value

Advantic provided a solution where no solution employing conventional materials and alternatives could be developed. In over two years of study KCGM had been unable to find a solution that satisfactorily achieved the balance between addressing the level of risk the asset presented to the operation and its appropriate cost to address these risks. In summary, the Advantic solutions provided,

- Valued \$5 million AUD cost savings, a 63-percent reduction over the nearest competing feasible solution employing steel or concrete.
- Provided installation within a scheduled shutdown window, thereby enabling execution without any disruption to the operation or impact to production.
- Advanced structural analysis and experimental validation as integral to the product delivery.
- Experienced construction phase services including onsite construction installation support, contractor training, and active participation and leadership in contractor daily work activities.



Figure 6 | Nonlinear finite element analysis stress field for existing damaged raking strut under design