The following paper focuses on Minera Zaldivar's need for a safe cover structure for their operations, that also enabled a conveyor to transport material, and how Geometrica's proposal was able to comply with their requirements in an efficient and cost-effective manner.

Keywords: structural cover, mine cover, conveyor, cooper mine, pile cover, dome.

Introduction

The Barrick Zaldivar mine is an open-pit, heap-leach copper mine in Region II of northern Chile at an elevation of 3,300 meters, approximately 1,400 kilometers north of Santiago and 175 kilometers southeast of the port city of Antofagasta. In 2006, Zaldívar produced 307 million pounds of copper, with reserves estimated at 5.7 billion pounds.

The mine uses conventional methods of open-pit mining: Pure cathode copper is produced by three stages of crushing and stacking the ore, followed by heap leaching and bacterial activity to extract copper from the ore into solution. A solvent extraction and electrowinning process then removes the copper from solution and produces the cathode copper. A flotation plant also recovers copper contained in the fine fraction of the crushed ore.

In 2006, an existing A-frame structure that covered copper ore from the mine's secondary crushing operation was damaged beyond repair. The material delivery configuration of this original structure had the conveyor carrying incoming ore directly over the low roof to drop ore into the building at its peak, and ore trickling from the sides of the conveyor had accumulated on the roof, overloading it.

A better solution had to be found, and fast: First, the Chilean Commission doesn't permit uncovered piles of this type since the extremely fine material leads to serious pollution problems. Second, Barrick Zaldivar is very concerned about worker safety, and the amount of dust created by the uncovered pile was not acceptable. Finally, some amount of copper was lost in the dust generated by the winds of the Andes.

Dome specifications for covered secondary ore storage

Covered area	12,155 m2
Plan area	7,088 m2
Base Diameter	95 m
Height from base to apex of dome	40.22 m

Weight of dome structural elements	210 t
Weight of dome cladding	80 t
Structural material	Galvanized steel with aluminum hubs
Number of tubes	34,000
Number of connectors	10,000
Installation of structure	90 days
Installation of cladding	59 days

The major issues faced by Barrick Zaldivar in designing a new structure included:

- Location challenges: The extreme altitude and the fact that much of the construction would take in the winter posed special challenges to worker health and safety.
- Environmental considerations: The operation of the ore pile creates large amounts of dust, making this a potentially hazardous environment to work in.
- Design requirements: The new cover had to be built while the ore pile remained in operation, making it impossible to use temporary internal supports during the building process. The design would have to eliminate any issues arising from ore falling off the conveyor, and the structure would also have to able to withstand the very large snow loads that occur in the high Andes (estimated pressures in the range of 3.0 kPa).

Barrick Zaldivar contracted with SKM-Minmetal, a leading global mining engineering company with a strong presence in Chile. SKM had previous successful experiences with metal domes and drew up specifications for a dome large enough to cover the conveyor's approach and drop point to avoid any possibility of conveyed material damaging the cover.

Selected Solution

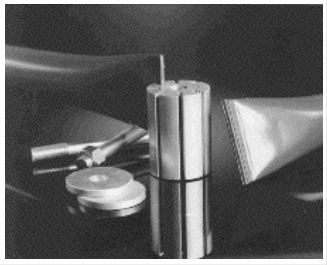

Figure 1. Geometrica joint system

Geometrica best met Barrick Zaldivar requirements for several reasons: First, the company has considerable experience with domed structures, having built several for mines in Chile (Mantos Blancos, Escondida, Pucobre, and others). Second, the Geometrica Economic and Technical Proposal provided a lower price than competitive structures, as well as a fast installation program and the ability to complete the installation while the pile was working.

Figure 2. Purlins provide a uniform surface for cladding support.

The Geometrica System is made up of structure and cladding. The structure was assembled from prefabricated galvanized steel tubes joined together by slotted aluminum hubs. No welding was required because the connection between tubes and hubs is mechanical. (See Figure 1.)

Geometrica's slotted aluminum hubs join tubes together in an efficient system that requires no welding.Tubes slide easily into

the hubs, and the parts are then secured with steel washers screwed onto a threaded steel rod that goes through the center of the hub.

To compensates for the flared ends of the tubing and provide a flat surface for attachment of the cladding, purlins were attached to the outer side of the tubes as shown in Figure 2. Like the tubing, purlins were prefabricated to the design of the dome. They were pre-drilled square galvanized steel RHS fixed to the tubes with self-drilling screws.

Cladding consisted of corrugated galvanized sheet metal panels plus FRP panels to admit light to the interior. Other cladding components included galvanized ridge caps, rain gutters and skirt flashings.

Geometrica's steel domes are always galvanized, which eliminates maintenance compared to painted steel. As with all Geometrica structures, parts were individually marked and packed in crates in reverse order from the way they were assembled. In the field, parts were accessible in the exact sequence in which they were required.

Construction start.

Crates weighed less than three tons to facilitate handling with a forklift or hydraulic jacks. This job required 15 crates that arrived in five shipments during April and May of 2006. Shipments originated in Monterrey, Mexico and arrived via Alta Mira, and Iquique.

Construction

The dome structure was erected entirely by Zaldivar's crews under the guidance of two Geometrica technical consultants, one for structure and one for cladding. Because many of the crew had worked on a previous Geometrica projects at El Tesoro and Escondida mines, their experience helped the project move along faster.

Construction started atop a concrete foundation. One of the major challenges during erection was that the ore pile was in use and operations were extremely dusty. Workers wore dust masks, and conveyor operators cooperated by slowing the conveyor when wind created especially hazardous conditions.

With no welding required, the job proceeded smoothly. The geometry of the Geometrica dome is inherently strong even before construction is complete, which proved important: At one point an earthquake interrupted installation of the cladding, but resulted in no damages or injuries.

Geometrica's structural components were checked for quality at the plant, and Geometrica's foremen visited the site to train the mine's laborers in making their own quality inspections of the completed structure. All "spiders" were inspected.

Results

The dome was built without having to stop the operation of the mine, and the completed dome covers the conveyor so that any ore slipping from its sides will fall inside the dome or slide harmlessly down to the ground outside. This dome can also support the heavy snow loads typical at this high Andes location.

Although low temperatures (an average high of 14°C) and dust burdened the construction, the entire dome was completed in 149 days, within the planned schedule. Barrick Zaldivar is satisfied with the results. Everyone credits the close working relationship between Barrick Zaldivar, SKM and Geometrica – as well as the inherent advantages of this type of dome structure – for the project's success.

Dome was built over operating stockpile.

Internal view of the dome with skylights.