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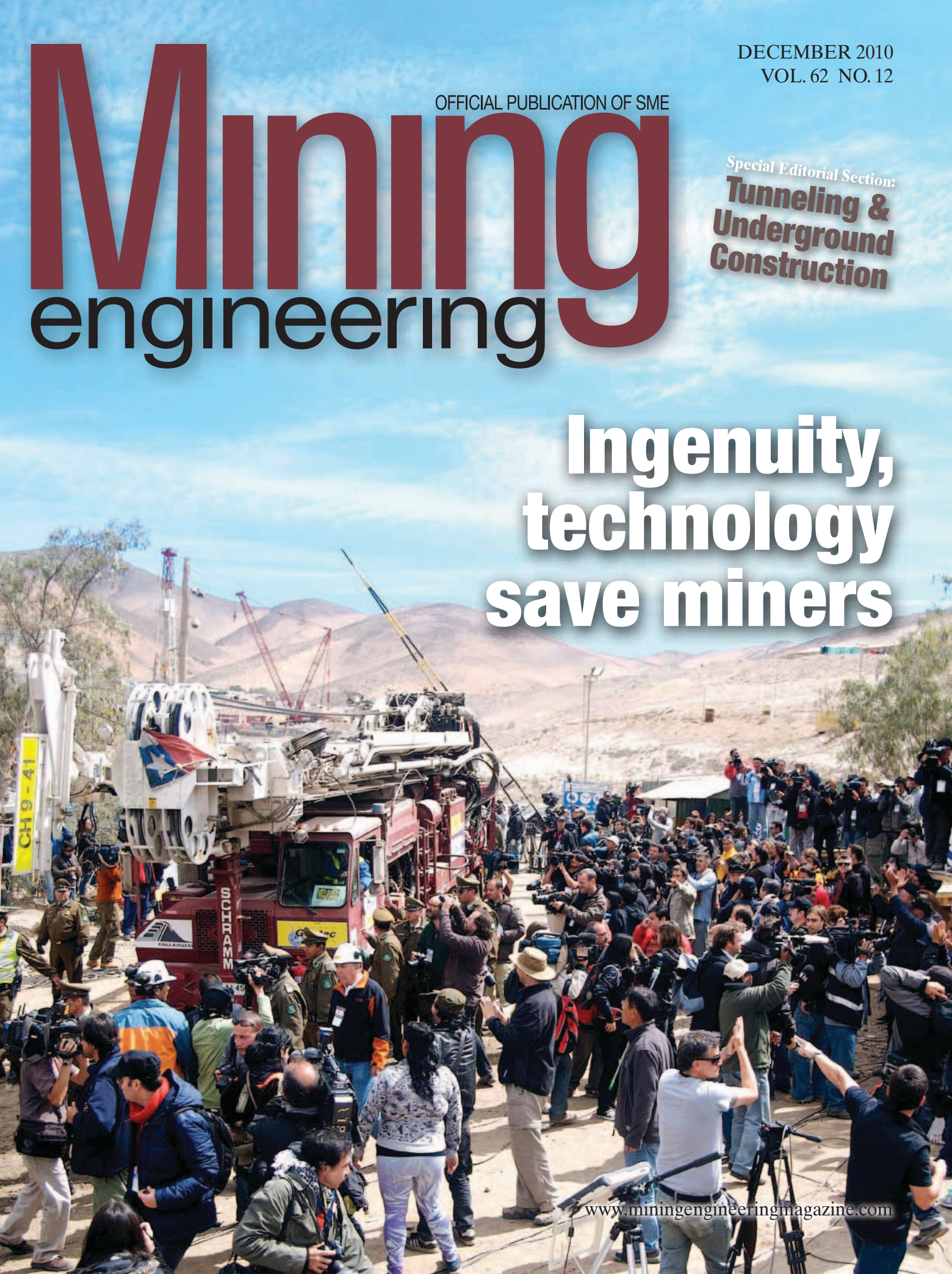
Special Editorial Section:
Tunneling & Underground Construction

Ingenuity, technology save miners



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Cover Story
For 69 days, 33 miners at the San José copper and gold mine in Chile waited as rescuers on the surface devised a strategy for bringing them out. This first-of-a-kind rescue attempt involved a multinational group of experts and a high level of technology. William Gleason examines the technology and ingenuity involved in the rescue beginning on page 27. Highwall mining is a method of extracting coal in opencut, trench and contour mining. Since its origination in the Applachian region in the 1940s, the design of highwall miners has improved, making this extraction method more popular, page 31. The Sudbury, Timmins, North Bay and Thunder Bay regions of northern Ontario have become the place for mining industry suppliers. More than 500 companies employing nearly 23,000 people are located there, page 37.

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An October to remember;

Chilean rescue and Gotthard Tunnel gave us something to cheer

by Nikhil C. Trivedi,
2010 SME president

October was an extremely eventful month for our profession. It was a month of triumph, punctuated with cries of "eureka!" from the high desert of Chile and the mountains of Switzerland.

It was a month of emotional highs and lows. Of anxiety, despair, prayers, jubilation and celebration. It was a month in which the entire world got involved in our profession. It was a month when there was a unified, worldwide sigh of relief. For those several days, our colleagues in Chile and Switzerland were the heroes that young adults looked up to. It was a brief moment when the mining and underground construction industries shone brightly, although the real heroes were literally in the dark and far away from daylight and sunshine.

I am referring, of course, to the miracle rescue of 33 miners in Chile that proved to be a testimonial to the mining profession's technological prowess as well as to the ever-present guiding light of Saint Barbara, the patron saint of mining. Mining engineers from around the world responded to the crisis and went to Chile to provide their assistance and expertise. When the call came to the community of mining professionals, not one, not two, but three distinct drilling technologies were deployed, and all three were successful in demonstrating to the world that we practice the best technology, and that we can put it to use on short notice and under the most adverse circumstances. It was this commitment and technology that we reached the emotion-filled moments when, one by one, all 33 miners came out from the collapsed shaft after more than two months of being buried alive.

I am also referring to the "eureka" moment that took place beneath the Swiss Alps. At roughly the same time that the three drills were racing to rescue the miners in the Chilean Atacama Desert, an awesome tunnel boring machine (TBM) was coincidentally drilling away horizontally under the Swiss Alps on the 57-km (35-mile) Gotthard Tunnel project, the longest tunnel in the world.

Both events were full of anticipation and expectation and both were successful in achieving their goals. The giant TBM brought a distant dream conceived decades ago to reality. Our colleagues in the UCA Division of SME can perhaps attest to the exhilaration one feels when a TBM cuts through the last bit of wall. But I can only imagine the sight and sounds under the Alps on that day, and I bet that they were no different, or no less exuberant than those when the two railroad crews met up in the desert at Promontory Point, UT a couple of centuries ago. Just as that railroad opened up trade and commerce and habitation between Saint Louis, MO and San Francisco, CA, the new tunnel will do wonders for travelers and traders between Zurich and Milan, and other destinations in central Europe and Italy.

Mining professionals and underground construction professionals do not get their fair share of recognition. However, we got a huge dose of euphoria during that short, eventful week in mid-October. And now, it is up to us to celebrate that technological accomplishment on both continents and to resolve to do even better next time around. We certainly hope that no miner ever gets trapped underground the way those 33 did. But, if history does repeat itself, we must resolve to be united as a community of professionals to carry out an equally elegant and flawless rescue, anywhere in the world – only faster. We also hope that the Gotthard Tunnel succeeds in realizing the dream of the original entrepreneurs and that it becomes a shining example of the myriads of technologies that go into underground construction. It should become a beacon for similar public works initiatives in other parts of the globe. Lastly, we must continue to remind ourselves, and those young adults who are still impressed with those events of mid-October, that ours is a profession worth joining. We owe it to ourselves to keep celebrating our successes.

It is my custom to end these columns with expressing my gratitude to you all for allowing me to lead the SME. SME members are the most skilled and talented mining and underground construction professionals I have ever come across, and I am proud to serve as your president.

So, let us all celebrate the holiday season … and our successes.

Note: At the SME Annual Meeting, on Monday, Feb. 28, 2011, during the keynote session, we will be honoring several of the people and companies that were intimately involved with the San José Mine rescue operation. I invite you all to be there and to celebrate their success. ■

EPA threatens to rescind water permit for Spruce No. 1 Mine

FOR THE FIRST time in the agency's 40-year history, the U.S. Environmental Protection Agency (EPA) could revoke a previously issued water permit.

The water permit for Arch Coal's proposed Spruce No. 1 Mine in Logan County, WV is in jeopardy of being revoked. The project could be halted following comments from the EPA's Regional Administrator for Region 3 who said the project should be stopped because it "would likely have unacceptable adverse effects on wildlife."

The U.S. Army Corps of Engineers approved the Spruce No. 1 Mine more than three years ago.

The Obama administration has asked a federal judge to give the EPA until Feb. 22, 2011 to make a final decision whether to withdraw a previously issued permit for Spruce.

The Wall Street Journal reported that a representative from Arch said that if the EPA vetoes the Spruce water permit, "every business in the nation would be put on notice that any lawfully issued permit — Clean Water Act 404 or otherwise — can be revoked at any time according to the whims of the federal government."

The EPA has not proposed blocking the mine outright, but Arch Coal contends that canceling the permit allowing it to dump debris in streams would effectively kill the project, which would employ about 250 people.

The Spruce No. 1 Mine was originally proposed as a 1,259-hm^2 (3,113-acre) extension of Arch's Dal-Tex Mine in 1998. A federal judge blocked the permit in 1999. The $250 million Spruce No. 1 project would encompass 922 hm^2 (2,278 acres).

The EPA argued, "data and information have become available since permit issuance, that have confirmed the EPA's earlier concerns regarding the potential for adverse water quality impacts, the potential for cumulative impacts, the availability of further avoidance and minimization measures and problems with the proposed mitigation measures."

However, the EPA said it will consult with Arch, the U.S. Army Corps of Engineers and West Virginia officials to discuss potential ways to minimize the project's impact. ■

Argentine judge grants exemption to Barrick

PRODUCTION OF Barrick Gold Corps.' Pascua Lama Mine will not be stopped because of an Argentine glacier protection law.

San Juan federal judge, Miguel Angel Galvez, ruled that key articles of a glacier protection law cannot be applied in San Juan province, where Barrick Gold is building the Pascua Lama Mine, *Daily La Nacion* reported.

Mining industry analysts had warned that the new law could hinder construction of the Pascua Lama Mine, although the company said the orebody it has permission to mine does not lie under a glacier.

The glacier protection law bans mining and oil drilling on glaciers and the areas surrounding them.

Galvez, ruling on a complaint presented by mining industry groups, suspended the application of six key articles of the law in the Andean province.

Galvez said provincial governments had the constitutional right to decide how to manage their natural resources. The judge suspended the article banning activities that could affect glaciers as well as the part of the law that defines glaciers.

President Cristina Fernandez vetoed a similar law two years ago on the grounds it would hamper growth of provincial economies, causing controversy in a country where anti-mining sentiment is strong. The new law was passed in September, *Reuters* reported. ■

Alaska takes over waste water discharge permits

MINES IN ALASKA will now deal with state authorities when it come to waste water discharge permits rather than the U.S. Environmental Protection Agency (EPA).

The Anchorage Daily News reported that as of Oct. 31 the change was made from federal to state oversight because in October 2008 the EPA turned over its Clean Water Act authority for waste water permitting and enforcement to the Alaska Department of Environmental Conservation (ADEC). The state agency began taking over its duties in phases — it already oversees waste water from seafood processors, fish hatcheries and many sewage plants. Next year, ADEC will take over waste water permits for oil and gas projects.

Alaska is one of the last states to take over waste water permitting from the federal government. In 2005, during the administration of Gov. Frank Murkowski, the Alaska legislature authorized the ADEC to apply to the EPA to take control. Then-Gov. Sarah Palin formally applied for the transfer of authority and the EPA approved the request in 2008. The legislature boosted the ADEC budget so the agency could add 13 positions to handle its new duties. ■

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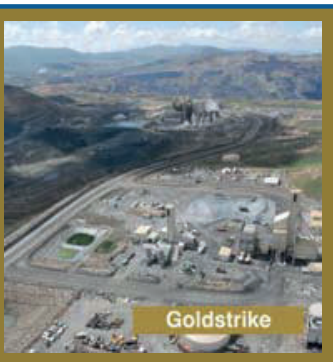

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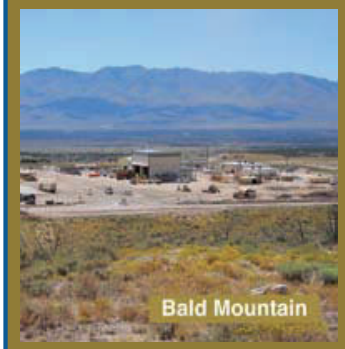

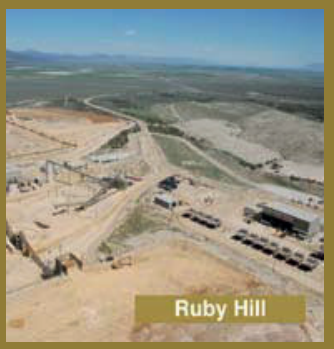

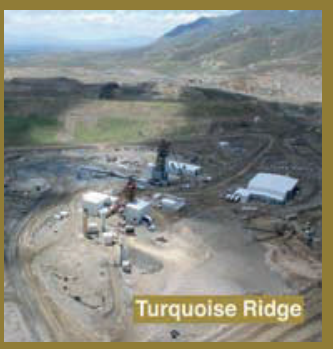

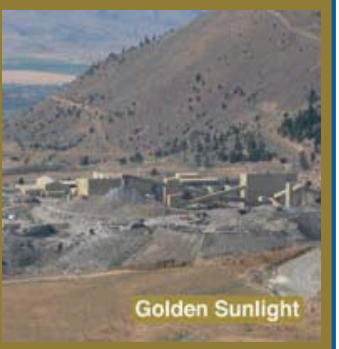

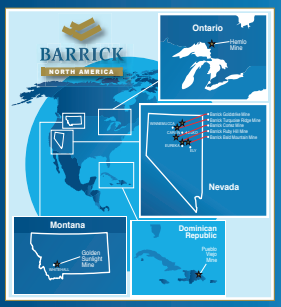

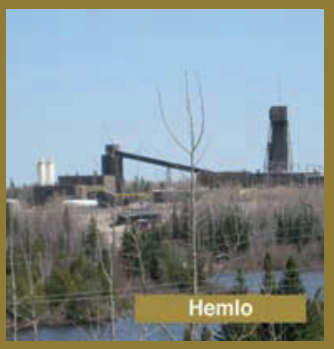

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Navajo Mine permit suspended;

District judge voids mine permit that was issued in 2005

A PERMIT to expand mining activities of the Navajo Mine on Navajo land in New Mexico that was issued by the federal Office of Surface Mining Reclamation and Enforcement in 2005 was voided by federal Judge John L. Kane of U.S. District Court for the District of Colorado.

Kane called for a more thorough review of the project's impact on the environment and cultural sites when making his ruling. He ordered a reassessment of the proposed expansion.

In 2005, BHP Billiton, which operates the mine, received the permit for the expansion of mining by 1,940 hm^2 (4,800 acres) after an environmental assessment found that the proposal would have no significant environmental impact, *The New York Times* reported.

Navajo groups have complained of lax oversight of coal operations, one of the largest sources of revenue for the Navajo Nation. Judge Kane said the federal agency did not comply with the requirements of the National Environmental Policy Act to fully assess potential environmental, cultural and economic effects, like disturbing burial grounds or having to relocate residents.

The judge also ordered "meaningful public notice," like radio ads in English and Navajo, to ensure public participation in decisions on mine permits.

The Navajo Mine feeds the Four Corners Power Plant, also on Navajo land in New Mexico. The U.S. Environmental Protection Agency (EPA) announced that it planned to require the plant to install $717 million in pollution controls to curb emissions.

The court decision came in response to a lawsuit filed by two conservation groups,

Christopher J. Holmes, a spokesman for the Office of Surface Mining Reclamation and Enforcement, said the agency's legal staff was reviewing the decision.

Officials from BHP Billiton said in a statement that they were reviewing the judge's order and had temporarily suspended mining operations in an area covered by the disputed permit.

"At this time, BHP Billiton does not know the specific impacts this decision may have on the Navajo Mine," the statement said. ■

Prosperity Mine halted;

Government cites environmental concerns

THE PROSPERITY gold and copper mine, an $815-million project that would have created hundreds of jobs in British Columbia, was blocked from moving forward by the Canadian government. It said the proposed project would devastate an entire ecosystem around the environmentally and culturally sensitive Fish Lake.

"We believe in balancing resource stewardship with economic development," federal environment minister Jim Prentice said in a written statement. He was explaining the government's decision to reject a proposal for the openpit Prosperity Mine in B.C.'s Chilcotin region, about 125 km (77 miles) southwest of Williams Lake. "The significant adverse environmental effects of the Prosperity project cannot be justified as it is currently proposed."

The B.C. government had already given its full approval for the Taseko Mines project and Premier Gordon Campbell had been pushing Ottawa for the final green light.

The $815-million Prosperity Mine would have created hundreds of new jobs in the economically struggling region. One estimate suggested it would create 60,000 person-years of employment and generate billions of dollars in new government revenues. The company has already spent $100 million and 17 years on the project to get approvals.

Taseko president and chief executive officer Russell Hallbauer called the federal government's decision to turn down its proposed copper-gold mine disappointing for the economy of Williams Lake, B.C., as well as for Taseko.

"Opponents of Prosperity say they are not against mining, only this particular proposal," Hallbauer wrote in an open letter delivered to newspapers across that province. "They say they are not against job creation and economic opportunity; their only concern is that it be done with the highest environmental integrity. On this point, we agree."

Hallbauer said that he wants discussions with both levels of government to talk about options for moving the project ahead in a way that is acceptable. ■

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Caterpillar to acquire Bucyrus;

$8.6 billion deal will move Cat's mining headquarters to Milwaukee

SHOWING AN unprecedented faith in the future of the mining business, Caterpillar announced that it has entered into an agreement to acquire Bucyrus International for $8.6 billion. It is the largest acquisition ever for Caterpillar and is based on Caterpillar's key strategic imperative to expand its leadership in the mining equipment Industry.

The deal "positions Caterpillar to capitalize on the robust long-term outlook for commodities driven by the trend of rapid growth in emerging markets, which are improving infrastructure, rapidly developing urban areas and industrializing their economies," Caterpillar said in a statement.

Under the terms of the transaction, which has been approved by the boards of directors of both companies, Bucyrus shareholders will receive $92 per share, $7.6 billion in aggregate consisting of all cash. The transaction represents an implied premium of 32 percent to Bucyrus' share price as of Nov. 12, 2010. Caterpillar will fund the acquisition through a combination of cash from the balance sheet, debt and up to $2 billion in equity. The transaction is expected to close in mid-2011. Caterpillar intends to locate its mining business headquarters in south Milwaukee, WI, where Bucyrus headquarters is currently located, and maintain the Bucyrus brand for the principal Bucyrus legacy products.

Bucyrus recently announced that it would be adding jobs to the facility as it was ramping up to meet demand for its products.

"For several years, mining customers have been asking us to expand our range of products and services to better serve their increasingly complex requirements," said Caterpillar chairman and chief executive officer, Doug Oberhelman. "This announcement says to those customers, we heard you loud and clear. It is a strong statement about our belief in the bright future of the mining industry. Our strategy calls for disciplined investment in attractive industries that value our product and service delivery model.

"Our performance through the

(Continued on page 26)

New coal mine in Illinois;

White Oak Mine #1 is expected to open in 2012 or 2013

ILLINOIS GOV. Pat Quinn announced the approval of a new underground coal mine to be opened in Hamilton County. The new mine will create 300 construction jobs and 350 permanent jobs and provide a significant economic boost to southern Illinois.

"The project will mean hundreds of jobs for Hamilton County and southern Illinois," Quinn said. "Our efforts at coal development, encouraging cleaner coal technology and finding markets for Illinois coal mean thousands of jobs for Illinois workers and a huge boost to the regional economy."

The White Oak Mine #1, operated by White Oak Resources LLC, will be located northeast of McLeansboro. The company will invest more than $400 million in construction of the mine, which is expected to open in late 2012 or early 2013. Projected annual production is 6.8 Mt/a (7.5 million stpy) of coal. The White Oak Mine #1 is the first of four the company has proposed for the area.

Development of the new mining operation will create 300 construction jobs and approximately 350 permanent jobs once the mine is in full production. Its annual payroll is expected to exceed $5 million. The Illinois Department of Commerce and Economic Opportunity indicated that, for every coal mining job in Illinois, seven indirect jobs are created, meaning the White Oak Mine #1 is expected to help support approximately 2,450 indirect jobs.

"While the coal mining industry has been particularly hard hit by the recent economic recession, White Oak remains committed to developing its reserves in Hamilton County," said White Oak president Scott Spears. "With these permits now in hand, we look forward to the next steps in the process of building a world class operation that will not only bring high paying jobs to the area, but also bring additional high quality production to the Illinois Basin."

The Illinois Department of Natural Resources (IDNR) Office of Mines and Minerals approved the permit for White Oak Mine #1 in October.

The IDNR Office of Mines and Minerals reported Hamilton County will receive $6.2 million in mining royalties during the mine's first five years, while the mine operation will also mean new tax revenues supporting state and local services. ■

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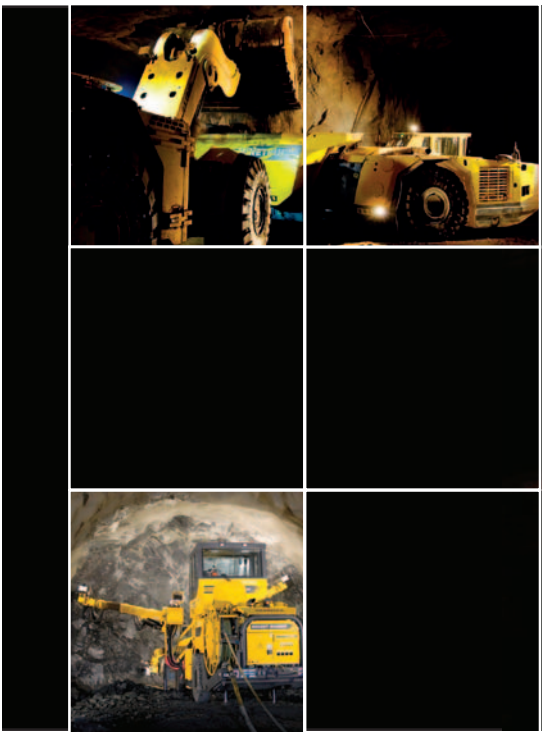

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BHP Billiton's bid rejected;

Canadian government blocks $39 billion bid for Potash Corp.

BHP BILLITON'S $39 billion bid of Potash Corp. was rejected by the Canadian government, which said the deal would not benefit the nation.

Following government guidelines, Industry Minister Tony Clement gave the Anglo-Australian miner 30 days to come up with additional proposals that might make its offer for Potash Corp., the world's largest fertilizer producer, more palatable to Canada, *Reuters* reported.

Given weeks of negotiations between BHP and Ottawa about how the mining giant should shape its offer, the biggest takeover bid of 2010, a new proposal seems unlikely.

Potash Corp. repeated its view that the $130-a-share offer was "wholly inadequate," and analysts said the shares were unlikely to tumble back to the pre-offer levels around $112/share, given a rising market and strong fundamentals in the fertilizer market. Even without any bid at all, the company's shares are expected to rise in the medium term.

BHP said it was disappointed with the decision and was reviewing its options. Its shares opened 3.2 percent higher in Australia after the rejection, and the price of insuring its debt through credit-default swaps eased.

BHP launched its bid for Saskatchewan-based Potash Corp. in August, seeking an entry into the lucrative fertilizer sector. But the Potash stock consistently traded above the offer price, indicating that investors thought a higher offer would come.

Under the Investment Canada Act, a foreign takeover must have a net benefit for the country in terms of jobs, exports, production and investment. The Canadian government had previously blocked a foreign takeover only once before.

Saskatchewan, which has large potash resources, argued that it would lose tax and royalty revenues if the deal went through. It said it would be wrong to let a resource as strategic as potash fall into foreign hands.

BHP launched its offer for Potash Corp. as population and income growth in developing countries like China and India create a bullish long-term outlook for fertilizer and food production. ■

MSHA files unprecedented injunction;

Agency targets Freedom Energy's Mine No. 1

THE U.S. DEPARTMENT of Labor's Mine Safety and Health Administration (MSHA) filed a motion for a preliminary injunction against Freedom Energy Mining Co.'s Mine No. 1 with the U.S. District Court for the Eastern District of Kentucky. Located in Pike County, KY., Freedom's Mine No. 1 is owned by Massey Energy Co.

MSHA said in a news release that the unprecedented legal move comes with the support of Section 108(a)(2) of the Federal Mine Safety and Health Act of 1977 that provides for injunctive relief against noncompliant mine operators who habitually violate health and safety standards. In this particular case, Section 108(a)(2) calls for an injunction because "Freedom Energy is engaged in a pattern of violation of the mandatory health and safety standards of the Mine Act, which constitutes a continuous hazard to the health and safety of the miners at Mine No. 1."

"Freedom Energy has demonstrated time and again that it cannot be trusted to follow basic safety rules when an MSHA inspector is not at the mine," said Joseph A. Main, assistant secretary of labor for mine safety and health. "If the court does not step in, someone may be seriously injured or die."

According to the brief filed by MSHA, Freedom Energy is engaged in a pattern of failing to examine and maintain critical areas of its mining operations as evidenced by the quantity and gravity of violations in four critical spheres of safety: failure to clear the mine of excessive accumulations of coal dust; failure to protect the roof, face and ribs from falls and maintain an effective roof control plan; failure to test and maintain electrical equipment in a safe working condition so as to protect against fire or explosion; and failure to effectively ventilate the mine of noxious and explosive gases.

"Massey does not believe the mine is unsafe," the company said in a statement. "Freedom Mine No. 1 is an "older mine with extensive underground workings."

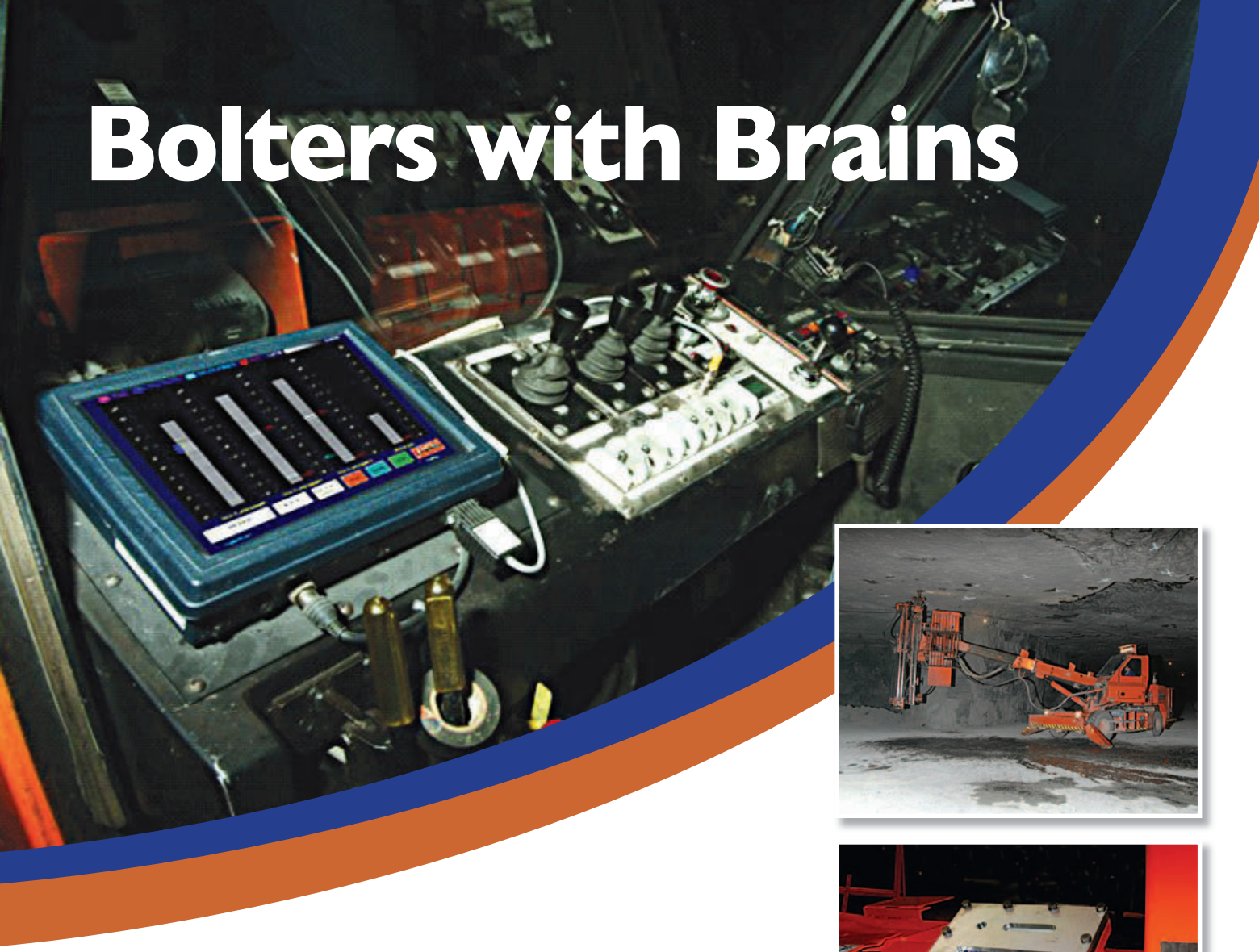
"The operation has struggled to comply with newer MSHA standards," Massey said, adding that chairman and chief executive officer Don Blankenship recently visited the mine for a safety review. "During the safety stand-down, all underground Massey operations .... gave their miners additional safety training, and took steps to identify and correct mine hazards."

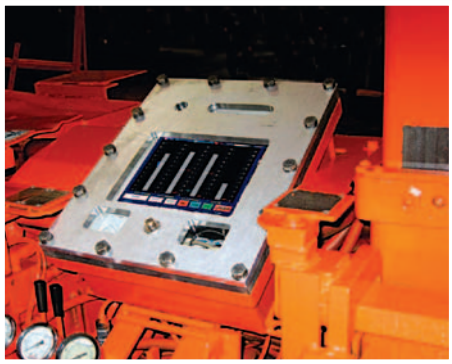
According to MSHA, seven miners have been injured as a result of falling roofs in the past two years. Six major roof falls have occured there since Aug. 11, the agency said.

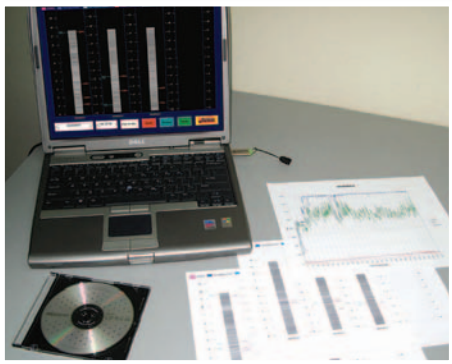
During the eight regular inspections conducted between July 2008 and June 2010, MSHA issued 1,952 citations and 81 orders (including 53 (d)(2) orders this year to Freedom Energy for violating critical safety standards, including improper ventilation, failure to support the roof, failure to clean up combustible materials, failure to maintain electrical equipment and failure to conduct the necessary examination of work areas.

If the U.S. District Court in Kentucky grants MSHA's motion as proposed for a preliminary injunction, Freedom Energy will be required to close its mine temporarily and take specific actions before it can reopen. ■

Bolters with Brains







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Mine expansion approved;

Xstrata receives go-ahead at Australian nickel mine

THE QUEENSLAND government approved Xstrata's decision to move ahead with its A$274-million (US$266-million) expansion of the George Fisher zinc mine in Mount Isa. The production rate at the site will increase by 30 percent from 2013 following the completion of the expansion.

Xstrata also recently won approval for its A$133-million development of the Black Star Deeps openpit mine. Xstrata has now announced A$407 million of new zinc projects this year, the *Mining Journal* reported.

Brian Hearne, Xstrata Zinc Australia's chief operating officer, said the expansion of the underground mine is indicative of the strategic opportunities for growth within the group's assets.

"George Fisher Mine contains one of the largest zinc reserves in the world and the expansion project enables us to further tap its resource potential," said Hearne.

Xstrata said the George Fisher expansion will increase zinc production to 4.5 Mt/a (5 million stpy), and will create jobs for an additional 250 contractors in construction and 120 employees in operation.

The project involves the development of a second hoisting shaft (and associated infrastructure) to service the northern area of the mine using large diameter raiseboring technology, the company said.

It will also include the installation of an underground crushing and ore-handling facility and upgrades to power and air ventilation service. An existing shaft servicing the northern end of the mine will be lined and extended by 420 m (1,400 ft) to a depth of 1,140 m (3,740 ft).

Hearne said the expansion project had been encouraged by a 126 percent increase in zinc reserves, from 33 Mt (36 million st) when Xstrata acquired the operation in 2003, to 76 Mt (84 million st) this year.

"While the increased production rate will reduce the life of the mine by five to 21 years, the orebody remains open at depth to the north of the mine," said Hearne. ■

South African gold mine ramping up

GREAT BASIN Gold, a Canadian/South African junior gold miner that is developing two gold mines, achieved its first gold pour at its new Burnstone gold mine in South Africa, located 80 km (50 miles) southeast of Johannesburg.

Proven and probable mining ore reserves are estimated at 30 Mt (33 million st) grading 4.25 g/t (0.12 oz/st) gold for a total reserve of more than 124 t (4 million oz) of gold.

For the past several months, plant construction has been under way at Burnstone and to date the crushing, grinding and gravity circuits have been completed. The carbon-in-leach circuit commenced operation late October. The mine winders have been licensed and have commenced hoisting men and materials in the vertical shaft and ore hoisting proper is due to commence in November.

Great Basin is also developing the Hollister gold mine in Nevada. ■

China to focus on
domestic mining with new investment

IN AN EFFORT to reduce its dependence on foreign sources, China announced that it plans to invest US$4.48 billion to explore for minerals in 21 provinces in the next five years.

Wang Min, vice minister of China's Land and Resources Ministry, told official state news agency *Xinhua:* "We believe China has great potential for mineral exploration."

The Chinese want to reduce their dependence on iron ore, which is needed to feed its growing economy.

Five deposits in the provinces of Liaoning, Hebei, Henan, Shandong and Shanxi may hold up to 5 Gt (5.5 billion st) of iron ore. However, several of these deposits are of low-grade ore, requiring China to still import large quantities of higher-grade iron ore.

As much as 38.5 Mt (42.4 million st) of copper ore reserves were discovered in Tibet, Xinjiang and Yunnan last year.

Chen Renyi, director of the China Geological Survey's Department of Mineral Resources Assessment, said imports of copper ore, iron ore and sylvite (potassium chloride) should account for, respectively, less than 75 percent, 50 percent and 60 percent of minerals' consumption in China over the next five years.

Meanwhile, *Xinhua* also reported that China may also tighten environmental regulations on rare earth mining, which will increase production costs and may raise the cost of China's rare earth exports.

China now mines 97 percent of global rare earths. ■

Stillwater plans two new projects;

Montana miner plans to develop Graham Creek and Blitz

STILLWATER MINING Co. announced that it will proceed with two mine resource delineation and development projects along the Stillwater Complex in Montana. The projects are the Graham Creek project, immediately to the west of Stillwater's East Boulder Mine, and the Blitz project, immediately to the east of the Stillwater Mine.

The Graham Creek project will extend development of the East Boulder Mine ore resource about 2,400 m (7,900 ft) to the west over the next several years, the company said in a statement.

East Boulder Mine's tunnel boring machine (TBM), which was used to develop initial access to the JM Reef 10 years earlier and then the west footwall lateral access paralleling the mineralized JM reef, has recently been recommissioned for this new project. Initial work will assess the continuity and structural controls related to the JM Reef in this area on the far western end of the Stillwater Complex.

The project potentially could develop an additional 5.4 Mt (6 million st) of ore grading on the order of 14 g/t (0.41 oz/st) of platinum group metals (PGM). Costs to complete the TBM development drive and assess the PGM resource for the Graham Creek area are projected at about $8 million over the next five years. The project is expected to yield information on the Graham Creek resource as diamond drilling work is completed behind the TBM drive.

The Blitz project at the Stillwater Mine is designed to explore and define the PGM resource along the far eastern extent of the JM Reef. It will extend some 4,000 m (13,500 ft) to the east of the existing Stillwater Mine by two driven footwall laterals from the 5000 and 5600 levels. Diamond drilling and geologic evaluation will be concurrent with footwall lateral advance on both levels.

Once the Blitz assessment project is completed, additional development will require excavating new ventilation raises to support bulk sampling, final preproduction development and eventual ore production. Based upon production experience to date and historical surface drilling, Stillwater Mining said it believes the project has the potential to define an additional 8.6 Mt (9.5 million st) of resources grading on the order of 24.3 g/t (0.71 ozst). The project will begin to yield resource results within its first couple of years. Initial development and resource evaluation costs for the Blitz area are expected to total about $60 million to be spent over the next five or six years. ■

500th Cat 797 delivered;

Australian coal mining contractor gets the ultra-class haul truck

CATERPILLAR RECENTLY manufactured and shipped its 500th 797 large mining truck to a coal mining contractor in Australia. The 797F that marks the milestone represents the third generation of the largest mechanical-drive truck ever built. With 363 t (400 st) payload capacity, the 797F continues the legacy of the 797 atop the ultra-class mining truck ranks.

The Caterpillar 797 population has grown rapidly in recent years. The first 797 started operational testing in late 1998, and the population in the field grew to 250 in 2007. In the ensuing three years, Caterpillar manufactured and delivered another 250 of the flagship model to large mining operations in Australia, North America and South America.

The Caterpillar 797 ultra-class haul truck was first produced in 1998. In 2009, the company launched the 797F series.

Initially designed with oil sands mining applications as the target, the 797's breadth of applications also is growing. The Canadian oil sands still host the biggest concentration of 797s, but coal and copper miners are now operating fleets of 797s and iron ore miners soon will be. The largest coal mining operations now use 797s for both overburden and coal haulage. One major Wyoming coal mine accumulated more than 8,000 hours on a 797B as it hauled more than 10.4 Mt (11.5 million st) of overburden in 2009. Other 797s in the mine's fleet also approached that utilization and production record.

The 797 itself has grown, too. The original 797 model had a nominal payload capacity of 327 t (360 st) and gross power of 2,535 kW (3,400 hp). The 797B, introduced in 2003, had increased gross power of 2,647 kW (3,550 hp) and nominal payload of 345 t (380 st), though target payload grew to nearly 363 t (400 st) with modifications. The 797F, introduced commercially in 2009, features the Caterpillar C175 engine, which produces gross power of 2,983 kW (4,000 hp). Nominal payload is 363 t (400 st). The C175-20 engine that powers the 797F is compact compared to previous 797 engines, and it delivers more power for faster acceleration, faster speed on grade, greater productivity and lower cost per ton.

Caterpillar manufactured the 500th 797, and all of its predecessors, at its Decatur, IL, facilities. The Cat mining truck manufacturing facilities also are growing. To meet increased demand for the 797 and other Cat trucks, Caterpillar announced in June an accelerated capacity expansion plan for the plant. An additional 30 percent truck manufacturing capacity will come online at the facility beginning in 2011. ■

Uranium production begins;

Uranium Energy Corp. begins phase I at Palangana project

URANIUM ENERGY Corp. announced that it has started uranium production using in situ recovery (ISR) methods at the Palangana project in south Texas.

Phase I of three separate development phases of the wellfield at Production Area 1 (PAA-1) is 100 percent complete, with more than 45 injection wells and production wells drilled, cased and tested. Water volume that each well has yielded during the testing phase is positive. Now, gaseous oxygen and carbon dioxide are being added to the circulating ground water, which has activated the mining process of dissolving the uranium from surrounding sandstones, Uranium Energy said in a statement.

"We are exceedingly proud that Palangana is the first new ISR uranium mine to achieve production in the U.S. in more than five years," Amir Adnani, president and chief executive officer said. "Kudos are due to our many professionals who have been working very hard to reach this important milestone. Palangana is one of the company's four projects in south Texas. This initial production is really just the first step in the company's regional strategy of greatly expanding resources and production in the re-emerging South Texas Uranium Belt, with the next project, the nearby Goliad ISR project, anticipated to join Palangana as a producing asset next year."

Phase 1 of the PAA-1 wellfield is in operation with 30 injection wells and 15 production wells online, with each being brought gradually up to maximum flow rates of approximately 3.15 L/s (50 gpm).

Phases II and III of the PAA-1 wellfield each will contain 45 production and injection wells. All Phase II wells have been completed and are targeted to commence mining in the first quarter of 2011. Installation of Phase III wells is under way with three rigs casing and then completing each well. The company is scheduling these wells to come online and to start production during the second quarter of 2011. The average depth of wells throughout the PAA-1 wellfield is 137 m (450 ft). ■

Cat: acquisition of Bucyrus is largest in company history

(Continued from page 12)

global economic turmoil of 2008-2009 allowed us to emerge with a strong balance sheet and the ability to make strategic investments in companies like Bucyrus. This, and other recent acquisitions, will position Caterpillar for industry leadership and will be positive for our stockholders, customers and employees."

"We are very pleased that Caterpillar has committed to locate its mining business headquarters in Milwaukee and we are confident that the combined global platform will be extremely well positioned to capitalize on the substantial growth opportunities in this market in the years ahead."

Bucyrus president Tim Sullivan

Tim Sullivan, Bucyrus president and chief executive officer, said; "This is an outstanding and financially compelling transaction for our shareholders. More fundamentally, it is a testament to the tremendous value our talented team of employees has created over the past several years and to the strength of our brand in the global mining machinery marketplace. I am confident that we have found an excellent partner in Caterpillar.

"We are very pleased that Caterpillar has committed to locate its mining business headquarters in Milwaukee and we are confident that the combined global platform will be extremely well positioned to capitalize on the substantial growth opportunities in this market in the years ahead," said Sullivan.

The closing of the transaction is subject to regulatory approvals, customary closing conditions and approval by Bucyrus stockholders. At that time, Caterpillar Group President Steve Wunning will have executive office accountability for Bucyrus, along with his current responsibilities for the company's mining business.

"Even today at mine sites around the world, our customers are using Bucyrus shovels to load Caterpillar mining trucks," Wunning said. "This combination, as well as the significant expansion in products and facility capacity already announced, gives us the opportunity to expand the range of surface and underground mining products and solutions offered to customers by Caterpillar and its dealer network."

A driving motivation for the transaction is Caterpillar's estimate of more than $400 million in annual synergies beginning in 2015 derived from the combined financial strength and complementary product offerings of the combined mining equipment businesses. ■

All 33 miners rescued;

Multinational effort frees miners after 69 days

by William Gleason, Senior Editor

When science and the human spirit come together amazing things can happen. This was perhaps never more evident than through the events that unfolded during August and October in a remote desert in northern Chile.

On Aug. 5, the main shaft of the San José copper and gold mine near Copiapó in Chile's Atacama Region collapsed, leaving 33 miners trapped more than 624 m (2,000 ft) beneath the earth's surface.

For the following 69 days, the miners would exemplify the strength of the human spirit, while on the surface, a multinational effort relied on some of the best technology available in an unprecedented story of survival and rescue.

Following the news of the collapse, Chilean President Sebastian Piñera quickly sounded an international call for help from anyone who could provide technology or expertise to those stranded in the mine. Nine drilling companies from around the world responded, mobilizing an impressive effort of man and machine.

Jeff Hart of Layne Christensen, pictured, was called to Chile from his duties in Afghanistan to operate the Schramm T-130XD drill rig that eventually opened a pilot hole wide enough to free 33 miners trapped in the San José Mine in Chile for 69 days.

On Aug. 22, more than two weeks after the initial collapse, the exploration efforts of more than 130 workers paid off when the Chilean drilling company Terra Service, operating one of four Schramm T 685 reverse air rigs, broke through the roof of the rescue chamber where the miners had been living. The miners put red paint on the drill pipe as a message to the surface.

"We knew that someone was alive, we didn't know who or how many, but we knew someone was alive," rescue team leader André Sougarret of Codelco, told the Discovery channel.

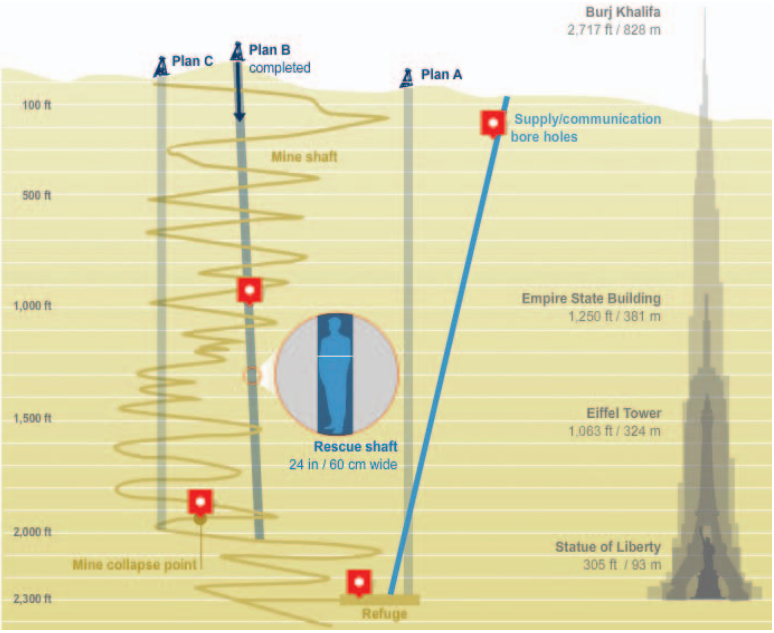
Sougarret and the rest of the people who had taken up residence on the surface near the mine at Camp Esperanza (Hope) would soon learn that all of the men survived the cave-in when they found a note that had been tucked into the bit that read: "We are fine in the shelter, all 33 of us."

This simple, handwritten note kicked off one of the most inspiring and uplifting stories the world has ever seen, and put on display the very best aspects of the mining industry.

Drilling provides a lifeline

When the drill bit broke through to the chamber, one of the miners, foreman Luis Urzua, reportedly said the men all wanted to hug the bit, and for good reason — it quite literally gave the miners a lifeline. For 17 days, they had survived on little more than a few sips of water and a couple crumbs of food each as they rationed out two days' worth of supplies for more than two weeks.

Upon learning of the miner's survival, the essentials were the first to go down the hole — oxygen, fresh water, flashlights, food, medicine and clothing. Later, and with the aid of a second bore hole that broke through on Aug. 23, and through a 1.5-m- (5-ft-) long hollow cylinder called a *paloma* (pigeon, in Spanish) that was dreamed up on site, the miners would be able to open communications with the surface and would begin receiving the comfort items, such as playing cards, religious figurines, a Chilean flag … even a cell phone with a built-in projector so they could



Three plans were launched to reach the miners trapped in the San José copper and gold mine near Copiapó, in Chile's Atacama Region. Plan B proved to be the one that worked. Graphic courtesy of CNN.

watch movies and recorded soccer matches in the mine. The *paloma* made about 40 trips a day.

Doctors, psychologists, nutritionists and experts at living through isolation from the Chilean navy and NASA responded with advice to help the men cope with the situation. On the surface, plans to get the men out were quickly put into place and equipment was requested and delivered from all across Chile.

One of the first options considered, Plan A, was to drill a rescue shaft using a Strata 950 raise bore machine that had just completed a shaft for Codelco's Andina Mine.

South African company Murray Roberts began operations with the Strata 950, a 28,500-kg (62,800-lb) machine capable of a pilot thrust of 69 t (76 st) and reaming pull of 950 t (1,047 st) at 330 bar.

Placed directly above the rescue chamber, it was estimated that the Stata 950 would advance at a rate of 20 m/day (65 ft/d), and would require as much as four months to reach the miners.

Plan B

Upon hearing that the miners might not be freed until Christmas, a consortium of drilling experts that included James Stefanic, operations manager for Geotec Boyles, Greg Hall, president of Drillers Supply S.A., as well as Mijali Proestakis and Igor Proestakis of Driller's Supply, presented an alternative solution to get to the miners by expanding an existing 14 cm (5.5 in.) bore hole.

Drillers Supply S.A. supplied drilling pipe for the initial exploration and the hammers and drill pipe that initially broke through.

The case was made that, by using an existing bore hole drilled by Geotec, it was nearly guaranteed that this plan would reach the miners and that the hole could be widened enough to extract the miners. And, even if it did not reach the miners faster than Plan A, it would at least be an alternative if something was to go wrong with Plan A.

The borehole that was chosen was between 9 and 10° off vertical. It had been drilled using a Schramm T685 that was brought in from drilling work at Minera Escondida. The T685 rig can drill at a rate of 50 m/day (165 ft/d) using hammer drills. It was used for the first pass and made contact with a tunnel near the maintenance workshop after 624 m (2,050 ft) with a final hole diameter of 14 cm (5.5 in.).

Plan B, as it would come to be known, was approved by the rescue team led by Sougarret and other representatives of Codelco.

Eight years earlier, nine coal miners were rescued from the Quecreek Mine in Somerset County, PA after a mine collapse there. Rescuers drilled a 760-mm- (30-in.-) diameter borehole into the mine and lifted the men out in an 2.5-m- (8.5-ft-) high steel mesh escape capsule.

To get to the 33 miners trapped in the San José Mine, the hole would have to be much deeper, 624 m (2,050 ft), as opposed to 76 m (250 ft) at Quecreek, and the drill would have to go through much harder ground.

After taking the geology into account, a crucial decision was made to use large diameter hammers rather than traditional tricones. The hammers, which have air-powered bits that pound the rock as the drill rotates, are ideal for hard rock conditions like those found in Chile.

"The very hard rock actually improved the likelihood that the Schramm hammer drills would be more successful," Schramm Inc. representatives Peter Christian, vice president of engineering, and Greg Hillier, senior product manager, said in an e-mail to *Mining Engineering*. "Operating at about 1,500 blows per minute, the hammer drills effectiveness increases with the density of the rock, compared with traditional drills. Through very hard rock, they're much faster."

Center Rock Inc., which provided equipment and personnel in the rescue at Quecreek and had support services in Chile, was chosen to provide the bits to widen the pilot hole.

With the help of UPS, Center Rock shipped two 66-cm (26-in.) LP Drill Systems, two 71-cm (28-in.) LP Drill Systems and two 30-cm (12-in.) CR 120 DTH Systems along with a large array of spare bits, spare parts and service equipment. In total, Center Rock shipped about 22,700 kg (50,000 lb) of equipment.

"This was technology that was unfamiliar to the officials in Chile," said Fisher.

The bits provided by Center Rock require less air to operate, about 4,000 cfm as opposed to

Rescue workers and Chile's Minister of Mines, Laurence Riveros (center) pose with the Center Rock hammer bit used in the rescue at the San José Mine.

7,000 cfm. This was important because it was not clear how the cuttings would be eliminated from the well.

"Safety was a factor because we did not require that the borehole be flooded with drilling fluids that could potentially rupture the formation and flood the mine," Fisher explained. "Our tools use air. Also, our system does not require heavy-on-bottom weight that could potentially collapse the mine ceiling when drilled through. Down-the-hole hammer technology is typically four- to six-times faster than roller bit technology."

"Accuracy was achieved by the addition of guide devices on the face of our drilling heads," said Fisher. "These guide devices ensured that our tooling would follow the existing 14 cm (5.5 in.) borehole."

To power the hammers, Atlas Copco was able to gather air compressors already in Chile to send to the mine site.

A Schramm T130XD, was called in to open the hole wide enough for the eventual rescue. The rescue team had coordinated with Minera Collahuasi for the transfer of the Schramm T-130XD – also owned by Geotec – 100 km (62 miles) to the mine site. It was given a police escort to the mine, and a hero's welcome when it arrived at the site.

The machine weighs about 45,000 kg (100,000 lb) and is propelled by five axels. It is about half the weight of traditional rigs.

"Because the Schramm drilling equipment used was mobilized from other drilling sites in the area, the rigs were already well suited for the terrain and underground conditions, but not ideal for the specific (and unexpected) rescue task," said Schramm. "This particular T-130 was set up to drill large diameter holes for dewatering deep in Chilean mines. It had our highest capacity top head for up to 71 cm (28 in.) diameter holes, and a large-diameter tooling breakout system for the 17.8 cm (7 in.) drill pipe that could accommodate the 15- to 31-cm (6- to 12-in.) and then 31- to 71-cm (12- to 28-in.) pilot reaming project. The top head also utilized a tilt-out feature that improved the safety and expedited drill pipe handling, which was done manually at the rescue."

With the tools in place, another call was made to find the right personnel. The drilling team of Geotec Boyles realized early on that it would require special skills to ream the 14 cm (5.5 in.) hole open to 31 cm (12 in.) and eventually out to 66 cm (26 in.) in diameter. So they contacted Layne Christensen, Geotec Boyles' American partner. Upon getting the call, officials at Layne Christensen decided that they needed their best man on the job and called Jeff Hart, who was working for the U.S. Army, drilling water wells in Afghanistan. Matt Staffel was also sent to Chile, as were two Spanish-speaking drilling assistants, Doug Reeves and Jorge Herrera, from Layne Christensen's western U.S. office, to aid in the efforts.

"Jeff was called because of his experience and his ability to exercise caution and finesse on a difficult job," said Mark Scharenbroich, business development manager at Layne Christensen.

The Schramm T-130XD rig arrived at the mine on Sept. 3.

Once it was set up to the correct inclination, it began to widen the hole to 44.5 cm (17.5 in.) with a tricone hole opener to about 3 m (10 ft) below the surface.

Next, a 30-cm (11.75-in.) air hammer was introduced with a 30.5-cm (12-in.) hole opener type bit and a 13-cm (5.25-in.) guide, suitable for opening up the existing 14.6-cm- (5.75-in.-) diameter hole. Then, a 35.5-cm (14-in.) casing with a drilling pipe was installed to the center of the hammer in the pilot well to protect the mouth of the well and allow Plan B to begin.

The use of the pilot hole allowed the drillers to drop the rock cuttings down the existing hole. This reduced the complexity of the operation.

Frank Gabriel, vice president of Schramm, told *The New York Times* that normally there would be the need to flush the cuttings back up to the surface, which takes a lot of air and time. By dropping the cuttings through the hole, the drill worked faster and with the communication lines that had been established, the miners were able to assist in their own rescue.

"In this hard of rock, a hammer is the best method," said Hart in an e-mail to *Mining Engineering* from the Helmond province in Afghanistan, where he returned to work following the

rescue. "In our mind, this was the only option that could get there in a short amount of time."

The miners, 32 Chilean and one Bolivian, were given jobs and schedules. For 33 days, the miners aided in the Plan B drilling operations.

They were split into three shifts, with each shift having a foreman. The shifts lasted eight hours and the men had eight hours to sleep and eight hours for recreation each day. Clearing debris from the pilot hole was one of the most crucial jobs the men had.

Stefanic, of Geotec Boyles, was one of the people on the surface who remained in contact with the miners.

"We dropped the cutting into the hole which sped the process up for us and also kept the miners motivated," said Stefanic. "The more cuttings that came down the better off they knew they were."

Communication lines, including phone lines and fiberoptic cables that stretched to the rescue chamber, allowed the miners to tell the drilling teams exactly where the drill had broken through. This information proved to be invaluable for the second phase of the operation, which was to widen the pilot hole to 71 cm (28 in.).

"The miners played a major role in this," said Hart. "It was a great help having them telling us what size the cuttings were, if we had steel in the bottom, if we were running enough water to keep the dust down. It was great to have communication with them."

"The miners played a major role in this. It was a great help having them telling us what size the cuttings were, if we had steel in the bottom, if we were running enough water to keep the dust down. It was great to have communication with them."

Jeff Hart, driller, Layne Christensen

But, despite best efforts above and below the surface, the plan was far from hassle-free.

The San José Mine has been in operation since 1885. As such, there was a great deal of infrastructure that had to be dealt with, much of which was not mapped precisely.

On Sept. 9, the T-130XD came to a halt at 268 m (880 ft) from the surface, when the nose of the 30.5-cm (12-in.) hammer bit broke after hitting a roof bolt. The piece of metal blocked the well and halted operations for five days as Hart and others worked to fish out the broken metal.

"This made international news," said Schramm's Christian and Hillier. "Drillers made several attempts to fish it out with magnets and other tools. The solution was to send a device called a spider down the hole, which wrapped itself around the bit and enabled drillers to pull it up. This was a major snag for which there was no ready-made solution. The spider was something of an experiment, which happened to work very well."

Another significant problem occurred in the final 30 m (98 ft) of the 71-cm (28-in.) diameter hole. The hard and abrasive nature of the rock forced the rig operators to fine-tune the drill several times to liberate it from the bars. The operators also faced the risk of breaking a rod, which would have led to the loss of the well. The rock also wore down the hammers.

"The hole had some areas in it where the hole changed direction and running the cluster hammer made it difficult to turn the corners and we would get stuck," explained Hart. "We only had 30 m (98 ft) to drill and we were having a lot of problems getting it back to the bottom."

On Saturday, Oct. 9, the Plan B drill rig finally reached the mine workshop.

With lessons learned from Quecreek, the Chilean navy, working closely with experts from NASA and the U.S. Mine, Safety and Health Administration, had developed a rescue capsule to be lowered to the miners to carry them out, one-by-one. Three capsules were built by Chilean navy engineers, the largest was named the Phoenix 1.

Painted the red, white and blue colors of the Chilean flag, the Phoenix 1 capsule weighed 420 kg (924 lbs) with an interior height of 1.9 m (6 ft, 4 in.). The miners were monitored while in the mine to be sure that they would be able to squeeze into the capsule.

With retractable wheels to help it travel down the shaft, the capsule was equipped with communications equipment, an oxygen supply and an escape hatch in case anything was to go wrong. It was feared that the capsule would rotate often while coming up. But the Center Rock bits proved to have another advantage; they cut grooves in the rock that the wheels of the capsule caught for a smoother ride with less rotation than expected.

On Oct. 10, part of the tunnel was encased with steel tubing to ensure safe passage for the Phoenix 1 and test runs were completed.

Manuel Gonzalez, a rescue expert with state-run Codelco, was the first to ride the Phoenix 1. He rode down to the mine and was followed by Roberto Ros, a member of the Chilean special forces.

The miners were put on a special high-calorie liquid diet that was prepared by NASA, fitted with a biomonitor to measure their vital signs on the ascent to the surface and given Oakley sunglasses to shield their eyes, as they had not been exposed to natural light for more than two months.

Shortly after midnight, Oct. 13, with a worldwide audience tuning in, Florencio Ávalos, a 31-year-old miner who was second in command, was lifted from the mine. He was chosen because he was the fittest, and most able to tell rescue workers on the surface of any problems on the way up. The miners shift foreman, Urzua, who was credited with keeping the men alive during the first 17 days, was the last to come up, 22 hours after Ávalos and 69 days after the main shaft collapsed. ■

Opencut coal mining;
History and future of highwall mining

by Pieter-Jan Kleiterp

Highwall mining is a mining method to extract coal from a final boundary in opencut mining, trench mining or contour mining. This boundary may have been reached because of economic constraints (economic strip limit) or geographic constraints, such as spoil heaps and rivers.

Coal is mined from visible, horizontal, or near-horizontal coal seams by making rectangular, parallel, unsupported drives with an unmanned cutterhead and coal transport system. This is controlled from a mining unit, or launch frame, positioned outside the drive, in front of the highwall. Removal of overburden is not required or is limited to small quantities only.

Highwall mining originated in the 1940s in the Appalachian coal fields. This article describes the history of the various machines that have been designed for highwall mining. Beginning in the 1990s, there has been more emphasis on safety in highwall mining. Many pillar strength formulae have been derived to determine the required width of pillars in highwall mining and, with that, the economic feasibility of highwall mining. The various pillar strength criteria are discussed, showing the countries where they are applied.

In order to make highwall mining equipment safer and more productive, there have been numerous technological improvements applied to the machines. These technologies make highwall mining ready for the future as a serious mining method that can expand beyond its traditional Appalachian mining area.

Figure 1

Auger miner.

History of highwall mining

Highwall mining started as a way to extract additional coal from outcrops in contour mining. It began in the 1940s in an Appalachian coal field. Natural outcrops of coal in the hills of the Appalachian mountains had been mined for many years, leaving thousands of miles of coal outcrops. In a 1950 edition of the *Mining Engineering Reporter,* it was mentioned that, "a new kind of mining is being pioneered by a West Virginia coal operator" (*Mining Engineering Reporter,* August, 1950). This was the start of highwall mining by means of large augers.

This auger mining system could mine circular drives of 1.5 m (5 ft) in diameter and 30-m- (100-ft-) long. The *Mining Engineering Reporter* further mentioned that a 746-kW (1,000-hp) power plant was required to move the 54 t (60 st) of equipment. A four-man crew could extract up to 726 t/d (800 stpd). Figure

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Figure 2

Bucyrus highwall miner.

1 shows an auger mining operation.

An article published in 1951 by professor D.M. Bondurant clearly showed how the auger system was working. He described all the advantages of the auger mining system, explaining that it is a low-cost, flexible mining method in which coal can be mined selectively at high recovery rates (Bondurant, 1951).

The advantages of the auger mining system, and the fact that a better alternative was not yet available, outweighed the disadvantages of the system. Because the diameter of the auger was not variable, it was difficult to get a good recovery. If a seam became thinner than the diameter of the auger, the auger would have to stop. In a thicker seam, a lot of coal would be left behind. In the earlier days, when auger holes were only 30 m (100 ft) deep, this was not really an issue. When the auger systems improved and drives of up to 120 m (394 ft) long were possible, mining companies saw the need for a better machine.

In 1984, M.B. Treuhaft wrote a technical paper outlining all highwall mining techniques that were available and proven at the time. The auger system had been perfected. Double augers, or dual augers, were used to increase extraction ratios. Many operators, who were regarded as opportunistic, were independent and continued the use of single augers. Treuhaft's article also introduced new methods that would help to increase the extraction ratio and extractable reserves (Treuhaft, 1984).

A drill that could drill square holes (based on the Reuleau triangle) ensured that extraction ratios increased. However, this machine never really succeeded. The Coaltex Edna miner is based on the auger miners. This machine would auger mine a drive, but the main difference from traditional auger mining is that, upon reaching final penetration depth, two side cutters were extended, so that additional coal was cut while retracting the auger. The side cutters were then retracted before reaching the drive entry so that highwall stability was guaranteed.

A completely new system was the RSV thin seam miner. This was the first system to use a drum cutterhead. Cutterheads were not new in mining. They had been in use in underground room-and-pillar mines. The RSV thin seam miner was capable of mining 67-m- (220-ft-) long drives. The major advantage of this machine was that the extraction ratio was higher. It could vertically follow the seams, allowing the full extraction of coal seams that varied in thickness. This machine later became known as the Metec miner and, from 1994, the Superior highwall miner. The current, modernized and improved machine is known as the Bucyrus highwall miner. In February, Bucyrus International acquired Terex's mining division, including its highwall miners.

Other designs that were considered futuristic in the 1980s were the variable wall mining system (VWMS), the miniminer system, the multiple unit continuous haulage system, on which the Archveyor was based and the variable high angle auger system.

Today, only the auger mining systems and the highwall miners using the cutter drum are being operated successfully. The most widely used system is the Bucyrus highwall miner. Other systems that are currently used in highwall mining include the AddCAR machine, which also uses the cutter drum.

The Bucyrus highwall miner (Fig. 2) is a system that uses a cutter drum of a continuous miner to cut rectangular drives. The coal is transported through pushbeams consisting of two augers that are driven from the base machine. The penetration depth of this machine is 300 m (984 ft), which is reached consistently. The penetration depth of this machine is double that of the current auger mining systems.

Pillar design in highwall mining

Highwall mining originated in an Appalachian coal field, but the method spread quickly around the world. The two most common methods, auger mining and highwall mining using cutter drums, have been used, and are currently being used in South Africa, Canada, Australia, India, Indonesia and Russia, with a great potential in many other countries.

Safety has been the most important factor in highwall mining, although in the past, this has not always been apparent. In 1985, Professor K.F. Unrug published an article about rock mechanics implications of highwall mining. He recognized that roof composition, geology, fracture patterns and geotechnical properties are all important factors in determining the stability of pillars, roof, floor and highwall (Unrug, 1985). It was not until 1997 that Christopher Mark determined a relationship between highwall pillar strength and pillar dimensions. He derived the Mark-Bieniawski formula for pillar strength. This formula is the foundation of a software tool, ARMPS, developed by the U.S. National Institute for Occupational Safety and Health (NIOSH), which helps mining companies to determine pillar widths in their mining operations (Mark and Chase, 1997). This formula has been in use mainly in the U.S. Other relationships between pillar strength in highwall mining and pillar dimensions have been derived in other countries as well.

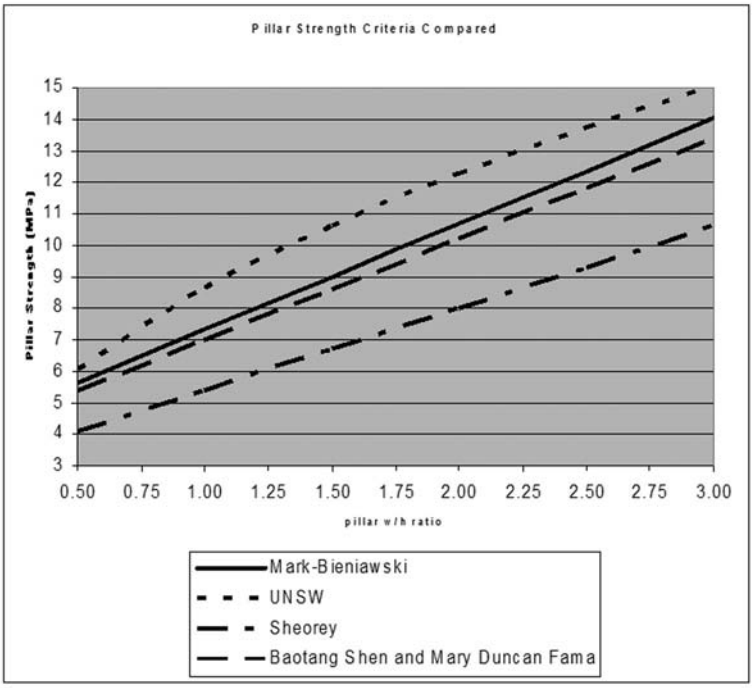
In Australia, a method to determine the pillar strength specifically for highwall mining has been derived. In other countries, formulae for pillar strength in room-and-pillar mining are being used.

The only method, other than the Mark-Bieniawski formula, that is specific for highwall mining is the method developed by Baotang Shen and Mary Duncan Fama for Australian coal mines. Their method shows that the pillar strength depends on the width-to-height (W/H) ratio and the coal strength, as well as the quality of the contacts. Contacts are defined as partings between the different coal plys forming the coal seam (Shen and Duncan Fama, 2000).

Figure 3 shows the pillar strength vs. the W/H ratio for several calculation methods. This graph is valid for coal pillars that are 1-m- (3.3-ft-) high, assuming that the coal and the contacts are strong. The Sheorey formula (Sheorey and Singh, 1996), used for Indian underground coal mines, is the only formula where the pillar strength also depends on the depth of cover (in this example 80 m or 262 ft). Neither the University of New South Wales (UNSW) formula, used in Australian underground coal mines, nor the Sheorey formula are used for highwall mining applications, but they are used for room-and-pillar applications.

Figure 3

Comparision of pillar strength criteria.



Many authorities outside of the U.S. require an additional numerical model to be made confirming the stability and strength of coal pillars, roof, floor and highwall. The challenge with numerical modeling is that the quality of the results strongly depends on the quality of data used, and mining companies do not always have good rock mechanical data available.

Current and future developments in highwall mining

Since the introduction of auger mining equipment in the 1940s, highwall mining equipment has improved significantly. The equipment is safer, more productive and easier to operate than it was before. Some of the technologies used to make the machine safer and more productive are:

- Gamma ray sensors to detect the distance between the cutterhead and the coal/roof rock interface.
- Navigation systems to more accurately position the equipment and to monitor the exact location of the cutterhead and make steering corrections if required.
- Pushbeams or other means of coal

conveyor ensure high production rates.

- Track-mounted highwall miners for added mobility.
- Anchoring systems to ensure stability when tough pulling conditions occur.
- Dewatering system to pump excessive water from drives.
- Modifications for steep dip applications.

Positioning a highwall miner accurately is very important. Surveyors can accurately line up the miner so that the position and direction of the miner are parallel to the previous drive. The Bucyrus highwall miner uses a rigid string of pushbeams. This results in a very straight drive if the miner is mining on true dip.

Gamma ray sensors

When shearing through coal, a cutter drum needs less power than when shearing through shale, sandstone or other types of hard rock. The operator of a highwall miner will see the required power of the electric motor increase when he is cutting in the harder roof rock. The machine will then automatically shear down, thus reducing the amount of waste that is being mined. To reduce the mined waste rock even further, a gamma ray sensor can be installed at the cutterhead. This sensor can determine the distance from the cutter drum to the coal-roof rock interface. It can then ensure that the cutter drum will shear down before it hits the roof rock. It works best when the immediate overburden has a higher naturally occurring level of radioactivity than coal. Shale, clay, silt and mud typically have higher levels of gamma radiation than coal (Stolarczyk and Stolarzcyk, 1996).

The principle of the equipment is that the coal seam absorbs natural gamma radiation that is emitted by the overburden. The amount of absorbed natural gamma radiation determines the thickness of the coal seam — in other words, the distance between the cutterhead and the coal-roof interface.

Industrial gamma radiation sensors can sense coal seam thicknesses from roughly 2 cm up to 50 cm (0.8 to 2 in.), which, in most mining conditions, suffices.

Navigation system

Positioning a highwall miner accurately is very important. Surveyors can accurately line up the miner so that the position and direction of the miner are parallel to the previous drive. The Bucyrus highwall miner uses a rigid string of pushbeams. This results in a very straight drive if the miner is mining on true dip. Other highwall mining systems rely on self-propelled cutterheads that can, and must, be steered to maintain a straight heading. In highwall mining, it is important that drives are mined parallel for maximum pillar stability. To ensure that the drives are parallel, a navigation system must be used that can also be used underground. One such technology is the fiberoptic gyroscope (FOG).

The FOG is based on the Sagnac effect. Light from a single optical source is split in two parts, each traveling through a coil of fiberoptic cable in opposite directions. When there is rotation, the two lights are not in phase. The difference in phase is a measurement for the amount of rotation (Gaiffe). A navigation system using the FOG is very accurate. The accuracy of such navigation systems could be better than 0.1° secant latitude. This means that in Phoenix, AZ, the accuracy would be 0.12°.

When permanently monitoring the heading of the cutterhead against the progress in the seam, the deviation from the desired path can be determined. This information is fed back to the steering system, which activates a mechanism that steers the cutterhead back into the desired heading.

Pushbeams and other coal conveying systems

In the 1940s, the auger mining systems would simply use the auger as a coal conveyor. With the introduction of cutter drum type highwall miners, two other coal conveying systems were introduced. The conveyor belt was introduced on machines such as the Archveyor. This machine consisted of many conveyor belt cars that are each powered separately. As a result, coal is transported across many short conveyor belts. A drawback of this type of conveying system is that it cannot handle wet coal well, especially on down-dip grades. Additionally, the coal on the conveyor belt can easily be contaminated by falls of ground that also can damage the conveyor belt.

The pushbeams, as used in the Bucyrus highwall miner, are simpler in design. A pushbeam consists of two augers that are contained in a steel housing. The augers are powered from the base machine and they do not require individual power sources. As the augers are fully enclosed, roof falls do not contaminate the coal. In fact, what is cut by the cutterhead comes out at the rear of the machine. This is the preferred type, currently accounting for almost 80 percent of all highwall mining systems in operation worldwide today.

Track-mounted highwall miners for added mobility

Only the Bucyrus highwall miner is mounted on tracks and even the genera-

tor set that is required on some sites can be mounted on tracks. A track-mounted highwall miner can move from drive to drive faster and easier than other highwall miners, such as the augers, that are mounted on skids. Additionally, the remote control system that has been developed by Bucyrus allows the operator to remotely operate the machine from a safe distance when required. It is also possible to monitor the entire machine from any place in the world through an Internet connection.

Anchoring system

Tough pulling conditions can be encountered. As an example, a cutterhead could be wedged in between the roof and floor. In that case, the base machine could be pulled against the highwall when the pushbeams are pulled with maximum power. In order to prevent the machine from moving, two drills can drill holes into the floor of the mine, in which two steel pins are inserted and act as anchors.

Dewatering system

In mining operations where excessive water can be expected, there is a risk of the cutterhead getting flooded. The Bucyrus highwall miner can handle small amounts of water by transporting coal and water by the augers in the pushbeams. Excessive rainfall in the pit, combined with steep grade or mining through water-bearing strata, may result in a water inflow that cannot be handled by the coal transport system alone.

For these circumstances, Bucyrus developed the Bucyrus dewatering system. This system consists of a specially designed pump beam containing two hydraulically driven progressive cavity pumps and an automatic hose reel system. The advantages of this system are that it can handle excess water with a high content of solids, as well as large particle size. The high pressure it can generate ensures that it can pump the water out of the drives dipping 10° more than 300 m (984 ft). The system allows mining with a water inflow of up to 20 L/sec (24 gpm). This is sufficient in most cases. The system is undergoing tests at the moment. The system opens up possibilities for highwall mining in countries where wet mining conditions are encountered.

Steep dip applications

The Bucyrus highwall miner can be equipped with a special device that makes it possible to mine at steeper dips. The main purpose of the steep dip module is to prevent the push beam string from sliding in the drive when inserting or extracting a new push beam. This module is required when mining on dips exceeding 12°. Bucyrus has experience with dips of around 16°. The penetration depth and production rate may be affected in these circumstances.

Summary

Numerous types of equipment have been designed in the past to extract additional coal from highwalls. Many coal mining companies have profited from the machines available, such as the auger miners, and the highwall miners using the cutter drum, such as the Bucyrus highwall miners.

Many technological innovations have been used in highwall mining that allow coal mining companies to extract more coal safer, faster and cheaper. The future is bright for highwall mining as more innovations are being developed. Mining companies outside of the United States will profit from this mining method more than before, as the knowledge increases and the applicability increases. ■

Acknowledgments

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Northern Ontario;
A hotbed of mining activity

by William Gleason, Senior Editor

Rail-Veyor's test site with complex geometry and 20 percent uphill grade has completed more than 6,000 loops. The site has a dump loop with reload capability. It is a reflection of the work being done in northern Ontario.

From a distance, the 0.75-km (0.5-mile) rail line that sits in the shadows of Vale-Inco's Stobie Mine outside of Sudbury, Ontario could be mistaken for a standard conveyor belt hauling ore from the nearby mine. But with its large, yellow-painted loop and interconnected green rail cars that invert themselves on the loop before correcting with a smooth rollover further down the track, one might assume that this is some sort of test track for a new roller coaster. The fact of the matter is that it is the proving ground for Rail-Veyor technology, a technology that the company hopes will one day change the face of ore transportation in surface and underground mines around the world.

With a line of linked, low-profile rail cars that are capable of carrying up to 1 t (1.1 st) per car of ore by way of simple, above ground, lightweight rail track, the technology is not groundbreaking. In fact, it was developed in the 1960s for the French State Railroad. A demonstration plant for the Florida Institute of Phosphate Research was installed in 2000 and the first commercial underground installation was in 2007 in South Africa at Harmony Gold's Phakisa Mine. There, a 4.7-km-(2.9-mile-) long tram between two shafts operates three Rail-Veyor trains on a shared track. The difference is that the application that is being tested day-and-night in Sudbury is getting closer to wide production, thanks to the use of computer controlled automation that has helped turn an old idea into a cost-effective modern solution.

"We have a niche here," explained Rail-Veyor president and chief executive officer Mike Romaniuk. "We have a simple technology that can do a lot of things that traditional conveyors, trucks and trains cannot do. It has low maintenance costs, no on board driver or operator and requires little energy."

The driving force to move the train consists of a series of equally spaced dual-stationary drive stations with ac motors and gear reducers that turn horizontal tires against the side drive plates of the cars, providing forward thrust. These computer-automated drive motors are what separate this version of the technology from previous versions. With modern programming and sensors, speed is controlled with a variable frequency drive (VFD), which allows operation in either forward or reverse directions with sufficient power to start a loaded train from any position on the track.

The drive system has no integral drive unit on the train, so rail weight is only based on car and content weight, not engine weight typical of a conventional railroad operation. The trains being tested in Sudbury are capable of carrying 1 t (1.1 st), but Romaniuk said that larger cars can carry as much as 3 t (3.3 st) per car, and there is no limit on the number of cars that could be attached.

Drive stations are spaced based on train lengths and track grades. Additional energy savings are achieved by shutting down the drive stations when the drives are not in contact with the train. The drive stations are designed to provide sufficient power to operate the system on grades up to 20 percent and control the cars through curves with a minimum 30-m (100-ft) radius at relatively high speeds.

The design of the rail cars allows for operation in an inverted position by use of a double set of parallel rails. This feature allows controlled, nonstop dumping of the cars by turning through an outside loop.

The rail cars are connected with flexible flaps that prevent leakage, allow articulated movement and form a chute as the product is discharged to a crusher, grinder, mill, train, truck or ore pile. This design allows the cars to be operated in the

upright or inverted position. And, because of the design, the trains can be easily dumped and continuously loaded and unloaded using roller coaster technology.

The system has been undergoing testing in Sudbury since April and testing will continue as different weights, types of ore, turns and grades are tested.

Romaniuk said that discussions are ongoing with many mining companies and that Rail-Veyor hopes to get tracks and cars out to mines soon.

"In terms of the future," said Romaniuk, "we are limited only by our imagination. There are no theoretical limits for the system. The unit train lengths and number of trains on the system will directly influence capacity. The maximum operational speed has not been established, but based on torque, gear ratios and drive train diameters, speeds of up to 32 km/h (20 mph) are realistic."

When Rail-Veyor begins landing in mines around the world, it will be a reflection of much of the innovative and crucial work that is being done on daily basis in northern Ontario, one of the most vibrant mining sectors in the world.

From green field to reclamation

Comprised of principal centers of Sudbury, North Bay, Timmins and Thunder Bay, northern Ontario's mining supply service sector is a hotbed of activity, with about 500 companies employing approximately 23,000 people in every aspect of the industry.

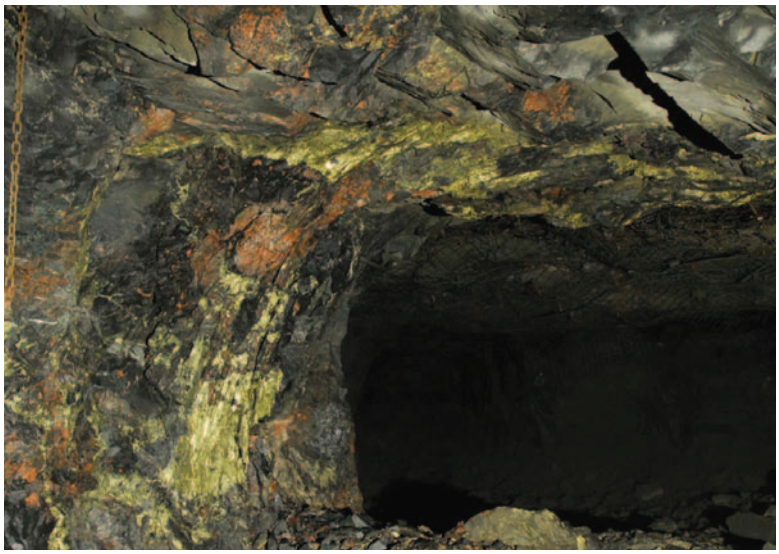
A report prepared for the Ontario North Economic Development Corp. (ONEDC) by Doyletech Corp. found that the total net value of the sector's output is $5.6 billion.

With such robust activity, it is no surprise that the area has become a kind of a one-stop shop for mining as a strong and stable sector in Canada (**ME**, April 2010, page 15).

The Fraser Institute annually ranks mining jurisdictions around the world based on the opinions of executives and exploration managers on 13 policy issues, such as taxation and stability, that contribute to the ability of jurisdictions to attract exploration investment. Ontario ranks 20th in the world.

The province has begun cutting taxes in a fundamental shift in tax policy covering capital, sales and corporate income taxes. In 2010, the marginal effective tax rate on new capital investments (provincial and federal combined) fell to 18.6 percent from 32.8 percent in 2009. By 2018, the tax rate is expected to drop to 16.2 percent.

In the mining sector, consultants and mining engineering firms, such as Red Path and Knight Piésold, have offices in North Bay. Minesteel Fabricators, a company that specializes in the design, fabrication and installation of things such as headframes, conveyances, shaftsteel and material handling equipment, also has a presence in North Bay. So do more than 60 other companies who provide equipment and services to the mining industry, despite the fact that there are no working mines in North Bay.



Highly mineralized narrow viens have been found frequently in the Quadra FNX Podolsky Mine in Sudbury, Ontario, where mining is the backbone of the economy.

Sudbury, though, is a town with a long mining history that remains active with numerous producing mines and continued exploration in the area. Like North Bay, mining is the backbone of the economy of the city of more than 155,000.

In addition to prosperous mines, such as Xstrata's Nickel Rim and the Quadra FNX Podolsky Mine, there is a vibrant mining sector that provides everything from mining engineering and management, equipment manufacturing, customization of wheeled, tracked and flanged vehicles, equipment repair and mining support, such as consulting, research, training and financing in the sector.

Because of this activity, the mining companies in northern Ontario make 81 percent of their sales within Canada, with 62 percent of those sales staying in northern Ontario and 19 percent of overall sales being exported.

As the trend of consolidation in the mining industry continues (see BHP's bid to buy Potash Corp. or Caterpillar's acquisition of Bucyrus), Northern Ontario's Mining Supply Service Sector hopes to position itself to a global market as a center in which complete mining solutions can be found.

The following is a look at just some of the services found in northern Ontario.

Drilling and exploration

In 2008, Atlas Copco opened its current exploration products headquarters in North Bay to meet the demands for its exploration products and rock reinforcement consumables.

Today, the site produces Atlas Copco's Swellex

Mining Technologies International Inc. is one of the most versatile mining equipment makers in the world.

rock bolts and is the production and competence center for Excore diamond drill bits that were brought to market during the 2010 Prospector's and Developers Association of Canada Conference (PDAC) in Toronto.

Atlas Copco's Excore bit offers superior bit life and penetration rate. The testing before launch was rigorous, with thousands of meters drilled under various conditions in numerous countries.

A global team of experts worked together over a two-year period, incorporating the latest in manufacturing and metallurgical technologies into the Excore product line.

The design and composition of the Excore bit line offers exploration drillers new levels of productivity in terms of longer bit life and higher penetration rates. With a longer bit life comes less frequent bit changes and, consequently, less pulling of rod. That factor alone saves a lot of time for the driller and more time can be spent on actual drilling.

With less pressure on the bit, it is easier to get straight holes and higher core sample quality at the same time as the wear on the drill string is reduced for better results without increasing rpm. On the other hand, when rock conditions allow the driller to push for maximum penetration rate, the Excore bits will give the driller the performance they are looking for.

With Excore's unique metallurgy and design, each bit type will cover a wider range of rock conditions, meaning that fewer bit types will be needed on the shelf for any given drill site.

Foraco

Foraco International SA is a global drilling contractor providing innovative solutions for mining, energy, water and infrastructure projects across 18 countries and five continents. In 2006, it expanded its operations to North America and established its headquarters in North Bay.

Tim Bremner, senior vice president and general manager, said the North Bay location gives Foraco better access to services, people and equipment than anywhere else.

With 170 drill rigs, Foraco works primarily with major mining companies at projects around the world on everything from greenfield exploration projects to closure of a mine.

In addition to its mining drilling services, which include diamond drilling, reverse-circulation, rotary, LD bulk sampling, air core and rotary air blast, the company also specializes in drilling wells for drinking, irrigation and industrial water, having drilled more than 36,000 water production wells in all types of geological formations ranging from 20 m to 2,000 m (66 ft to 6,560 ft) in depth.

These projects include large-scale rural water drilling programs in western Africa, some of which have developed as many as 500 wells per project and highly specialized drilling projects to access mineral water, utilizing sanitary protection methods, and large-diameter well fields in urban and suburban environments.

Mining equipment

While not the largest manufacturer of equipment, Canadian-owned Mining Technologies International Inc. (MTI) is one of the most versatile. Based in Sudbury, MTI operates four manufacturing facilities, producing a wide range of advanced mining equipment including: hydraulic drill jumbos, long haul dumpers, dump trucks, shaft drilling jumbos, long hole jumbos, in-the-hole (ITH) drilling rigs, computerized drill rigs, automated ITH drills with rod handlers, rail haulage systems (chutes, rail cars and dump stations), mine locomotives, buckets, bucket lip assemblies, bucket wear parts and low-profile crushing plants, as well as custom designed equipment for specific underground requirements.

MTI also manufactures a full complement of high-quality drill string components for drilling large diameter raises, blastholes, exploration holes and ITH applications. MTI is the result of the merger of several companies now operating as divisions, with names familiar to the mining industry: Drillex International of Canada, Continuous Mining Systems, LHD Equipment, John Clark Inc., Drillex U.S. Inc., CMS Pacific and Drilco Australia PTY.

Boart Longyear, Atlas Copco and Sandvik also have a presence in Sudbury. ■

Lime's effect on equipment;

Disruptions can come without proper care

by Todd Loudin

A majority of the chemical process industry uses lime in either a powder or liquid form. Engineering and maintenance personnel often face a long and potentially expensive trial-and-error period in order to find the best process equipment to handle lime.

Limestone is mined from a quarry in the form of calcium carbonate ($CaCO_3$). Then, it is crushed and fed into a kiln at approximately 1,093° C (2,000° F), where the carbon dioxide is burned off (calcining) to make calcium oxide (CaO).

CaO is ground into a powder in a tower mill, a spiral classifier or a slaker. The milk of the ground lime is used for many industrial purposes, including pH control, power fluegas cleansing, calcium extraction in pharmaceutical manufacturing and more. One of the most common uses of lime in the chemical process industry is pH control.

Lime is extremely difficult to handle in piping systems, instrumentation and valves, because its particles are jagged and will not dissolve, but are rather merely suspended in solution. Any cracks or crevices will cause the lime particles to fall out of suspension and fill these voids. Lime further aggravates this situation when it hardens in these collection points. The lime changes its state to a solid mass of material — commonly referred to as scaling. Scaling causes a pipeline's inner diameter to become smaller and smaller. Material buildup on valve seats and other surfaces can cause the valves to freeze in position.

Limestone removed from caverns such as this finds use in many industrial applications.

Tips for lime service

Process equipment, instrumentation and valves selected for use in lime slurry systems should limit cavities, cracks and void areas. Even a small collection point of lime can cause equipment failure and countless hours of downtime and maintenance.

The ideal product to supplement lime slurry should be able to clean itself and break apart scale. It should also be completely free of void spaces, cracks and cavities. A piping product installed in a lime slurry system should be full port in order to limit obstruction and potential lime slurry buildup.

A significantly oversized actuator is a typical initiative for increasing plug and ball valve performance in lime slurry systems. Because the size of the actuator is increased, the output capability is roughly two times the normal manufacturer's recommended torque for clean liquids.

An oversized actuator may improve performance while decreasing downtime as a result of sticking valves, but it will not solve all related maintenance problems. Because lime is very abrasive, it affects most ball and plug valves severely. A hard material cover, such as stellite coating on the ball, will help protect the valve against the abrasive nature of lime.

The seats also are a major concern. Again, hardened-steel seats with a scraping edge are most likely the best alternative in lime applications. "Scraping" hard-coated metals will perform better in scaling substances because they have the ability to scrape built-up material off the ball and plug surfaces.

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20-cm (8-in.) air actuated pinch valves on high-pressure lime slurry solution.

Most polymeric seats will not maintain durability over time in lime slurry. The scaling that occurs in these valves is like a wrecking ball to most polymeric seats. The ball or plug with scale buildup is turned through these seats, usually resulting in a short lifetime. Because ball and plug valves have cavity areas that house the ball or plug, a substantial amount of material accumulates in this void area over time. It is beneficial to install flushing ports in the valve so that the body cavity area can be cleansed with water to wipe out material accumulation after each cycle. This process will help minimize material buildup in the cavity area.

It is expensive to build a ball or plug valve with all of the previously mentioned features. The cost of a ball or plug valve equipped with these features can be five to six times the price of a traditional Teflon-seated ball or plug valve. However, the performance of most Teflon-seated ball or plug valves in lime slurry is less than-satisfactory.

Gate and knife gate valves

Gate- and knife-gate valves can be used in many slurry services. Most gate valves force the gate into a wedge area to close the valve, so tight shutoff is not always guaranteed.

Knife gate valves have a sharpened edge to improve the ability to cut through solid particles. In lime service, the seating area is a spot for material accumulation. The lime will accumulate in this area, causing difficulties in valve operation, which could prevent sealing the valve completely against the line pressure.

The ideal knife gate valve for lime service features a hard-surfaced leading knife edge. Actuator forces in knife gates should be increased to give the valve the ability to cut through or close tightly against the lime buildup in the wedge.

The knife of the knife gate is exposed to scaling and the scale buildup on the knife is most likely accumulated from packing problems in knife gates. As the knife opens, the scale buildup is dragged through the packing, which requires increased forces to open the valve. In most instances, significant packing leaks occur.

Using knife gates in lime slurry service requires a scraping packing material. This material should be a hardened substance that has the ability to scrape the knife clean with every operation. The knife gate valve should have increased actuator forces that are capable of dragging the knife through the packing material.

Pinch valves

Pinch valves are an efficient solution for lime slurry service because they have a straight-through design with no crevices or cavities for material collection. Pinch valves have a proficient self-cleaning effect on scaling materials.

A rubber tube, or sleeve, is pinched by steel bars on the centerline of the valve, causing the tube to close. Upon stretching the rubber sleeve, it begins to reach the closing position and the material or scale buildup flakes. As the valve is being closed, the flaking becomes greater, but the fluid velocity increases substantially. Thus, the flaked material or scale is pressure washed from the elastic surface of the rubber sleeve.

Pinch valves also address abrasion concerns. When dealing with abrasive flows, there are two options. The first is to make the ball, plug, or gate valve and piping materials much harder and more durable. The second approach is to make the valve or piping material softer. Softer materials allow the abrasive particles to bounce off the surface without destroying it.

For this reason, pinch valves have been used in mining applications on very coarse slurries for the past 30 years. With any mineral-based slurry, pinch valves are a viable option for protecting against abrasion. A pinch valve also offers protection against clogging or jamming that can occur with other valves in lime

Manual pinch valves used for lime classification on hydrocyclones.

slurry service. Many valves, such as ball valves with stellite or harder coatings, may be able to withstand the abrasiveness of lime slurry. However, they are subject to jamming or clogging because they have cavities that allow for material collection.

Pinch valve selection must be performed carefully and with due diligence. Stainless steel or carbon steel ball valves and plug valves do not vary greatly from one reputable manufacturer to another. Choosing one of the more reputable ball or plug valves will most likely guarantee a valve that is free from porosity or imperfections. In addition, some ball or plug valves have modified designs to enhance performance in difficult services.

Pinch valves, however, can vary greatly from one another, and rubber quality and properties can differ drastically from one manufacturer to another. A comparable analogy is purchasing automobile tires with the option of either a 48,000-km (30,000-mile) set of tires or an 50,000-km (80,000-mile set). Side by side, these tires look almost identical, but the 50,000-km- (80,000-mile-) rated tire certainly will cost more. The price increase secures two times the useful life of an inferior tire.

Good designs are available and reputable companies will stand behind their products after the initial sale. A high-quality pinch valve typically handles lime slurries without any special product enhancements.

A pinch valve or diaphragm that has a preset weir could decrease valve performance quite substantially, however. This nonflexible weir will accumulate scale and, because it does not flex, it will result in increased wear to the rubber sleeve. The nonflexible weir also defeats the self-cleaning effects of pinch valves.

Is it a fit?

Many manufacturers and valve users try to force their standard valves into applications in which they do not belong. Obviously, a large process plant tries to standardize products as much as possible, in order to cut costs with spare parts and personnel training.

However, what many large plants fail to recognize is that this practice may, in turn, prove to be very costly. For example, there was a company that was using a standardized control valve that needed repairing every six months. However, when the company finally switched to a product that was more suited for a slurry process, the plant was able to double its mean time between failures.

The plant had 22 control valves in this process. The five-year operating cost of the previously used 22 control valves, excluding the cost of downtime, was $242,000. By replacing these valves with better-suited slurry control valves, the five-year cost was reduced to $55,000.

The financial ramifications of improper valve, instrumentation and piping selection for processes such as lime slurry can have a long-term negative impact on most operations. Although a simple lime slurry control loop for pH control in many chemical plants is a small portion of the process, it can be a large drain on operating costs. Plant decision-makers would be wise to choose process valves and instrumentation for this portion of the process carefully.

Conclusions

Chemical process plants can select from an array of valves for use in lime slurry service. No types of valves were excluded intentionally and the author attempted to focus on the types of valves more commonly used in lime slurry, as well as to offer recommendations that might help improve valve performance, regardless of which type of valve is selected. Improper valve selection for lime slurry service can have a significant negative effect on continued operating costs. A larger upfront investment could result in substantial savings in the future. ■

National Mining Hall of Fame and Museum welcomes four from the Class of 2010

by William Gleason, Senior Editor

Keeping an eye on the future while honoring the past, Frank McAllister, chief executive officer of Stillwater Mining Co., and life member of the National Mining Hall of Fame and Museum, gave the keynote address to a packed house during the 23rd National Mining Hall of Fame and Museum Banquet in Leadville, CO on Sept. 11.

McAllister's company made news just days before the induction ceremony, when it was announced that Stillwater Mining would acquire Marathon PGM Corp. for $118 million (**ME**, Oct. page 14).

The Montana-based Stillwater Mining Co. is the lone producer of palladium and platinum in the United States and was expected to be able to expand to Canada with the purchase of Marathon. During his keynote address, McAllister did not focus on the merger; instead, he chose to speak about the history of the commodities his company produces and the way in which Stillwater goes about its business, which includes the innovative Good Neighbor Agreement.

In 2001, Stillwater Mining Co., Northern Plains Resource Council, Stillwater Protective Association and Cottonwood Resource Council established the Good Neighbor Agreement as a means to settle disputes, protect the environment and encourage responsible economic development.

Tony Jensen, master of ceremonies, presents a Prazen statue to keynote speaker Frank McAllister (top). Visitors to the National Mining Hall of Fame and Museum in Leadville, CO stroll through the Frost Mineral Gallery prior to the 23rd National Mining Hall of Fame Banquet.

The legally binding agreement addresses a range of issues in a positive and proactive manner. The challenge, McAllister said, is for miners to do more than what is legal, but to also do what is right. He said this includes taking into account everything from shareholders to the environment to the neighbors of the mine.

In addition to the thought-provoking keynote address, the night was also a chance for attendees to reflect on their industry and honor the pioneers who have come before them.

This year's class included four men from mining's past: William Wheeler Coleman, founder of the company that would become Bucyrus International; Dr. Allen V. Heyl, an economic geologist who authored or co-authored 227 books and papers; Arthur Lakes, a geologist, teacher and writer and Samuel Calvin McLanahan, inventor of the log washer and single roll crusher (**ME**, July 2010, page 39). Each man was immortalized on a plaque that will hang in the halls of the museum, along with 206 other mining greats already inducted.

Prior to the induction ceremony, Jackie Dorr, president of the Minerals Information Institute and National Mining Hall of Fame board member, presented the 2010 Prazen Award to the Rocky Mountain Coal Mining Institute for its efforts as a nonprofit corporation dedicated to the promotion of coal in the western United States through education. ■

SME Recognizes and Celebrates

The San José Mine Rescue

After 69 days trapped underground at the San José Mine in Chile, 33 miners were rescued while the world watched and rejoiced. The rescue was an impressive marriage of determination, technology, compassion and planning.

As the premier association of mining professionals, SME, along with the Colorado Mining Association (CMA), will showcase and celebrate the tremendous human effort and technology that made it all possible during the 2011 SME/CMA Annual Meeting. The following is planned to recognize the rescue and the accomplishments of those involved:

Recognition during the
2011 SME/CMA Keynote Session and Special Q&A Session

The following will be recognized for their contributions during the SME/CMA Keynote Session:

- **Jeff Hart,** Layne Christensen
- **Brandon Fisher,** Center Rock Inc.
- **Frank Gabriel,** Schramm Inc.
- **James Stefanic,** Geotec Boyles Bros.
- **Laurence Golborne Riveros,** Minister of Mining, Chile (invited)

Additionally, these representatives will answer audience questions about the rescue and the technology they employed onsite in Chile during a special session, Monday, February 28, 2011 at 2 p.m.

Rescue Technology Showcased On the Exhibit Floor:

- **A model of the Center Rock 26-inch hammer bit that was used to free the miners.**
- **The 5-inch and 12-inch bits.**
- **Attendees will be able to see the progression of how the hole was opened.**
- **Actual or replica of the capsule used for the rescue.**

SME and CMA wish to thank Layne Christensen, Center Rock Inc., Schramm Inc., Drillers Supply Inc. and Geotec Boyles Bros. for their contribution to the rescue and the SME/CMA Annual Meeting. Their outstanding efforts are an inspiration.

2011 SME/CMA Meeting & Exhibit
February 27-March 2, 2011
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Haul truck fuel consumption and CO_2 emission under various engine load conditions

by V. Kecojevic and D. Komljenovic

Abstract ■ Environmental and economic costs related to equipment fuel consumption and carbon dioxide (CO_2) emission present a substantial challenge to the mining industry. Haul trucks are an integral part of the overall surface mining system and they consume a significant quantity of fuel. Consequently, they produce a significant amount of CO_2. The objective of this research is to (i) establish a mathematical relationship among a truck's fuel consumption, power and engine load factors and (ii) determine the amount of a truck's CO_2 emission and the associated cost that may arise from potential CO_2 legislation. In order to achieve these objectives, the authors have considered original equipment manufacturer (OEM) haul trucks, which are commonly used in surface mining operations. The research presented here may be used by mining professionals to help determine the cost and environmental burden of the trucks' application and efficiently manage energy consumption.

Introduction

Haul trucks account for the major share of overall surface mining equipment costs. Fuel consumption is always the primary operating cost associated with trucks. Fundamental changes in fuel conservation, efficiency and reducing negative environmental impact related to CO_2 emission are of crucial importance.

A number of factors contribute to fuel consumption. These factors include truck load, speed, power, weight (empty and gross), accelerations, idle time, fuel quality, aerodynamics, road surface and tire quality, wheel alignment and tires' inflation pressure, road grade, the operator's driving style, outside temperature, weather and adequacy of a truck's maintenance program. The majority of these factors can be controlled to a certain extent by mine operators. Adequate management of these factors may significantly reduce truck fuel consumption while providing required truck performance, without important investments or operational changes. It translates into decreased engine load, which allows for the same performance with lower fuel consumption and, consequently, a lower CO_2 footprint. Thus, this study will analyze the impact of truck power and engine load factors on fuel consumption and on the subsequent CO_2 emissions and cost.

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Fuel consumption

The most accurate method to determine the fuel consumption of trucks is to obtain data from actual mine operations. However, if no such opportunity exists, various equations and data published by the truck original equipment manufacturer (OEM) can be used for estimation purposes.

According to Runge (1998) and Filas (2002), an hourly fuel consumption (FC) (L/hr) can be determined from the following equation:

$$FC = P \times 0.3 \times LF \qquad (1)$$

where P is engine power (kW), 0.3 is unit conversion factor (L/kW/hr) and LF is an engine load factor (the portion of full power required by the truck). Values for the truck engine load factors range from 0.18 to 0.50 (Runge, 1998), while Filas (2002) states that engine load factors typically range between 0.25 and 0.75, depending on the equipment type and use level.

A similar equation for fuel consumption was suggested by Hays (1990):

$$FC = (CSF \times P \times LF) / FD \qquad (2)$$

where CSF is the engine-specific fuel consumption at full power (0.213 – 0.268 kg/kW/hr) (0.35-0.44 lb/hp per hr), P is power (kW), LF is engine load factor and FD is the fuel density (0.85 kg/l [7 lb/gal] for diesel). Hays recommends the following values for engine load factors: 25% (light: considerable idle, loaded hauls on favorable grades and good haulage roads), 35% (average: normal idle, loaded hauls on adverse grades and good haulage roads) and 50% (heavy: minimum idle, loaded hauls on steep adverse grades).

Liebherr has developed a method to determine the truck fuel consumption per hour. According to this OEM, the fuel consumption rate is directly proportional to delivered power

(Baucom, 2008). An 100% load factor is assumed and the following fuel consumptions were obtained: 455 L/hr (120 gal/hr) for 1,864 kW (2,500 hp) truck power, 490 L/hr (129 gal/hr) for 2,013 kW (2,700 hp), 522 L/hr (138 gal/hr) for 2,163 kW (2,900 hp), 547 L/hr (146 gal/hr) for 2,237 kW (3,000 hp), 617 L/hr (163 gal/hr) for 2,610 kW (3,500 hp) and 640 L/hr (169 gal/hr) for 2,722 kW (3,650 hp). Figure 1 shows a relationship between engine power *P* (kW) and fuel consumption *FC* (L/hr) for Liebherr trucks at 100% engine load factor. Analyzing Fig. 1, it can be concluded that an increase in truck power at a load factor of 100% will lead to an average increase in fuel consumption at the rate of 0.2139 L/hr (0.056 gal/hr) per kW. It should be noted that as engine ratings approach and exceed 2,237 kW (3,000 hp), fuel efficiency (L/hr per kW) continues to improve (Baucom, 2008). A high value of $R^2 = 0.9964$ indicates a strong positive linear correlation between engine power and fuel consumption for Liebherr trucks.

Analyzing Eqs. (1), (2) and the results depicted in Fig. 1, the following can be observed: the gradient of an increase in fuel consumption is 0.300 L/hr (0.079 gal/hr) per kW, from 0.250 L/hr (0.066 gal/hr) per kW to 0.315 L/hr (0.083 gal/hr) per kW, and 0.214 L/hr (0.056 gal/hr) per kW, respectively. Equations 1 and 2 can be used for approximate calculation of fuel consumption, while the result obtained using OEM data reflects modern and more efficient truck engine designs, and is a more relevant and accurate for calculation of fuel consumption at 100% load factor.

Caterpillar (2009) provides data on fuel consumption for its trucks and various engine load factors. According to Caterpillar (2009), an engine continuously producing full-rated horsepower is operating at a load factor of 100%. Trucks may reach 100% load factor intermittently, but seldom operate at this level for extended periods of time (Caterpillar, 2009). During acceleration, the engine usually operates at full power with a load factor of 100%. While idling, a truck engine operates at about 10% of full power (Hays, 1990).

Values of engine load factor are given by Caterpillar (2009) as follows:

- Low: 20%-30% (Continuous operation at an average gross weight less than the recommended. Excellent haul roads. No overloading, low load factor.)
- Medium: 30%-40% (Continuous operation at an average gross weight approaching the recommended. Minimal overloading. Good haul roads, moderate load factor.)
- High: 40%-50% (Continuous operation at or above maximum recommended gross weight. Overloading. Poor haul roads, high load factor.)

Figure 1

Relationship between fuel consumption of Liebherr trucks and their engine power at a load factor of 100%.

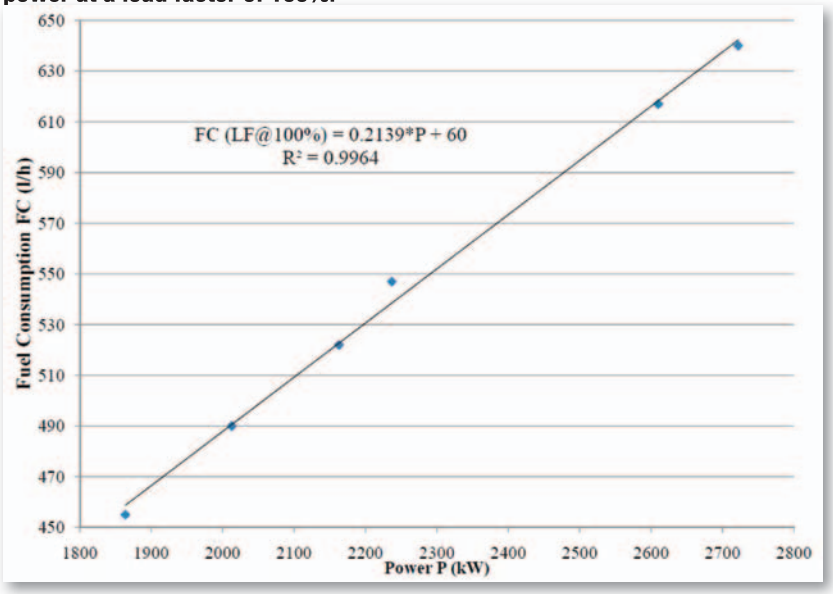
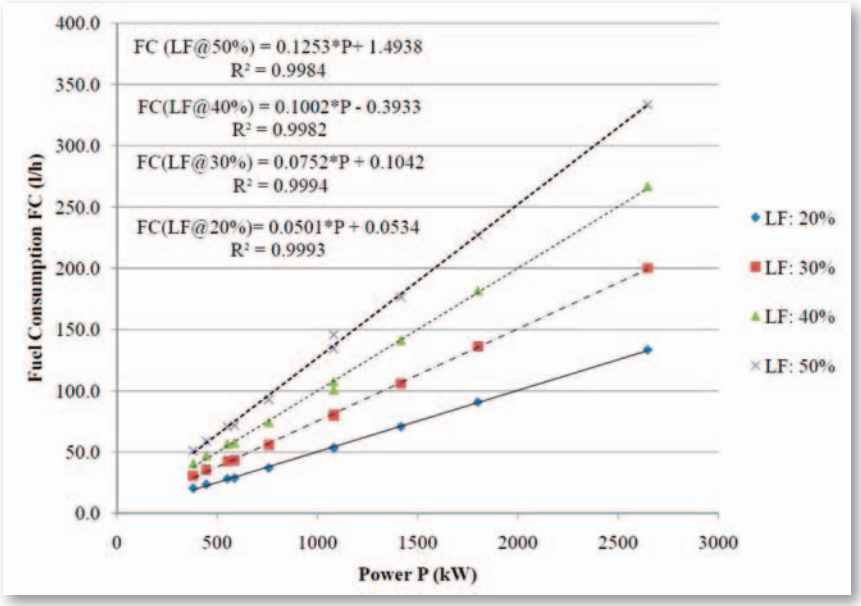


Figure 2

The relationship between fuel consumption (L/hr) and gross power (kW) for Caterpillar trucks.



Data on engine load factors given by Caterpillar are similar to those provided by Hays (1990) and Runge (1998).

A sample of 10 mining truck models from Caterpillar were selected for this study. All data of Caterpillar trucks related to design characteristics (gross and net power, gross and empty truck weight, payload, body volume) and hourly fuel consumption are available from the manufacturer's handbook (Caterpillar, 2009). Based on these data, the relationship among fuel consumption, power and load factor was established (Fig. 2). The obtained results show that fuel consumption increases in average from 0.050 L/hr (0.013 gal/hr)

Figure 3

Change in fuel consumption as a function of engine load factor.

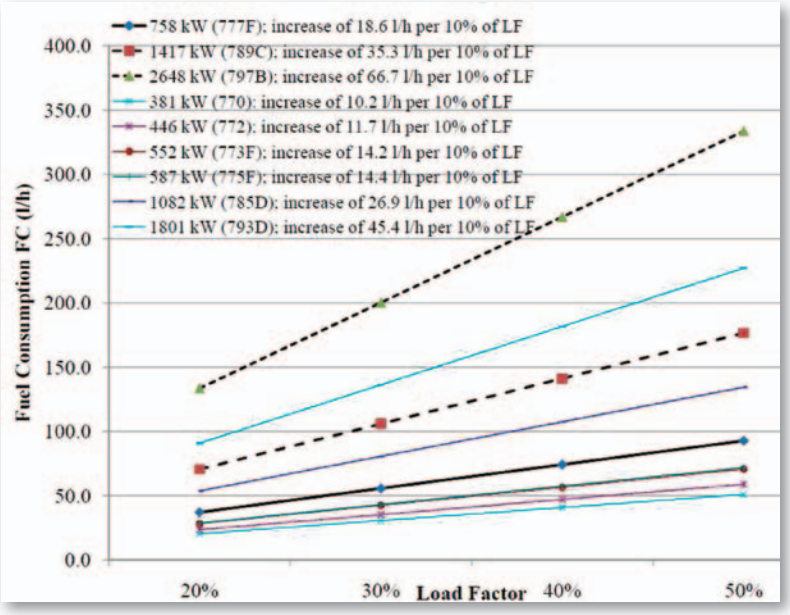


Figure 4

Potential annual savings ($/year) for 10% reduction in load factor.

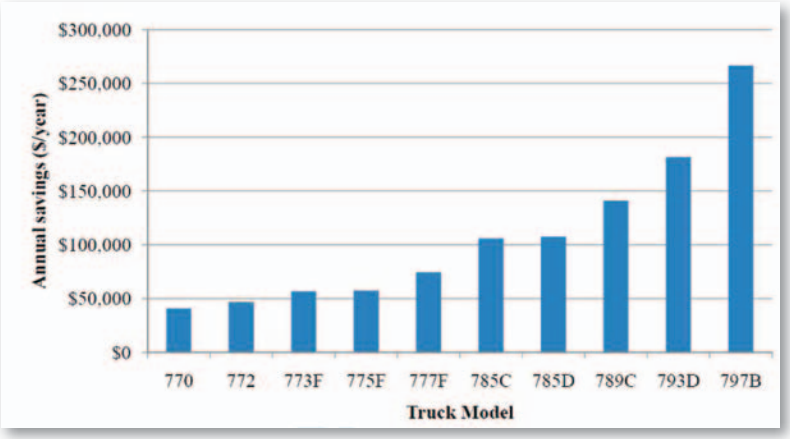
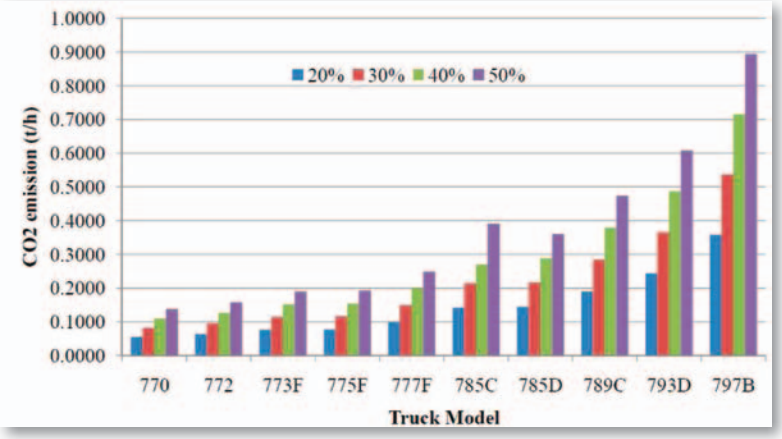


Figure 5

The CO_2 emission (t/hr) of Caterpillar trucks for various engine load factors.



per kW at a load factor of 20% to 0.075 L/hr (0.02 gal/hr) per kW at a load factor of 30%. It can also be seen that the fuel consumption increases from 0.100 L/hr (0.026 gal/hr) per kW at a load factor of 40% to 0.125 L/hr (0.033 gal/hr) per kW at a load factor of 50%. High values of R^2 indicate a strong positive linear correlation between power and fuel consumption for Caterpillar trucks.

Figure 3 shows the change in fuel consumption as a function of load factor for all Caterpillar trucks. It is to be noted that fuel consumption is a linear function of the load factor. However, the former increases faster in absolute values for larger trucks. Also, it can be observed, for example, that the increase in fuel consumption for the smallest truck (Cat 770) is 10.2 L/hr (2.69 gal/hr) for each 10% increase in the load factor. The largest model (Cat 797B) has an increase in fuel consumption of 66.7 L/hr (17.6 gal/hr) for each 10% increase in the load factor. This is an important finding, because mine operators can control factors that influence the load factor (road quality, operator's driving style, load, maintenance, etc.).

Figure 4 shows an example of total annual savings if the load factor is reduced by only 10%. It is assumed that the cost of fuel is $0.8/L ($3/gal). The total number of truck operating hours per year is considered to be 5,000, which is consistent with average data obtained from an operating coal mine in the southern U.S. The number of hours can also be considered as a means of approximately estimating the cost. Therefore, reducing the load factor by 10% can result in $40,800 savings per year for the smallest truck (Cat 770) and almost $267,000 per year for the largest truck (Cat 797B).

Determination of CO_2 emission

The CO_2 emission from combusted fuel can be determined by on site metering. However, on site metering units that continuously monitor equipment emission can be expensive and require permanent maintenance (Mining Environmental Management, 2008). The other alternative is to determine CO_2 emission by using mathematical equations.

The CO_2 emission from diesel fuels in t/hr can be written as:

$$CO_2 = FC \times CF \qquad (3)$$

where FC is diesel fuel consumption (L/hr), and CF is the conversion factor. The conversion factors of CO_2 emission for diesel fuel can be calculated as:

$$CF = CC \times 10^{-6} \times 0.99 \times (44/12) \qquad (4)$$

where CC is carbon content for the diesel fuel (g/L), and 0.99 is the oxidation factor.

Figure 6

The CO_2 cost ($/hr) for various engine load factors (%).

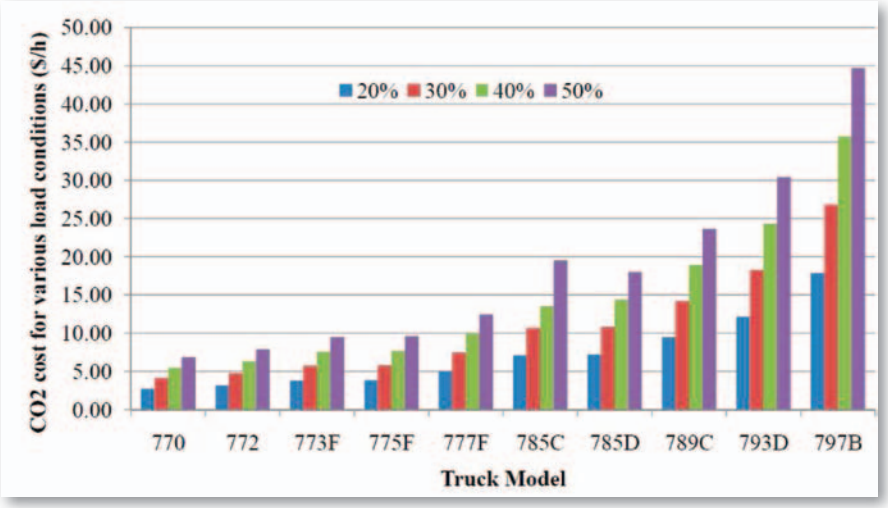
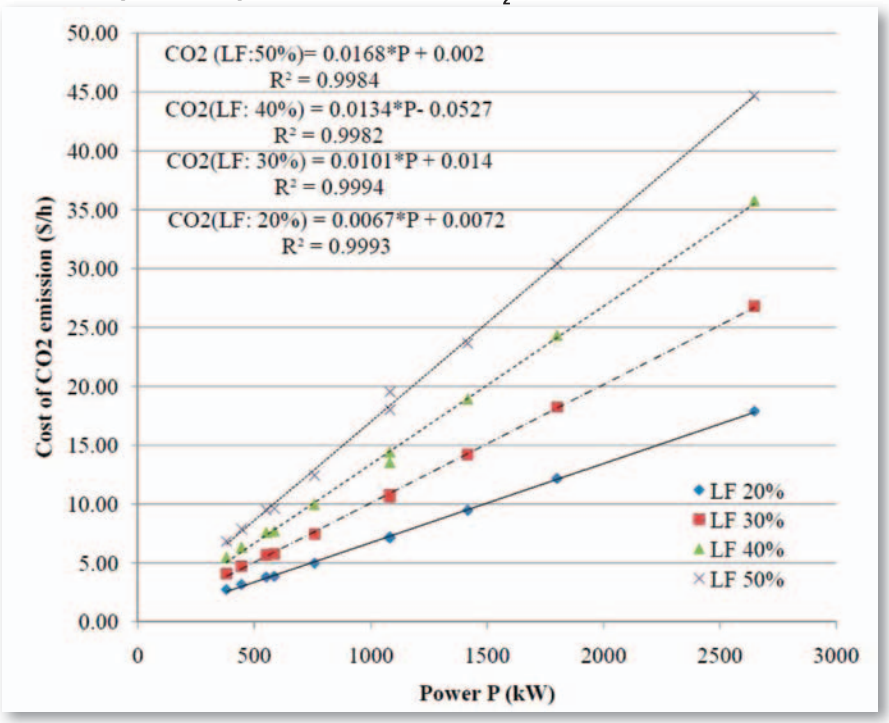


Figure 7

Relationship between power and the cost of CO_2 emission.



According to the Environmental Protection Agency (EPA, 2005), the conversion factor for diesel fuel *CF* is 0.00268. This factor is calculated based on the carbon residue in one liter of diesel. The carbon content for the diesel is *CC* = 733 g/L (EPA, 2005). The oxidation factor for all oil and its products is 0.99. Practically, this means that 99% of the fuel burns out, while 1% remains unoxidized.

Figure 5 shows CO_2 emission (t/hr) of Caterpillar trucks for various engine load factors. These values are calculated using an hourly fuel consumption and conversion factor of *CF* = 0.00268 for diesel. The value of CO_2 emission ranges from 0.0547 t/hr (0.0601 st/hr) to 0.1367 t/hr (0.1507 st/hr) for load factors of 20% and 50%, respectively, for the smallest truck (Cat 770), and from 0.3578 t/hr (0.3944 st/hr) to 0.8940 t/hr (0.9835 st/hr) for load factors of 20% and 50%, respectively, for the largest truck (Cat 797B).

There are many empirical models with a range of values for the cost of CO_2 emission, and they are based on potential CO_2 legislation. Two of the most recognized models include the U.S. Energy Information Agency's (EIA) National Energy Modeling System (NEMS) model and the Massachusetts Institute of Technology's (MIT) Emissions Prediction and Policy Analysis (EPPA) model. These models consider a cost of CO_2 that ranges from $17 to $50 per ton of CO_2 emitted (Aziz and Kecojevic, 2008). For the purpose of this study, the value of $50 per ton was considered.

Figure 6 shows the cost of CO_2 emission per hour for various engine load factors. The cost of CO_2 emission ranges from $2.73 to $6.83 per hour for load factors of 20% and 50%, respectively, for the smallest truck (Cat 770) and from $17.89 to $44.70 per hour for load factors of 20% and 50%, respectively, for the largest truck (Cat 797B). Figure 7 depicts the mathematical relationship between the cost of CO_2 emission ($/hr) and truck power (kW).

Figure 8 shows the cost of CO_2 emission on an annual basis, assuming 5,000 operating hours per year. The costs range from $13,668 to $34,170 per year for load factors of 20% and 50%, respectively, for the smallest truck (Cat 770), and from $89,445 to $223,512 per year for load factors of 20% and 50%, respectively, for the largest truck (Cat 797B). Assuming that large-scale surface mining operations may have a fleet of 10 Cat 797B trucks, the cost for CO_2 emission may run from $900,000 to almost $2.3 million.

Figure 9 shows a potential cost savings related to CO_2 emission for the analyzed Caterpillar trucks. These savings are obtained by averaging the values given in Fig. 8 for reducing the load factor by 10%. The results show that savings per 10% load factor may range from approximately $7,000 per year per truck for the smallest model (Cat 770), to approximately $45,000 per year per truck for the largest model (797B).

A study by Leslie (2000) indicates that there is a decrease in fuel consumption when we move to larger and more productive trucks that have more efficient engines. The author also states that, since the production of CO_2 is directly proportional to fuel consumption, the amount of CO_2 released into the atmosphere decreases by 21.4% when moving from a 154-t (170-st) capacity truck to a 218-t (240-st), and another 16.3% from a 218-t (240-st) to a 290-t (320-st) truck capacity. It should be noted that Leslie's study (2000) relates to specific values of fuel consumption (lb/hr per ton of truck

Figure 8

The CO_2 cost ($/year) for various engine load factors (%).

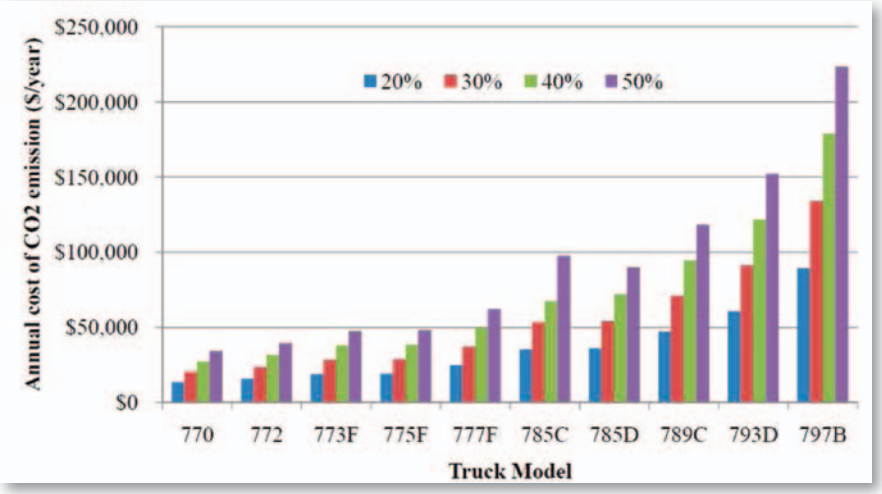
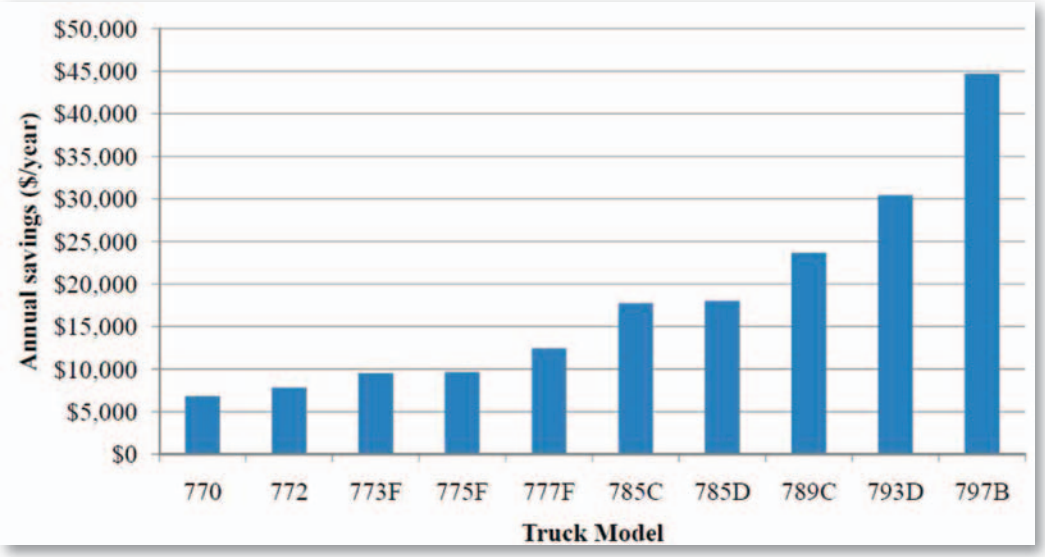


Figure 9

Potential annual savings ($/year) for a 10% reduction in load factor.



capacity), while this study has focused on absolute values of fuel consumption (L/hr) and CO_2 emission (t/hr) for various engine load factors.

Conclusions

This research was carried out to study the fuel consumption and CO_2 emission of haul trucks under various load conditions and to determine the associated costs of such consumption and emission. OEM trucks were considered for this study and it was determined that fuel consumption bears a strong correlation with power and engine load factor. It was determined that a reduction in load factor of 10% can significantly decrease fuel consumption and CO_2 emission and, consequently, reduce operating costs. Future studies may focus on specific factors (acceleration, idle time, road grade, maintenance and quality of road surface, the operator's driving style) to determine the potential savings in fuel consumption and CO_2 emission. ■

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Potential of roof screening to reduce workers' compensation costs

by S.M. Moore, J. Pollard, S.K. Bhatt and C. Mark

Abstract ■ Each year more than 400 coal miners are injured (fatally and nonfatally) by rock falling from between or around roof supports. Many of these injuries can be prevented by the installation of roof screen. However, many coal mines are reluctant to use roof screen because of the added cost. The goal of this study was to determine the potential savings in workers' compensation (WC) premiums that can be achieved due to a reduction in rock fall injuries after roof screening. The WC rate-setting methods utilized by Illinois and Kentucky were investigated in this study. Using data obtained from the Mine Safety and Health Administration, national and state WC bodies and individual insurance companies (e.g., average cost per injury, loss cost rate, number of injuries per year, number of injuries preventable each year with roof screening), baseline mines (representing two mine sizes: 67 and 150 employees) were constructed with realistic ranges for estimates of injuries and WC premium costs. Using each state's actual WC rate-setting formulas, a sensitivity analysis was conducted to determine the total savings in WC costs after a three-year period. Annual savings in WC premiums ranged from $41,000 to $326,000 for the 67-person mine, and $96,000 to $843,000 for the 150-person mine. An economic analysis of the cost of a roof screening program at a 67-person mine was also conducted. The annual cost of a roof screening program here was estimated at $240,000. At this mine, the reduction in WC premiums alone could pay for the entire screening program.

Introduction

More than 400 roof fall injuries are reported to the U.S. Mine Safety and Health Administration (MSHA) each year. Nearly all of these injuries are caused by rocks falling between and around roof supports. Such rock falls also caused six fatal injuries between 2006 and 2008. Technology is available to prevent the majority of these injuries and fatalities. Surface controls like straps, headers and large roof bolt plates can help, but the most effective prevention is roof screen (Fig. 1). Screen works best because it can cover up to 94% of the roof (Robertson et al., 2003). Screen also offers a first line of defense for roof bolter operators, by confining or deflecting small rocks that can come loose during drilling or bolt installation.

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Studies have shown that mines that use screen routinely have much lower rates of "struck by" rock fall injuries. Robertson et al. (2003) reported on two eastern longwall mines that reduced their rock fall injuries by more than 80% after screening was introduced. A room-and-pillar mine in Indiana implemented a screening program, in which screen was installed in about half of the total drivage, typically in the belt and track entries, and in the intake and return escapeways (Compton et al., 2007). The number of rock fall injuries that this mine reported to MSHA was reduced from an average of seven per year in the three years prior to screening to less than three per year in the five following years.

Despite the fact that roof screening has obvious benefits to the safety of mine workers, some mining companies have yet to implement this safety measure due to concerns about the cost. However, injuries are also very expensive. According to information provided to the National Institute for Occupational Safety and Health (NIOSH) by the National Council on Compensation Insurance (NCCI), in the years 2002–2004, the average lost time workers' compensation claim from a Kentucky underground coal mine cost $99,258. Medical inflation would have increased this loss to more than $130,000 in the years since (St. Louis Federal Reserve, 2010). While injury costs vary widely, the savings from preventing injuries may be so large that they can largely offset and, in some cases, even exceed, the direct costs of a

Figure 1

Roof screen provides superior protection from rock falls.

roof screening program.

In the U.S., the costs of injuries are covered by workers' compensation (WC) insurance. Some coal companies, generally the larger ones, are self-insured and essentially bear the costs of injuries themselves. The others buy coverage from WC insurance providers. The goal of this study was to quantify the potential reduction in WC premiums that mining operations might expect after reducing the number of rock fall injuries with roof screening. These savings are then compared to the costs associated with a roof screening program at a typical room-and-pillar mine.

Methods and results

This study focused on WC premiums in Illinois and Kentucky. These states were selected because mines in the Illinois Basin have higher rock fall injury rates than mines in other coalfields (Molinda et al., 2008). Mines in these states may be highly interested in reducing WC costs through various methodologies, such as the one proposed in this study.

WC rate-setting calculations for NCCI states. WC rate-setting functions may be performed by a state insurance fund or department of insurance. Some of these organizations designate these functions to rating bureaus or advisory organizations. The National Council on Compensation Insurance (NCCI) is the licensed rating organization in 36 states. Both Illinois and Kentucky are NCCI states.[1]

NCCI uses "experience rating" plans to modify premiums based on each individual employer's past loss experience. Experience-rating plans, therefore, provide economic incentives to employers to reduce the frequency and severity of work-related injuries. The experience period is usually three full policy years, ending one year prior to the effective date of the modification.

The NCCI formulas used to calculate the "experience rating modification" (MOD) are shown in Eqs. (1) and (2) (NCCI, 2003; printed with permission by NCCI). In Eq. (1), "Total A" reflects the individual employer's actual loss experience, while in Eq. (2), "Total B" reflects its expected loss experience, based on the entire group of similar employers.

Primary losses	Stabilizing values	Ratable excess	Total	
APL	$+ (1 - WV) \times EEL + BV$	$+ WV \times AEL$	= Total A	(1)
EPL	$+ (1 - WV) \times EEL + BV$	$+ WV \times EEL$	= Total B	(2)

Where:

APL	=	Actual primary losses
WV	=	Weighting value
EEL	=	Expected excess losses
BV	=	Ballast value
AEL	=	Actual excess losses
EPL	=	Expected primary losses

The total expected losses are determined by multiplying the expected loss rate (ELR – obtained using a table provided by NCCI; use Classification 1016 for underground bituminous coal) by the payroll for the three years used in the rating. This value is then multiplied by 0.01 to put the number in terms per $100 of payroll.

The primary losses are the ultimate losses with each injury at a mine up to the primary limiting factor ($5,000 per claim). The expected primary losses are then determined by multiplying the D-ratio (obtained using a table provided by NCCI; this ratio determines the portion of a mine's expected losses that are expected to be primary losses) by the total expected losses (EL) (Eq. 3). Expected excess losses (EEL) are determined by subtracting the total expected primary losses (EPL) from the total expected losses (Eq. 4).

$$EPL = (D \text{ ratio}) \times ELR \times (\text{3-year pay}) \times 0.01 \quad (3)$$

$$EEL = EL - EPL \quad (4)$$

[1]Prior to 2008, Illinois mines used a different equation to arrive at the WC premium to be paid by each mine than they do today. However, since Illinois now employs the same equation as Kentucky, the currently used equation was implemented in both states for the purpose of this study.

Table 1

Characteristics of WC claims, according to information provided to NIOSH by NCCI. Values are annual averages for the period 2002-2004.

State	Average annual payroll ($ million)	Estimated workers covered	Average annual WC claims	WC claims per worker per year	Average cost per WC claim
Illinois	$51.2	1,003	268	0.267	$29,577
Kentucky	$143.6	3,055	869	0.284	$40,829

The weighting value is obtained using a table from the *NCCI Experience Rating Plan Manual* and is based on the expected losses (note: different tables exist for different states). The weighting value determines how much of the actual losses and expected excess losses are used in the experience rating. The weighting value increases as expected losses increase. The ballast factor in the experience rating formula helps prevent the MOD from shifting too far above or below unity. It is added to both the actual primary losses and the expected primary losses. This value also increases as expected losses increase.

Finally, the MOD is calculated by dividing Total A by Total B:

$$MOD = \text{Total A} / \text{Total B} \qquad (5)$$

An MOD that is less than unity implies that an employer has a better-than-average loss experience.[2]

Potential savings with roof screening. The rating period used for this study was 2001, 2002 and 2003, yielding WC costs for the year 2005. To demonstrate the expected amount of savings in WC premiums, baseline mines were created that are representative of mines that are experience-rated in Illinois and Kentucky. In each state, two baseline mines were used in the analysis, one with 67 employees and the other with 150 employees.

To conduct the analysis, data for the following parameters had to be obtained:

- payroll for 2001, 2002 and 2003;
- total number of injuries for each of the three years;
- number of injuries that would have been prevented by implementing roof screening for each of the three years;
- base loss cost rate in 2005;
- administrative fee multiplier applied by their insurance provider; and
- the ultimate losses associated with each injury.

In 2005, loss cost rate for Illinois was $33.13 (effective Jan. 1, 2005), which included $9.67 and $6.99 for the state and federal black lung coverage, respectively, leaving $16.47 subject to a MOD factor (NCCI, 2009). For Kentucky, the loss cost rate was $31.02 (effective 9/1/04), whereby $1.18 and $5.06 were for the state and federal black lung coverage, leaving $24.78 subject to a MOD factor (NCCI, 2009).

Communications with NCCI and a large insurance provider in Kentucky (NCCI, 2009; Kentucky Employers, Mutual Insurance, 2009) yielded information regarding typical administrative multipliers used by insurers in Illinois and Kentucky. The multipliers used for Illinois and Kentucky were 1.46 and 1.115, respectively. To estimate the remaining parameters, several assumptions were made:

- **Payroll** – The average mine worker salary in 2002 was determined to be $50,538 in Illinois and $47,473 in Kentucky (U.S. Bureau of the Census, 2002). These salaries were adjusted for inflation to estimate the salaries in 2001 and 2003. To determine the total payroll, the average salary was multiplied by the number of employees at the mine.
- **Total number of injuries** – Table 1 summarizes the data provided to NIOSH by NCCI for experience-rated coal mines for the claim years 2002 – 2004. (For Illinois, the actual period covered was April 2001 to March 2004. For Kentucky, the period was May 2001 to April 2004). The average number of workers covered by NCCI plans during those years was estimated to be 1,003 in Illinois and 3,055 in Kentucky.

Table 2

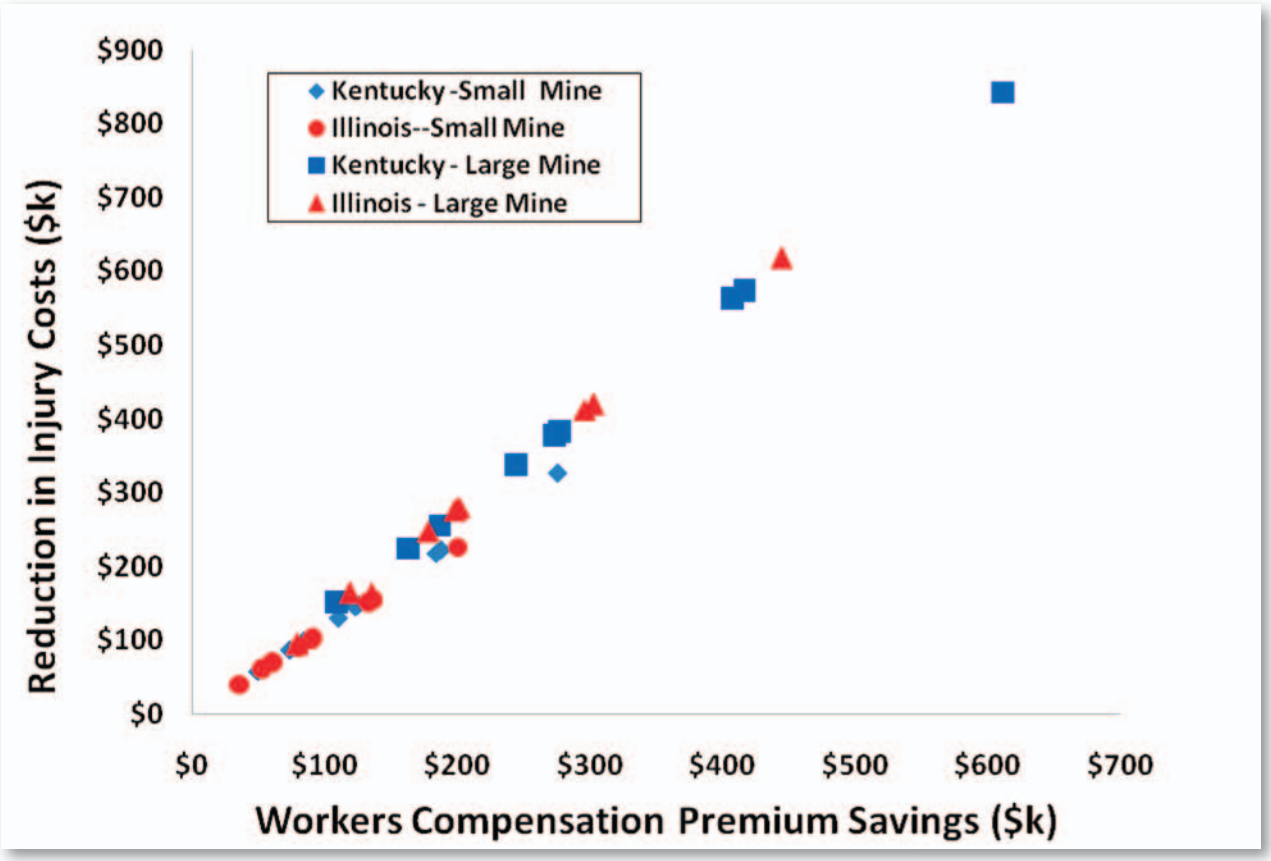
Characteristics of underground accidents from the MSHA database. Values are annual averages for 2002-2004.

State	Average annual workers	Average annual accidents	Accidents per worker	% Roof fall accidents	Avg. days lost per roof fall accident	Avg. days lost per nonroof fall accident
Illinois	2,555	335	0.131	20.0%	29.6	39.2
Kentucky	8,542	1,002	0.117	17.1%	48.2	46.0

[2] In many states, WC premiums may also be modified by a schedule rating factor. The schedule rating factor, which may be positive or negative, reflects additional characteristics of the employer such as its use of "safety devices." Details are reported in the NCCI Basic Manual, Appendix D, which can be obtained at www.ncci.com.

Figure 2

Potential cost savings from roof screening. The *x* axis is the potential reduction in WC insurance premiums and the *y* axis is the estimated total losses avoided, due to the screening program.



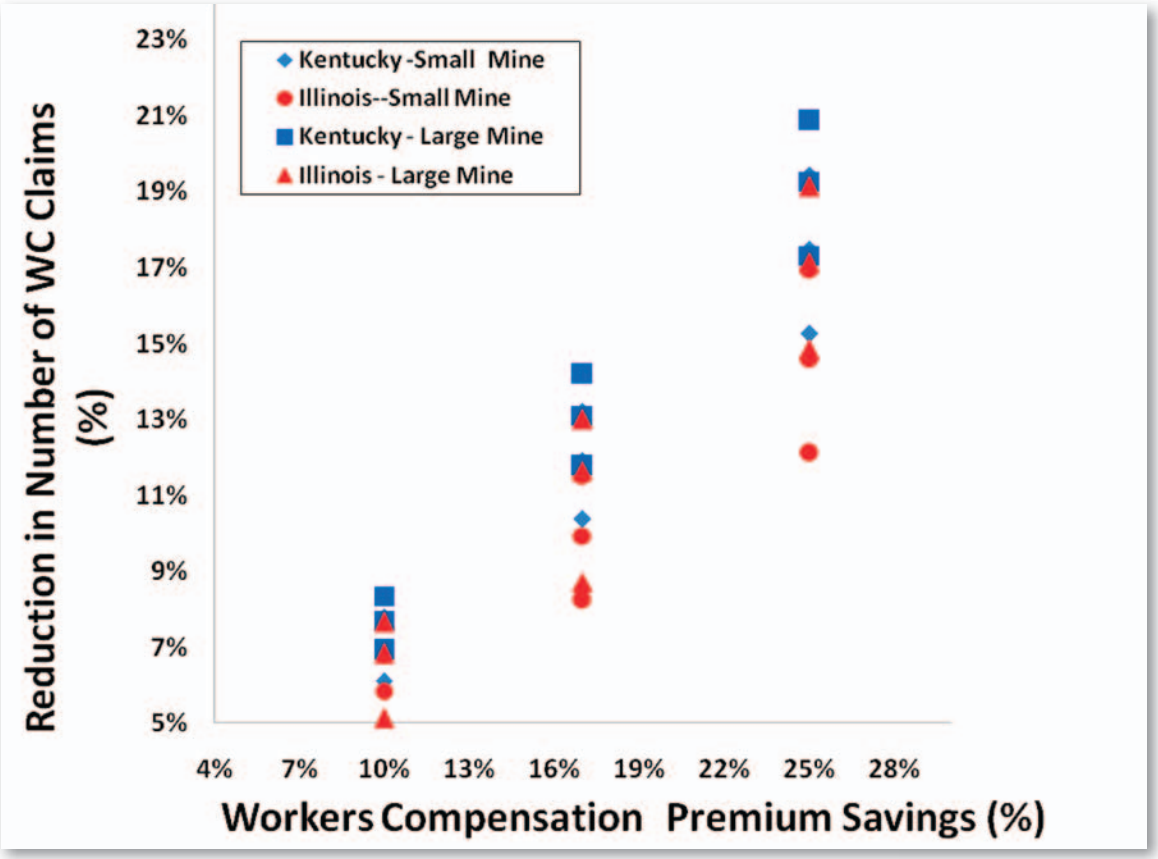
Dividing the reported number of claims by the estimated number of workers yields the average number of claims per worker. Using these data, the expected number of claims was then estimated to be 18 and 19 for the 67-person mines in Illinois and Kentucky, respectively, and 40 and 43 for the 150-person mines in the two states. To accommodate mines that would be slightly above or below this average number of claims, the ranges used in the sensitivity analyses were 12-27 claims per year for the 67-person mine, and 27-60 claims per year for the 150-person mine.

- **Number of preventable injuries** – NCCI does not report information on the causes of the injuries that result in WC claims. So the MSHA injury database was used to estimate the number of injuries that might have been prevented by roof screening. The MSHA data indicated that 17% of all Kentucky injuries, and 20% of all Illinois injuries, were the result of rock falls (Table 2). We assume these values to also be representative of the NCCI injury database. An analysis of the MSHA injury narratives determined that nearly all of these injuries could have been prevented by roof screen (Roberston et al., 2003). Table 2 also shows that the severity of the rock fall injuries, expressed in terms of the average days lost per injury, was similar to that of other injuries that occurred underground. To accommodate mines that would be slightly above or below these expected preventable injuries, the sensitivity analyses assumed that the screening program reduced the number of WC claims at the baseline mines by 10%, 17% and 25%.
- **Ultimate losses per injury** (actuarially determined amount; loss estimate at resolution of the claim based upon statistical trends for a specific state) – the incurred losses and claims data obtained from NCCI shown in Table 1 indicate that the average cost per claim (including both lost time and medical claims) was $29,577 in Illinois, while in Kentucky it was $40,829.
- **NCCI equation parameters:** The expected loss ratio used for Illinois was 10.21 and the discount ratio was 0.15. For Kentucky, these values were 12.9 and 0.17. The weighting value used for the 67-person mine was 0.40 in Illinois and 0.56 in Kentucky, and the ballast values were 133,125 and 133,900, respectively. For the 150-person mine, the weighting values were 0.55 in Illinois and 0.67 in Kentucky, and the ballast values were 260,925 and 285,693, respectively. Again, all of these values are determined using tables provided by NCCI for each state.

The findings from the analysis are summarized in Figs. 2 and 3. Depending on the total number of WC claims, the number of claims prevented by roof screening ranged between 1 and 7 for the 67-person mine, and between 3 and 15 for the 150-person mine. Figure 2 shows that the cost savings (total losses avoided) for these prevented injuries ranged from $35,000 to $612,000. The potential reduction in WC premiums actually exceeded the cost savings by 37% for the larger mines and 19% for the smaller ones. In Illinois, po-

Figure 3

Potential reduction in WC premiums (excluding Black Lung) due to roof screening.



tential annual savings in WC premiums ranged from $41,000 to $227,000 for the 67-person mine, and $96,000 to $612,000 for the 150-person mine. In Kentucky, potential savings were $58,000 to $326,000 for the smaller mine, and $151,000 to $843,000 for the larger one.

Figure 3 shows that, on average, a 10% reduction in the number of WC claims results in an average 6.2% reduction in the traumatic portion of the WC premium (the portion affected by the MOD, which does not include the state and federal Black Lung portions of the premium). The percent reduction in the premium varies substantially, however, with the highest value (of 7.7%) for the larger mines with the largest number of total WC claims.

Economics of screening. An economic analysis was conducted in order to estimate what fraction of the costs associated with the implementation of roof screening would be offset by the reduction in WC premiums. The analysis was performed for a typical Midwestern room-and-pillar mine employing 67 people and producing 726 kt (800,000 st) per year. The mine was assumed to operate two shifts per day, using a single super section employing two continuous miners and two roof bolters. A critical assumption was that adding roof screen did not decrease the footage of advance per shift. This assumption is reasonable if best practices for screen installation, such as those described by Compton et al. (2007), are used, and particularly if only about 50% of the drivage is screened. Other assumptions were:

- The section advances 122 m/shift (400 ft/shift) in a 1.5-m- (5-ft)- thick coal seam.
- Straps, costing $8 each, are currently installed in all headings and crosscuts.
- Screen installation requires an additional 10 minutes per 12 m (40 ft) of advance (Note: This additional time for screening affects the time to install roof support materials, but does not affect the time for cutting coal (production time), because that is done by the continuous mining machine in a different heading).
- Screen, costing $16 per piece, will replace the straps in 50% of the drivage.
- Labor cost (fully loaded) is $40/hour.
- Maintenance costs may be excluded, as they are not normally required for screening.
- No additional injuries due to material handling.

The incremental costs associated with the roof screening program can be calculated as follows:

- Cost of screen = $6.56/ m ($2/ft).
- Cost of labor to install screen = 0.82 min/m (0.25 min/ft) with two roof bolter operators = $1.08/m ($0.33/ft).
- Cost of supplying screen to the section is approximately $0.33/m ($0.10/ft).

The total cost for installing screen is, therefore, approximately $8/m ($2.43/ft) or $0.64/t ($0.58/st). If screen is installed in 50% of the drivage, the cost per ton for the mine

drops to $0.32/t ($0.29/st). If this one-section mine produces 726 kt (800,000 st) annually, the yearly cost for the screen installation in half of the drivage is approximately $240,000.

The analysis summarized in Figs. 2 and 3 showed that the potential WC premium savings after implementing a roof screening program could approach, or even exceed, these estimated costs for the screen installation. Moreover, it is important to consider that the WC expense is only a fraction of the total cost of "struck by" injuries. In addition, the mining operation will incur indirect administrative costs to replace injured workers, costs to train new replacement workers and production delays due to inexperienced workers on the continuous miner or roof bolter. A roof fall that causes an injury can also cause production delays, due to MSHA inspection of the fall area and plan/operational changes made to accommodate MSHA requirements to prevent further "struck by" accidents. "Struck by" injuries can have a negative effect on the morale of the entire underground work force and may make the miners question their own safety. There may also be legal costs linked to "struck by" injuries, such as fines or penalties related to reportable injuries, legal fees and possible "gross negligence" lawsuits. It should be noted that the costs discussed in this paper are from the employer's perspective and not from a societal perspective, which would also include the costs associated with pain and suffering of the mine worker and the consequences this would place on their families.

Roof screening also improves general ground control in the mine and can provide substantial economic benefits above and beyond those directly related to injury prevention by:

- Reducing the need for spot bolting due to deteriorating roof conditions.
- Minimizing production losses due to cleanup and re-support of important belt, travel and escape entries.
- Reducing major roof falls by providing confinement between bolts and preventing unraveling above bolt anchorage.

Conclusions

In this study, the methods utilized by Illinois and Kentucky to determine a mine's WC premiums were detailed. A sensitivity analysis was conducted, in which the number of total injuries and the number of injuries that could have been prevented with roof screening were varied. The potential savings were substantial. It was found that the reduction in premiums actually exceeded the reduction in actual losses by 19-37%, depending on the size of the mine evaluated. In many cases, the potential savings approached or even exceeded the estimated costs of a screening program. Roof screen can also bring additional benefits to a company's bottom line by improving ground control and reducing the sizable indirect costs of injuries.

There were several limitations to the current study. The mines utilized in the study were hypothetical, as opposed to using real mine demographic and injury data. The total number of injuries and the preventable injuries at each hypothetical mine were based upon injury data obtained from NCCI and the MSHA injury database in each state. For each state, an average injury cost was used for every claim, rather than using a realistic distribution of claim costs. Finally, it should be noted that large coal companies tend to purchase nonstandard WC policies. Specifically, they often purchase some type of risk-sharing policy, such as a large deductible, or they may be self-insured and purchase an excess WC policy. For the latter case, the cost associated with every claim eliminated through roof screening is directly saved by the company. Additional savings would then be observed by the reduction in the MOD associated with the excess WC policy.

Roof screen has the potential to prevent hundreds of injuries caused by the fall of small rocks between and around roof supports. Currently, these injuries occur while miners are located under "supported" roof. Many mines may be overestimating the costs of installing screen and underestimating the potential economic benefits from reducing the number of "struck by" injuries. It is hoped that this paper will help convince mining operations to give this valuable technology another look. ■

Acknowledgments

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Disclosure

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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The SME Foundation;

Your favorite 501(c)3

by Barbara Arnold, SME Foundation vice president

It is time to start thinking about year-end charitable contributions, and the SME Foundation (SMEF) would be remiss if it did not ask. So here I am asking you to consider giving generously to the SME Foundation general fund or to one of its many "buckets."

Buckets? You ask. Buckets, I reply. The SME Foundation has kicked off its Bucket campaign and each program is represented by a bucket. This campaign allows you, the donor, to decide where your contribution goes, whether it is to the general fund, the Professional Engineers Exam Committee program, the GEM program, ABET (formerly known as the Accreditation Board for Engineering & Technology), the MMSA/SMEF Presidential Scholarship, the Mineral Information Institute or into an endowment fund to support one of the programs long term. New buckets this year include the Rong Yu Wan Memorial Scholarship and the George Weisdack Memorial Scholarship. Each scholarship was developed as a tribute to an esteemed SME member who recently passed away. The memory of these colleagues will continue through educating the next generation of mining engineers. The choice of where to allocate your donation is yours.

More in depth information about all of these programs can be found on the SME website at www.smenet.org/foundation or by calling AnnMarie Estrada, SME Foundation development manager, at 303-948-4224. No matter which bucket you choose, you will support your industry through education, outreach, licensure and scholarships. There is no better way to give back to your profession than to give to your SME Foundation.

Donations may be made on the SME website at www.smenet.org/foundation/foundationcontributions, by mailing your check to 8307 Shaffer Pkwy., Littleton, CO 80127 or by calling SME headquarters 303-948-4224. And remember, all donations to the SMEF are tax deductible. Happy holidays from all of the foundation trustees and staff. ■

Consol Energy will sponsor the SMEF dinner-dance

During the 2011 SME Annual Meeting, Feb. 27-March 2, the foundation trustees will hold a Luau-themed foundation dinner-dance and awards presentation on Sunday, Feb. 27. You can look forward to an evening filled with great food, Hawaiian ambiance and music, a live auction, dancing and much more. The activities we have planned will provide an opportunity to relax and enjoy the evening, while supporting the SME Foundation's fundraising efforts and taking part in the vision the trustees have for its future. The foundation dinner-dance provides a wonderful opportunity to see old friends and colleagues. And as always, the SME Foundation is appreciative of the tremendous support SME members give to this event. We extend our gratitude to Consol Energy for hosting the dinner-dance. Please purchase tickets for this event on your SME Annual Meeting registration form. ■

Visit the SMEF silent auction in the exhibit hall

Once again, the SME Foundation is soliciting items for auction. This is an excellent way for a company to advertise while donating to the foundation. Donors and their booth numbers will be listed with the auction items. The unique and valuable items that are donated make the SME Foundation booth one of the most popular stops in the exhibit hall. Cash donations are also greatly appreciated, as this helps us purchase highly desirable items for the auction.

SMEF Auction items needed

- **Historical memorabilia**
- **Equipment models**
- **Jewelry and gem specimens**
- **Mineral and fossil specimens**
- **Maps and books**

This will be the fifth year for the silent auction to benefit the programs under the umbrella of the SME Foundation. These

(Continued on page 63)

The 2009 SMEF booth had many items for auction.

Your industry is counting on you — Part 1

by Robert Reisinger, Environmental Division Program Committee Chair

After graduating from college as a mining engineer, I ran across an article titled, "Dear Engineering Senior." The author of the article, Louis Guy, former treasurer of the National Society of Professional Engineers, was asked to give some advice to an engineering school senior about what he could expect as he sets out on a career in engineering. Among the many words of wisdom offered, Guy writes that active membership in engineering societies is an excellent means for a young engineer to develop contacts and collect information on what is happening beyond his employer.

I remember the first mining conference I attended. It was an Indiana Coal Mining Institute conference held in Evansville, IN about a year after I graduated from college — some 30 years ago. I worked for Peabody Coal at the time. A couple of guys, perhaps in their mid-50s, sat next to me at the conference luncheon. I can still recite their words to me, "The future of our industry is counting on you." Quite a responsibility for a young person relatively new to the mining industry.

I have always believed in service, whether to your community, church or profession. I'm not sure exactly why. Maybe it has to do with being part of something bigger than yourself. Performing the service itself provides the benefit, but there are also positive side effects, like getting to know people and becoming more knowledgeable about your community, church or profession.

Taste of Colorado volunteers

The Taste of Colorado is an annual festival held in Denver over the Labor Day weekend. For the past 16 years, a mining exhibit has been part of the festival. Many mining companies and other organizations have contributed financially to the success of the mining exhibit. In addition, it takes hundreds of volunteer hours to set up, run and take down the exhibit. This past Labor Day was my third year as a volunteer. Others have been helping out for much longer. Guy Johnson, a U.S. Bureau of Mines alumnus, started the mining exhibit way back in the mid-1990s and has been there through it all. It has been a huge success and a wonderful way to reach people with mining's story. The children especially enjoy panning for gold and digging for fossils.

The Taste of Colorado mining exhibit is just one example of serving your profession and industry. Indeed, there are countless ways that one could get involved.

SME and the Environmental Division offer many opportunities for serving your profession and industry — for the young professional as well as someone with years of experience. With the annual conference around the corner, the next couple of months are a perfect time to consider your involvement. Next month's *Environmental Division News* will discuss ways that you might want to get involved with SME and the Environmental Division. As someone told me some 30 years ago, the future of our industry is counting on you.

To be continued . . . . ■

Environmental Division News **serves as a forum for the presentation and discussion of facts, ideas and opinions pertaining to the interests and technology of the Environmental Division. Accordingly, all material published herein is signed and reflects the individual views of the authors. It is not an official position of SME or the division. Comments by readers will be referred to the division for response. The division chair in 2010 is Anne Williamson.**

Northern Nevada section offers historic calendar

The 25th edition of the Nevada Historic Mining Calendar is available for sale. It is published by the Northern Nevada Section of SME together with the W.M. Keck Museum at the Mackay School of Mines, University of Nevada-Reno. The calendar has large squares for daily notes and makes an excellent Christmas gift. The 2011 calendar features photos of Searchlight, NV which was, for a short period, the largest gold producer in the United States. The history of the Searchlight area includes gold production information abstracted from Searchlight -The Camp That Didn't Fail, *a book written by U.S. Senator Harry Reid, born in Searchlight and the son of a hard-rock miner.*

In 2010, the proceeds from the sale of the calendars allowed the section to award $1,500 in scholarships to students at the University of Nevada studying for careers in the minerals industry.

Send $10 (includes shipping) for each calendar ordered to: Northern Nevada Section of SME, 1790 Brunetti Way, Sparks, NV 89431, phone 775-358-2723. Make checks payable to the Northern Nevada Section of SME.

Oil-Dri—facing forward

by Candace Trimble, Raw Materials Geologist, Oil-Dri Corp.

There is a vision that is necessary to carry businesses on into the future. That sort of vision is always necessary, but never more so than when times get tough. Without vision, organizations lose focus, products become dated and businesses become obsolete. The vision I am talking about is more than just the knowledge and ability to imagine and create new products and produce them efficiently, although that is certainly part of it. This vision requires that we see ourselves and our workforces as people, not labor and staff and management. It requires that we see ourselves and our businesses as integral parts of the communities and ecosystems in which we live and work. It requires that we see ourselves and our businesses in these places and environments in the future — working, living well and continuing to succeed. It requires we do the right thing simply because it is the right and ethical thing to do. Without this vision, any business is temporary and its success ephemeral.

These last two years have been very tough for mining, manufacturing and related businesses. Everyone is striving to be leaner, meaner and more fit. Increasing fuel prices mixed with tightened consumer spending has not helped. So, it was quite a blow when belt-tightening measures led some key customers to rethink the number and variety of the Oil-Dri company products they carry.

Without vision, we might have done what common wisdom would have had us do, what so many others did — accept the new realty as permanent and reduce the workforce companywide. Well, that is what one would have expected, but that is not what we did.

Flying in the face of all expectations, Oil-Dri opted to keep all of its people. Our visionary management chose to spend more money and energy on marketing our products to other customers. But that is not all. We continued to invest in reserves and innovation. We asked everyone, top to bottom, to make sacrifices together to make this work. The company froze salaries at 2009 levels across the board. Salaried folks worked longer hours. Hourly folks did more in less time. Not forgetting those around us, we sent our production bonuses to less fortunate people through charitable contributions. We all strove to work smarter and more effectively and to do our part in carrying out the plan. It is kind of funny, too, that through all this shared sacrifice, morale actually improved. Go figure. You see, we knew we really were all in it together.

Today, I am here to report that the choice to invest in keeping our people and working to grow our business in the worst global economy since the Great Depression is paying off. We have ended fiscal year 2010 with strong performance and, while others are takings pay cuts, we are paying bonuses to our people and dividends to our investors.

There is a vision that is necessary to carry us on into the future. It starts with everyone caring. All of us invested in each other, our communities, our environment, our businesses and our future together. At Oil-Dri, we care. ■

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Mary M. Poulton named Distinguished Professor

Mary M. Poulton (SME), head of the Department of Mining and Geological Engineering at the University of Arizona (UA), is the 2010 recipient of the university's Distinguished Professor Award. She is the only distinguished professor named this year for the entire university.

POULTON

The award was created in 1995 to recognize faculty who have a long-term commitment to undergraduate education, and who have made outstanding contributions at the university. Criteria used for award selection include a demonstrated commitment to undergraduate education, a distinguished record of creative scholarship, advising and mentoring undergraduates and involvement in undergraduate curriculum innovation.

In addition to her outstanding commitment to undergraduate education, Poulton brought more than a dozen mining companies and Science Foundation Arizona together with the UA to form the Lowell Institute for Mineral Resources (IMR). The IMR at the UA goes beyond the normal extractive industry curricula by drawing in the interdisciplinary environmental, health and community functions that accompany these processes into the IMR from other departments and colleges within the university.

The goals are to build long-term capacity for research and education in the sustainable development of mineral resources and to pursue research projects that address major challenges in sustainable resource development. She also undertook the responsibility of spearheading the IMR. Through Poulton's tireless commitment, the first courses were offered in the 2009-2010 academic year. ■

The rest of the *Story of Stuff*

by Dayan Anderson, Micon International

In my last article, in the February 2010 issue of *Mining Engineering*, I hinted that I would be writing a feature article on the Mineral Footprint Initiative. Well, I am not going to do that — just yet. You see, I have a story to tell, and somewhat like the *Star Wars* saga, it is a story that is perhaps better told in a nonchronological manner. There are a few subplots I want to engage you in first. This may be frustrating, but I am asking you to bear with me, as I use a storytelling technique that Hollywood has mastered quite well. Recall how George Lucas began his amazing story somewhere in the middle? He captivated us with characters from a galaxy far, far away by starting his story with episodes IV, V and VI, returning decades later to tell us the rest of the story through episodes I, II and III. Some would argue he botched up his second batch of movies, however his overall approach to telling a story was effective, and it is one I am going to attempt to emulate.

Speaking of telling stories, there is a story that every member of the extractive industry should be aware of called *The Story of Stuff* by Annie Leonard. I strongly recommend that you visit www.storyofstuff.com, perhaps even before finishing my article, as long as you promise to come back and finish my polemic rant.

The decisions we make today about how we use and produce natural resources, renewable and nonrenewable, are very complicated ones, much more complicated than is often presented to the general public or even within academia. Leonard, in her crisp, short video, tries to convey all the complexities of our global economy and material supply in about 20 minutes and 40 seconds.

I must warn you — once you have made it through the first two minutes and 50 seconds of the video, I can almost guarantee you will experience a range of emotions including, but not limited to, anger, frustration, defensiveness and an overall sense that this industry is sorely misunderstood. These are most likely the same emotions that inspired messages such as, Ban Mining — Let the Bastards Freeze to Death in the Dark. (Note: If you have not read "Mining and Sustainable Development in a Star Trek Universe" in the February 2010 issue of *Mining Engineering*, now might be the time to take a look at my commentary on the lack of wisdom behind such a message.)

Despite the nausea and heartburn you might feel after watching the first two minutes of Annie Leonard's video, please finish the story she is telling. Once you have made it up to four minutes and 38 seconds, you must soldier on and get through it. Although you may not like or agree with what you hear, you need to finish the story that she is telling. She has raised some very important issues, and the short video has led up to her book of the same title. In other words, this story is being told whether we like it or not.

After I watched the video, I decided to order her book so I could dig down deep, look for holes in her "well-researched" story, identify how many "facts" were probably presented out of context and prepare some pithy rebuttals. However, after watching her interview with Steven Colbert, my initial defensive fever dissipated somewhat, and I realized she and I agree wholeheartedly on some important key premises. She argues that our attitudes about our stuff need to change. This is what she had to say.

"I am not against stuff. The fact that this is stuff is not bad. I'm actually for stuff. I want us to have greater reverence and appreciation for our stuff instead of just this mindless buying and chucking all the time. I want us to look at our stuff and think someone made this, someone mined this metal, someone felled that forest or produced those crops or fished in the ocean or whatever they had to do to get that stuff. Someone brought it to us, let's have a little more appreciation and reverence for the stuff we have instead of mindless consumerism all the time."

She hit a few nails on the head. However, there is still a "rest of the *Story of Stuff*" that needs to be told. The first four minutes of the story she is telling is not based 100 percent on fiction, and we cannot justifiably argue it is based on only historic and dated information. The story is not wrong, it just is not complete. But how can we as an industry help tell the subplots that are missing beneath some of the gross generalizations in the first four minutes and 38 seconds of her video? Notice I used the plural because there are many stories that make up the great saga that our industry needs to tell. These stories are difficult to tell, especially in the wake of recent accidents and environmental disasters. But before we can tell them effectively, there are some fundamental societal misunderstandings that need to be addressed to prepare the listener for the stories we want to share. The remainder of this article will touch on just one of the many storylines.

Those of us in the extractive industries fully understand the complex and dynamic nature of mineral availability, but the general public, and many other academic and professional disciplines that weigh in on the topic, do not. Many national and international dialogues on the subject of resource availability and raw material supply have emerged

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Which Pen is More Sustainable?

The Montblanc Pen
I use it for writing
Made from platinum and precious resin
It costs about US $250

The Sundance Pen
I use it for writing
Made from wood and recycled materials
It costs about US $1

More Information

- I never take the Montblanc pen out of my office, so I use it the rest of my life and then pass it on to a relative.
- I lose the Sundance pen almost every time I take it away from my home; so I have to buy many dozens each year.
- When the Montblanc pen ink cartridge becomes empty, I buy a refill.
- If I still have the Sundance pen when its ink cartridge becomes empty, I will throw it away and get a new one.

AGAIN, WHICH PEN IS MORE SUSTAINABLE?

Main Lessons

- Many votes change after the new information.
- The new information did not describe the pen's physical technology; it described my relationship, habits and attitudes toward the pens.
- Sustainability is not mainly in the physical technology of the tool, it is in our relationship to the tool.
- Achieving sustainable development in the next two decades will require changes in attitudes and goals.

recently, each approaching the issues from different vantage points and levels of understanding. A group of 350 participants convening in Davos Switzerland for the World Resources Forum last year issued the following call for action:

"We call for a new global strategy for governing the use of natural resources . . . We should seek to stabilize resource use at six to 10 tons per capita per year by 2050 . . . with reduction at the top of global society and catch-up from the bottom . . ."

I will leave it to the reader to determine the merits of such a proposal. I am curious how this group arrived at a resource usage per capita number of six to 10 tons and with what certainty that estimate is based? Do we even have enough information as a society to reach any number at all at this point? According to some estimates, we have catalogued approximately 1.9 million of the 11 million species scientists estimate are living on the planet. We have physically identified less than 20 percent of what we can actually see on the surface of the planet. However, there appears to be an uncanny consensus (notably outside the expertise of the extractive industry) that we know all we need to know about the subsurface. With an almost disturbing air of certainty, the consensus agrees that all the good deposits are gone and that we are rapidly approaching the limits of all the nonrenewable resources the planet can offer.

How will the misunderstanding of scarcity and raw material supply influence the choices society is beginning to consider? Where will these decisions lead us? Could we be more effective with our time, money and resources if we approached the problem differently, from a more holistic vantage point? In fact, have we really defined the problem at all? Have the complex issues at hand, and the proposed "silver bullet" solutions, been communicated in such a grossly oversimplified manner that society cannot really see what the problem is? Perhaps the single, largest obstacle to a sustainable future is best described by Cool Hand Luke. "What we've got here is a failure to communicate."

I will save those cans of worms for future articles and most likely a Ph.D., but in the meantime I will call your attention back to an intriguing presentation at the World Resources Forum. A few slides in particular are insightful and speak to themes remarkably similar to Annie Leonard's story (See above).

In short, Dennis Meadows aptly illustrates that our attitudes toward and our relationship to the tools we use must change to achieve sustainability. I could not agree more. However, it is not only our relationship to our tools we must change. Our attitudes toward the materials from which the tools are made must also be re-examined. It appears the general public has been conditioned into a belief that recycling is always good and universally applicable, that mining is always bad and making something that grows back is always better than using a material that does not, because we are so close to running out of everything. It is much, much, much more complicated than that.

To be continued . . . ■

Events for rising professionals
at the 2011 Annual Meeting

by Justin Anderson

The Young Leaders Committee (YLC) is planning several events for the upcoming annual meeting in Denver, CO. In conjunction with one of our mission statements, we are trying to provide educational and developmental activities for rising professionals throughout the SME membership.

Networking is a very important component of the annual meeting as well as a key in the development of a young career. So, the YLC will again host a social event directed to the rising professional. The event will consist of YLC members, invited guests, including past and present SME leadership, and any other rising professionals who want to attend. The event provides young SME members an opportunity to meet their peers. More importantly, it provides a personal arena for the young members to interact with the leadership of SME.

The YLC will also host a technical session focused on topics important to professionals just beginning their career. During the session, four topics will be presented:

- The professional engineer: who, what, when, where, why and how.
- Everything you wanted to know about government regulations but were afraid to ask.
- Understanding company financial statements.
- Trial by fire: The challenges of being a new engineer.

The rising professionals are the future of SME, and the Young Leaders Committee is working hard to provide worthwhile events to encourage them to be active in SME. I strongly encourage all young professionals to attend the annual meeting this year in Denver and to attend both of these worthwhile events. ■

Miners Give Back
will pack food for the needy in Denver

Got Time? Volunteer it to Miners Give Back. Participate in the second annual miners project on Friday, Feb. 25, 2011 from 1-5 p.m. benefiting the Food Bank of the Rockies. Individuals that the Food Bank provides for have to choose between buying food or paying their power bill each month. Join your fellow miners to inspect, clean, sort and pack donated food items at the Food Bank of the Rockies warehouse. These will then distributed to numerous Colorado families in need.

In Phoenix in 2010, 40 miners volunteered their time. We hope to expand our efforts and double that participation in 2011. No special skills are required, just the desire to give back to the community. Volunteers should wear comfortable clothing and closed-toed shoes, as they will be working in a warehouse environment and standing during the majority of the project.

Transportation to the project will depart the Hyatt Regency Denver Convention Center hotel promptly at 12:30 p.m. So, plan your arrival into Denver accordingly. Beverages and snacks will also be provided.

Sign up to volunteer online at www.smenet.org. Can't volunteer your time? Donate financially at www.foodbankrockies.org/goto/minersgiveback.

Food Bank of the Rockies has been fighting hunger and feeding hope since 1968. For further information about the organization, visit www.foodbankrockies.org. ■

In September 2010, SME members and staff filmed a commercial promoting SME and the Food Bank of the Rockies. From l-r, Samantha Richardson, Lyntek; Neil Eurick, Behre Dolbear and SME staff members Steve Kral, Liz Jones and Raven Johnson.

The Hoover Medal;
nominations are now being accepted

The Hoover Medal recognizes outstanding extra-career services by engineers to humanity. Herbert Hoover, in accepting the first Medal in 1930, stated, "The purpose of the medal is to mark the public service of men who have gone outside of their strictly professional work to interest themselves in civic and humanitarian affairs. Engineers have something to contribute to public service."

The key item for the award board's consideration shall be the description of the nominee's most outstanding contribution to the well-being of humanity performed or achieved as a result of the nominee's leadership or through the nominee's own personal efforts. This contribution shall not have been made as part of, or as a direct result of, the nominee's regular career or job.

The Hoover Medal is administered by a board representing five engineering organizations: the American Society of Mechanical Engineers (ASME), the American Society of Civil Engineers, the American Institute of Chemical Engineers, the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME) and the Institute of Electrical and Electronics Engineers.

Nominations must be received by Feb. 15, 2011. The nomination cover sheet and additional information, including a list of past award recipients, may be obtained by visiting ASME's website at www.asme.org/Governance/Honors/UnitAwards/Hoover_Medal.cfm. Nominations must be approved by a member of one of the boards named above. AIME representatives to the Hoover Medal board are P. Somasundaran (PS24@columbia.edu) and S.A. Ravishankar (sa.ravishankar@cytec.com).

Tax-deductible contributions to advance the Hoover Award may be sent to: ASME Hoover Award, ASME M/S 22E1, Three Park Ave., New York, NY 10016 USA. Please contact David Soukup, secretary to the board, for further information at soukupd@asme.org, 212-591-7397. ■

Membership

Sadik Al-Musawe, Irving, TX
Michael Allen, Rolla, MO
Daniel Anderson, Hacker Valley, WV
Misty Arbogast, Morgantown, WV
Arturo Arellano A., Lima, Peru
Hamer Arevalo L., Lima, Peru
Rodrigo Arevalo T., Lima, Peru
Manohar Arora, Golden, CO
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Fernando Barroso, Lisboa, Portugal
Jason Bates, Lexington, KY
Mario Bendezu D., Lima, Peru
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Grace Bernard, Golden, CO
Blake Bogart, Fairbanks, AK
Casey Bollmann, Rolla, MO
Chris Bottoms, Golden, CO
Patrick Brennan, Rolla, MO
Christopher Brown, State College, PA
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Francisco Camarena, Tucson, AZ
Oscar Capcha R., Lima, Peru
Dominic Capitoni, Carmichaels, PA
Victor Cardenas V., Lima, Peru
Charles Case, Morgantown, WV
Hellen Caycho R., Lima, Peru
Pedro Chacaltana R., Lima, Peru
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Jocelyn Cotrina I., Lima, Peru
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John Czulno, Chicago, IL
Rich Davis, Cornelius, NC
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Ke Fan, New York, NY
Robert Farr, Blacksburg, VA
Ebrahim Farrokh, State College, PA
Emily Figer, Morgantown, WV
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Branden Goad, Fenton, MO
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Fabio Guevara V., Lima, Peru
Flavio Guimaraes, Surrey, BC, Canada
Stuart Gula, Gordonsville, TN
Arash Habibijavanbakht, Rolla, MO
Selemani Hassani, Vancouver, BC, Canada
Joshua Hellen, Jefferson, PA
Miguel Heredia S., Lima, Peru
Derek Hird, New Lambton, NSW, Australia
Peter Hollenbeck, Rolla, MO
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Christopher Kijak, Morgantown, WV
Daniel Kohira R., Lima, Peru
Poppy Krause, Butte, MT
Christopher Lantz, Morgantown, WV
Robert Learmont, Grand Rapids, MN
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Wilson Leon C., Lima, Peru
Michael Lesar, Aurora, MN
Mengxing Li, Rolla, MO
Thabiso Mannathoko, Rolla, MO
Dallin Martin, West Valley City, UT

(Continued on page 63)

Penn State's mine rescue team;

students train for emergency response

By Susan B. Bealko, Pittsburgh Section Chair

Penn State mine rescue, a collegiate activity in which there is 100 percent SME student membership, is showing great progress and increasing in momentum. Under the leadership of R. Larry Grayson, SME student chapter faculty sponsor, professor of energy and mineral engineering and George H. Jr. and Anne B. Deike chair in mining engineering, the Penn State mine rescue team has demonstrated a passion to become proficient in mine rescue and emergency response. In less than two years from its formation, the team is performing very well at professional mine rescue competitions. Students are learning skills that help them recognize the importance of mining health and safety.

Partnerships were formed with the Penn State mine rescue team that provided equipment and supplies, specialized training, funding, leadership and opportunities. Dräger Safety donated the team's BG-4 breathing apparatus and CSE provided specialized BG-4 training. Rosebud Mining provided uniforms. Other supporting organizations provided additional equipment, mentoring and training opportunities. These included Consol Energy, Alpha Natural Resources, PA DEP, the Mine Training and Technology Center, the National Institute of Occupational Safety and Health (NIOSH) Office of Mine Safety and Health Research, the Pittsburgh Coal Mining Institute of America and the SME Pittsburgh Section.

The next big event for the Penn State mine rescue team is in conjunction with the 2011 SME Annual Meeting in Denver, CO. The Colorado School of Mines and the Colorado Division of Reclamation, Mining and Safety are hosting the first biennial collegiate Mine Emergency Response Development (MERD) exercise and Edgar Mine rescue challenge events. Penn State will compete against other collegiate mine rescue teams in a MERD exercise on Thursday, Feb. 24 and in mine rescue challenge events on Friday, Feb. 25. The challenge events are open to SME student members; all are welcome, no mine rescue team experience is necessary. For more information and registration forms, please e-mail cosmith@mymail.mines.edu.

Kent Armstrong, Dräger Safety sales manager NAFTA, teaches Penn State mine rescue students about the Dräger BG-4 breathing apparatus.

The formation of the Penn State mine rescue team is just one example of a successful collaboration among groups that care about the future of mining. Supporting SME student activities is a great way for SME local sections to demonstrate their support and provide mentoring to new mining professionals. It also provides opportunities to create industry partnerships and offer unique learning opportunities. Please consider getting involved with SME student activities within your local or regional area. It is a rewarding experience. ■

Mine rescue team members and supporters are shown from left to right: Susan Bealko, NIOSH and SME Pittsburgh Section chair; Chuck Edwards, CSE Corp.; Bob Burns, team member; Randall Bennis, CSE Corp.; Ryan Mauser, team member; Drew Mason, team captain; D.J. Doctorick; and team members Ben Klein, Tom Cook, Patrick D'Elia, John Decker, Dan Chirdon and Evan Garfield.

Why be involved in your section?

by Joe Crawford, Chicago Section chair, Vulcan Construction Materials

The Chicago Section membership represents a diverse group of industry segments: the mining of aggregates, industrial minerals and metals; construction; mining engineering; safety and environmental; drilling; equipment and chemical manufacturing; academia; federal and state research; financial, insurance and legal counsel. One might draw the conclusion that, with all of this talent and experience, we should be able to get more participation in our bimonthly meetings and perhaps help increase our membership through positive experiences. As of Sept. 15, our membership and e-mail roster has 283 people. Not bad, but your section leaders are looking at options to improve your membership experience and to promote meeting attendance.

This article is taken from a Chicago Section newsletter, but it is good advice for all local sections and their members.

A big part of increasing attendance at our meetings is to increase interest and awareness in the section goings-on. This season's line-up of speakers will cover such diverse topics as community relations and mining, geophysics and mining, a geotechnical workshop and materials handling-transportation. With your input, we can schedule even more topics or field trips that are enjoyable and informative.

Why go to the meetings? What's in it for me? Is it worth the time and effort? As much as possible, we encourage interaction among attendees to strengthen professional networks. The meetings are a forum for these interactions, and you will get out of it what you put into it. Obviously, some of our attendees are in competition with each other and will have a tendency to be tight-lipped at times. But there is an element of fellowship among folks involved in a common industry that I think we overlook. After all, we have similar concerns and probably share common interests once out from behind the desk. See it as a time to make new friends and to share a laugh with some old ones. ■

Membership

(Continued from page 61)

Joseph Martos L., Lima, Peru
Andres Mayor G., Lima, Peru
Melyssa McFarland, Cynthiana, KY
Robert Meier, Vienna, MO
Osvaldo Merino P., Lima, Peru
Bryant Miller, Morgantown, WV
Christopher Miller, Wheeling, WV
Dale Miller, Rolla, MO
Robert Miller, Tucson, AZ
Renzo Misari J., Lima, Peru
Bakang Moatlhodi, Rolla, MO
Sanaz Moghodam-Zadeh, Vancouver, BC, Canada
Charles Moore Jr., Littleton, CO
Paris Morgan, Salt Lake City, UT
Collin Morris, Morgantown, WV
Jacob Morris, Camdenton, MO
Mbako Mosweu, Rolla, MO
Letlhogonolo Mpetsane, Rolla, MO
Xavier Naeger, Rolla, MO
Paul Nicholas, Bethesda, MD
Paul Nicol, Morgantown, WV
Nikki Nixon, Butte, MT
John Nunley, Safford, AZ
Almas Nurlybekuly, State College, PA
Ontuetse Oboletse, Rolla, MO
Goitsemang Orapeleng, Rolla, MO
Travis Ord, Morgantown, WV
Codi Osborne, Charleston, WV
Trevor Otte, Lake Saint Louis, MO
Colton Parsons, Salt Rock, WV
Dhwani Patel, Lexington, KY
Patrick Paul, Vancouver, BC, Canada
Paul Penland, Blacksburg, VA
Christopher Peter, Morgantown, WV
Mohammed Portilla C., Lima, Peru
Jorge Quispe D., Lima, Peru
Fadi Qutaish, Lexington, KY
Skyler Roberts, Hendricks, WV
Cody Rogers, Rolla, MO
Enzo Roldan V., Lima, Peru
Drew Runyan, Morgantown, WV
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Tony Saldani L., Lima, Peru
Jorge Sampaio Jr., Success, WAS, Australia
Kathryne Sewester, Viola, KS
Goutam Shahani, Blue Bell, PA
Bradley Shoulders, Morgantown, WV
Max Shrout, Mount Sterling, KY
Huanru Si, Penryn, England
Scott Simon, Hamilton, IL ■

SMEF booth and auction

(Continued from page 55)

programs include ABET, GEM, Mii, the PE Exam Committee, the MMSA/SMEF Presidential Scholarship, the Syd S. Peng Award and scholarship, McIntosh Scholarships and, most recently, the Rong Yu Wan Memorial Scholarship and the George Weisdack Memorial Scholarship. All of these programs benefit SME members though education, outreach, professional licensure, scholarships and awards.

If you or your company would like to make a tax-deductible donation of items or cash, please contact John Murphy (jmurphy@pitt.edu) or AnnMarie Estrada (estrada@smenet.org) or mail your donation directly to the SME Foundation, Attention-AnnMarie Estrada, 8307 Shaffer Pkwy., Littleton, CO 80127.

Popular items in the past have been historical mining memorabilia, maps, high-quality mineral or fossil specimens, quality jewelry or gem specimens, artwork and books. This year we are excited to again offer the Pebble Project trip/tour to Alaska for four, generously donated by the Pebble Ltd. Partnership, as well as the Carlin Trend Mine trip/tour in Nevada, generously donated by Newmont Mining Corp. These, and all our donated items, will be displayed on the SME Foundation website for early viewing, www.smenet.org/foundation.

Please plan to drop by and visit with SME Foundation trustees and SME staff to learn more about the current activities and future goals of the foundation. ■

BinMaster introduces stainless steel connection for rotary indicators

BinMaster Level Controls has introduced a stainless steel process connection for the BMRX and Maxima + rotary level indicators designed for use with corrosive materials. The 304 SS solid, stainless steel fitting is available in 31.75 mm and 38.1 mm (1.25 in. and 1.5 in.) NPT sizes and comes with a stainless steel seal-bearing carrier. All materials that come into contact with the rotary are stainless steel, making it ideal for applications with caustic materials. The rotaries can be used in conjunction with any of BinMaster's three-vane, two-vane, insertable or bayonet-style stainless steel paddles. The rotaries are designed for the level detection of dry, bulk material storage and flow in bins, hoppers, tanks, chutes and conveyors. Managing material storage and flow with the rotaries helps prevent bin overflows and costly spills, empty conditions, clogged chutes and jammed conveyors. They eliminate the need to climb bins to check levels and reduces material waste and unnecessary down time.

www.binmaster.com

The connections are machined in-house in the company's ISO 9001:2008 registered facility.

New company markets brucite for acid neutralization

International Brucite Corp. has been formed to market the mineral brucitic marble or brucite — the natural form of magnesium hydroxide. It has primary applications as an acid neutralizer and metal precipitator for the water treatment and mining markets. In addition, the mineral can be applied as a flame and smoke retardant.

The company will market the brucite reserves of its parent company, Texas Architectural Aggregate. The unique properties of the brucitic marble product allow it to be a clean, natural alternative to other neutralization products and chemicals used to achieve pH balance and remove unwanted metals from industrial waste streams. With its neutralization effect and ability to precipitate metals, brucitic marble can help companies reduce costs, improve operational performance and satisfy environmental requirements.

www.internationalbrucite.com

Oliver upgrades its boots with metatarsal protection

A unique protective shield absorbs up to 90 percent of the most intense force.

Oliver Footwear has recently upgraded its AT 65-691 350 mm (14 in.) lace-up mining boot and AT 65-690 250 mm (10 in.) lace-up mining boot with the Poron XRD metatarsal guard. The boot is not only comfortable, flexible and lightweight, but it also frees the wearer from traditional rigid and bulky guards. The high performance molecules create a protective shield that absorbs up to 90 percent of the most intense force. Oliver still offers its hard-wearing, dual-density nitrile rubber layer outsole, combined with a polyurethane midsole. This ensures that the foot is protected from shock absorption while maintaining a hard-wearing, slip and abrasion resistant sole.

The black-water resistant upper is fully lined with a sympatex waterproof liner and also comes with heavy-duty Nomex heat and flame resistant stitching. For jobs sites with a danger of penetration from nails or other sharp objects, the AT 65-691 and 65-690 feature the Qflex Zero nonmetallic insole, which protects against the risk of penetration from beneath the soles. Further safety protection comes from the nature-form Type 1 protective toe cap. Its wider shape allows greater foot comfort and avoids contact between the foot and the toecap. There is also an integrated TPU safety cell around the boot that protects against scuffing and early failure.

Oliver offers the boots in sizes 6 to 15 and half-size increments from 7 ½ to 11 ½. The lace up design of the AT 65-691 has been altered to allow for the inclusion of a lace-in zipper attachment.

www.oliversafetyboots.com

Chemineer offers top-entering agitators

The Chemineer model 20 HT/GT agitators are designed for service in the chemical, ethanol and biofuels, water and wastewater, FGD, power and general process industries. The agitators feature a high-efficiency gearbox designed specifically for agitator service. Models are available in right-angle and parallel-shaft configurations to meet specific requirements from critical chemical reactor systems to routine storage.

The agitators incorporate a modular design package that reduces the number of replacement parts carried in inventory by the customer. The wide range of speeds available provides improved process control and greater application versatility. The model 20 HT/GT agitators are designed to meet AGMA, OSHA, ANSI, IEC, DIN, EU and ATEX standards and requirements.

Other features include quick and easy seal-change capability to save time and reduce maintenance costs and a variety of seal options. The agitators have high energy efficiency due to an optimized gear design and lighter weight shaft diameter requirements. The standard cast dry-well seal eliminates lubrication oil leakage from the gearbox. This is superior to maintenance intensive, unreliable lip seals.

www.chemineer.com

The agitators have reversible rotation to meet a variety of process requirements.

Atlas Copco boomer meets challenge of narrow-vein mining

A new face drilling rig for narrow-vein mining and tunneling has been introduced by Atlas Copco. Based on its predecessor, the Boomer 104, the new Boomer T1 D offers an array of technical and environmental improvements.

For underground mining and construction's narrow tunnels and drifts, a small and flexible face drilling rig is a necessity. This role has long been filled by Atlas Copco's Boomer 104, but the new T1 D introduces improvements and upgrades aimed at improving productivity, safety and operator comfort. The hydraulically controlled rig has a tight turning radius and, with the enclosed cabin option, stands 13 m (42.7 ft) wide and 27.2 m (84.2 ft) high. Serviceability is improved on the Boomer T1 D with easy access to all service points. The standard protective roof is FOPS approved, as is the optional enclosed cabin. It is equipped with SAHR emergency and parking brakes; improved LED tramming lights that provide better visibility with lower power consumption and HID (Xenon) work lights that provide better visibility and are less sensitive to water splash.

New improvements and options include a more powerful and cleaner Tier 3 engine for higher tramming speed and environmental benefits.

www.atlascopco.us

The first Boomer T1 D was tested at the Lovisa lead/zinc mine in Sweden where it achieved top results.

MB crusher buckets save energy

MB Crusher offers four models of crusher buckets that can be used on all brands and models of excavators from 7.3 t (8 st) and up. The smallest model in the range, BF 60.1, is ideal for excavators weighing from 7.3 to 12.7 t (8 to 14 st). The largest model, BF 120.4, is built for jobs at large construction sites and is suitable for excavators weighing at least 25.4 t (28 st).

MB's crusher bucket saves time, energy and resources. Jobs are performed with a minimum amount of dust and low noise levels. This can also lead to a significant reduction in costs for the entire disposal and procurement activity. The crusher bucket can be moved easily and is inexpensive to maintain. It does not require an operator in addition to the one assigned to the excavator, and it saves the fuel required by a movable crusher.

MB, a Vicenza, Italy-based company, has opened up its new U.S. headquarters in Reno, NV, with offices and warehouses specifically intended for its American customers. The new American subsidiary will allow MB to manage product sales and deliveries quickly and efficiently. ■

www.mbcrusher.com

The profitability of the crusher bucket is comparable to, or higher than, a regular movable crusher.

Upcoming SME Events

George A. Fox Conference
January 25, 2011
Graduate Center
City University of New York
New York, NY, USA

2011 SME Annual Meeting and CMA 113th National Western Mining Conference
February 27-March 2, 2011
Denver, CO, USA

Offshore Technology Conference
May 2-5, 2011
Reliant Center
Houston, TX, USA

For additional information, contact: Meetings Dept., SME
Phone 800-763-3132 • 303-948-4200 • Fax 303-979-3461 • E-mail: sme@smenet.org • www.smenet.org

December 2010

8-10 • Procemin 2010
Sheraton Santiago Hotel and Convention Center, Santiago, Chile
Phone: 56 2 6521555 • Fax: 56-2 6521570
E-mail: procemin@procemin.cl
www.procemin.cl

17-18 • Present Challenges in Mining and Allied Industries
Mayfair Beach Resorts, Puri, Orissa, India
Phone: 91 674 2352358
E-mail: hotaeditor@gmail.com

January 2011

18-20 • 43rd Canadian Mineral Processors Operators Conference
Westin Hotel, Ottawa, ON, Canada
Phone: 613-996-8985 • Fax: 613-947-3325
E-mail: wessgriff@nrcan.gc.ca
www.cmpsoc.ca/annual-conference.cfm

23-24 • 2011 Vancouver Resource Investment Conference
Vancouver Convention Center-West, Vancouver, BC, Canada
Phone: 604-687-4151
E-mail: hfitch@cambridgehouse.com
www.cambridgehouse3.com

February 2011

3-4 • 11th Annual Coaltrans USA
Ritz Carlton Hotel, Coconut Grove, FL, USA
Phone: 44 0 20 7779 8084 • Fax: 44 0 20 7779 8946
www.indmin.com/events

6-9 • 37th Annual Conference on Explosives and Blasting Techniques
Town and Country Resort/Convention Center, San Diego, CA, USA
Phone: 440-349-4400 • Fax: 440-349-3788
E-mail: isee@isee.org
www.isee.org/FPconference.htm

7-9 • Arctic Technology Conference
George R. Brown Convention Center, Houston, TX, USA
Phone: 888-945-2274 ext. 617
E-mail: convene@aapg.org
www.arctictechnologyconference.org

March 2011

1-3 • World CTL Conference
Novotel Paris Tour Eiffel, Paris, France
E-mail: management@world-ctl.com
www.world-ctl.com

21-25 • 10th International Conference on Mining with Backfill
Table Bay Hotel, Cape Town, South Africa
Phone: 27 11 834-1273 • Fax: 27 11 838 5923/833 8156
E-mail: cs@saimm.co.za
www.saimm.co.za/minefill2011

April 2011

4 • Asia Mining Congress 2011
Marina Bay Sands, Singapore
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www.terrapinn.com/2011/asiamining

5-7 • 14th International Seminar on Paste and Thickened Tailings
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E-mail: acginfo@acg.uwa.edu.au
Phone: 61 8 6488 3300 • Fax: 61 8 6488 1130
www.paste2011.com

28-30 • Colorado MPD Annual Meeting
Broadmoor Hotel, Colorado Springs, CO, USA
E-mail: gporter@knightpiesold.com or jenny@pumpsplus.inc

May 2011

10-12 • Sustainability Through Resource Conservation and Recycling '11
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15-17 • 47th Forum on the Geology of Industrial Minerals
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www.isgs.illinois.edu/sections/indust-min/im-home.shtml

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MAY'11 CLOSE 4/5 MATERIAL CLOSE 4/12	**Canada, Review of Exploration, Mining, Coal** 20% Canada section discount and earns free repeat ad in any remaining 2011 issues or a 2012 coal issue	CIM Annual Conference and Exhibit GAC MAC Annual Meeting
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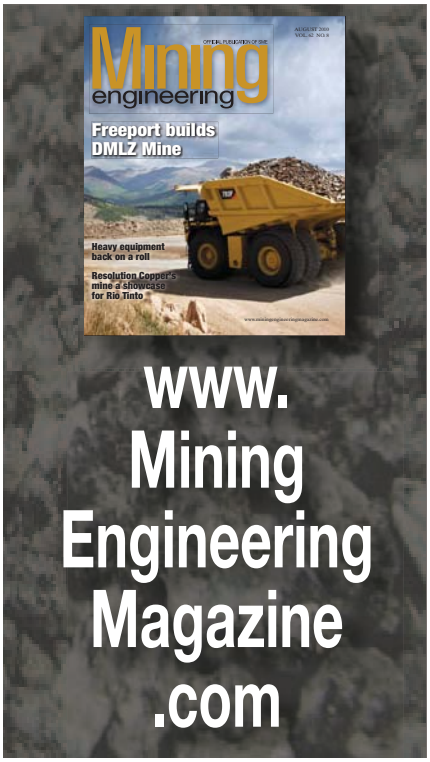

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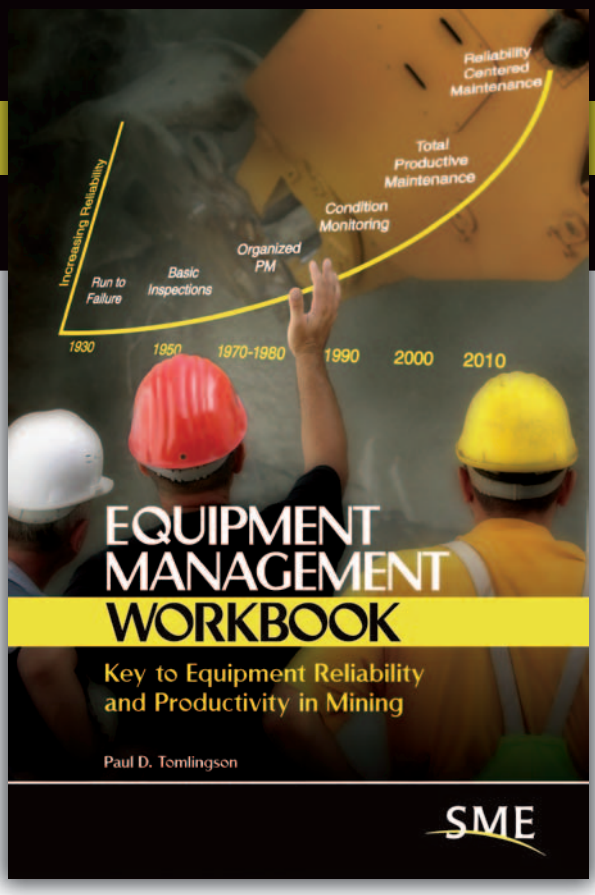

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Ingenuity saves Chilean miners

Steve Kral,
Editor

SME to honor San José rescuers

Between August and October, the world's focus was on a remote region of Chile's Atacama Desert, as rescuers devised several schemes to extract 33 miners trapped underground at the San José Mine.

The outcome was not only heartwarming, but miraculous. The miners survived 69 days and, when they emerged, were in remarkable condition, considering their ordeal. In addition to their physical health upon their rescue, the miners' mental attitudes were nothing but positive. Certainly a tribute to the human spirit.

The miners and their rescuers have gone on to become global celebrities, mostly as a result of the global coverage the rescue garnered by the international media. The accolades they have received are deserved, but probably a bit overwhelming at times. Remember, these are humble miners and drillers who, before the accident, went quietly about their work, just as miners do throughout the world. In time, the dust will settle, the international media will shift its attention to other tragedies and near-tragedies in other parts of the world, and the miners and rescuers will be able to return to their lives.

But, for a few months, the world was reminded what can be accomplished when technology and ingenuity are combined. And the world was able to see the mining industry at its best. There was no giving up — not by the Chilean government, nor the technicians, suppliers and drillers who affected the rescue. **ME's** William Gleason provides a look at the technology involved in the rescue, beginning on page 27.

For its part, the SME leadership believes the remarkable rescue should not be allowed to fade into obscurity. So plans are being made to acknowledge the efforts that took place at the San José Mine.

During the keynote session at the SME Annual Meeting in Denver, CO on Feb. 28, special recognition will be given to some of key players involved with the rescue and their companies. Among them are Jeff Hart of Layne Christensen, Brandon Fisher of Center Rock, Frank Gabriel of Schramm and James Stefanic of Geotec Boyles Bros. In addition, Laurence Golborne Riveros, Chile's minister of mining, has been invited to be part of the ceremony. He was heavily involved with all aspects of the rescue plan and was steadfast in his position that any attempt at rescuing the miners would not be rushed, instead waiting until all of the safety factors had been investigated.

These five people will also discuss their part of the rescue — how decisions were reached and which technologies and equipment to use — during a question-and-answer session Monday afternoon at 2 pm.

Meanwhile, part of the exhibit hall at the annual meeting will showcase some of the equipment and technology used in the rescue. Included will be a model of the Center Rock 26-in. hammer bit; the 5-in. and 12-in. bits used; and the actual or a replica of the capsule, designed by the Chilean Navy, that brought the miners to the surface.

Fox's focus is drill-and-blast excavation

The George A. Fox Conference, set for Jan. 25, 2011 in New York City, has a drill-and-blast theme. More than 300 tunneling and underground construction professionals are expected to attend.

Victor A. Sterner, a blasting consultant with Austin Powder, will provide the keynote address: "Changes in blasting technology." Nine other authors will address specific projects that involve drill-and-blast excavation methods. And a panel discussion is planned that will examine integrating the advances in blasting technology and vibration/crack monitoring. To register, contact the SME Meetings Department, 8307 Shaffer Parkway, Littleton, CO 80127, or fax your registration to 303-979-3461.

In this month's issue of *T&UC*, Seattle, WA's Sound Transit University Link tunnel connection is featured. The authors of this article discuss the many challenges involved with designing this project — geotechnical conditions, buried obstructions, the geometry requirements for construction and balancing the operational considerations with neighborhood stakeholder concerns. ■

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TUNNELING & UNDERGROUND CONSTRUCTION

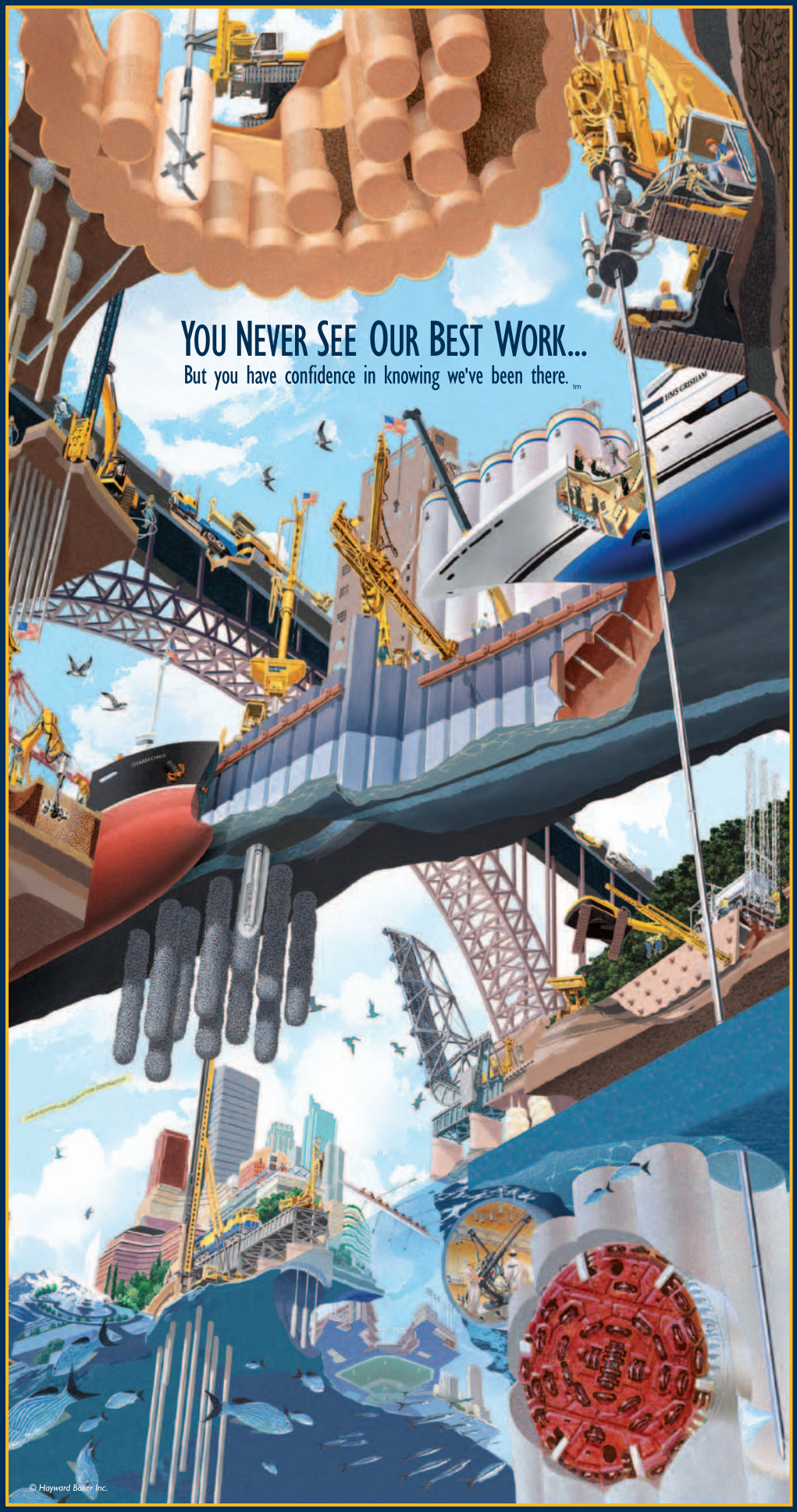
THE OFFICIAL PUBLICATION OF UCA OF SME WWW.TUCMAGAZINE.COM VOLUME 4 NO 4 DECEMBER 2010

Sound Transit University Link

On time project delivery

Tunnel demand forecast

Special Editorial Section from the publisher of *Mining Engineering*



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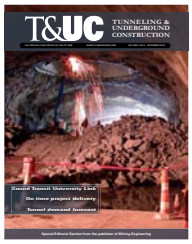
COVER STORY



COVER — This month's cover shows the Weehawken Light Rail project in Jersey City, NJ, where workers are adjusting the reinforcing steel connections for one of the stations. The photo is part of the 2010 UCA of SME calendar. Some of the photos deserve a wider audience, so *T&UC*, on occasion, will publish some of the calendar photos on its cover. Photo courtesy of George Yoggy.

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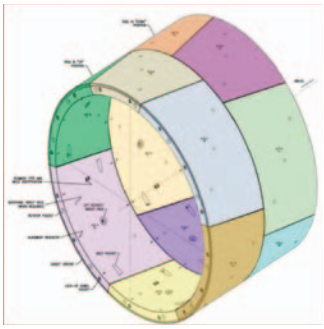

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CHAIRMAN'S COLUMN

Underground construction industry has been on wild ride recently

The underground construction industry has had a tumultuous time since my last column that was written in August. We have had a national election that will impact our industry in positive and negative ways. And we have seen the cancellation of a major underground construction program when the governor of New Jersey announced his intent to cancel the New Jersey Transit Access to the Region's Core (ARC) program. In my opinion, the underground construction industry remains strong, as there are many ongoing and upcoming programs and projects that continue to make our industry vibrant when compared to other aspects of the construction industry.

The Nov. 2 general election is sure to have an impact on our industry. The new Congress that will be seated may not be as "willing" to fund new projects as has occurred during the past years. High speed rail programs in various states might be among the projects impacted by the election, as some elected governors and House members campaigned against these programs. As I travel across the U.S. and visit various contractors and designers, I have found that, contrary to the belief of the general populace, the American Recovery and Reinvestment Act (ARRA) program has had a marginal benefit to our industry. A few major projects were funded by ARRA. But, in general, tunnel projects have been reliant on traditional funding sources for financing. An interesting statistic is that, of the $787 billion in the ARRA Bill, only 21 percent was allocated to all types of construction, and some of these funds have not yet been allocated.

The actions taken by New Jersey Gov. Chris Christie have many of our members bewildered, as everyone thought this program was fully funded and advancing forward. The reason given for the cancellation was a potential cost overrun that would be the responsibility of the people of the state of New Jersey (see page 3). I can understand this concern, but it would be interesting to see the report that was the basis for the governor's decision. There is industry concern that the final cost to build was based on computer modeling that escalated construction costs that had already included cost escalations based on the nature of the project and length of time to construct. Many of us in this business have invested considerable amounts of time and money meeting with the design engineers and owners to freely dispense information and suggestions under the pretense that there would be a project from which we could recover our costs and make a potential profit. How do we recover these costs?

Despite the cancellation of the ARC project, the industry is still advancing. Price and technical proposals were made in late October for the Washington DOT Alaskan Way Tunnel Project in Seattle, WA. Based on a news release from the owner, both design-build proposals received and were within the agency's budget. Thus, both proposals will be evaluated and an announcement on a project awardee will be made before the middle of December. Other major tunnel projects were bid during the quarter in Cleveland, OH and Austin, TX. Please refer to the Tunnel Demand Forecast in this issue for additional upcoming projects (page 52).

During the next UCA of SME Executive Committee meeting in late January, we will be selecting our UCA 2011 awardees and Project of the Year. If you have a person or project that you would like to

(Continued on page 8)

David R. Klug,
UCA of SME Chairman

New Jersey governor kills ARC project

What was to be the largest public works project in the United States was killed by New Jersey Gov. Chris Christie who, on Oct. 7, cancelled the $8.7 billion Access the Region's Core (ARC) tunnel project.

Citing escalating cost estimates of $2.3 billion to $5.3 billion over the estimated total, Christie announced the cancellation of the project, *The New York Times* reported.

"There has not been significant change in those $2 billion to $5 billion numbers," said Christie. "This was a project that had the potential for crowding out everything else that New Jersey is trying to do regarding fiscal responsibility. The potential for $2 billion to $5 billion cost overruns was something that was unacceptable for me to contemplate, knowing that it was just the beginning, potentially, of what this project would cost."

The Trans-Hudson Passenger Rail Tunnel, planned for about 20 years, was meant to add a second pair of tracks between New Jersey and Manhattan. Currently, about 275,000 people from New Jersey commute across the Hudson River to New York every day. During rush hour, Amtrak and regional trains are full and the two Hudson River tunnels are near, or at capacity. The third tunnel would provide room for 70,000 more New Jerseyans to reach Manhattan each day (*T&UC*, March 2009, page 22).

The ARC tunnel would reduce traffic congestion and pollution, shortening commuting times, increasing suburban property values and creating 6,000 construction jobs along the way.

Christie argued that the renovation of the Portal Bridge that runs from Kearny to Secaucus over the Hackensack River, an essential part of the project, was not included in the initial estimates. That project alone, he said, would add an additional $800 million to the price tag.

The project broke ground in 2009 and was expected to be finished in 2018.

Billions of dollars had already been committed to building the tunnels. The federal government had promised $3 billion in federal money. The Port Authority pledged another $3 billion, about half of which is money normally dedicated to New York state, and New Jersey was supposed to commit at least $2.7 billion in stimulus and turnpike funds.

In September, Christie halted spending on the tunnel. Officials at New Jersey Transit, the project's overseer, said they had placed a 30-day moratorium on all new work and contract bids until they could determine if the project's cost would be covered by its budget. The review was prompted by months of talks with federal officials concerned about cost overruns.

In early October, Christie said he was canceling the project because his staff had concluded it would cost more than $11 billion and possibly as much as $14 billion. At the request of the federal transportation secretary, Ray LaHood, Christie agreed to a further two-week review. LaHood came back with a different set of numbers that gave a cost range of at least $9.775 billion and possibly more than $12 billion.

On Oct. 27, Christie said that was still too much, and reaffirmed his decision to cancel the project. ■

Two teams remain in bid for Alaskan Way project

With just two construction teams, the Seattle Tunneling Group and Seattle Tunnel Partners, left in the bidding process for the Alaskan Way viaduct replacement project, Washington state sweetened its Highway 99 tunnel contract by offering the pair of bid teams $230 million in concessions.

The changes reflect a view by construction executives that the real costs of the project are higher than the state projected several months ago, *The Seattle Times* reported.

The money for the concessions can be shifted out of a large pool of risk and contingency funds, so the overall tunnel budget remains $1.96 billion, said Ron Paananen, state program administrator.

The Seattle Tunneling Group is made up of S.A. Healy Co., from Lombard, IL.; Spain's FCC Construction; S.A. Parsons Transportation Group, which has a Seattle office and Halcrow, which has an office in Vancouver, B.C.

Seattle Tunnel Partners is made up of Dragados-USA, from New York HNTB Corp., which has a Bellevue, WA office, and Tutor-Perini Corp. of Sylmar, CA.

"The best thing to me about all this is there are two very serious teams," said Dick Page, district leader for HNTB, the engineering managers for Seattle Tunnel Partners.

Tunnel boring machine (TBM) manufacturers were also in the bidding process for the project that will include a 16.7-m- (55-ft-) diameter tunnel that will carry four lanes of traffic from the stadiums to South Lake Union, replacing the old Alaskan Way Viaduct.

To keep both construction teams in play, *The Seattle Times* reported that the state offered three allowances in a series of contracting

(Continued on page 5)

World's longest tunnel completed

Miners met for the final breakthrough of the world's longest tunnel, the Gotthard Base rail tunnel in Switzerland, on Oct. 15 when the tunnel boring machine drilling from Faido broke through. The breakthrough happened 30 km (18 miles) from the north portal and 27 km (17 miles) from the south. The tunnel breakthrough was highly accurate at 8 cm (3 in.) horizontally and 1 cm (0.4 in.) vertically.

The twin-tube, single-rail tunnel is 57 km (36 miles) long connecting the Swiss towns of of Erstfeld, north of the Alps, with Bodio, on the southern side. With a rock overburden of up to 2,500 m (8,200 ft), the Gotthard base tunnel is also the most deeply set rail tunnel in the world. Together with the 15.4 km (9.5 mile) Ceneri base tunnel, the Gotthard base tunnel will provide a level track through the Alps. The Base tunnel through the Gotthard is the core of the new rail connection. It is planned to become operational by the end of 2017. It is designed to carry international 250-km/h (155 mph) high-speed trains. The price tag for the project is around 10 billion Swiss francs (US$10.4 billion).

The trans-alpine rail connection "is a key project for sustaining the long-term viability of both passenger and goods traffic," said Manfred Schellhammer, managing director of freight and logistics company Kuehne & Nagel International AG, *The Wall Street Journal* reported.

The first works were carried out in 1993, with the Piora exploratory boring, and from 1996 to 1998 with the blasting of the access shafts in Sedrun, Faido and Amsteg. Since 2001, the main lots have been constructed. The final breakthrough in the west tube is planned to take place in April 2011.

Some 2,500 miners, drawn from all over Europe, as well as from countries with mining expertise like South Africa, have worked around the clock to move around 24.5 Mt (27 million st) of rock and rubble from the twin tunnels.

(Continued on page 7)

Alaskan Way tunnel project

(Continued from page 3)

updates issued earlier:

- The state will pay the winning tunnel team $110 million to cover inflation.
- The state will reimburse the team an additional $100 million for bonds and insurance, an indication of the risky nature of boring such a large tunnel beneath downtown Seattle, in soils that are watery or abrasive in spots. Teams must obtain a surety bond to guarantee a half-billion-dollar restart if the cylindrical drill gets stuck mid-project, or if a new contractor must step in.
- $20 million "deformation allowance" would fix buildings that are damaged, if the tunnel drilling causes soil to settle. The Department of Transportation (DOT) identified five structures that require reinforcement, such as steel or concrete beams, and 34 that require concrete grouting to reinforce the earth. Also, the tunnel passes below the old Viaduct foundations.

Paananen said managers expected all along to make these or similar kinds of adjustments before the bids came in.

They are designed to reduce the companies' risk, so bids are more likely to meet the target price of $1.1 billion, published many months ago.

On the upside, Paananen said, the state will recoup $50 million from the city of Seattle for utility relocations in parts of the 2.7-km (1.7-mile) tunnel corridor, a figure that was not budgeted earlier.

After all the changes, the state DOT's original $415 million cash reserve stands at about $235 million — to cover potential cost overruns. Paananen said the figure is still above the 10 percent a DOT expert panel suggested.

Other enticements might also be offered, including a reimbursement because DOT moved the south tunnel entry 182 m (600 ft), an allowance if the tunnel machine does not require costly repairs in the ground, and an incentive payment to finish the job before November 2016. ■

Correction

In the September issue of *T&UC*, it was incorrectly reported that a tunnel boring machine (TBM) had been chosen for the Alaskan Way Viaduct (*T&UC*, Sept. 2010, page 6). Several TBM manufacturers are still in close discussion with the remaining contractors. At this time, neither contractor being considered for the job has selected a TBM manufacturer for the project and the TBM decision will not be decided until contracts are officially awarded. ■

Rio Tinto teams with Aker Wirth on new tunneling solution

As part of its Mine of the Future program designed to improve the construction of underground mines, Rio Tinto partnered with Aker Wirth to develop a new underground excavation system. The first of three of these tunnel boring systems has been made ready for full scale performance verification trials in 2012 at Northparkes' copper and gold mine in the Central West of New South Wales.

Rio Tinto head of innovation, John McGagh, said the significant new investment offers the possibility for a step-change improvement over conventional drill-and-blast practices.

"Depending on rock conditions, this system should provide a capability to excavate at more than double the rate of conventional methods," McGagh said in statement released by Rio Tinto. "For example, in a typical deep copper orebody, the rate of horizontal tunneling could be as high as 10 to 13 m/d (33 to 43 ft/day) using this new system.

"Aker Wirth is one of three partners with whom Rio Tinto is working to develop new equipment and systems for the rapid construction of deep underground mines," he said.

This new tunneling boring system trial has been integrated into a previously announced $90 million prefeasibility expansion study at Northparkes in August 2010 by Northparkes' joint venture partners Rio Tinto and Sumitomo Group companies.

McGagh said the trial will complete the final stage of performance verification of the new system.

The Mine of the Future program aims to enable Rio Tinto to more effectively carry out exploration; more efficiently exploit resources; and to allow safer, faster and deeper underground operations while economically recovering valuable mineral resources from increasingly difficult deposits.

"We are proud to have been selected by Rio Tinto as a partner in this ambitious project," Aker Wirth chief executive officer Christoph Kleuters said. "This system confirms Aker Wirth's commitment to maintain our position as a technology leader in hard rock excavation for the underground mining and tunnelling industry."

"This is about The Mine of the Future program going underground, as we promised we would at the start of 2010," McGagh said. "This system incorporates continuous mechanical rock excavation that will not damage new tunnel walls, while still providing the ability to mechanically install ground support in parallel with tunnel advance. Importantly for Rio Tinto, it provides an opportunity to introduce fundamentally safer processes into the underground mining industry."

The new tunnel boring system is expected to arrive in Australia in early 2012, and be operational with trials completed at Northparkes by the end of 2012. The system is 64-m- (210-ft-) long, has a maximum boring diameter of 6 m (20 ft) and has minimum tunnel dimensions of 5 m x 5 m (16 ft x 16 ft). After the trial, this technology is destined for use in other Rio Tinto underground mining operations internationally. ■

Design phase begins on Ohio tunnel

Black & Veatch has begun planning for the Lower Mill Creek Tunnel, a $244-million, 1.9-km (1.2-mile) tunnel system, pump station and enhanced high-rate treatment facility in Cincinnati, OH.

The project could reduce the mixture of sewage and stormwater that enters local waterways, improving the quality of life for the more than two million people living in the metropolitan area.

It could be a part of the Metropolitan Sewer District of Greater Cincinnati's Project Groundwork, a multi-billion dollar and multi-year public works program that will reduce combined sewer overflows by 85 percent and eliminate all sanitary sewer overflows.

The Metropolitan Sewer District is also exploring alternatives or supplements to the tunnel.

"Tunnel design and implementation for reducing sewer overflows is a steadily growing practice at Black & Veatch," said Dan McCarthy, president and CEO of Black & Veatch's global water business. "We expect this growth to continue as more cities – both large and small – work to reduce their sewer overflows." ■

Sound Transit agrees to pay for damaged home

As many as seven underground voids were formed by shifting soils as a result of twin light rail tunnels in Seattlle's Beacon Hill area.

Because of these voids, Seattle's Sound Transit paid $400,000 to buy a Beacon Hill property where two large holes formed.

Owners Rommel Panganiban and Christine Miller-Panganiban filed a claim for damages after two underground voids were discovered on their property in March 2009. Engineers later found a second one, and then uncovered seven more voids deeper underground along the tunnel's path, *Seattlepi.com* reported.

As part of a settlement, Sound Transit agreed to purchase the home located about 41 m (135 ft) directly above the tunnel that carries northbound trains. In addition, the agency agreed to pay $11,350 for a construction easement for prior work on the property and $65,000 in damages for "loss of quiet enjoyment and claims of emotional distress," according to terms of a Sept. 10 settlement agreement.

The voids resulted from shifts in layers of sand caused by the over-excavation with the tunnel-boring machine. Construction of the tunnels ended more than two years ago. For the past year, Sound Transit crews have been drilling and probing for more potential voids.

The first hole was about 6 m (20 ft) deep. Crews filled the voids with a quick-setting, cement-based filler. Other areas of loose soil around the voids were compacted by pumping cement grout through a pattern of drill holes near the locations.

Sound Transit spokesman Bruce Grays said the agency intends to recoup the money from the contractor, Obayashi Corp. Sound Transit is still investigating and plans to do more drilling work on the property, he said. The home will be resold in the future, he said.

Sound Transit's governing board authorized up to $4 million on void remediation, with about $2 million spent so far.

The voids demonstrate the risks with tunneling in this area. The state transportation department expects to encounter similar soil conditions along the path of the deep-bore tunnel that is planned to replace the Alaskan Way Viaduct. ■

Gotthard Tunnel

(Continued from page 4)

About 13.3 million m^3 (469 million cu ft) of aggregate, enough to build the equivalent of five Giza pyramids, have been excavated since the tunneling began, and eight miners have died.

The Swiss approved the project in a 1998 referendum in an effort to alleviate the environmental and logistical problems caused by a surge in heavy goods vehicles traveling through Switzerland from northern and southern Europe. When the twin tunnel is opened for traffic, it should cut the travel time between Zurich and Milan to 2.5 hours from 3.5 hours, and will provide the key north-south axis link between the ports of Rotterdam and Genoa.

The tunnel will be longer than the Seikan tunnel, which links the Japanese islands of Hokkaido and Honshu. It is the third tunnel to be bored through the Gotthard alpine range following the original rail tunnel, finished in 1880, and the 17-km- (10.5-mile-) long road tunnel completed 100 years later.

The new alpine transit project, or NEAT, is managed by Alp-Transit Gotthard AG. Some of the companies involved in the tunnel construction include Swiss cement maker Holcim Ltd., insulation materials specialist Sika AG, construction conglomerate Implenia AG and German mechanized tunneling technologists Herrenknecht AG.

The volume of road traffic using the alpine transit routes is estimated to double every eight years, reaching around 12.7 Mt (14 million st) in 2009, according to data from the Swiss Federal Office for Transport, while the level of traffic using the alpine rail network has seen little growth in recent years. The new Gotthard and existing Loetschberg railway nodes should increase the freight-carry capacity to 45 Mt/a (50 million stpy) by 2030 from 19 Mt (21 million st) at present. ■

Chairman's column

(Continued from page 2)

nominate, please go to the UCA of SME website (www.uca.smenet.org) and submit your nominations or contact Mary O'Shea at the UCA of SME; phone 303-948-4211; e-mail: oshea@smenet.org. The awards will be given out at the Rapid Excavation and Tunneling Conference in San Francisco in June 2011.

Heather Ivory is the Conference Chair for the 2012 North American Tunneling Conference that will be held in June 2012 in Indianapolis, IN. The first conference committee meeting will be held later this month in Denver, CO.

As I stated in my last column (*T&UC*, Sept. 2010, page 3), the UCA of SME is making some changes in the committee structure in an attempt to make the committees more responsive to the needs of the industry and to be realistic in what a committee of volunteer members can accomplish with the demands from their respective day jobs. We are still looking for members to participate on the Education Committee. The committee will act in an advisory capacity. It will review, consult and provide industry comments and assistance where feasible. The current committee is non-active and, at the request of myself (e-mail: dklug@drklug.com) and Bill Edgerton (e-mail: Edgerton@jacobssf.com), we request that if you are interested in serving on this committee forward an expression of interest complete with your full contact information to either one of us.

Membership dues renewal notices were recently sent out to our current individual, corporate and sustaining members. It is most important that you renew your membership for 2011, as these are the funds required to enable our organization to function. We have added a line on the dues form where you can now make a contribution to the UCA Scholarship Fund. I encourage all members to make a contribution to this fund for 2011. The goal of the UCA Executive Committee is to have a functioning scholarship program that can make multiple scholarships on a yearly basis to assist in educating our young people and thus advance our industry. I would also ask that you request people or companies who are not members of the UCA to join. This is an overall membership responsibility and not just that of Executive Committee members and/or the staff of the SME. We are all on this boat together, so please help row. It will be appreciated.

Please feel free to contact me with any comments or suggestions regarding our organization. ■

George A. Fox Conference returns to New York

The UCA of SME's George A. Fox Conference returns to the Graduate Center City University of New York in Manhattan on Tuesday, Jan. 25 with a full agenda.

As is the case each year, the conference will focus on one aspect of tunneling and underground construction industry. This year, the conference's primary topic is drill-and-blast excavation.

There are five presentations scheduled about drill-and-blast methods with a panel discussion focusing on integrating advances in blasting technology and vibration/crack monitoring to follow. Charles H. Dowding, professor at Northwestern University will moderate the discussion between Andrew F. McKown, president McKown Associates and James P. Lauer, chief inspector - explosives unit, NYC Fire Department. The panel discussion is a new element introduced to the one-day conference this year.

Victor A. Sterner, blast consultant for Austin Powder Co. is scheduled to give the keynote presentation — "Changes in blasting technology."

Among the drill-and-blast projects in Manhattan that are to be discussed during the afternoon session are the East Side Access station caverns and shafts, by Steven J. Maggipinto of Schiavone Construction and the No. 7 Subway extension station cavern by Peter Ayers, director, Arup and Robert Emmert, cavern superintendent for Schiavone.

Steven K. Mergentime, president of MERCO Inc., will conduct a presentation about the Hudson Falls Tunnel Drain Collection System in Hudson Falls, NY and Joel Volterra, associate, Muesser Rutledge and John S. Lizzo, principle geotechnical engineer, port authority of New York and New Jersey, will discuss the rock excavation efforts at the World Trade Center site.

Dean Brox, senior project manager of tunnels for Hatch Mott MacDonald, will wrap up the afternoon session with a presentation titled "Historical and recent performance review of drill-and-blast excavation for tunneling."

As always, there will also be a update on projects in the Northeast U.S. with a special focus on the Second Avenue Subway project with presentations from Alaeden Jlelaty, project manager, Skanska USA Civil Northeast Inc. and Julio C. Martinez, tunnel manager, Schiavone Construction Co.

To register for the conference, contact the SME Meetings Dept., Society for Mining, Metallurgy, and Exploration, Inc., 8307 Shaffer Parkway, Littleton, CO 80127, fax 303-979-3461, e-mail meetings@smenet.org. ■

T&UC

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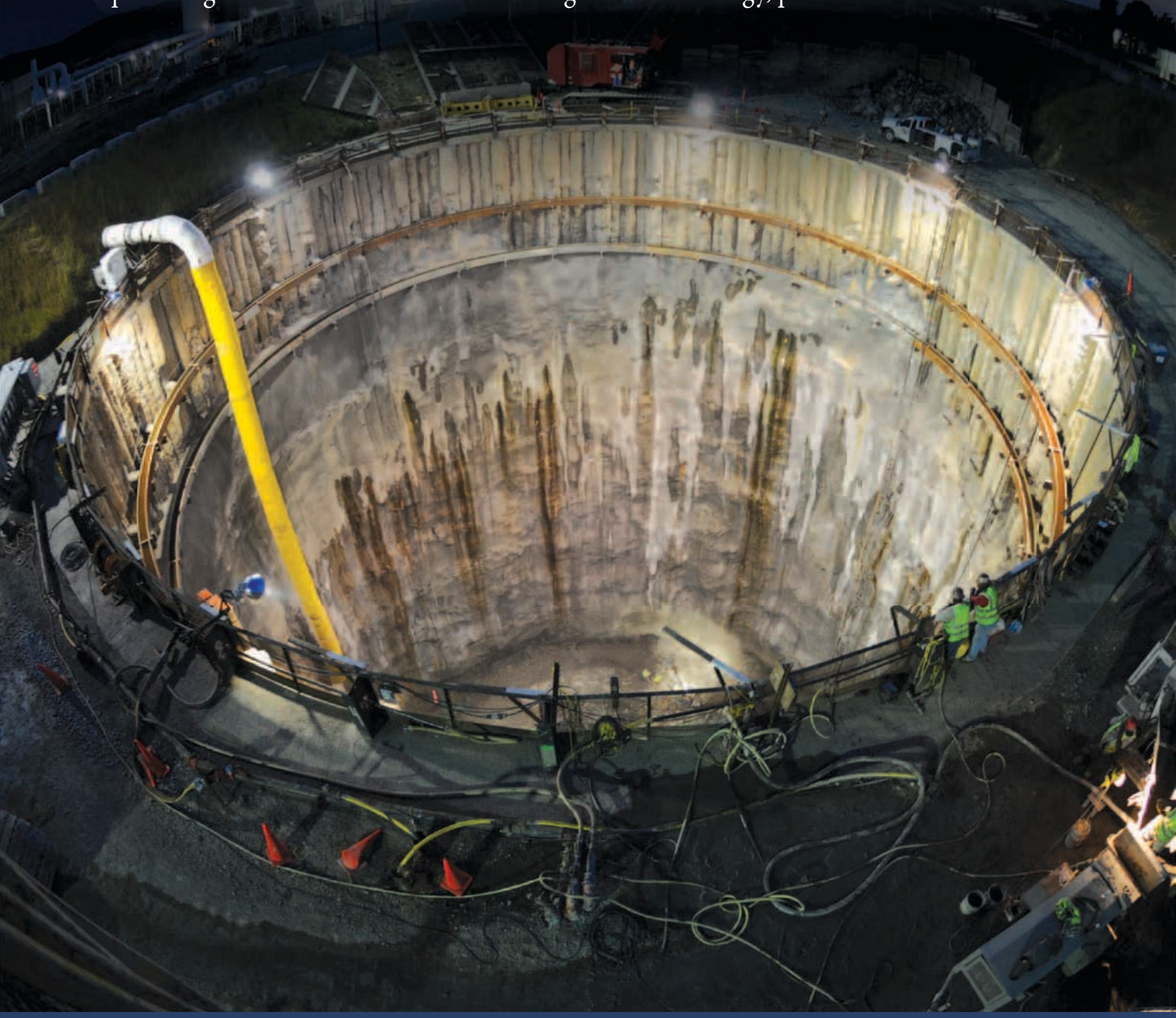

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Jennmar – World Class in Ground Control Technology

Frank Calandra Jr. – President

Jennmar is a multi-national company owned and operated by the Calandra Family. Frank and Jack Calandra are the two common stockholders. In 1972 Frank Calandra shifted Jennmar's focus to manufacturing ground support products for the mining and tunneling industry.

Over the years most of Jennmar's growth has been internally driven. The company currently owns over 80 patents relating to ground support applications. The majority of Jennmar's ten plants have been built exclusively by Jennmar. We maintain eight steel related bolt plants, located throughout the Appalachian, mid-west, and western coal fields. All of them are within two hours of our major customers.

During the late 1990's and into this century, we have been aggressively transplanting our values and technology in the international markets. Currently we have manufacturing facilities in Sturgeon Falls, Ontario; Sydney Australia; Paget, Mackay, Queensland, Australia; and Jining City, Shandong Province, China. Jennmar has two more international expansions coming in 2010 and 2011. This includes, moving from a small, leased space in Sturgeon Falls, Ontario and into our new 50,000 square foot building also located in Sturgeon Falls. Jennmar is also in the process of opening a new facility in Santiago, Chile.

In 2006, we entered the resin market making Jennmar a complete provider of strata-control products. We are the only manufacturer that maintains our resin plants on the same property as our bolt plants emphasizing optimal steel and resin delivery. Today, we maintain three resin plants located in Pennsylvania, Kentucky, and Sydney Australia.

The majority of our steel bolt plants are fed flat stock from our large steel processing plant located on Nucor Steel's Berkley Campus, near Charleston, South Carolina.

Tony Calandra – Executive Vice President

As a company we believe that our most important asset lies in our 1500 dedicated employees. We believe in developing a closeness to our customers by keeping the lines of communication open at all levels. We believe that hard work on our part is as important as the quality of products we sell. We are a customer-oriented company. It's the only way we do business.

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Messinger Bearings – A Kingsbury Brand

Messinger Bearings is one of an elite few companies in the world capable of producing large, custom-designed bearings in limited quantities for tunnel boring machines (TBMs). In its new business model, Messinger is addressing the challenge from most end users today about how to get new or repaired bearings of this size delivered in a reasonable timeframe. Customers who purchased 3-row TBM main bearings from competitors just a few years ago took delivery within about eight to nine months. Since then, deliveries have stretched out to 18 to 24 months, or longer. Why the big difference? Many of these manufacturers have shifted their attention to the high volume bearing business and away from small quantity custom applications. Not so with Messinger Bearings.

TBM Bearing Customers Have an Option

Based in Philadelphia, Messinger Bearings was established in 1912 as a designer and manufacturer of large, heavy duty rolling element bearings. Today, Messinger Bearings focuses on providing large diameter custom bearings for unique applications, including those found in much of the TBM equipment. Messinger can now manufacture new bearings to 25 ft in diameter, as well as repair them. In fact, Messinger is one of the few bearing manufacturers in the United States capable of turning bearings of this size. Messinger's manufacturing facility has recently been expanded to include a new state-of-the-art CNC vertical boring mill along with new induction heat treat capabilities.

New or Rebuild? Your Choice

Deliveries for 3-row TBM main bearings have been a recurring challenge for TBM customers. Given the increased focus for renewable energy, this will likely get worse. Messinger chooses not to participate in the wind energy business because it does not enable the company to support its current customers and its core business, that is, large heavy-duty custom bearings for specialty applications in limited quantities. Aside from new bearings, many of Messinger's customers ask us to repair their existing bearings.

For example, a TBM project was recently under way and the spare bearing was found to have a broken outer race. In addition to manufacturing a new outer race, Messinger was able to repair the entire bearing in more than enough time to have it on site when needed. Considerable savings were realized, not only with the repair itself but also by limiting downtime.

TBM Bearings and More, Planning for the Future

Messinger has recently expanded its capacity to manufacture and repair bearings up to 25-ft OD for TBM and other custom applications. Aside from equipment capacity, additional personnel for engineering and design, metallurgy and manufacturing have been and continue to be added to the team. In addition to the large 3-row and other style cylindrical roller bearings, Messinger is also now well positioned to repair and manufacture new large bore tapered roller bearings.

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J.H. Fletcher & Co. – Technology at Work Worldwide

Since 1937, J. H. Fletcher & Co. has affirmed its position as the premier engineering and design firm that creates mobile equipment solutions for underground mines. When rail was recognized as too cumbersome, Fletcher applied rubber-tire technology to underground supply and haulage vehicles. When quicker timbering methods were needed, Fletcher introduced tire-mounted timbering machines. When new methods of roof control were being explored, Fletcher built the first practical roof control drill.

Today, Fletcher remote-controlled and operator-up roof bolters secure overhead rock using advanced computer technology that senses geologic conditions for optimum drilling and roof mapping – without the operator leaving the compartment. Fletcher single- and dual-boom drill jumbos cover headings up to 60′ wide by 35′ high, using high-performance hammers with unsurpassed efficiency, and new Graphic Operator Angle Display technology for greater accuracy. Fletcher scaling vehicles, built from the ground up for the rigors of underground work, remove hazardous materials from heights up to 50′. Fletcher powder loaders allow charging crews to work in lower-than-ever DPM and noise levels. And powerful Fletcher diesel tractors ply in and out of the mines hauling supplies quickly and efficiently.

Features like ergonomically-designed, pressurized operator compartments and demand-based engine speed improve efficiency and operator comfort. Today's Fletcher customers have more options than ever for integrating their overall equipment strategies across machines.

Listen. Think. Create.

Fletcher engineers spend more time in the field, listening to customers telling what they like – and don't like – about mobile equipment. How can operations be made more efficient? How

can operators be kept safer, or more comfortable? Some of our best ideas begin when a customer asks, "Why can't..?" This eagerness to solve customer problems sets Fletcher apart.

Research & Development looks into major ideas that require new designs or application of new technologies. Perhaps a company with more than 70 years in the business has resolved that issue before. In that case, Engineering may be able to apply earlier solutions to modern machines. Either way, Fletcher hires and keeps some of the best electrical, mechanical and hydraulic engineering minds in the business – the same people who will work on your equipment.

Fletcher's unique manufacturing process allows each machine to be assembled by a single team of technicians, following the process from start to finish. It's their handiwork, and every team takes pride in the equipment it ships.

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Every equipment manufacturer and mine should do all it can to optimize the safety and comfort of its workers. No one takes safety more seriously than J. H. Fletcher & Co. Our full-time, fully-staffed Risk Management Department focuses on equipment safety and product liability issues. They support every customer with operator training and re-training programs, audio-visual operating programs, newsletters and safety bulletins, manuals, warning tags -- whatever it takes to help our customers operate profitably, efficiently and with greatest worker safety.

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Kiewit Construction Company

Kiewit is one of North America's largest and most respected construction and engineering organizations. With its roots dating back to 1884, the employee-owned company operates through a network of offices in the United States, Canada and abroad. Kiewit offers construction and engineering services in a variety of markets including transportation, water/wastewater, heavy civil, power, oil, gas and chemical, building and mining. With 2009 revenues of nearly $10 billion, Kiewit's workforce includes approximately 10,000 salaried and hourly staff along with more than 15,900 craft workers.

Kiewit's Underground District has been constructing underground facilities for over 50 years and is recognized as a leader in the tunneling industry with more than 100 underground-related projects ranging from fast-track mining jobs to a $1 billion undersea rail tunnel. Kiewit's underground team incorporates state-of-the-art technology with proven construction methods to ensure excellence and ongoing success. They serve virtually every segment of the construction industry, including projects related to transportation, environmental facilities, water/wastewater/storm water handling and treatment, power, mining and telecommunications.

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A Century of Shotcrete Solutions

Allentown Shotcrete Technology, Inc. is celebrating its 100th anniversary in the sprayed concrete industry.

In the early 1900s, Allentown's pioneering technology was first developed for taxidermy purposes when its originator, Carl Akeley, a famous hunter and professor, devised a method for spraying plaster onto a wire frame. The outcome was a strong, thick plaster coating that didn't slump from the frame or set before being fully placed.

Forty years later, a new process was developed involving the use of pressure tanks to force stiff mortar through a hose. This new wet-process became known as shotcrete – and the rest is history.

"In this day and age, very few companies are able to succeed in business for 100 years," says Patrick Bridger, President of Allentown. "We are very proud of our longevity, and see it as a testament to our reputation for quality, and the value we have brought our customers for a century."

Since the 1950s, the Allentown name has been synonymous with the process of spraying mortar at high velocity onto surfaces in the refractory, underground, mortar and civil industries. The Allentown equipment line has expanded to include a wide range of Gunning Machines, Pre-dampeners, Pumps, Combination Mixer-Pumps, Mixers, Chemical Additive Pumps, Nozzle Carriers, Mortar Machines, Concreting Machines and parts and accessories.

Throughout the years, Allentown has experienced numerous milestones, which have strengthened its position in the market. To find out more about these milestones and Allentown's century of experience, visit www.allentownshotcrete.com or call (800) 553-3414.

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Robbins Revolutionizes Soft Ground Tunneling

The Robbins Company, the world's foremost supplier of advanced, underground construction equipment, is now offering soft ground TBMs worldwide. Robbins Earth Pressure Balance Machines (EPB TBMs) are now making swift headway on a dozen projects in multiple countries. Although known in the industry for its hard rock machines, innovative machine designs are expanding the company's product offerings to now include machines for mixed ground and soft soils at high pressures.

Over 50 years of Experience

In 1952, James S. Robbins developed the first rock tunnel boring machine in South Dakota, after witnessing the relatively slow rates achieved by a prototype drilling and blasting machine. Subsequent TBM designs, at the Humber River Project in 1954, saw the first use of rolling disc cutters—the discs effectively excavated limestone up to 200 MPa (29,000 psi) UCS.

From those inventive beginnings, The Robbins Company has grown into an international supplier of underground equipment, with foundations in the soft ground, hard rock, and trenchless construction markets. Today, 12 offices and 22 representatives are located in 28 countries around the world, with many local offices providing comprehensive support on regional projects.

Rapid Excavation

Throughout 2009 Robbins Earth Pressure Balance Machines have exceeded project requirements, achieving dozens of project records. In the U.S., a 4.25 m (13.9 ft) diameter EPB is boring the Upper Northwest Interceptor Sewer in Sacramento, CA, has realized rates of 210 m (690 ft) during multiple weeks, all while simultaneously erecting a PVC-embedded concrete liner never before used in North America.

Overseas, two 6.3 m (20.7 ft) diameter Robbins EPBs boring China's Guangzhou metro set an astounding 16 project records in some of the country's most challenging geologic conditions. The machines set records of up to 377 m (1,235 ft) per month in silt, sand, highly weathered granite, and hard rock—rates higher than any of the other 16 machines boring on the project.

In 2010, Robbins will launch three 8.9 m (29.3 ft) diameter EPB TBMs for Mexico's largest infrastructure project—the 63 km (39 mile) long Emisor Oriente waste water tunnel. The tunnel will add much needed capacity to Mexico City's aging and deteriorated sewage system.

A fourth 10.2 m (33.5 ft) diameter machine will excavate a new metro line through the heart of Mexico City after its assembly at the jobsite. Onsite First Time Assembly (OFTA) is a process developed by Robbins to save both time and money to the contractor. By initially assembling the machine onsite, rather than in a manufacturing facility, shipping costs and man-hours required for disassembly are eliminated. The results often yield an assembly schedule several months shorter and high dollars in savings.

Robbins innovations will continue to advance in 2010, with major EPB projects planned for launch in the Dominican Republic, Azerbaijan, India, and China. For more information on recent tunneling and groundbreaking R&D, visit www.TheRobbinsCompany.com or call +1 440 248 3303.

The Robbins Company
Telephone:440-248-3303
www.therobbinscompany.com

CDM – Global Solutions Since 1947

CDM is a global full-service consulting, engineering, construction and operations firm founded in 1947. With more than 4,500 professionals in 110 offices worldwide, CDM maintains a global network of offices and affiliations.

CDM's underground construction staff includes geotechnical, structural, and civil engineers and geologists located worldwide. Our staff has extensive experience in providing the full range of tunnel and geotechnical related services. Our tunnel related work includes planning, feasibility and design, including both 2D and 3D FEM analyses. We offer construction services including construction and program management, inspection and geotechnical instrumentation monitoring and interpretation for soft ground and rock tunnels. Design and construction includes all types of ground modifications including ground freezing, grouting, and dewatering.

Our field equipment includes geotechnical instrumentation and construction data acquisition equipment. Our field personnel are NICET, OSHA and NRC certified. CDM's tunnel services include:

- Shaft Design: Ground Freezing, Slurry Wall and Secant Pile Wall
- Conventional Soft Ground and Rock Tunnel Design, Microtunneling, Pipe Jacking and Directional Drilling
- Evaluation and Rehabilitation of Existing Tunnels
- Ground Investigation, Testing and Evaluations
- Groundwater Control System Design

CDM
www.cdm.com

URS Tunneling - From Conventional to Innovative

URS focus on your project and project goals, helping you choosing the Right Approach when committing your resources to infrastructure construction, and making the best choices considering:

- Geology
- Best construction technologies
- Risk management
- Equipment selection
- End use

Our strengths are our diversity of experience and depth of resources: from microtunneling to 40′ diameter transportation, water and CSO tunnels, to large hydropower caverns and nuclear waste repositories; and multiple tunnel mass transit projects. From 70,000 psi rock to "zero blow count" saturated river silts, to highly variable glacial tills.

Our emphasis is on developing solutions that are thorough, practical, and cost-effective.

Our Tunnel Design and Construction Services include:

URS

NATIONAL TUNNEL PRACTICE

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Planning
Modeling
Design
Construction
Inspection
Rehabilitation

Industry Expertise

Transit
Water
Highway
Wastewater/CSO
Power
Rehab
Utilities
Federal

Facility Types

- Pressure and Gravity Water Conveyance Tunnels
- Gravity Sewer Interceptors and Force Mains
- Roadway Tunnels
- Mass Transit and Rail Tunnels
- Utility Tunnels
- Gas and Petroleum Pipeline Tunnels
- Underground Mines
- Transit Chambers and Underground Powerhouse Structures

Services

Planning and Feasibility

- Identification of System Requirements
- Systems and Fire/Life Safety
- Horizontal and Vertical Alignment Analysis
- Tunnel Construction Method Evaluation
- TBM Evaluation
- Site Investigation
- Soil and Rock Engineering
- Preparation of Geotechnical Reports

Design and Construction

- Preliminary and Final Design Reports
- Plans, Specifications, and Cost Estimates
- Pre-qualification, Bid and Award Phase Assistance
- Construction Phase Services / CM
- Dispute Avoidance and Claims Resolution
- Risk Management Evaluations

URS Corporation
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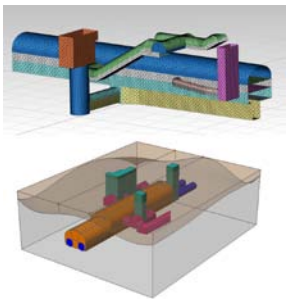
tel: 510.893.3600
carlos_jaramillo@urscorp.com

MidaSoft – Next Generation Solutions

Midas GTS is a 3D finite element geotechnical and tunnel analysis software program fully integrated with CAD, automeshers, solver and post-processing. Midas GTS handles geotechnical engineering applications, that include tunneling, mining, foundations, excavations, slope stability, soil-structure interaction, settlement, seepage (groundwater flow), consolidation, vibration and seismic analyses.

Midas GTS offers an intuitive GUI that enables the user to create complex geometry in the smallest number of steps based on CAD formats. Different structural and ground elements in conjunction with super pile elements can be incorporated in one model file. Moreover, there are various types of interface elements, which enable the user to simulate soil-structure interaction regardless of the complexity of geometry and interface positions.

All types of T-type and Y-type interconnections, curved tunnels, shaft-lateral-main tunnel connections and tunnel entrances, as well as subway stations can be easily modeled in detail. A special feature exists for defining automated and realistic construction stages for sequential activation and deactivation of excavation segments, structural parts, loads and boundary conditions.

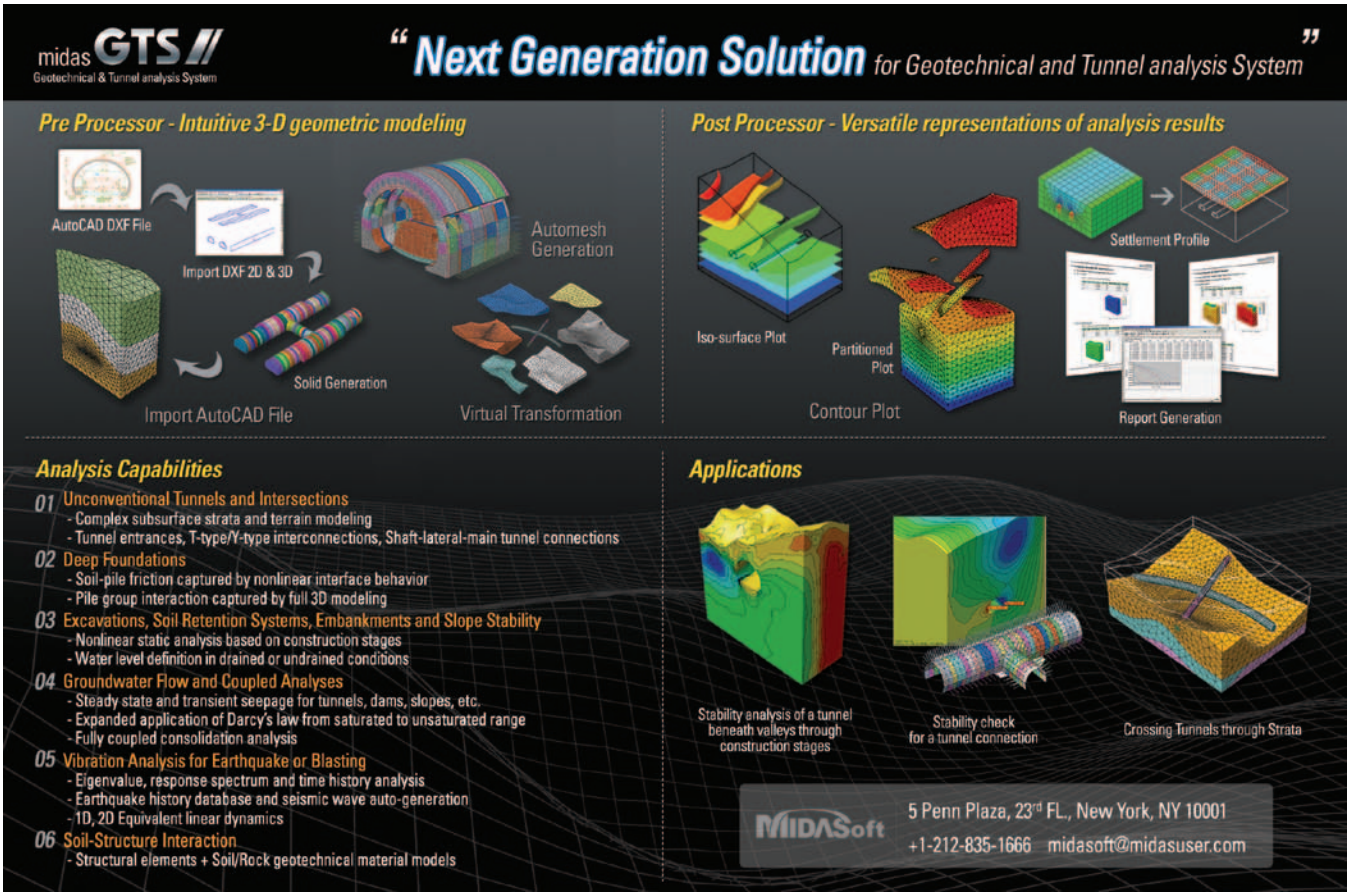


Also, 3D excavation in real time construction sequence including a dewatering procedure may be simulated, and structural support systems including anchors and diaphragm walls may be generated automatically.

The newest version incorporates the robust and advanced DIANA kernel, which supports 64-bit OS & multi-core parallel processing. The solver has been used for over 30 years and proven to be reliable in all research and industrial fields solving complex nonlinear problems.

Midas GTS is a new generation finite element software tool for those who face complex geo-structural projects in urban environments. MIDAS operates and provides technical support worldwide.

MIDASOFT
5 Penn Plaza, 23rd Floor
New York, NY 10001 USA
Telephone: 212-835-1666
Email: midasoft@midasuser.com



Normet in North America - Equipment and Construction Chemicals for Tunneling and Mining

Normet produces solutions for demanding customer processes in underground mining and tunnelling.

For over 40 years we have developed, manufactured and marketed equipment and vehicles for underground applications. In addition, we provide a comprehensive range of Life Time Care services e.g. maintenance, service programs, spare parts and training around the equipment and the processes they are used for. With over 7500 delivered machines we have became one of the market leaders in our product areas.

One of Normet's key missions is to improve the safety and efficiency of workers underground, through solutions targeted to the work processes of:

- Concrete Spraying and Transport
- Explosive Charging
- Lifting and Installation
- Underground Logistics
- Scaling

Normet offers also a comprehensive range of constructions chemicals for underground mining and tunnelling processes. We distribute the TAM line of products, developed by our partner Tam International.

In North America, Normet is headquartered in Union Grove, WI, USA (Normet Americas, Inc.), and operates in Canada from our new location in Sudbury, ON (Normet Canada, Ltd.) We have sales and field service professionals in a number of locations across the continent, and operate a comprehensive parts management program with stocking in various locations to ensure an efficient means of distribution to our customers.

We are supported by our global head office in Finland (Normet Line Production, R&D and Group functions), Semmco Line Production in Santiago de Chile, and Sales, Marketing and Product Offering Development are headed from Switzerland. With global customer satisfaction in focus, we now employ over 540 business professionals in 23 locations worldwide.

Normet understands not only the equipment we manufacture and the chemicals we supply but the rigors of the customers' underground processes for which they are designed.

Normet Americas, Inc
PO Box 64, 19116 Spring St.
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Telephone: 262-787-5760
Fax: 262-878-5763
Email: info@normet.fi
www.normet.fi

Bradshaw Offers Innovative Tunnel Engineering and Construction Technology

Bradshaw Construction Corporation is a leading contractor in the tunneling industry. With over four decades of experience, we've earned respect as technological innovators through the construction of highly difficult tunneling projects. We owe that success to our commitment to excellence, craftsmanship, safety, and earning our clients' trust.

For your next project, let our knowledgeable staff of tunnel engineers and construction professionals create the most cost effective, safest, and highest quality solution for your unique tunneling needs."

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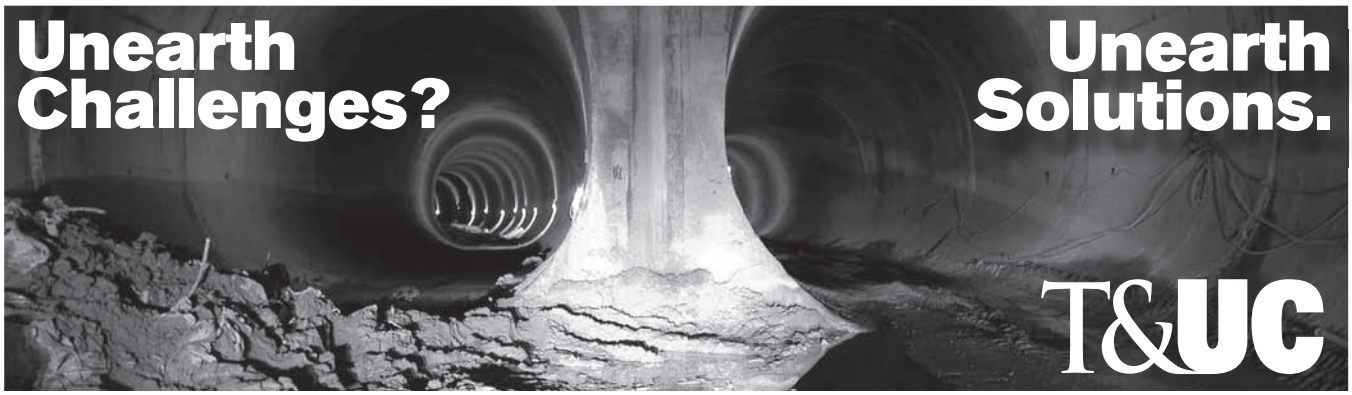

There's More to Moretrench

Moretrench, headquartered in Rockaway, New Jersey, is a full-service geotechnical contractor specializing in design/build and turnkey solutions for challenging construction requirements and subsurface conditions.

The company's wide range of services includes construction dewatering and groundwater control; ground/water treatment; ground freezing; grouting systems; cut-off and containment systems; earth retention and excavation support systems; underpinning and foundation support; deep foundations; landfill gas and leachate systems; and specialized civil and mechanical construction.

These services are available nationwide through full service offices in New Jersey, New York, Florida, Massachusetts, Pennsylvania, Delaware and Washington D.C. Moretrench is a USGBC member which oversees the LEED program.

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www.moretrench.com

David R. Klug & Associates, Inc.

David R. Klug & Associates, Inc. provides international and national manufacturer representative services to the underground heavy civil and mine construction industries. The company specializes in the coordination of products, equipment and services for NATM, soft ground, precast segmental and conventional tunnel construction. This is inclusive of initial support systems, FRP bolts and soft-eye structures, high performance ultrafine cements, flexible membrane waterproofing systems, final lining reinforcement products, steel moulds, connectors and gasket sealing systems for one pass precast tunnel linings, tunnel profiling / scanning equipment and associated site services, design and supply of project specific material handling systems, and complex final lining forming systems.

David R. Klug & Associates, Inc.
6000 Waterdam Plaza Dr., Ste. 120
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Telephone: 724-942-4670
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Email: dklug@drklug.com

HIC Fibers is Selling Direct in North and South America

HIC Fibers, Inc. has opened offices in Los Angeles, California, for North America and Lima, Peru for Central and South America. This marks the first time that HIC Corporation, based in Korea, has opened offices with the intention of selling direct to the end user in lieu of selling strictly through distributors.

HIC Fibers has a full line of products including steel and synthetic fibers, rock bolts and anchors and products for shoring and leveling as well.

Contact HIC Fibers direct at (323) 935-4500 or (801) 293-8379 or visit us on the web at HICFibers.com.

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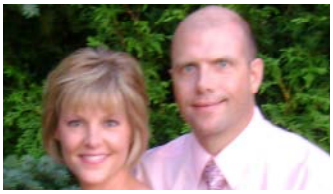
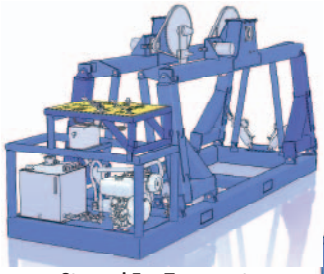


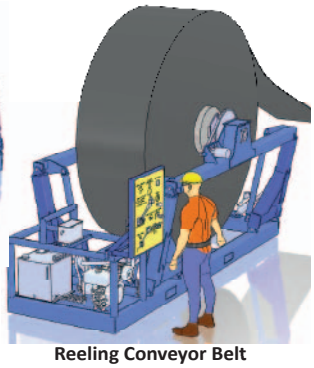
Kelley Engineered Equipment, LLC was founded in 2007 by Brian and Cindy Kelley. Brian, has extensive experience in tunneling and mining equipment design, with 7 years of experience at Robbins, and 13 years at Kiewit Underground Division. Brian is a licensed Mechanical PE in Nebraska, New York, and Washington State. The company has several standard products, such as cable reelers, premium quality rail trucks, skip boxes, and diesel power packs. In addition, Brian leads the design efforts for a broad range of custom equipment, including lifting systems, gantries, pipe carriers, trailing gear, custom attachments, conveyors, heavy load moving equipment, equipment modifications, personnel access systems, and more. KEE partners with select shops, or customers can choose the manufacturer.

Kelley Engineered Equipment, LLC
1210 Beaver Lake Blvd.
Plattsmouth, NE 68048
Telephone: 402-267-0143
www.keellc.com

Are you ready to get reel serious?



Stowed For Transport



Reeling Conveyor Belt

The **Mobile Reeler** by Kelley Engineered Equipment, LLC is a self contained, diesel powered reeling device that clamps reels up to 10 foot in diameter, and 70 Inches wide. Reels conveyor belt, electrical cable, wire rope and more. In the payout mode, reels against adjustable resistance. Two speed option available.

Specifications
Width: 56 inches
Length: 175 inches
Height: 84 inches
Weight: 4500 lbs.
Maximum Reel Diameter: 120"
Maximum Reel Width: 70"
Minimum Reel Width: 16"
Maximum Reel Weight: 16,000 lbs.
Engine: Tier 4 Diesel, with scrubber
Maximum Torque: 7000 ft-lbs.
Maximum Speed: 9.2 RPM

Kelley Engineered Equipment, LLC

1210 Beaver Lake Blvd.
Plattsmouth, NE 68048
PH: 402.267.0143
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ALPINE Cutters with a Bite

Founded in 1968, Alpine Equipment Corp. is North America's oldest and most experienced manufacturer of roadheaders, especially the Multi-Tool-Miner and those for the NATM, rock and concrete grinder attachments, cutter buckets, scalers, mixers, and shaft sinkers. Willy Kogelmann, Alpine's founder and President, holds numerous patents on these cutting machines. Mr. Kogelmann invented the quick-change transverse and inline axial cutter heads for roadheaders. Spur-gear type cutter transmissions, one of Alpine's unique features, are superior to conventional bevel-gear-type transmissions because they excel in hard rock cutting. The novel cutter buckets can be used for concurrent cutting, mucking, crushing, and sizing. Alpine's advanced cutters can excavate rock and minerals at the lowest-possible cost per ton. Alpine's products are backed by the most experienced team in the industry.

Alpine Equipment, LLC
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Fax: 814-355-0046
Email: info@alpine-aec.com
www.alpinecutters.com

ALPINE SALES & RENTAL CORP. is an industry leader in new and used roadheaders, NATM Miners, shaft sinkers, scalers and hydraulic cutter head attachments of all sizes. Quality machines for lease or purchase backed by one of the most experienced teams in the industry.

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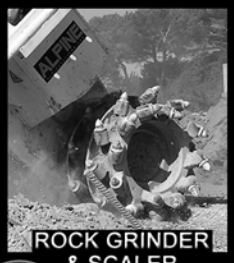

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North America's Leader in Geotechnical Construction

However difficult the ground, only Hayward Baker, North America's leading specialty geotechnical construction contractor, has the diversity of ground modification techniques to solve your geotechnical problem. Tunneling services include: Earth Retention, Underpinning, Waterproofing, Bottomseals, Soil Improvement, and Ground Stabilization.

Hayward Baker has worked on hundreds of tunneling projects and has the right tools and experience for yours.

Seattle, WA
Brightwater Conveyance System

Construction of the Brightwater Conveyance System required surgical jet grouting to facilitate tunneling operations. Utilizing their proprietary jet grouting equipment, Hayward Baker created soilcrete blocks outside of four deep vertical shafts to assist with both TBM and handmined tunneling operations. The ground improvements allowed TBMs to be launched or received into and out of the shafts without the risk of water and ground run-in. Overlapping columns to depths up to 94-feet compose the soilcrete blocks.

Brightwater Conveyance System

Los Angeles, CA
Lower North Outfall Sewer Rehabilitation Project

Rehabilitation of the 82-year-old Lower North Outfall Sewer included grouting around the outside of the tunnel to densify and strengthen the soil above the tunnel in order to protect the overlying structures from settlement. Hayward Baker performed permeation and fracture grouting through over 3,500 holes from within the tunnel, stabilizing the overlying structures. State-of-the-art survey technology and proprietary grouting instrumentation allowed Hayward Baker to first probe the soil to determine existing conditions, and then observe the soil response during grouting while monitoring the ground surface in real time.

Lower North Outfall Sewer

Los Angeles, CA
East Central (ECIS) & North East (NEIS) Interceptor Sewer Tunneling Projects

Extensive tunneling operations for ECIS and NEIS required numerous ground modifications. Hayward Baker provided chemical grouting and microfine cement grouting for four shaft breakins, five major freeway over-crossings, 27 manhole connections, and six major or sensitive utility crossings as well as for a major siphon structure and hand-mined access shaft, founded in silty soils containing less than 35% fines.

Other ground modification included locating and filling an abandoned water tunnel, and compaction grouting.

Los Angeles, CA
Metro Gold Line C800

Construction of twin subway tunnels for the LA Metro's Gold Line would cause ground loss, endangering overlying structures unless the soils surrounding the tunneling zone were treated prior to excavation. Using conventional horizontal drilling to install steel and PVC sleeve port grout pipes, Hayward Baker performed chemical grouting to stabilize soils and soilfrac compensation grouting to protect overlying structures. Heave and settlements were monitored by exterior remote robotic total stations and interior wireless tiltmeters.

Metro Gold Line

St. Louis, MO
Baumgartner Tunnel Alignment

Water-bearing rock formations in the path of the Baumgartner Tunnel Alignment needed to be sealed. Unsafe levels of hydrogen sulfide forced the grouting to be performed from the surface in advance of the tunneling operation. Hayward Baker drilled and grouted the water-bearing rock formations along a 1,200-ft long segment of the proposed 20,000-ft long, 12-ft diameter combined sewer tunnel. A total of 40,000-feet of grout holes were drilled to complete the project. Depths of the drill holes were approximately 170-ft from ground surface.

Hayward Baker
Geotechnical Construction
1130 Annapolis Road, Suite 202
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40 Years of High-Performance Waterproofing Solutions

Established in 1970, Stirling Lloyd leads the world in the provision of high performance waterproofing systems for tunnels and bridges. Utilizing our advanced MMA technology, over 75 million square feet of Integritank and Eliminator sprayed membranes have been applied and are protecting many of the world's key infrastructure crossings from premature degradation.

Innovative solutions are available for the external waterproofing of cut and cover and immersed tube tunnels as well as for the waterproofing of suspended decks in all tunnel types. The latest addition to the Company's range is the Integritank HF sprayed waterproofing membrane, which enables owners, designers and contractors to effectively waterproof the internal linings of SCL/NATM tunnels, and can be non-destructively tested to confirm 100% integrity.

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Telephone: 860-666-5008
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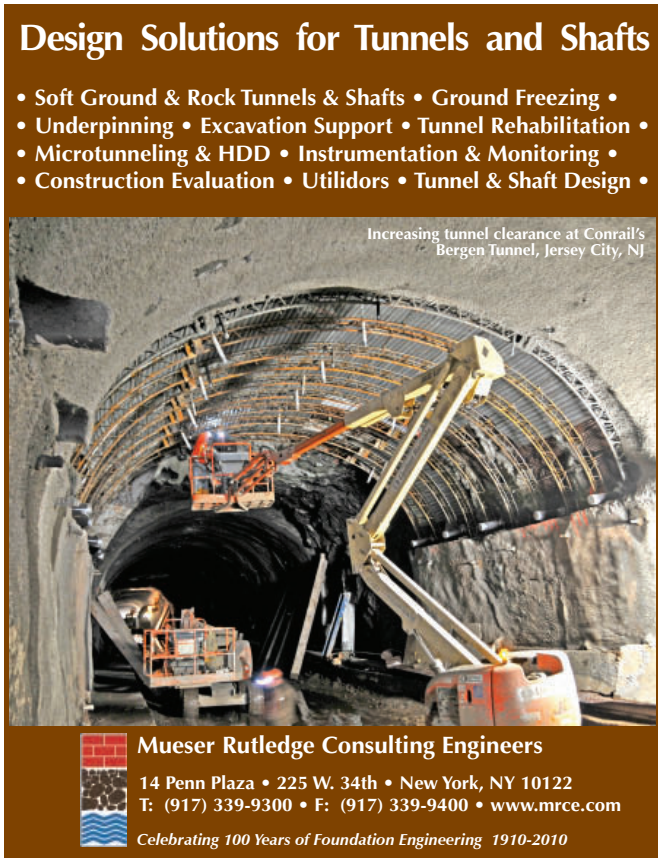

Mueser Rutledge Consulting Engineers

Mueser Rutledge Consulting Engineers (MRCE), founded in 1910, is a leading engineering firm focused on the below-ground disciplines of geotechnical, marine and structural / foundation engineering.

"One of our specialties is providing design solutions for tunnels and shafts," say Hugh Lacy, one of the firm's partners. Lacy is the Chair of the 2011 George Fox Conference. "We are involved in a wide range of tunnel projects in both soft ground and rock for railroads, highways, subways, pedestrians, utilidors, CSOs, interceptors, and wastewater treatment." Some of firm's current tunneling projects include Conrail's Brightwater tunnel, East Side Access, 2nd Avenue Subway, #7 Line Subway Extension, and the ARC tunnel.

MRCE celebrated their 100th anniversary of providing foundation engineering services in 2010.

Mueser Rutledge Consulting Engineers
14 Penn Plaza, 225 W. 34th Street
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Advanced Concrete Technologies, Inc. (ACT) is a single source supplier of turnkey concrete batching and mixing plant solutions that draws on over 45 years of experience and more than 4,000 concrete plant installations worldwide. ACT provides the industries most flexible and proven solution for producing highest-quality, central mixed concrete and backfill grout for on-site construction, tunneling and mining projects. ACT's MobilMat batch plants, come in ten different sizes, ranging from 30 up to 240 cubic yards per hour concrete output. We offer high intensity HPGM counter-current mixers and DWM twin-shaft mixers, advanced PCS control automation, commissioning services as well as an industry leading training & support program.

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31 Years of Growth at Geokon

Geokon's President, Barrie Sellers, near the loading dock of their new addition.

The end of 2010 marked Geokon, Inc's 31st year of operation as a premier manufacturer of geotechnical instrumentation. Geokon's sales increased 35%, over their previous record year, as a result of their participation in several large civil engineering projects throughout the world.

Geokon's fourth building expansion was completed in 2010, bringing their total industrial space to 35,000 sq ft. The larger facility allows for increased production and expanded capabilities in the latest data acquisition and communications techniques to further augment Geokon's world leadership in vibrating wire technology.

Geokon has over 90 employees—many of whom have been with the company for over 20 years. Their wealth of experience allows Geokon to do what it does best: to quickly and effectively service customers' needs in the rapidly growing field of geotechnical monitoring. In addition, Geokon has a network of 40+ worldwide agents and has, through their efforts, participated in major Civil Engineering projects throughout the world.

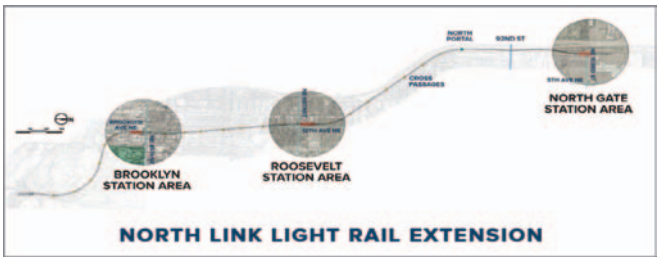
For more information, please contact Geokon, Inc.:

Geokon, Inc.
Telephone: 603-448-1562
Email: info@geokon.com
www.geokon.com

North Link Design Underway

Jacobs Associates has been selected by Sound Transit to deliver civil engineering and architectural final design services for the North Link light rail extension in Seattle, Washington. North Link will connect the University Link light rail segment to the Northgate neighborhood via 4.3 miles (6.9 km) of double-track light rail, which consists of 3.2 miles (5.2 km) of twin bored soft-ground tunnels, 1.1 miles (1.7 km) of retained cut fill, and elevated guideway structures. The extension includes two underground transit stations (Brooklyn and Roosevelt), one elevated station (Northgate), a portal structure, and 20 cross passages. With a target completion date of 2020, North Link aims to increase light rail ridership, improve travel time, and add transit capacity in the congested Interstate-5 corridor.

Jacobs Associates
Telephone: 800-842-3794
www.jacobssf.com



Dā-mite Rock Splitting Mortar from the Daigh Company, Inc.

Daigh Company is the supplier of Dā-mite Rock Splitting Mortar. Dā-mite is used to fracture rock and concrete in "no-blast" conditions. Dā-mite is an ideal and effective tool for fracturing mass rock, boulders, trench rock, dimensional stone, concrete and reinforced concrete. Dā-mite is mixed with water and placed in predrilled holes, where it sets and expands with a compressive strength of over 18,000 PSI, Dā-mite has more than enough force to get the job done. No license or permits are required. There are four grades of Dā-mite, providing enough versatility to be utilized in drilled hole diameters from 1" to 2 3/4". www.da-maite.com

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Celebrating 10 years of "Creating Space Underground" Brierley Associates partners with clients and peers to produce underground facilities that are cost effective, timely, and employ the best that technology has to offer. A vibrant and growing national firm with offices in seven states (and counting!), Brierley offers a full range of underground design, geotechnical, and construction consulting services throughout the United States, with extensive experience in design, design-build, and construction management of hundreds of major projects in all types of ground conditions. At Brierley, we enjoy what we do and spend a great deal of time doing it. Hence, we strive to create a working environment conducive to cooperation, motivation, innovation, and accomplishment.

Brierley Associates: Creating Space Underground

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www.brierleyassociates.com

The Heintzmann Group

The Heintzmann Group, which has been in business approximately 165 years, manufactures support systems in the tunneling and mining industries. In the last decade, we have greatly expanded our line of products, as well as our regions of service. We currently have offices located in Virginia, West Virginia, Alabama, Colorado, and Illinois. Our range of products and services include but are not limited to standing supports, pumpable roof support, arches, square sets, prestressing devices, heat treated beams, polyurethane grout injection, shaft rings, lattice girders, two flange liner plates and four flange liner plates.

The goal of the Heintzmann Group is to provide resources to make the tunneling and mining environments safer and to achieve the highest level of customer satisfaction by providing our customers with a variety of support options.

The Heintzmann Group
Telephone: 276-964-7413
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FEATURE ARTICLE

Integration of operations and underground construction: Sound Transit University Link

As part of the Link Light Rail project in Seattle, WA, work was completed at the Pine Street Stub Tunnel (PSST) in early 2007 for the Central Link project. This tunnel was excavated using cut-and-cover construction within the limits of Pine Street. The stub tunnel provides a turn back via double crossover for light rail trains running in the Downtown Transit Tunnel (DTT), as well as a connection point for the next phase of the project, the University Link (Fig. 1).

Designing the new University Link tunnel connection to the existing PSST was a tricky task. The on-site geotechnical conditions, buried obstructions, geometry, requirements for construction and balancing operational considerations and neighborhood stakeholder concerns associated with the recently completed PSST combined to create a uniquely challenging assignment.

Site geotechnical challenges included rubble fill, landslide deposits and possible contaminated soils. Soldier piles and tiebacks in the path of the northbound and southbound running tunnels, an electrical vault, duct bank and a vent shaft partially above the tunnels, in addition to an existing deep sewer above the southbound tunnel, rounded out the buried obstructions that had to be dealt with.

The geometry of the PSST connection was originally designed for a tunnel alignment toward First Hill. However, during the preliminary engineering design, the alignment was changed to Capitol Hill. The recent history of construction in the area presented a further challenge of making the connection without causing disruption of traffic on Pine Street. Operational considerations within the PSST dictated limited access and work hours impacting the construction stage, where complicated connections to the PSST for waterproofing, electrical, mechanical, temporary ventilation and systems components needed to be made.

Jet grouting at the Pine Street Stub Station was completed in 2007 as part of the Sound Transit University Link in Seattle, WA.

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Preliminary engineering design

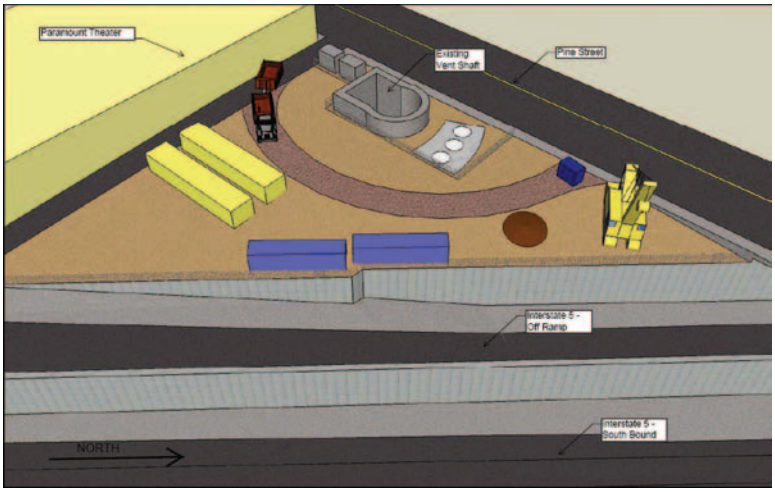
The preliminary engineering concept for the connection shown in Fig. 2 involved the excavation of two tunnel boring machine (TBM) retrieval shafts (one for the southbound tunnel and one for the northbound tunnel), and the construction of tunnels excavated using the sequential excavation method (SEM) between these shafts and the PSST headwall. The proposed short SEM tunnels, which were between 27 and 35 m (90 and 115 ft) in length, would have included the removal of tiebacks and soldier piles that intersect the proposed tunnel alignment adjacent to the PSST headwall.

During final design, an alternative approach was developed that would fulfill the tall order of:

- Reducing the overall costs of the connection.
- Facilitating access to the existing PSST headwall.
- Avoiding excavation of retrieval shafts in close proximity to the existing I-5 freeway.
- Removing the soldier piles and anchors within the tunnel envelope.
- Preparing for TBM excavations up to the face of the PSST headwall.
- Removing the heavily reinforced concrete tunnel "eyes" without undue disturbance to the ongoing transit operations.
- Keeping traffic operation on the street above.

FIG. 1

Conceptual layout of the Pine Street site showing temporary access and adjacent to the PSST ventilation shaft.



Alternative design

A few alternative approaches were originally considered, in addition to the preliminary engineering design. One of the initial ideas was to determine whether any of the TBM breakthrough preparation work could be carried out under the PSST contract that was still under way at the beginning of the University Link design period. This preparation work would have consisted of the removal of the partially exposed soldier piles and part of the anchors that intersect the proposed tunnel alignment from the surface prior to the restoration of Pine Street, as well as removal of the break-out panels in the PSST headwall. However, it was quickly ascertained that this idea would be difficult to implement given the necessity for a very late change to the scope and schedule of the PSST contract, which was near completion at that time.

The alternative was developed as part of the Capitol Hill Tunnel contract (U230) and eliminated the need for any further construction work within Pine Street. This minimized disruption to residences and businesses in the area. This alternative was used in the final design and involved the following activities:

- Ground treatment to facilitate tieback removal through the TBM cutterhead for the southbound tunnel, and stabilizing TBM break-ins for both tunnels.
- Installation of "demising wall" bulkheads within the PSST to facilitate the removal of the northbound and southbound break-out panels and installation of utility connections and light rail operations within an agreed length of the PSST.
- Temporary access/retrieval shaft construction for the northbound tunnel only, taking advantage of the PSST headwall and the existing controlled density fill (CDF) backfill on two of the four shaft sides.
- Access drift from the temporary shaft to a temporary chamber, constructed within the safety of the CDF located between the existing soldier pile wall and the PSST headwall.
- Removal of soldier piles from the temporary chamber and replacement with CDF backfill.
- In-tunnel disassembly of the southbound tunnel TBM.

FIG. 2

Plan view of the preliminary engineering concept shafts and SEM works.

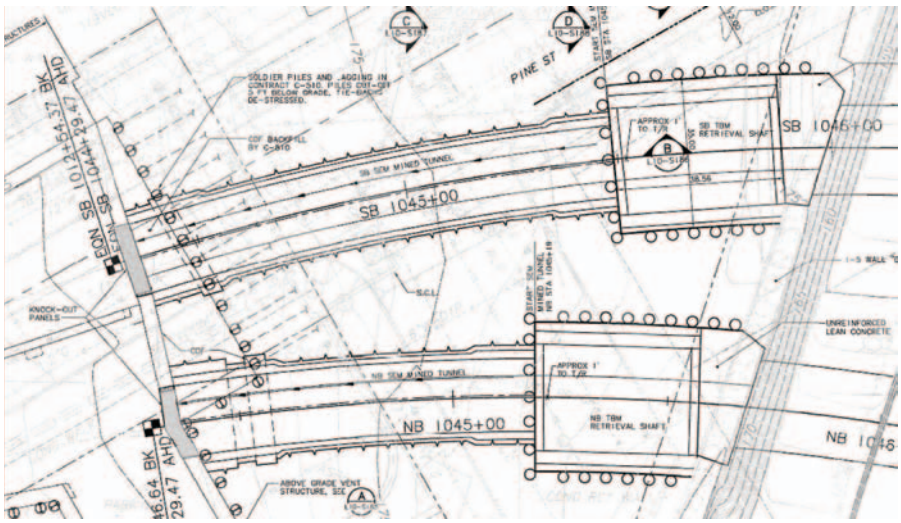
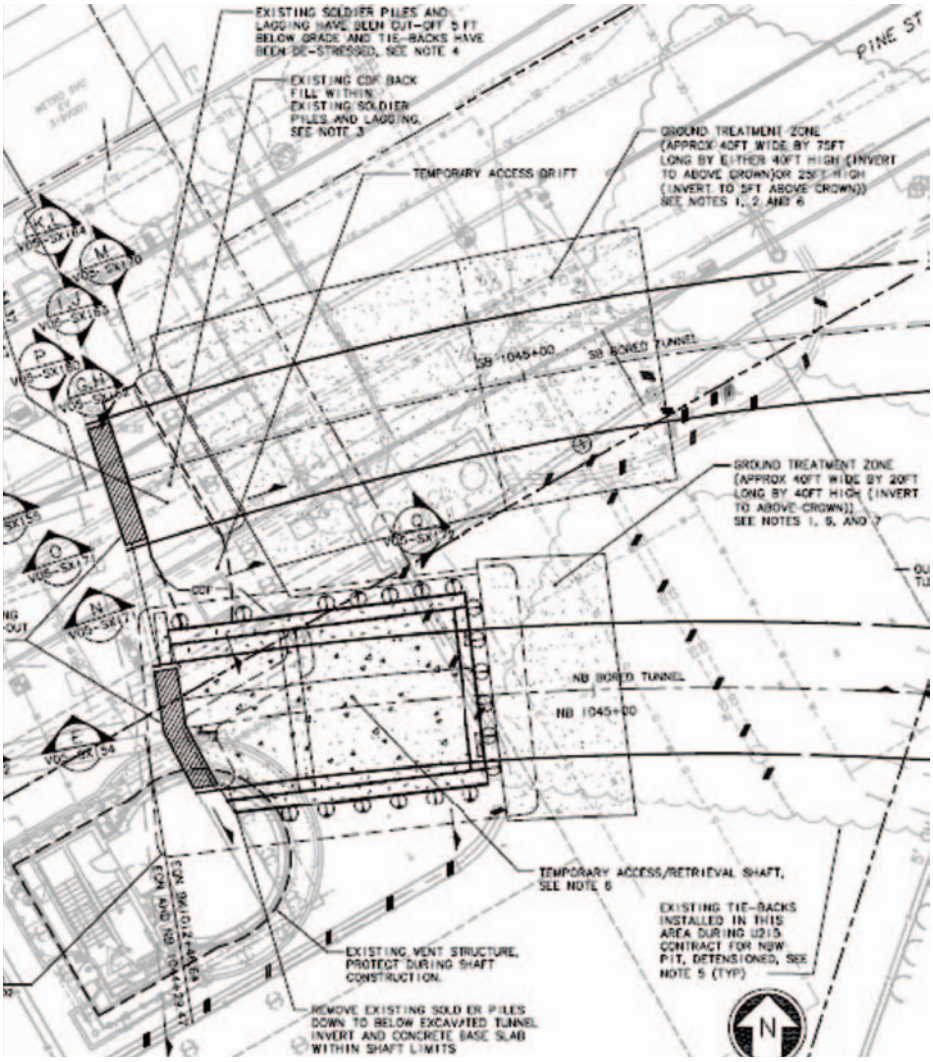


FIG. 3

Plan view showing the adopted final design alternative connection (section arrows provide some idea of the detailed engineering required to make the design work).



- Removal of soldier piles from northbound retrieval shaft.

Figure 3 shows a general layout of the alternative used in the final design.

Ground treatment

Due to the presence of recent alluvium deposits and landslide deposits below the ground water and overlying the overconsolidated glacial soils, a limited ground treatment zone was determined to be required for both tunnels. The ground treatment zones, as shown in Fig. 3, vary for each tunnel. For the northbound tunnel, the zone is large enough to provide a stable face to allow for bottom removal of the east soldier piles, which are used for support of the retrieval shaft and would later be removed from the path of the TBM. For the southbound tunnel, the zone needed to provide a stable face for the east soldier pile removal, but also provide stability for the tunnel heading to allow removal of tiebacks from within the face of the TBM, to be carried out under atmospheric pressure. The southbound tunnel geometry was also dictated by an existing sewer that had to stay in operation throughout the tunnel construction phase.

Ground treatment to stabilize the tunnel crown and improve the soil standup time was designed as jet grouting because of the high silt content of the in situ soils, and used to create a consolidated block of material in the zone of landslide debris between the alluvium and overconsolidated glacial soils. This work had been planned to be carried out from the Sound Transit staging site shown in Fig. 1 next to Pine Street and extend at an angle below the street to prevent further surface disruption and minimize any potential traffic impacts.

Operational considerations, neighborhood stakeholder concerns

Early in the design of the connection design it was made clear that disruption of the Sound Transit and King County Metro operations within the PSST had to be held to a minimum. After some reflection on all of the construction activity that could not be avoided within the PSST, and the risks this posed to ongoing transit operations, the concept of "demising walls" was developed. The demising walls are fixed bulkheads fitted out with roller and personnel access doors constructed between 15 and 20 m (50 and 65 ft) from the PSST headwall in order to create a construction exclusion work zone. These bulkheads have been designed to prevent the communication of dust and noise from the construction zone, control personnel access into the active transit operations area and maintain the integrity of the existing fire-life-safety (FLS) ventilation. Installation of the bulkheads could not avoid impacts to the PSST.

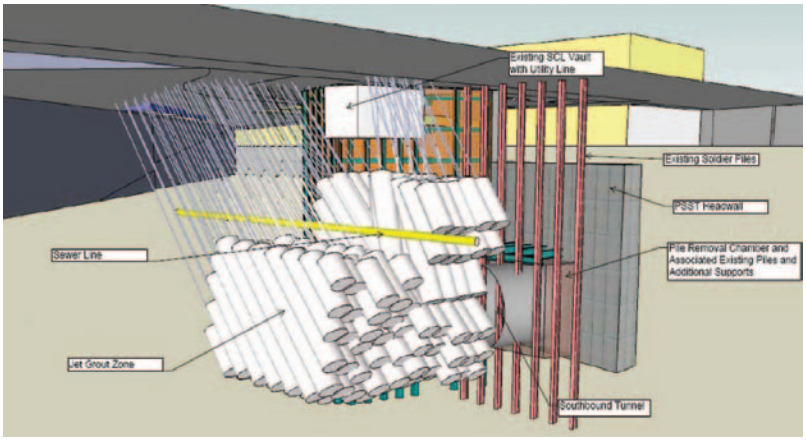
Relocation of the light rail "bumper posts" reduced the available storage length for light rail vehicles by

approximately 18 m (60 ft) and restricted Sound Transit to two-car travel. However, the advantages of the bulkheads outweighed this temporary inconvenience to operations and Sound Transit will not need a three-car service until the completion of University Link in 2016. Once the bulkheads have been installed, they will remain in place until all systems and other finishing works have been carried out, so that the seamless integration of the U-Link with the PSST can be completed.

To address the concerns that site neighbors and other stakeholders would have of further construction being carried out that would disrupt traffic on Pine Street, the design team came up with a feasible approach that would ensure that, for the most part, construction activities would take place within the site boundaries, only stepping outside into the sidewalk areas for very specific operations, such as the angled jet grouting below Pine Street as shown in Fig. 4.

FIG. 4

Jet grouting below Pine St.



Temporary shaft support

Construction of the temporary access/retrieval shaft for the northbound TBM tunnel has been designed to proceed according to the following steps:

- A roughly rectangular shaft will be constructed so that the PSST headwall and additional temporary soldier piles will support the shaft excavation from elevation 52 m (170 ft) to the base of the PSST structure. The layout of the piles avoids the electrical duct bank and the overhang of the existing vent structure.
- The 22-m (70-ft) shaft will rely on the temporary soldier piles, wales at 2.4 to 3.7 m (8 to 12 ft) level intervals, and timber lagging, similar to the successful model used for temporary excavation support of the PSST.
- Temporary soldier piles will be installed in order to safely excavate the shaft to the level of the access drift and provide access for removal of the existing soldier piles within the shaft.
- Upon completion of the works for the temporary pile removal chamber, the shaft will be excavated to a point where the northbound tunnel headwall break-out panel can be removed.
- Existing soldier piles that were used as temporary support for the PSST and are within the temporary access shaft will be removed.
- Once this work has been completed, all of the soldier piles within the tunnel envelope will be cut or extracted after bracing the existing piles in lifts, with removal carried up to 0.6 m (2 ft) above the crown.
- The shaft will then be partially backfilled in lifts corresponding to the pile removal sequence above, with CDF material to allow

FIG. 5

View of shaft showing existing and additional support elements.

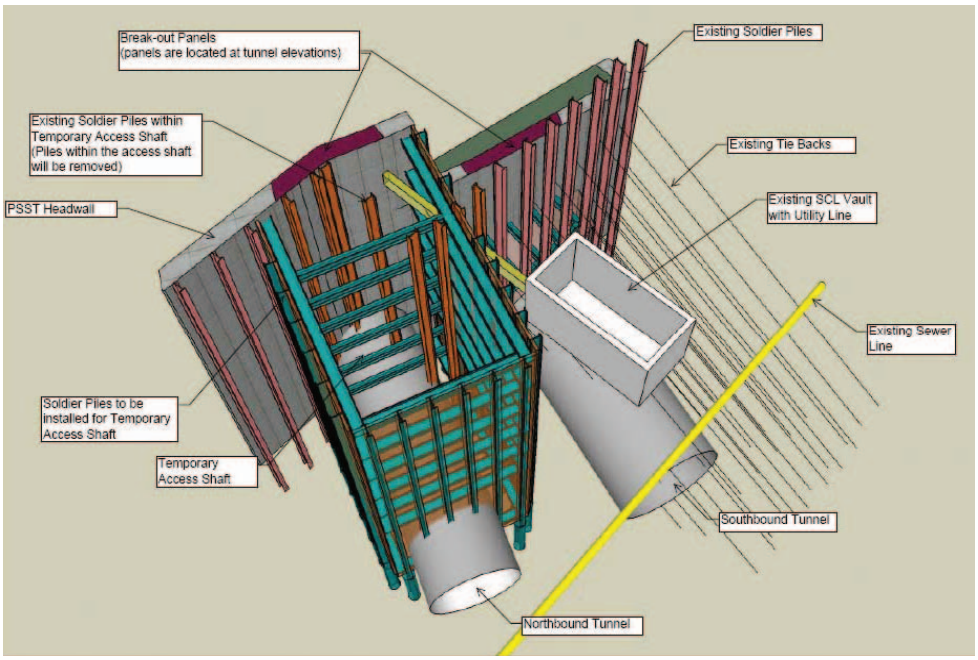
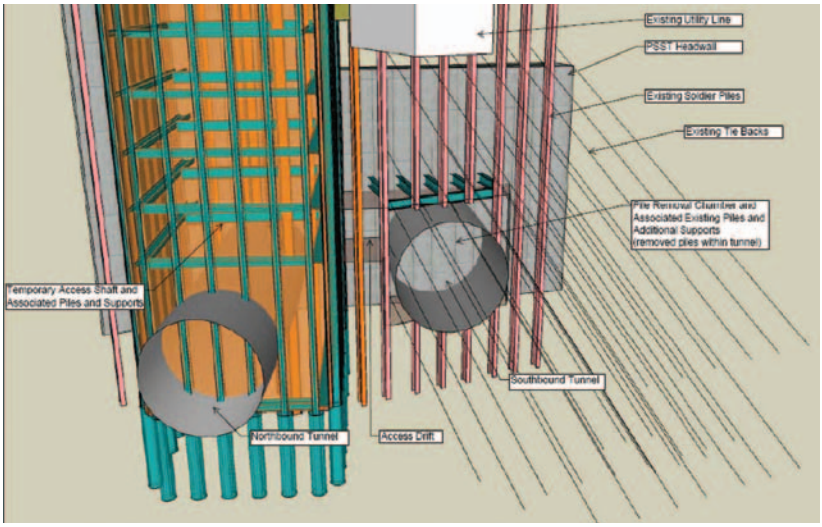


FIG. 6

Transverse section showing access drift and SB pile removal chamber.



for the northbound tunnel TBM to mine into the shaft (Fig. 5).

Access drift and pile removal chamber

To avoid surface disruption to Pine Street, a 3-×3-m (10-×10-ft) access was designed to be driven from the shaft above tunnel axis level within the CDF material between the northbound and southbound tunnels.

This access drift will take advantage of the existing PSST soldier piles on the east side for support. The drift excavation and chamber top bench will be supported by partial steel sets, with lagging or shotcrete to ensure ground stability, placed in line with the existing piles. At this stage, it will be possible for the upper part of the southbound tunnel break-out panel to be exposed and removal of the concrete will begin.

Subsequent benches will be excavated from the top down, exposing the entire break-out panel for removal and the complete length of piles and laggings to be removed from the tunnel envelope.

Beginning from the bottom bench, laggings, piles and 0.9 to 1.2 m (3 to 4 ft) of existing tieback will be removed after stabilizing the soldier piles. The lower portions of the pile removal chamber are expected to be in the overconsolidated Qpgm and Qpgl materials, which are stiff to very stiff clays. The upper portion of the chamber will be within the zone of ground treated soils, which should not become unstable during the short period that they are left unsupported. Figure 6 illustrates a section through the fully developed access drift and pile removal chamber that is larger than required to accommodate the tunnel envelope (southbound tunnel profile shown) because of the presence of tieback anchor points that connect with tiebacks intersecting the tunnel horizon, as well as to allow waterproofing, mechanical, electrical and systems connections to the existing PSST structure. To facilitate TBM excavation, the tiebacks will be disconnected from their associated piles within the pile removal chamber.

Tieback removal through the TBM

During construction of the PSST headwall structure, the temporary excavation support soldier pile wall running northwest was supported by a tieback anchoring system. The tieback system was arranged in five rows at intervals of 3.4 to 3.7 m (10 to 12 ft), which intersect the proposed SB tunnel envelope, as shown in Fig. 6. The tiebacks consist of steel cables anchored over a minimum 4.6 m (15 ft) length at the cable terminus, and intersect the SB tunnels to varying degrees. The TBM is likely to encounter tiebacks over a 13.7-m- (45-ft-) long interval, starting approximately 16.8 m (55 ft) before the PSST headwall.

In accordance with the specification, an earth pressure balance (EPB) TBM will excavate in closed mode (pressurized face) up to this position and then convert to open mode (nonpressurized face) while excavating under the cover of the jet-grouted tieback zone. Following each of the seven- to eight-ring excavation sequences required to mine through the tieback zone, interventions are to be carried out as necessary to cut the cables engaged by the cutterhead or exposed in the face. This is anticipated to ensure that at no time will there be more than 1.5 m (5 ft) of cable exposed that could become entangled in the TBM cutterhead. Stability of the crown during these interventions will be provided by the ground treatment zone. Figure 7 shows a perspective view of the intersection of tiebacks with the SB tunnel envelope.

TBM drives from I-5 to PSST

Once the temporary excavation supports have been removed from the tunnel envelope, both northbound and southbound tunnel TBMs should be able to proceed up to the PSST headwall without difficulty. The northbound TBM will be driven up to the PSST headwall and removed by the temporary access shaft. The cutterhead and shield components will be hoisted out of the shaft and loaded onto a flatbed trailer in easily transportable pieces, to be reassembled at the Capital Hill Station for the southbound tunnel drive.

The southbound TBM will pass through the anchors (as already described) and then through the CDF, aligning roughly perpendicular with the PSST headwall. Once the southbound TBM shield is in position, it will be grouted and the internal elements disassembled, leaving the shield carcass as temporary support for the tunnel.

The gap created following removal of the cutterhead

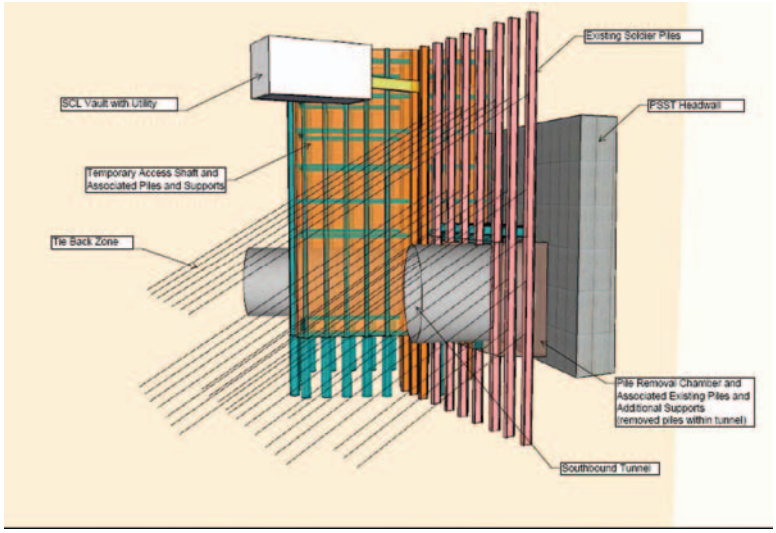
between the shield and the PSST headwall will be temporarily supported by bracing around the shield in order to ensure ground stability. The shield diaphragms will be removed, and waterproofing, rebar and concrete or shotcrete will be used to complete the circular cross section of the tunnel up to the PSST headwall. Connections for mechanical, electrical and systems components will be made prior to placing the final lining.

Final lining and connections

After completion of the tunnel drives, the temporary shaft will be left open to allow subsequent contractors to transport materials to tunnel level without requiring access from the existing PSST. As a final step, a cast-in-place concrete lining will be installed to bridge the gap between the precast concrete segmental lining installed in the tunnel and the PSST headwall, including connections for waterproofing, mechanical, electrical and systems components. The shaft will then be backfilled to the ground surface and the existing site restored.

FIG. 7

Perspective of tiebacks intersecting the SB tunnel envelope (ground treatment not shown for clarity).



Lesson learned: Design of the Northlink connection interface

The conditions in and around the PSST were less than ideal for reception of the TBMs and considerable design was required to address the unique challenges of the site. As part of the University Link, both Sound Transit and its designer wanted to think ahead and avoid the difficulties encountered in designing the Pine Street connection. To address this issue, the north end of the University of Washington station (UWS) has been designed to incorporate a reception area and shaft for TBM removal. A number of design elements were incorporated into the north end of UWS to ease future construction. These elements include:

- Access rights have been worked out with the University of Washington to allow for the removal of TBMs from the north end of UWS.
- A TBM retrieval shaft has been built into the permanent works of the north end of the UWS, to allow removal of the TBMs as they mine into the station.
- Fiberglass reinforcing bars have been incorporated into the final design of the headwall at the north end of the UWS, to allow easier removal of the concrete headwall for the TBM break-ins.
- A block of treated ground will be created at the break-in points to the shaft headwall.
- The north headwall was designed to be perpendicular to the direction of the anticipated TBM drives.

Conclusions

The design of the connection of the University Link tunnels to the existing infrastructure at the PSST presented many challenges. Preliminary engineering concepts anticipated retrieval shafts and short tunnels excavated using SEM for this connection, as shown in Fig. 2. However, limited access within the existing PSST structure for the SEM tunnels required an alternative approach. Use of a retrieval shaft adjacent to the existing box structure was designed to accommodate the northbound tunnel, and a short access drift to the southbound tunnel will allow construction to be performed with only limited impact on operations within the existing PSST structure by the use of a demising wall.

This method also limits impacts to adjacent Pine Street; eliminates SEM works; allows tunneling to be performed by TBM for the entire tunnel alignment, which has both schedule and cost advantages; ensures safety and security in the PSST; minimizes interference with existing or ongoing transit operations to reduce risks from safety and contractual points of view; reduces schedule risk by performing preparatory works at PSST prior to the arrival of the TBMs; and gives some additional flexibility for making connections to the existing structure for waterproofing, as well mechanical, electrical, ventilation and systems components.

Finally, the lessons learned from the PSST connection have been directly put to use at the north end of the U-Link project, where UWS ties in with the future running tunnels expansion to the north. Future running tunnels coming into the station will be provided with a TBM retrieval shaft built into the permanent works of the station, greatly reducing the impact of the future expansion on the operations of the University Link light rail. ■

FEATURE ARTICLE

2010 permeation test results for grouts made with ultrafine cement

The 31th annual short course "Grouting Fundamentals and Current Practice" was held at the Colorado School of Mines, in Golden, CO June 7-11, 2010. The field demonstration portion of the course was conducted June 10 at wlh Construction Co.'s yard in Denver, CO.

The full-scale field demonstration presents many types of drilling and grouting equipment in operation as well as numerous grouting methods performed under various field conditions.

As part of the field demonstration, the class was shown the proportioning, mixing, testing and injection of various cement grout mixes into sand columns under controlled and recorded conditions. These sand column demonstrations have been conducted under controlled and measured conditions each year as part of the short course since 1999. The sand column demonstrations were conducted prior to 1999, but with less quality control and minimal record keeping of the proportioning, mixing, testing, injection pressures and the final permeation results.

The goal of the sand column demonstration is to show the students the effect of the water cement ratio and the use of admixture, as well as the fineness of the cement (portland versus ultrafine) used, have on the engineering properties of the grout and the grout's vertical permeation height through the sand.

Test results for the demonstrations conducted in 1999, and for two separate demonstrations conducted in 2000, one at the grout course and one at Geo Denver, were published in the 2001 proceedings of the Rapid Excavation and Tunneling Conference (RETC) (Henn et al., 2001). The test results for the 2002 and the 2003 demonstrations were published in the 2005 proceedings of the RETC (Henn et al., 2005).

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FIG. 1

Hany grout plant.

Test results for the demonstration conducted in 2009 were published in the December 2009 issue of *Tunneling & Underground Construction* (*T&UC*) magazine (Henn et al., 2009).

Past demonstrations

The demonstrations over the years have included cement grouts made with various brands of Type I-II portland cements and various brands of ultrafine (microfine) cements. The grouts have been batched with and without admixtures, and the water cement ratios have ranged from approximately 0.7:1 to 4:1.

Beginning in 2000, the injection pressure was set at a maximum of 10 psi (0.7 bar) and held constant during the entire injection period. Previously, the injection pressures ranged from 5 psi (0.3 bar) to 10 psi (0.7 bar). The maximum injection time was, and remains, 20 minutes per column. The sand columns have always been 191 mm (7.5 in.) inside diameter and 1,524 mm (60 in.) tall and are

made of a clear plastic. Several different manufacturers and designs of grout plants have been used.

Basic field-testing has always included the grout mix temperatures, specific gravity and marsh funnel viscosity. Several additional field and laboratory test procedures, including cohesion testing, flow cone tests and unconfined compressive strength testing of the cured grouted sand sample, have been performed during several of the previous demonstrations.

More detailed information for a better understanding of the data available and how it compares with the 2010 results presented below is available in the two papers published in RETC proceedings, (Henn et al. 2001 and Henn et al. 2005), and in the 2009 *T&UC* (December, page 28) paper (Henn et al. 2009).

2010 demonstration

The 2010 demonstration consisted of five grout mixes (batches) and five sand columns labeled #1 through #5. There was one mix (#1) of Type I-II portland cement and four mixes made using ultrafine (microfine) cements. Mixes #1 through #4 were mixed using a Hany high shear (colloidal) mixer, mix #5 was mixed using a paddle mixer. Mixes #4 and #5 were identical except #4 was mixed with the high shear mixer and #5 was mixed with the paddle mixer.

Each grout batch was injected into the sand column immediately after mixing and QC testing at the maximum injection pressure of 10 psi (0.7 bar), and the maximum injection time of 20 minutes per column, which remained unchanged from previous demonstrations. Specifics, such as the cement manufacturers, name of the product, water cement ratios and the admixtures used for each mix, are given in Table 1.

Additionally, in the 2010 demonstration, three approximately 41-mm- (1.6-in.-) inside diameter, and 1,181-mm- (46.5-in.-) tall, plastic tubes were each also filled with the same grout mixes used to inject sand columns #2, #3 and #4. There was no sand placed in these three tubes and the grouts were simply poured into the top of the tubes, with each tube being completely filled. The purpose for using the tubes was to demonstrate the shrinkage characteristics of the three grout mixes to the students.

Supervision of the demonstration, as well as quality control, testing and record keeping, were performed by personnel from Lyman Henn, a division of Brierley Associates, LLC of Denver, CO.

FIG. 2

Sand columns (2010) prior to grout injection.

Equipment

A model IC325 Hany Injecto-compact (IC) grout plant was used for the 2010 demonstration. The plant consists of standard components: HCM mixer, HRW agitator and a ZMP grout pump. It is important to note that this is a plunger pump with a maximum output capacity of 51 L/min (13.5 gpm) at a maximum discharge pressure of 1,470 psi (100 bar). The plant is shown in Fig. 1.

FIG. 3

Three plastic tubes used to show shrinkage.

Table 1

Permeation grouting test data summary (June 25, 2010).

Test Number	Supplier	Name of product	(W:C)	Cement lbs (kgs)	Water lbs. (kgs)	Water (L) gallons	Admixture	Mixer	Mixing time (minutes)
T-1	USM Portland	Portland I-II cement	(1.8:1)	47 (21.3)	84 (38.1)	10.1 (38.7)	8 oz DeNeef NS-200 dispersant	Hany high shear mixer	3
Comments: None									
T-2	DeNeef	MC-500 Microfine Cement	(2:1)	55 (24.9)	110 (49.9)	13.2 (50)	7 oz DeNeef NS-200 dispersant	Hany high shear mixer	3
Comments: The column leaked at the bottom of the seal.									
T-3	Nittetsue	Super Fine	(2:1)	88 (39.9)	176 (79.8)	21.1 (79.9)	10 oz Nittetsue mighty 150	Hany high shear mixer	3
Comments: None									
T-4	Minova	Ultracem super	(2:1)	80 (36.3)	160 (72.6)	19.2 (72.6)	None*	Hany high shear mixer	3
Comments: Grout pushed up (jacked) sand column toward the end of the injection, causing the cap to lift up a few inches.									
T-5	Minova	Ultracem	(2:1)	80 (36.3)	160 (72.6)	19.2 (72.6)	None*	ChemGrout 550 pneumatic paddle mixer	5
Comments: Grout pushed up (jacked) sand column toward the end of the injection, causing the cap to lift up a few inches.									

The Hany IC325 plant was used to batch and inject grouts into sand columns #1 through #4. At the request of one of the ultrafine cement suppliers (Minova), the paddle mixer from a ChemGrout model CG550 Rugged series grout plant was used to batch the mix used to inject grout into sand column #5. However, after mixing, the grout was transferred into the Hany IC325 plant's agitator, and the Hany plant's plunger pump was used to inject the grout into sand column #5. The ChemGrout paddle mixer was pneumatically powered and had a capacity of approximately 85 L (3 CF).

The sand columns were 191 mm (7.5 in.) inside diameter and 1,524-mm- (60-in.-) tall. These are the same redesigned and newly fabricated columns used for the first time during the 2009 demonstration. Figure 2 shows the five sand columns during the 2010 demonstration just prior to the start of the grout injection. The three additional plastic tubes used to show the shrinkage are shown in Fig. 3.

Inspection, record keeping and testing

Inspection was performed and the results recorded on each batch of grout. The recorded data includes the quantities of cement and water added to the mixer, the quantities and types of admixtures used, the mixing times, injection pressures and the vertical travel distance of the grout in the sand column versus time. In addition to the inspection, three field tests were performed on each batch of grout. These tests were grout temperature, specific gravity and marsh funnel viscosity. The results of the inspection and testing are given in Table 1.

Inspection and testing were also performed on the three plastic tubes that were filled with grout. The amount of shrinkage in each tube was recorded just after the grout reached its initial set. Table 2 gives the consistency of the grout in the tube as gauged by feel (squeezing the tube between fingers). The three tubes were left to set out doors and out of direct sunlight, and shrinkage measurements were taken periodically. The results of the

Ambient air temp F° (C°)	Grout temp F° (C°)	Specific gravity	Unit weight (pcf) and kg/m³	API (13 B-2) Marsh funnel viscosity (sec/946cc)	Duration injecting into column (min)	Injection pressure psi & (bar)	Final grout water height in column in. and (mm)
80 (27)	71 (22)	1.30	81 (1,297.6)	29	4:00	10 (0.7)	57 (1,447.8)
80 (27)	62 (17)	1.24	77.5 (1,241.6)	29	1:36	10 (0.7)	57 (1,447.8)
80 (27)	65 (18)	1.29	80 (1,281.6)	30	2:11	10 (0.7)	57 (1,447.8)
80 (27)	65 (18)	1.26	79 (1,265.6)	29	1:15	10 (0.7)	57 (1,447.8)
80 (27)	70 (21)	1.28	80 (1,281.6)	29	1:17	10 (0.7)	57 (1,447.8)

shrinkage measurements are shown in Table 3.

It was decided during the demonstration that an attempt would be made to obtain a rudimentary (non-compliant with ASTM) compressive strength for grouts #2, #3 and #4 using the samples collected in the plastic tubes, in order to correlate the approximate strength of each ultrafine cement with the particular water cement ratio used. Two samples of the hardened neat ultrafine cement grouts from each tube were prepared and tested for unconfined compressive strength. The samples were prepared at the Earth Mechanics Institute at the Colorado School of Mines, and testing was performed at Lyman Henn's soil and CMT laboratory. Table 4 shows the results of the 29-day unconfined compressive strength testing.

Discussion of test results

All of the mixes used in the 2010 demonstration used a water cement ratio of 3:1 by weight. Additionally, the sand used to fill the sand columns for the 2010 demonstration was the same sand gradation used prior to the 2009 demonstration. The paper presenting the 2009 demonstration test results, published in the December 2009 issue of *T&UC* magazine, talks about these sand gradations in more detail (Henn et al., 2009).

Four cement products were batched in five batches. One batch was made with portland type I-II cement and the remaining four batches were made with ultrafine cements from three different manufactures. One of the ultrafine cement manufacturers, Minova, requested that one batch of its product be mixed with the high shear mixer and one batch be mixed with the paddle mixer. Minova had performed in-house tests to show that grout made with its ultrafine product would behave the same regardless of which mixer type was used. The company wanted to see if the same results could be achieved independently by using equipment and staff provided at the demonstration.

All five batches did well in the sand column grout

Table 2

Consistency of grout in tube.

Date	Time	#2 DeNeff	# 3 Nittesu	#4 Minova
06/12/2010	16:28	Soft	Med. hard	Hard
06/13/2010	14:00	Hard	Med. hard	Hard
06/14/2010	07:07	Hard	Med. hard	Hard
06/14/2010	18:48	Hard	Med. hard	Hard
06/15/2010	07:05	Hard	Hard	Hard

Note: Batch date 06/11/10

Table 3

Results of shrinkage measurements.

	#2 DeNeef	#3 Nittetsu	#4 Minova
Tube height (in.)	46.5	46.5	46.5
Initial grout height (in.)	46.5	46.5	46.5
Final grout height (in.)	35	36.5	32.5
Final bleed height (in.)	11.5	10	14
Percent reduction	24.7%	21.5%	30.1%

Table 4

29-day unconfined compressive strength test results.

Sample	2-1	2-2	3-1	3-2	4-1	4-2
Sample height (in.)	3.161	2.854	3.026	3.04	3.147	3.017
Sample diameter (in.)	1.73	1.604	1.62	1.62	1.595	1.641
Strength (psi)	500[1]	610[1]	2290	2190	2550	1320
Break type[2]	n/a	3[1]	5	3 or 5	2	2

[1] Estimated value; sample had no clear break point because it was too soft.

injection. All grouts made it to the top of the columns well under the prescribed 20 minutes. After reviewing the results of the vertical flow of the grouts' various times from past demonstrations, it was concluded that the methods used to fill and densify the sand used in the columns needed to be evaluated. This is the one operation in the demonstration that has not received as much attention as the grout batching and injection. It was agreed by the sand column demonstration team to address this issue for next year's demonstration.

As previously noted, there was a last minute addition to the 2010 demonstration of three approximately 41 m (1.6 in.) inside diameter and 1,181-mm- (46.5-in.-) tall clear plastic tubes, meant to show grout shrinkage. Several interesting results of these tests were observed. The first was the time required by each to harden. Second, the grout in each tube turned a dark green color and stayed that color for approximately 29 days from the time of casting until compressive strength testing. During preparation of the grout cylinder from the tubes for testing, when the hardened grout cylinders were removed from the plastic tubes, the grout turned from dark green to a gray color. Additionally, from approximately 24 hours after casting until compressive strength testing, the grout in the tubes gave off the "rotten egg" smell of hydrogen sulfide. This smell can be attributed to the high slag content of the mix of the ultrafine cements. The grouts lost approximately one third of their volume to shrinkage when setting, as was expected.

As noted above, the two hardened grout cylinders from each tube were tested for unconfined compressive strength. Grout #2 was very soft and, as a result, didn't break in a normal fashion but failed by compressing as clay would. Because of this, it was difficult to determine when the sample technically "failed" and, therefore, the strength value is only an estimate. The other two grouts performed at strengths that would be expected for ultrafine cements.

We are planning to perform these shrinkage tube demonstrations and testing next year on all five grout batches. ■

Acknowledgments

The authors thank Warren Harrison of wlh Construction Co. for the use of his yard, paddle mixer and other facilities. Thank you to Joe Schatz of ChemGrout for providing the sand columns, grout header and supervising the batching of the grouts. Thanks to Fred Sherrell of Surecrete for supplying the Nittetsu SuperFine cement, to Brian Iske of DeNeef for supplying the MC500 microfine cement and to Joe Burdette of Minova for supplying the Ultracem ultrafine cement. Thank you Bobby Cannon of DSI Underground Systems for providing the Hany IC325 grout plant and to Billy Brown for operating the plant. Thank you Brian Asbury for the use of the EMI equipment. And, as always, a big thank you to Don Hegebarth, independent grouting consultant, for doing all of the preplanning and organizing the overall demonstration. ■

FEATURE ARTICLE

How to deliver your project on time: An owners' procurement strategy

The Regional Municipality of York, located north of the City of Toronto in Ontario, Canada, has experienced unprecedented growth during the past decade, with new home construction averaging 15,000 units per year. This rate of growth is planned to continue well into the future with a projected growth of more than 500,000 new residents by 2031, combined with a target of more than 300,000 new jobs to provide a sustainable economic base for the region. It should be noted that York region has been designated as one of the key growth centers by the province of Ontario, aimed in part to meet the housing and employment needs of Canada's growing population.

York Region is a mix of urban and rural areas and is one of the most desirable areas to live in Southern Ontario. York region offers an attractive lifestyle, with its nine municipalities and the amenities created by the many rivers, streams and protected greenbelt areas that encompass more than 69 per cent of the region's area.

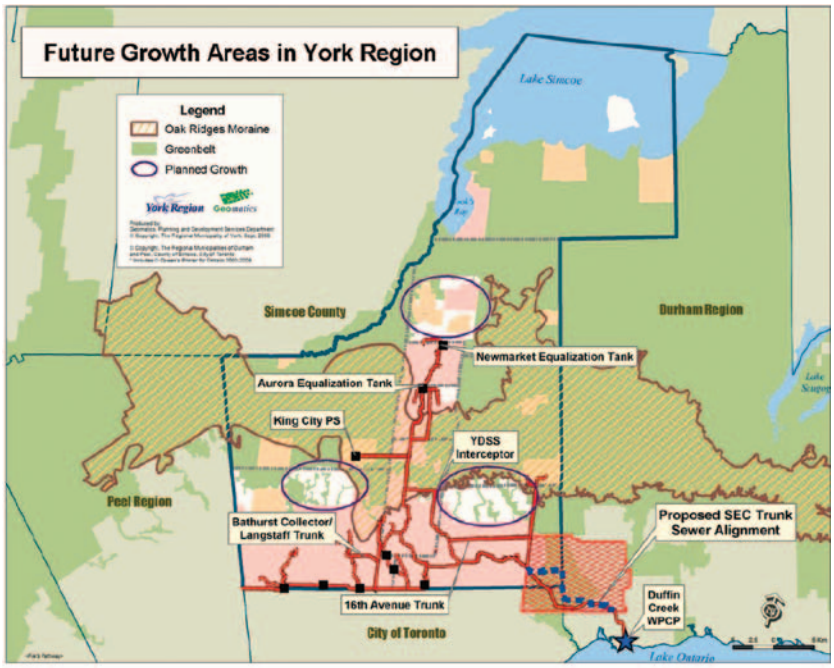
The existing wastewater system, the York Durham Sewage System, was constructed in the 1970s and is comprised of more than 200 km (124 miles) of large 2.4 to 3 m (7.8 to 9.8 ft) diameter trunk sewers, extending from a water pollution control plant (WPCP) on Lake Ontario to the most northerly community, approximately 80 km (50 miles) from the WPCP (Fig. 1).

Parts of this system, and in particular, a 15-km (9-mile) length of the Southeast Collector Trunk Sewer, will approach its hydraulic capacity within the next few years, thus necessitating a major program of twinning and trunk system expansion to accommodate the servicing needs for the planned future growth in York region.

Growth pressures, combined with the need to protect and sustain York region's many natural and heritage features, are the key challenges for planning and expanding the capacity of the Southeast Collector Trunk Sewer portion of the waste water system. York region has undertaken an extensive individual environmental assessment (IEA) and developed a unique strategy for procuring equipment, materials and labor to meet the challenges of providing new trunk wastewater capacity in a timely manner. The strategy should also protect the many natural and cultural features of the area. A number of strategies are underway to achieve these goals.

FIG. 1

Future growth, greenbelt and watershed areas.



Extensive environmental planning

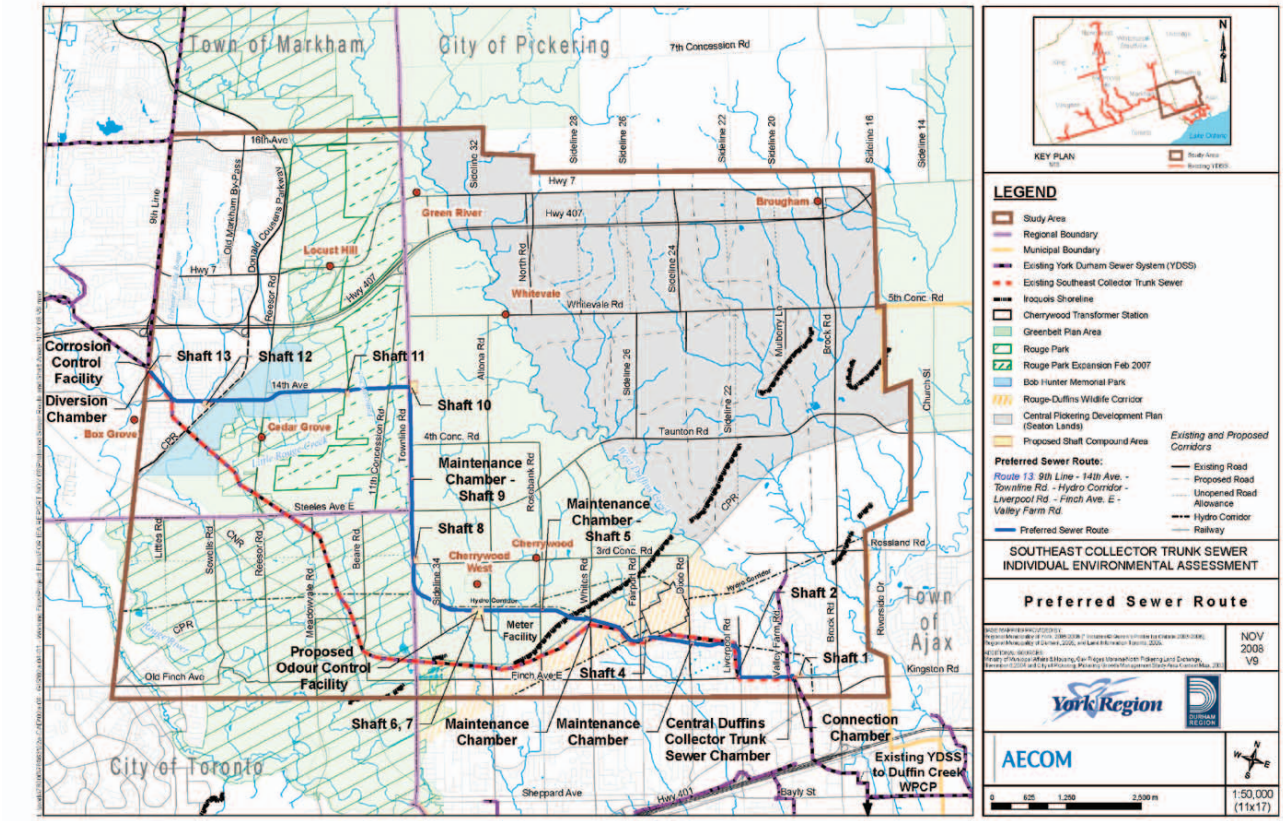
Government approval of the IEA was required prior to construction starting on the capacity expansion of the Southeast Collector Trunk Sewer (Fig. 2). This project is the first large-scale waste water project in Ontario to undergo this level of scrutiny. The study examined a full range of alternative solutions, including an assessment of 13 alternative routes for the trunk sewer expansion, along with an extensive program of public consultation with agencies, stakeholders and property owners. This comprehensive environmental planning study included the collection of baseline data on soils, surface and ground water conditions, as well as data on natural environmental features related to terrestrial and aquatic species of the area. A detailed geotechnical and hydrogeological investigation was carried out at an early stage of the project planning. This thorough knowledge of soil conditions was used to set the sewer profile, alignment and location of drop structures to maintain

Wayne Green

Wayne Green, member UCA of SME, is senior project manager with The Regional Municipality of York, Newmarket, Ontario, Canada e-mail wayne.green@york.ca.

FIG. 2

Southeast collector trunk sewer — preferred sewer route.



the tunneling activity in very competent till material, regionally referred to as the Newmarket Till deposit. This geological database was used for the development of a geological baseline report (GBR) for construction purposes (Fig. 3). Similarly, groundwater pump tests were conducted along the pipe alignment, confirming that minimal dewatering would be required at the construction shaft locations.

The study recommended the use of earth pressure balance tunnel boring machine (EPBM) technology, using a single pass segmental liner system. Further, sealed shaft construction has been recommended for the construction shafts. The study concluded that the use of this equipment and construction methods would ensure a minimal impact on the communities and natural environment along the construction route. This early planning study and community engagement program provided a solid framework for the design, approvals and construction phases of the project.

Advanced procurement of equipment and materials

Procurement of tunnel boring machine (TBM) equipment. York Region pre-purchased four EPBMs from Lovat Inc., with a machine specification to undertake the tunneling activity in the Newmarket Till materials. The Lovat Inc. local office and assembly plant is located in Ontario, Canada, making it a logical choice for York region to use this equipment manufacturer for the four machines.

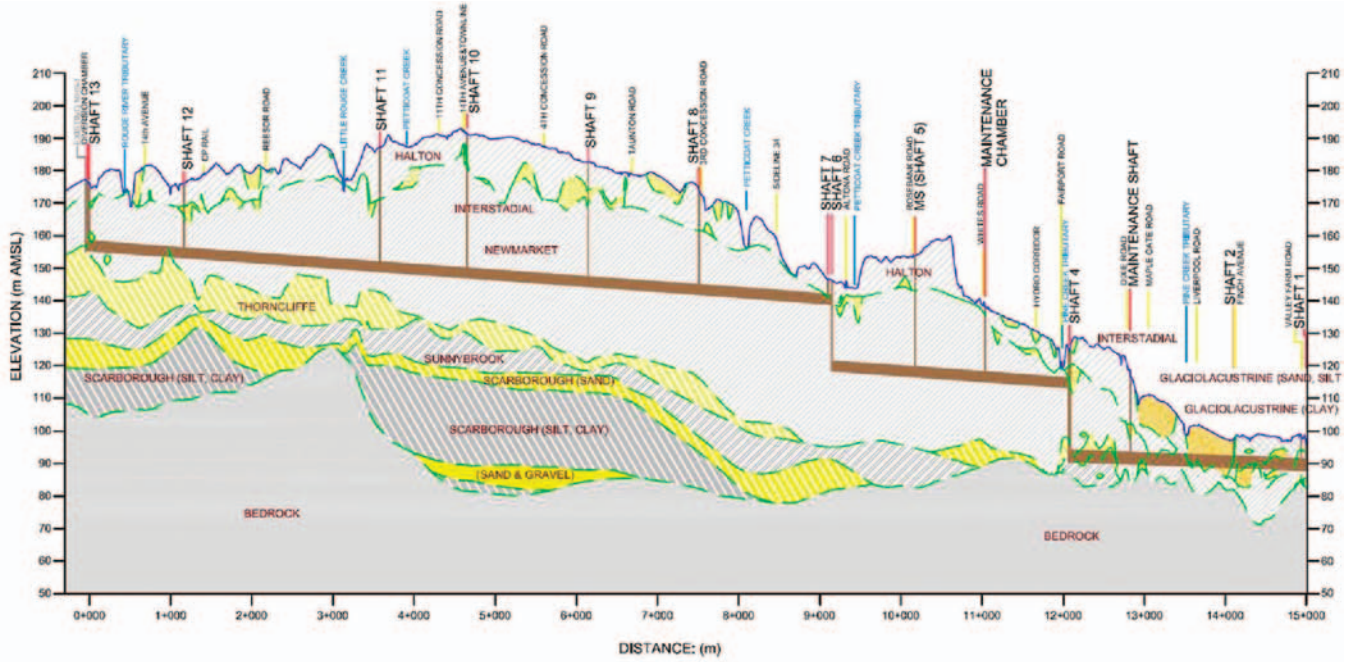
The TBMs are in production and will be available for delivery to the site immediately upon start of construction. This early procurement of equipment by York region will allow the contractor to begin tunneling activity at or about the same time, using all four machines. The total project length of 15 km (9 miles) will be split into approximately equal length segments to allow concurrent tunneling effort by four tunnel crews.

Procurement of segmental liner materials. York Region issued a tender for the supply of segmental liner materials to all four TBMs (Fig. 4).

A supply of up to 400 liner segments will be required on a daily basis to meet the pipe installation progress of the four TBMs. Given this volume, the contract specification for the liner materials required the successful bidder assemble a dedicated plant to maintain this liner supply rate. The liner segments are now in production and will be available for supply to the site immediately upon start of construction.

FIG. 3

Geological profile.



Advancing project funding

York region's commitment to allocate significant funds in advance of government project approval — in order to undertake the purchase of long delivery items such as TBM equipment — is a key aspect of the project. Another key aspect is the establishing of a plant for the delivery of segmental liner materials prior to approval. This advance funding of materials and equipment demonstrated York region's commitment to the successful commissioning of the new Southeast Collector Trunk Sewer on schedule in 2014. It should be noted that the capital cost of this trunk infrastructure is funded through a 'per lot' charge levied against the future developments that will be serviced by the trunk system. In this way, a user-pay principle is maintained and the burden for payment is allocated against the future homeowners benefiting from the expanded waste water system.

Early prequalification of contractors

A prequalification process was completed and four firms were prequalified to bid as the general contractor for the entire project. The contractor prequalification process was an important step in the procurement process to ensure a successful delivery of the project on time, with competent and knowledgeable contractors with appropriate resources. The pre-purchase and assembly of the TBM machines, along with the pre-ordering of the segmental liner system, will ensure an early startup of tunneling activity, thus increasing the tunneling construction time to meet the project delivery date. York region, along with its consulting team and Lovat Inc., developed a detailed TBM specification that will ensure "state-of-the-art" tunneling machines are assembled and delivered to the site on time, as required by the contractor's schedule. Other important design steps included a constructability review early in the design process to incorporate the ideas and suggestions from the construction industry into the design details.

Project marketing

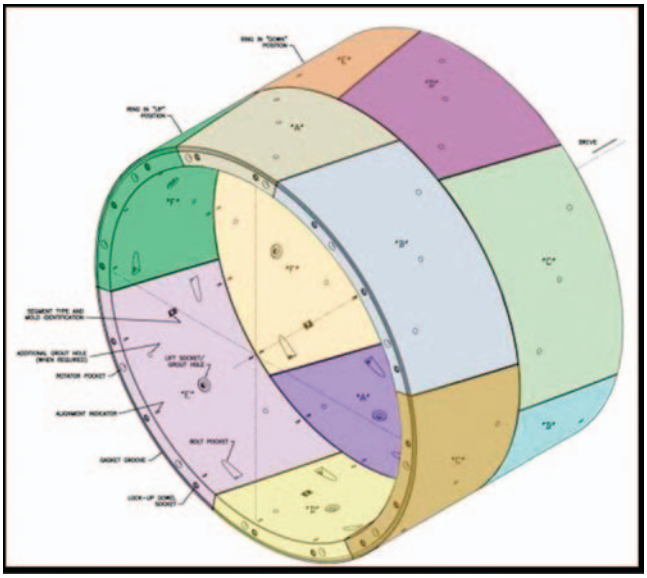
Conventional tendering allows the marketplace to assess the opportunities for tenders based on a number of factors relating to current workload, proximity of work to home base, owner/consultant reputation and early knowledge and awareness of project details. Owners can influence some of these factors by making an effort to inform the construction industry of project details and seeking feedback on design, construction and tendering issues. Workshops, trade journals, conferences and bidders' information packages are all useful techniques to keep the industry informed and prepared for the tender packages when released.

Assessing bidders' risk

One key factor that limits bidders' interest in project tendering may relate to the exclusive transfer of risk to the successful contractor through general conditions clauses, performance bonds, liquidated damages and the absence of dispute resolution methodologies. In certain circumstances, owners may consider some degree of risk sharing clauses to increase bidders' interest in the competitive bidding process.

FIG. 4

Segment shape — trapezoidal.



Preapproval by owner

Schedule certainty can be increased through the early procurement of project approvals and permits. Given that the Southeast Collector Trunk Sewer is time-driven, York region acquired many of the key project approvals, permits and permissions in advance of project tendering. Where appropriate, the conditions of approval will be assigned to the general contractor as part of the contract specifications. This early procurement of permits is a further step in clearing the way for an early construction start and successful completion of the project.

Some of the key project approvals secured in advance of tendering included environmental approvals, local approvals of site plans for compounds and above-ground buildings and structures related to meters and odor control facilities. Further, it is planned that York region will acquire bylaw exemptions for extended construction hours to permit two shifts of tunneling activity.

Advanced site preparation contracts

A number of early works prepared the work sites for the general contractor in advance of the contractor mobilizing tunneling contacts.

Haul road construction

The upgrading of haul roads for spoil removal in advance of the TBM launch and the start of tunnel mining is underway. This proactive improvement of haul roads will reduce impacts from spoil removal on local community residents and will provide a positive legacy for the local communities impacted by the construction activity. Such road improvement will also ensure the uninterrupted access of heavy loads relating to construction equipment and segmental liner delivery.

Securing of spoils disposal site

Several options were considered to secure a satisfactory spoil site or sites for the approximate 20,000 m^3 (706,000 cu ft) of spoils material. Spoils sites selected in advance of the tunneling activity ensure that all local and environmental approvals are in place for site filling, allowing for continuous and uninterrupted haulage of spoils from the construction shaft locations. Alternative sites will be considered based on the net benefit that can be realized from clean fill to enhance communities or improve areas for alternative land use opportunities.

Property acquisition

York region formalized the acquisition of all property needs, including purchases, property access rights as well as temporary and permanent easements in advance of contract awards. Any conditions resulting from property access agreements were transferred, where appropriate, into tender documents for compliance by the contractor. The early resolution of property issues for the use of lands for construction compounds, shafts, material and spoils storage will ensure the uninterrupted progress of construction activity, particularly where private lands are involved.

Local utility relocation

The size of construction launch shafts, particularly within developed areas along the sewer alignment, will necessitate the relocation of local utilities to accommodate 10- to 12-m- (33- to 39-ft-) diameter construction shafts. The relocation of local utilities will be done in advance of the general contractor's site mobilization. This early work clears the way for an early and continuous mining operation.

First Nation clearance of compound areas

As many as 13 First Nations communities have inhabited the planned work site areas over a 300-year period leading up to the early 1800s. Past cultural and burial sites are unrecorded and can only be determined through on-site stripping of top soil and involvement of First Nations communities and archaeologists. This type of advanced contract work was carried out to clear the compound and shaft locations of any such cultural artifacts and confirm no evidence of burial sites, thus ensuring uninterrupted construction.

Conclusions

The need for additional sanitary servicing capacity by a firm date of 2014 to allow the continued development of residential, commercial and industrial growth in York Region has necessitated an owner-initiated procurement of materials and equipment, including a number of site preparation contracts, all aimed at ensuring final delivery of increased sewer capacity on schedule. York region's risk of undertaking expenditures of up to 30 per cent of the project capital cost in advance of the project approvals and general contract awards is offset by the increased certainty of delivering the project schedule on time. ■

FEATURE ARTICLE

Robbins tunnel boring machines embark on projects around the world

From some of the largest tunnel projects in the some of the most vibrant cities, to smaller projects in remote corners of the globe, the Robbins Co. announced two tunneling projects in which its tunnel boring machines will be used.

Robbins earth pressure balance (EPB) machines undercut Downtown Zhengzhou. Zhengzhou, a city of 7 million people, is set to become a crossroads for rail commerce in China. The country's future main routes, traveling between Beijing and Guangzhou (North-South), and between Xuzhou and Lanzhou (East-West), will intersect in the city. The plan includes up to four rail lines in Zhengzhou itself, which will eventually link up to the national lines. Excavation of Zhengzhou Metro's new Line 1 tunnels began on Sept. 28, 2010, when the first of two 6.3-m (20.7-ft) diameter Robbins earth pressure balance (EPB) machines was launched from a 16-m- (52-ft-) deep shaft.

The second machine was scheduled for a launch in late October. Both tunnel boring machines (TBM) for the 11th Bureau of the China Railway Construction Corp. (CRCC) will excavate under downtown Zhengzhou with cover as low as 8 m (26 ft). The parallel 3.6-km- (2.2-mile-) long tunnels will pass through four intermediate stations between Kaixuan and Tongbo areas of the city. Ground is expected to consist of clay, fine sand, loess and some pebbles, with little ground water.

"The most critical issue for this project is passing under Xi Liu Lake, a large body of water with a depth of 1 to 2 m (3.2 to 6.6 ft). The distance between the bottom of this lake and the top of the tunnel is just 7.0 m (23 ft)," said Steven Zhu, Robbins project manager.

The tunnel will also pass beneath building foundations and a highway interchange bridge. In order to reduce settlement, foam and bentonite will be injected for soil conditioning. The advance rate and the material removed will be continuously and closely monitored to prevent subsidence.

As the machines bore, they will line the tunnel with 300-mm- (12-in.-) thick concrete segments in a 5+1 arrangement. Curves with radii as small as 200 m (656 ft) will be negotiated using active articulation to prevent segment deformation.

Line 1 of Zhengzhou Metro will consist of 26 km (16 miles) of tunnel and 22 stations when complete in 2013. The Zhengzhou Metro Co. has invested Yuan 10.2 billion in the six rail lines, which will total 188 km (117 miles) by their completion between 2015 and 2030.

Veteran Robbins TBM to carve out Faroe Islands Tunnel. The Faroes, a collection of 18 windswept islands in the North Atlantic, are home to nearly 48,000 people. Situated between Iceland and Norway, the mountainous islands receive an average of 250 days of rainfall annually, creating significant runoff. These features make the islands ideal for small hydropower plants utilizing collector tunnels to transport rainwater. The first and only TBM to ever operate in the Faroes, a 3.35-m- (11-ft-) diameter Robbins main beam machine, is extending one such hydropower project with an 8.4 km (5.2 mile) collector tunnel on the island of Eysturoy. A launch ceremony was held in mid-September 2010.

Two Robbins TBMs will be used at China's Zhengzhou Metro. Tunneling in September.

The Robbins TBM, for Danish and Faroese contractors MT Hojgaard and J&K Petersen, was originally purchased in 1984 and has since excavated about 25 km (16 miles) of tunnel for the Eidi Hydropower Plant. The latest project, known as Eidi II, is part of a new green energy initiative by the utility agency for the Faroes: Streymoy, Eysturoy and Vágoy (SEV). The tunnel will collect water from 25 streams, increasing the annual capacity of the plant from about 43 GWh to about 60 GWh.

Prior to startup, the SEV-owned machine underwent some refurbishment to the gearboxes, main bearing, lube system and hydraulic hoses. Robbins is also providing key spare components, including the cutterhead, grippers, hydraulic and lube systems. Robbins field service personnel have also been provided for the project duration.

By October 2010, the machine had excavated several hundred meters of tunnel in basalt rock with no problems. ■

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Hudson River Crossing	NJ Transit ARC Program	Newark	NJ	Subway	8,000 x 2	24.5	2010	Cancelled
Palisades Tunnel	NJ Transit ARC Program	Newark	NJ	Subway	5,400 x 2	24.5	2009	Cancelled
Manhattan Tunnel	NJ Transit ARC Program	New York	NY	Subway	6,000 x 2	24.5	2009	Cancelled
THE 34th St. Cavern & Station	NJ Transit ARC Program	New York	NY	Subway	2,200	100 x 100	2011	Cancelled
Second Ave. 86th Street Station	NYC-MTA	New York	NY	Subway	615	60	2010	Bid date 12/21/2010
Water Tunnel #3	NYC-DEP	New York	NY	Water	24,000	20	2012	Under design
Cross Harbor Freight Tunnel	NYC Regional Development Authority	New York	NY	Highway	25,000	30	2013	Under design
Cross Sound Link Highway Tunnels	Sound Link	Long Island	NY	Highway	190,00	55	2014	Under design
Cross Sound Link Service Tunnel	Sound Link	Long Island	NY	Highway	95,000	38	2014	Under design
Clinton CSO Tunnel	City of Syracuse	Syracuse	NY	CSO	2,000	17	2011	Under design
Silver Line Extension	Boston Transit Authority	Boston	MA	Subway	8,400	22	2013	Under design
East-West Subway Extension	Baltimore MTA	Baltimore	MD	Subway	32,000	18	2012	Under design
WASA CSO Program Blue Plains Tunnel Anacosita River Tunnel Northeast Branch Tunnel Northeast Boundry Tunnel	DC Water and Sewer Authority	Washington	DC	CSO CSO CSO CSO	23,400 12,500 11,300 17,500	23 23 15 23	2011 2013 2018 2021	Bid date 1Q 2011 Under design Under design Under design
North/South Tunnel	Georgia DOT	Atlanta	GA	Highway	77,000	41	2015	Under design
Snapfinger Interplant CSO Tunnel	Dekalb County	Decatur	GA	CSO	26,400	28	2010	Under design
Lockbourne Interceptor Sys. Tunnel	City of Columbus	Columbus	OH	Sewer	10,000	12	2012	Under design
OSIS Aug. & Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	25,300	18	2010	Awarded Kenny/ Obayashi JV
Olentangy Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	58,000	14	2012	Under design
Alum Creek Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	74,000	10 - 18	2014	Under design
Black Lick Tunnel	City of Columbus	Columbus	OH	Sewer	32,000	8	2013	Under design
Euclid Creek Tunnel	NEORSD	Cleveland	OH	CSO	18,000	24	2010	McNally/ Kiewit JV low bidder

The editors of Tunneling & Underground Construction encourage UCA of SME members to submit projects to the Tunnel Demand Forecast online at www.smenet.org. The items will be posted on the online TDF once they are verified.

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Dugway Storage Tunnel	NEORSD	Cleveland	OH	CSO	16,000	24	2014	Under design
Lower Mill Creek CSO Tunnel	M.S.D. of Greater Cincinnati	Cincinnati	OH	CSO	9,600	30	2015	Under design
Water Treatment Plant #4	City of Austin	Austin	TX	Water intake	45,000	7 to 9	2010	Bid date 11/12/2010
Waller Creek Tunnel	City of Austin	Austin	TX	CSO	5,300	22	2011	SJ Louis low bidder
Deep Rock Connector Tunnel	City of Indianapolis	Indianapolis	IN	CSO	34,000	18.5	2011	Under design
Pogues Run Tunnel	City of Indianapolis DPW	Indianapolis	IN	CSO	11,000	18	2013	Under design
Drumanard Tunnel	Kentucky DOT	Louisville	KY	Highway	2,200 x 2	35	2012	Under funding review
Drumanard Tunnel - Pilot Tunnel	Kentucky DOT	Louisville	KY	Highway	2,200	12 x 12	2011	Under funding review
Alaskan Way Highway Tunnel	Washington DOT	Seattle	WA	Highway	10,500	54	2011	Final bids submitted
Central Subway Tunnel	S.F. Municipal Trans. Authority	San Francisco	CA	Subway	16,600	20	2011	Under design
San Francisco DTX	Transbay Joint Powers Authority	San Francisco	CA	Transit	6,000	35 to 50	2012	Under design
LA Metro Wilshire Extension	Los Angeles MTA	Los Angeles	CA	Subway	24,000	18	2012	Under design
SVRT BART	Santa Clara Valley Trans. Authority	San Jose	CA	Subway	22,700	20	2011	Under design/ delayed
Kaneoheww Tunnel	Honolulu Department of Env. Services	Honolulu	HI	Sewer	15,000	13	2012	Under design
Spadina Line Extension	Toronto Transit Commission	Toronto	ON	Subway	22,000	18	2010	McNally/Kiewit/ AECON low bidder
Eglinton West Tunnel	Toronto Transit Commission	Toronto	ON	Subway	10 km	20	2011	Bid date 12/01/2010
Yonge Street Extension	Toronto Transit Commission	Toronto	ON	Subway	15,000	18	2013	Under design
Port Mann	Greater Vancouver Regional District	Vancouver	BC	Water	3,300	10.5	2010	Final bids submitted
Evergreen Line Project	Trans Link	Vancouver	BC	Subway	10,000	18	2012	Under design
UBC Line Project	Trans Link	Vancouver	BC	Subway	12,000	18	2014	Under design
Kicking Horse Canyon	BC Department of Transportation	Golden	BC	Highway	4,800 x 2	45 x 32	2012	Under design
LRT Expansion North	City of Edmonton	Edmonton	BC	Subway	1,200 x 2	20	2011	Under design

Allentown Powercreter 20 is in production

Allentown Shotcrete Technology Inc. announced that its 2011 version of the Powercreter 20 is now in production.

"This version of the Powercreter 20 has a larger hopper and mixer," said Patrick Bridger, president of Allentown. "These features make projects more efficient for our customers by accommodating larger amounts of material."

Ideal for mid-range pumping requirements, the 2011 model uses the sturdy Thom-Katt frame and the familiar Thom-Katt control box.

"Because the 2011 version incorporates Thom-Katt parts, we determined it would be most efficient to move Powercreter 20 manufacturing to Putzmeister America," added Bridger.

Standard features of the Powercreter 20 include:

- Hopper capacity of 270 L (9.5 cu ft).
- Rated up to 13m^3/hr (17 cu yd/hour).
- Maximum concrete pressure up to 2,000 psi (138 bar).
- Deutz TD 2011L04i diesel engine.
- Smooth delivery and least pulsation of any shotcrete machine available.
- Easily handles harsh mixes, including low cement, low moisture and refractory pumping castables.
- Can be fed by a ready mix truck, on-site mixer or optional integrated batch or a continuous mixer.

The 2011 version of the Powercreter 20 will be available for order in fall 2010.

www.allentownshotcrete.com

Allentown Powercreter 20.

Gyromat 3000 kept Gotthard Tunnel lined up throughout

On Oct. 15, 2010, the last few inches of rock in the Gotthard Base Tunnel were broached. Thus, the breakthrough for this rail tunnel, the world's longest at 57 km (35 miles), was celebrated. Engineers from DMT, the technology services provider based in Essen, Germany, experienced first-hand the completion of the passage for the eastern tube. Their assignment had been to support exact surveying of the tubes far beneath the Swiss Alps. Ever since 2004, DMT has used the Gyromat 3000 high-precision surveying gyroscope at regular intervals to verify measurements in various sections of the tunnel.

"With rock overburdens up to 2,500-m (8,200-ft) thick, the Gotthard Base Tunnel is the deepest rail tunnel anywhere in the world," said the DMT project manager, Volker Schultheiss. "That is why maintaining the correct location, course and altitude while drifting the tunnel was imperative, making high-precision surveying an absolute necessity.

"The tolerances specified for the breakthrough point were 25 cm (10 in.) in the lateral direction and 12.5 m (41 ft) in altitude. Ultimately, the actual deviations in the tunnel were only 8 cm (3 in.) in the horizontal and 1 cm (0.4 in.) in the vertical direction," explained Schultheiss.

The surveying gyroscope was originally developed for high-accuracy surveying of underground galleries in mining operations. This explosion-proof device achieves deviation of no more than 3 cm/km. At its heart is a high-speed gyroscope mounted so as to isolate it from outside forces. Due to the interaction of gyroscope spin, gravity and the earth's rotation, the gyroscope maintains orientation to the north.

The Gyromat 3000 is a fully automatic gyroscopic surveying system, able to specify true north at precision achieved nowhere else (1.5 cm/km). The Gyromat has been employed in a number of tunneling projects beyond pure mining operations including the Eurotunnel underneath the English Channel between France and the United Kingdom. ■

www.gyromat.de

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2011

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January 25, 2011 • Graduate Center, City University of New York
New York, New York

Rapid Excavation and Tunneling Conference
June 19-22, 2011 • San Francisco, California

2012

North American Tunneling Conference
June 24-27, 2012 • JW Marriott • Indianapolis, Indiana

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PERSONAL NEWS

Jacobs Associates has announced the following promotions at the associate level.

RENÉE FIPPIN, P.E., G.E., has 12 years of experience and has specialized in geotechnical and structural excavation support design. She has managed and designed several excavation shoring and temporary structural supports. Currently, she manages San Francisco's Sunnydale auxiliary sewer project.

MICHAEL T. KOWALSKI, P.E., has been with Jacobs Associates for 10 years and has 17 years of experience in the underground industry. In his current role as contracts and corporate insurance manager, he is responsible for reviewing all contracts and billing requirements in addition to managing project controls and insurance certificates.

ANDREW McGLENN, P.E., S.E., P.Eng., has 14 years of experience and is currently leading the design of the permanent tunnel lining for the Airport Link project in Brisbane, Australia. McGlenn has worked on the Brightwater conveyance system project in Seattle, WA, the Northern sewerage project in Melbourne, Australia, the Port Mann water supply tunnel in Vancouver and the University Link in Seattle, WA.

JOHN MURRAY, P.E., has 12 years of experience in underground design and construction management. He recently worked as the design engineer on site at the San Vicente pipeline project in San Diego, CA. He is currently working on the design of the New Jersey Transit Trans-Hudson Express, the Manhattan tunnels project and continues to support the San Vicente Project.

MARK TRIM, P.E., has 12 years of underground design experience. During his five years with Jacobs Associates, he spent nearly four years in Australia, where he split time between projects in Melbourne and Brisbane and helped establish the firm's Melbourne office. Trim is currently working on the Northern sewerage project in Melbourne, Australia and the Kaneohe-Kailua wastewater conveyance project in Honolulu, HI. ■


FIPPIN


KOWALSKI


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OBITUARIES

DRUPAD (DRU) DESAI

Drupad (Dru) Desai of Highland, MD died Nov. 2, 2010 in Columbia, MD. During his 45-year career in the tunneling industry, he was a leading civil and geotechnical engineer involved in many working groups, organizations and committees. He was a member of the Underground Construction Association, participating in numerous presentations and panel discussions.

Desai began his career in the 1970s working for Daniel, Mann, Johnson and Mendenhall on the original Baltimore subway system design. Other projects that benefited from his expertise included the H5 highway tunnel in Hawaii, section C of the Baltimore subway and Tren Urbano in Puerto Rico.

Desai established himself as a mentor and trainer for generations of young tunnel engineers. His associates have gone on to work on tunnel projects around the world.

Desai's most recent assignment with AECOM was as chief tunnel engineer for the conceptual and preliminary engineering of the Second Avenue subway project for Metropolitan Transportation Authority Capital Construction in New York, NY. There, he supervised the design of the 13.7-km (8.5-mile) two-track subway alignment. The system will ultimately comprise 16 new stations, six cavern stations and 10 cut-and-cover stations. The full length of the route will be constructed between 125th St. and Hanover Square in the financial district. During the final design of phase one between 96th St. and 63rd St., Desai participated in several peer reviews of the cavern designs for the 86th St. and 72nd St. stations.


DESAI

Desai continued to work as a consultant to AECOM's Tunneling and Underground Technology Group, as his health permitted, through 2008 and 2009. He will be remembered by many for his true professionalism and gentlemanly style.

Desai is survived by his wife, Tarini Drupad Desai; sons, Apurva Desai, Vienna, VA, and Parag Desai, Washington, D.C.; grandson, Rithik Desai and three brothers, Harshad, Dushyant and Janak Desai. ■

March 2011

- **2-3, World Underground Mining Conference,** Beijing, China. Contact: ARA Conference, phone 0086 21 6652 3700, e-mail 17th-dialogue@araworldwide.com, website undergroundminingtech.com.

- **16-18, INTERtunnel 2011,** Moscow, Expocenter, Moscow, Russia. Contact: Natalia Charman, Mack Brooks Exhibitions, Romeland House, Romeland Hill, St Albans, AL3 4ET, Great Britain, phone 440-1727-814-400, fax 440-1727-814-401. e-mail: intertunnelrussia@mackbrooks.com, website www.intertunnelrussia.com.

27-31, NASTT's 20th No-Dig Show, Gaylord National Resort & Convention Center, Washington, D.C. Contact: Michelle Hill, Benjamin Media, Inc. 1770 Main St., P.O. Box 190, Peninsula,OH 44264-0190 USA, phone 330-467-7588, fax 330-468-2289, e-mail mmagyar@benjaminmedia.com, website www.benjaminmedia.com.

More meetings information can be accessed at the SME website — http://www.smenet.org.

May 2011

- **2-5, 29th International No Dig Conference and Exhibition,** Berlin Exhibition Grounds, Berlin, Germany. Contact: Dagmar Eichorn, German Society for Trenchless Technology, Messedamm 22, 14055 Berlin, Germany, phone 490-30-3038-2398, e-mail eichorn@gstt.de, website www. nodigberlin2011.com.

21-26, ITA-AITES World Tunnel Congress, Helsinki, Finland. Contact: Congrex/Blue & White Conferences Oy, P.O.Box 81, FI-00371 Helsinki, Finland, phone 358-9-5607500, fax 358-9-56075020, e-mail wtc11@congrex.fi, website www.wtc11.org.

June 2011

- **19-22, RETC,** San Francisco, CA. Contact: Meetings Department, SME, 8307 Shaffer Parkway, Littleton, CO 80127 USA, phone 800-763-3132 or 303-979-3461, e-mail sme@smenet.org, website www.smenet.org.

May 2012

- **18-23, ITA World Tunnel Congress,** Bangkok Thailand. Contact: Thailand Underground & Tunnelling Group (TUTG), e-mail: info@wtc2012.com, website www.wtc2012.com. ■

UCA of SME

George A. Fox Conference
Jan. 25, 2011
Graduate Center City University of New York, New York, NY USA

FOR ADDITIONAL INFORMATION CONTACT: Meetings Dept., SME 800-763-3132, 303-948-4200 fax 303-979-4361, e-mail sme@smenet.org

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SME Annual Meeting & Exhibit	Feb. 19 - 22, 2012	Seattle, WA, USA

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Sales Close: Tuesday, Nov. 1 — Material Close: Tuesday, Nov. 8

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