MINING WITH WIRELESS

A granite quarry in California combines RTK GPS with wireless radio communications to improve operations.

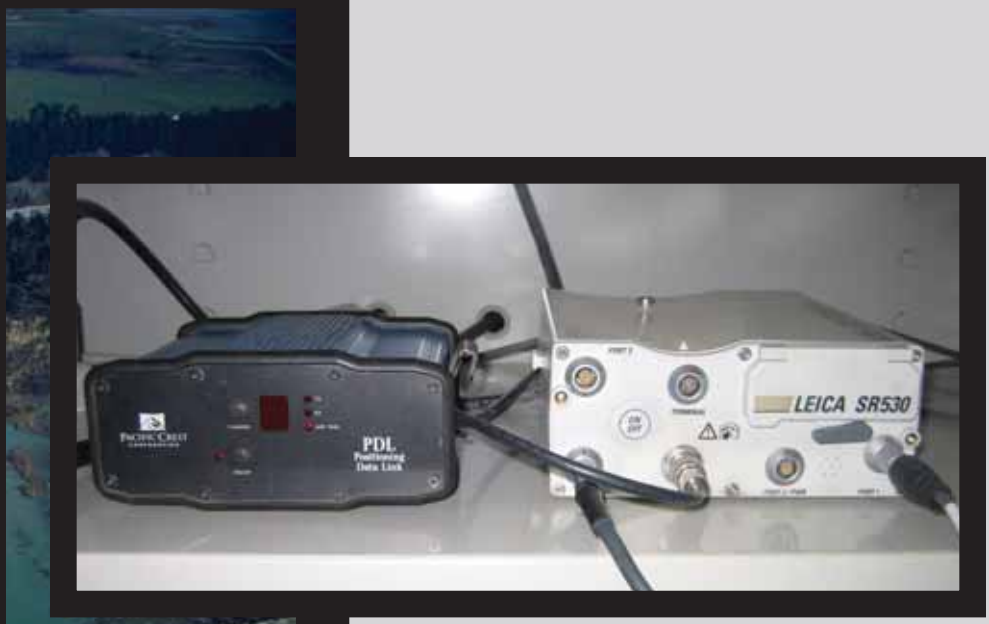
Granite mined from the expansive quarry is used to make a host of construction materials

By Joshua Steelman

Nestled among the rolling hills of California's beautiful Central Coast lies a major rock quarry that produces hundreds of tons of granite a year for customers in a wide variety of industries worldwide. Aromas, California is home to the 500-acre A.R. Wilson Quarry. Formed in 1900 by quarry owner A.R. Wilson, the Granite Rock Company's mining operations have gone on at the quarry for the last 107 years. Graniterock, the modern name of the original company, is a privately held and vertically integrated materials supply company best known for the quality of its crushed granite. From this rigorously refined granite, Graniterock produces asphalt, concrete, and other construction materials.

Judging from the sheer size of the quarry, you would assume operations take place on a large scale and that efficiently mining this area would require high-tech equipment to help pinpoint areas in which to drill. Both assumptions are correct. Graniterock uses GPS extensively to obtain precise positioning coordinates for pre-operation planning and throughout everyday mining operations. Wireless communication technology relays the GPS data from a fixed base station located inside Graniterock's offices at the quarry to a rover in the field. With GPS technology, only a single surveyor is required to operate a rover as compared to the traditional two- or three-person crew needed when using a total station. Costs are significantly reduced, and it works well because a surveyor is frequently needed anyway at the quarry to supply data for a multitude of tasks.

For each step in the mining process, intricate guidelines for equipment operators are developed using current data supplied by GPS. This includes anything from placing stakes in the ground to computer printouts of topographic maps generated from GPS data. As operations move forward throughout the day, progress reports are updated



▲ At the base station, a Leica GPS System 500 type SR530 teams with a Pacific Crest PDL HPB radio modem to communicate correction data to the rover

from the positioning data. These reports assist those managing operations and operating the equipment throughout the entire mining process.

RTK versus DGPS

While many mining GPS systems use differential GPS (DGPS), the one at Graniterock uses RTK (real-time kinematic) GPS. A DGPS system relies on several fixed reference stations strategically placed around the mining site to broadcast the difference between the positions indicated by the satellites and known fixed positions throughout the entire GPS network. These stations broadcast the difference between the ranges measured by the satellites and the stations' internally computed ranges to receiver stations that may then correct the data. This system provides each GPS unit in the network with an accurate measurement of its position up to one meter.

The main technological difference between the DGPS and RTK GPS is that RTK uses a GPS satellite's carrier signal rather than the encoded messages contained within. The hardware used in RTK is also quite different, as a single base station receiver and an unlimited number of mobile rover units comprise the system. The base station is located at a known surveyed location, often a benchmark, and the mobile units can then produce a highly accurate map by taking fixes relative to that point.

The workings of the system are similar to a DGPS system but with several minor differences. The base station re-broadcasts to the rover units in the phase of the satellite carrier that it measured. The rovers compare their own carrier phase measurements with those received from the base station. Each rover can then calculate its position to millimeters. Although RTK gives a user the advantage of having sub-centimeter accuracy, one caveat is that a rover's position is accurate only to the same accuracy as the position of the base station. Care should be taken to ascertain the position of the base station first before beginning survey operations.

To maintain communication between the base station and rovers, a wireless communication network is required. If for some reason, radio communication is required over longer distances between another job site and the quarry amidst uneven terrain, then a repeater can be installed at the quarry to send data to another site. This would enable Graniterock to quickly get data from their offices to a surveyor at a new site.

At Graniterock's quarry offices, a fixed base station is secured inside a cabinet to wirelessly transmit data to a GPS rover located within the quarry, which can be as far away as almost three miles. The base, a Leica GPS System 500 type SR530 with a Pacific Crest PDL HPB (High Power Base) radio modem, communicates with the rover, a Leica GPS System 500 type SR530 with a Pacific Crest GFU6 side attachment powered by Pacific Crest's PDL (Positioning Data Link) technology, at the site. This base-to-rover communication is ongoing not only before but throughout mining operations, so surveyors can find their own position at any time of day. Although the base system with the PDL HPB and Leica GPS is a fixed installation, it can be disassembled and taken to other locations, which Graniterock does when conditions make it difficult to get a signal.

At times, adverse conditions can make it difficult to transmit data across several miles due to signal interference from unfavorable atmospheric conditions (solar flares), man-made conditions, or natural structures. During times like this when the signal is weak, Graniterock uses a repeater—a PDL LPB radio modem—placed on a tripod between the rover and base station.

Plan before You Dig

Before Graniterock even begins mining operations, they first carry out an extensive process involving the creation of several plans and maps, including the mine plan, drill pattern map, and blast pattern, using the most current RTK GPS positioning data. Characteristics of the deposit partly determine the layout of the surface mine, sequence for mine development, and plan for how to blend the various aggregate materials to meet specifications. The mine plan helps management estimate the size and scope of the project. Specific

locations throughout the site are researched and chosen to blast and drill.

After the plan is developed, blast design lines are staked out at the quarry, and then a blast pattern is laid out on the ground using a regular tape measure—nothing fancy. A surveyor surveys this pattern, and the GPS data is meshed with AutoCAD to develop a blast pattern map for the driller. These carefully recorded GPS positions are staked out to give the driller precise operational parameters. The drill operators drill according to the drill pattern layout with the vertical depths determined by the operator's drill pattern map.

After the entire pattern has been drilled out, it is blasted with explosives. After the smoke and dust clear, the blasted rock is mucked out (broken rock is removed), and haulers (large-wheel loaders with 15-cubic-yard bucket capacities) dump the rock onto a conveyor system. On the conveyor, the rock goes through a rigorous process of crushing, screening, and washing to ensure customers receive the highest quality granite. This sequence of events is repeated many times each day with surveying and staking using GPS positions measured every time for precise, efficient, and cost-effective operation of the equipment.

Not only does the drilling pattern need to be surveyed using GPS, but predetermined bench elevations must be maintained throughout the operation to keep the required grade integrity of the quarry roads. Careful monitoring of this through surveying helps to maximize haul truck efficiency and keep operational costs low. The bench elevations are faced with the problems of degradation through use, inclement weather, or by accidental digging and drilling. GPS helps the engineers and machine operators stay on grade or repair a road to grade specifications.

Besides these beneficial uses of surveyed GPS data in the quarry, the data has come in handy in developing volume calculations, progress reports, and monthly topographic maps. A.R. Wilson Quarry uses a topographic map generated from GPS survey data each month to verify correct implementation of the mine plan.

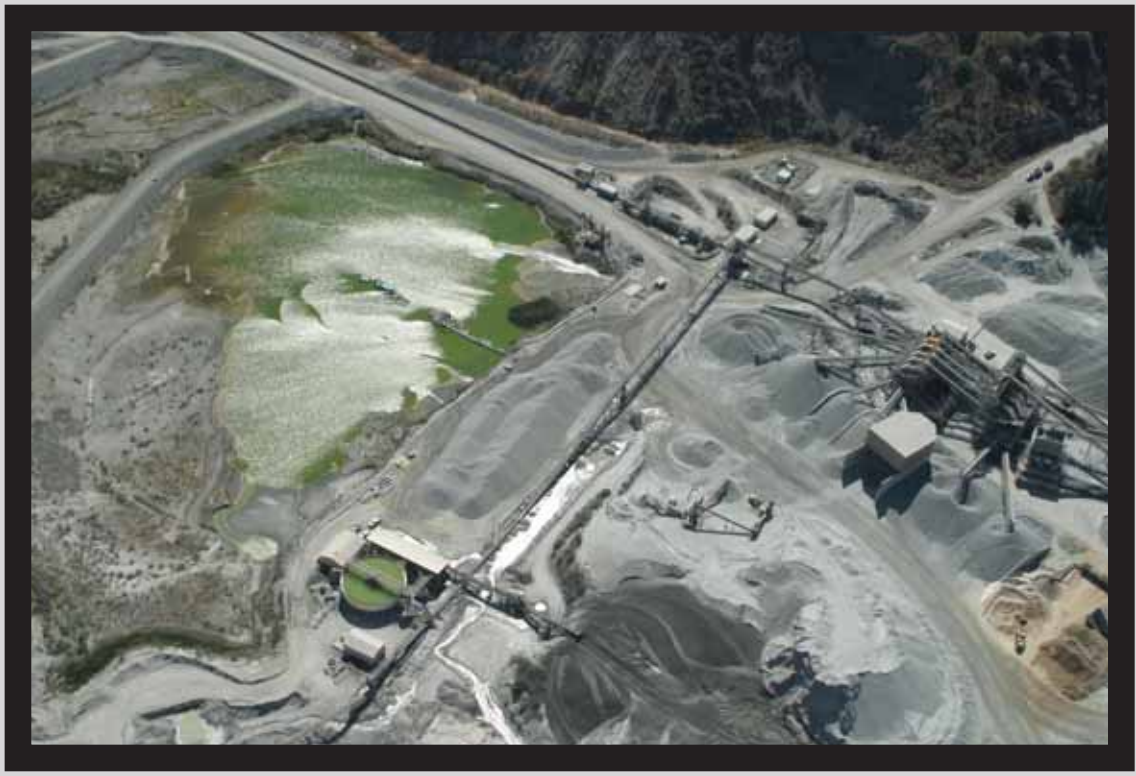
Increased Efficiency

Working without GPS at any mining or construction endeavor could be compared to losing one's eyesight, since the planners and operators rely on real-time positioning data to build or drill according to pre-planned specifications. Going off course even a little can spell catastrophe. Costs would also increase dramatically without this technology. A seasoned mining engineer with Graniterock, Benito Mendoza explains that it would take them three- to four-times longer using two or three people equipped with a total station than using a simple GPS setup handled by one surveyor. He says, "Without the GPS system, it would be nearly impossible for us to follow our mine plan design or keep accurate progress records."

Without GPS, Graniterock could not keep updated progress reports that help management monitor their efficiency levels and overall progress of the operation. Without these reports, efficiency levels could slide without anyone being the wiser, costing the company hundreds of thousands of dollars. Cost savings and operational efficiency are major benefits GPS and wireless communication technology bring to the table.

Mining operations at A.R. Wilson Quarry are expected to continue indefinitely until the source of granite rock depletes—not likely to happen within the next 25 years or more. Over the years, thousands of tons of rock have been mined like clockwork from the quarry and processed to be made into building materials. Graniterock has used GPS along with wireless communication technology since 2001.

Wireless communication and GPS technology have seen increased use in the mining industry over the last several years, becoming a competitive advantage for those who have it. Operating without these technologies in this age could prove a costly mistake.



▲ Extensive planning, which factors in data from GPS surveying, takes place before extracting stone

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