LASER TERRAIN PROFILING

Repetitive and dangerous rock face surveys using an autoscanning laser system

WORLD LEADERS IN MEASUREMENT TECHNOLOGY

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A rock face blast

The survey community is only just beginning to recognise the value of laser range finders. This has not been the case for a number of industrial survey applications, where the ability of lasers to range to dangerous or in accessible places has meant that valuable and, previously unavailable survey information can be obtained which dramatically improves the industrial process. No where has this been more true than in the area of hard rock mining.

The primary process of rock product production is blasting.

A blasting engineers objective is to shatter solid rock into manageable pieces. In order to do this a precise survey of the rock face is imperative to determine rock mass and subsequently the explosives energy needed to achieve the objective. Face surveys are difficult, repetitive and often continuous operations. Traditional survey methods are often impossible to employ, dangerous, costly and slow.

This paper describes Measurement Devices Ltd's (MDL) Quarryman ALS, the autoscanning laser based surveying system and its software as used in a number of mines throughout the world, today.

Introduction

Pulsed, eye safe, laser range finders have been used within the industry for some twenty years. The latest models offer typical accuracy's of 5cm at distances up to 500m. The main advantage of a laser range finder is that it can be used to measure to dangerous or in accessible places, such as rock or cliff faces, unstable slopes or piles of soft material, amongst others.

Laser range finders are fast, obtaining data within a fraction of a second. Therefore combining them with manually operated devices for measuring vertical and horizontal angles reduces the potential for rapid survey data collection.

MDL's Quarryman combines laser range finding, electro - optical horizontal and vertical angle measurement and motorised pan and tilt control to provide operators with the ability to carry out automated scans of an entire rock face, for example. Scanning at user specified intervals is achieved by the operator. Who can select either a constant angle or a constant, subtended distance.

A

Quarryman ALS system at work in an open cast quarry

Whilst automatic scans do not relieve the operator of referencing the instrument to co-ordinated points or shooting specific points of interest, the advantages can be summarised as follows:-

1. Reduces operator fatigue on large surveys.
2. Data points are regularly spaced.
3. Operators freed to undertake other tasks whilst scanning is in progress.
4. Repetitive scans of the same area may be carried out with a very high degree of repeatability.

5. ‘Mosaics’ of scanned areas can be merged to form larger surveys.
6. Where instruments are used at fixed installations, remote control by cable or telemetry is possible enabling the instrument to carry out surveys robotically without any operator being present.

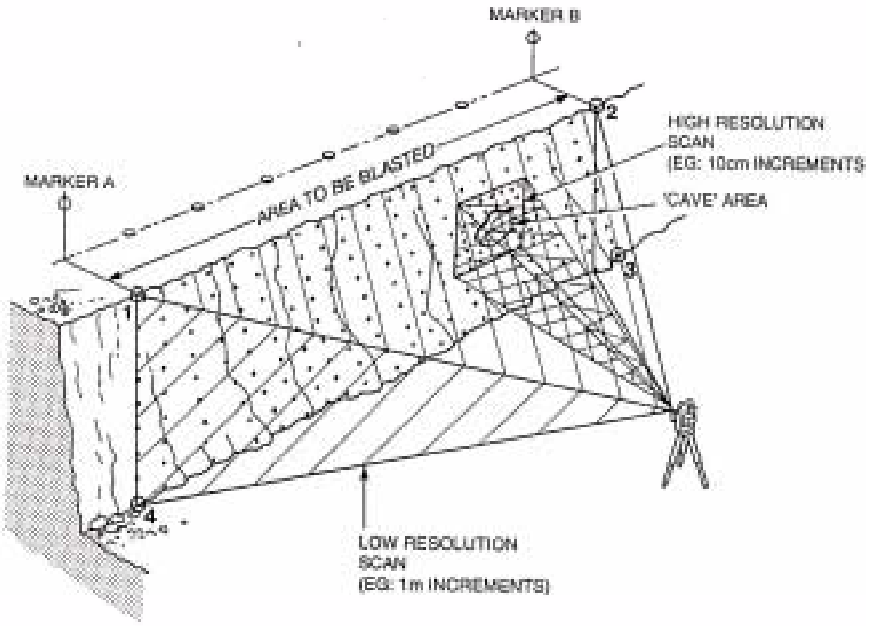
Application of autoscanning lasers to rock face surveying in hard rock mines.

The world-wide method of mining hard rock is by bench drilling and blasting - terraces of rock are repetitively drilled and explosives used to cut slices of rock into manageable pieces. The size of the rock pieces depends on the use to which the rock product is to be put e.g. large stones for coastal armour or small stones destined for grinding to dust and used in talcum powder or cement.

The blasting engineer must not only blast the rock into manageable pieces but he must do so at minimal cost with maximum safety and with the least possible environmental impact. If too much explosive energy is used, rocks may get projected out of the mine causing injury or even death. Too little energy and rocks are not broken efficiently. The key to precision blasting is to know the amount of rock or burden in front of each drill hole to be charged with explosives. Armed with this information the engineer can optimise the ratio of explosive energy to rock.

The first stage therefore is to produce an accurate survey of the rock face. This is not easy. A typical rock face may be 25m in height and extends to 100m in length. The crest or top of the face is often heavily cracked and fissured, uneven and unsafe. Over the last several years, MDL, has worked closely with its mining customers to develop a safe and practical technique with which to survey these difficult faces, to process the information and to present it in an easily understood way.

This technique is known in the industry as the ‘quarryman’ technique and is described as follows:



Two reference markers are set on top of the rock face close to the edge and visible from the floor below (the later setting out of designed hole pattern is made with reference to these markers). The Quarryman ALS is set up, approximately, central to the face at a distance twice the height of the face from the toe of the face and the base of the rock terrace, if possible. The Quarryman™ firmware prompts the operator to enter survey file reference data such as day, date and face number. Further prompts request the operator to take manual shots to the markers and specific points or features of interest on the face. ‘Scan’ mode prompts the operator to shoot points at the upper right and lower left of the rock face, there by creating a ‘scan window’. Finally, firmware prompts the operator to in put the scan interval.

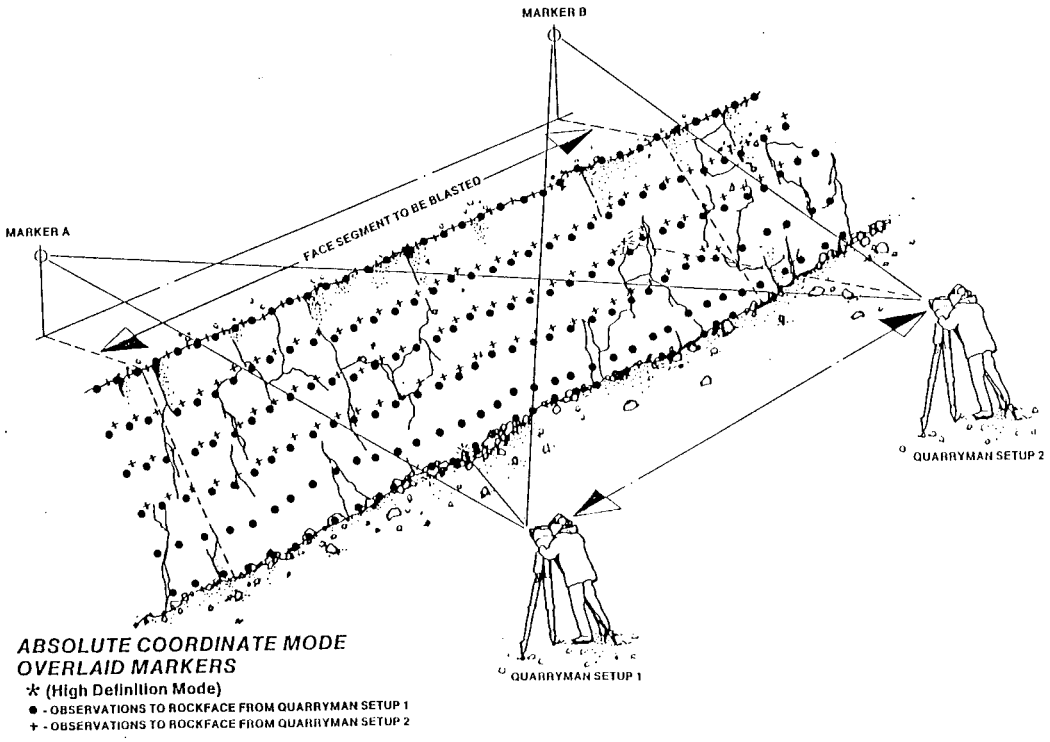
Two choices are presently available:

1. To scan by constant increment of arc (minimum increment 0.1°).
2. To scan by constant subtended distance (minimum entry being 1 cm).

Upon completion of instruction entries, the Quarryman proceeds to automatically scan the face. All reference and observation data is stored on internal RAM with sufficient capacity for 7,000 data points. A 25 x 100m face scanned at 1m intervals takes approximately, 40 minutes to observe. A Quarryman ALS can observe points at the rate of 3,600 per hour.

At this point the operator usually proceeds to carry out other survey or blasting duties, leaving the Quarryman to operate, unattended.

Where rock faces are complex and heavily fractured two or more scans can be taken to the face from different locations to avoid ‘observation shadow’. Simple survey routines are used to inter-relate the scans and the data is merged at the processing stage.

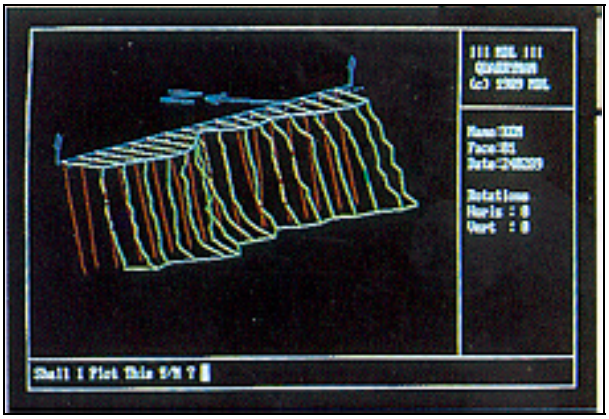


Observing a face from More than one Position

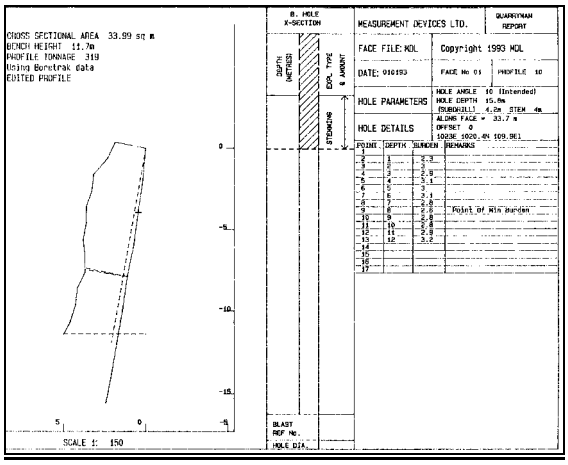
After completing the survey observations the Quarryman is returned to the site office and the data is down loaded to a PC for processing, using MDL’s Face 3D software suite.

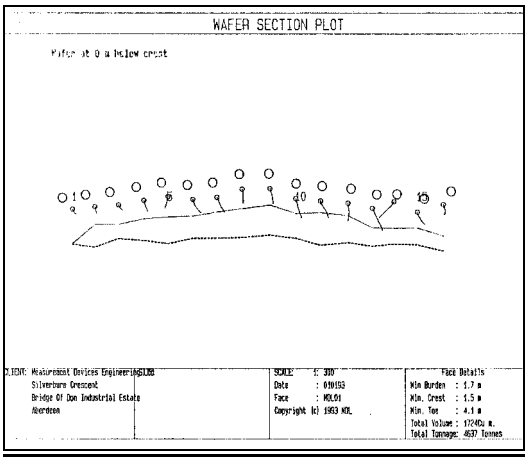
Quarryman Face 3D Software

The software allows for the usual data formatting, archiving and peripheral configurations prior to data down load. A full graphical editing facility allows obvious errors to be corrected and for various display and blasting parameters to be input. After sorting the data into a logical array face measurements can be observed in a random order and a wire graphics model of the rock face created. Plans, sections and 3D views can be presented on the next page.-



A 3D graphics model of the rock face

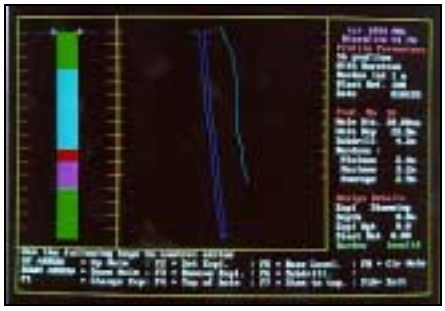




A section plot ***A plan wafer plot***

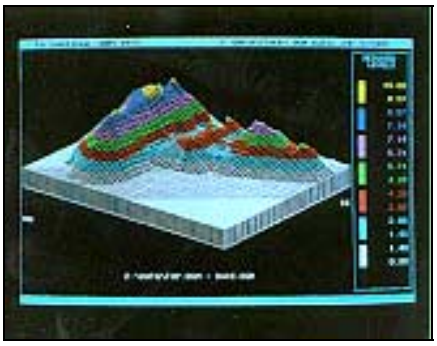
By inputting planned or trial borehole positions the blast engineer can optimise the amount of rock in front of each borehole by experimenting with various borehole layouts, drill angles and explosive products. Each time a new set of borehole parameters are entered, the programme re-interpolates the survey information from the model and outputs the new information. Using this method has enabled MDL's customers to achieve overall drilling and blasting cost savings of 30 to 40%. This represents an enormous industry wide saving of 10's of millions of dollars per annum.

An advanced software programme enables different explosives' densities and properties to be stored in the programme database to optimise the actual blast ratio i.e. the ratio of explosives to rock mass.



Plot of a single hole explosives load

Other uses of the Quarryman equipment



Stockpile volumetric surveys are an obvious second use for the Quarryman™ ALS equipment. A typical 250,000ton stockpile can easily be surveyed (several thousand points) by one man in half a day. This makes the Quarryman™ a seriously more efficient and accurate way to carryout volume surveys than existing total station methods and it is profoundly cheaper than ariel surveys.

Conventional surveys can also be carried out using the Quarryman™.

Conclusions:

The industrial quality and user friendliness of the Quarryman ALS is such that since its launch in December 1995 over 200 systems are already in use world-wide, in addition to, several hundred earlier, manually, operated Quarryman™ models. Besides the original industrial application mentioned here, systems are being used in applications such as stability monitoring in the United States and volcanic movement surveys in Japan. The combination of laser range finding and autoscanning enables survey techniques to be utilised for a wide range of industrial as well as surveying applications . The sheer quantity of data obtained and ease of operation make the Quarryman an ideal potential data capture tool for the geographical information systems (GIS) industry. The future for autoscanning laser systems is a bright one, with links to global positioning systems (GPS) and video data capture soon to be realised.

Biography of the author

Steve Ball is the Managing Director of Measurement Devices Ltd (MDL) - an Aberdeen (Scotland) based designers and survey equipment manufacturers.

Steve started his survey career with the National Coal Board and qualified as a mine surveyor in 1969. Since then Steve has been involved at many different levels of the offshore construction survey industry and may best be remembered as the founder and owner of Oilfield Hydrographic Projectds Ltd MDL was formed in 1983 and under Steve's technical direction has been heavily involved in laser based survey systems development and production. Other notable MDL products include Fanbeam laser Radar, GOLF and Lasertrak Range Bearing systems and Microtel telemetry products.