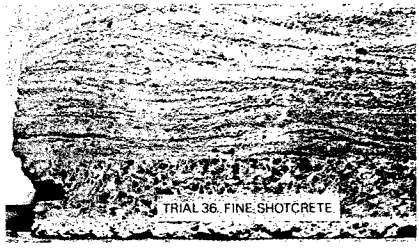
homogeneous jet
without any dust

The effect of premixing can be visualized on a test specimen of shotcrete of about 15 cm thickness, cut apart with a diamond saw. While sample one shows a stratification due to inhomogeneity of the air-water-solid-jet, sample two, sprayed with a premix nozzle, proves to be absolutely homogeneous. The test results produced herein are being published by courtesy of Dr. Ward of the British Building Research Station, London.



Sample 1: sprayed
with ordinary nozzle

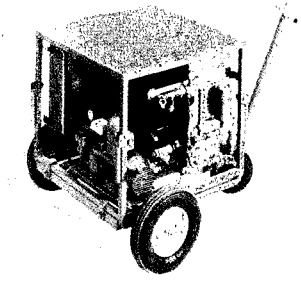
Sample 2: sprayed
with premix nozzle

For various reasons it is recommended to use liquid accelerators rather than powderous ones. The liquid additive is more readily mixed with the cement and starts to react immediately. This results in less dust and in higher tackiness of the

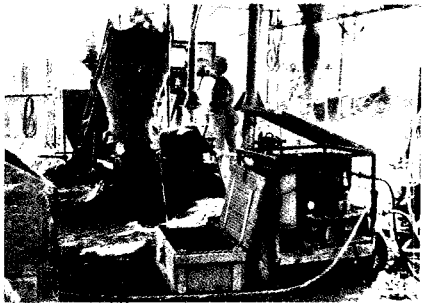
material, thus in less rebound. The positive action is multiplied when operating a premix nozzle.

Let me in this context quickly qualify liquid accelerators: Silicates give a very quick setting, but need high dosage and are therefore expensive. Aluminates are economic, reduce the water/cement ratio and eventually increase the strength instead of reducing it, as powderous aluminates do. They even allow to reduce the cement dosage at equal ultimate strength, which again reduces dust and shrinkage. But aluminates are not easy to tune into changing cement qualities - certain cements with low C3A-content cannot be accelerated at all. We therefore favour the organic liquid accelerators; these give excellent setting times at low dosage.

I wish to emphasize that liquid accelerators should be dosed with a dosage pump. The correct percentage is then controlled and can be adapted to the needs of the moment. When spraying onto the roof of a tunnel, the quantity can easily be increased; when operating on the wall, it can be reduced or given up completely. The saving of accelerator will soon match the cost of the pump. Further the dosage pump delivers the liquid under high pressure to the nozzle. This provides a fine dispersion into the material/air stream.



dosage pump
for blending
liquid additives
into the
water supply hose



installation of shotcrete gun GM 76 with dosage pump

The dosage of water by the nozzleman has been a subject of critic since there is shotcrete. I feel that its importance is overestimated. A good nozzleman will vary the water dosage within very narrow limits. Otherwise rebound will become excessive and very obvious. Or the mix will be too soft and fall down. He has the best measuring instrument in his own head: his eyes. I do not see why the instruments at a batching plant which control the water dosage should be better than the eyes of the nozzleman.

Now let us look at the output. I must say that the production capacity offered by e.g. a GM 76 is more than enough than what a nozzleman can handle. Please note that with a properly installed machine with generous air supply, high water pressure and a well designed back-up system average rates of 7 yd^3 per hour have regularly been achieved on many projects both in Europe and in the U.S.

Let us summarize what the conditions are under which a good result is guaranteed:

Use of a premix nozzle, a dust collector, liquid accelerators, adequate size of equipment and, last but not least: let a trained nozzleman do the job.

We come to the conclusion that the initially mentioned deficiencies no longer exist. The important advantages of the dry procedure which are not achieved by the wet process now have become prevalent.

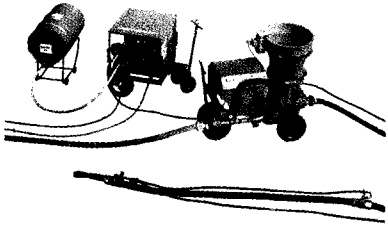
These are:

1. Use of a fresh mix, no risk of prehydration,

2. higher ultimate strength and better bonding, thanks to higher impact energy,

3. flexible procedure, independent from other operations and material supplies.

Time does not command you, but you master the time and the whole system.



shotcrete gun
with dosage pump,
barrel of liquid additive
and premix nozzle

SHOTCRETE EQUIPMENT

by G R Packham, General Manager, Wallco Chemicals Ltd, United Kingdom

The three systems of transporting and spraying concrete are:

1. Dry process.
2. Wet process.
3. Compressed flow process.

The dry process, dry mixtures with water added at the nozzle, is the oldest and the most reliable for engineering processes at this moment. The other methods are being used in the USA and elsewhere. My company, Wallco Chemical Corporation, is a distributor for the dry process equipment and so my lecture today relates to this type of equipment.

The development of spraying machines has taken place over many years in several countries. The machines that are used in Europe today are of the rotary feed type, which has the following advantages:

1. Continuous production - aggregates moisture content - not exceeding 5%.
2. Variable output from the nozzle
   Wallco Mini 2 - 4 m^3/hr
   Wallco IGM 70 - 75 5 - 8 m^3/hr
3. Simplicity in operation and maintenance, experienced fitter takes minutes to replace worn plates.

However the advantages of the equipment can only be realized if the planning engineer chooses a suitable feeding system.

Feeding such a machine by hand tools can serve only very small and limited projects and therefore will not be mentioned further. The type of construction under consideration at this conference, namely pits, shafts, tunnels, and caverns, etc., require planning based on consideration of local conditions like space, height, rate of work, etc.

In most cases, transporters with a carrying capacity of 2 to 6 m^3 are used successfully when equipped with two feeding chutes to feed one or two machines as required. Continuous spraying requires continuous feeding with the minimum of interruption. If truck feeding is not applicable, then a conveyor, combined with a storage hopper, will be used. The scraper will require adjustment to give a continuous consistent direct feeding to the spraying machine.

On very big construction projects, it is sometimes necessary to develop a system which combines the two mentioned previously: transporting trucks to storage hoppers to conveyor belts, according to the number of shotcrete machines used.

On the Arlberg tunnel site (fully described in the paper of Mr H Treichl in this conference), the system consisted of mounting spraying machines on trucks for a profile drive of 100 m^2.

Two WALLCO IGM 70 machines were mounted on the front, powered by 12 hp electric engines, equipped with segment rotors and a feed hose of 65 mm (2.5"). The two machines are being fed by conveyor belts out of a 8 m^3 site, which is fed by a conveyor belt, itself fed continuously with spraying material. This has been found to work successfully for this contract.

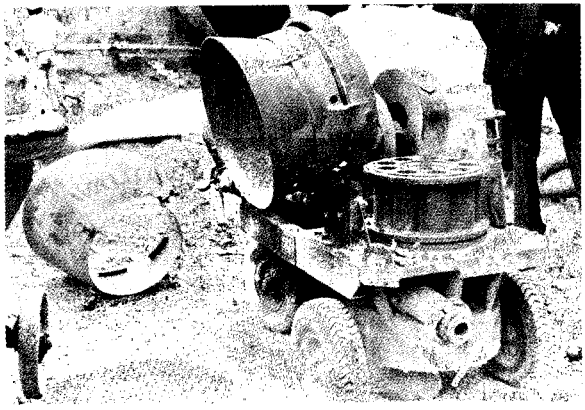
The entire combination was fed by a number of mixer trucks, unloading their drums via the intake installation without disturbing the operation. The metering device has been placed at the top end of the conveyor prior to reaching the shotcrete machine.

As mentioned previously, it is necessary to add the set accelerator (WALLCRETE) as late as possible to avoid the chemical reaction known as hydration, starting too early due to moisture in the aggregate.

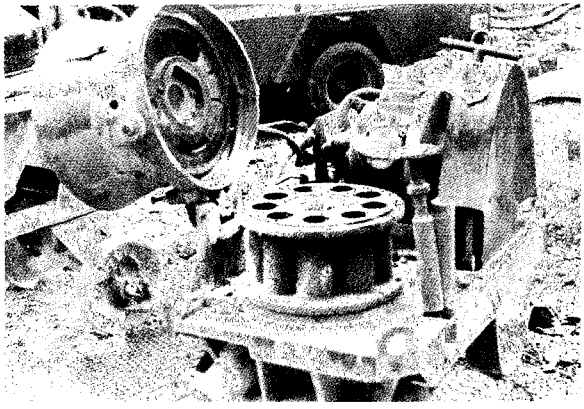
The whole operation employs two men, one per machine, who put it in gear and out of gear, regulate the feed of spraying material and control the metering device.

Communication with shotcrete applications is done, for short distances (40 - 60 m) by hand signals and in the case of longer distances (about 100 - 150 m) by means of light or radio.

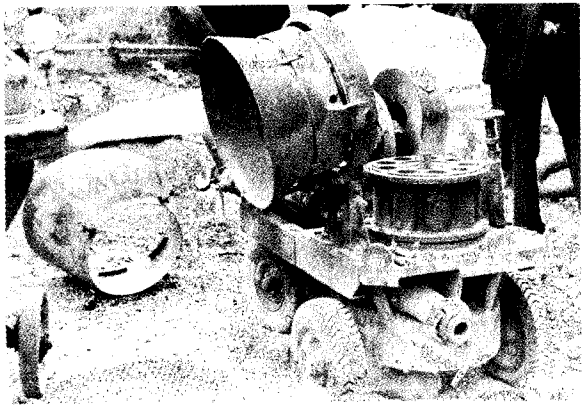
The mobility of the whole system is a great advantage. The feeding distances can be kept short, with subsequent savings on hoses, pipes, and consumption of air.



WALLCO ICOMA 70 rotary feed shotcrete machine dismantled for servicing during break in spraying operations.



Condition of the rubber gasket must be checked to ensure efficient operation of the machines.



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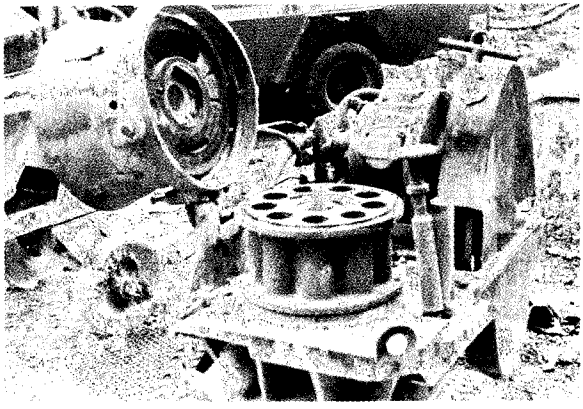

Condition of the rubber gasket must be checked to ensure efficient operation of the machines.

Swedish shotcrete equipment and developments in fibrous shotcrete

By Claes Alberts x)
and Maarten Kramers x)

The ROBOT

Background

At South Berwick, Maine (Bibl. 8) it was reported how the remote controlled spraying nozzle was developed to make it possible to spray over the muck pile when excavating a tailrace tunnel in Sweden.

Operation

On one of the basic designs the nozzleman works on a platform at the end of a long, truck-mounted boom which extends out over the muck pile. He operates a nozzle on the end of an extendable arm which provides a long reach. The nozzle is operated hydraulically and all movements are remotely controlled by the operator - this has been called the Robot method (Fig 1).

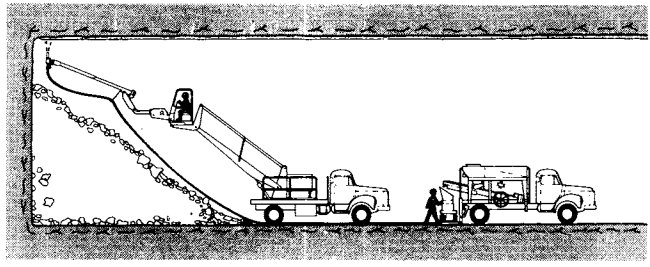

Fig. 1 Robot shotcreting method

Development

A number of important developments (Figs 2-8) have been made on the latest Robot models, for instance:

- the Robot is now equipped with its own advanced hydraulic system so that it can be easily put on whatever carrying system is available.

x) Claes Alberts, Managing Director, Stabilator AB, Stockholm
Maarten Kramers, Mining Engineer, MSc., Stabilator AB, Stockholm