Technology News

From the Bureau of Mines, United States Department of the Interior

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An "Insulating" Shotcrete for Heat Abatement in Deep Mines

Objective

Develop and demonstrate a lightweight material that has low thermal conductivity and that would be suitable for placement using shotcrete methods. This material could be applied in deep, hot mines where mine drifts must be insulated. Its use would decrease mine refrigeration needs and reduce energy costs.

Background

As mining goes deeper, rock becomes hotter. The mining process itself exposes large surface areas that release geothermic heat from the rock into a mine's ventilation system. Operating mining equipment also releases quantities of heat. Ores at many mines contain minerals, primarily sulfides, that exhibit exothermic behavior when exposed to air. Past mining practice has been to use underground refrigeration units to cool mine air. However, energy costs limit mechanical refrigeration. A solution that could lower energy costs is to insulate mine drifts. U.S. Bureau of Mines (USBM) researchers are developing an "insulating" material for this need.

Approach

In cooperation with a mining company, a manufacturer specializing in shotcrete equipment, and a cement materials company, the USBM has conducted laboratory and field research to develop such a specialized material. Cement-based products are well known for their fire-resistant qualities. Perlite has long been used for its insulation capabilities. Shotcrete technology has now become well developed throughout the world. This project blends these well-known technologies.

How It Works

The cement materials company developed a cement-based mix design that contained enough silica fume to let the mix stick to the mine walls. Perlite was added to the mix as the insulating component, along with air-entraining agents and other additives. Low-pressure, wet-mix shotcrete equipment was used because it is inherently safer than other types of shotcrete equipment and lessens rebound (only a few percent versus up to 30 percent). Although the shotcrete mix was applied manually in the demonstration, it is suggested that robotic shotcrete equipment be used to allow the operator to be removed from potentially hazardous situations. The material had been packaged in small-volume bags before the demonstration. Bulk packaging could be used to reduce costs.

Test Results

The field demonstration at the cooperating mine showed that the mix designs could be successfully applied with wet-mix shotcrete equipment. The unit weight of oven-dried shotcrete material averaged about 1,120 kilograms per cubic meter (kg/m^3) (70 lb/ft^3), with a thermal conductivity of 0.36 watt per meter kelvin (W/m K) (2.5 Btu in/h ft^2 °F). Oven-dried, unshotcreted material averaged about 640 kg/m^3 (40 lb/ft^3), with a thermal conductivity of about 0.24 W/m K (1.66 Btu in/h ft^2 °F). All values were reached at zero moisture. The

shotcreted material exceeded a compressive strength of 21 megapascals (3,000 psi) at 90 days. These strengths are considered to be adequate for ordinary mine support, although the insulating shotcrete has not been designed as a ground support material.

A preliminary computer analysis of insulating shotcrete placed in a typical mine drift indicated that use of insulating shotcrete might result in up to a 25-percent decrease in heat transfer between an insulated mine drift and an uninsulated drift. Each mine will have site-specific conditions, however, and its own set of circumstances.

Guidelines for Use

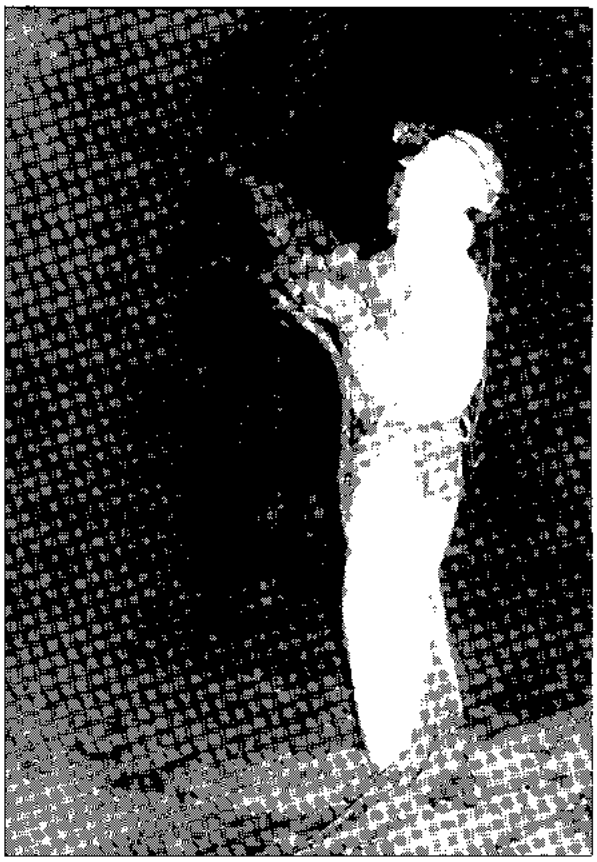
Suggested application in mines is with the wet-mix shotcrete process. Neither high pumping pressures (which cause rebound) nor repeated passes with the shotcrete nozzle (which cause increased compaction of the shotcrete) are recommended. Rebound can also be decreased by the generous use of silica fume. Regular concrete-forming methods may also be used, in which the material is pumped into place. Since thermal conductivity is directly related to unit weight, mix designs in the range of 640 to 960 kg/m^3 (40 to 60 lb/ft^3) are preferred to attain the desired thermal values.

Patent Status

The USBM does not intend to pursue patents. Shotcrete equipment, including robotic shotcrete equipment, is presently available from commercial vendors. The insulating mix design was formulated by a commercial vendor of concrete supplies.

For More Information

This research has been conducted by the USBM and its cooperators. Additional information may be obtained by contacting the principal investigator: Eugene H. Skinner, U.S. Bureau of Mines, Spokane Research Center, East 315 Montgomery, Spokane, WA 99207-2291, (509-484-1610), FAX: 509-353-2652.



Field application of an "insulating" shotcrete.

CAUTION: Under certain conditions, cement can be hazardous. See NIOSH Pocket Guide to Chemical Hazards, p. 198. Protective clothing is recommended when shotcreting.