

MATES

MICHIGAN DEPARTMENT OF TRANSPORTATION



Issue No. 48

November 1990

ANOTHER WASTE PRODUCT THAT MAY HELP

Michigan's Department of Transportation is ever alert to the possibilities of using non-hazardous industrial waste products in our transportation system. Due care and caution, of course, must be exercised in order to ensure that these products are cost effective, and that they are as good as the materials that they replace. At present, MDOT is either routinely using, or in the process of evaluating such things as recycled asphalt and concrete pavements, recycled plastic materials, reclaimed rubber tire material, fly ash, and many others. One material that seems promising is 'silica fume' as an additive for concrete used in overlaying bridge decks.

In order to extend the life of a bridge deck, many resurfacing treatments have been tried (See MATES Issue No. 20, June 1988). Older bridge decks are overlaid to rehabilitate a distressed surface, but in recent years we have found that overlaying new bridge decks with a layer of more dense (less permeable) concrete prolongs the life of the deck by retarding the penetration of water into it. When water penetrates a bridge deck it carries with it deicing chemicals, and these cause corrosion problems when they reach the reinforcing steel. Pressure caused by the build-up of corrosion products on the steel causes the concrete to fracture or spall and the deck to deteriorate.

The most successful overlay material to date is latex modified concrete (LMC), in which an emulsion of water and synthetic rubber (latex) is added to the concrete. MDOT currently specifies a 1-1/2-in. thick LMC overlay. LMC gives a strong, dense, and durable overlay with superior bonding characteristics, but it is costly. The Department is currently looking for products to compete with LMC as an overlay and reduce the cost of bridge deck resurfacing. Recent experimental overlays using silica fume have shown some promise.

Silica fume, which is also known as condensed silica fume or microsilica, was first recovered in the Scandinavian countries as a waste product from the metallic silicon and silicon carbide industries in the early 1950s. Silica fume has an extremely fine particle size (about 1/100 the size of a portland cement particle, or roughly equivalent to the particles in cigarette smoke), and it can be used as a 'pozzolan' in concrete.

Pozzolans are materials that react with the lime produced in concrete when the cement and water react (hydrate) and are added to concrete for a variety of reasons. These include greater strength, decreasing permeability (making the concrete more dense, thus inhibiting the absorption of moisture), and decreasing the amount of portland cement required. Other pozzolans are available such as 'fly ash' from coal-burning power plants. This fine, spherical material has particles about the size of portland cement particles. However, there are some problems associated with the use of fly ash in bridge deck overlays. The chemical composition of fly ash varies considerably between individual batches, causing a quality control problem. Another problem is the relatively large particle size of fly ash which slows down the concrete's strength gain. Silica fume seems to have less of a quality control problem than fly ash. In

addition, due to its smaller size, silica fume reacts with the lime much faster than does fly ash. Typically, silica fume is substituted for cement in concrete on a one-to-one basis in dosages between 7.5 and 12 percent of the total cement used in concrete.

Since silica fume particles are incredibly small, a given amount of them presents a much larger total surface area than the same quantity of cement. The large specific surface area of silica fume requires more mix water than does ordinary concrete or concrete with fly ash. This significantly increases the water/cement ratio and causes shrinkage problems. The water requirement, and thus the shrinkage, however, can be controlled by using superplasticizers (high range water reducers—HRWRs) which are additional chemical additives in the concrete mix. Concrete with silica fume, then, is a far more complex mixture than ordinary concrete. Our silica fume concrete overlays are thicker than the LMC overlays, a 2-in. thick application is required.

Michigan Bridge Deck Overlay Application

Three common reasons for using silica fume are to: 1) increase the compressive strength of concrete, 2) improve its abrasion resistance characteristics, and 3) reduce its permeability; the latter being of primary interest to MDOT. If the concrete is less permeable (that is, dense enough to inhibit the passage of moisture) waterborne deicing chemicals will be less apt to reach the reinforcing steel in the deck.

Experimental Application - In the spring of 1986, a latex modified concrete overlay was placed on the Ferry Ave bridge over I 75 in Detroit, to serve as a control for comparison with the behavior of silica fume overlays on nearby bridges. Two silica fume overlays were applied to the bridges carrying Mt. Elliott Ave and Frontenac Ave over I 94. The silica fume employed was in the form of a slurry, or mixture with water and other materials, and included a heavy dose of HRWR. The mix design was provided by MDOT and featured 658 lb (7 sacks) of cement, 66 lb of silica fume slurry, 9.4 cu ft of fine aggregate, and 8.4 cu ft of coarse aggregate. The total mix water amounted to 240 lb/cu yd; this included the added mix water plus the water in the silica fume slurry. Hence, the ratio of the total mix water divided by the cement plus silica fume equalled 0.33. Water/cement ratios of near 0.30 are desirable for this type of work.

In the spring of 1990, a silica fume overlay was placed on the chipped-out and scarified deck of a bridge carrying Grand River Rd over I 69 near Bancroft. The silica fume slurry was provided by a different supplier than the one used for the Detroit bridges. The supplier also furnished the mix design which included some very fine polypropylene fibers. The slurry included a small amount of HRWR that acted as a dispersant in the slurry. The remainder of the HRWR was added when the concrete was mixed. Any increase in fluidity (slump) necessary at the bridge site was required to be obtained by adding more HRWR, rather than additional water. The mix design features 610 lb (6-1/2 sacks) of Type I cement, 100 lb of the silica fume slurry, 1 lb of 3/4-in. polypropylene fibers, 6.6 cu ft of fine aggregate, and 10.6 cu ft of coarse aggregate. The

total mix water amounted to 283 lb/cu yd; this included the added mix water plus the water in the silica fume slurry. Hence, the ratio of the total mix water divided by the cement plus silica fume equalled 0.40.

The silica fume overlays on the Detroit area bridges were moist cured for four days and developed a coarse pattern of shrinkage cracks that extended through the overlay. The Grand River Rd bridge was moist cured for seven days, and it developed no shrinkage cracks.

The major differences between the silica fume jobs in Detroit and Bancroft were:

- 1) The cement plus silica fume content of the Bancroft job was less than for the mixes used in Detroit;
- 2) A smaller portion of fine aggregate was used on the Bancroft job;
- 3) Polypropylene fibers were added to the Bancroft job, which are reported to reduce shrinkage cracking while the concrete is in a plastic state;
- 4) The Bancroft job was cured longer and with greater care than the Detroit jobs, and
- 5) Less HRWR was used in the Bancroft job which reduced the amount of shrinkage.

Conclusions

The early silica fume jobs in Detroit showed extensive shrinkage cracking. However, permeability tests on the uncracked concrete showed very favorable results, even better than for the latex modified concrete used on the adjacent bridge used for comparison. The shrinkage cracks, however, are unacceptable since they pass through the overlay.

The Bancroft silica fume job showed no shrinkage cracking. The previously mentioned differences between the Detroit and Bancroft jobs contributed to the improved crack resistance of the later job. Coring for rapid chloride penetration tests will take place at the Bancroft site after a winter's exposure, to determine how readily deicing chemicals may penetrate the mix.

The latex modified concrete was bid at \$290/cu yd in place. Typical latex modified jobs average around \$350/cu yd. The Detroit silica fume concrete was bid at \$250/cu yd, while the Bancroft silica fume concrete cost \$150/cu yd. It is assumed that if silica fume concrete becomes an alternate to latex modified concrete its price will be substantially less than latex modified concrete. Given its low permeability, high strength, and moderate cost, silica fume may well give latex modified concrete a run for its money on future MDOT bridge deck work.

-Harry Patterson
-Steve Beck

TECHADVISORIES

The brief information items that follow here are intended to aid MDOT technologists by advising or clarifying, for them, current technical developments, changes or other activities that may affect their technical duties or responsibilities.

1990 STANDARD SPECIFICATIONS FOR CONSTRUCTION BOOK IS NOW AVAILABLE

The new Standard Specifications can now be purchased by Michigan residents for \$11.44 postpaid. The "Standard Specifications for Construction" is the standard for the basic requirements governing the materials, equipment, and methods used in construction contracts administered by the Michigan Department of Transportation. This latest edition can be ordered from:

Financial Services Division
Bureau of Finance
Michigan Department of Transportation
P.O. Box 30050
Lansing, Michigan 48909

or they can be picked up at the Transportation Building at 425 W. Ottawa Street, Lansing.

NEW MATERIALS ACTION

The New Materials Committee recently:

Approved

Dust Palliative DCE-100 - K&D of Ohio, Inc.
RELEEZE, Truck Bed Release Agent for Asphalt - ALZO, Inc., Matawan, N.J.
Corvel Green 10-6071 epoxy coating for rebar
Unistrut and Qwik-Punch sign posts as an alternate to U-channel
Miragrid 5T and Paragrid 100/25 geogrid material (aggregate fill only)

It should be noted that some products may have restrictions regarding use. For details please contact Gail H. Grove at (517) 322-1632.

MDOT'S TRASH HOTLINE!

Did you know that Michigan is the only state with a toll-free number to report highway litter? It started in the Detroit area in 1988, when signs were posted along freeways, displaying the toll-free number **1-800-44-TRASH**. Since that time, additional locations have been posted in the state, and the program has proved to be a great success.

Ernie Savas, MDOT Maintenance Engineer for Metro Detroit, suggests that when motorists see a litterbug, "... get the license number and description of the vehicle, location, and note the time of day. A description of the person is helpful, too. We have tremendous cooperation from state and local police who follow up on our reports." Violators of Michigan's anti-litter laws can face up to \$500 in fines or 90 days in jail.

So remember, if you see our state's anti-litter laws being violated, the number is: **1-800-44-TRASH!**

PERSONNEL NOTES

We are pleased to welcome three new Division members, **Steve Beck**, who joins the Research Laboratory's Materials Research Unit as its new assistant chief, **Dennis Dodson**, as a statistician in the District Support Section's Roadway Management System Development Unit, and finally, **Nick Lefke** as a technician in the Research Laboratory's Structures Unit. We look forward to working with these new staff members, and we're sure they'll prove to be valuable players on the team.

This document is disseminated as an element of MDOT's technical transfer program. It is intended primarily as a means for timely transfer of technical information to those MDOT technologists engaged in transportation design, construction, maintenance, operation, and program development. Suggestions or questions from district or central office technologists concerning MATES subjects are invited and should be directed to M&T's Technology Transfer Unit.

Technology Transfer Unit
Materials and Technology Division
Michigan DOT
P.O. Box 30049
Lansing, Michigan 48909
Telephone (517) 322-1637