FATS AND PROTEINS RESEARCH FOUNDATION, INC.

Director's Digest

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TALLOW SEALS CONCRETE HIGHWAYS

Deterioration of reinforced concrete highways and bridge decks due to salt application in winter, a well-known problem to every motorist in the northern climates, can be greatly reduced with a tallow-based, internal concrete sealant developed by the Fats and Proteins Research Foundation and the Monsanto Research Corporation.

Concrete is a porous material that readily absorbs salt and water from de-icing chemicals and from ocean sprays along the coastlines. As these salts reach the reinforcing steel bars, corrosion begins. The corrosion product, or rust, occupies a greater volume than that of the original steel and generates compressive forces which cause the concrete to fracture and crumble. Crumbling of concrete, called spalling, is the major cause of the early and costly deterioration of our concrete highways and bridges. So serious is the problem that the Federal Highway Administration has designated its elimination as one of the highest priority projects.

Many solutions have been proposed to prevent surface chlorides from penetrating the concrete and initiating the sequence of corrosion and crumbling. Waterproof polyethylene barrier membranes, epoxy coating of steel reinforcing rods and a variety of concrete additives are among the methods that have been tested in new highway structures. Cathodic protection and surface coatings such as the fatty acid derivatives developed under FPRF sponsorship have been employed to treat existing highways.

Internal sealing of concrete, a process developed by the Monsanto Research Corporation for the Federal Highway Administration, utilizes tiny wax beads that are mixed into the wet aggregate. After the concrete cures, warming the structure with specially designed electric blankets melts the wax beads and causes the wax to flow into the pores of the concrete, changing the originally porous material into a sealed, impermeable and salt-resistant structure.

The wax used must have several key properties. Its melting point must be high enough that it does not soften or melt during the mixing process or during normal exposure to hot weather, yet low enough that the finished structure can be easily heated to melt the wax and achieve the sealing effect. The viscosity of the wax melt should also be low enough to enable it to flow rapidly into the pores of the concrete and, most importantly, it must have a high affinity for the concrete to effectively wet it.

The wax beads developed by the FHWA are composed of 25% montan wax and 75% refined paraffin. Montan wax, which is designated as a polar ester wax, functions as a wetting agent for the blend and the water-repellent paraffin wax provides chemical inertness. This system is highly effective in blocking the penetration of water and chlorides but several factors limit its general application. The relatively high melting point of the montan/paraffin beads (185° F) is difficult and costly to achieve in the field and it entails some risk of damage to the concrete from thermal stresses. Furthermore, montan wax, which is obtained by the solvent extraction of lignite or brown coal, is a relatively costly material. It is available from several sources in Iron Curtain countries and from but one manufacturer in the United States.

Our objective in this development was to replace montan wax by low cost, annually renewable animal fat derivatives of the rendering industry in combination with lower melting and cheaper hydrocarbon waxes. A lower melting point within a narrower range is also desirable to reduce the cost of sealing with the electrically heated blankets used in the sealing process.

A combination of 20% hydrogenated tallow, 5% stearic acid and 75% paraffin waxes appeared to meet all the criteria set for a replacement of the montan/paraffin formulation. Laboratory tests demonstrated that a small amount of stearic acid in the paraffin-hydrogenated tallow mixture improved concrete wetting properties of the melt. Furthermore, the viscosity of the tallow blends was significantly lower and the melting range shorter than those of the montan/paraffin product. These factors are important in assuring rapid spreading of the melt into the pores. Although the tallow beadlets were slightly softer than the montan wax product, abrasion resistance was not significantly different and their durability in the concrete mixing process was judged to be very similar.

Beadlets were produced by spraying the formulation of hydrogenated tallow, stearic acid and paraffin through a nozzle. A limited amount of air was sprayed with the melt to build small voids into the beads. Because the wax formulation expands more than concrete during heat treatment, the air void allows each bead to expand inwardly before melting to absorb the pressures that would otherwise result in microcracking of the concrete around the bead. Air pressure injected with the liquid wax feed serves the dual function of forming the air pockets and of controlling beadlet size.

Laboratory specimens containing two and three percent tallow-based waxes were prepared by mixing the beadlets into the wet aggregate, casting it into forms and allowing it to set and cure for several weeks. Identical test specimens were prepared using three percent montan wax/paraffin sealant, the level recommended by FHWA. All samples were then sealed by heating slightly above the melting point of the waxes. Each sample was analyzed periodically for chloride absorption during a three month period of immersion in salt solution. None of the sealed concrete specimens absorbed a significant amount of chloride when compared with untreated concrete specimens. At the 2% level, the new tallow-based sealants were at least as effective as the montan/paraffin sealant at a 3% concentration.

The effect of wax beads on compressive strength of the experimental concrete specimens was essentially the same as that of an equal volume of entrained air. All samples met the minimum requirements for compressive strength. It is important to note that concrete specimens containing the tallow-based sealant at 2% exhibited a significantly higher compressive strength and greater degree of protection against chloride penetration than those prepared with 3% of the montan-based sealant.

Based upon the results of these tests, FHWA is continuing the evaluation of our sealant formulation of hydrogenated tallow, stearic acid and paraffin. Prototype concrete highway bridge decks reinforced with steel bars and containing this sealant have been cast, heat sealed and are being tested under a FHWA contract at the University of California.

Now, can this new application of tallow consume substantial amounts of tallow? The U. S. Bureau of Mines estimated that over 4.6 million tons of portland cement were used by highway contractors in 1977, equivalent to roughly 15.3 million cubic yards of concrete. At a use level of 2%, the potential consumption of tallow would have exceeded 180,000 tons had all of the 1977 highway concrete been treated with the new FPRF internal sealant. At a cost of roughly ten dollars per square yard of road surface treated, highway engineers believe the internal sealing process to be a promising solution to the high cost of highway maintenance. Preliminary FPRF experiments indicate that in some climates electrical sealing, which accounts for about 80% of the cost of the treatment, could be replaced by solar sealing using black, heat absorbent polyethylene film.