HOT SAND FOR IMPROVED TRACTION ON ICY ROADS:

ESTIMATIONS OF COSTS AND BENEFITS

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INTRODUCTION

Sand is often spread on icy roads in order to improve traction. Much of this sand, however, is soon thrown off the roads by passing vehicles. Furthermore, on hard icy surfaces, the sand particles which remain cannot "seat themselves". Under these conditions the loose sand may provide little or no improvement in traction.

This last point has been confirmed in laboratory work done for the Research Section at Pennsylvania State University. The main purpose of that laboratory work, however, was to test traction improvements provided by sand which had first been heated. This hot sand would melt itself partially into an icy surface and refreeze in place, producing a gritty, sandpaper-like surface.

The dramatic improvements in skidding friction achieved by heating the sand are documented in an earlier research report (reference 1). The figure below, reprinted from that report, illustrates typical results.

Legend:

- $\mu$ = coefficient of friction in locked wheel sliding.
- $R$ = sand applied at the same temperature as the room ambient.
- Curve labels = sand application temperature in degrees Fahrenheit.
- $c$ = clean ice

Figure A.4 Results for $\#4 - \#16$ crushed sand.
This brief report is a follow-up to the laboratory report. Estimates are made of the costs and benefits of a field program of spreading heated sand.

COSTS

There are at least two practical ways of heating maintenance sand. The first of these is to use a stationary drum dryer (from an asphalt plant) to heat the sand, which would then be transported and spread by conventional equipment. The second is to use specialized truck-mounted sanding units which would heat the sand continuously as it left the truck. This type of equipment has recently been advertised by a private manufacturer.

The two methods have various advantages and disadvantages. The specialized units would have a greater capital cost, since one would be required for each hot-sanding truck. These trucks, however, could use sand from any available source, lending a flexibility to the program which would not be possible with a stationary dryer drum.

The truck-mounted units use propane fuel, which is more expensive than the oil used in drum dryers. Propane burners, however, are usually somewhat more efficient than oil burners, and maintenance requirements are generally smaller. Furthermore, the sand would not need to be heated as much in the truck-mounted units, since it would not have a chance to cool off before it was spread. The net result of these tradeoffs appears to make fuel costs for the two methods about the same at current prices.

The following estimates are based on a sanding program on a scale similar to the current one in Fairbanks. The estimates are for costs in excess of those for the existing sanding program (which are neglected in the analyses). The estimates assume the use of 15 or 20 truckloads of sand per day on 35 days annually, for a yearly total of 5,000 cubic yards. Tests on the Fairbanks stockpile in October 1983 showed sand densities of 89 to 100 pcf and moisture contents of 2 to 3%.

Trade publications indicate that a small, used drum dryer might be purchased for about $20,000 delivered. Assuming a ten year life and a 5% real discount rate, this is equivalent to about $2,600 annually in capital costs.
Advertised costs for truck mounted units are "about $20,000". Four units delivered, mounted on trucks, and started up, might thus cost about $100,000. Assuming a 15 to 20 year life for these new units and the same discount rate as above yields an equivalent of about $9,000 annually in capital costs.

Maintenance costs for the four truck-mounted units, estimated at 5% of purchase price annually, would total about $5,000 a year. For the single drum dryer, estimated maintenance is half as much, or $2,500 per year.

Both methods would require additional labor compared to current sanding programs. A drum dryer would require an operator while in operation. This would not be needed for the truck-mounted units. Because they hold somewhat less material than conventional sanding units, however, more time would be spent returning to the material source to reload the trucks. It is assumed that this additional labor cost would be about the same for either method, and would total about $8,000 per year.

The greatest costs of a hot-sanding program would be for fuel. For the drum dryer method, an estimate of $\frac{3}{4}$ gallons of fuel oil per cubic yard of sand was made based on the following assumptions:

- dry density of sand: 100 lb/ft$^3$
- moisture content of sand: 3%
- specific heat of sand: 0.22 Btu/lb·°F
- temperature rise: 300°F
- heating efficiency: 50%
- heating value of fuel: 126,000 Btu/gallon

At $1.10$ per gallon, fuel costs would be about $5.00$ per cubic yard of sand, or about $25,000$ annually. Similar calculations for the truck-mounted propane burners yielded similar fuel cost estimates.

Fuel costs are very sensitive to the moisture content of the sand (which must be boiled off). An increase in moisture of 1% increases fuel requirements by about 1/2 gallon per cubic yard of sand.

The sum of capital, maintenance, labor and fuel costs for a hot sanding program using a dryer drum is about $38,000$ per year, or $7.60$ per cubic yard of sand. For a program using truck-mounted units, the total is $47,000$, or $9.40$ per cubic yard.
If the heated sand successfully provides greatly improved traction, it is likely that less sand would be needed at any given time and/or that the frequency of sanding could be reduced. The potential cost savings from this has been ignored in the analyses above.

**BENEFITS**

The benefit expected from a hot-sanding program is, of course, a reduction in accident rates. A literature search revealed very little work relating accident rates to the sanding of icy roads; none of it related to heated sand. The information that was found was almost entirely qualitative, not quantitative.

In the absence of better information, hot-sanding benefits can be roughly estimated by relating them to other types of improvements to tire-to-road skidding friction. One such improvement for which quantitative information exists is the placement of friction courses on pavements to improve traction.

Another recent Research Section report (reference 2) concluded that surface seals ("friction courses") could reduce stopping distances by 25% on icy roads under Alaskan conditions. The laboratory work with hot sand (reference 1) showed reductions in stopping distances of 50% or more. These results were found under rather ideal laboratory conditions. Given the excellent results, however, it seems reasonable to assume that hot sand would provide at least as much improvement to traction as friction courses under field conditions.

Friction courses have been estimated to reduce accident rates under wet conditions by 21% in Alaska (reference 3). This figure is the one currently used by the DOT&PF in priority rankings of safety improvement projects.

A statistical study (reference 4) examined the relationship between accident rates and skid numbers on wet pavements using a national sample of highway sections. This study found that a skid number increase of one (i.e., an increase of 0.01 in the coefficient of friction) resulted in an average of 0.046 fewer accidents per million vehicle miles. This relationship was true of all types of roads examined, despite the fact that the accident rates themselves varied between road categories.
Data was provided in the report (reference 4) for the accident rates and mean skid numbers for all road types studied. The study's average figures for all road types and the accident reduction relationship shown above indicate that a 21% accident reduction could be expected from a skid number increase of 13.5 over the mean value. This increase seems to be a reasonable estimate of what might be expected from placement of a friction course.

The lab work with hot sand indicated that it could increase skid numbers by 30 or even more over that of bare ice. Thus it again appears that a hot sanding program may provide at least as much improvement as friction courses (i.e., 21% reduction in accident rates).

Statistics were obtained for accidents in Alaska involving intersections during snowy or icy conditions. These indicate that between 1977 and 1981 there was an average of about 200 such accidents on State-maintained roads in the Fairbanks area (as of this writing no statistics had been obtained for more recent years).

If a State hot-sanding program could reduce such accidents by 20 to 25% this implies a reduction of 40 to 50 accidents annually on State-maintained roads in the Fairbanks area.

CONCLUSIONS

Rough estimates of costs and benefits resulting from a hot-sanding program are presented in this report. They indicate that such a program on State-maintained roads in the Fairbanks area might cost $38,000-$47,000 per year. A reduction of 40 to 50 accidents a year from such a program was conservatively estimated. The cost to prevent a single accident, in other words, is estimated to be about $1,000.

Interviews with local insurance adjusters indicate that, despite the difficulty of defining a "typical" skidding accident, they would expect property damages alone to average at least this much for such incidents. It therefore appears that a hot-sanding program may be a cost-effective safety measure.

There are, however, significant uncertainties about both the costs and the benefits of a hot sanding program. This is unavoidable in light of the
fact that there is no field experience with such a program. It is therefore concluded that before committing large sums of money to a hot sanding program, the DOT&PF should conduct field trials which would provide more accurate cost/benefit information.

IMPLEMENTATION

A field trial of hot sand seems warranted. It is recommended that a truck-mounted sand heater/spreader be purchased for such a trial, rather than a drum dryer. Reasons for this include the following:

- A drum dryer would be oversized for field trials. Operating costs would thus be disproportionately high.
- A truck-mounted unit could easily be tested in several areas because of its mobility.
- Comparisons of hot vs. cold sand performance could be easily compared (even in adjacent lanes of a single road) merely by turning the heater unit on and off.
- Should tests indicate heating sand is not desirable, the equipment will still be useful (as a conventional sand spreader). The same cannot be said of a drum dryer.

Evaluation of these field trials should include measurements of skidding friction by use of a Tapley meter or equivalent. Comparisons should be made between road surfaces before and after hot sand application and between hot and cold sanded surfaces.

The evaluation should also include observations as to the ease of use, the reliability, and the maintenance requirements of the equipment.

Following the field test program, a decision should be made whether or not to incorporate hot-sanding as a regular maintenance tool.
REFERENCES


