PROBLEM OF BLOWING SNOW IN WYOMING UNDER ATTACK BY HIGHWAY DEPARTMENT

The forces of winter have been challenged by the Wyoming Highway Department, whose experts are making a concentrated effort to curb blowing snow, improve visibility, and thus make the state's roads safer for winter driving. The problem of blowing snow is especially acute on Interstate 80 between Laramie and Walcott Junction.

The highway, which gained some notoriety for blowing snow conditions during the winter of 1970-71, is a prime proving ground for snow control. Located in some of the windiest country in Wyoming, much of the highway is at elevations above 7,000 ft above sea level. This gives it all the characteristics of being a sometimes hazardous road, especially when the windblown snow causes drifts and limited visibility.

Because of these factors, the department set out to do something about the conditions that prevail over about 34 miles of the highway that was opened to traffic on October 3, 1970. During the winter of 1970-71, blowing snow caused the road to be closed to traffic for a total of 208 hours between October 11, 1970, and April 26, 1971, mostly because of poor visibility. Although this was only 5.3 percent of the total time between those two dates, the department was determined to find a solution to this problem.

For some reason (many theories have been advanced, but few of them proved), new highways are always susceptible to drifting and icing conditions, and I-80 west of Laramie was no exception. In future years, however, this problem is expected to be at least partially solved.

To help solve the problem, the highway department enlisted the services of Ronald D. Tabler, principal research hydrologist for the Rocky Mountain Forest and Range Experiment Station in Laramie. Tabler, who holds a PhD in watershed management from Colorado State University, has spent many years studying the most effective methods of storing snow to increase usable water yields from windswept watersheds.

Tabler was asked by the highway department to help design snow fence systems that would yield optimum results, but not the results he was accustomed to: The objective was just to keep the snow off the road.

To accomplish this task, Tabler has relied on his own experience and knowledge about drifting snow and other research that has been carried out. Generally, information about blowing snow is relatively limited, but that which is available can be used to solve many of the problems associated with the management of blowing and drifting snow.

Studies of moving snow have revealed some interesting relations. For example, until recently, it was generally assumed that the factor that caused most sublimation, or evaporation, of blowing snow particles was solar radiation, or heat from the sun. This has been disproved through theoretical considerations and experimentation. There are many factors involved.

The sublimation rate of snow particles is one of the most critical factors in determining the design capacity of snow fence systems and, therefore, has received much attention in the studies. R. A. Schmidt, Jr., of the Rocky Mountain Forest and Range Experiment Station in Fort Collins, developed a mathematical model that explains the evaporation of blowing snow. The model takes into account the many factors that influence the sublimation rate and, therefore, makes it possible to accurately determine how far a snow particle will move before it completely evaporates.

The Schmidt model dispels many a myth about how far snow travels when blown by the wind. Many veteran observers will swear the wind blows the snow for miles. Observations and the mathematical model indicate that the average particle of snow will travel only about 1,000 meters (3,300 ft) in the conditions that generally prevail between Laramie and Walcott Junction.

The only time the transport distance is limitless is at night when the relative humidity is 100 percent. Experience has proved this to be a very rare feature, for the humidity seldom reaches 100 percent at night in mountainous climates.

Weather conditions generally prevailing during drifting required a considerable amount of study to determine the sublimation rate and, hence, the average transport distance of the snow. Factors influencing the sublimation rate include temperature, solar radiation, relative humidity, and particle size. As the temperature increases, so does the sublimation rate; for each 10 C rise in temperature, the sublimation rate approximately doubles.

Because the sublimation rate is essentially independent of wind velocity, the faster the wind blows, the farther a snow particle will go before it evaporates. Changes in relative humidity affect the sublimation rate by inverse proportions; that is, as the humidity increases, the evaporation rate of the snow particle decreases. Relative humidity can have the greatest effect on the evaporation rate, greater even than temperature or solar radiation.

Studies during the 1970-71 winter on Pole Mountain indicated that during drifting conditions the mean temperature was about -8 C (18 F), the average wind velocity was 12 meters/sec (27 mph), and the relative humidity was about 72 percent. The size of an average snow particle transported by the wind is about 100 microns or 0.01 cm.

The study of weather conditions on I-80 will continue with a battery of instruments Tabler has set up at Cooper Cove near the Albany-Carbon County line and near Elk Mountain. Instruments at these two locations will help evaluate snow fence efficiency and gather other pertinent data.

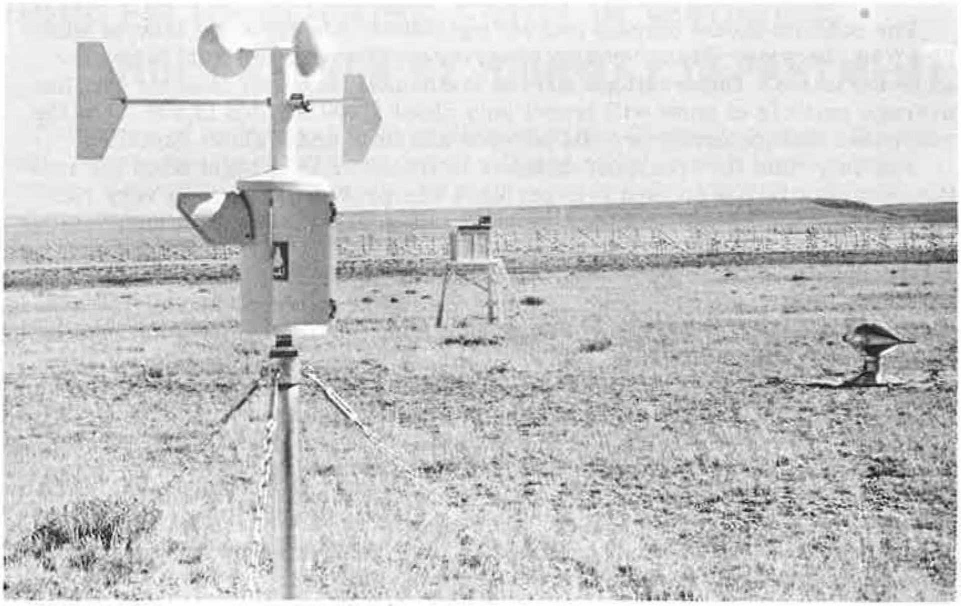
Gauges at the sites (Cooper Cove and Elk Mountain) include a recording pyrheliometer, precipitation gauge, recording anemometer (for wind velocity), recording wind vane (for wind direction), recording thermometer (thermograph), hygrometer (for relative humidity), and a blowing snow gauge.

The blowing snow gauge, engineered and built by Tabler, was copied from a smaller model used in the Antarctic for measuring the amount of blowing snow. Tabler's model, a scaled-up version of the original, resembles a rocket placed horizontally to the ground. Its fins, or vanes, keep the nose pointed into the wind.

As it swivels on a rotating base, always pointed into the wind, snow is blown into the nose, slows down in the stilling section, and drops into a precipitation gauge buried underneath. From the graph on the precipitation gauge, Tabler can tell how much snow is going through the air at any given time. The accompanying anemometer records the speed of the wind, while additional equipment records temperature, wind direction, relative humidity, and solar radiation.

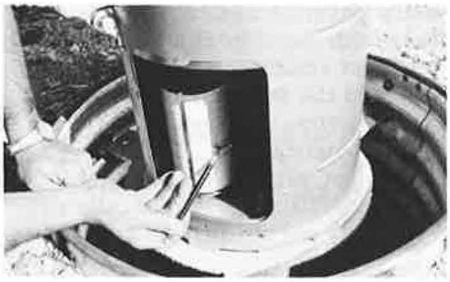
Because 95 percent of all the snow blown by the wind is within 1 meter (about 39 in.) of the ground, the blowing snow gauge is set ½ meter from the ground. With so much snow blowing so close to the ground, the term "ground blizzard" becomes even more descriptive.

The blowing snow gauge actually measures the mass flux of the snow (grams/cm^2/hour), and these data will be compared with the total catch of the snow fence. All data will be recorded to determine efficiency of the fence and ultimately used for additional background information in the whole spectrum of studying blowing snow and, consequently, how to control it.



Some of the instruments used to collect weather data are shown here. Mounted on the pole is an instrument cluster consisting of an anemometer, wind vane, and thermometer to record wind velocity, wind direction, and temperature. In the center of the photograph is a station containing a pyrheliometer for recording solar radiation, and at the far right is the blowing snow gauge that measures the amount of snow blown by the wind.

A precipitation gauge is placed in a sheltered spot for accurate recording. Baffles break up wind currents around the gauge.



A precipitation gauge under the blowing snow recorder measures the amount of snow driven by the wind. It is easily removed for checking and maintenance.

Snow expert Ronald D. Tabler checks the anchorage on a portion of the snow fence used as a test section at Cooper Cove, Wyoming.

Once it has been determined how much precipitation will fall, how fast the wind will blow, and how much of the snow will be transported, this information is combined with other climatological data; then the actual design of the snow fence system begins.

It has been generally conceded among experts that for maximum efficiency a snow fence should have a density of between 40 and 60 percent. That is, if 6-in. boards are used to build the fence, the gaps between boards should be about 6 in.

In addition to the density factor, it has been determined that the bottom of the fence should be between 6 and 18 in. from the ground. If the fence is closer than 6 in., the fence will become "choked" and its efficiency reduced; if it is higher than 18 in., the drift will move farther downwind and, again, efficiency is reduced.

Effectiveness of a fence is also related to its total height. The taller the fence is, the more snow it will hold and the more efficient it is for trapping blowing snow. The length of a drift downwind from the fence is about 16 to 20 times the height of the fence. Fences, obviously, are most effective when placed at right angles to the prevailing winds.

Taking all the factors into account, Tabler and the highway department designed a snow fence system that would hold specific quantities of snow. This is the first time holding specific amounts of snow has been the principal criterion in snow fence design.

During the past winter, Tabler monitored the equipment and determined efficiency of the snow fences by measurement and physical observation at the fence systems and on the highway.

Tabler has another idea about the design of the fence system. He feels that the basis for controlling blowing snow is just as solid as for many other engineering projects.

Part of the confidence will lie in the results of one of the most sophisticated experiments ever tackled in the science of controlling drifting. Tabler envisions the prospective use of equipment now installed, coupled with some transmission gear, for forecasting blowing snow conditions.

If account is taken of historical data and comparisons are made with wind direction and velocity, relative humidity, temperature, mass flux, and information from the U. S. Weather Service, it may just be possible to say that a road should be closed 4 hours from now and that the visibility will improve 2 hours from that time and the road can be reopened.

This science is not finite yet, but it has many possibilities. Tabler hopes to make further investigations along these lines with the help of a closed-circuit television system that will allow the current conditions from Laramie to be monitored. Visual monitoring of weather and the telemetry of other pertinent data from other recording instruments may prove to be some of the biggest breakthroughs in the history of highway maintenance.

Such a system may be quite a few years away, but with increased knowledge about a given section of highway and the weather conditions that generally prevail, more data and an advanced state of the art may permit prognostication beyond wildest expectations.

HUNDRED EXPERTS FILL FIVE SESSIONS AT BOARD'S HUMAN FACTORS WORKSHOP

Henry M. Parsons*

The Fifth Annual Human Factors Workshop in Highway Transportation was held January 16 in Washington, D.C., at the 51st Annual Meeting of the Highway Research Board.

Attesting to the relatively flourishing state of human factors in highway transportation, more than 100 persons currently or formerly doing research in this field attended. Organized by J. E. Uhlaner with the support of Slade Hulbert, former chairman of the HRB Committee on Road User Characteristics, the early workshops were somewhat informal but are now sponsored annually by HRB with enthusiastic backing from William N. Carey, Jr., HRB Executive Director, and Harold L. Michael, chairman of the HRB Group 3 Council.

This year five concurrent all-day sessions were arranged by A. James McKnight, workshop chairman. Their highlights illustrate the scope and variety of human factors interests in highway systems.

Led by Albert Burg, the session on "The Role of Vision in Driving" discussed the following themes:

- Visual functions required by the driving task—how these can be determined, measured, and modified through training and experience; concepts of face validity and the "design driver"; and compensation for visual deficiences.
- Existing vision screening of driving-license applicants, nonuniformity among the states, and lack of data to support the cutoff scores.
- Use of eye-movement recording techniques in research.
- Rear-vision requirements in relation to vehicle design and current and proposed standards.

Among recent developments have been a System Development Corporation study of visual requirements by Robert L. Henderson, a combination vision

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