

Tech Brief No. 1 2007

This *Tech Brief* summarizes the key findings of a recently completed WYDOT research study.

SNOW FENCES: A NEW BREED

Blowing snow is the primary cause of icy roads in wind-exposed areas—melting extracts diurnal solar radiant heat stored in the pavement and substratum, and the quantity of snow blowing across a road can be hundreds of times greater than direct snowfall. A recently completed safety improvement study on I-80 between Laramie and Rawlins showed that for the period 1990-2004, icy road conditions were reported for 54% of all crashes. Although conventional snow fences are effective in reducing blowing snow originating outside the right-of-way, snow relocated from areas close to the road also causes icy road conditions, and this is especially true in areas where vegetation has been denuded by construction activities.

The objective of this study was to develop a practical and economical method of retaining snow along roadsides in order to reduce road icing caused by blowing snow. Although multiple rows of conventional 4-ft snow fence could serve this purpose, it was hypothesized that a three-dimensional array of elements might be more effective and aesthetic, and might prove to be more economical. An idea leading to the research reported here was a tetrapodal element constructed from 2"x 4" lumber, and this was later expanded

to include the development and testing of tubular, wire-frame-supported plastic netting. The study consisted of developing, testing, and comparing these alternative roughness elements. The research plan as originally proposed consisted of three phases:



Phase I (2003-2004):

1. Determine the optimum spacing of tetrapods using small-scale wind tunnel tests and simulated blowing snow. The results from this preliminary research would indicate the practicality of the concept, and hopefully guidelines for spacing.
2. Conduct a field test of a single row of tetrapods on a flat area west of Cooper Cove interchange to determine the overlap required to store as much snow as a 50%-porous snow fence, to provide an independent indication of the required

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spacing in a three-dimensional array, and to provide data on the actual times required for fabrication and installation.

3. Conduct a field test of tank baffles as a possible roughness element, as previously suggested by highway maintenance personnel. Phases II and III (2004-2006 winters) were to consist of testing tetrapod arrays on a roadway embankment, with the third phase allowing for testing another spacing, if necessary.

Conclusions from the first phase of study were as follows:

- The 3-ft-tall tetrapod developed in this study is an efficient design that minimizes costs for materials and labor.
- The wind tunnel tests showed that 3-ft-tall tetrapods at any spacing reduced snow erosion on a 2h:1v slope, but the tests did not provide a conclusive indication of optimum spacing. The wind tunnel investigator concluded, however, that the spacing *between* element footprints (not center-to-center distance) should not exceed the width of the footprint (S).
- In a full-scale test on flat terrain, a row of 3-ft-tall tetrapods on 0.6 S centers caught as much snow as a 2-ft-tall 50% porous snow fence. Calculations suggest that tetrapods spaced on 0.4 S centers would capture as much snow as a 3-ft-tall, 50% porous fence.
- The maximum depth of snow accumulation behind the row of tetrapods suggests that spacing between footprints equal to 0 ft in a three-dimensional array would result in a comparable snow depth on flat terrain. This suggests that spacing would have to be even closer on a 2h:1v slope.
- Tetrapods are the most costly element to fabricate and install, and their physical structure presents a potential collision hazard to errant vehicles.
- Using tetrapods to stabilize snow on embankments does not appear cost effective.
- Tank baffles are effective in collecting snow, but their cost is approximately twice that of tetrapods.

- A more economical alternative was needed.

The last conclusion led to the idea for a tubular plastic mesh device supported by wire frames which, because of its reptilian resemblance and functionality, was given the name “snow snake.” The interim report of April 10, 2005, recommended that Phases II and III be modified to consist of field tests to quantify the snow retention characteristics of the snakes in relation to their height, and to evaluate their effectiveness in actual roadside installations.

The change in element geometry required much additional effort to design a cost effective device utilizing materials totally different from those of the original tetrapod configuration, and led to a patented design. The first field test of snakes was in place by 27 October 2004, and the following month roadside tests were installed at I-80 RM 270.3, 273.0, 304.9, and 331.6.



An additional large-scale roadside test was installed east of the I-80 College Drive Interchange at Rock Springs (RM 103.82) in November, 2005.

Conclusions from the snow snake study were as follows:

- Snow snakes are significantly less costly than tetrapod arrays, and their cost per unit volume of snow storage is comparable to that of conventional snow fence of equal height installed on wood or steel posts.
- Wire frames supporting the plastic netting should be spaced 2-ft apart, have a 2-ft-wide base, and utilize pre-galvanized 0.187-inch-diameter wire. Steel spikes

3/8-inch x 12-inches provided adequate anchorage in all locations tested.

- Vexar® L-300 is suitable netting for snakes, and the tan color blends in well with the sagebrush grass-land vegetation in Wyoming.
- A sage-green color that was tested did not blend in as well with background vegetation, and faded significantly over two years of exposure.



- For snow snakes with height H (inches), snow storage volume V (ft³/ft of length) is approximately $V = 0.0355 H^{2.38}$ (where 54 d" H d" 24).
- Length of the equilibrium lee drift formed by a snow snake is $35H$.
- The optimum height for snow snakes is 30 inches.
- The maximum height for snow snakes is 30 inches. Taller snakes are permanently deformed by strong winds.
- On embankment slopes the required horizontal spacing, S_p , of snakes is hypothesized to be the same as for conventional vertical fences: $S_p = H / \tan \alpha$, where α is angle of slope above the horizontal.
- The optimum spacing for snakes on flat areas would depend on snowfall at the location in question, but $20H$ is expected to be a general rule.
- The primary advantages of snow snakes over conventional snow fences are their unobtrusive appear-

ance, and the fact that they present no hazard to errant vehicles. They also promote the reestablishment of vegetation by increasing soil moisture, providing shade, and by providing protection from wind and grazing animals.

- Snow snake drifts in medians would also help to restrain vehicles that would otherwise cross over into oncoming traffic.
- Below-normal snowfall and blowing snow over the last two winters limits the conclusions that can be drawn from the roadside tests. Observations and evaluation of these should continue as long as the installations are in place and serviceable, particularly the more elaborate tests at Johnson Hill and Rock Springs.

Recommendations for implementation are as follows:

1. Recommendations for implementation should be deferred until additional results are available.
2. A formal study of the Rock Springs installation should be conducted over a year with more normal winter weather. This study should involve photographic and video documentation and pavement temperature measurements, if possible. Because of their qualifications, and familiarity with the snow snake research, PMPC Civil Engineers should be invited to submit a proposal for this work.
3. The roadside test at RM 331.6 should be reinstalled after construction. Additional rows of snakes should be installed at 25-ft centers on the embankment.
4. WYDOT's Winter Services Research should continue evaluating the other roadside tests over the next one or two seasons. Tasks should include observing and documenting effects on road conditions, and interviews with maintenance personnel.

The full report entitled "Three-Dimensional Roughness Elements for Snow Retention", Report No. FHWA-WY-06/04F, can be obtained by calling the WYDOT Research Center at 307-777-4182. The report is also available on-line at the following web site: <http://tablerassociates.com>.



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The Wyoming T² Newsletter is produced by the Wyoming Technology Transfer Center at the University of Wyoming. The T² Center is financially supported by the Federal Highway Administration, Wyoming Department of Transportation, University of Wyoming, and the Cities and Counties of the State of Wyoming. Any opinions, findings, conclusions, or recommendations presented in the T² Newsletter are those of the authors and do not necessarily reflect the views of the supporting organizations. Any products mentioned are for informational purposes only and should not be considered as product endorsements.

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