CONSTRUCTING SCALED MODELS FOR SNOWDRIFT TESTS OUTDOORS

by

Robert L. Jairell and R. A. Schmidt[1/]

INTRODUCTION

Success in using small-scale models to design solutions to snowdrift control problems depends on attention to two areas of detail: (1) aerodynamic similitude and (2) model construction. The similitude requirements for outdoor modeling of snowdrifts have been examined by Tabler (1980b), and examples of the procedure are presented by Tabler and Jairell (1980). The objective of this paper is to present the methods of constructing models that are properly scaled, sufficiently robust, and conveniently packaged for the rigors of modeling in low-level snowdrifting outdoors.

Most of our modeling experiments are run on a frozen lake that provides a smooth surface where model scales as small as 1:30 are practical. The precision required in measuring drifts of such small scale, and the accumulation rate in comparison with the time required to measure a drift profile, make the minimum practical height of these model barriers about 5 cm. When the object of a modeling experiment is to determine the maximum accumulation of snow by a long barrier such as a fence or shelterbelt, model length must be at least 30 times the barrier height, to provide a center test section free from end effects (Tabler 1980a).

Modeling snowdrifts offers the opportunity to replicate drift accumulation, often several times during a day's experiments. At the end of each replication, the models are removed from the drift, and either moved to a new location, or replaced after the drift has been shovelled or plowed away. To take full advantage of drifting conditions, the models must withstand these frequent excavations, and must be easily and quickly installed on the model surface. Since the drifting is uncontrolled, realigning a model to a new wind direction needs to be a simple procedure.

Our experience is most extensive with model snowfences (Fig. 1), but the work has included vegetative barriers, both shrubs and trees, terrain models (hills, road cuts, strip mine reclamation), and model buildings. The rest of this paper presents the principles, tips, and tricks we've developed for constructing each of these model types.

Figure 1. Conditions required for successfully modeling snowdrifts are low windspeeds (below 7 m s^{-1}), low-level drifting, and properly scaled models, well-constructed.

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1/ Research Technician and Hydrologist, respectively, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Laramie, in cooperation with the University of Wyoming. Station headquarters is at Fort Collins, in cooperation with Colorado State University.

SNOWFENCES

By far the most satisfactory material for constructing models of wooden fences is printed circuit board made of copper-coated fiber glass. Available in thicknesses that allow 1:30 scaling of common lumber dimensions, it can be easily cut to required widths with a bandsaw or shear. The copper surface allows soldering of pieces into a durable model (Fig. 2) that requires no special handling. When constructed in panels that model the 16-foot long prototype panel, rubberized magnetic strips attached to the base elements facilitate placement on steel plates for anchoring a row of panels. Adjustments for wind direction are much easier when panels are attached to plates than when frozen directly to the surface, an alternative we've tested.

By a process called chemical milling (identical to etching a printed circuit) models may be produced from sheets of brass or copper (Fig. 3). This method has advantages where a photographic image of the barrier face can be produced.

Surface attachment is a critical detail, not only for model fences, but for models of vegetative barriers. Drift geometry is extremely sensitive to the gap between the model and the surface, and thus to the obstructions created by attachment. For model snowfences, regardless of height, gaps of less than 1.2 cm produced drifts that poorly represented those behind prototype fences.

VEGETATIVE BARRIERS

Plastic models of various leafy plants are available from florist supply houses. Models of shrub rows have been produced by shaping pieces of this material and fastening them in rows on a wooden base, using silicone rubber adhesive (Peterson and Schmidt 1984). Plastic model trees, particularly of conifers similar in shape to spruce, are also available, usually from companies that supply hobby shops. Models have also been constructed from nursery stock of the same species, again mounted in rows on wooden bases.

The difficulty in modeling vegetation is to duplicate the porosity of the prototype, which is not easily measured. Again, the treatment of the base is critical. In windswept areas, vegetative barriers often trap debris that decrease porosity near the surface, compared to the porosity of the individual plants, and that determined by their spacing.

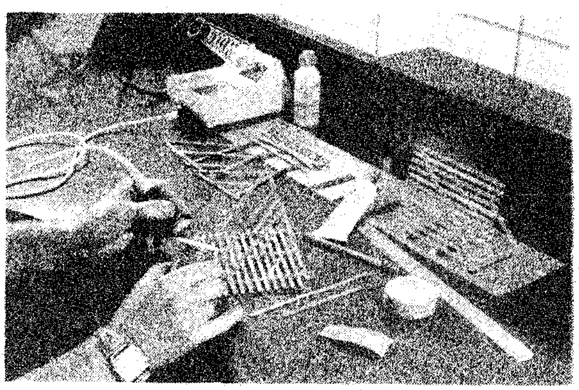

Figure 2. Printed circuit board is easily cut and soldered to form models of prototypes built from lumber.

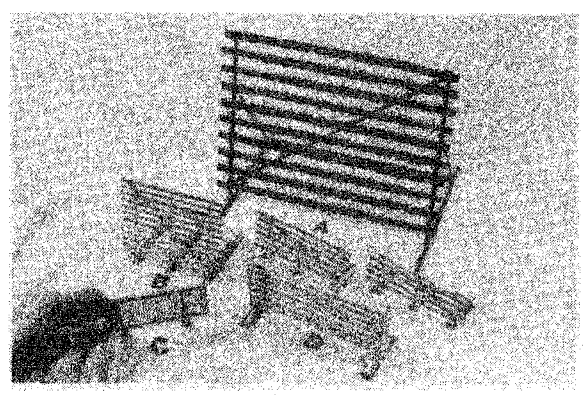

Figure 3. Examples of model snowfences constructed from (a) wire mesh and plastic strips, (b) printed circuit board and (c) brass sheet, by chemical milling, and (d) wooden dowels.

Attachment of the individual plants to strips of wood or metal is essential because aligning individual trees or shrubs into rows before each experiment costs too dearly in "run" time (and good humor of the experimenter). However, the profile of the base is an important part of the model. A wooden base of nominal 1-inch stock on a 1:30 model represents a 2-foot berm in a prototype. If such a berm is not present in the prototype, then it is important to bury such a model base in a groove cut in the ice with a wood chisel, so it is flush with the surface, preserving the scaling in the critical gap at the surface. A better design is to minimize base thickness (Fig. 4), as with a sheetmetal strip to which wires that form the plastic elements are soldered. On the lake, these strips are easily frozen to the ice surface with a dash of water.

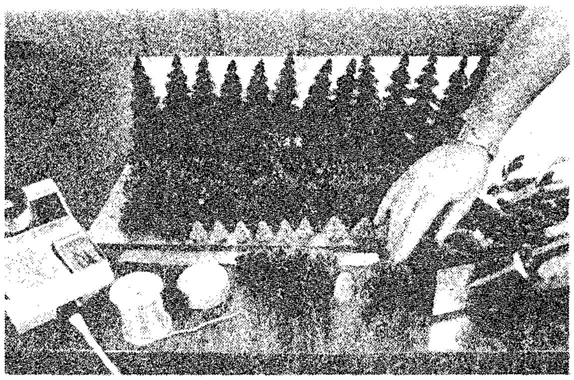

Figure 4. Model trees are fastened to sheetmetal strips by soldering the wires that form the plastic elements.

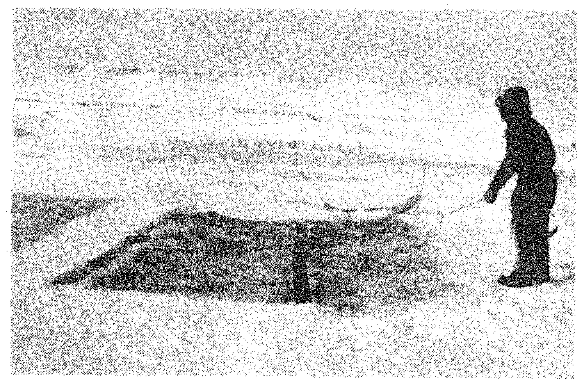

Figure 5. Lightly spraying the surface with colored water stabilizes a terrain model constructed from snow, while providing contrast with drifts formed on the surface.

TERRAIN BARRIERS

Inexpensive models of terrain can be constructed from snow that is compacted by plowing, smoothed by troweling, and stabilized by spraying lightly with water. Brown dye, added to the spray, colors the surface to provide contrast for photographs of snow deposition on the model (Fig. 5). A small tractor with blade and snowblower is handy for such experiments, but still this technique requires much handwork, and the model deteriorates under warm or high-wind conditions.

For terrain models with uniform cross-section (so-called two-dimensional models such as long dikes or ridges), forming a test section of plywood and extending both ends of the model with snow may be a better investment of time than shaping the entire model from snow. The wooden test section is stable and easily moved, while the snow extensions meet the requirement for a length 30 times the model height, and may be shaped with less attention to detail.

In another experiment, we used premixed concrete to produce a model--in this case, of an earth berm around a stockwater source (Fig. 6). The mix was poured on a plastic sheet on a concrete floor and troweled into the desired shape, then cut into segments and allowed to set. The segments were small enough for easy handling (Jairell and Tabler 1985).

BUILDINGS

Two examples of model buildings we've tested (Fig. 7) were constructed by very different techniques. The elevated structures were simply blocks of wood, glued and cut to size, then painted to provide good contrast in photographs. The model Jamesway huts were coated nylon fabric stretched over a plywood framework. Both methods produced successful experiments.

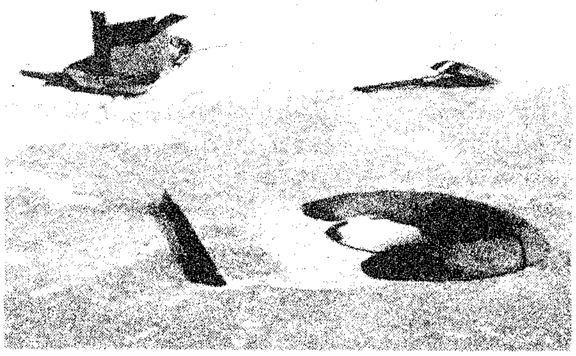

Figure 6. Concrete, formed or molded to shape, then cut into movable sections produces useful terrain models, such as this berm around a stockwater pond.

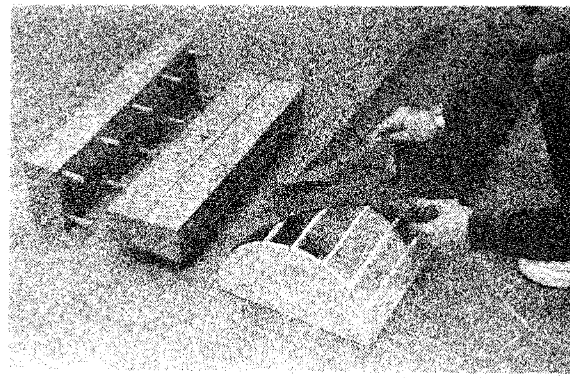

Figure 7. Models of elevated buildings, constructed from wooden blocks, and fabric-covered Jamesway huts both proved durable.

CONCLUSIONS

Accurate scaling, durability, and handling convenience are the important factors an experimenter must address in building models for snowdrift experiments outdoors. Details where the model meets the surface are extremely important. Construction methods that minimize damage from rough handling and allow quick relocation of models are essential for successful experiments under drifting conditions. Since photographs provide an important record of modeling experiments, good color contrast with snowdrifts should be part of the model's design.

REFERENCES

Jairell, Robert L. and Ronald D. Tabler. 1985. Model Studies of Snowdrifts Formed by Livestock Shelters and Pond Embankments. Proceedings, 53rd Annual Western Snow Conference (Boulder, Colo. April 16-18, 1985) pp. 167-170.

Peterson, Thomas. C. and R. A. Schmidt. 1984. Outdoor Scale Modeling of Shrub Barriers in Drifting Snow. Agricultural and Forest Meteorology, 31:167-181.

Tabler, Ronald D. 1980a. Geometry and Density of Drifts Formed by Snowfences. Journal of Glaciology 26(94):405-419.

Tabler, Ronald D. 1980b. Self-similarity of Wind Profiles in Blowing Snow Allows Outdoor Modeling. Journal of Glaciology 26(94):421-434.

Tabler, Ronald D. and Robert L. Jairell. 1980. Studying Snowdrifting Problems with Small-Scale Models Outdoors. Proceedings, 48th Annual Western Snow Conference (Laramie, Wyo. April 15-17, 1980), pp. 1-13.