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Technical Report

SNOW-COMPACTION EQUIPMENT — VIBRATORY FINISHERS

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SNOW-COMPACTION EQUIPMENT — VIBRATORY FINISHERS

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by

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OBJECT OF TASK

To investigate the feasibility of surface-hardening compacted snow by vibration and, if feasible, to develop vibratory finishers for this work.

ABSTRACT

Aircraft tests on compacted snow have shown that a harder wearing surface is required on snow compacted by depth processing. A special rolling technique improved the surface hardness, but a preliminary experiment on cold-dry polar snow indicated that vibration might produce a better surface. As a result, two types of construction vibrators were tested as surface finishers for compacted snow at winter test sites in the Sierras of California.

One of the units used in these tests was a 6180-pound flat-plate or shoe-type vibrator. It performed best at a travel speed of 80 feet per minute and a compacting frequency of 600 to 700 cycles per minute. The other unit was an 8100-pound rolling-type vibrator. It performed best at a travel speed of 300 feet per minute and a compacting frequency of 2000 cycles per minute.

Both units resulted in increased surface hardness of compacted snow within 16 to 36 hours after vibration. However, the warm-wet snow condition at the Sierra test site coupled with temperatures of 40 to 55 F and bright sunshine caused considerable daily decay in this hardness unless the test strips were insulated with a layer of sawdust.

It was concluded from the Sierra tests that vibration improves surface hardness in compacted snow but that investigations are needed on cold-dry snow to determine the magnitude and durability of this improvement on compacted snow in polar areas. It was also concluded that the apparent differences in the two types of vibratory finishers used on warm-wet snow were insufficient for selection of the more suitable type of finisher for further testing.

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INTRODUCTION

Polar icecaps are perennial snow fields. Most land and sea areas in these regions are also covered with light to moderate snow pack during the fall, winter, and spring. Techniques and equipment to utilize this snow as a building material for emergency and temporary roads, runways, and skiways could materially improve year-round operations in these regions.

The Navy first investigated the feasibility of producing static and dynamic load-bearing snow in 1947. Since then, cold-processing compaction techniques have been developed that will produce high-strength snow capable of supporting vehicles and aircraft on both annual and perennial snow fields. The basic equipment needed to do this includes a machine to pulverize and intermix (depth-process) the natural snow, and a large roller to compressively compact the pulverized mass. Other special equipment needed for compaction includes drags, planers, and finishers.

This report covers an investigation of two types of vibratory finishers for attaining a hard-wearing surface on compacted snow. One was a shoe-type finisher which transmitted the vibrations to the snow through a flat steel plate. The other was a rolling-type finisher which transmitted the vibrations through a rolling steel drum.

HISTORICAL BACKGROUND

In February 1947, during Operation Highjump,[1] a snow airstrip was constructed on the Ross Ice Shelf, Antarctica, near Little America IV. The technique used for its construction was relatively simple. The sastrugi, or snow ridges on the surface which are formed by the wind, was rough-graded with a Canadian snow drag.[2] The graded area was then compressively compacted with a tractor and a pontoon drag. In addition to compaction, the pontoon drag produced a fairly smooth, level snow surface.

Though the Highjump airstrip received a minimum of maintenance, it proved satisfactory for repeated landings of R4D aircraft on skis during February 1947. Near the end of February it was tested with an R4D on wheels, but the wheels broke through the compacted-snow mat. Regardless of this failure, which was attributed to nonuniformity of strength and an inadequate depth of compaction, the taxi test was sufficiently encouraging to warrant further investigation of snow as a construction material.

Following the Highjump Operation a cold-processing compaction technique employing depth processing followed by compressive compaction was developed for in-situ acceleration of the natural hardening processes occurring in snow. Special techniques developed during this period to improve the strength of compacted snow and to adapt its use to special conditions included: (1) precompaction of snow areas; (2) surface hardening of compacted snow; (3) maintenance of snow roads and runways; and (4) surface protection of compacted snow under high ambient temperatures and solar radiation.

During the development of these techniques a small vibrator was used experimentally for compacting snow on the Greenland Ice Cap.[3] Later, surface hardening of compacted snow with vibratory finishers was investigated at winter test sites in California.[4,5]

VIBRATORY FINISHING CONCEPT

The hardness of a compacted-snow mat on deep perennial snow is not uniform with depth. Instead, its hardness distribution with depth is parabolic, with the bulk of the hardness in the middle third of the mat (Figure 1). In the 1953 Greenland Trials[6] it was observed that the average hardness in the relatively soft top layer was only 150R, as compared to 600R for the entire mat thickness.* Aircraft tests in an air temperature of 15 F showed that the surface of the mat was easily damaged by traffic and was too soft for good mobility of the aircraft.

A snow-finishing drag with cylindrical bottom skids[7] was first used for improving the surface hardness of compacted snow. Finish dragging produced a smooth surface and doubled the hardness of the relatively soft top layer (150R to 300R). Aircraft tests, however, showed that the surface layer was still too soft to withstand repeated trafficking with heavy wheel loads.[3] Next the snow was rolled with a standard 13-wheel, pneumatic-tired roller[8] followed by the finishing drag. This treatment, in an air temperature of 10 F, increased the average hardness in the top layer to

* R is a snow hardness index obtained with the CRREL RAMMSONDE rod. This index has no true physical value but it does show the relative hardness of snow not only at the surface but also in depth.

over 600R within 24 hours. Much of the increase occurred 2 to 6 inches below the surface, but there was some increase in the top 2 inches (Figure 2). With this change in hardness, the test area of compacted snow easily supported a taxiing aircraft with tire inflation pressures of 90 psi in the main wheels and 100 psi in the nose wheel.

During these same trials[3] an experiment was conducted on the cold-dry granular icecap snow with a lightweight, flat-plate vibrator. It was found that vibration tended to increase the density and hardness of the natural, wind-packed snow to depths of 24 inches, but the largest increase was in the top 5 inches. This increase ranged up to 500 percent more than the hardness in the top 5 inches of natural snow. Further, the hardness in this 5-inch layer was more uniformally distributed with depth than that achieved by special rolling on the runway.

Based on these findings the following criteria were used to develop experimental vibratory finishers for surface-hardening compacted snow:

1. The finishers were to be single-element units of adequate size for effective surface coverage in large-scale tests.

2. The finishers were to be of suitable design for easy tow and maneuverability.

3. The contact surface of the finishers was to have a smooth finish.

4. The vibration frequency was to be variable within reasonable limits through control of the driving force.

5. The compacting energy, or impact force, was to be variable within reasonable limits through control of the vibrating mass.

SHOE-TYPE FINISHER

The first vibratory finisher developed for surface-hardening compacted snow employed a vibrating mechanism mounted on a flat-bottomed steel plate or shoe. This unit was tested and evaluated between 1956 and 1959 at winter field sites in the Sierras of California.[4,5] Its functional performance was progressively improved by modifications during these tests. The commercial components and accessories for the finisher are identified in a supplement to this report, designated "For Official Use Only."

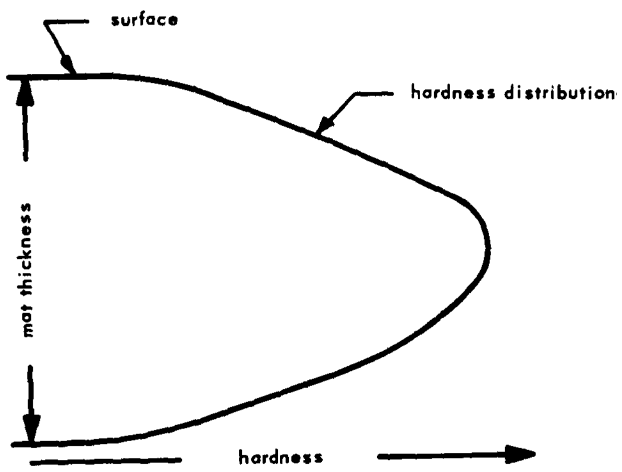

Figure 1. Normal hardness distribution in compacted snow.

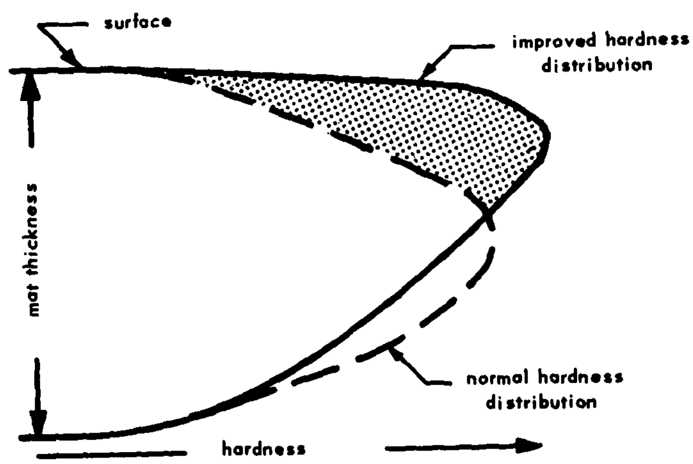

Figure 2. Improved hardness distribution in compacted snow after special rolling.

Development

The shoe-type vibratory finisher was initially designed by a manufacturer of road-building equipment. Modifications to improve the finisher were accomplished by the Laboratory. Its final design is detailed in Y&D Drawings 943610 and 943611.

As designed by the manufacturer, the finisher consisted of a pan, side-pan extensions, a surface cutter, a vibrator, a variable-speed electric motor, and a cable bridle with a shock-absorber hitch. The finisher was 3 feet 8 inches long, 8 feet wide without the side-pan extensions, and 1 foot high. With the side-pan extensions it was 10 feet wide. Its net weight with vibrator and motor was 3300 pounds. The ground-contact area was 21.36 square feet for the 8-foot width and 26.70 square feet for the 10-foot width.

The pan and side-pan extensions were open-top welded steel boxes fabricated from 3/8-inch-thick mild-steel plate. The side-pan extensions were attached to the pan with bolts. The leading edge of the pan was curved upward on a 1-foot radius to form a bow angle of 55 degrees. An adjustable cutter blade, which projected at a 30-degree angle to the surface to remove surface irregularities during vibration, was mounted under the bow. The cable bridle was attached to pad eyes welded to each end of the leading edge of the main pan section.

The vibrating mechanism, a 300-inch-pound unit with counter-rotating eccentric weights, was located in the exact center of the ground-contact area. The vibrator was driven with a 5-hp, variable-speed electric motor through a manually operated clutch. With this arrangement the speed of the eccentric-weighted vibrator shaft could be varied from 438 to 1750 rpm.

In the initial test of the finisher at a winter field site in 1956 (Figure 3) it was found that:

1. The side-pan extensions were ineffective.

2. The surface cutter coupled with the steep bow angle caused digging and slabbing of the snow ahead of the finisher. Furthermore, the cutter caused excessive surface damage.

3. The variable-speed electric motor was too delicate for sustained vibration. It failed after only 15 hours of operation.

4. The cable bridle was continually slipping and pulling loose.

5. The mass of the finisher, even when loaded with odds and ends of ballast, was too light for effective vibratory compaction. Furthermore, the loose ballast was continually shifting.

Figure 3. 1956 field trials of shoe-type finisher.

Between the 1956 and 1957 winter test seasons the following modifications were made to the finisher:

1. The side-pan extensions were discarded.

2. The surface cutter was discarded and a new leading edge was added to provide a better bow angle.

3. The variable-speed electric motor was replaced with a hydraulic motor.

4. The cable bridle was replaced with a chain bridle.

5. A 1/2-inch-thick mild-steel plate was added to the bottom of the finisher to increase its mass weight.

For the 1957 winter field tests the modified finisher weighed 4290 pounds. In these tests it was found that additional improvements were needed. These included:

1. Relocating the point of tow from the bow to a point near the transverse centerline (Figure 4) to permit sufficient freedom under tow for the entire bottom of the finisher to contact the surface.

2. Providing additional ballast to improve the balance and increase the mass weight of the finisher, and furnishing tie-downs for this ballast.

Description

A schematic of the shoe-type vibratory finisher in its final design is shown in Figure 5. As modified it consists of a pan, a vibrator, a hydraulic motor, ballast, and a drawbar assembly. In addition, two power sources are provided to energize the hydraulic motor. One is through the hydraulic system of the Navy dual-rail snow tractor[9] and the other is with a portable hydraulic power-pack unit (Appendix).

Figure 4. Fabricating drawbar yoke for shoe-type finisher.

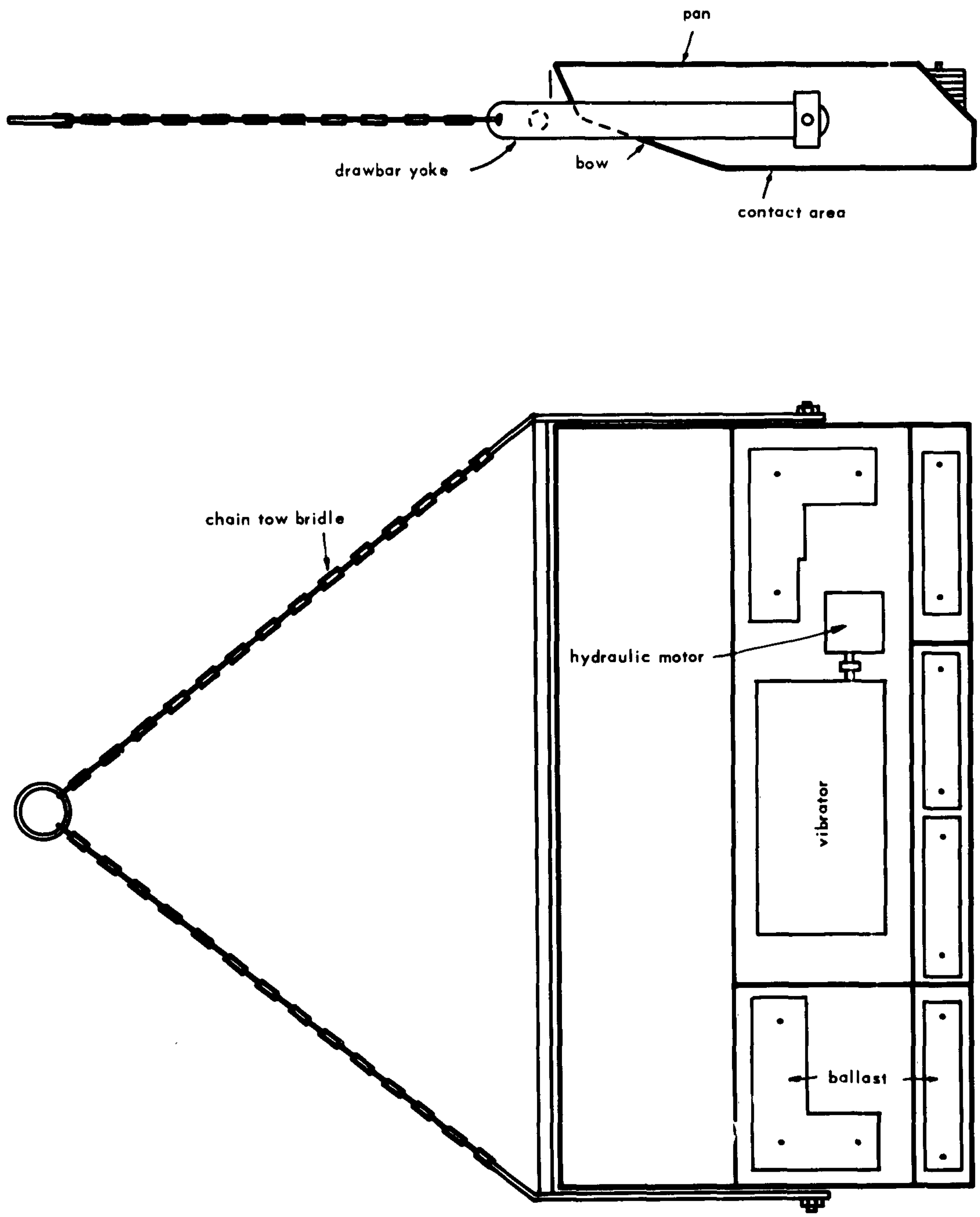

Figure 5. Schematic of final design for shoe-type vibratory finisher.

The net weight of the modified finisher (Figure 6) is 4080 pounds; when balanced with steel-plate ballast, its total weight is 6180 pounds. It is 4 feet 4-1/2 inches long, 8 feet 3 inches wide, and 1 foot 1/2 inch high. Its ground-contact area is 21.36 square feet. The leading edge of the finisher has an initial bow angle of 20 degrees and a final bow angle of 65 degrees. This combination of angles was used to obtain a proper approach angle to prevent digging and slabbing of the snow[10] and at the same time to reduce the overall length of the bow.

Except for the bow, the pan is essentially an open-top welded steel box made of mild-steel plate. The bottom of the pan under the ground-contact area is 7/8 inch thick (laminated from 1/2-inch and 3/8-inch plate) and under the bow it is 1/2 inch thick. The sides, back, and stiffeners are 3/8 inch thick. The bow section is covered with 1/8-inch plate. This cover was added to prevent an accumulation of snow and ice in the bow.

The original vibrating mechanism, a 300-inch-pound unit with counter-rotating eccentric weights, was retained. It is located in the exact center of the ground-contact area and is bolted to a laminated 2-inch-thick mild-steel base which in turn is bolted to the bottom of the pan. Stud bolts are used for these connections.

Figure 6. Shoe-type vibratory finisher.

A 7.7-hp hydraulic motor is used to drive the vibrating mechanism through a flexible coupling. With this arrangement the speed of the eccentric-weighted vibrator shaft can be varied from 380 to 1000 rpm. The motor is mounted to the right of the vibrator (Figure 3). Two 20-foot lengths of 3/4-inch and one 20-foot length of 1-inch low-temperature hydraulic hose are provided to energize the motor from an outside source. The 3/4-inch hose is used on the return side of the motor and the 1-inch hose is used on the pressure side.

Ballast is used to balance the finisher and increase or decrease the compacting energy. Five pockets are provided for this ballast. They are located to the right and left of the vibrator and along the rear of the pan (Figure 5). The ballast, which is made of precut sections of 1/2- and 1-inch mild-steel plate, is secured to the pan with stud bolts. The total weight of the precut ballast is 2100 pounds.

The drawbar assembly consists of a rigid yoke and a two-leg chain bridle. The yoke arms are made of mild-steel bar stock and the spreader bar is made of black steel pipe. This welded assembly is attached to the pan just forward of the transverse centerline of the ground-contact area. To permit rotation, the yoke is attached to the pan with 3/4-inch-diameter steel pins. The bridle is made of 5/8-inch-diameter close-link chain. It is attached to the arms of the yoke with clevises and, when extended, its draw ring is about 5 feet 3 inches from the bow of the pan.

On short hauls the shoe-type finisher and its portable hydraulic power-pack unit can be shipped by truck or rail without crating or disassembly. For this type of shipment the finisher with ballast weighs 6180 pounds and occupies 110 cubic feet, and the power-pack unit weighs 2030 pounds and occupies 55 cubic feet. Packaging the finisher for overseas shipment increases its weight to 7240 pounds and its cube to 186 cubic feet. Packaging the power-pack unit increases its weight to 2523 pounds and its cube to 123 cubic feet.

Based on 1959 prices the cost of the shoe-type finisher complete with ballast is about $5000. The cost of a portable hydraulic power-pack unit is about $2000, and the cost of installing a hydraulic take-off at the rear of the Navy dual-rail snow tractor is about $200.

Performance

As originally designed the electrically driven shoe-type vibratory finisher required a 3-phase, 60-cycle, 220-volt electrical power source for operation. A 15-kw portable electric generator mounted on a toboggan was used for this purpose in the 1956 field tests. The toboggan, located between the tow tractor and the finisher (Figure 7), impeded maneuverability of the finisher. When the electric motor failed after 15 hours of vibration, it was replaced with a hydraulic motor. A portable hydraulic power-pack selected to energize this motor (Appendix) was mounted on a snow-finishing drag[7] instead of the toboggan. The finishing drag was placed ahead of the vibratory finisher (Figure 8) to form a tandem tow 22-1/2 feet long. The change in power-pack carriers resulted in considerable improvement in maneuverability of the finisher, and the drag removed minor surface irregularities before vibration. In straight-line travel over fairly flat surfaces the two units tracked well and towed easily, but on turns the finisher drifted to the outside of the curve and on rolling surfaces it drifted with the slope.

With the hydraulic motor the vibration frequency of the finisher ranged from 380 to 1000 cycles per minute (cpm). The lower frequency was controlled by the minimum pressure and volume of fluid required to keep the hydraulic motor rotating and the upper frequency was limited by the output of the hydraulic power sources.

Figure 7. Transporting generator on toboggan for 1956 test of shoe-type finisher.

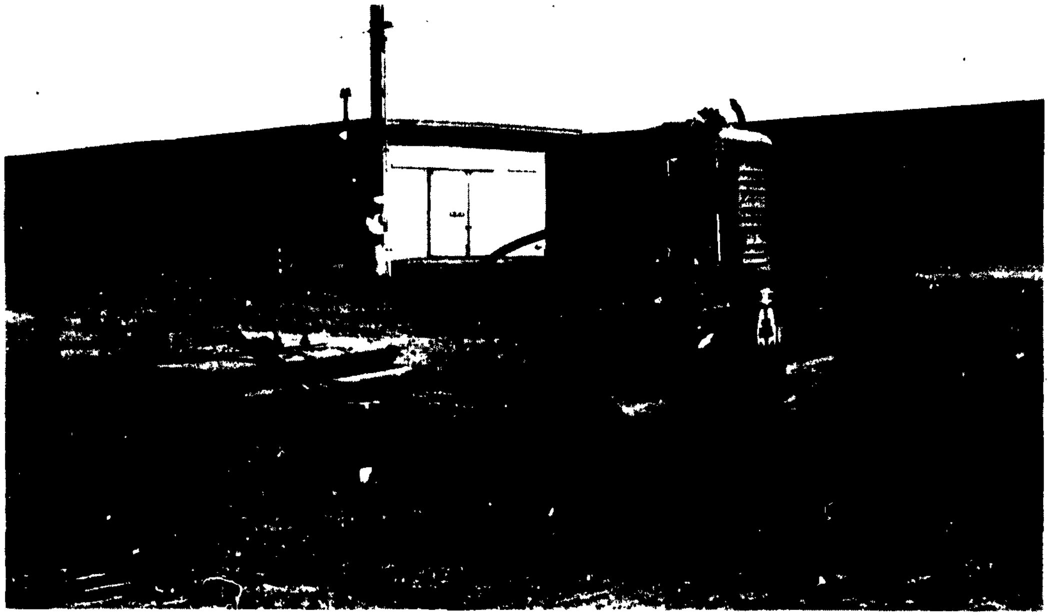

Figure 8. Tandem hook-up of finishing drag (with hydraulic power pack) and shoe-type finisher.

After the finisher was properly balanced in 1957 it weighed 6180 pounds. At this weight field tests on compacted snow showed that the finisher worked best at a travel speed of about 80 fpm and a vibration frequency of 600 to 700 cpm. At a faster travel speed or slower frequency it produced a rippled surface, and at a higher frequency (715 cpm and up) it bounced off the surface.

Tests to determine the effectiveness of the finisher for surface-hardening compacted snow were hampered by the diurnal freezing-thawing cycle and warm-wet snow conditions at the test sites. Except on infrequent days of total cloud cover or below-freezing temperatures, the surface of the compacted snow softened daily to a depth of 4 to 6 inches. Consequently, observations on surface-hardness growth as a result of vibration were usually limited to periods of 16 hours or less.

In the 1958 field tests a small area was compacted to a depth of 16 inches by depth processing followed by compressive compaction. Five days of continuous above-freezing temperatures delayed hardening in the compacted snow but an overnight temperature of 25 F on the sixth day resulted in some hardness growth. The distribution of this hardness with depth is shown as a solid line in Figure 9.

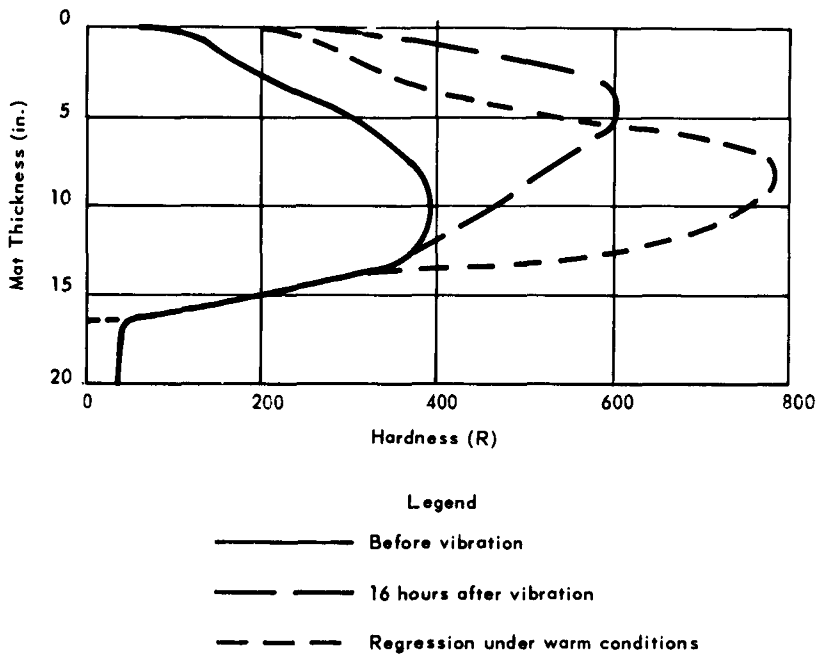

Figure 9. Distribution of hardness growth in compacted snow after treatment with shoe-type vibratory finisher.

Late in the afternoon of the same day the compacted area was treated with five snow-compacting roller passes and two shoe-type vibratory finisher passes. The following morning, or 16 hours later, after an overnight temperature of 20 F the average hardness in the top 5 inches of compacted snow had increased 145 percent (197R to 483R), as compared to an average hardness growth of 30 percent (324R to 418R) in the bottom 11 inches, and 57 percent (281R to 440R) in the total 16-inch thickness. The curve depicting this redistribution and increase in hardness 16 hours after vibration is shown as a long-dashed line in Figure 9.

On the following day, after an overnight temperature of 25 F, the weather was bright and clear and the air temperature reached 50 F before noon. Examination of the test area in early afternoon (46 hours after vibration) showed that the average hardness in the top 5 inches of compacted snow had regressed 26 percent (483R to 360R). Even so, the average hardness had increased 35 percent (418R to 565R) in the bottom 11 inches, for a net increase of about 13 percent (440R to 496R) in the total 16-inch thickness. The curve depicting the regression of hardness in the top 5 inches after several hours of warm temperatures and solar radiation is shown as a short-dashed line in Figure 9.

Other tests on compacted snow with the vibratory finisher during the 1958 field season showed similar results. With nocturnal below-freezing temperatures the normal growth of hardness was fairly uniform in the lower layers of compacted snow, but overnight increases in surface hardness decayed on clear, warm days.

ROLLING-TYPE FINISHER

The second type of vibrating finisher used for surface-hardening compacted snow was a vibrating steel drum. This unit was tested and evaluated in 1959 at a winter field site in the Sierras of California.[5] The commercial components and accessories for the finisher are identified in a supplement to this report, designated "For Official Use Only."

Description

The rolling-type vibrating finisher, illustrated in Figures 10 and 11, consists of four main parts: the roller, the vibrating mechanism, the frame, and the power package. The total weight of the finisher is 8100 pounds. It is 12 feet 4 inches long, 7 feet 5 inches wide, and 5 feet 6 inches high. The drum, or roller, is 4 feet 3 inches in diameter and 6 feet wide. It is mounted on a free-turning axle and houses the vibrating mechanism.

Vibration is obtained by loading the axle with two 50-pound eccentric weights, which are attached to the axle inside the roller adjacent to each end. The axle is belt-driven by the power supply.

The frame, of box-type construction, is underslung from the axle by rubber-shock-mounted bearings. The axle is free-turning in these bearings. The forward position of the frame tapers to an adjustable hitch; the rear frame member supports the power package.

The power package consists of a 6-cylinder, liquid-cooled gasoline engine, rated at 59 hp at 1800 rpm. It drives the vibrating mechanism through a manually operated clutch and a spring-loaded, centrifugal-type, automatic clutch. The manual clutch is used to disconnect the engine from the drive line; the automatic clutch prevents the vibrating mechanism from operating until the engine speed exceeds 800 rpm. The belt drive between the automatic clutch and the axle has a ratio of 1:1.29. With this arrangement the vibrating frequency of the roller can be varied from 1290 to 2320 cpm by changing the engine speed.

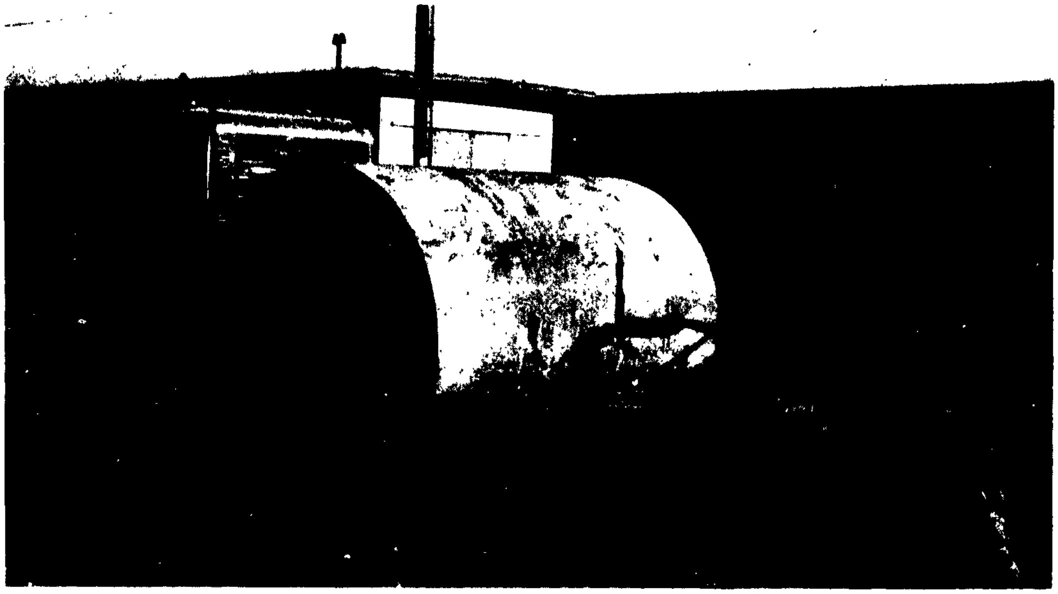

Figure 10. Front of rolling-type vibratory finisher showing roller, frame, and adjustable hitch.

Figure 11. Rear of rolling-type vibratory finisher showing power unit and drive line.

On short hauls the finisher complete with its power unit can be shipped by truck or rail without crating or disassembly. For this type of shipment it weighs 8100 pounds and occupies 529 cubic feet. For overseas shipment the power unit is removed and shipped separately from the roller. The roller without the power unit weighs 7410 pounds and occupies 487 cubic feet. The power unit packaged for overseas shipment weighs 830 pounds and occupies 33 cubic feet. Both packages weigh a total of 8240 pounds and occupy 520 cubic feet.

Based on 1959 prices the cost of the rolling-type finisher is about $10, 500.

Performance

For tow, the finisher was coupled directly to the tractor (Figure 12). With this arrangement it was very maneuverable. It followed directly behind the tractor on all types of surfaces and showed no tendency to drift or slew on turns or side slopes. A remote throttle control for the vibrator power unit was mounted on the tractor cab (Figure 12) so that the operator could reduce the engine speed and thus disengage the vibrating mechanism when stopping, to prevent the roller from digging in while standing. Tests showed that the roller worked best at a travel speed of 300 fpm and a vibration frequency of 2000 cpm. At a faster travel speed and a slower frequency it produced a textured surface; at a slower speed and a higher frequency (2100 cpm and up) it bounced off the surface.

Figure 12. Rolling-type vibratory roller hooked up to tractor. Note remote throttle control on tractor cab.

To reduce the normal daily surface-hardness decay in the vibrated test strips, the strips were covered with a 1/2-inch layer of sawdust after vibration. As a result, observations of hardness growth in the top layer of compacted snow were possible with some degree of reliability for about 72 hours. After that, ice began to form under the sawdust.

Observations on a roller-vibrated test strip are shown in Figure 13. At the time of vibration the 16-inch layer of compacted snow was 40 hours old. Its average hardness was 158R in the top 5 inches, 220R in the bottom 11 inches, and 200R in the total 16-inch thickness. Almost immediately after one pass of the vibrating roller the surface of the compacted snow began to disintegrate and within a few hours in an air temperature of 10 F the top 4 inches of snow attained a structure and consistency similar to that of popcorn. Observations 12 hours after vibration showed that the average hardness in the top 5 inches had regressed about 32 percent (158R to 107R). Even so, the average hardness had increased about 50 percent (220R to 331R) in the bottom 11 inches, for a net increase of about 28 percent (200R to 256R) in the total 16-inch thickness.

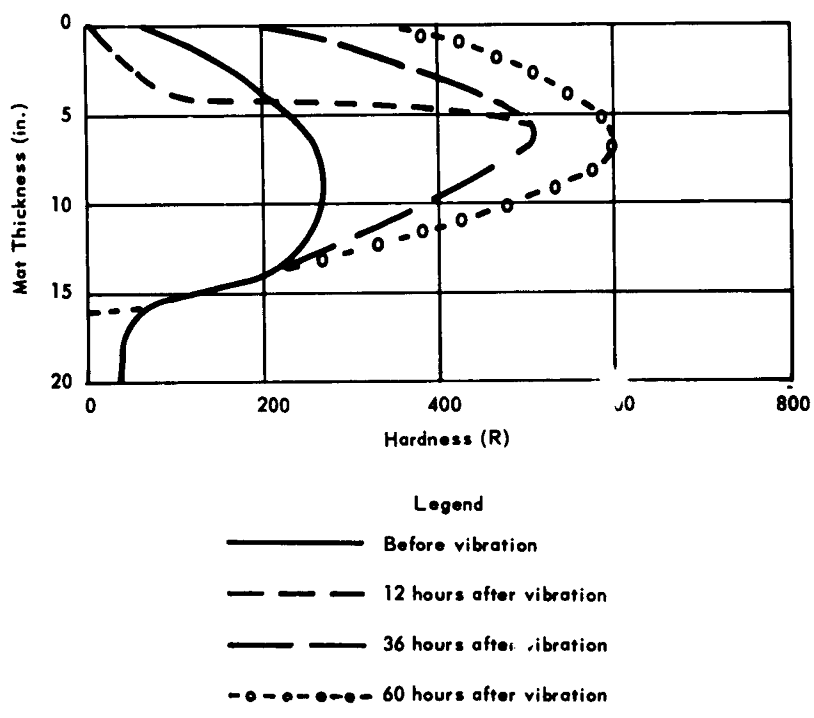

Figure 13. Distribution of hardness growth after treatment with rolling-type vibratory finisher. Sawdust cover used for insulation.

Within the next 24 hours the top 5 inches of snow had reconsolidated, and 36 hours after vibration its average hardness had increased 240 percent (107R to 363R) over that observed 12 hours after vibration, or 130 percent (158R to 363R) over that observed before vibration. During this same period the average hardness had increased only 2 percent (331R to 338R) in the bottom 11 inches, but the net increase was about 35 percent (256R to 346R) in the total 16-inch thickness.

After another 24-hour period, or 60 hours after vibration, the average hardness in the top 5 inches had increased an additional 34 percent (363R to 485R), or 207 percent (158R to 485R) over the hardness observed before vibration. During this same period the average hardness had increased about 19 percent (338R to 403R) in the bottom 11 inches, for a net increase of 25 percent (346R to 431R) in the total 16-inch thickness. During this 60-hour period of observation the high day temperatures ranged from 40 to 55 F and the low night temperatures from 10 to 15 F.

Other tests on compacted snow with the rolling vibrator during the 1959 field season showed similar results. There was a rapid decay of hardness in the top 4 to 5 inches of compacted snow soon after vibration, with recovery and improvement during the next 36 hours.

FINDINGS

1. The diurnal freezing-thawing cycle and warm-wet snow conditions at the test sites prevented positive evaluation of the vibratory finishers for surface-hardening compacted snow.

2. Tests with the shoe-type finisher showed a favorable overnight trend toward improved hardness in the top 5 inches of compacted snow; but decay of the surface hardness, because of warm weather, on the days following vibration prevented prolonged observations of this trend. Functionally the shoe-type finisher was:

    a. Relatively easy to operate.

    b. Limited to good performance only on straight tows over relatively flat areas, as it tended to drift on turns and side slopes.

    c. Most effective at a travel speed of 80 fpm and a vibration frequency of 600 to 700 cpm.

3. Tests with the rolling-type finisher showed a favorable trend with time toward improving the hardness in the top 5 inches of compacted snow; but the use of protective covers of sawdust over the test strips to prolong observations prevented a true evaluation of its effectiveness as a surface hardener for compacted snow. Functionally the rolling-type finisher was:

   a. Easy to operate.

   b. Maneuverable on all types of surfaces, with no tendency to drift on turns and side slopes.

   c. Most effective at a travel speed of 300 fpm and a vibration frequency of 2000 cpm.

CONCLUSIONS

1. Investigations on warm-wet snow indicated a favorable trend toward improving the surface hardness of compacted snow by vibration, but tests are needed on cold-dry snow to evaluate its positive effectiveness for this purpose under polar conditions.

2. Both the shoe-type and rolling-type finishers should be used in any further investigations on surface-hardening cold-dry snow, as the apparent differences observed on warm-wet snow are insufficient for selection of the more suitable type of finisher at this time.

RECOMMENDATION

It is recommended that further investigations on the surface-hardening of compacted snow by vibration be conducted on cold-dry snow.

ACKNOWLEDGMENTS

The authors are indebted to the many military and civilian Navy personnel and contractor personnel who assisted in the development and testing of the vibratory finishers.

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Appendix

ENERGIZING THE HYDRAULIC MOTOR ON THE SHOE-TYPE VIBRATORY FINISHER

The hydraulic motor on the shoe-type vibratory finisher is rated at 7.7 hp at 1800 rpm, and 24.4 gpm of hydraulic fluid at 1000 psi. Two alternate methods were developed to energize this motor. One was with a hydraulic power take-off on the Navy dual-rail snow tractor;[9] the other was with a portable hydraulic power-pack unit that could be mounted on the finishing drag.[7]

The dual-rail snow tractor developed by the Laboratory was fitted with a front-mounted hydraulic unit for operating its bulldozer blade. This unit included a 43-gpm pump which operated at a pressure of 1000 psi. The tractor was also fitted with two sets of rear-mounted hydraulic power take-offs (Figure 14). One set was for direct operation from the pump and the other was for operation in conjunction with the bulldozer blade. Both were standard accessories modified for quick couplings. This modification was made by replacing the steel tubing through the tractor cab with 1-inch-diameter, double-strength pipe and fitting the terminal ends of the pipes with quick-disconnect nipples.

Figure 14. Hydraulic power take-off sets at rear of low-ground-pressure snow tractor.

Criteria for the portable hydraulic power-pack unit to energize the motor were:

1. It was to be skid-mounted and fitted with lifting eyes.

2. It was to be driven with a liquid-cooled, winterized, 1400-rpm, 20-hp gasoline engine fitted with a power take-off controlled by a hand-operated clutch.

3. The hydraulic package, designed to deliver 26 gpm at 1000 psi, was to include a hydraulic pump, a flow-control valve with an integral relief valve, a 60-gallon-capacity reservoir, and all necessary piping and other fittings for continuous operation.

4. The gasoline engine and the hydraulic pump were to be connected with a flexible coupling.

5. The power take-off ports were to be fitted with quick-disconnect nipples.

The power pack (Figure 15) selected by this criteria was 4 feet 9 inches long, 2 feet 6 inches wide, and 4 feet 8 inches high. It weighed 2030 pounds and was designed for hoisting with a forklift or a boom. Packaged for shipment, it weighed 2523 pounds and occupied 123 cubic feet. Components used in the power pack are identified in the supplement to this report, designated "For Official Use Only."

Figure 15. Portable hydraulic power-pack unit.

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