GUIDE TO THE TEXTURING OF CONCRETE BRIDGE DECKS

by

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INTRODUCTION

Skid resistance is recognized as a most important factor in the safety of a road or bridge deck. In fact, the loss of skid resistance under traffic wear may require the overlaying of a sound bridge deck or the cutting of grooves in the riding surface at considerable expense. Recognizing that wear caused by increased traffic volumes on the interstate system was diminishing the skid resistance of concrete pavements and bridge roadways, personnel from the Research Council and the Department of Highways & Transportation performed a study to develop a specification for a more durable surface texture.(1) It was recognized that a combination of surface drainage to prevent hydroplaning and a harsh surface texture was needed.

Evaluations of the skid resistance, durability, noise, and roughness of a variety of surface textures were used as the basis for selecting those finishes now included in the Department's Road and Bridge Specifications.(2) Section 404.19(f) of the specifications allows two alternative configurations of grooves or striations in the deck surface. While the specifications use only the term "grooves", currently accepted terminology uses "striations" to refer to channels impressed into the plastic deck concrete and "grooves" to refer to channels sawed into hardened concrete. In either case, the end product should meet the following specification.

> Bridge decks which are to serve as the riding surface shall receive a good grooved texture. Prior to grooving, multiple-ply damp fabric shall be dragged over the deck surface to provide a gritty texture on the ridges between the grooves. The bridge deck finished surface shall be textured with uniformly pronounced grooves approximately 1/8 in. deep by 1/8 in. wide on approximately 3/4 in. centers and transverse to the bridge centerline, or with a combination

of uniformly pronounced grooves approximately 1/8 in. deep by 1/8 in. wide on approximately 3/4 in. centers and longitudinal to the bridge centerline and additional 1/8 in. deep by 1/8 in. wide grooves on approximately 3 in. centers and transverse to the bridge centerline. The surface texture shall extend to within 12 inches of the parapet wall or curb line.

Methods for attaining the required finishes were not a part of the evaluations conducted, and, properly, were not incorporated into the specification. Instead, the development of texturing devices was left as the contractor's option to encourage innovation. Problems have been encountered in attaining the desired finish, however, and in several instances texturing devices have failed to produce striated surfaces conforming to the specifications. More seriously, in some instances confusion as to when to initiate the striating operation appears to have delayed the application of a curing compound. Section 404.13 of the Road and Bridge Specifications requires the initiation of an approved curing method before the sheen disappears from the surface of the fresh concrete. Failure to apply the curing compound or polyetheylene sheeting at the proper time can have adverse effects on deck durability that far outweigh the failure to obtain the desired surface texture.

As part of an effort to provide some guidelines, it was suggested that the Research Council evaluate decks finished to the current specifications and report on the most promising means of attaining the desired deck surface.

PURPOSE AND SCOPE

The purpose of the study was to inspect decks built under the current specification to determine the procedures and precautions required in the finishing operations to attain a properly striated and textured roadway surface. The subject report is the first to be issued in the study.

The inspections included measurements of the width and spacing on centers of the striations and of their depth at a minimum of 25 points using a tired tread gage. The consistency of the depth and spacing of the pattern and the presence of any significant areas of shallow striations or areas indicating finishing problems were also noted.

The overall evaluation was supplemented by skid resistance measurements using one of the Department's skid trailers, with both treaded tires in accordance with ASTM E274-79[3] and bald tires meeting ASTM Specification E524-82[4] at the specified test speed of 40 mph. These two tires represent the spectrum of tire conditions found on vehicles using the highways, and the bald tire is more sensitive to the drainage provided by the grooves. Virginia strives to maintain skid numbers of 30 or greater for treaded tires and 25 or greater for bald tires.

The findings in this report are based on limited data. Requests for candidate structures for the inspections indicated that relatively few suitable bridges were available. To date, 13 bridges have been included in the study, but only 6 of these have been skid tested because the others were not open to traffic. These bridges, and others that may be added, could be evaluated in the future to complete the study. A further limitation is that, since the texturing specification is relatively new, the effect of traffic wear over a substantial period of time could not be measured. Skid resistance data from tests with treaded tires at 40 mph in the traffic lanes of interstate highway bridges, obtained routinely as part of another program, were available to indicate the effect of wear on earlier bridge deck textures.

In summary, this initial report must be viewed as an attempt to disseminate useful data in an early stage of a research effort. Discussion of the findings, additional information on texturing methods, and new bridges for evaluation will be welcomed.

RESULTS

Five bridges which received complete evaluations, including both inspection and skid testing, provided an indication of the relationships between the textures obtained by various means and skid resistance. These are discussed under the subheads which follow. Other bridges, though not skid tested, were included to provide a more complete range of finishing techniques. Among these is a structure having sawed grooves that will be skid tested after it is opened to traffic.

Route 60 Bridge Over Pedlar River, Amherst County

The deck on this bridge was textured using the "Flexi-Glide Tine" shown in Figure 1 (all figures are appended). The transverse striations are 1/8 in. wide and spaced 3/4 in. on center. The measured depths were reasonably consistent, ranging from 3/32 to 9/32 in., with an average of 6/32 in. The depth readings were probably increased by the heavy surface texture shown in Figure 2. There was one area of shallow striations in which the depth averaged only 1/16 in. In general, however, the deck finish, regularly spaced striations with heavy texture, looked good and was in compliance with the specifications.

Average skid numbers were 61 for the treaded tire and 62 for the bald tire. The excellent rating with the bald tire is due to the drainage provided by the striated texture. Some wearing of this texture under traffic would be expected, but it should prove to be durable finish.

Route 604 Bridge Over South Fork of the Holston River, Washington County

The deck on this bridge was textured using a tine similar to the "Flexi-Glide," but manufactured by the Bidwell Company. The transverse striations showed some variance in spacing, as in Figure 3, but were acceptably close to the specified distance of 3/4 in. In the center span of the 3-span bridge the average depth was 5/32 in., but there were extreme variations in the depths with some striations approaching scratch marks, possibly due to operator inexperience. The variance in depth along the length of the striation, Figure 4, may indicate that the tines were too flexible. There was acceptable texture between the grooves, though less than on the Pedlar River bridge.

Skid numbers were 53 with the treaded tire and 46 with the bald tire. These values, especially those for the bald tire, are quite high.

Route 718 Bridge Over Laurel Creek, Washington County

The deck on this bridge was textured with beveled metal wheels on a rod. As would be expected, the spacing between the striations was consistent at 3/4 in., but their depth was seldom 1/8 in. and in many places was less than 1/16 in. Widths were less than 1/8 in. over most of the deck. As indicated by Figure 5, a close view of the surface, there was a generally light texture betwen the striations. There was evidence that problems were encountered in the finishing operations, so it is possible that the surface may not represent the potential of the beveled wheel device. It has been employed successfully under more controlled conditions in the plant fabrication of concrete tee-beams.

In spite of the fact that the job did not meet the specifications, the skid numbers, which varied widely between lanes, were acceptable. Skid numbers in the southbound lane were 50 (treaded tire) and 39 (bald tire), while those on the northbound lane were 51 (treaded) and 50 (bald). The cause of the high values in the northbound lane, which are suspect, is unknown at this time. However, all of the values, even the bald tire value of 39, are still quite good.

Route 220 (SBL) Bridge Over Route 419, Roanoke

The striations in the roadway surface on this bridge, Figure 6, were formed with a leaf rake. The spacing was generally consistent but greater than specified, the average being about 1 1/4 in. The striations were consistently 1/4 in. wide, with an average depth of 1/8 in. There were few areas of shallow depth, but the depths varied along the length of the striations. There was pronounced, though not harsh, texture between the striations.

Skid numbers were again very good, averaging 47 for the treaded tire and 30 for the bald tire.

Route 220 (NBL) Bridge Over Route 419, Roanoke

This deck was not finished to meet the current specifications. Instead, as shown in Figure 7, its finish was made up of generally closely spaced scoring commonly 1/8 in. wide with an average depth of 1/8 in. The resulting texture was harsh, resembling a surface dragged with astroturf.

Skid numbers averaged 44 for the treaded tire and 45 for the bald tire.

Route 619 Bridge Over Stony Creek, Scott County

The striations in the deck of this bridge were formed with a tine made up of welding rods welded to a reinforcing bar, Figure 8. The spacing of the striations shown in Figure 9 varied from 3/4 in. to 15/16 in., but it generally matched the required 3/4 in. The width was uniformly 1/8 in. The depth was generally consistent, averaging 1/8 in., but there were shallow areas throughout the deck. The striations waver as they cross the deck, but this should not affect the skid resistance. Longitudinal dragging provided a distinct texture between the striations.

Skid testing was not performed on this structure due to its remote location. However, results on the 5 bridges cited previously would indicate that the skid numbers would be acceptable.

Route 615 Bridge Over the Clinch River, Russell County

Striations were impressed in this deck by dragging a pan with raised ridges on its bottom, Figure 10, across the surface. The resulting finish, Figure 11, had striations 1/8 in. wide, regularly spaced at 3/4 in. The depth of a striation was reasonably consistent along its length, but the depth was sometimes less than 1/8 in. In the southernmost end span, the depth was often shallow and in some areas there were no striations.

A major disadvantage of this system is that the operator cannot vary the pressure on the pan to allow for differing consistencies between loads of concrete or for late texturing after set has begun. Some shallow striations may, therefore. be expected. In spite of the pan dragging over the deck, there was good texture between the striations.

No skid data are available, but initial readings for most of the bridge would be expected to be satisfactory.

Route 23 Bridge Over Route 74, City of Norton

This bridge is unusual in that the grooves were sawcut into the hardened concrete deck. The resulting grooves, Figure 12, were uniformly 3/4 in. apart and 1/8 in. wide. Unlike striations made by tines, the grooves pass through the coarse aggregate, and the only changes in depth with length are caused by variations in the surface elevations of the deck. There were small areas of shallow grooves 6 in. wide across the deck, possibly caused by differences in the elevation of the saw. The deck was dragged during construction, leaving good surface texture between the grooves.

The deck has not been skid rested because the approaches are not yet completed, but testing will be scheduled later. Sawing the grooves is an expensive procedure, but one which can produce a surface meeting the specification requirements.

Route 64 Bridges in Staunton District

The earlier study cited as reference 1 found that even a relatively harsh burlap-dragged surface was subject to substantial wear on heavily traveled highways. This was verified by the results of skid testing performed on 37 bridges on Route 64 in the Staunton District which were subsequently inspected. Skid testing was done only in the right-hand traffic lane, using treaded tires at a nominal speed of 40 miles per hour. The resulting skid numbers ranged from a high of 54 to a low of 33. As mentioned earlier, the minimum acceptable value is 30 for treaded tires.

These decks were finished in accordance with earlier specifications with relatively light, dragged textures, without striations. Low skid numbers were found to correlate with heavy wearing of the texture. The surface was smooth on those decks with skid numbers in the 30's, and occasionally coarse aggregate was exposed. Conversely, the high values usually correlated with relatively heavy dragging in a direction transverse to traffic flow.

GUIDELINES FOR DECK TEXTURING OPERATIONS

The skid numbers obtained in this study indicate that excellent skid resistance can be obtained when the specification for bridge deck finish is met. An acceptable level of skid resistance is possible initially, even with a less acceptable finish. Howver, as indicated by skid tests of old interstate bridges, deck surfaces are subject to significant wear and loss of texture. Every effort should, therefore, be made to obtain the two components of the specified finish: a harsh surface texture applied by dragging after screeding and striations of the proper size and spacing. In fact, research performed by the New York State Department of Transportation indicates that striations as deep as 3/16 in. may be desirable.[3] A full-size view of the Pedlar River bridge deck finish, which meets the Virginia specification, is provided in Figure 13 as a guide to the desired end product.

Two alternative patterns of striations are allowed by the specification: (1) a combination of longitudinal striations at 3/4 in. spacing with transverse striations at a 3 in. spacing, or (2) transverse striations, alone, at a spacing of 3/4 in. All contractors to date have elected to use the second alternative, and this seems a wise choice. In bridge deck construction, forming striations in two directions will require two separate operations, because the tines cannot be attached to the screed. This increases the chance that the concrete may be too hard for impressing the second set of striations to the proper depth, and it further delays the initiation of curing.

The following guidelines, based on experience to date, are provided to facilitate the finishing of bridge decks to meet Section 404.19(f) of the Road and Bridge Specifications.

1. There are two components to a successful striating operation: the proper tool and an experienced operator. Results to date indicate that the best product is obtained if a single operator is employed, because the procedure remains something of an art.

2. Dragging and striating should begin immediately after the deck is screeded to its final evaluation.

3. The device used to impress the striations into the concrete must allow the operator to vary the pressure on the deck surface. This is essential because the concrete varies in firmness from load to load and with time.

4. Experience indicates that a tined tool is probably the best means of obtaining the specified striation configuration. There are at least two commercially available tines that can be used successfully, the Flexi-Glide and Bidwell tools, and there is no reason that others cannot be developed by contractors.

5. The tines should contact the deck surfaces at a flat angle to impress the striations into the concrete as opposed to dragging the surface, because dragging pulls coarse aggregate particles to the surface. The tines should be stiff enough to allow the operator to exert sufficient pressure to impress striations of consistent depth.

6. Some close spacing of striations at the laps between passes of the tines and some failure to match striations across thd deck may occur. These are not critical, if there is a sufficient length of channel to allow water to escape from beneath the tires of crossing vehicles.

7. Finishing operations, including screeding, texturing, and striating of the deck, must be completed and curing compound applied as required by specifications before the sheen disappears from the concrete.

8. At present, it appears that an acceptable finish can be obtained, if due care is exercised, without resorting to expensive sawing operations.

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The subject research was suggested by W. T. Ramey, Bristol District bridge engineer, who supplied information on several of the structures included in the study. Additional information was provided by W. L. Sellars and L. L. Misenheimer, district bridge engineers at Lynchburg and Staunton.

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REFERENCES

1. Mahone, D. C., K. H. McGhee, J. G. G. McGee, and J. E. Galloway, "Texturing New Concrete Pavements," Virginia Highway & Transportation Research Council, Report No. VHTRC 77-R25, November 1976.

2. Virginia Department of Highways & Transportation Road and Bridge Specifications, July 1, 1982.

3. American Society for Testing and Materials, "Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire," ASTM E274-79, ASTM Annual Standards, Part 15, 1983.

4. American Society for Testing and Materials, "Standard Specification for Smooth-Tread Standard Tire for Special-Purpose Pavement Skid Resistance Tests, ASTM E524-82, ASTM Annual Standards, Part 15, 1983.

5. Grady, John C., and William P. Chamberlain, "Groove-Depth Requirements for Tine-Textured Pavements," paper presented at the 60th Annual Meeting of the Transportation Research Board, January 1981, Engineering Research and Development Bureau, New York State Department of Transportation, Albany.

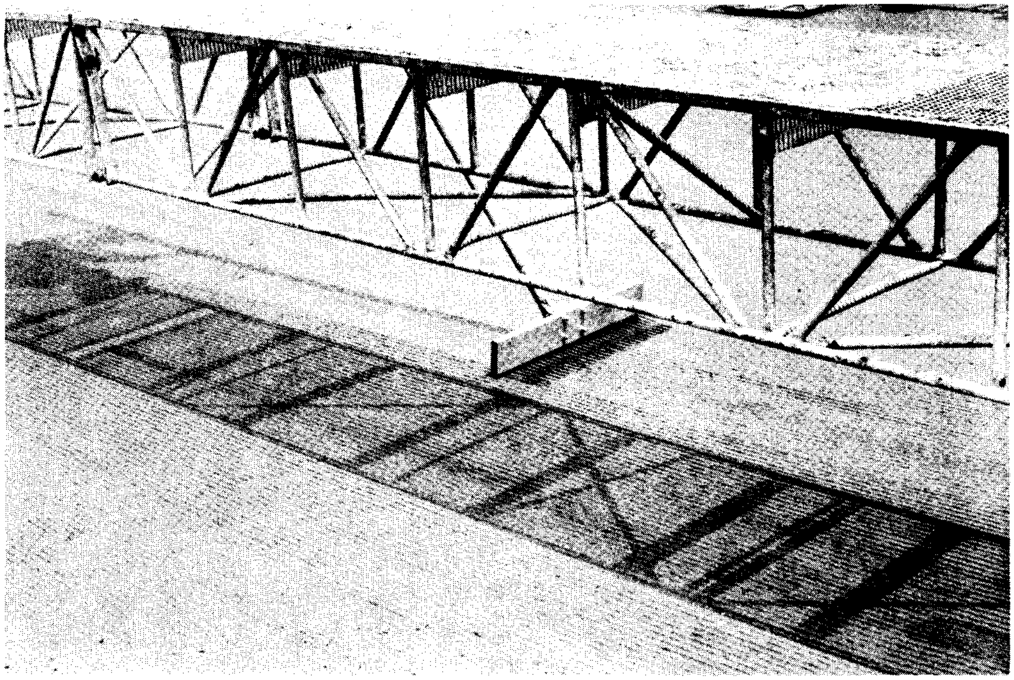

Figure 1 Flexi-Glide tine.

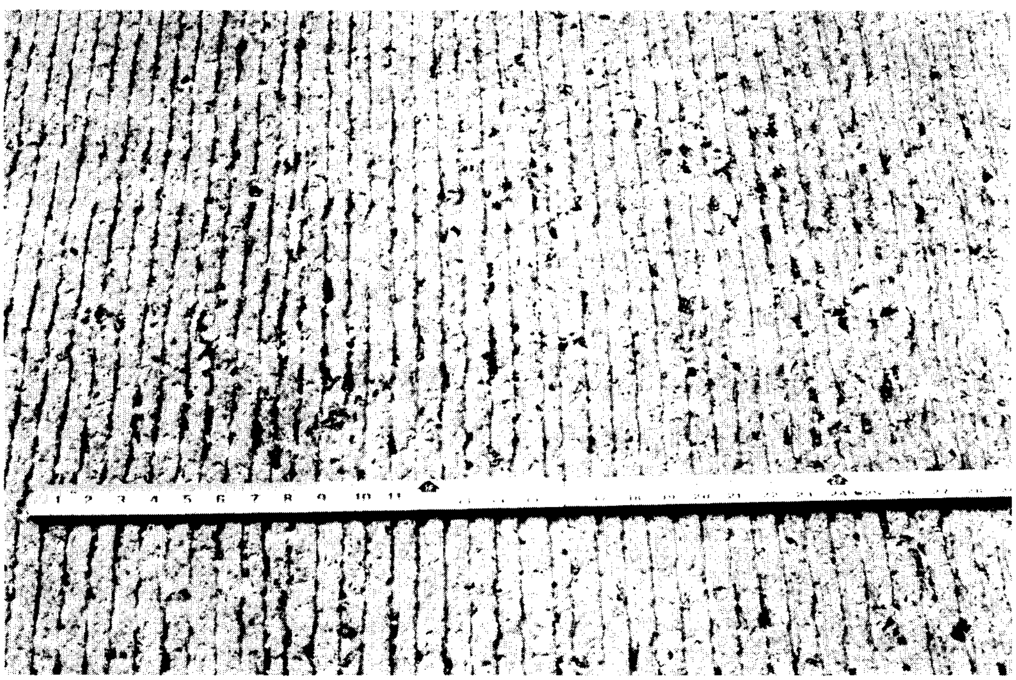

Figure 2 View of striations impressed by the Flexi-Glide tine. Note the harsh texture between the striations.

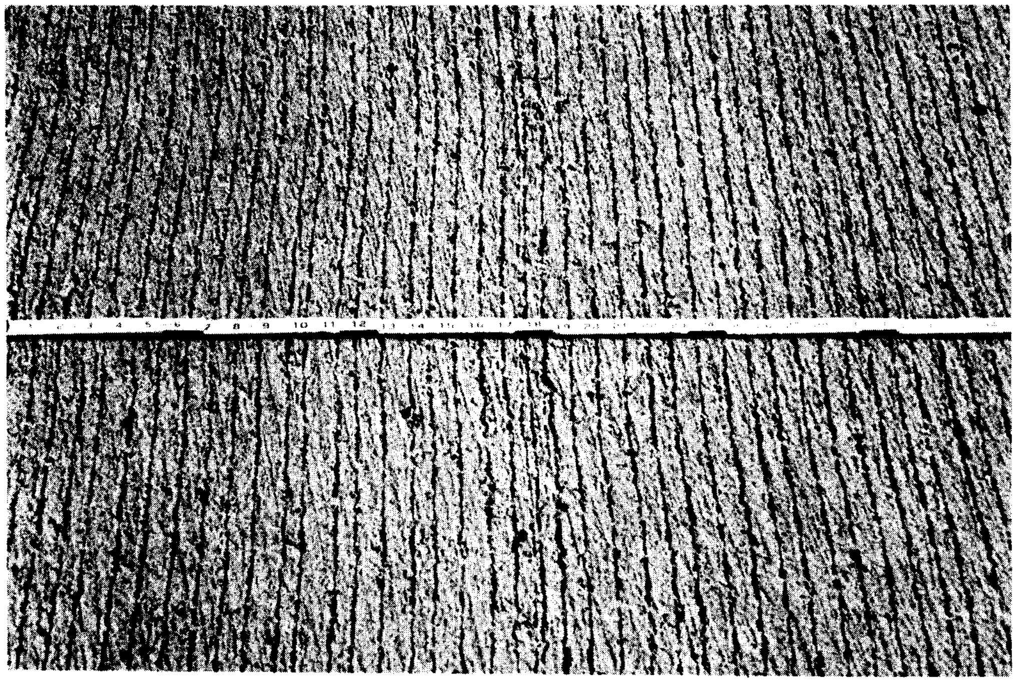

Figure 3. Deck surface texture with Bidwell tines.

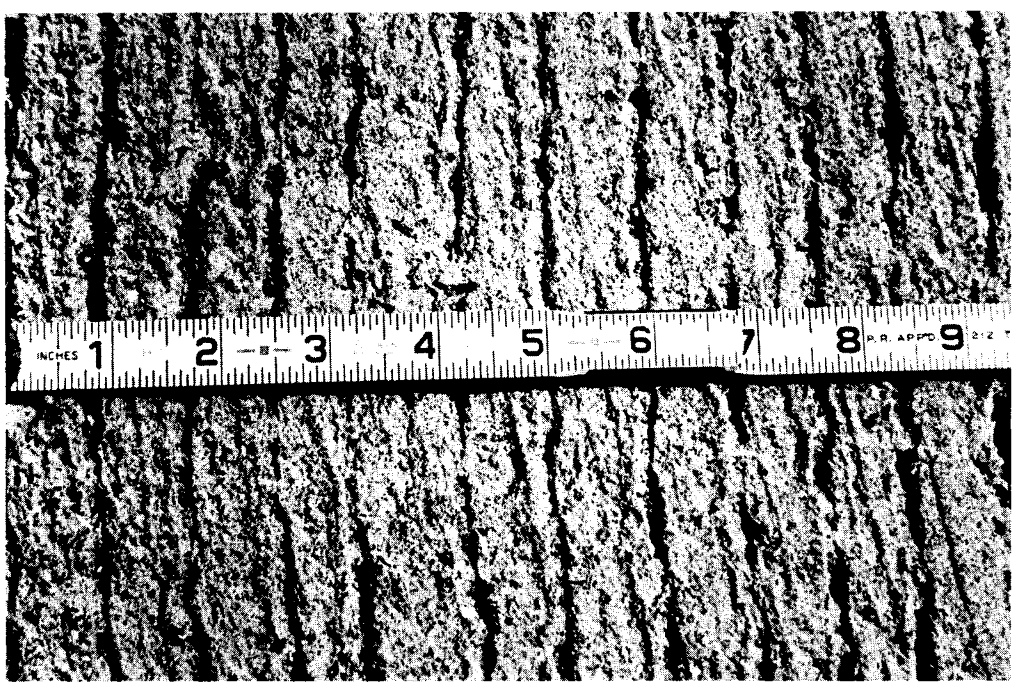

Figure 4. Variance in depth along length of striations.

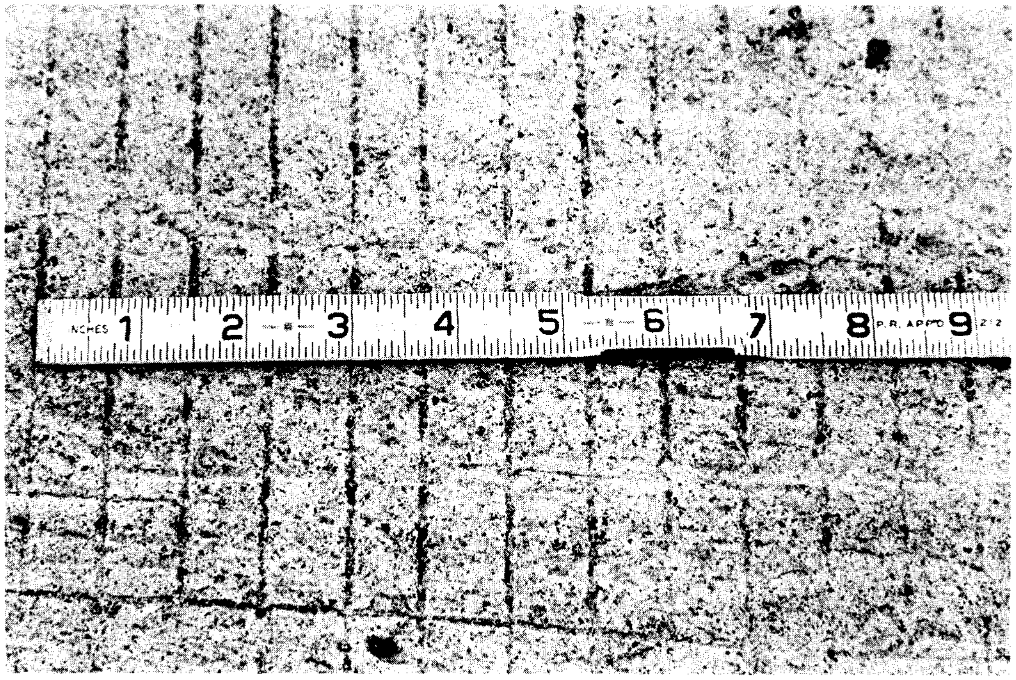

Figure 5. Close view of striations produced by beveled metal wheels.

Figure 6. Deck striated with leaf rake.

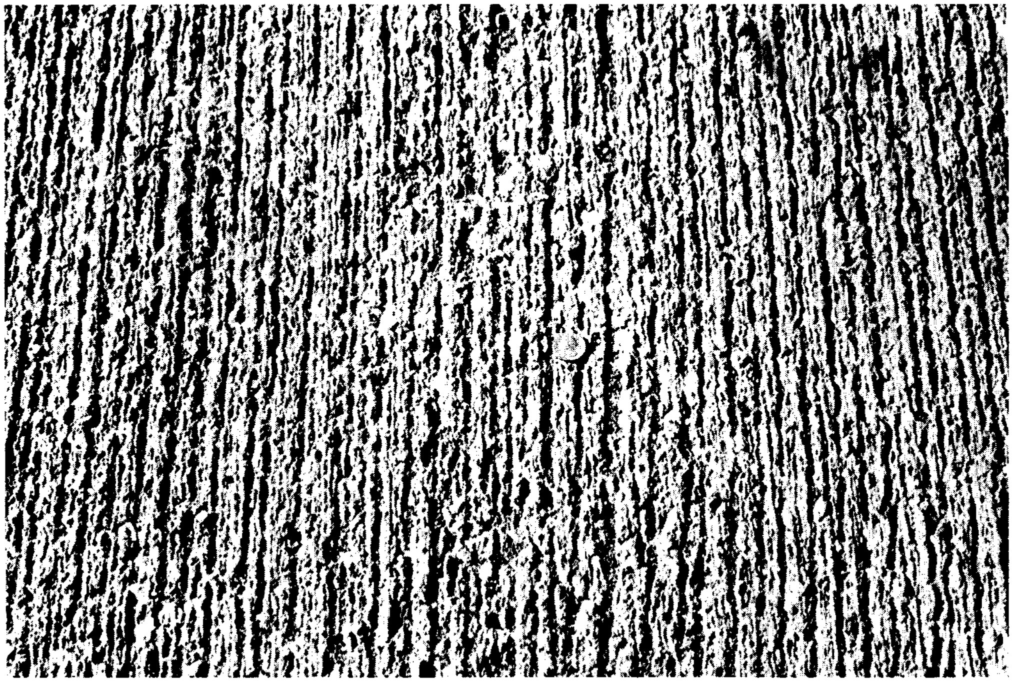

Figure 7. Scoring on deck of Route 220 NBL bridge over Route 419.

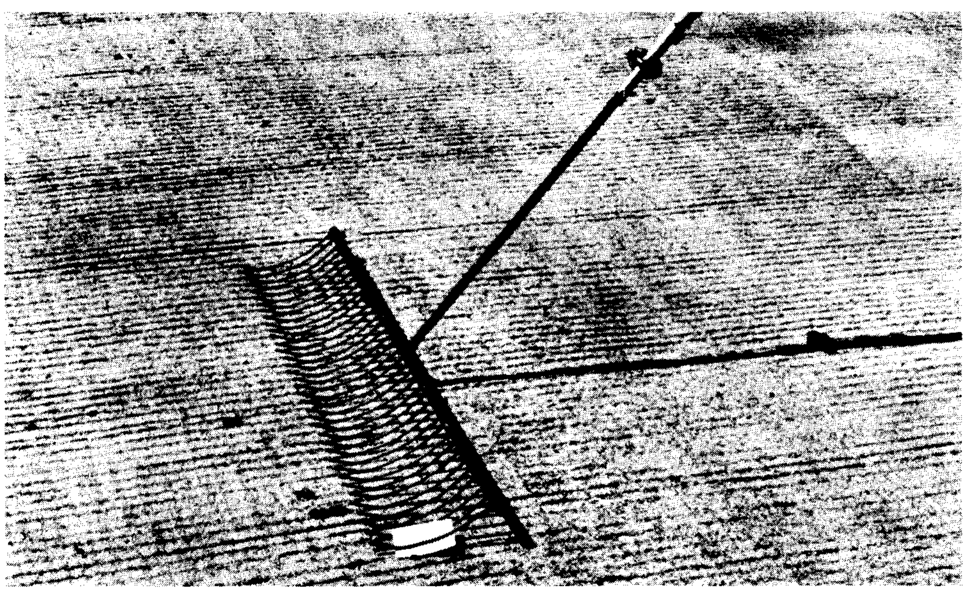

Figure 8. Tine made of welding rods attached to reinforcing bar.

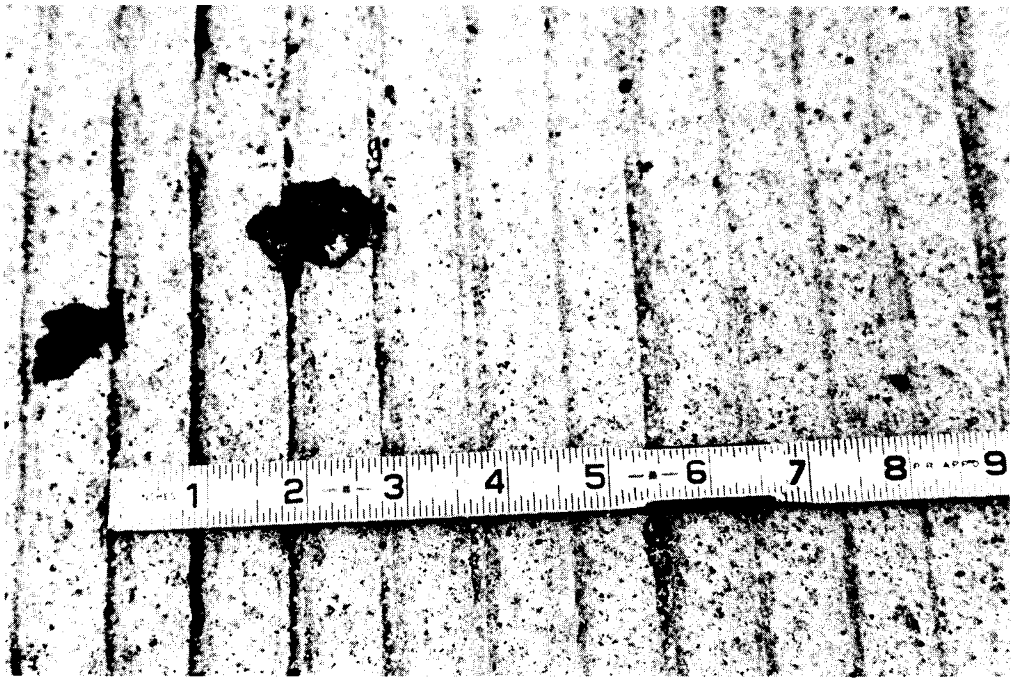

Figure 9. Striations produced by the tines shown in Figure 8.

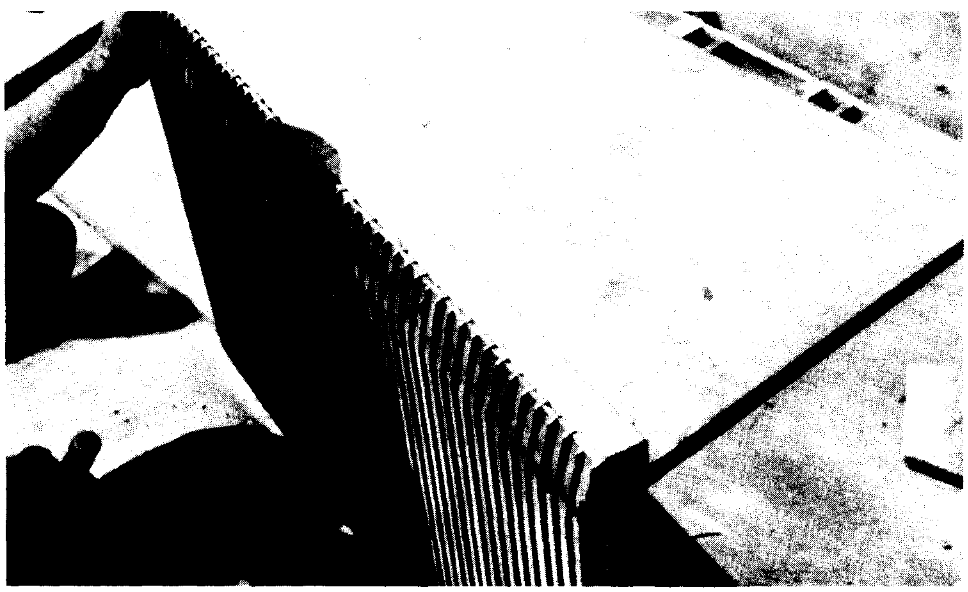

Figure 10. Pan with raised ridges for impressing striations into the deck surface.

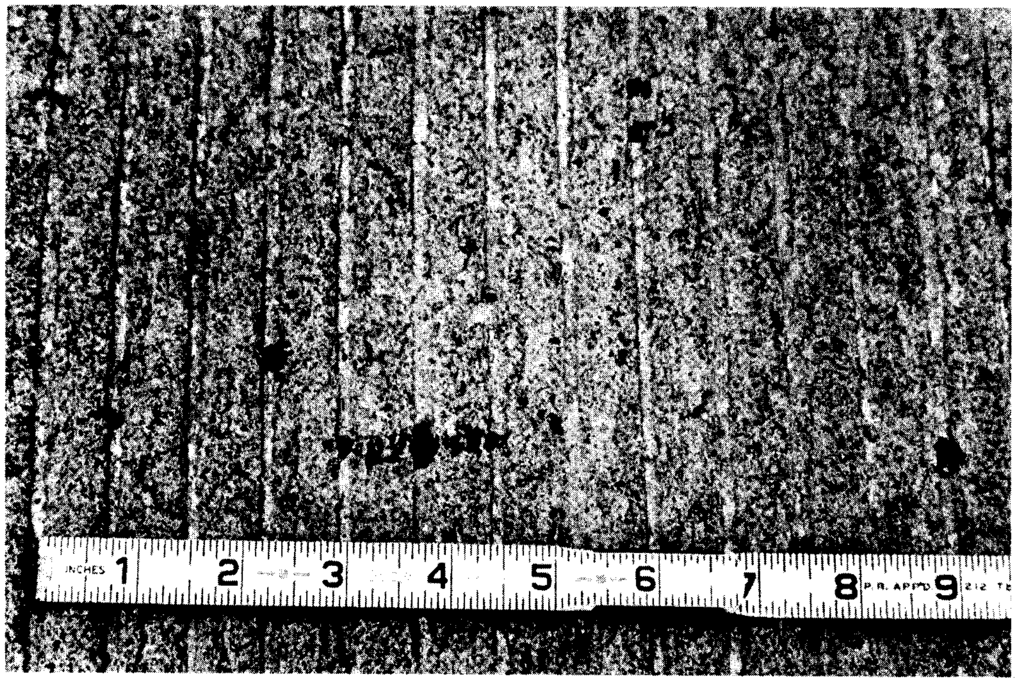

Figure 11 Striations produced by pan shown in Figure 10.

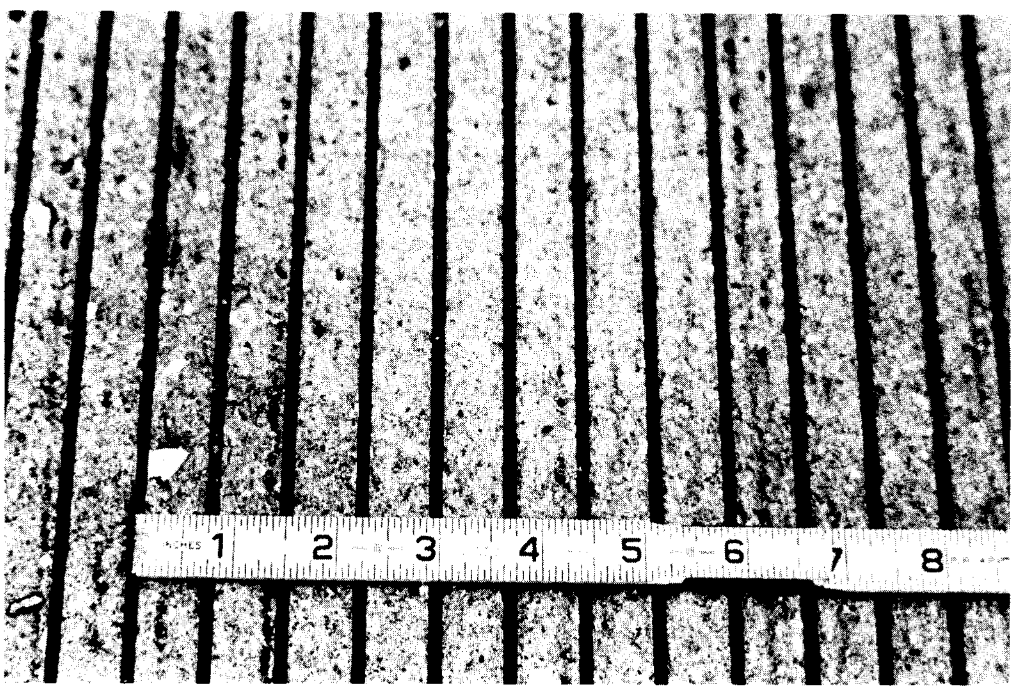

Figure 12 Grooves sawcut into hardened concrete deck.

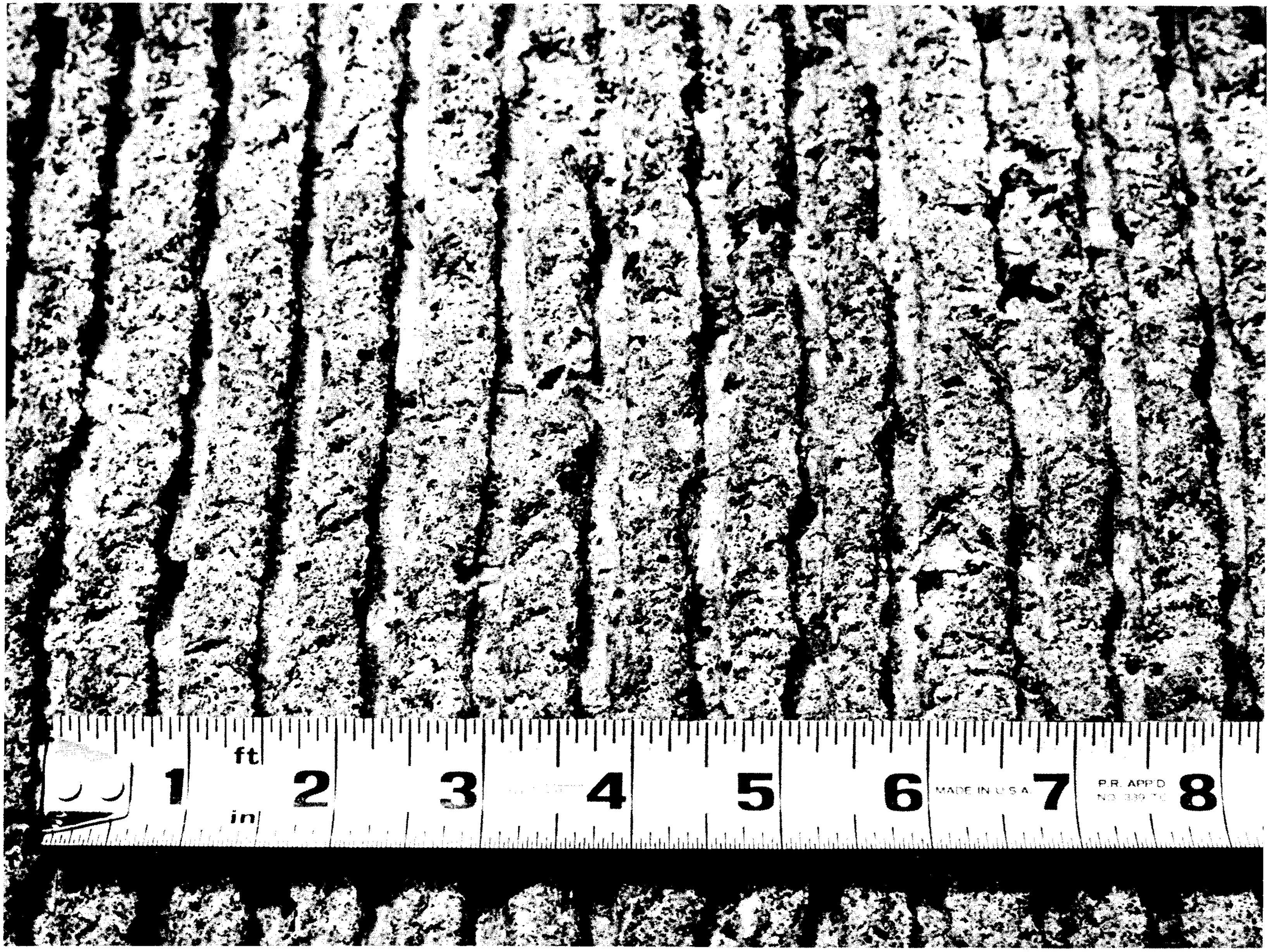

Figure 13. Full-size view of deck surface of the Pedlar River bridge on Route 60 is an example of a deck finish meeting the Virginia specification.