Interim Report No. 1

A LABORATORY EXPERIMENT IN EVALUATING MEANS OF IMPARTING A HARSH TEXTURE TO PORTLAND CEMENT CONCRETE SURFACES

by

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Charlottesville, Virginia

September 1970
VHRC 70-R12

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INTRODUCTION

Skidding may be defined as the motion of a vehicle under conditions of partial or complete loss of control caused by the sliding of one or more wheels.[1] This physical phenomenon is a contributing cause in many accidents, and it is becoming more important as the volume of traffic and the speed of modern vehicles increase.

The effective friction between the tires of a vehicle and the road surface is called the coefficient of friction. The coefficient of friction and the skid number, which is 100 times the coefficient of friction, are the measures of skid resistance. During their service life all pavement surfaces show some loss of skid resistance, but a certain level of tire-pavement friction is necessary for the proper and safe performance of any highway.

ROLE OF AGGREGATES IN SKID RESISTANCE

A good skid resistant surface should have a texture consisting of both fine and coarse asperities. In portland cement concrete pavements the fine asperities, which impart the adhesion component in the tire-pavement interaction, are formed by the paste coated fine aggregates. The coarse asperities, which have the dual role of imparting the hysteresis and providing drainage channels for water, are formed by the sculptured surface given during finishing operations.

The skid resistance is mainly controlled by the fine aggregate in the mortar layer of portland cement concrete. The coarse aggregate functions as a portion of the surface if the mortar is abraded away.

In Virginia the use of silica sand in portland cement concrete pavements has been required for some time. This material, combined with burlap drag finishing, sufficed in providing skid resistant surfaces until recently when the extremely high traffic volumes we are now experiencing caused a tremendous amount of wear that rendered the surface smooth and thus less skid resistant than desirable.

PURPOSE AND SCOPE

The purpose of this study was to explore methods of obtaining a rough, durable texture on test slabs fabricated in the laboratory in an attempt to provide high skid resistance. The exploration involved the investigation of types of texture, time of texturing, and the effects of coarse aggregates and curing methods.

FACTORS AFFECTING SURFACE TEXTURE

In texturing there are two problems: one is to get the desired texture, and the other is to maintain it.[2]

In obtaining the desired texture geometrics of the surface grooves, the pattern. the depth, the width of the grooves, and the spacing between them are important. Also, the physical roughness and toughness or abrasion resistance of the surface should be considered.

The surface texture is applied before the water sheen has disappeared. Some of the methods used are burlap dragging, brooming, and belting. The time of texturing may affect the surface roughness considerably.

Texture is lost by tire wear and by the action of abrasives, tire chains, tire studs, salt, freezing, and thawing. To provide a long wearing life for the texture, the strength and durability of the materials in the surface should be investigated. To improve the strength and durability of the surface:[2]

(1) Materials of good quality should be used. The wear of aggregates and concrete has been found principally dependent on the mineral composition and hardness of the aggregates. Siliceous sand has been found to give high skid resistance values.[3]

(2) The cement factor should be increased. This, in effect, is done by lowering the water-cement ratio. Aggregate or possibly a cement-aggregate mixture may be sprinkled on the surface. Increasing the cement factor increases the density of the mix and thus increases the strength.

(3) Monomolecular films may be used on the surface to retard evaporation and provide curing and enhance adherence of sprinkled aggregates.

(4) Admixtures or surface treatments can be used to harden and toughen the surface. Air entrainment must be used for durability and for protection against deicing chemicals.

APPROACH

To investigate the roughness, strength, and durability of the pavement surface with the objective of providing better skid resistance, the following procedures were employed.

Concrete mixes were prepared in 2 ft^3 batches. A-3 paving concrete was used, and the slump was kept below 3 inches. $6 \pm 2\%$ air content was maintained. The batches contained sand with a high, actually +95 percent, silica content. From each batch two sample slabs 18" x 18" x 3 1/2" were cast. First the desired rough texture was sought. On one slab of each of the first five batches, the surfaces were finished by soft, medium, and heavy brooming, burlap dragging, and wire brushing. (Figures 1A-5A) (All figures and tables are appended.)

In investigating the effect of the time of texturing, the same finishing was attained on the other slabs at a later age than for the first slabs (Figures 1B-5B). The soft broom had 2-inch long horse tail hair bristles; the medium broom 7-inch long straw bristles; the heavy broom 7-inch long stiff bristles; and the wire brush 1 1/2-inch wire bristles. Later the wire brushing with a larger spacing (Figure 6) and a pattern type texturing (Figure 7) were used in an attempt to produce a harsh texture. The pattern type texture was prepared by a roller used in planting seeds.

To measure the surface texture and evaluate the degree of roughness, a photographic method was used[4]. In this method a thin wire is stretched above the pavement, and a flash bulb is positioned above and to one side of the wire to cast a shadow of the wire on the slab and thus indicate the shape and size of asperities (Figures 8-15). The average height of the asperities are measured by calculating the area between the shadow and the wire and dividing it by the length of the wire.

To investigate the effect of the coarse aggregate four batches were prepared. Two of the batches contained gravel, and the other two crushed stone with different fineness moduli. The surface of one slab of each batch was treated with a surface retarder, "Rugasol", which was put on the surface during finishing so that after casting the mortar could be washed away to expose the coarse aggregate. On the other slabs the best textures obtained from the initial batches, heavy brooming and wire brushing, were maintained.

In the next batch the first slab was used to study the effectiveness of an aggregate on the surface by spreading stone chips of "intermediate size" (maximum 3/8") dipped in a cement-water mixture on the wet concrete surface. For further investigation the second slab was covered with a monomolecular film, "Confilm", which reduces rapid evaporation of water from freshly placed concrete, and then textured with a wire brush. The batches are summarized in Table I.

RESULTS AND CONCLUSIONS

The results of the roughness measurements obtained with the photographic method are shown in Table II. As can be seen, the coarsest texture was obtained by wire brushing.

The depth of the texture is influenced by the time of finishing. The deepest grooves were obtained when the surface was finished just after casting. The time interval between casting and texturing has a varying influence, depending upon the type of texturing used. For burlap dragging the influence is more pronounced than for brooming.

The concrete mix design also has an affect on the texture depth. The Virginia specifications were followed and mixes with small variations were prepared.

To investigate the abrasion resistance of the surface a test procedure developed within ASTM Committee C-9, Subcommittee III-m, will be used. Also, the effect of monomolecular film on the surface durability will be investigated.

Due to a shortage of time construction of the abrasion testing machine was not completed in time for the Maintenance Research Advisory Committee Meeting. Therefore, the complete report will be prepared after the machine is ready and the slabs are tested, which is expected to be in October.

REFERENCES

1. Stonex, K. A., "Elements of Skidding", First International Skid Prevention Conference, Proceedings, Part I, 1959.

2. Spellman, D. L., "Texturing of Concrete Pavements", HRB Special Report 101.

3. Balmer, G. G. and Colley, B. E., "Laboratory Studies of the Skid Resistance of Concrete", PCA Bulletin D 109.

4. Smith, P. and Schonfeld, R., "Pavement Wear due to Studded Tires and the Economic Consequences in Ontario", Report No. RR 152, Department of Highways, Ontario, January 1970.

5. Colley, B. E., Christensen, A. P., and Nowlen, W. J., "Factors Affecting Skid Resistance and Safety of Concrete Pavements", HRB Special Report 101.

6. Csathy, T. I., "Skidding and Skid Resistance", Department of Highways, 1964, Ontario.

7. "Interim Recommendations for the Construction of Skid Resistant Concrete Pavement", Technical Subcommittee on Surface Properties, American Concrete Paving Association, August 1969.

TABLE I
Batch Data

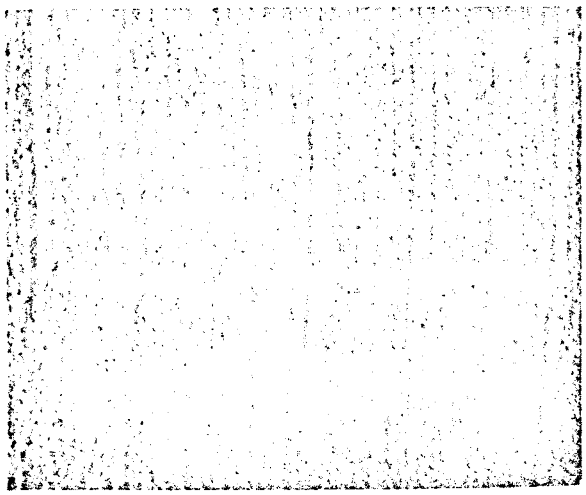
tch	Variable	Aim	Mix	Slab 1	Slab 2
1	Type and time of texturing	To obtain rough and uniform texture	F.A., C.A., and Protex	Soft broom	Same texturing as on Slab 1 at a later time
2				Medium broom	
3				Heavy broom	
4				Burlap drag	
5				Wire brush	
6	Type of texturing			Wire brush (larger spacing than #5)	Pattern type texture
7	Fineness Modulus of the aggregate	To obtain texture by exposing C.A.	F.A., C.A., Protex, and Rugasol (retarder on surface)	Crushed stone with different fineness modulus	Best texture from batches 1-6
8					Wire brush Heavy broom
9	Same as 6 and 7	Same as 6 and 7	Same as 6 and 7	Gravel with different fineness modulus	Same as 6 and 7
10					
11	a. Aggregate on the surface b. Monomolecular film on surface	a. To roughen the surface b. To retard evaporation	F.A., C.A., and Protex	Spread stone chips of "intermediate size" (max. 3/8")	Put monomolecular film on the surface

TABLE II

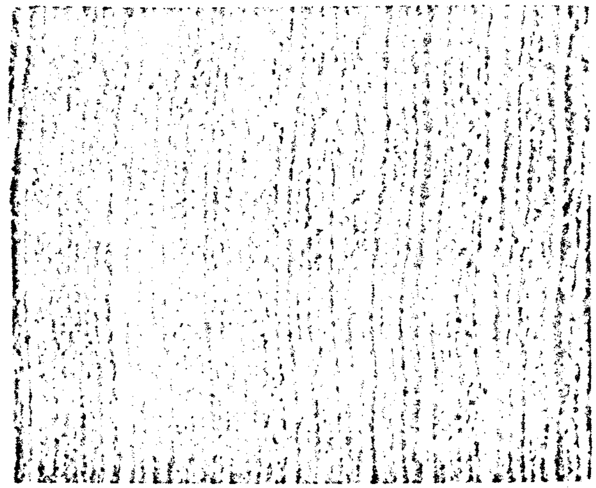
Texture Depths

Method of Finish	Texture Depth* (in)
Soft broom	.028
Burlap drag	.035
Medium broom	.039
Heavy broom	.046
Wire brush (double spacing)	.053
Pattern type texture	.055
Exposed aggregate (crushed stone)	.074
Wire brush	.090

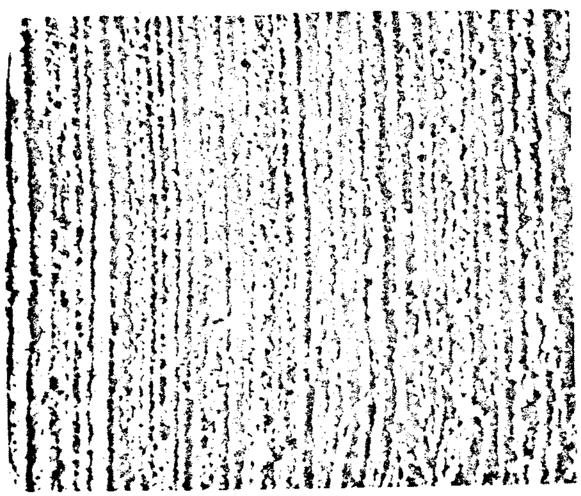
*The values obtained are the result of preliminary study and will be refined after further evaluation of the data.



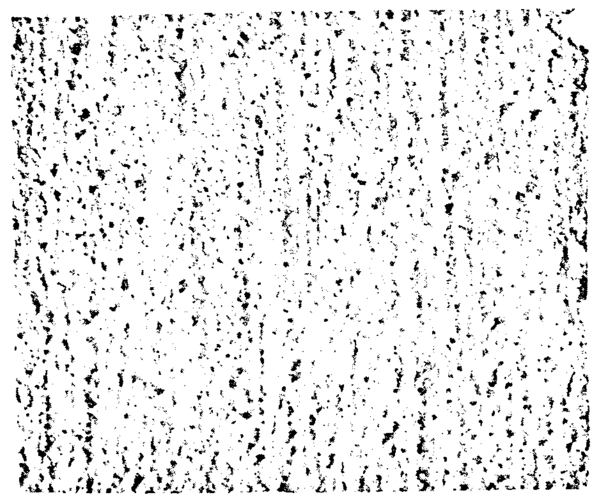
1A — Soft Broom



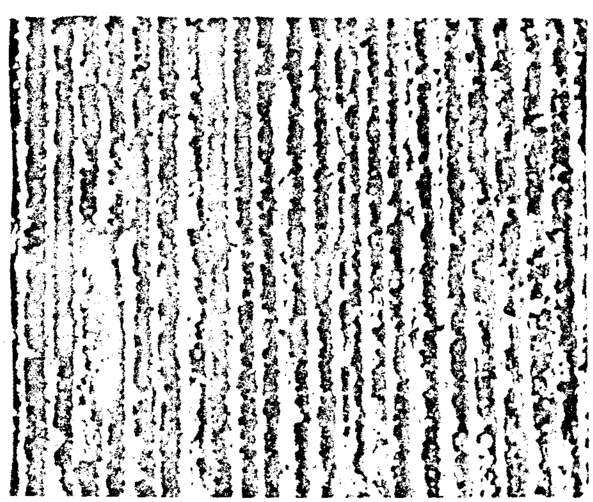
2A — Medium Broom



3A — Heavy Broom

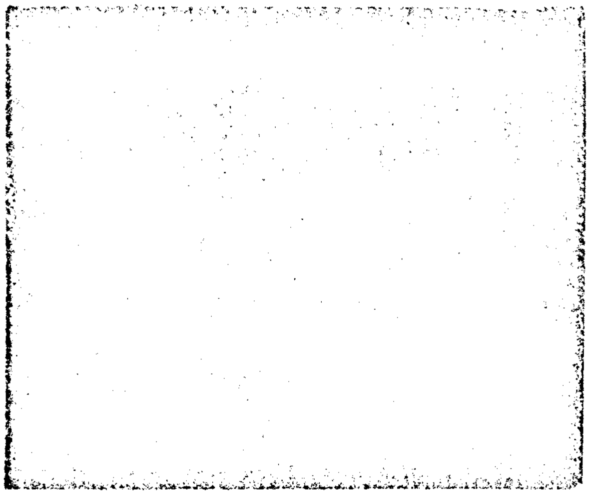


4A — Burlap Drag

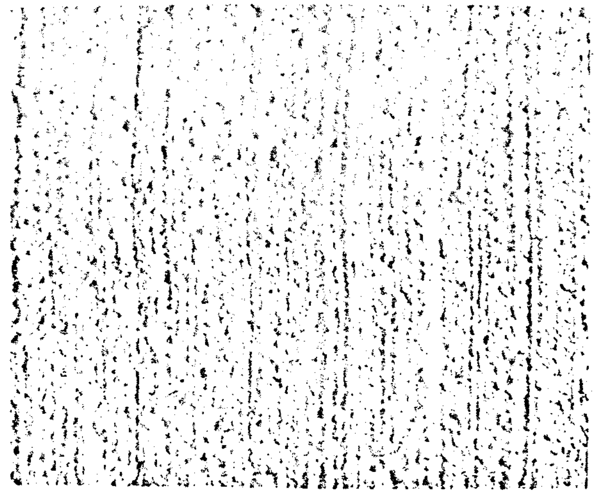


5A — Wire Brush

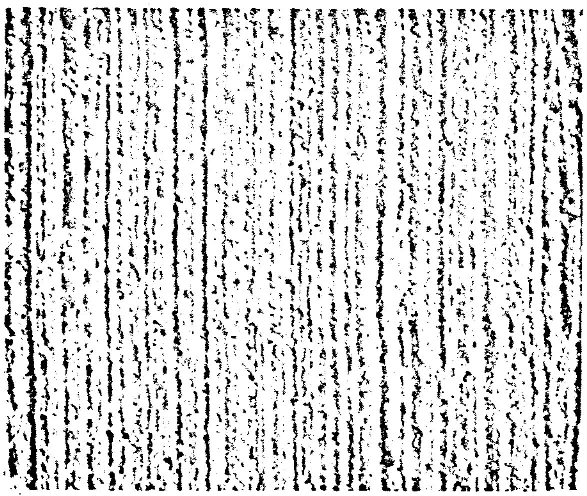
Figures 1A - 5A. Types of Texture.



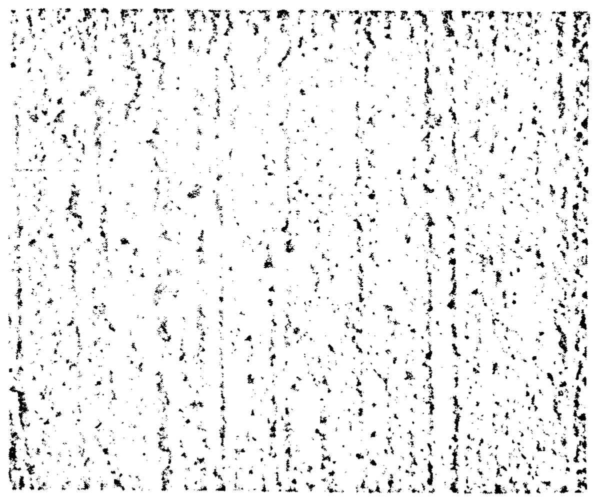
1B — Soft Broom



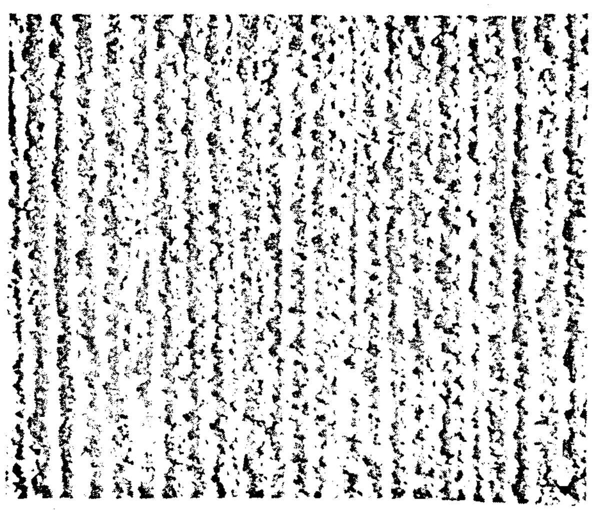
2B — Medium Broom



3B — Heavy Broom



4B — Burlap Drag



5B — Wire Brush

Figures 1B - 5B. Types of Texture at a Later Time than the Corresponding Slabs in Figures 1A - 5A.

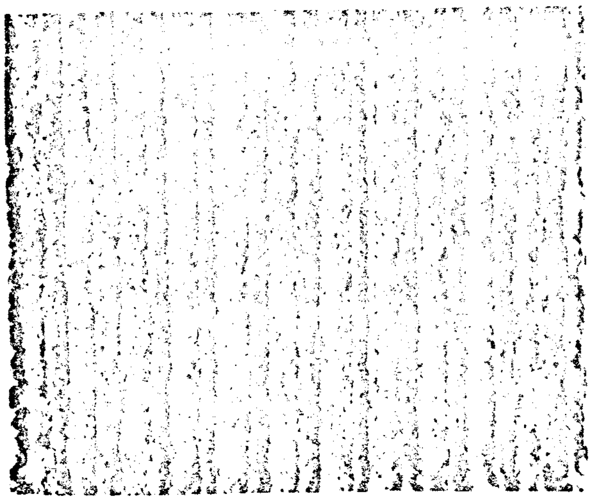


Figure 6. Wire Brush (Double spacing).

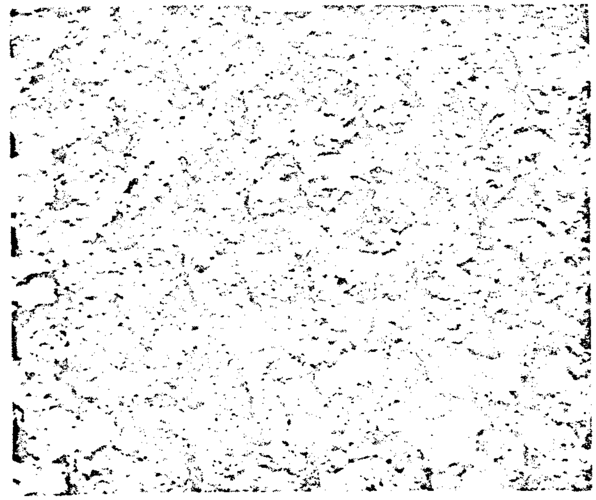


Figure 7. Pattern Type.

Figures 6 and 7. Types of Texture.

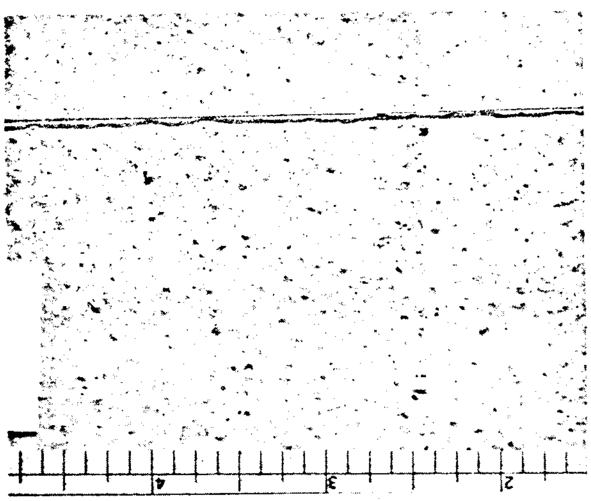


Figure 8. Soft Broom

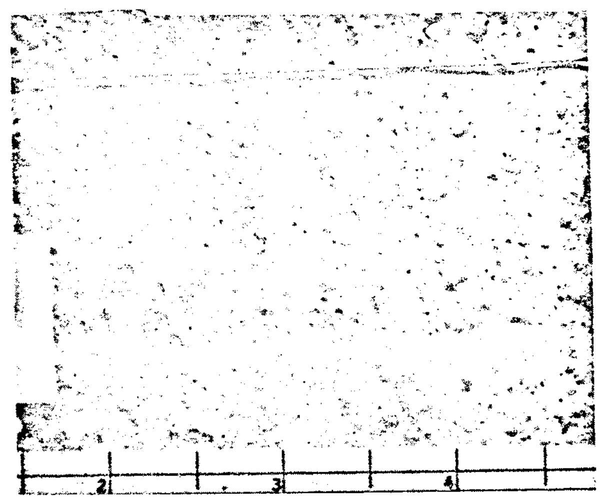


Figure 9. Burlap Drag

Figures 8 and 9. Photographic Method for the Evaluation of Texture Depth.

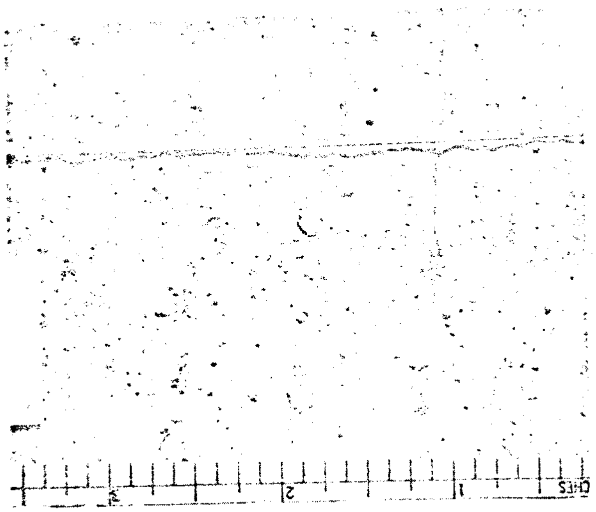


Figure 10. Medium Broom.

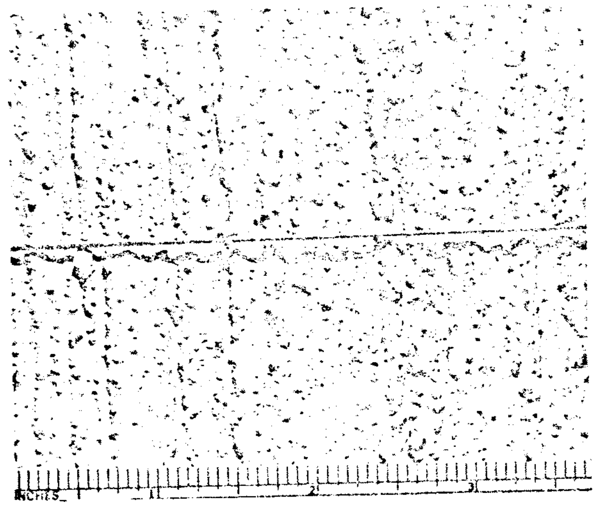


Figure 11. Heavy Broom.

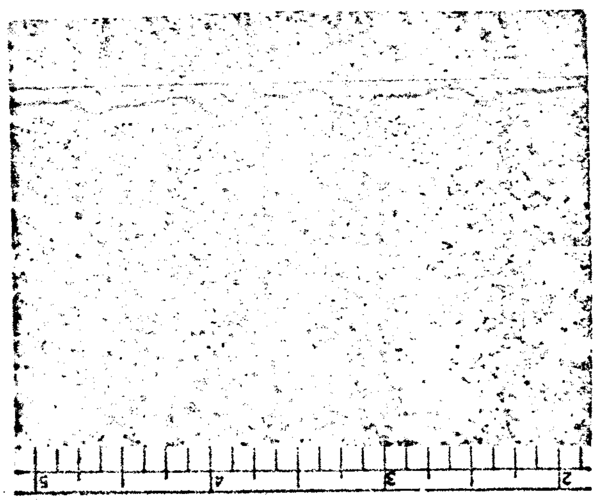


Figure 12. Wire Brush (Double spacing).

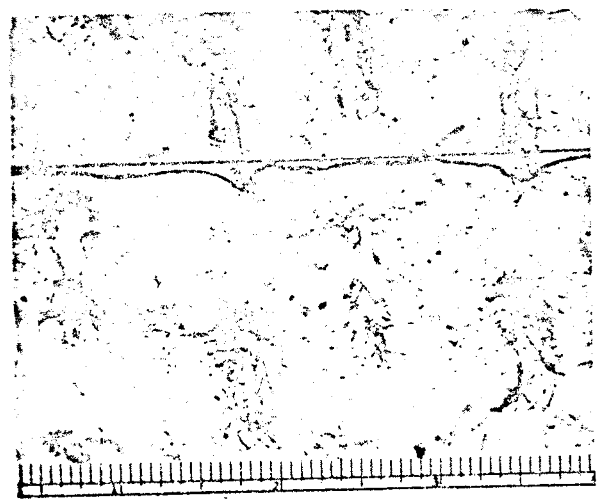


Figure 13. Pattern Type Texture.

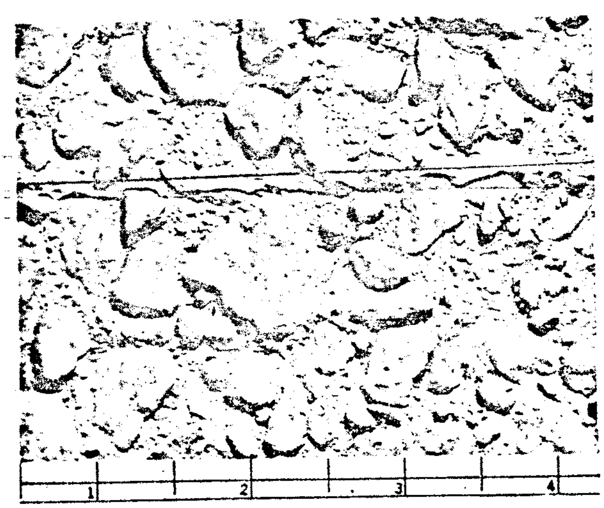


Figure 14. Exposed Coarse Aggregate.

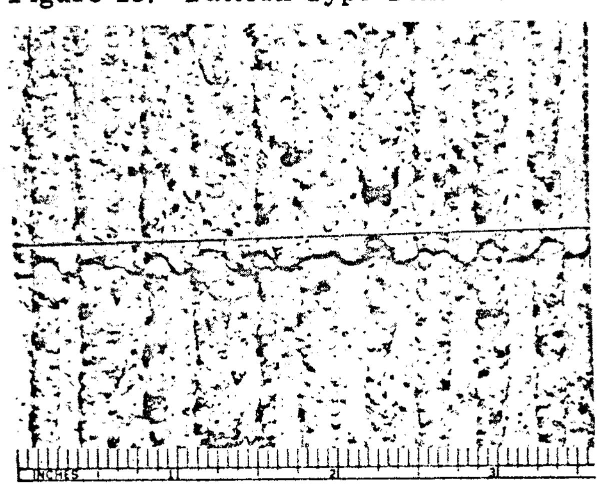


Figure 15. Wire Brush.

Figures 10-15. Photographic Method for the Evaluation of Texture Depth.

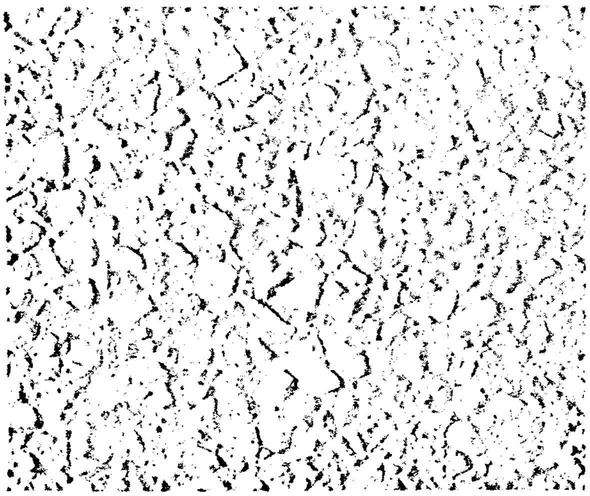


Figure 16. Crushed Stone.

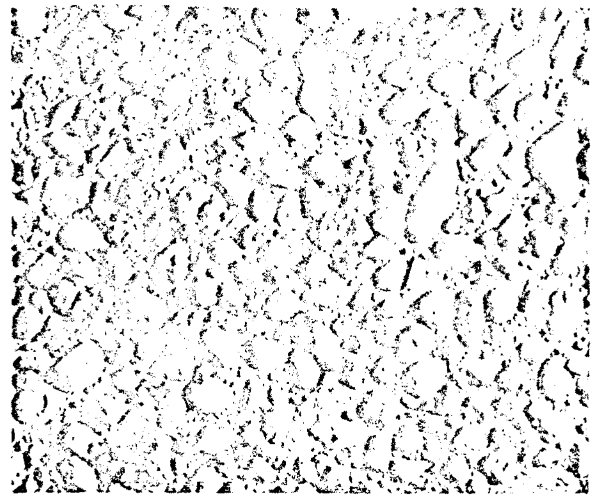


Figure 17. Gravel.

Figures 16 and 17. Exposed Coarse Aggregate.

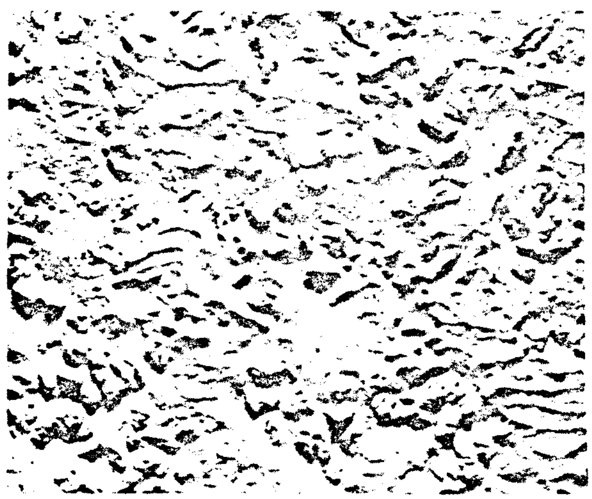


Figure 18. Stone Chips Spread on the Surface.