# Asphalt Surface Treatments and Seal Coats

By DR. NORMAN W. McLEOD*

In nearly all countries of the world many asphalt surface treatments and seal coats are performing very poorly. In general, this is due to the inadequate and even careless design and construction procedures commonly employed. The three most serious defects in seal coats and surface treatments are:

(a) Streaking
(b) Use of too much asphalt
(c) Use of too little asphalt.

Streaking is usually caused by lack of uniformity in the quantity of asphalt applied inch by inch across the road surface. Too much asphalt causes blackening of seal coats, and the serious flushing or bleeding that results in a slippery surface in wet weather. Too little asphalt leads to loss of cover aggregate because not enough asphalt is employed to cement the cover aggregate into place.

**Streaking**

Streaking results when alternate longitudinal strips of seal coat contain different quantities of asphalt. Strips that are deficient in asphalt binder are unable to hold sufficient cover aggregate in place. These are the points of weakness from which the complete seal coat wears away first under traffic. Streaking, therefore, can lead to a serious reduction in the normal life expectancy of a seal coat.

Some of the more common mechanical causes of streaking are illustrated in Figures 1 and 2. The top diagram represents what one would see when looking vertically down on a spray bar discharging asphalt from spray nozzles. The short lines indicate the positions of the fans of asphalt leaving the spray nozzles. The arrow shows the direction of travel of the asphalt distributor. It is obvious that no two spray nozzles are applying asphalt over the same width of road surface. The correction required is illustrated by the lower diagram of Figure 1. It consists of using a simple wrench, equipped with a proper stop, so that each nozzle can be turned to discharge its fan shaped spray to make a uniform angle, e.g. 30°, with the longitudinal axis of the spray bar. Each nozzle will then discharge over exactly the same width of road surface.

The diagram at the top of Figure 2 demonstrates that improper height of the spray bar above the road surface is a frequent cause of streaking. Alternate strips across the road surface receive the discharge from one and two spray nozzles, respectively, resulting in uneven asphalt application. As indicated by the middle diagram of Figure 2, the remedy in this case consists of adjusting the spray bar to height "h" at which each inch width of road surface receives the discharge from two spray nozzles. The bottom diagram of Figure 2 shows that by raising the spray bar to an elevation of 3/2 h, each inch width of road surface receives the discharge from three spray nozzles, (triple overlap).

Other common causes of streaking are:

(a) clogged or partly clogged spray nozzles,
(b) spray nozzles of different sizes and different rates of discharge in the same spray bar,

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(c) holes for nozzles in the spray bars not drilled to accurate uniform spacing. Differences in hole spacing of as much as 3/8 inch have been detected,

(d) varying the rate of discharge through the spray nozzles to obtain different application rates to the road surface. In Victoria, Australia, asphalt distributors are always operated to discharge exactly four gallons per minute through each spray nozzle. Different rates of application on the road surface are obtained entirely by controlling the forward speed of the distributor.

After each of these mechanical faults has been corrected, uniformity of rate of discharge through the spray nozzles depends on two basic factors,

(a) fluidity or viscosity of the asphalt

(b) the hydraulic pressure in the spray bar that forces the asphalt through the spray nozzles.

The fluidity or viscosity required for uniform rate of discharge of each grade of asphalt through the spray nozzles is illustrated by Figure 3. The recommended range of viscosity is 25 to 50 seconds Saybolt Furol. The temperature required to provide this degree of fluidity for each grade of asphalt can be quickly read from the bottom of the chart. In Victoria, Australia, where excellent surface treatments are built, the asphalt must be heated to have a viscosity not exceeding 20 second Saybolt Furol when sprayed.

The proper hydraulic pressure to be maintained in the spray bar can be determined only by calibration. In Australia, and South Africa, special testing stations have been established for calibrating asphalt distributors. The hydraulic pressure required to provide a discharge of exactly four gallons per minute through each spray nozzle is determined for each length of spray bar that might be employed. Uniformity of discharge is tested by mounting the spray bar at the proper height above a special container that collects the discharge for each two inches of width.

**Influence of Spray Nozzles**

Figure 4 illustrates the wide differences in uniformity of application of asphalt in 2-inch widths across a road surface measured in Victoria, Australia, for different spray nozzles. The upper diagram shows a range from 44 per cent above the average to 53 per cent below. The lower diagram indicates the great improvement in uniformity of application of asphalt provided by the Copley spray nozzles in current use in Victoria, Australia.

**Effect of Chip Spreaders**

Figure 5 illustrates the wide range in uniformity of application of stone chips foot by foot across a 10-ft. width of road surface, by two different types of chip spreaders. The cross-hatched areas show the distribution over the 10-ft. width provided by the centrifugal or spinning plate type of chip spreader. The stone chip application ranges from 43 per cent above the average to 58 per cent below. For the belt-type of chip spreader developed in Victoria, Australia, the uniformity of chip application is much better, and ranges from 8 per cent above the average to 5.0 per cent below. Uniformity of chip application conserves cover aggregate, eliminates the need for brooming, and gives a superior seal coat or surface treatment.

**Design**

The most consistently good seal coats or surface treatments that the author has seen in any country in the world are in Victoria, Australia. Their success is due to the care employed in both the design and construction of these surfaces. For design they employ Hanson's method which very briefly involves the following principles, —

1. As illustrated by Figure 6, when one size cover aggregate is dropped by a chip spreader on an asphalt film, the particles lie in helter-skelter positions, and the voids between the particles are approximately 50 per cent.
2. After rolling, the particles of aggregate are reoriented and the voids are reduced to 30 per cent.
3. Finally, after considerable traffic, the aggregate particles become oriented into their densest positions, with all particles lying on their flattest sides, and the voids become approximately 20 per cent, Figure 7.
4. Since the aggregate particles lie on their flattest sides, the average thickness of a seal coat is given by the overall average of the smallest dimension of the cover aggregate particles. Hanson referred to this as the "average least dimension" of the cover aggregate.
5. The average least dimension of any approximately one-size cover aggregate can be determined by calipering a number of individual aggregate particles. In Victoria, Australia, however, it is rapidly determined by first making an ordinary sieve analysis using sieves with square openings, and then determining the proportion of long flat particles ("flakiness index"), by means of elongated or slotted sieve openings, Figure 8. From these two measurements, the average least dimension value can be quickly read from a graph.
6. As soon as the "average least dimension" of the stone chips is known, the number of square yards covered by each cubic yard can be calculated, and the quantity of cover aggregate to be ordered for any job can be quickly determined. Figure 9 provides a graph for this purpose.
7. The "average least dimension" of the aggregate is very important in another respect. It provides the basis for determining how much asphalt binder should be employed with any given cover stone.
8. After the cover aggregate has become oriented into its densest configuration in a seal coat, with about 20 per cent of voids, Hanson observed that for good performance the quantity of asphalt binder employed should fill about 70 per cent of this 20 per cent of void space if the traffic volume was low. However, the asphalt binder should fill not more than 60 per cent of this 20 per cent of void space if the traffic volume is high.
9. For example, if the average least dimension of a given cover aggregate is 0.5 inch, and the void space between the particles is 20 per cent, for light traffic the thickness of the asphalt film should be (.7) (.2) (0.5) = 0.07 inch. For heavy traffic the thickness of asphalt film would be (.6), (.2) (0.5) = 0.06 inch.
10. It is more usual to express an asphalt application in terms of gallons per square yard rather than as film thickness in inches. Figure 10 enables film thickness to be converted to gallons per square yard. For example, a film thickness of 0.6 inch corresponds to 0.25 gallon per square yard.

### Size of Cover Aggregate

Figure 11 demonstrates that the possibility of flushing or bleeding may be greater with a smaller sized cover aggregate than when it is of larger size. For a small size cover stone (ALD = 1/4 inch) the difference between the asphalt required for filling the void space 70 per cent for light traffic, and filling this void space 100 per cent at which serious bleeding occurs, is only 0.07 gallon per square yard. For a larger size aggregate (ALD = 1/2 inch), this difference is 0.14 gallon per square yard. Consequently, the margin of safety against flushing due to poor operation of the asphalt distributor is larger for coarse than for fine cover aggregate.

## Effect of Average Least Dimension

Figure 12 demonstrates that for two aggregates that might both be purchased as 1/2 inch cover stone, the quantity of asphalt required for one could be just a fraction of that needed for the other, because of differences in particle shape.

## Influences of Engineering Properties of Asphalt

Figure 13 illustrates various factors that must be considered if a successful seal coat or surface treatment is to be obtained when using 3/8 inch cover stone. First of all, Figure 13 is an asphalt viscosity temperature chart. It indicates the viscosity of each grade of asphalt from special primer to 150/200 penetration at various air temperatures in the shade. The line running diagonally from lower left to upper right across the chart points out the grade of asphalt required at different air temperatures in the shade for use with commercial cover aggregates ranging in size from 1/2 to 3/8 inch. The left hand boundary of the cross-hatched area is a temperature of 50°F, which is the lowest temperature at which a seal coat or surface treatment should be built. The right hand boundary is a temperature of 100°F in the shade, the highest temperature ordinarily expected in Canada in summer. The lower boundary indicates the highest viscosity of the asphalt binder at which the rapid wetting of the stone chips by the asphalt, required for fast initial adhesion between asphalt and aggregate, can be expected. The top boundary of the cross-hatched area marks the lowest viscosity of the asphalt binder at which good retention of the cover aggregate by the seal coat can be obtained when it begins to carry traffic. The slope of the line selecting the grade of asphalt to be used for each ambient air temperature for 1/2 to 3/8 inch cover aggregate, indicates that in cold weather, the developing of fast initial adhesion is the more important problem, while at high temperatures, retention of cover aggregate when traffic begins, is the more serious consideration.

Figure 14 provides information quite similar to that of Figure 13, but for four different sizes of cover aggregate, ranging from sand at one extreme to 3/4 inch at the other.

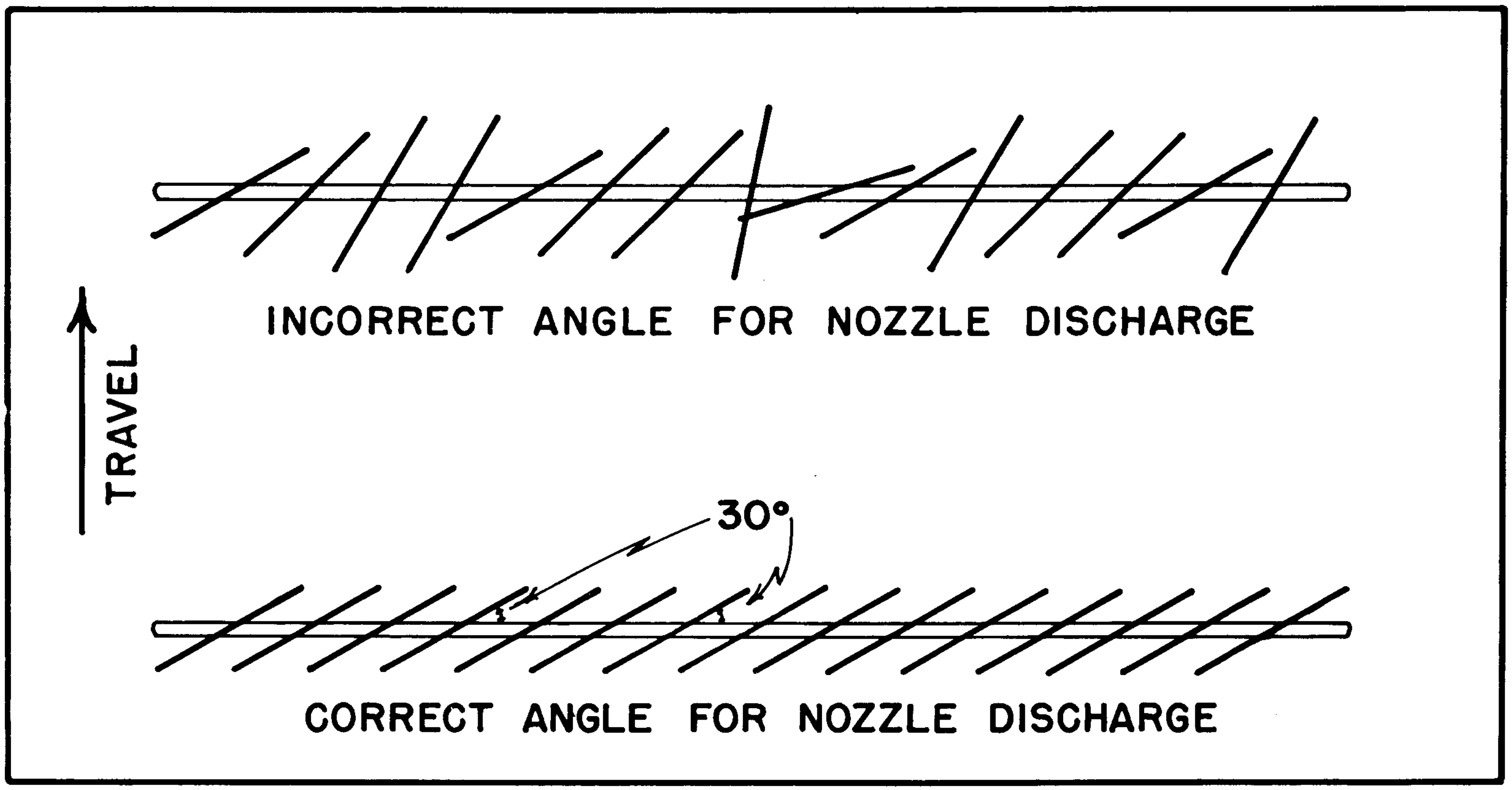


FIG. 1 INFLUENCE OF ANGLE FOR NOZZLE DISCHARGE.

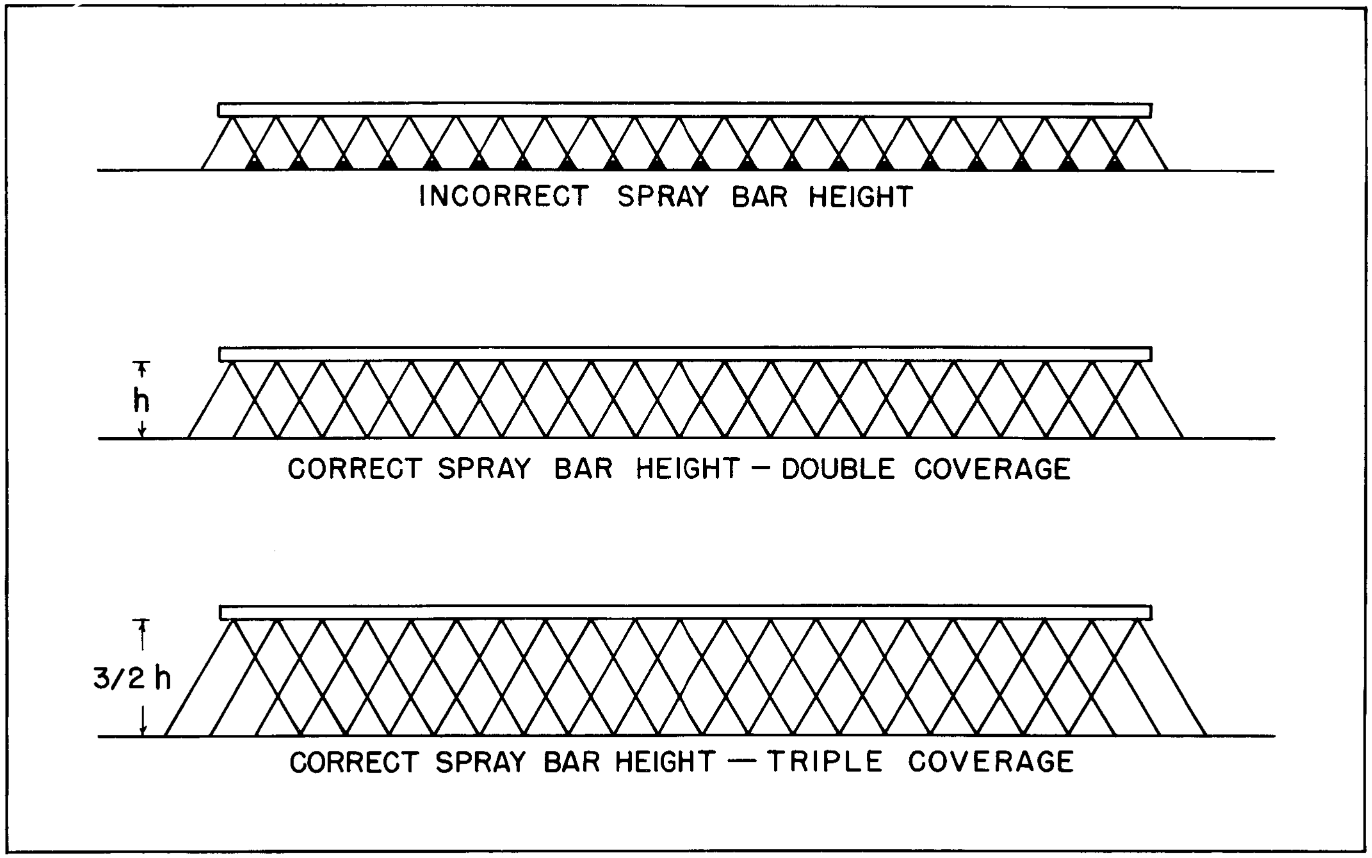


FIG. 2 INFLUENCE OF SPRAY BAR HEIGHT

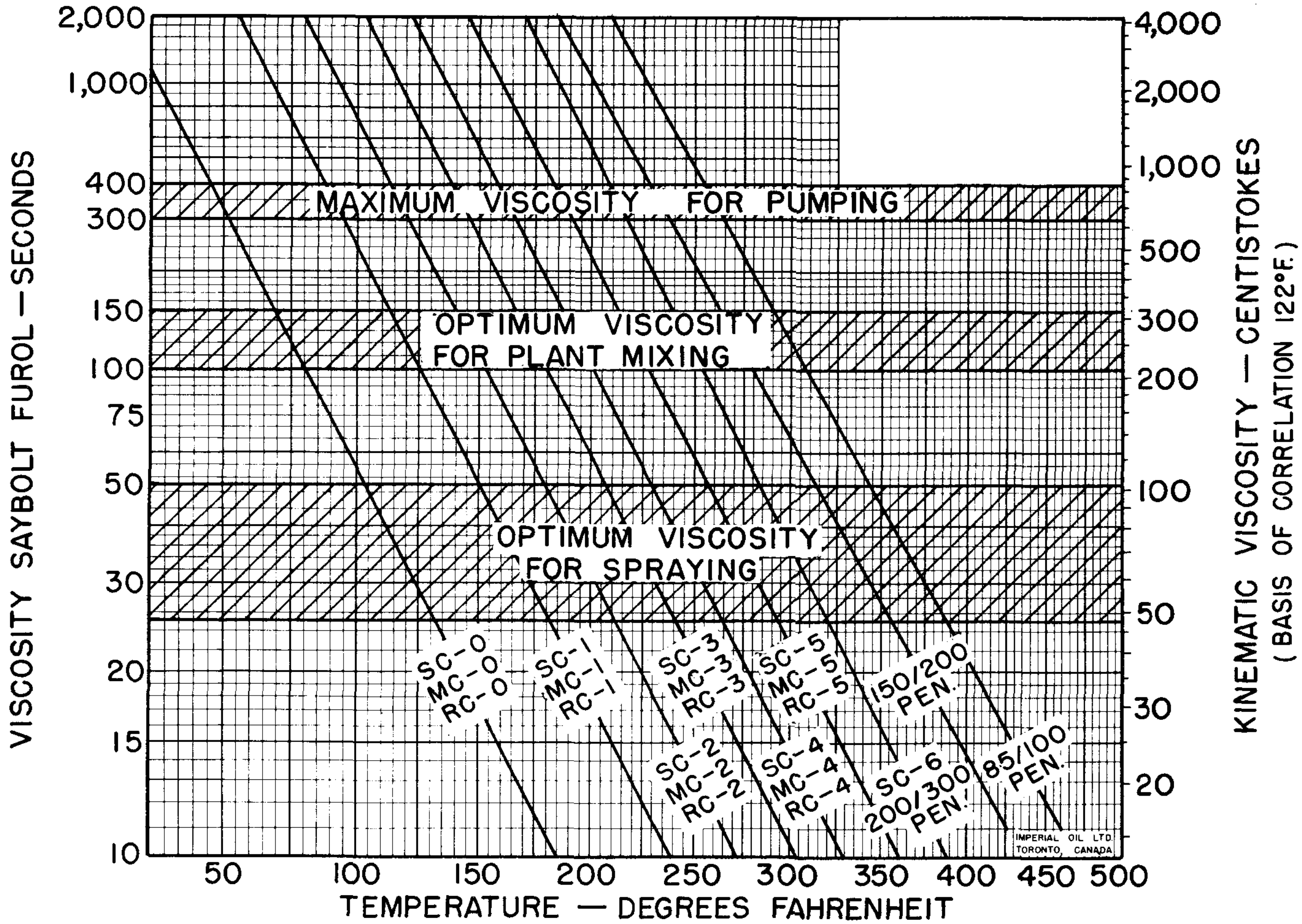


FIG.3 ILLUSTRATING RECOMMENDED VISCOSITIES FOR SPRAYING AND MIXING ASPHALT PRODUCTS, AND MAXIMUM VISCOSITIES FOR PUMPING.

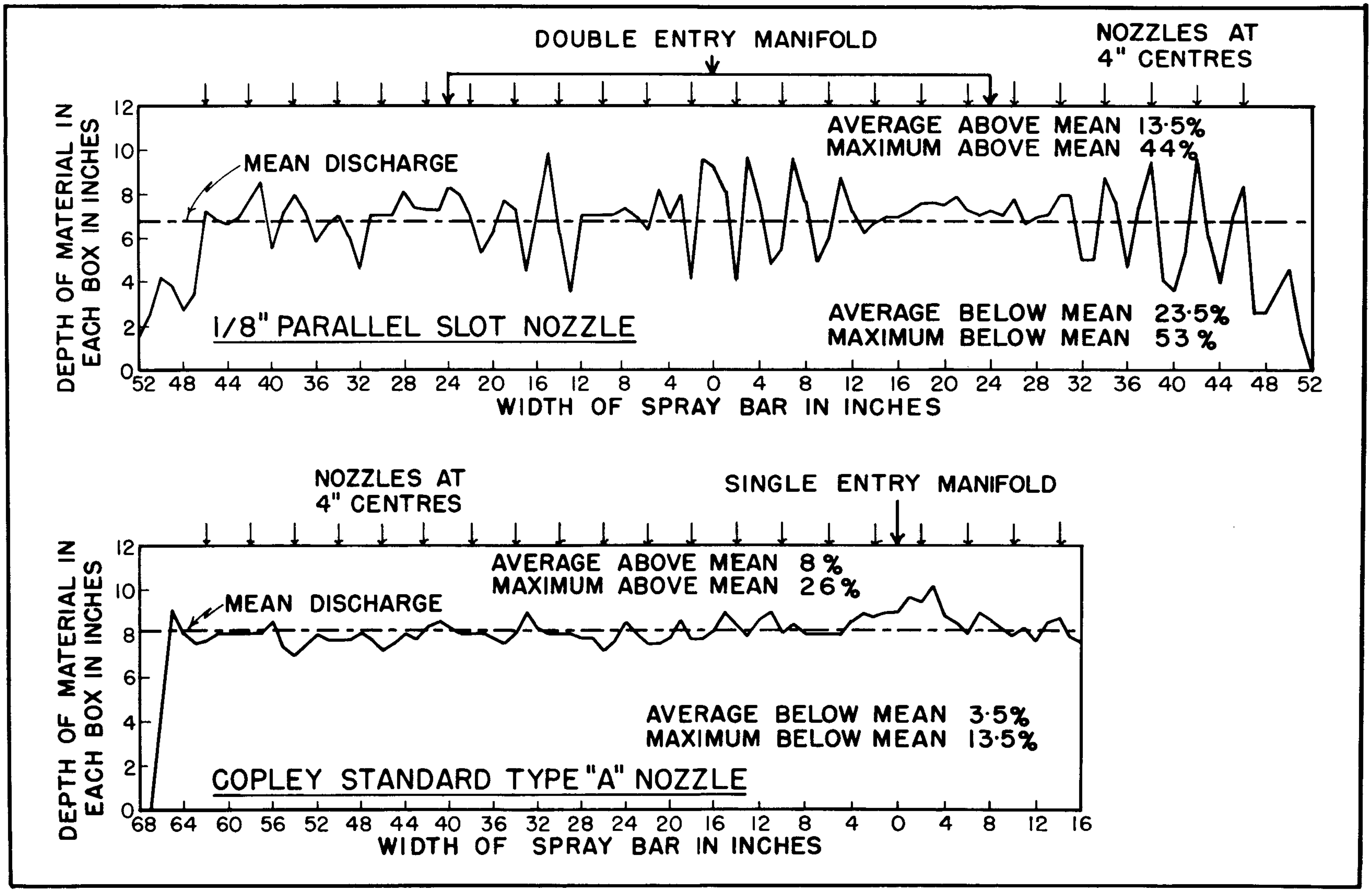


FIG. 4 COMPARISON OF DISCHARGE FROM TWO TYPES OF SPRAY NOZZLES

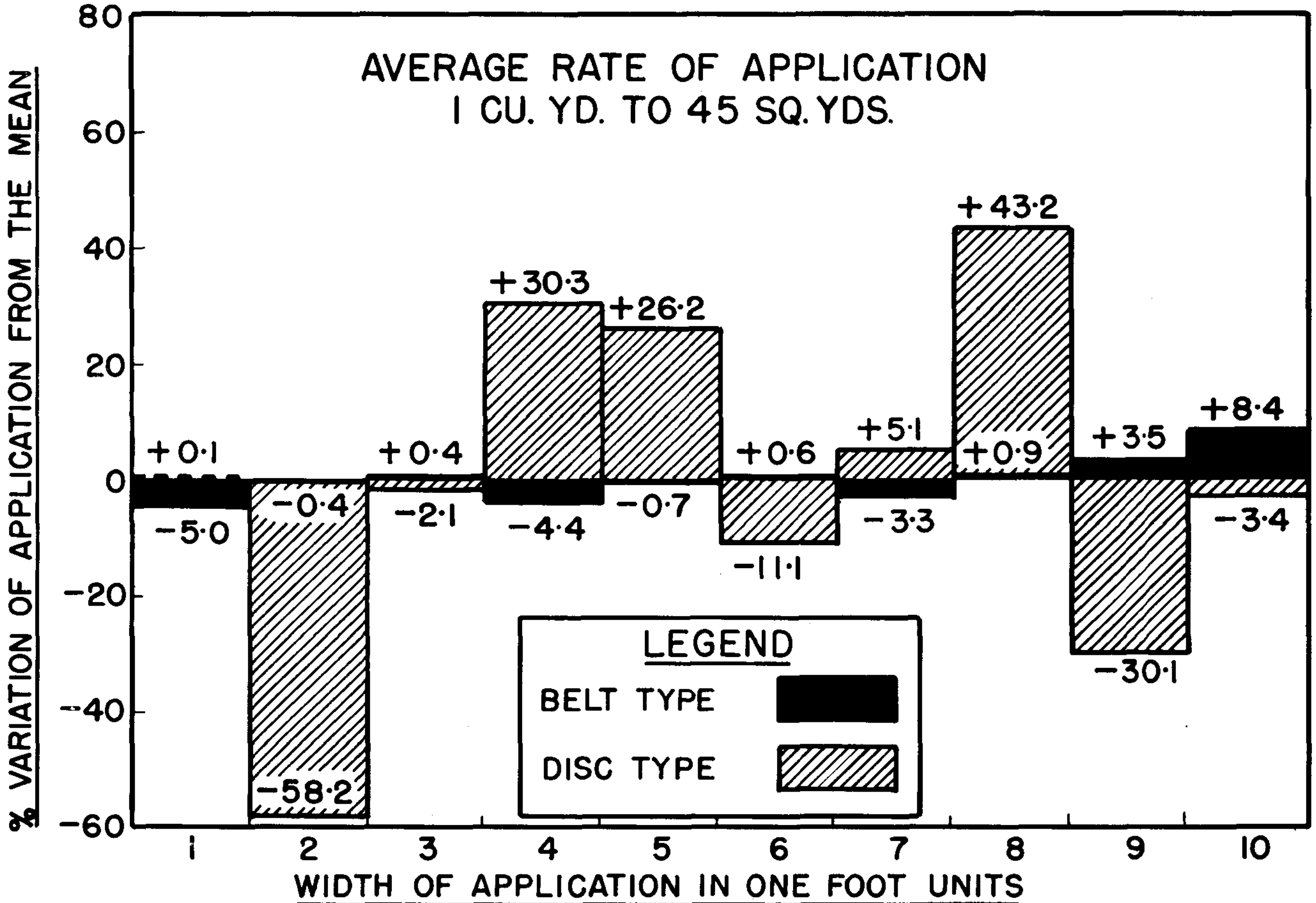


FIG. 5 COMPARISONS OF VARIATIONS IN TRANSVERSE DISTRIBUTION OBTAINED WITH A ROTATING DISC SPREADER AND A BELT SPREADER (AGGREGATE MAXIMUM SIZE 5/8 IN. — AVERAGE RATE OF APPLICATION- 1 CU. YD. TO 45 SQ. YDS.)

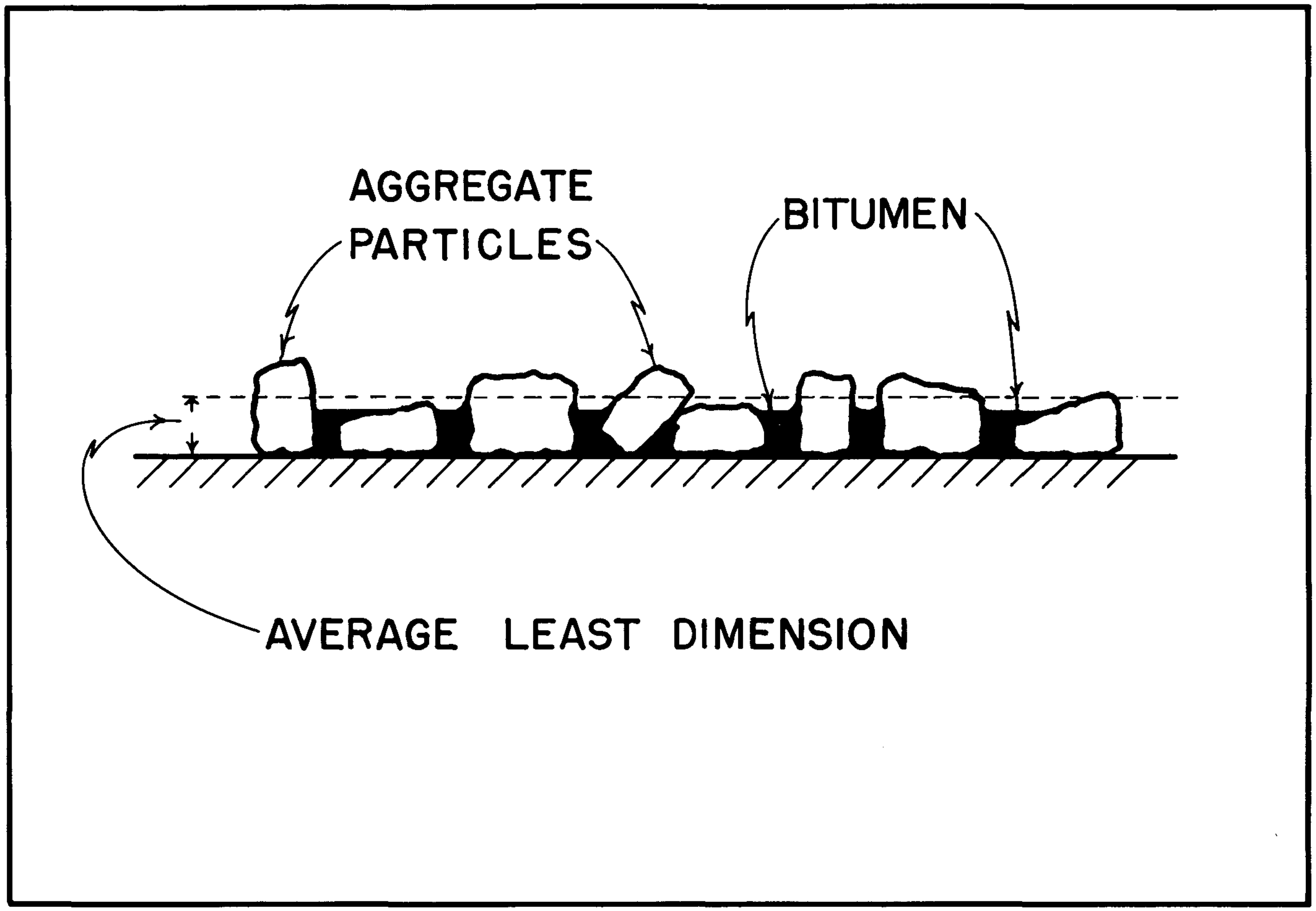


FIG. 6 ILLUSTRATING THE AVERAGE LEAST DIMENSION OF THE COVER AGGREGATE FOR A SEAL COAT OR SURFACE TREATMENT.

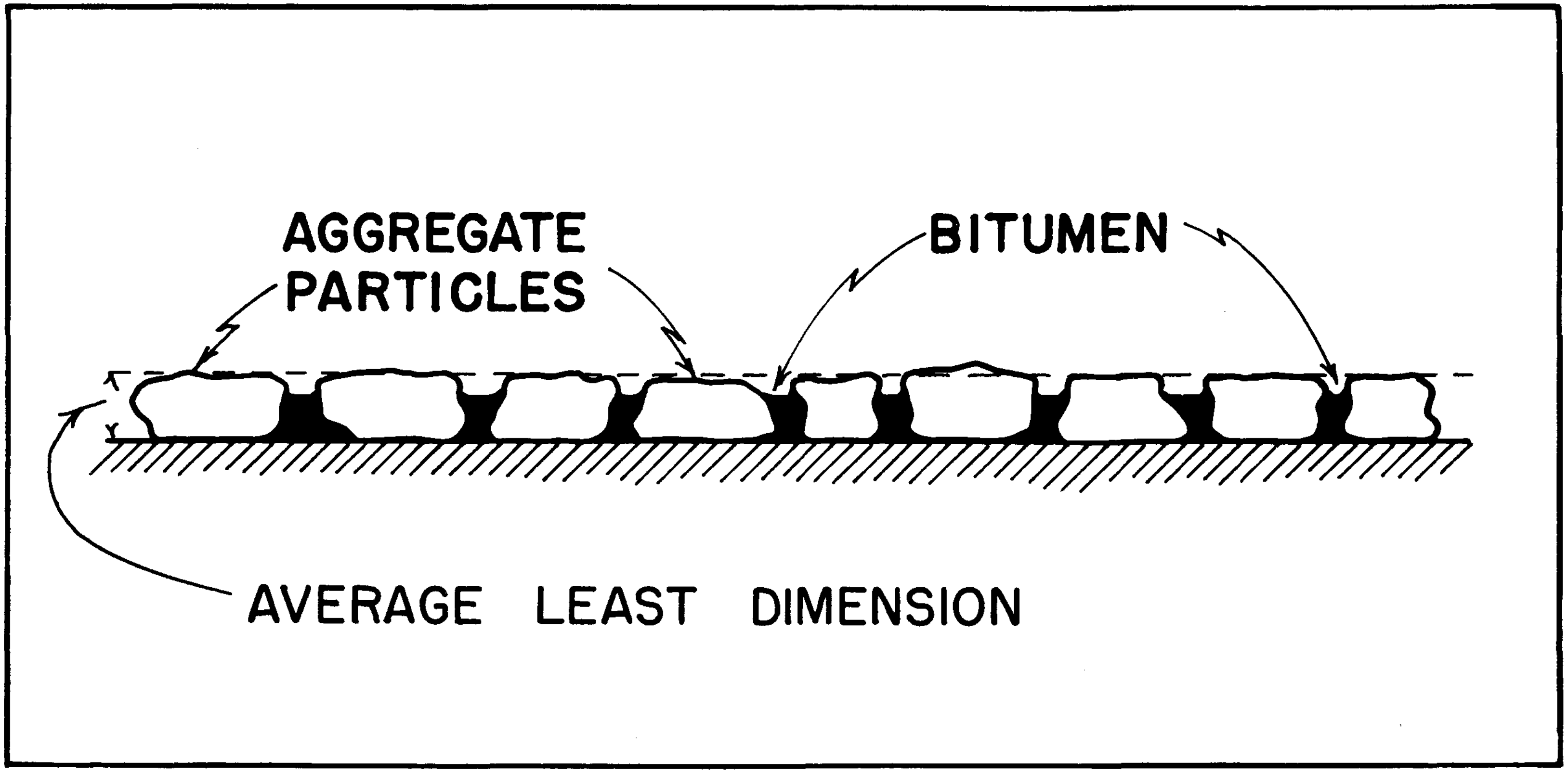


FIG. 7 PROPERLY CONSTRUCTED SURFACE TREATMENT OR SEAL COAT.

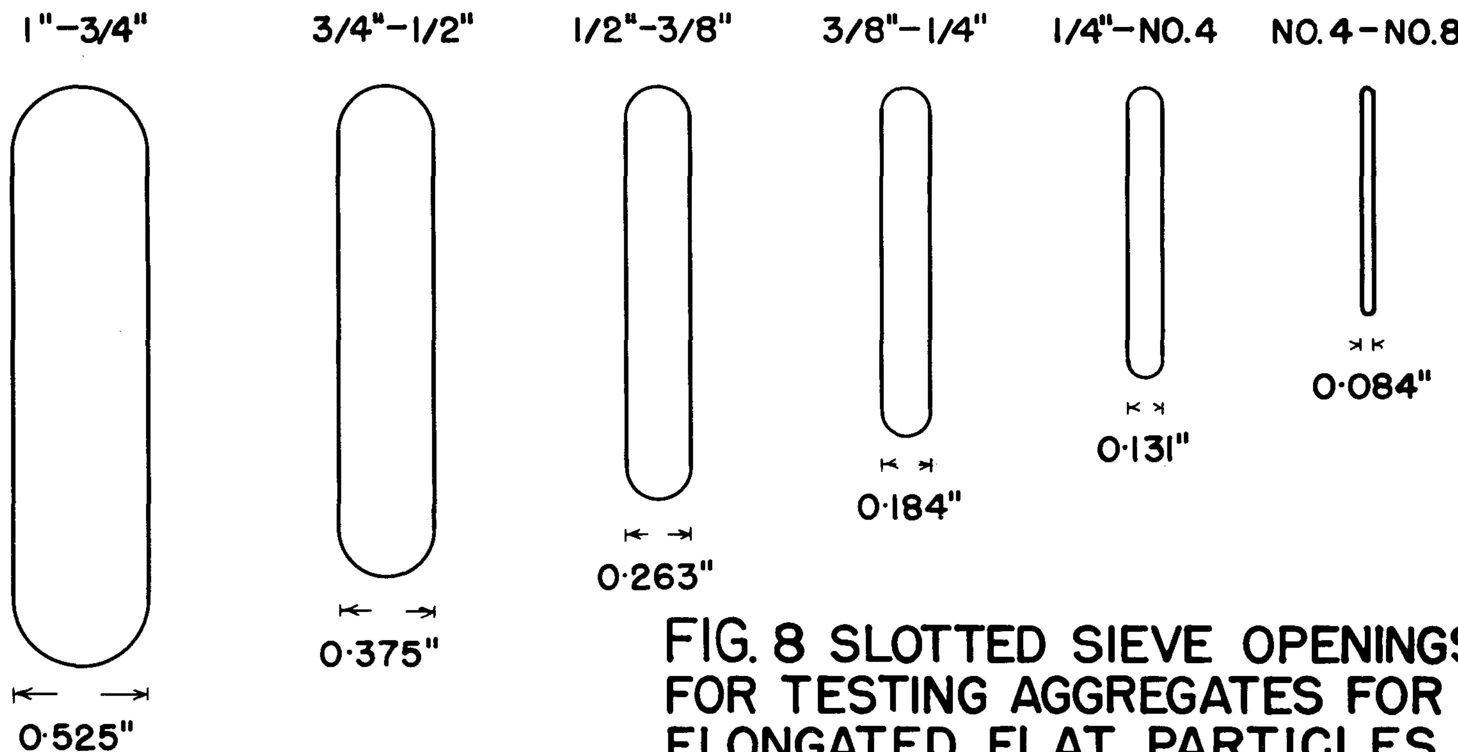


FIG. 8 SLOTTED SIEVE OPENINGS FOR TESTING AGGREGATES FOR ELONGATED FLAT PARTICLES.

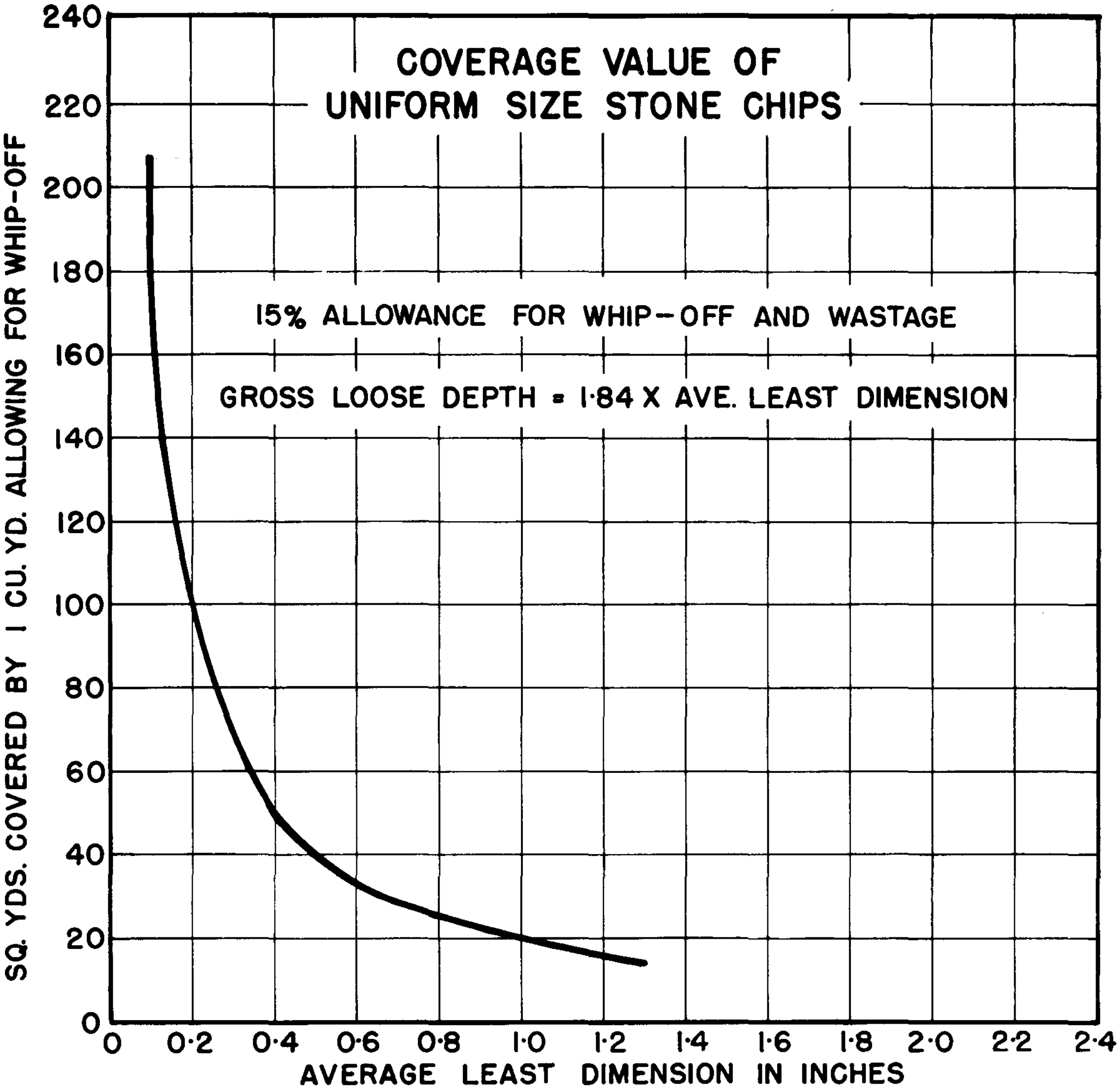


FIG. 9 RELATIONSHIP BETWEEN AVERAGE LEAST DIMENSION AND COVERAGE VALUE WITH ALLOWANCE FOR WHIP-OFF AND WASTAGE.

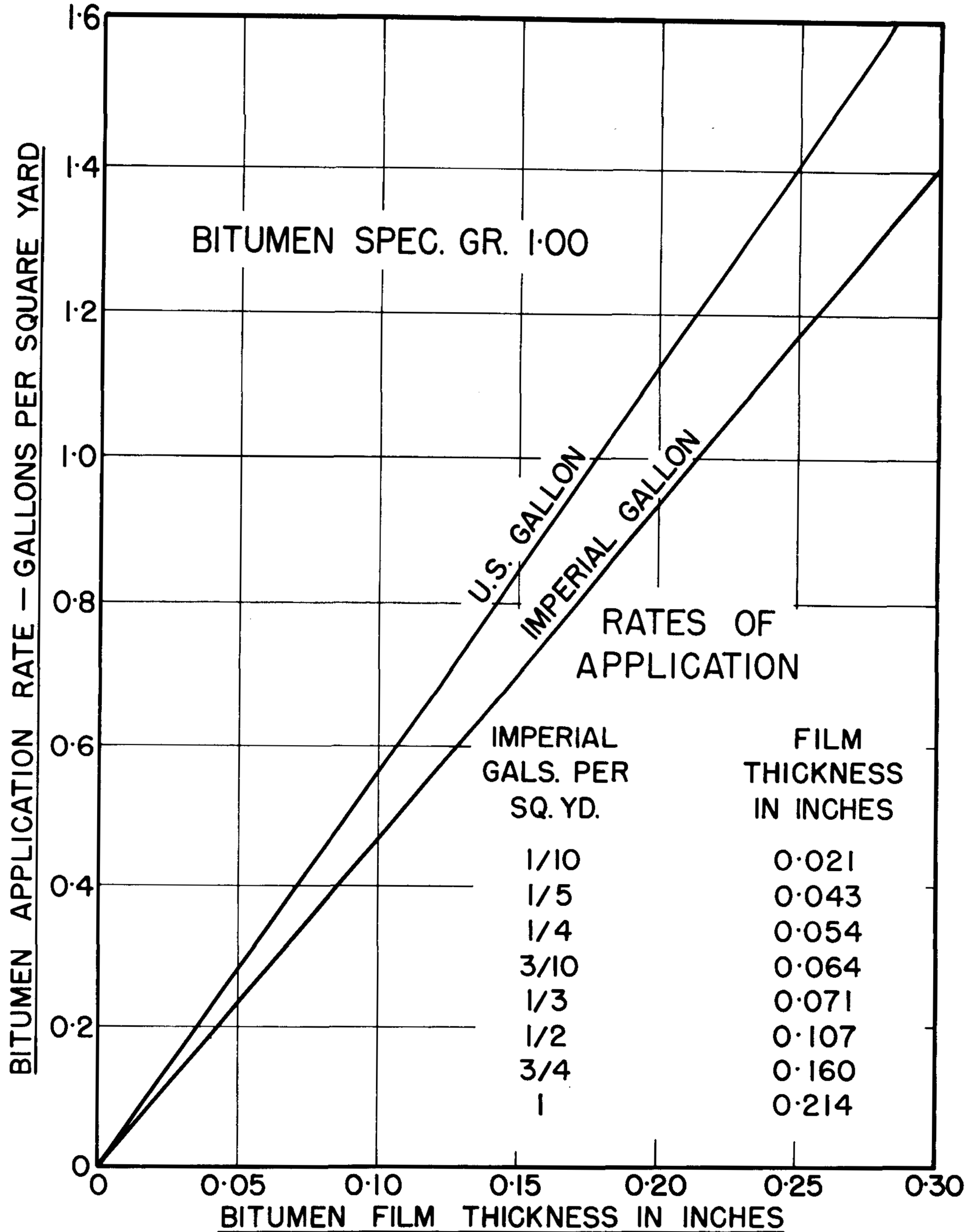


FIG. 10 RELATIONSHIP BETWEEN BITUMEN FILM THICKNESS AND GALLONS PER SQUARE YARD.

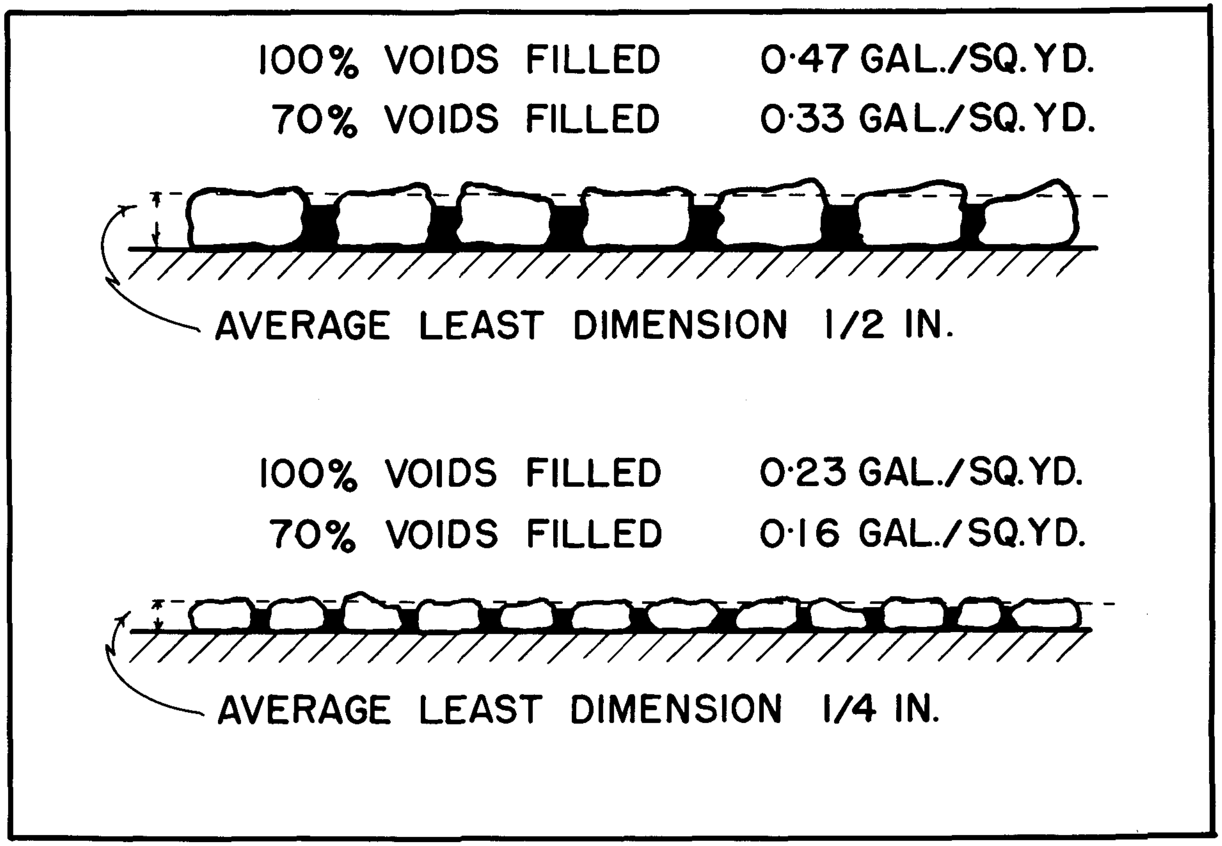


FIG. 11 ILLUSTRATING THAT SURFACE TREATMENTS MADE WITH LARGER AGGREGATES ARE LESS SENSITIVE TO SMALL VARIATIONS IN BITUMEN APPLICATION THAN WHEN SMALLER COVER AGGREGATES ARE USED.

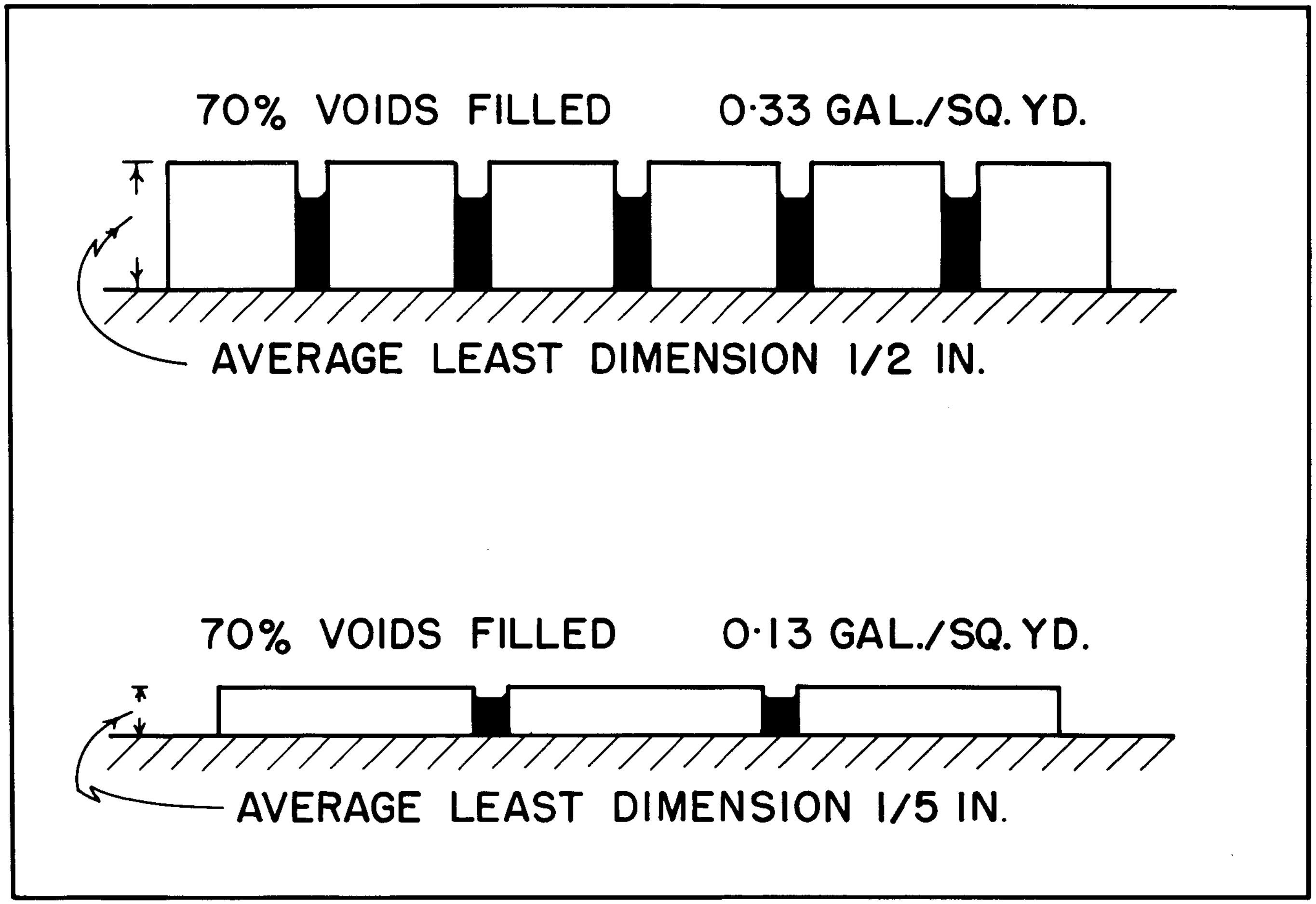


FIG. 12 COMPARING BITUMEN REQUIREMENTS FOR SEAL COATS MADE WITH 1/2 INCH COVER AGGREGATES OF DIFFERENT PARTICLE SHAPES — ONE CUBICAL, THE OTHER FLAT AND ELONGATED.

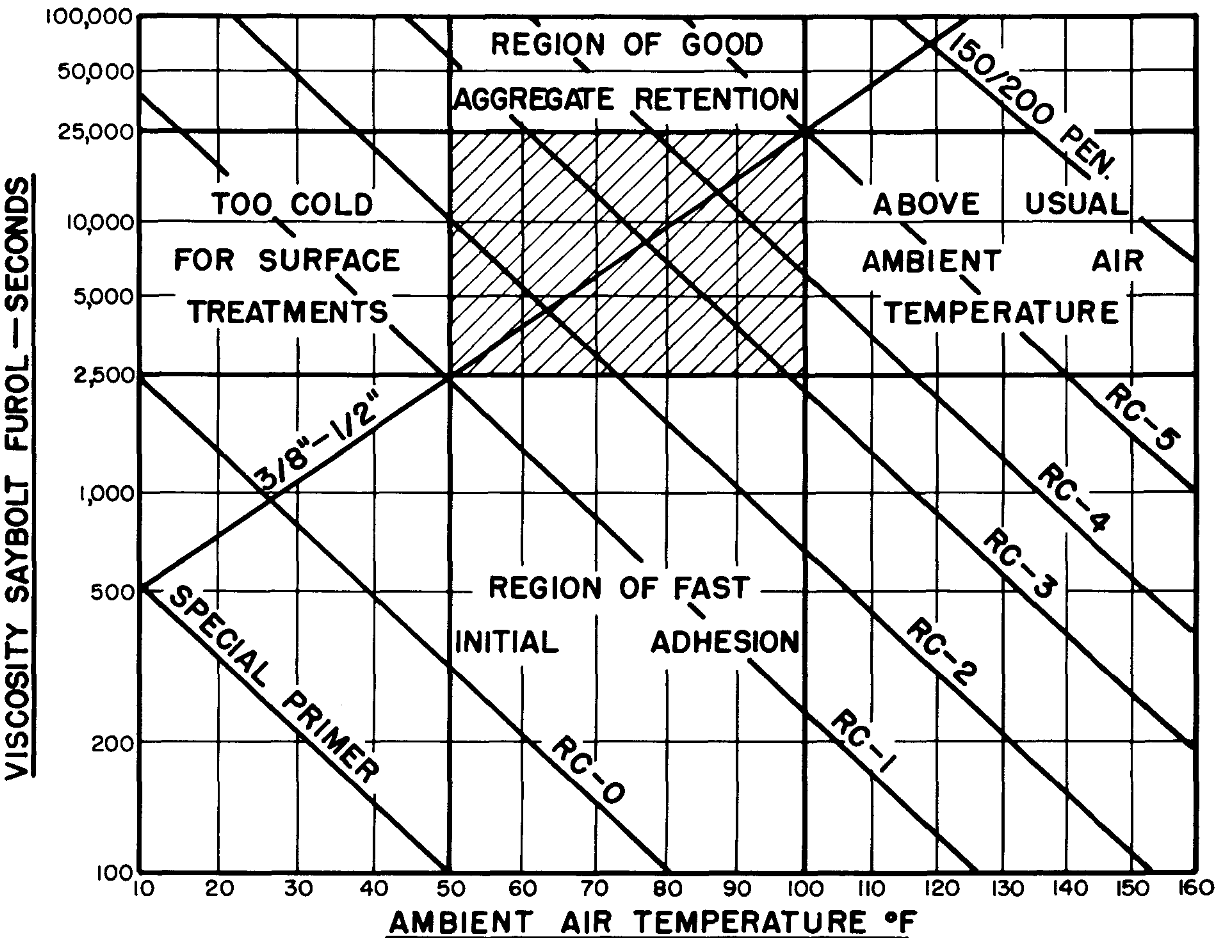


FIG.13 INFLUENCE OF INITIAL ADHESION, RESISTANCE TO DISPLACEMENT BY TRAFFIC, AND AMBIENT AIR TEMPERATURES ON SELECTION OF ASPHALT BINDER (3/8" TO 1/2" COVER AGGREGATE)

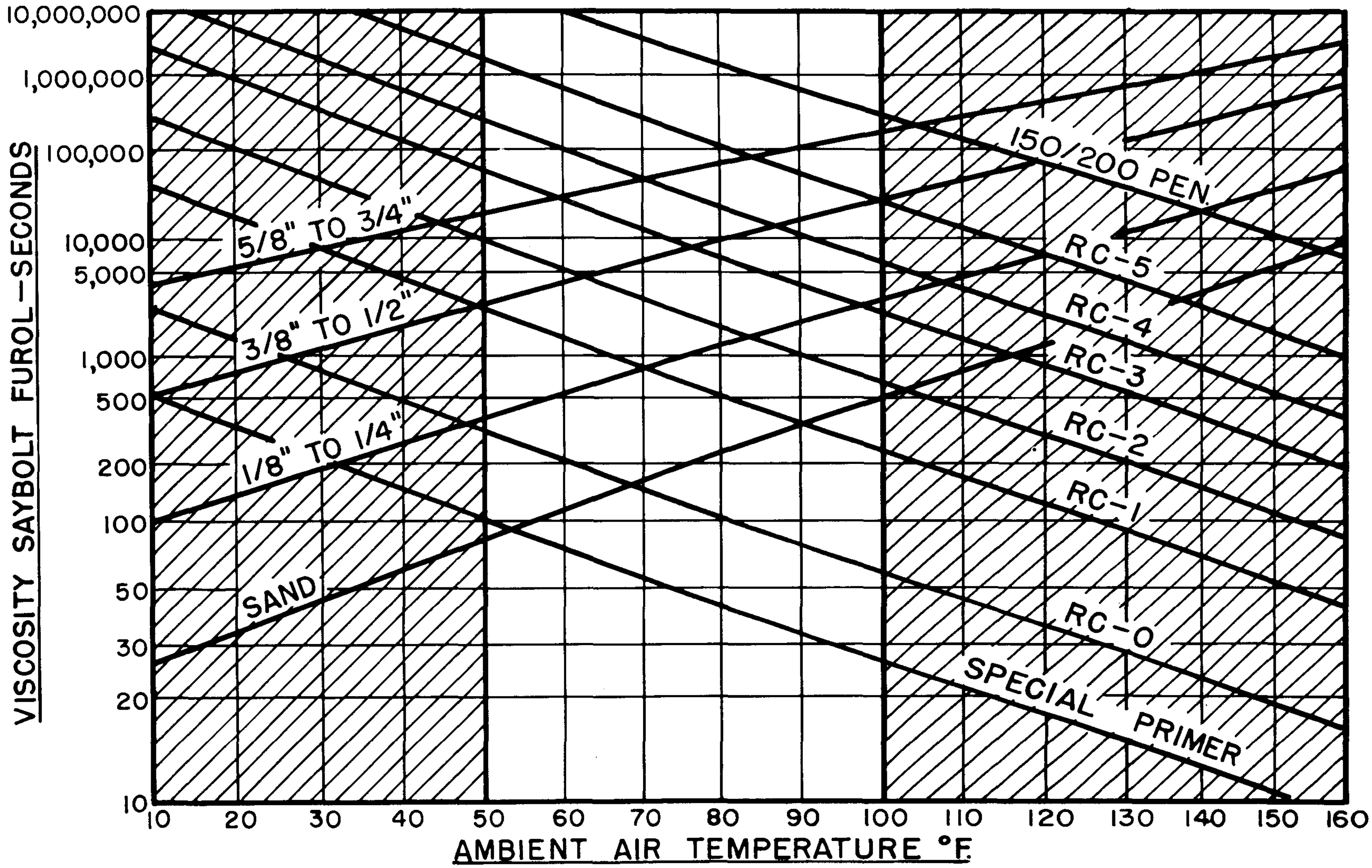


**FIG.14 INFLUENCE OF AMBIENT AIR TEMPERATURES AND SIZE OF COVER AGGREGATE ON SELECTION OF ASPHALT BINDER.**