OUTLINE DRAFT - NOT FOR PUBLICATION

CONSIDERATIONS OF FIELD RESULTS AND TRAFFIC RESPONSE IN THE LABORATORY DESIGN OF SLURRY SEAL AND MODIFIED BITUMEN MICROASPHALT SURFACES

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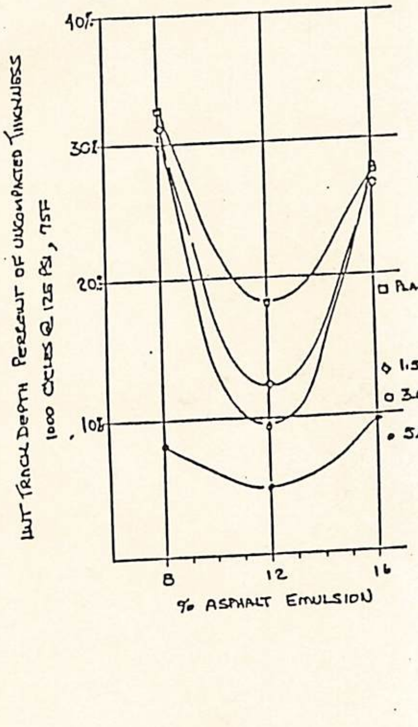
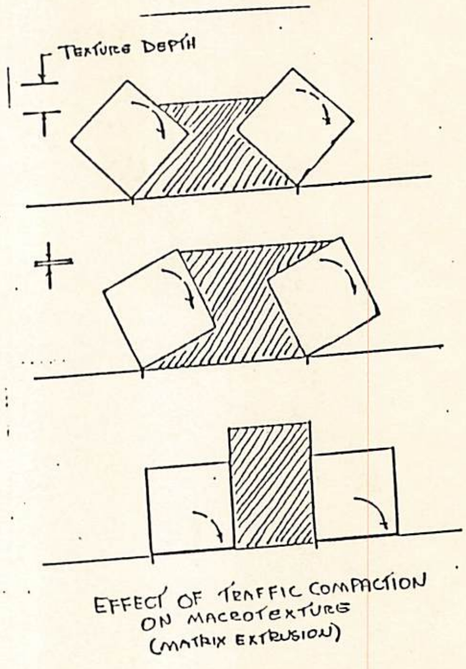
Prepared for presentation at the International Slurry Seal
Association Users Conference, Denver, Colorado
May 18, 1989





EFFECT OF TRAFFIC COMPACTION
ON MACROTEXTURE
(MATRIX EXTRUSION)

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INTRODUCTION

It is our purpose here to:

1). Review the conventional slurry seal laboratory tests and design methods.

2). To review field precision results and traffic response of typical slurry seals.

3). To compare conventional mono-layer slurry seals with multiple layer modified bitumen micro asphalt concrete (= COLD MAC).

4). To relate new design tests for Micro Asphalt Concrete.

CONVENTIONAL SLURRY SEAL DESIGN

The design approach to both Slurry Seal and COLD MAC is the same as the design of any bituminious pavement system:

1). State clearly the objectives of the treatment

2). Select materials combinations to meet the objectives

3). Subject laboratory specimens to field related tests

Slurry Cold mixes are very different than Hot mixed asphalt concrete since slurry must deal with the effects of the presence of water.

The laboratory designer is concerned with the questions:

Will "it" mix?
Will "it" set and cure?
Will "it" last?
Will "it" be safe?
Will "it" meet the objectives?

A typical generic slurry design procedure is:

1). Materials testing:
 Aggregate: S.E. & Gradation, etc.
 Emulsion: % residue, sieve, etc.

2). Trial mixes and wet cohesion

3). Compatibility, non-segregation, adhesion

4). Wet Track Abrasion - Minimum bitumen

5). Loaded Wheel Sand Adhesion - Maximum bitumen

6). Graphical selection of optimum bitumen

Trial Mixes and Wet Cohesion Test, Filler Optimization

A series of 100 or 200 gram mixes are performed at a standard emulsion content, but varying the filler, water and additive contents. These are tested with the cohesion tester, a power steering simulator, to determine the best or optimum combinations for workability, mix time, set time and traffic time.

Compatibility

The air-cured wet cohesion specimens are examined for coating, adhesion, aggregate segregation or liquid separation to determine compatibility.

Wet Track Abrasion Tests

WTAT specimens at the determined optimum filler/additive contents are prepared at 3 levels of emulsion content, oven cured, soaked for one hour and abraded for 5 minutes in the WTAT machine. The weight loss is determined, 24.5 grams is the maximum allowable loss.

The WTAT determines the minimum bitumen content.

Loaded Wheel Test - Sand Adhesion

6mm LWT specimens are prepared at the same WTAT mix formulas, compacted with 1000, 57 kg cycles. Hot, calibrated sand is compacted onto the surface of the samples and the weight of adhered sand determined. 7.6 grams is the maximum allowable for heavy traffic while 10.6 grams is satisfactory for very light traffic.

The LWT determines the maximum bitumen content.

Optimum Bitumen Content (JMF)

The optimum bitumen content is determined graphically and is defined as the maximum allowable bitumen for the traffic count expected, less one-half the field tolerance range. The minimum bitumen content must not be less than the minimum WTAT determination.

FIELD RESULTS AND TOLERANCE SELECTION

(1) In a 1975 study of the extraction results of 10 jobs, the best recorded job results suggested that +/- 15% of the optimum was the best field performance that could be expected.

(2) In some instances, precision limits of +/- 9% and even 6% have been achieved. The ISSA A143 guide spec. calls for +/- 10%.

(3) A 1984 series of 20 extractions on 3100 ton job ranged from 5.1 to 6.1% extracted bitumen (+/- 10%) on field samples from a continuously self-loading machine. However, the physical field measurements averaged not 5.6% but 6.8%!

Reliability of extractions from field samples is not generally good with slurry systems. It is our preference to use field acceptance lot measurements when possible.

By careful calibration and attention to detail such as the bulking effect of aggregate moisture contents and avoidance of gradation variation and further equipment improvement, tolerances of +/- 5% may be regularly achieved.

(4) The AB Road Test data, which we believe is accurate, shows the critical importance of the field control of bitumen quantity where the friction members were related to bitumen content after 26 million, 2-lane vehicle passes:

Satisfactory	FN_{40} = 39 @ 7.4% bitumen
Unsatisfactory	FN_{40} = 34 @ 8.2% bitumen

(5) Another example is the Ohio SR 65 project which was performed with a consistent, single, continuously-self loading machine. Even though the proportioning was uniform, the traffic count affected the compaction rate, consequently the macrotexture and friction numbers:

8000 ADT	FN_{40} = 39
2000 ADT	FN_{40} = 49

The fact is that variations in field proportioning do occur and the traffic counts do vary in a given project.

The inevitable variations in field application and conditions are critical and should be considered in laboratory design to meet the objectives of the user agency.

EFFECT OF GRADATION, LAYER THICKNESS, VOIDS AND MATRIX STIFFNESS IN THE DESIGN OF SLURRY SEAL AND COLD MICROASPHALT MIXES.

Recent studies and observations have shown very large differences in test responses due to gradation, voids and properties of the bitumen-filler matrix which surrounds or holds the larger aggregate particles in the mix.

(6) The gradation band of ISSA type 3 (0/8mm) grading allows 10 to 30% 8mm (5/16") large particles. The number of large particles that protrude through a monolayer relates contact area at the tire-surface interface are as illustrated. There are 3 times more contact points with 30% than the 10%, and hence, a higher friction value would be expected with the 30% top size.

(7) The speed gradient we believe, will be much better with more contact points per unit area. (Speed gradient is the rate of FN decrease with increase in vehicle speed).

But the texture depth or macrotexture is critical and this depends upon a number of factors, but primarily on gradation and the quantity of matrix surrounding the large particles.

(8) To illustrate this, typical slurry seals have excellent initial friction characteristics due to macrotexture and high initial voids. Initial voids are due to the loose nature of the placed mix and water presence. These voids can be as high as 35%; more typically in the 25% range. In time, traffic (and temperature cycling) compacts the mix and macrotexture is reduced and in some cases totally lost.

(9-10) A hypothetical illustration shows the requirements of matrix voids and total mix voids to maintain a constant macrotexture as layer thickness increases. Note that mix voids required vary from 21.5% in a monolayer to 13.8% in a multilayer while the matrix voids required varies only from 10.8 to 9.9% through the layer thicknesses.

(11) Another hypothetical illustration shows the effect of matrix stiffness. Normal slurry seals have what we term "soft" matrixes; i.e., they are highly susceptible to traffic compaction, especially during the hot summer months. A monolayer, conventional, soft matrix slurry looses it's surface macrotexture ~~so~~ rapidly with compaction as layer thickness increases.

On the other hand, "stiff" matrix COLD MACs resist high temperature compaction and the macrotexture actually INCREASES with layer thickness and voids remain high!

MODIFIED BITUMEN COLD MAC DESIGN

Recent field studies have shown that nearly all satisfactory multilayer COLD MAC have relatively high void contents (8-12%) and low densities (2.10) as well as good friction properties in spite of 4 years of heavy traffic and high temperature compaction; i.e., they compact somewhat initially but they resist further compaction which is independent of exposure time or compaction energy!

To measure the compaction characteristics in the laboratory, two tests have been developed:

1. Multilayed Loaded Wheel Test
   Vertical and Lateral displacement at ambient temperature (23C)

2. Wheel Tracking Test (British)
   at high temperature (45C)

(12) The ambient LWT vertical displacements yield very interesting curves. Always, maximum stability or resistance to vertical displacement is reached at about 12% emulsion content for the 0/5mm gradations. Inverse Marshall curves are found and it is possible to select the optimum bitumen content for maximum stability or minimum vertical displacement from these rolling, traffic-simulating curves.

A maximum 10% multilayer vertical displacement and 5% lateral displacement has been found to perform very well in the field.

(12-13) Two examples show the effects of polymer type and quantity and the effects of various mix content additives. The saucer-shaped curve is IDEAL because it allows a very wide variation of bitumen content which makes less need for precise field proportioning. Users and contractors alike, would be pleased with the predictability and reliability of this design method.

For severe applications, the Wheel Tracking Test at 45C (115F) is used.

(14-15) While multilayer conventional slurry mixes may do well in the ambient temperature LWT, they always fail the COLD MAC criteria in the WTT at 45C. This example shows differences in the plain and modified emulsions.

Additional New Tests

Because of the relative low levels of bitumen, high voids of the traffic compacted mixes and the high filler (0/#200) contents, the quality of the bitumen-polymer-emulsifier residues, their mutual system compatibility becomes extremely important to the long term performance and durability of COLD MAC.

These tests are:

1). 60C Cured Cohesion

2). Low temperature (7C), 5-hour Wet Cohesion

3). Strength and Stretch, 1-RPM Rotational Shear

4). Low Temperature Flexural Tension

5). WTAT, 6-day Soak

6). Schulze-Breuer-Ruck Bitumen-Filler Compatibility

SUMMARY

We have reviewed conventional slurry seal design, precision limits of field construction and the subsequent need to develope laboratory designs that give excellent performance over A BROAD RANGE of field variables. We have examined the effects of matrix quantities and properties as well as gradation on the macrotexture and compacted voids. New methods of testing and designing high performance materials systems have been briefly discussed.

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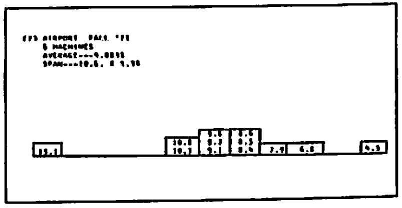
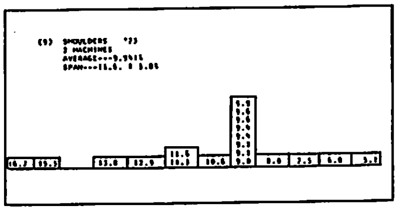
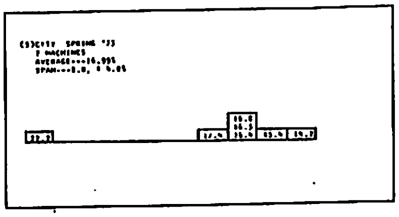
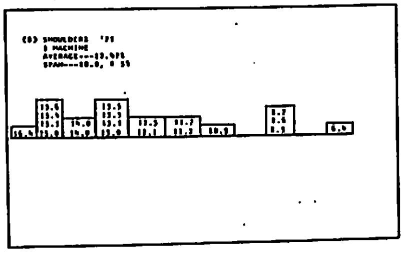
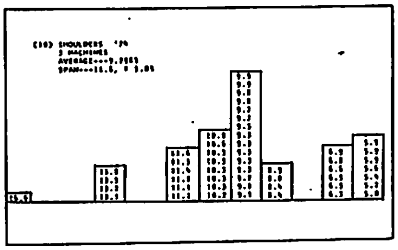
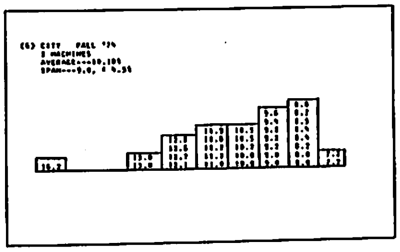


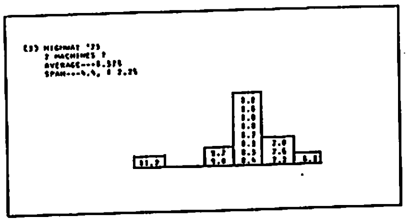


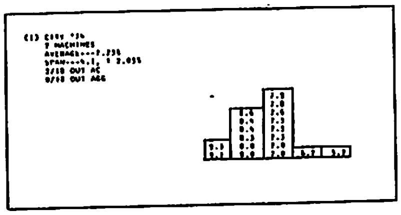


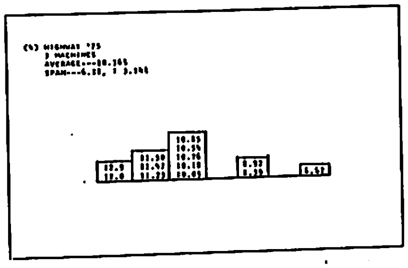


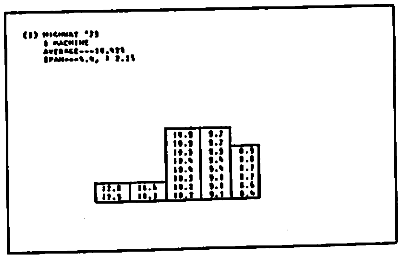












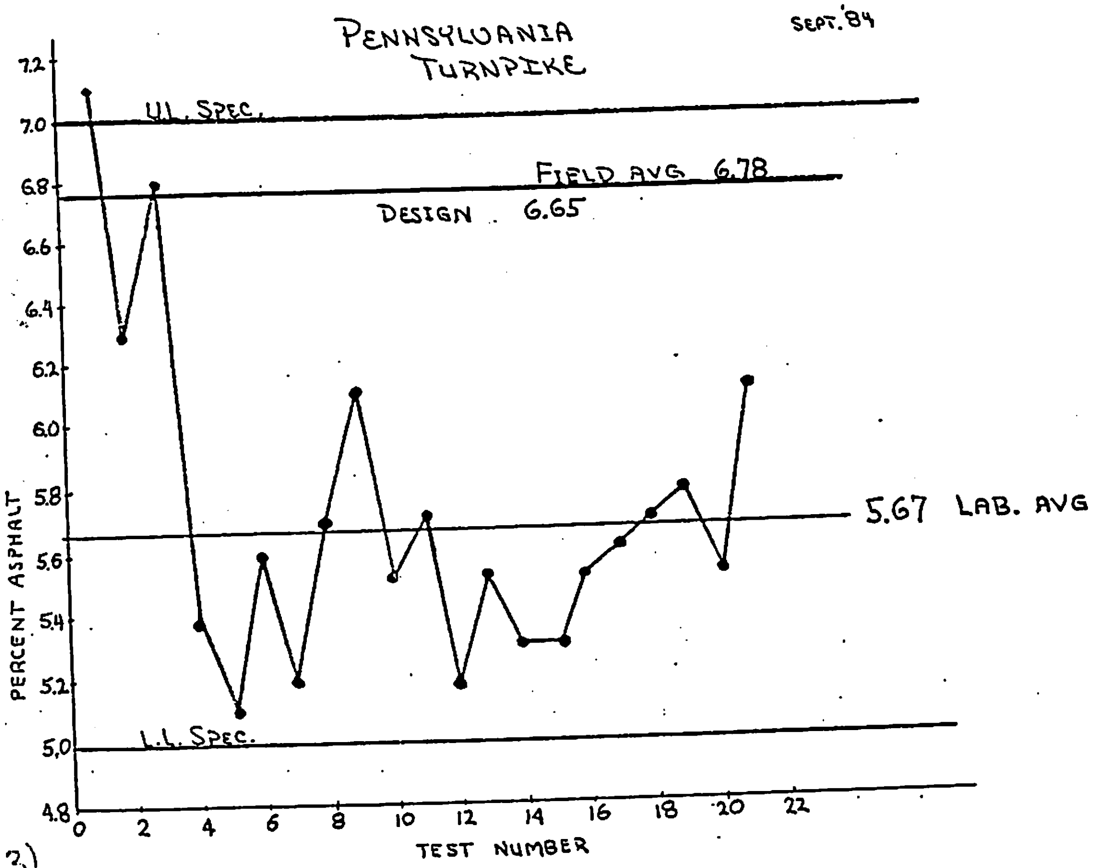
7 (1)

	AVERAGE %	RANGE	TOLERANCE FROM MEAN	% VARIATION FROM MEAN	ELIMINATE OUTLIERS	% VARIATION FROM AVERAGE
1.	7.73%	4.1%	±2.05%	±26.5%	±1.15%	±14.9%
2.	10.42%	4.4%	±2.2%	±21.1%	±1.75%	±16.8%
3.	8.57%	4.4%	±2.2%	±25.7%	±1.25%	±14.6%
4.	10.36%	6.38%	±3.14%	±30.3%	±1.80%	±17.4%
5.	16.99%	8.0%	±4.0%	±23.5%	±1.60%	± 9.4%
6.	10.18%	9.0%	±4.5%	±44.2%	±2.5%	±24.6%
7.	9.08%	10.6%	±5.3%	±58.4%	±2.0%	±22.0%
8.	12.47%	10.0%	±5.0%	±40.1%	±3.35%	±26.9%
9.	9.94%	11.6%	±5.8%	±58.3%	±3.15%	±31.7%
10.	9.29%	11.6%	±5.8%	±62.4%	±4.4%	±47.3%

TABLE SUMMARY OF U.S. SLURRY SEAL ASPHALT EXTRACTION RESULTS, 1970-1975

	JMF	TOLERANCE	FIELD RESULTS
SR 42	30 gal/ton	±5 (16.7%)	28.99 ± 3.01 (10.4%)
SR 35	43.8 gal/ton	±5 (11.4%)	44.86 ± 3.02 (6.7%)

(2) TABLE OHIO DOT 1977 QUALITY ASSURANCE JOB RESULTS



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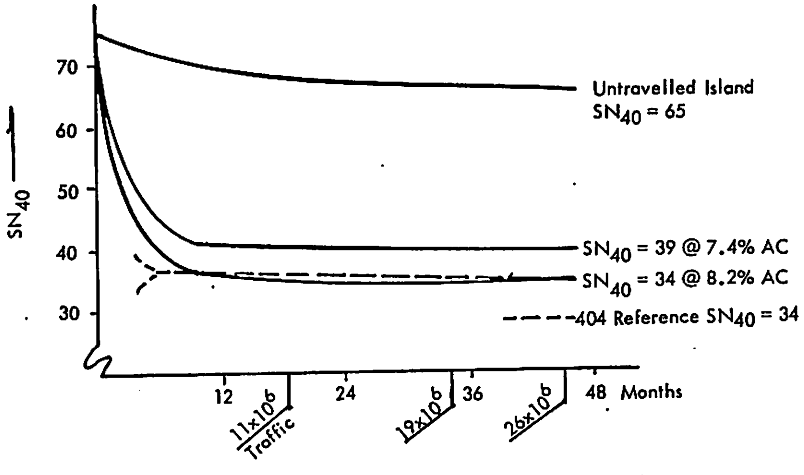


Figure (4) Effect of Asphalt Content on A-B Road Test Skid Numbers after 45 Months and 25,000,000 Accumulated Traffic

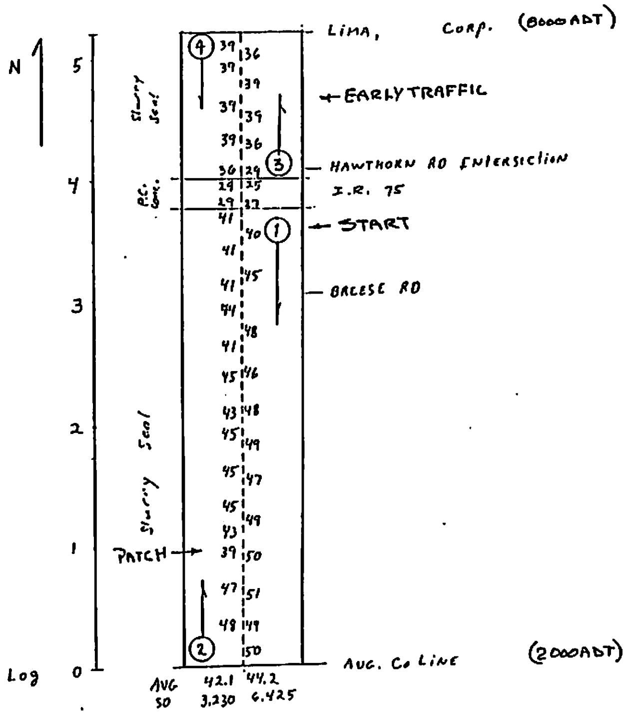
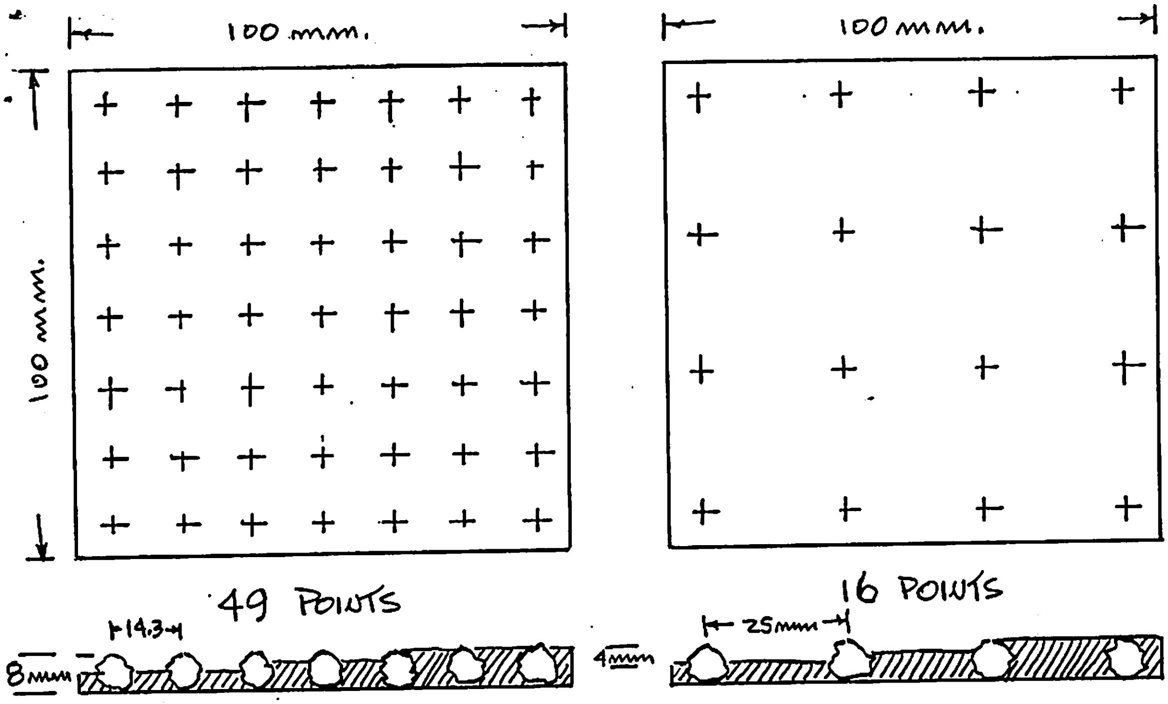


Figure Skid Resistance Tests, SR 65.
Project 563-78 (November 2, 1978)

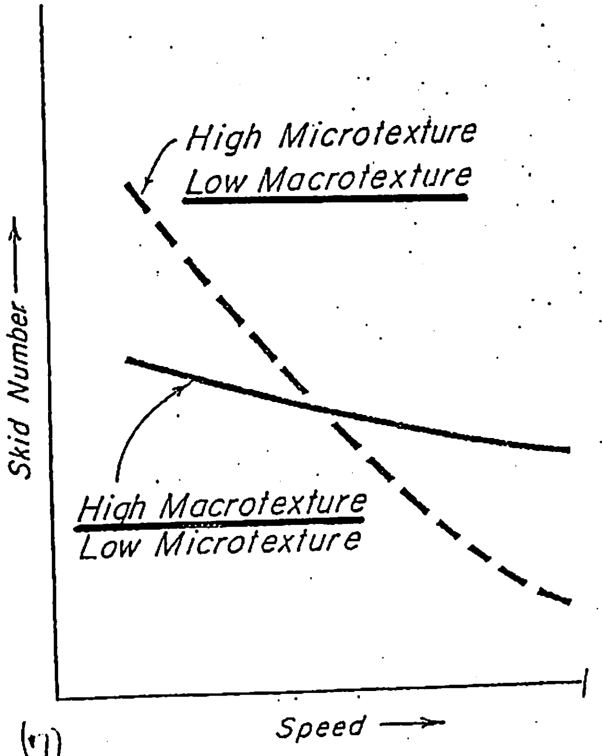


TYPE 3 COARSE - 30%, 8mm

TYPE 3 FINE - 10%, 8mm.

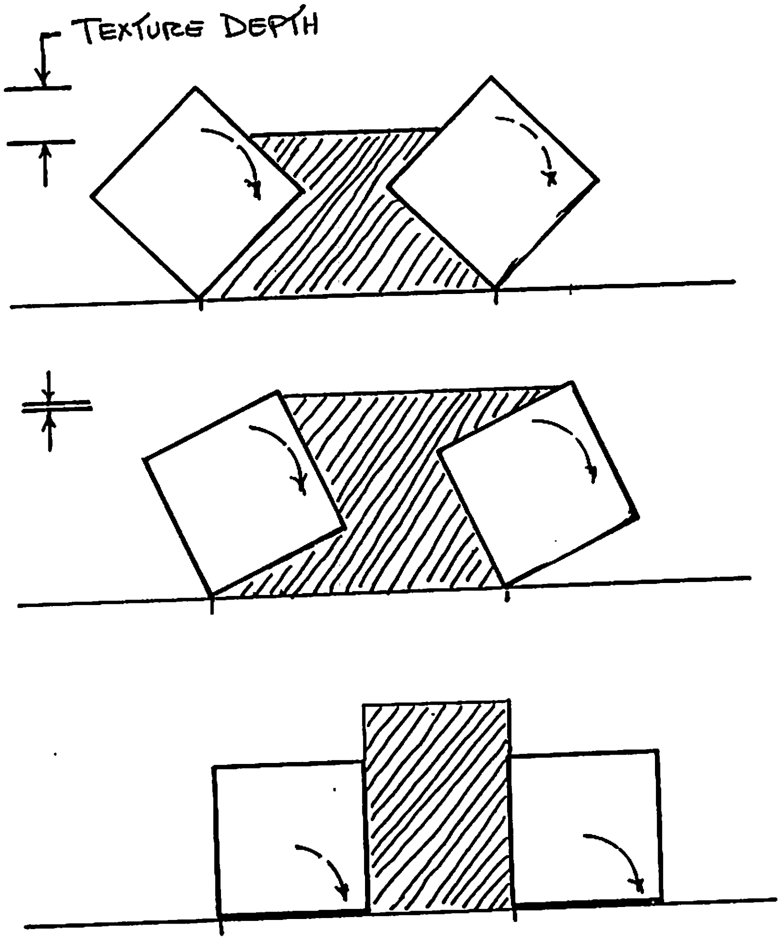
SCHEMATIC MONOLAYER TEXTURE
ISSA TYPE 3 COARSE & FINE
GRADATION - 0/8mm.

(6)



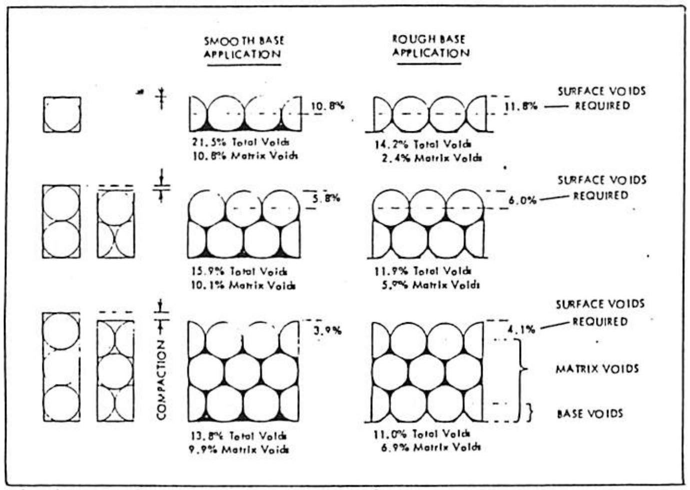
(7)

FIGURE 3. EFFECT OF TEXTURE ON WET PAVEMENT PERFORMANCE.



EFFECT OF TRAFFIC COMPACTION
ON MACROTEXTURE
(MATRIX EXTRUSION)

(8)



(9) Figure HYPOTHETICAL VOID STRUCTURE REQUIRED TO MAINTAIN ADEQUATE SURFACE MACROTEXTURE (50%) IN MONO AND MULTIPLE LAYERED ONE-SIZE SPHERICAL AGGREGATE PAVEMENTS.

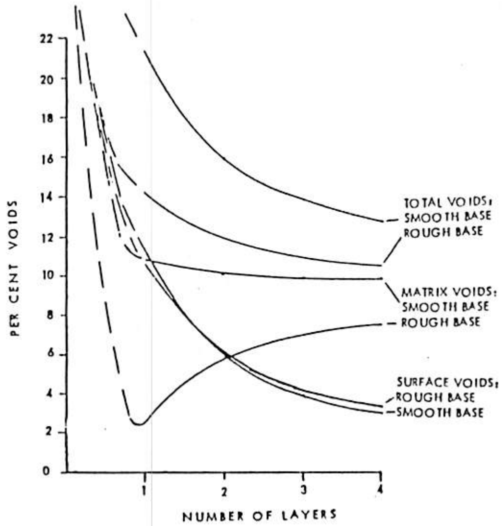
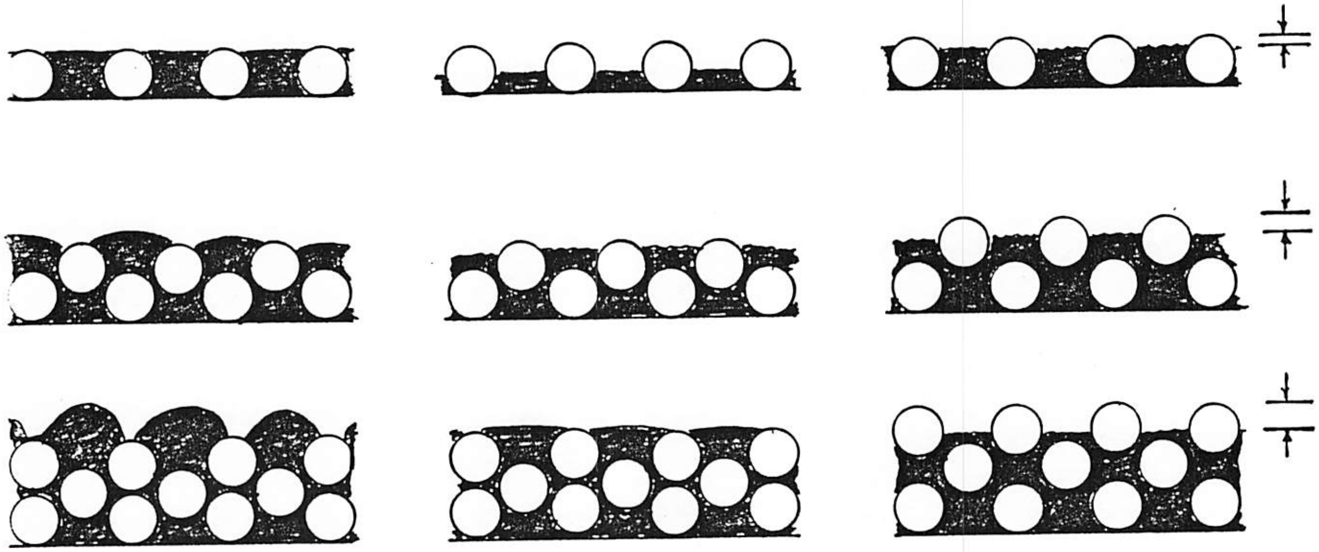


Figure 5. RELATIONSHIP OF TOTAL, SURFACE AND MATRIX VOIDS OF A HYPOTHETICAL MONO AND MULTILAYERED PAVEMENT

(Surface macrotexture remains constant)

(10) Figure



LOW VOIDS
SOFT MATRIX

HIGH VOIDS
SOFT MATRIX

MEDIUM VOIDS
STIFF MATRIX

(11) EFFECT of LAYER THICKNESS & MATRIX PROPERTIES ON MACROTEXTURE DEPTH

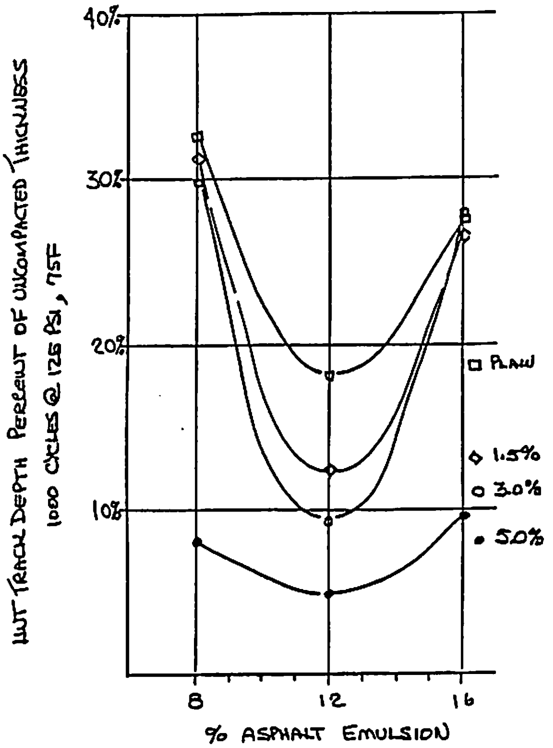


FIGURE (12) POLYMER "F"
61201-1 @ 5%; 61201-2 @ 3%
70206-3 @ 1.5%; 61201-3 - PLAIN
VS. SAND 2 AGG. + KA ADD

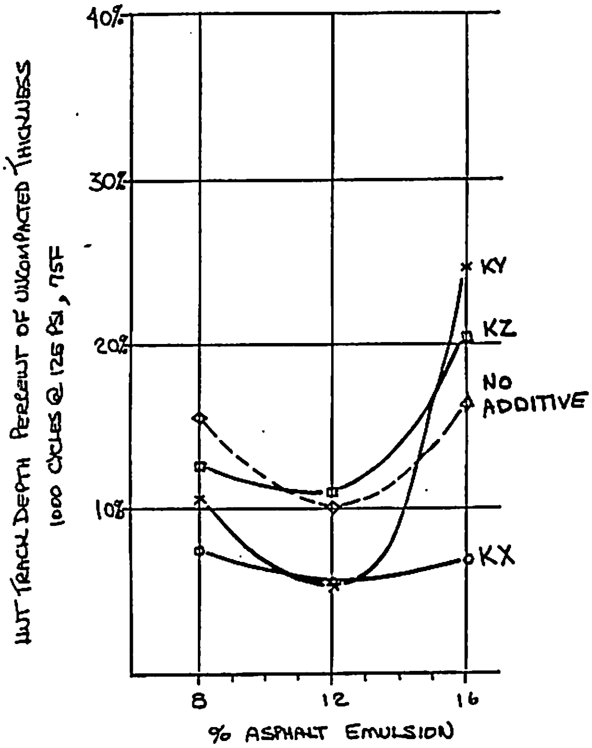
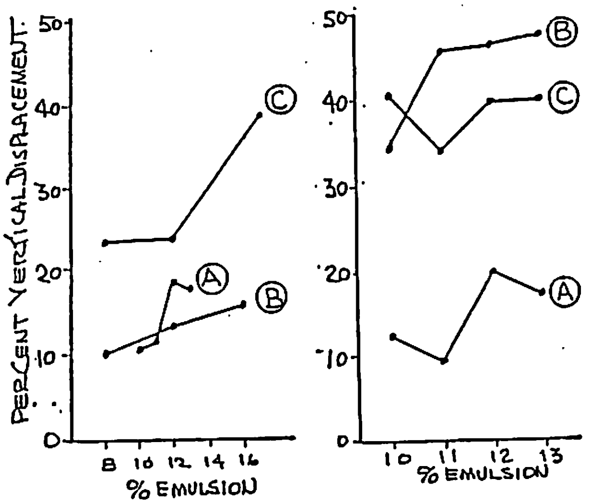


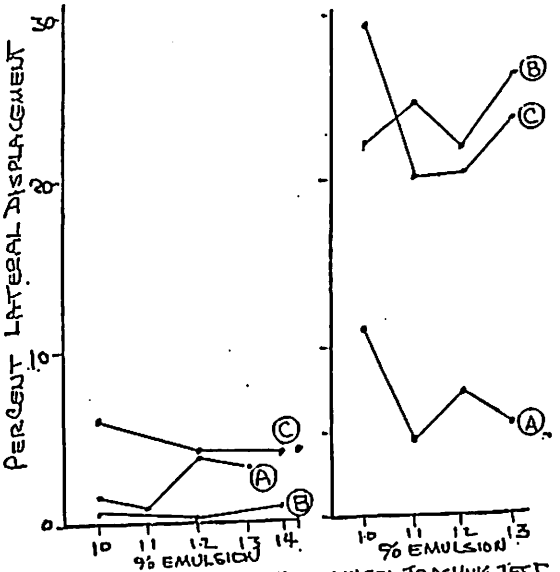
FIGURE (13) EFFECT OF MIX ADDITIVES
POLYMER "A" - 3%
VS. SAND 2 AGG.



LWT@ 23C

WTT@ 45C

(14) VERTICAL DISPLACEMENT



LOADED WHEEL TEST
1000 CYCLES, 125 LBS, @ 23C

WHEEL TRACKING TEST
1-HOUR, 60 PSI @ 45C

FIG (15) LWT @ 23C (72F) & WTT @ 45C (115F)
LATERAL DISPLACEMENT COMBINED