LABORATORY TESTS
and
THE DESIGN AND CONTROL OF
SLURRY SEAL

by

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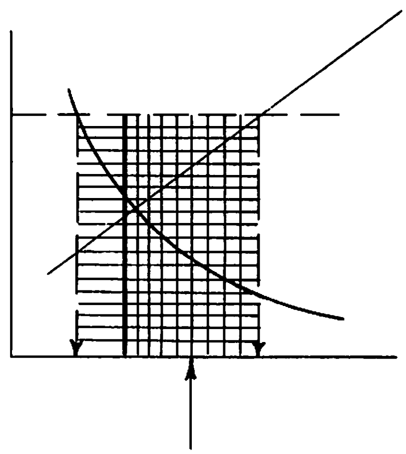

AN ISSA RESEARCH AND DEVELOPMENT COMMITTEE REPORT ON A NEW PROPOSED GUIDE DESIGN PROCEDURE AND METHODS OF CONSTRUCTION CONTROL FOR PRESENTATION TO THE LABORATORY TESTS SESSION OF THE 15TH ANNUAL CONVENTION OF THE INTERNATIONAL SLURRY SEAL ASSOCIATION.

ISSA'77

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----LABORATORY TESTS AND THE DESIGN AND CONTROL OF SLURRY SEAL----

INTRODUCTION

It is our great pleasure to receive the hospitality of Señor Balaguer, our hosts, Composan, S.A., Probisa, and the people of Spain and to greet our fellows-in-industry from the world over and to participate in this International Congress, the 15th annual convention of the International Slurry Seal Association.

The principle concern of this session is laboratory tests which ultimately relate to the design and control of slurry seal. I wish to briefly review the role of testing in the following three areas:

1. ISSA Research & Development Committee current Task Force Projects
2. A new Proposed Guide Design Procedure
3. Methods of Construction Control

ISSA R & D COMMITTEE TASK FORCE PROJECTS

As discussed previously by Mr. John Huffman, where slurry seal meets its greatest success, we will discover men who have mastered the essential complexities of the art. They have learned that when properly designed and constructed, slurry seal achieves the common goals of economy, durability and safety.

Slurry seal is a most complex art. Benedict's law states that "Complexity varies with the square of the number of variable components". A corollary states "Understanding complexity yields simplicity". The ISSA R & D committee seeks to improve our art by understanding and simplification of the many complex variables.

The ISSA R & D committee membership is open to all who have a special technical interest in slurry seal. Our method is the free interchange of ideas and open communication through the media of individual, task force and committee reports published as technical bulletins, ISSA newsletter articles and convention proceedings. Research is conducted by non-funded volunteers.

Additionally, many of our members represent our interests at the American Society for Testing Materials (ASTM), The Asphalt Emulsion Manufacturer's Association (AEMA) and the Transportation Research Board (TRB). Liason is maintained also with trade associations such as the Asphalt Institute, the National Crushed Stone Association, the National Slag Association, material and research departments of many State Departments of Transportation (-DOT) and University Laboratories.

From the some 90 problems discussed during the past three years, the R & D committee has elected to concentrate on the following task force projects:

ISSA R & D COMMITTEE CURRENT PROJECTS - FEBRUARY, 1977

TASK FORCE PROJECTS:

(a.) Allowable and Attainable Standards of Uniformity and Tolerances
   Tom Sands - Interstate Asphalt - Quakertown, Pennsylvania
   Fred Dabney - Slurry Pavers - Richmond, Virginia
   Bob Elliot - Elliot Brothers - Oklahoma City, Oklahoma

(b.) Prediction and Maintenance of Spread Rates or Application Quantities
   Bill Miteff - Emulsified Asphalts - Chicago, Illinois
   John Bellizzi - City of Des Moines - Des Moines, Iowa
   *Romain Hagebock - City of Des Moines - Des Moines, Iowa

(c.) Aggregate Surface Area, Aggregate Absorbtivity and Slurry Design Procedures
   Les Harkness - Armak - Chicago, Illinois

(d.) Field Mix Control by Water Flow Meter
   Greg Herrling - Madison Slurry Machine Co. - Madison, Wisconsin

(e.) Study of Aggregate Toughness/Durability by Shaker and Acid Insolubility
   Bob Province - Slurry Seal, Inc. - Waco, Texas
   Raymond Young - Slurry Seal, Inc. - Waco, Texas

(f.) Strip Chart Mixing Profiles for Slurry Mixes
   Dick Zinn - Ashland Chemical Co. - Columbus, Ohio
   Roger Starkey - Ashland Chemical Co. - Columbus, Ohio
   Ben Benedict - Benedict Slurry Seal, Inc. - Dayton, Ohio

(g.) Paper Reviewing Slurry Emulsion Technology
   Charley Schmitz - Chevron - Towson, Maryland

(h.) Loaded Wheel Tester Correlation
   Jaime Gordillo - Composan - Madrid, Spain
   Luis Sanchez - Composan - Madrid, Spain
   Sam Mitchell - Bitucote Products - St. Louis, Missouri
   *Da-Yinn Lee - Iowa State University - Ames, Iowa

(i.) Method of Gate Metering Slurry Machine Calibrations
   Fred Dabney - Slurry Pavers - Richmond, Virginia
   Merle Luck - Slurry Pavers - Richmond, Virginia

(j.) Variations on Consistency, Mixability, Set Time and Cure Time with Saturated and Dry Aggregates
   Estell Johnson - Bitucote Products - St. Louis, Missouri
   *Dick Hatfield - Bitucote Products - St. Louis, Missouri

GROUP PROJECTS:

(a.) Performance Specifications
(b.) Improved Design Procedures

PROPOSED PROJECT:

(a.) Quick-Cure vs. Quick-Set Slurry Systems

* Informal Members

New tools and laboratory test procedures will be developed during the research we have proposed here. Many of our old techniques may be discarded or revised.

Currently, Dr. Da-Yinn Lee of the Iowa State University Engineering College at Ames, Iowa is conducting an extensive graduate level research evaluation of slurry seal laboratory tests and field evaluation of these tests and design procedures. Hopefully, the results of his work will be reported at our 1978 ISSA convention to be held at Atlanta, Georgia.

OUTLINE OF A PROPOSED GUIDE DESIGN PROCEDURE FOR SLURRY SEAL

The underlying philosophy for this proposed design procedure is pragmatic; the approach is to ask three questions to guide us through a particular design:

1.) Does this Slurry mix well?
2.) Will this Slurry wear well?
3.) Will this Slurry be safe?

Part I - Preliminary Design Considerations

1.) Describe the Pavement to be treated
   - a.) Surface condition - macro texture, absorbtivity, surface and structural cracks, surface contamination, longitudinal and transverse geometry, rutting, vegetation.
   - b.) Climate and weather conditions - temperature, rainfall, shade, wind.
   - c.) Average Daily Traffic (ADT) (VPD + trucks)

2.) State Objectives of the Treatment
   - a.) Skid numbers required, surface texture
   - b.) Crack sealing, rut correction, wedging, ravelling correction & c.
   - c.) Life expectancy requirements

3.) Evaluate and Select Materials
   - a.) Evaluation of proposed AGGREGATE
     - 1.) Field Durability record
     - 2.) Skid Resistance Level (SRL), polish susceptability
     - 3.) Gradation, void content, quality of fines, sand equivalent, particle shape, microtexture
     - 4.) Mechanical properties, resistance to mechanical abrasion, L.A. Rattler, Shaker loss, British Wheel abrasion, hardness, crush resistance, freeze-thaw, friability
     - 5.) Chemical properties, acid insolubility, sodium sulfate soundness, water solubility
     - 6.) Mineralology/petrology, geology
     - 7.) Economics - location, availability, transportation, cost
   - a.1.) SELECT AGGREGATE AND GRADATION TO MEET OBJECTIVES
   - b.) Evaluation of proposed EMULSION
     - 1.) Field Durability record
     - 2.) Base asphalt source and type-oxidation/hardening resistance
     - 3.) Emulsion particle size-stability, shear sensitivity, sieve
     - 4.) Climate/penetration-viscosity requirements
     - 5.) Weather-shade, sun, wind, ice, salt, traffic time required
     - 6.) Quick-set/slow-set requirements
     - 7.) Compatibility/adhesion characteristics of the aggregate-filler-retarder-accelerator system, re-emulsification.
     - 8.) Economics-location, availability, transportation, cost.
   - b.1.) SELECT EMULSION TO MEET OBJECTIVES

Outline of a proposed guide design procedure for slurry seal (cont'd)

PART II - Job Mix Formula Procedures

1.) Estimate the theoretical Pure Asphalt Requirement (PAR) or Bitumen Requirement (BR) by Surface Area Method for an 8um coating.
   - a.) Aggregate Sand Equivalent
   - b.) Aggregate Apparent Specific Gravity
   - c.) Aggregate Gradation (dry sieving)
   - d.) Aggregate Centrifuge Kerosene Equivalent
   - e.) Calculate Total Surface Area
   - f.) Emulsion per-cent asphalt residue
   - g.) Calculate the theoretical PAR/BR for an 8um thickness coating of the calculated surface area and record as
     - 1.) Per-cent asphalt added to dry weight of aggregate
     - 2.) Per-cent emulsion added to dry weight of aggregate
     - 3.) Per-cent asphalt of total dry solids.

2.) System Compatibility Determination
   - a.) Estimate filler/additive requirements
     - 1.) Run 100-gram trial cup mixes using 100% PAR to estimate optimum water content, filler requirement and mix-set-traffic/cure time characteristics (ISSA TB 102)
     - 2.) Adjust PAR for added filler if required
   - b.) Cone Consistency Tests run to obtain 2.5 centimetre consistency, ISSA TB 106
     - 1.) Determine optimum mix-water content for three levels of emulsion content; e.g., 100%, 85%, 70% PAR for 2.5 cm. consistency.
     - 2.) Adjust filler content, mix-water content and PAR for changes in mix-set-traffic time if required.
     - 3.) Construct 3-point consistency/mix-water curve for consistency ranges of 2-3 cm., 4-5 cm. and 6-7 cm. ranges for each of the three PAR levels selected. Air dry at ambient and save each specimen.
   - c.) Compatibility Test
     - 1.) Examine cross-sections of centrally split consistency specimens for evidence of asphalt or aggregate migration or existence of excessively sticky surfaces.
     - 2.) If suspicious disuniformity is observed, run Cup Compatibility Test
       - a.) Mix 100 grams of each formulation in a small, plastic-lined drinking cup, cure in the cup for 12 hours. Separate into upper and lower halves, dry, run asphalt extraction by reflux and split median gradation of extracted aggregate. Substantial variation (10 to 15%) from top and bottom halves indicates an incompatible system.
     - 3.) Wet Stripping Test - 10 grams cured slurry in 400 ml. moderately boiling water for 3 minutes. Decant and place on absorbent paper towel. Low asphalt retension can indicate lack of adhesion, low film coalescence, poor emulsion formulation, re-emulsification or possible false slurry.

3.) Traffic/Cure Time by Slurry Cohesiometer
   - a.) Mix and set time by ISSA TB 102 at job temperature conditions
   - b.) Traffic Time by Slurry Cohesiometer at job temperatures of 50°, 80°, & 110° F.

Outline of a proposed guide design (cont'd)

Part II – Continued

4. Physical Tests on Cured Slurry
   - a.) Wet Track Abrasion Test (WTAT) – measurement of resistance to mechanical abrasion, kick-out, internal mat adhesion.
   - b.) Loaded Wheel Test (LWT) – traffic simulation, measurement of resistance to flushing under heavy traffic loads.

5.) Selection of Optimum Design
   - a.) State Maximum limits to WTAT = minimum asphalt content (75g/SF?)
   - b.) State Maximum limits to LWT = maximum asphalt content or State Maximum LWT limits for Traffic Counts

Light =	0	to	500 ADT	(70 g per SF?) sand adhesion, 1000 ₰ @ 125 lbs
Medium =	250	to	1500 ADT	(60 g per SF?)
Heavy =	1500	to	3000 ADT	(55 g per SF?)
Very heavy =	3000 +			(50 g per SF?)

   - c.) State Job Tolerance Limits (Contractor Proficiency)
   - d.) Draw graphs of the physical test data and superimpose the stated limits and read optimum asphalt content.

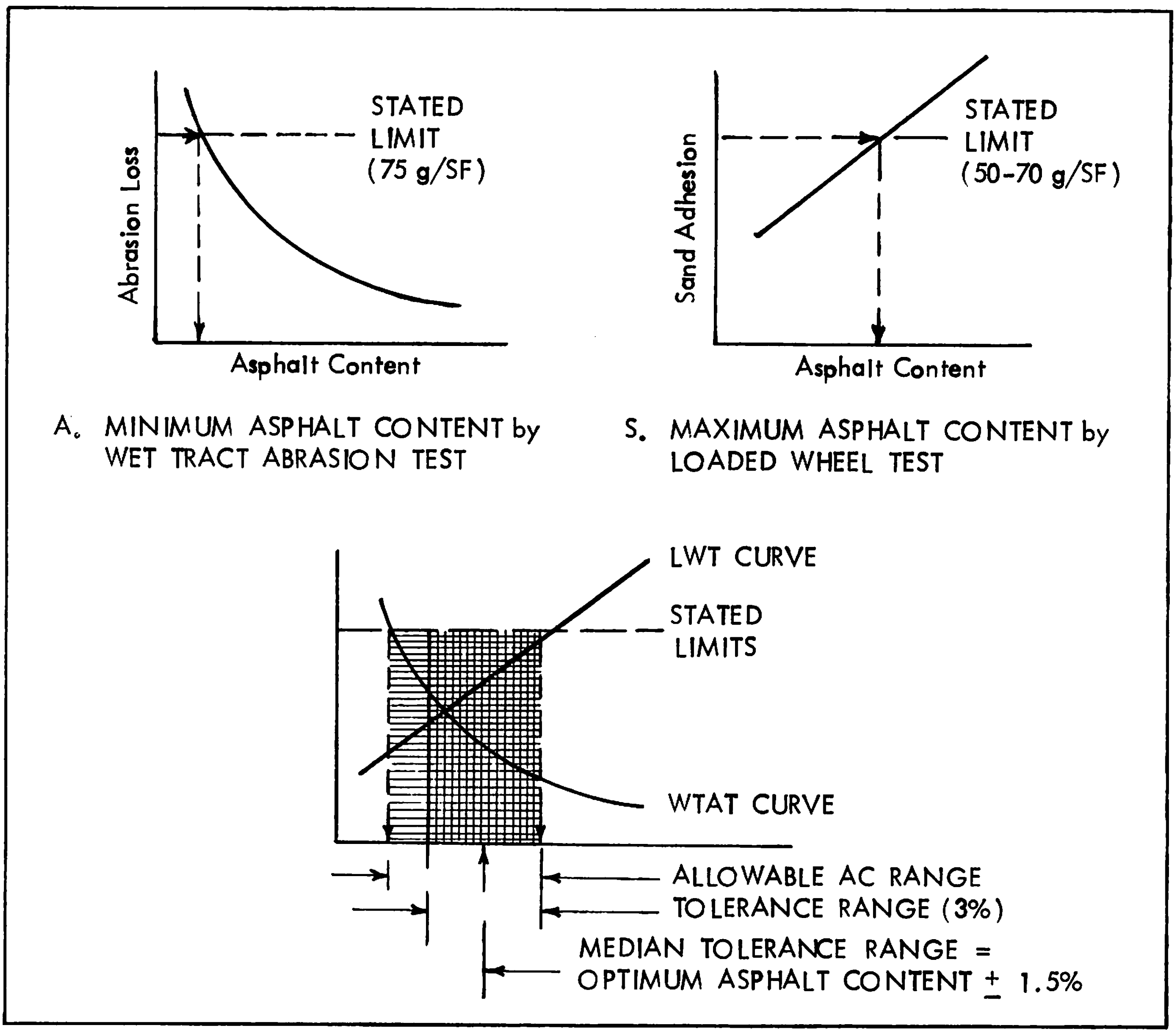

Figure 1. GRAPHICAL DETERMINATION OF OPTIMUM ASPHALT CONTENT

CONTROL OF SLURRY SEAL CONSTRUCTION

After the optimum design is established, it is necessary to translate this design into field control quantities as described in ISSA Technical Bulletin #107 "A Method for Unit Field Control of Slurry Seal Quantities". The objective of this method is to aid operators and inspectors to control the field material quantities and application rates so that design results are obtained. The method is essentially to translate laboratory design into field units of gallons, tons and bags and to measure these during application.

The following is an example of the laboratory design translation into the essential field control quantities:

LABORATORY DESIGN FOR FIELD CONTROL
— EXAMPLE —

	Optimum Lab Design	Control Quantities	Tolerances
a) Aggregate	100.0%		
b) Filler* Type PC-II	1.0%	2-bags/10 tons	+ 1/2 bag
c) Mix Water*	12.0%	29 gals./ton	∓ 2.3 g/t
d) Cone Flow Consistency	2.5 cm.		∓ .75 cm.
e) AC Target Extraction	10.5%		∓ 1.5%
f) Emulsion* @ 61.0% Res. AC	17.2%*	41.0 gals/ton	∓ 4.0 g/t
g) Design Width	20.0 Ft.	2 lanes x 10 ft.	∓ .5' OA
h) Spread Rate	15.0 lbs/SY		∓ 2.0 Lb/SY
	133 SY/ton	118 to 154 SY/ton	
i) Lineal Ft./ton @ Lane Width	120 LF/ton	106 to 138 LF/ton	

j) Aggregate Specific Weight vs. Moisture Content:

Moisture Content	Moist Lbs/ CF Loose	Dry Lbs/CF of Moist Ag.	% Dry/Wet
0%	96.4	96.4	100.0
1	95.4	94.5	98.0
2	83.6	81.9	84.9
3	79.7	77.3	80.1
4	79.0	75.8	78.6
5	78.0	74.1	76.8
6	77.9	73.2	75.9

* Per Cent added to the dry weight of the aggregate

Figure 2
Example of laboratory design for field control.

Control of slurry seal construction (cont'd)

Factors involved in the determination of the proper spread rate is dealt with in another paper to be presented at this congress.

There are at least four (4) methods of field proportion control which have been suggested. They are:

1.) Batch Unit Control by measurement of batch weights and net liquid usage as described in TB #107.
2.) Field consistency tests vs. gross RPM and water flow meter.
3.) RPM, emulsion flow meter and water flow meter ratios versus field consistency measurements.
4.) Continuous measurement by emulsion flow meter and aggregate weigh meter ratios versus field consistency measurements.

There are four (4) important factors involved in the construction of the optimum laboratory design that should be emphasized here.

1.) Field changes in the aggregate specific weight (pounds per cubic foot) due to the bulking effect of moisture in the aggregate are critical. Operators must be made aware of this critical variation and trained how to recognize changes and to compensate for them by adjustment of machine settings. Four methods are suggested to recognize these changes and to relate them to machine settings:
    a.) Direct percentage moisture analysis of the job with the soiltest carbide-acetylene bomb versus a machine setting chart
    b.) Unit weight of specific container filled with the job aggregate versus a machine setting chart.
    c.) Continuous moisture content by electronic capacitance probe versus a machine setting chart.
    d.) Aggregate color-moisture content comparison specimen versus a machine setting chart.
2.) Control of materials at the source can alleviate many problems in the achievement of the optimum design. Aggregate gradation changes such as over-size or under-size contamination can radically alter the asphalt requirements. These changes are most economically controlled at the source. Subtle changes in emulsion formulation and manufacture can play havoc with mixing and setting characteristics. Measures should be taken at the source to assure delivery of emulsion as specified such as the mixing profile with the job aggregate. Changes in the residual asphalt content should be noted on the delivery tickets so that field adjustments can be made to insure application of optimum design.
3.) Operating crews must be trained to understand acceptable operating procedures. Each contractor must develope his own operator training program to best suit his local situation. Film and manuals may be most helpful. We find that actual laboratory bench experience in making proper and improper mixes, learning the "feel" of the mix and the hand-eye association to be the most expedient training technique.
4.) The achievement of steady state operations: i.e., uniformity equals the best chance of success. Operators should seek the steady state.
    a.) Maintain constant mix consistency
    b.) Maintain constant mixer speed, output, slurry mixer depth
    c.) Maintain constant forward speed
    d.) Maintain uniform, constant depth of slurry in the spreader

I have tried here to review the contribution of the ISSA R & D committee to the technology of slurry seal; presented a proposed guide for the complete design of slurry seal; presented a new method for the determination of optimum asphalt content in slurry seal; and discussed methods and principles for the field control of slurry seal construction. I invite and encourage the expression of your views of the subjects set forth here.

Thank you.

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