DRAFT - NOT FOR PUBLICATION

LABORATORY TESTS AND TESTING TRENDS FOR SLURRY SEAL AND COLD OVERLAY DESIGN AND RESEARCH; A STATE -OF-THE-ART REPORT.

BY

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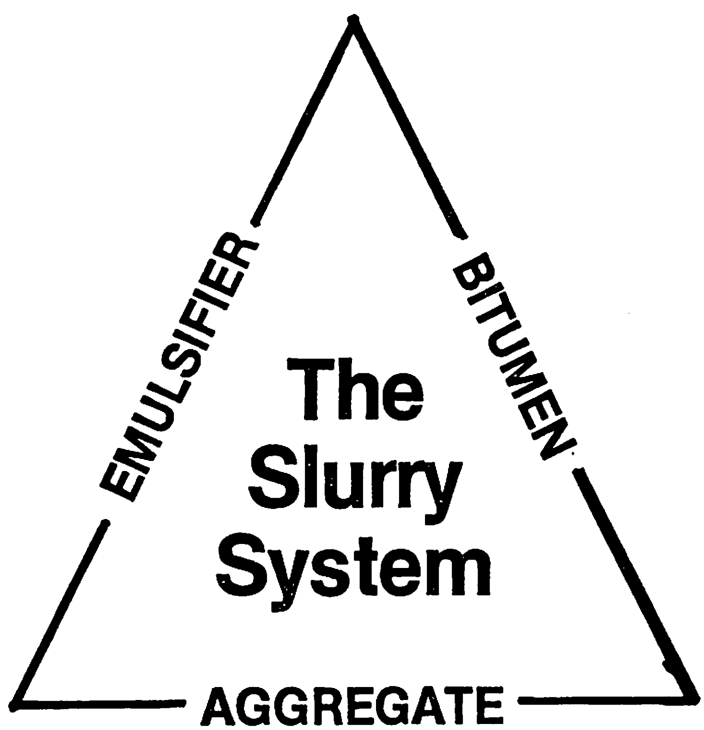
PREPARED FOR PRESENTATION AT THE INTERNATIONAL SLURRY SEAL ASSOCIATION
SECOND WORLD CONGRESS AND 25TH ANNIVERSARY CONVENTION,
INTERCONTINENTAL HOTEL, MARCH 8-12, 1987,
GENEVA , SWITZERLAND



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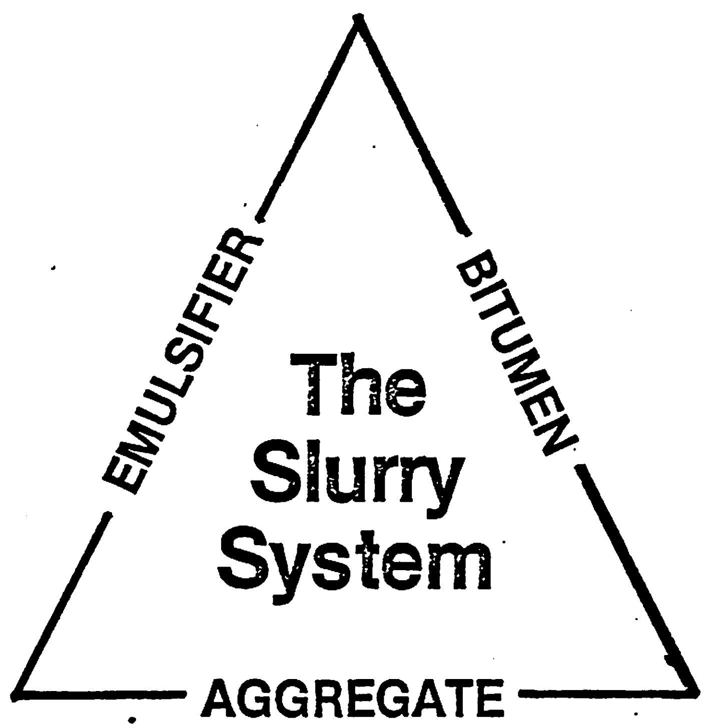


I. INTRODUCTION

THE INTRODUCTION OF EMULSIFIED BITUMENS IN THE EARLY 20TH CENTURY MADE POSSIBLE THE USE OF COLD APPLIED EMULSIFIED BITUMEN - AGGREGATE MIXES TO PAVEMENT SURFACES. THE GERMAN SCHLAMME, THE ORIGINAL SLURRY SEAL DEVELOPED IN THE 20'S AND 30'S, WAS APPLIED IN VERY THIN LAYERS AS A MASS CRACK SEALER AND SURFACE DRESSING. SINCE THAT TIME THERE HAS BEEN A LONG AND STEADY TREND TOWARD THE USE OF THICKER AND COARSER MIXES RANGING FROM THE ORIGINAL 1.5 - 3 KG/SM (3-6 LBS/SY) THROUGH THE MORE NORMAL 8 KG/SM (15 LBS./SY) TO AS HEAVY AS 108 KG/SM (200 LBS/SY), BUT NOW MORE COMMONLY IN THE 10 -16 KG/SM (18 -30 LBS/SY) RANGE.

EQUIPMENT TO PRODUCE AND LAY THESE HEAVIER SLURRIES AND COLD MIXES HAS DEVELOPED OVER THE YEARS FROM THE ORIGINAL BATCH MORTAR BOX, AND BATCH REDI-MIX TRUCKS THROUGH THE SELF-CONTAINED CONTINUOUS MIX, TRUCK MOUNTED MACHINE TO THE PRESENT DAY, HIGHLY SOPHISTICATED CONTINOUSLY SELF-LOADING MACHINES. A WORLD RECORD WAS ESTABLISHED FOR SUCH A MACHINE ON JUNE 16, 1978, WHERE, IN 10 HOURS, 700 LONG TONS (780 SHORT TONS) OF AGGREGATE AND 107,000 LITRES (28,000 GALLONS) OF EMULSION WAS CONTINUOUSLY MIXED AND APPLIED TO 24 LANE-KILOMETERS (15 LANE-MILES) OF INTERSTATE 64 NEAR RICHMOND, VIRGINIA.

PRODUCTIVITY RESTRAINTS CAUSED BY THE USE OF CONVENTIONAL "SLOW-SET" AND "QUICK-SET" EMULSION-AGGREGATE SYSTEMS HAS STIMULATED THE DEVELOPMENT OF "QUICK-TRAFFIC" SYSTEMS. THE DEMAND FOR IMPROVED BITUMEN PROPERTIES AND FOR IMPROVED AGGREGATE QUALITY BROUGHT ABOUT BY HEAVIER, MULTILAYERED APPLICATIONS HAS, IN TURN STIMULATED THE RISE OF "PERFORMANCE" MATERIAL SYSTEMS PRODUCED IN CONTRACTOR-CONTROLLED EMULSION AND AGGREGATE PLANTS.

THESE FACTORS, IN TURN, HAVE REQUIRED A REAPPRAISAL OF SLURRY SEAL AND COLD OVERLAY TESTS AND DESIGN METHODS. IT IS OUR PURPOSE HERE TO:

1. REVIEW THE CURRENT ISSA AND ASTM TESTING AND DESIGN PROCEDURES AND

2. TO RELATE THEM TO NEW TESTING METHODS AND RESEARCH REQUIRED TO MEET THE NEEDS OF OUR NEW PRODUCTIVITY AND EXPANDING MARKETS AND

3. TO PROPOSE A PERFORMANCE APPROACH TO OUR DESIGN METHODS.

II. CURRENT DESIGN APPROACH

OBJECTIVES

WE HAVE COME TO LOOK UPON A PAVEMENT SYSTEM AS CONSISTING OF 2 ELEMENTS, THE UNDERLYING STRUCTURE AND THE VISIBLE SURFACE.

PAVEMENT ELEMENTS:

1. STRUCTURE
2. SURFACE

SLURRY SEALS AND COLD OVERLAYS ARE USED IN THE TREATMENT OR RENEWAL OF THE SURFACE ELEMENT. THIS RENEWAL OF THE SURFACE ELEMENT MAY INCLUDE THE DESIGN OBJECTIVES OF:

DESIGN OBJECTIVES:

1. PREVENTION OR CONTROL OF WEATHERING
2. REPAIR OF WEATHER AND WEAR DAMAGE
3. IMPROVEMENT OF WET FRICTION CHARACTERISTICS
4. IMPROVEMENT OF SURFACE DRAINAGE PROBLEMS CAUSED BY RUTTING AND CROSS-SLOPE DEFICIENCIES.

DISCUSSION

THIN LAYERED SURFACE MIXES MAGNIFY THE PROBLEMS OF BOTH COLD AND HOT-MIXED THICK LAYERED MIXES SINCE ANY DEFECT IN THIN LAYERS WILL BECOME APPARENT IN MUCH LESS TIME THAN IN THE CASE OF THE THICKER LAYERS. THE DESIGN PROBLEMS OF MONO-LAYERED APPLICATIONS ARE VERY DIFFERENT FROM THOSE OF MULTI-LAYERED SYSTEMS, AS IN RUTFILLING, AND EACH MUST BE APPROACHED DIFFERENTLY.

HOT MIXED ASPHALTIC CONCRETE SYSTEMS (HMAC) ARE RELATIVELY SIMPLE SYSTEMS TO DESIGN AND APPLY SINCE THEY ARE USUALLY ONLY A 2-COMPONENT SYSTEM (BITUMEN AND AGGREGATE). THEIR THERMOPLASTIC BINDERS ARE FLUIDIZED FOR APPLICATION BY HEAT AND "SET" TO TRAFFIC SIMPLY BY COOLING TO THE AMBIENT TEMPERATURE. DENSE-GRADED EMULSION MIXES, CMAC (COLD MIXED ASPHALTIC CONCRETE), ARE MULTI-COMPONENT SYSTEMS WHICH ARE FLUIDIZED FOR APPLICATION BY WATER. THE "SET" TO TRAFFIC (WET ADHESION, WET COHESION, PARTICLE COALESCENCE) ARE CHEMICAL PHENOMENON RATHER THAN MECHANICAL. CMAC MUST CONSIDER AND OVERCOME THE EFFECTS OF THE PRESENCE OF WATER.

CMAC'S HAVE THE ADVANTAGES OF USING THE EFFECTS OF THE RESIDUAL EMULSIFYING AGENTS AND ADDITIVES TO IMPROVE ADHESION, COHESION, HIGH AND LOW TEMPERATURE PROPERTIES. ADDITIONALLY, NO HEAT OR HOT AIR IS USED SO THERE IS NO-INITIAL, RAPID HARDENING OF THE BINDER AS IS THE CASE WITH HMAC'S.

MATERIALS AND VARIABLES

SINCE CMAC, IS A CHEMICAL SYSTEM, NOT A MECHANICAL SYSTEM, WE MUST CONSIDER THE CHEMISTRY OF EACH INGREDIENT AND THEIR INTERRELATIONSHIPS RATHER THAN THE SIMPLE MECHANICAL PROPERTIES OF THE AGGREGATE AND THE BITUMEN.

IN THE U.S. THERE ARE:

1. 1300 DIFFERENT AGGREGATES
2. 400 DIFFERENT BITUMENS
3. 10 CLASSES OF EMULSIFIERS
4. 350 DIFFERENT EMULSION MANUFACTURERS
5. 1,820,000,000 SIMPLE POSSIBILITIES

WITH ANY ONE SET OF MATERIALS PRESENTED TO US FOR EVALUATION, WE ARE IMMEDIATELY FACED WITH 1,820,000,000 POSSIBLE COMBINATIONS.

THE COMPLEXITY IS EXPONENTIAL WITH THE VARIABLES AND GIVES RISE TO "BENEDICT'S LAW":

$$C = V_n^2$$

WHERE: C = COMPLEXITY
V = VARIABLES.

THE SYSTEMS APPROACH

ALONG WITH A LARGE DEGREE OF HUMILITY, WE HAVE LEARNED: (1) TO VIEW OUR MATERIALS MORE AS CHEMISTRY RATHER THAN SIMPLE MECHANICAL ELEMENTS AND (2) "THAT EACH SYSTEM IS ITS OWN THING".

AGGREGATE IS CHEMISTRY
BITUMEN IS CHEMISTRY
EMULSION IS CHEMISTRY
THE SYSTEM IS CHEMISTRY

"EACH SYSTEM
IS IT'S
OWN THING"

WE STRESS THE IMPORTANCE OF HOW THE MATERIALS INTER-REACT AND INTERACT WHEN COMBINED INTO A SINGLE MIX SYSTEM. ANY CHANGE IN ANY SINGLE INGREDIENT MAY, USUALLY WILL, CHANGE THE SYSTEM PERFORMANCE.

WHILE WE PREFER A THEORETICAL OR BASIC RESEARCH APPROACH TO TESTING AND DESIGN PROBLEMS, BECAUSE OF THE NUMBERS OF VARIABLES, WE MUST USE THE EMPIRICAL OR PRAGMATIC APPROACH TO THE PROBLEMS: I.E., MAKE LABORATORY SPECIMENS AND SUBJECT THEM TO FIELD SIMULATED TESTS. OBJECTIVE NUMBERS ARE PLACED ON THE TEST RESULTS FOR COMPARISON WITH FIELD CORRELATED STANDARDS.

HISTORICAL PERSPECTIVE

HISTORICALLY, THE HISTORY OF SLURRY TESTING AND DESIGN METHODS HAS BEEN THE HISTORY OF THE SEARCH FOR OBJECTIVE NUMBERS.

1964 - WET TRACK ABRASION TEST - (KARI & COYNE)
1968-72 - SHAKER WEAR TEST (BALDWIN, FIOCK)
1969 - LABORATORY MIXING AND SETTING TESTS (SCHMITZ ET.AL.)
1975 - LOADED WHEEL TEST (BENEDICT)
1975 - CONE CONSISTENCY (BALDWIN AND USA-WES)
1978 - DESIGN TECHNICAL BULLETINS (ISSA R&D)
1978 - COMPATIBILITY
1981 - ISSA/ISU UNIVERSITY RESEARCH PROGRAM (D.Y. LEE)
1983 - MODIFIED COHESION TEST (BENEDICT)
1985 - CURED COHESION, STRENGTH & STRETCH
1987 - LOW TEMPERATURE FLEXURAL TENSION

AS OUR TESTING AND DESIGN METHODS DEVELOPED, WE BORROWED FROM THE EXISTING HMAC TECHNOLOGY AND TO A LESSER EXTENT ON CMAC TECHNOLOGY. HOWEVER, MANY OF THE TRADITIONAL HMAC TESTS AND TECHNIQUES SIMPLY WERE NOT DIRECTLY APPLICABLE TO SLURRY. WE HAD TO INVENT OUR OWN TESTING AND DESIGN PROCEDURES.

THESE TESTS HAVE PROVIDED OBJECTIVE NUMBERS RELATED TO FIELD PERFORMANCE OBSERVATIONS. THE NUMBERS ALSO SORT OUT THE EFFECTS OF MANY OF THE VARIABLES WHICH MAKES POSSIBLE A DIRECTION FOR A NEW THEORETICAL APPROACH RATHER THAN OUR PRESENT EMPIRICAL DESIGN APPROACH.

IN 1978 ISSA PUBLISHED IT'S FIRST EDITION OF "DESIGN TECHNICAL BULLETINS". SUBSEQUENTLY NEW EDITIONS HAVE BEEN PUBLISHED IN 1980 AND 1984. THEY ARE COLLECTIONS OF TESTING TECHNIQUE PROCEDURES AND REPRESENT GUIDES TO CURRENT TESTING TECHNIQUES. IN ALL SOME 33 TECHNICAL BULLETINS HAVE BEEN PUBLISHED.

TECHNICAL BULLETIN #111, "OUTLINE GUIDE DESIGN PROCEDURE FOR SLURRY SEAL" (LAST REVISION 1980) PRESENTS A THOROUGH, STEP-BY-STEP PROCEDURE. A CHECK LIST OF ALL TESTS IS PRESENTED FROM WHICH THE SPECIFYING AGENCY MAY SELECT THOSE TESTS WHICH ARE RELEVANT TO THE PARTICULAR JOB AT HAND.

A TYPICAL PROCEDURE SELECTED IS AS FOLLOWS:

1. MATERIALS TESTING:
    A. AGGREGATE SAND EQUIVALENT AND GRADATION
    B. EMULSION % RESIDUE, SIEVE, PH
2. TRIAL MIX
3. COMPATIBILITY
4. CONSISTENCY
5. WTAT (WET TRACK ABRASION TEST)
6. LWT (LOADED WHEEL TEST)
7. GRAPHICAL AND SELECTION OF OPTIMUM BITUMEN CONTENTS AND REPORT.

SLURRY SEAL MIX DESIGN CHECK LIST

PART I — BASIC MATERIALS TESTS

- EMULSIFIED ASPHALT SPECIFICATIONS ASTM D977, D2397, LOCAL
  - STABILITY, VISCOSITY, SIEVE, ASPHALT RESIDUE, PENETRATION &c. ASTM D244
  - SLOW-SET, QUICK-SET IDENTIFICATION ASTM D244 & ISSA TB102
  - QUICK AND SLOW SET EMULSIFIED ASPHALT SPECIFICATIONS ISSA TB 116, TB 117
- AGGREGATE SPECIFICATIONS, ISSA A-105, LOCAL, ISSA TB 123
  - SAND EQUIVALENT ASTM D2419
  - DURABILITY - L.A. RATTLER ASTM C131
    - SODIUM SULFATE SOUNDNESS ASTM C88
    - ACID INSOL ASTM D3042, LOCAL
    - SHAKER WEAR TEST ISSA R&D ISSA TB 123
  - GRADATION (DRY) ASTM C136
    - WET SIEVE -200 ASTM C117
  - UNIT WEIGHT ASTM C29
    - WET UNIT WEIGHT ASTM C29 @1-6% Note 2
- FILLER SPECIFICATION ASTM D242, LOCAL
  - FILLER SIEVE ANALYSIS ASTM D546

PART II — JOB MIX FORMULA

1. ESTIMATE THEORETICAL BITUMEN REQUIREMENT (BR) or (PAR)

- SURFACE AREA METHOD WES S-75-1, CalDOT 355-A & 303-F
  - AGG. GRADATION (DRY) ASTM C136
  - APPARENT SPECIFIC GRAVITY ASTM C128
    - ABSORPTION ASTM C128
  - CENTRIFUGE KEROSENE EQUIVALENT Cal.DOT 303-F ISSA TB 121
  - CALCULATE TOTAL SURFACE AREA WES S-75-1
  - CALCULATE BR FOR 8μm COATING WES S-75-1
- ALTERNATE METHOD-ESTIMATE BY EXPERIENCE e.g., 20%AE/Type IIC

2. SYSTEM COMPATIBILITY

- TRIAL MIXES (50, 100 or 200g) TO ESTIMATE REQUIREMENTS FOR FILLER, MIX WATER, ACCELERATOR, RETARDER & BR ADJUSTMENTS ISSA TB 113
- CONSISTENCY TESTS @ 100, 85, 70% BR, ISSA TB106
- COMPATIBILITY TESTS ISSA TB #115
  - SPLIT CONSISTENCY TEST Note 3 ISSA TB 115
  - SPLIT CUP TEST Note 4 ISSA TB 115
  - WET ADHESION TEST Note 5 ISSA TB 114

3. TRAFFIC & CURE TIME

- MIX AND SET TIME ISSA TB102, TB 135
- TRAFFIC TIME AT JOB CONDITIONS BY COHESIOMETER ASTM D04.24 prop., TB 135

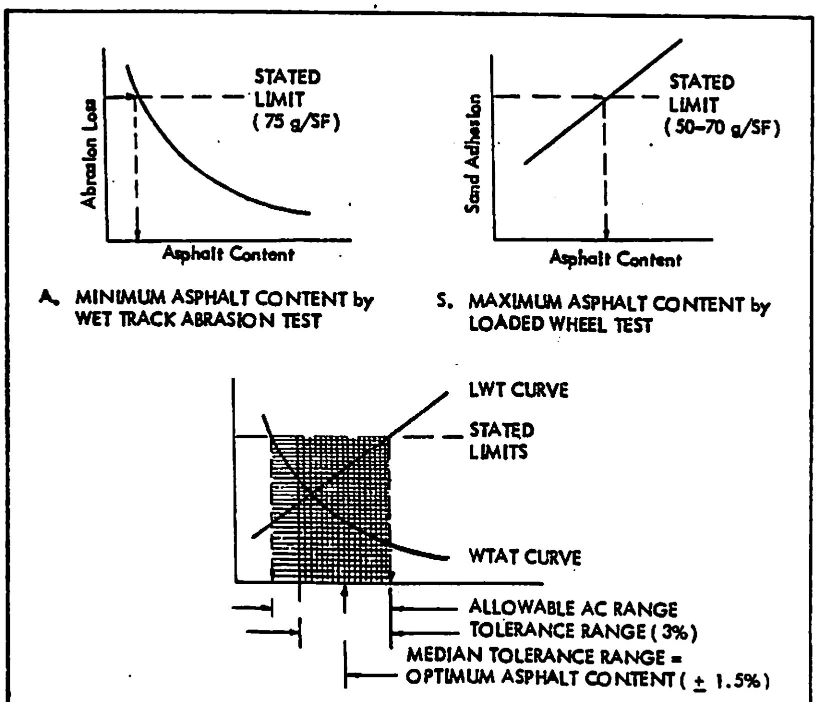
4. PHYSICAL TESTS ON CURED MIX SPECIMENS

- WET TRACK ABRASION TEST ISSA T-100
- LOADED WHEEL TEST ISSA TB109
- OPTIMUM DESIGN BY GRAPHICAL SELECTION

PART III — TRANSLATION OF OPTIMUM DESIGN TO FIELD CONTROL QUANTITIES

- ISSA TB 107 "UNIT FIELD CONTROL"
  - OPTIMUM DESIGN DATA (Above)
  - SPREAD RATE ESTIMATE Note 2 ISSA TB 112
  - WET UNIT WEIGHT @ 0-6% MOISTURE ASTM C29 Note 2
- ALTERNATE METHODS
  - CALIBRATION/MFR. & EXTRACTION ISSA TB 101
  - CONSISTENCY VS. WATER FLOW METER
  - CONTINUOUS AGG. & AE METERING

Note 1. Dashed boxes indicate tests not suggested in ISSA A-105 Guide Specification
Note 2. Required for unit control data.
Note 3. Consistency specimens are cast on paper at 3 levels of mix water and A.E. and are centrally split and examined for asphalt and aggregate migration.
Note 4. A 100 g mixture is cured in a 6 oz. paper cup. Upper and lower halves are analyzed.
Note 5. 10 g cured mix, three minutes in boiling water, decant and examine coating.



GRAPHICAL DETERMINATION OF OPTIMUM ASPHALT CONTENT

THE DIRECT EXPERIMENTAL METHOD IS OUR APPROACH TO THE DESIGN OF SLURRY SEALS AND COLD OVERLAYS; I.E., CONSTRUCT A REPRESENTATIVE RANGE OF LABORATORY SPECIMENS AND SUBJECT THEM TO TESTS RELATED TO FIELD PERFORMANCE. THE DESIGNER MUST PROCEED BY ANSWERING THE QUESTIONS OUR CUSTOMERS ASK:

1. WILL "IT" MIX?
2. WILL "IT" SET?
3. WILL "IT" LAST?
4. WILL "IT" BE SAFE?
5. WILL "IT" PERFORM?

ANSWERS TO THE QUESTIONS AND RELATED RESEARCH.

1. WILL "IT" MIX?

A). ISSA TECHNICAL BULLETIN #113 TRIAL MIX PROCEDURE
B). TB #106 CONSISTENCY/SEGREGATION
C). TB #114 WET STRIPPING TEST (ADHESION)
D). TB #115 COMPATIBILITY
E). TB'S 116, 117, 140 SPECIFICATIONS FOR SS (SLOW-SET), QS (QUICK-SET), QT (QUICK-TRAFFIC) SYSTEMS

RESEARCH:

2. A STRIP CHART MIXING CHARACTERISTIC METHOD TO:

A). CONTROL EMULSION MIXING QUALITIES BEFORE SHIPMENT TO THE FIELD
B). IDENTIFY AND CLASSIFY MIXING PHASES; E.G.,
   (A). DRY AGGREGATE MIXING FORCE
   (B). TIME-SHEAR FORCE (BREAK-DOWN) FOR COMPLETE DISPERSION OF FILLER
   (C). BREAK-DOWN TIME AND FORCE FOR MIX WATER ADDITION
   (D). BREAK-DOWN TIME AND FORCE FOR ADDITIVE ADDITION
   (E). BREAK-DOWN TIME AND FORCE FOR EMULSION ADDITION
   (F). STEADY STATE EMULSION MIX "LUBRICATION"
   (G). BOUNDARY LUBRICATION PHASE (INITIATION OF BREAK, OR RUPTURE; RAPID PLATING OR DEPOSITION OF BITUMEN
   (H). COMPLETE EXHAUSTION OF EMULSION
   (I). MECHANICAL DESTRUCTION OF COHESION (CRUMB PHASE)
   (J). RESIDUAL SURFACTANT LUBRICATION

C). MEASURE THE EFFECT OF MIXER SPEED AND CONFIGURATION (TIME VS SHEAR FORCE).

D). MEASURE EFFECT OF TEMPERATURE AND ENVIRONMENT.

E). MEASURE EFFECT OF EMULSION FORMULATION ON MIXING CHARACTERISTICS AND CORRELATE WITH SET AND CURE TIMES.

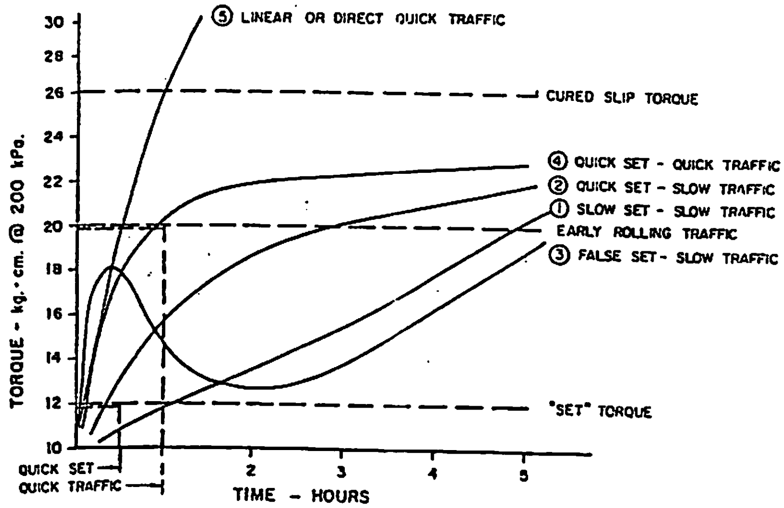
F). RELATE MIX CHARACTERISTICS TO PARTICLE SIZE ANALYSIS OF BOTH EMULSION AND AGGREGATE FILLER.

2. <u>WILL "IT" SET (AND CURE)?</u>

A). TB #102 Blotter/Water Resistance Tests
B). TB #139 System Classification by Cohesion Tester (CT)
C). ASTM D3910.80A Cohesion Test

RESEARCH

A). Wet Cohesion Tester ISSA-AEMA Study, Effects of Different Water, Cements, Emulsifier Systems, Aggregates: Spin Torque Identification and Definition; Frictionless Turn Table and Motorized Drive with Recording, Benedict & Dunning Study.
B). Cured Cohesion Test Development, Punch Test to Measure Cohesive Strength-Stretch and Long-Term Rate of Cure. Mini Hubbard-Field Test.
C). Wet and Dry Effects of Environment and Low-Temperature Coalescence Studies. Alan Brooker.
D). Effects of Cement Hydration and Mix Dehydration and Aggregate Moisture.



CLASSIFICATION OF MIX SYSTEMS BY
MODIFIED COHESION TEST CURVES

3. <u>WILL "IT" LAST?</u>

A). TB #100, Wet Track Abrasion Test (WTAT) Primarily Measures "MAT" Cohesion and to a Lesser Extent, Adhesion. Determines Minimum AC Contents Only. Adopted by ISSA in 1967.
B). TB #136 Causes of WTAT Inconsistencies
C). TB #114 Wet Stripping Test
D). TB #123 Aggregate Quality and Gradation Selection for Traffic Count Design by Shaker Wear Test (SWT)

RESEARCH:

A). Effect of Filler Content and Layer Thickness, Sang Soo Kim, ISU
B). Effect of Layer Thickness; Use of -4 Only for WTAT & Back-Calculate Film Thickness for +4.
C). Extreme Variations Noted from 5 Grams Loss to 200 Grams Loss, 4 Emulsions, Same Aggregate & AE %
D). Good Test, Poor Performance
E). AEMA Recommendation of 40 Gram Minimum Loss in Error?
F). WTAT Results after a 5 or 6-Day Soak
G). Use of Test for System Evaluation Number "SEN". 6-Day Soak

4. WILL "IT" BE SAFE?

A). TB #109 LOADED WHEEL TEST
1. RATE OF COMPACTION BY PROFILOGRAPH
2. TACKINESS POINT
3. EXCESS AC BY SAND ADHESION

B). TB #112 MACROTEXTURE MEASUREMENT

C). TB #141 MACROTEXTURE VS. LAYER THICKNESS AND GRADATION RESEARCH BY ORDEMIR, ISSA/ISU (IOWA STATE UNIVERSITY) RESEARCH PROGRAM.

RESEARCH:

A). INVESTIGATION OF SAND ADHESION MEASUREMENT OF BITUMEN FILM THICKNESS. MEASURE OF MAXIMUM AC CONTENTS.

A). DEVELOPMENT OF A DESIGN PROCEDURE FOR SPECIFIC MACROTEXTURE AT VARIOUS LAYER THICKNESSES VS. TRAFFIC COUNTS.

C). INVESTIGATION OF MIX RESISTANCE TO DEFORMATION: RATE OF COMPACTION VS. TEMPERATURE AND FILLER CONTENT: MIX STABILITY OR RUTTING RESISTANCE AT LAYER THICKNESS.

D). INVESTIGATION OF VOID CONTENTS, % VOIDS FILLED WITH BITUMEN, ZERO VOIDS MIXTURES AND GRADATIONS.

E). POSSIBLE REVISION OF TYPE 3 GRADATION OR SPECIAL GRADATIONS FOR LAYER THICKNESSES AND FOR MONO-LAYERED AIRFIELD RUNWAYS.

5. WILL "IT" PERFORM?

THOUGH ALL PREVIOUSLY DESCRIBED TESTS ARE SUCCESSFUL ATTEMPTS TO DEFINE THE TEST METHODS THAT RELATE TO FIELD PERFORMANCE, NO SPECIFIC DEFINITION FOR THE ACTUAL FIELD PERFORMANCE EXISTS.

IN OUR OPINION THE KNOWLEDGE GAINED IN THE LABORATORY AND SUCCESSFULLY TRANSFERED TO THE FIELD SHOULD BE SPECIFICALLY APPLIED BY THE DETAILED ANALYSIS OF ACTUAL FIELD PERFORMANCE DATA. THOUGH WE "KNOW" "IT" WORKS, WE MUST PROVE THAT "IT" WORKS.

WE PROPOSE THAT MUCH OF OUR FUTURE RESEARCH EFFORTS BE CONCENTRATED IN ACCUMULATING AND ANALYZING FIELD, PERFORMANCE RELATED DATA. TOWARDS THIS END WE SHOULD SEEK ANSWERS TO THE FOLLOWING "FIELD PERFORMANCE QUESTIONS":

1. WILL "IT" BE CONSTRUCTED CORRECTLY?

A). WILL THE CONTRACTOR APPLY THE LABORATORY DESIGN WITHIN THE DESIGN TOLERANCES?
B). CONTRACTOR'S FIELD RECORD
C). CONTRACTOR'S EQUIPMENT PRECISION
D). CONTRACTOR'S PERSONNEL TRAINING

2. WILL "IT" REALLY SEAL?

A). PERMEABILITY, AIR AND WATER ENTRANCE AND EXIT FROM THE PAVEMENT STRUCTURE.
B). EFFECTS OF PERMEABILITY ON LONG TERM ADHESION.
C). EFFECTS OF PERMEABILITY ON THE SERVICE LIFE EXTENSION OF THE PAVEMENT STRUCTURE. IS THE KANDHAL CURVE AFFECTED?
D). EFFECT OF PERMEABILITY ON WET FRICTION CHARACTERISTICS.

3. WILL "IT" ADHERE TO THE SUBSTRATE?

A). COMPATIBILITY OF THE MIX SYSTEM WITH THE SUBSTRATE.
B). AMOUNT OF "FREE" EMULSION IN THE MIX REQUIRED FOR SUBSTRATE ADHESION.
C). TACK COAT REQUIREMENTS.

4. WILL "IT" LAST?

A). BITUMEN QUALITY, OXIDATION RESISTANCE AND EFFECT OF EMULSIFIERS AND AGGREGATE ON EMBRITTLEMENT. TFOT (THIN FILM OVEN TEST), PEN-VIS NUMBER.
B). LONG TERM ADHESION. SOLUBILITY OF EMULSIFIERS. CHEMICAL CHANGE AT THE AGGREGATE-BITUMEN INTERFACE.
C). LEACH RATE OF AMINES.
D). AGGREGATE QUALITY, WEATHER DEGRADATION

5. WILL "IT" REMAIN SAFE?

A). FRICTION CHARACTERISTICS OF AGGREGATE
B). MAINTENANCE OF MACROTEXTURE, EFFECT OF TRAFFIC CONSOLIDATION
C). EFFECT OF GRADATION AND LAYER THICKNESS ON MACROTEXTURE

6. WILL "IT" BE FLEXIBLE AT LOW TEMPERATURES?

A). RESISTANCE TO SUDDEN THERMAL SHOCKS.
B). DEGREE OF LOW TEMPERATURE STRETCH

7. WILL "IT" BE STABLE AT HIGH TEMPERATURES?

A). RESISTANCE TO DEFORMATION, RE-RUTTING, SHOVING, CORRUGATIONS.
B). EFFECT OF TRAFFIC COMPACTION ON SURFACE VOID CLOSURE, MACROTEXTURE AND FRICTION CHARACTERISTICS.

PERFORMANCE CLASSIFICATION OF SLURRY AND COLD OVERLAY MIXES

FINALLY, WE PROPOSE DESIGN CRITERIA, WHICH, AFTER FIELD CORRELATION WITH THE LABORATORY TESTS MAY BE APPLIED TO A TRUE MATERIAL PERFORMANCE SPECIFICATION.

THE TERM "PERFORMANCE" IS USALLY APPLIED TO ABILITY OF THE CONTRACTOR TO MAKE APPLICATIONS WITHIN SPECIFIED LIMITS. HERE, WE USE THE TERM "PERFORMANCE" TO MEAN BOTH:

1. MATERIALS SYSTEM FIELD PERFORMANCE AND
2. CONTRACTOR'S ABILITY TO APPLY THE LABORATORY DESIGN CORRECTLY.

CRITIQUES OF THE WTAT AND LWT CLAIM THAT UNIVERSAL APPLICABILITY IN THE ESTABLISHMENT OF OPTIMUM BITUMEN VALUES DOES NOT EXIST. THESE TESTS HOWEVER MAY BE USED IN DIFFERENT WAYS TO ESTABLISH COMPARATIVE PERFORMANCE DATA:

THE LABORATORY DESIGN CRITERIA FOR PERFORMANCE SYSTEM CLASSIFICATION WOULD INCLUDE ALL OR SOME OF THE FOLLOWING INFORMATION.

1. S.E.N. (SYSTEM EVALUATING NUMBER) = PERCENT BITUMEN REQUIRED TO ACHIEVE A 6-DAY SOAK WTAT LOSS OF 75 GRAMS/SF OR 800G/SM.

2. L.W.N. (LOADED WHEEL NUMBER) = NUMBER OF LWT CYCLES TO ACHIEVE A CONSTANT RATE OF DISPLACEMENT COMPACTION AT 22-25C.

3. W.T.R. (WHEEL TRACKING RATE) = RATE OF VERTICAL DISPLACEMENT AFTER INITIAL COMPACITON IN MM/HOUR AT 45C.

4. M.T.N. (MACRO-TEXTURE NUMBER) = MACROTEXTURE DEPTH AFTER 1 HOUR LWT COMPACTION AT 45C.

5. L.T.D.M (LOW TEMPERATURE DUCTILITY OF THE MIX) = LOW TEMPERATURE DUCTILITY OF THE MIX; MM FLEXURAL TENSION FAILURE AT 4C.

IN SOME WAY THESE NUMBERS OR NUMBERS VERY LIKE THESE MAY BE USED TO CHARACTERIZE AND CLASSIFY THE LABORATORY PERFORMANCE OF THE FINAL MIX:

12.0 - 800 - 1.5 - 1.2 - 150

SEN (6-DAY WTAT)	:	12.0% EMULSION
LWN	:	800 CYCLES @ 25C
WTR	:	1.5 MM/HOUR @ 45C
MTN	:	1.2 MM.
LTD	:	150 MM.