- ROUGH DRAFT - NOT FOR PUBLICATION -

DEVELOPEMENTS IN SLURRY SEAL AND COLD OVERLAY MIX DESIGN, TESTING AND RESEARCH

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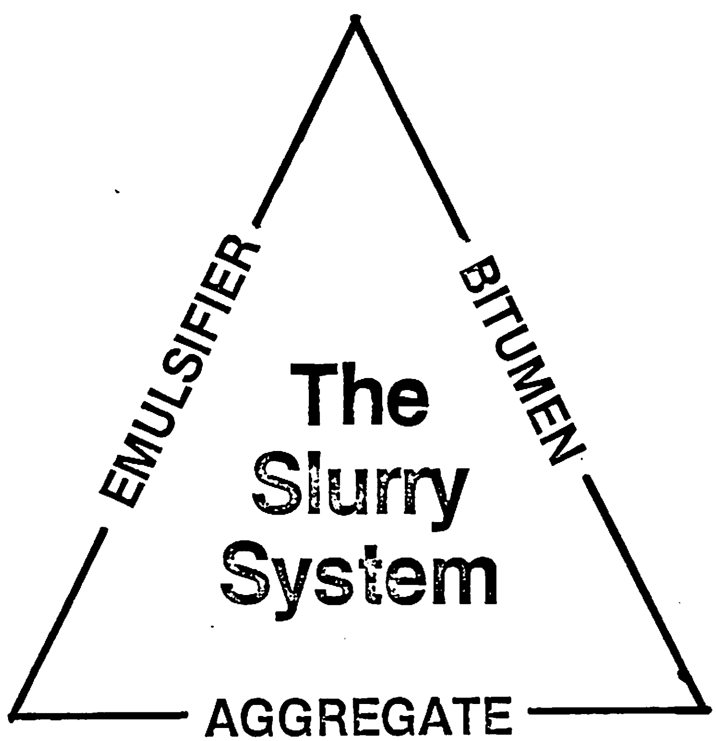
OUTLINE OF AN INFORMAL PRESENTATION PREPARED FOR THE ISSA USER SEMINAR HELD AT THE RIVERFRONT HILTON INN, NORTH LITTLE ROCK, ARKANSAS. NOVEMBER 13, 1986.



(A) PAVEMENTS CONSIST OF 2 PARTS OR ELEMENTS:

(1) THE STRUCTURE
(2) THE SURFACE.

SLURRY SEAL AND THIN LAYERED COLD OVERLAYS ARE USED IN THE TREATMENT OR RENEWAL OF THE SURFACE ELEMENT. THIS RENEWAL OF A PAVEMENT'S SURFACE ELEMENT MAY INCLUDE THE DESIGN OBJECTIVES OF:

(1) PREVENTION OR REDUCTION OF WEATHERING
(2) REPAIR OF WEATHER DAMAGE
(3) IMPROVEMENT OF WET SKID RESISTANCE OR FRICTION NUMBERS
(4) IMPROVEMENT OF SURFACE DRAINAGE PROBLEMS CAUSED BY RUTTING AND CROSS-SLOPE DEFICIENCIES.

THE DESIGN PROBLEMS OF A SINGLE LAYERED SURFACE TREAMENT ARE VERY DIFFERENT FROM THOSE OF MULTI-LAYERED APPLICATIONS (AS IN RUT FILLING OR 2-COURSE SURFACES).

THE FOLLOWING PRESENTATION BRIEFLY REVIEWS OUR DESIGN APPROACH TO SUCCESSFULLY SOLVE THE DUAL LABORATORY DESIGN PROBLEM OF MONO-LAYERED AND MULTIPLE LAYERED MIXES.

(B) HISTORICAL PERSPECTIVE - THE SEARCH FOR OBJECTIVE NUMBERS

1964 - WET TRACK ABRASION TEST
1975 - LOADED WHEEL TEST
1975 - CONSISTENCY TEST
1978 - DESIGN TECHNICAL BULLETINS 1ST EDITION
1981 - ISSA UNIVERSITY RESEARCH PROGRAM INITIATED
1983 - MODIFIED COHESION TEST
1985 - CURED COHESION, STRENGTH AND STRETCH TESTS

(C) CURRENT DESIGN METHOD:

THE DESIGN APPROACH IS TO ASK AND ANSWER THESE QUESTIONS:

1. WILL "IT" MIX?
2. WILL "IT" SET AND CURE?
3. WILL "IT" LAST?
4. WILL "IT" BE SAFE?
5. WILL "IT" PERFORM?
   (MEET THE OBJECTIVES)

PHYSICAL SPECIMENS ARE PREPARED AND SUBJECTED TO SIMULATED FIELD CONDITIONS:

1. WTAT DETERMINES MINIMUM ASPHALT CONTENT
2. LWT DETERMINES MAXIMUM ASPHALT CONTENT
3. GRAPHICALLY COMBINED WTAT AND LWT DATA DETERMINES THE OPTIMUM AC CONTENT.

(D) EXPERIENCES IN LAB DESIGN OF MANY MATERIALS COMBINATIONS INDICATE EXTREME VARIATIONS IN MIX PERFORMANCE.

THIS IS NOT SURPRISING WHEN THERE ARE IN THE U.S.:

1. 1300 DIFFERENT AGGREGATES
2. 400 DIFFERENT BITUMENS OR ASPHALTS
3. 10 DIFFERENT CLASSES OF EMULSIFIERS
4. 350 DIFFERENT EMULSION MANUFACTURERS
5. 1,820,000,000 POSSIBILITIES
6. BENEDICT'S LAW: C = Vn2

AGGREGATE IS NOT GRADATION ALONE
BITUMEN IS NOT PENETRATION ALONE
EMULSION IS NOT VISCOSITY OR QS.

IN ALL THE ASTM SPEC'S NOTHING IS SAID ABOUT THE BINDER'S FUNDAMENTAL PROPERTY; THE ABILITY OF THE BINDER TO BIND TWO STONES TOGETHER.

THE TOTAL SYSTEMS APPROACH:

WHAT IS IMPORTANT IS NOT THE PROPERTIES OF THE INDIVIDUAL MATERIALS, BUT HOW THE MATERIALS INTERACT WHEN COMBINED IN A MIX SYSTEM.

(E) REVIEW OF RECENT FINDINGS IN MIX SYSTEM TESTING -

1. MODIFIED COHESION TEST - CLASSIFICATION OF THE SYSTEM BY SET AND CURE OR DEVELOPMENT OF COHESIVE STRENGTH CHARACTERISTICS.

2. METHYL BLUE TEST - FRENCH/IRISH, MEASURES ONE QUALITY OF THE FINE AGGREGATE: THE AMOUNT OF METHYL BLUE REQUIRED TO SATURATE THE FINES.
   MEASURES CLAY, ORGANIC MATERIAL, ABSORBTIVITY.

3. STRIP CHART MIXING CHARACTERISTICS - POSSIBLE TO CLASSIFY SYSTEMS BY RESPONSE TO TIME-SHEAR FORCES.

4. SCHULZE-BREUER TUMBLING PILL AND RUCK ADHESION - MEASURES BITUMEN-FILLER COMPATIBILITY: 6-DAY SOAK.

5. 6-DAY VS. 1-HOUR SOAK WTAT - DIFFERENCES IN VARIOUS SYSTEMS. SYSTEM CLASSIFICATION INTO COMMODITY VS. PERFORMANCE GRADES.

6. 60C CURED COHESION TESTS - MANUAL CURVES AND MOTORIZED STRENGTH AND STRETCH CURVES.

(F) REVIEW OF PAPER, "EXPERIMENTS WITH CURED COHESION TESTING OF SLURRY SEALS AND THIN LAYERED COLD MIXES".

OR

"THE SEARCH FOR COLD MARSHALL CURVES FOR THIN LAYERED COLD MIXES".

(G) RESEARCH IN PROGRESS ON THE TRAFFIC SIMULATING LOADED WHEEL TEST AND WHEEL TRACKING TEST.

1. TRRL EXPERIENCE WITH WTT. CRITERIA ESTABLISHED AT A VERTICAL DISPLACEMENT OF 2 MM/HOUR AT 45C FOR HEAVY TRAFFIC LOADINGS.

2. CORRELATION OF MARSHALL TEST WITH THE BRITISH WTT-SHEFFIELD POLYTECH, UK.

3. CURRENT RESEARCH ON LWT TRACKING RATE AND % DISPLACEMENT CURVES VS. LAYER THICKNESS.

(a) INVERSE SIMILARITY TO MARSHALL CURVES.
(b) LAYER THICKNESS RESPONSE VARIES WITH THE POLYMER TYPE AND EMULSIFIER TYPE.
(c) DIFFERENCES BETWEEN MODIFIED AND PLAIN SYSTEMS.
(d) SIMILARITY OF PLAIN AND POST-ADDED CURED COHESION CURVES TO 1974 LWT CURVES AND MARSHALL FLOW AND WTT CURVES.
(e) MODIFIED EMULSION 60C CURED COHESION CURVE SIMILARITY TO LWT TRACKING CURVES.

(H) 2 SPECIAL PROBLEMS OF INTEREST REGARD:

(1) THE REAL DIFFERENCE BETWEEN HOT BITUMEN MIXES AND COLD BITUMEN MIXES AND

(2) THE DILEMMA OF THICK AND THIN BITUMEN COATINGS IN THIN LAYERED MIXES.

THE KANDHAL CURVE CORRELATES A PAVEMENT'S SURFACE CONDITION WITH THE 60F DUCTILITY OF THE BITUMEN.

INITIALLY, HOT MIXED BITUMEN LOOSES ABOUT 50% OF IT'S 60F DUCTILITY (STRETCH) DURING THE MIX AND LAY OPERATIONS. THIS STIFFENING ACCOUNTS IN LARGE PART FOR THE FIELD STABILITY EXPERIENCED WITH NEWLY LAID HOT MIX. HOT MIXES MADE WITH AN AC-20 BECOME AC-40. WHEN EMULSIONS ARE USED, NO SUCH BITUMEN STIFFENING OCCURS SO THAT EMULSION MADE WITH AN AC-20 IS APPLIED AS AN AC-20.

WHEN MULTI-LAYERED COLD MIXES ARE REQUIRED, AS IN RUT FILLING, THIS LOWER BITUMEN VISCOSITY (= LONGER LIFE) MUST BE DELT WITH IF A STABLE MIX IS TO BE APPLIED. 2 METHODS OF ACHIEVING STABILITY BESIDES GRADATION AND EMULSIFIER SELECTION ARE THE ADDITION OF FINES AND FILLERS AND THE USE OF POLYMERIC MATERIALS OR BOTH.

THE USES AND PROPERTIES OF THESE MATERIALS (FILLERS AND POLYMERS) ARE BEING STUDIED IN PRIVATE LABORATORIES AROUND THE WORLD AND AT IOWA STATE UNIVERSITY UNDER ISSA SPONSORSHIP.

(I) DISCUSSION

REFERENCES

Benedict, C. R., Ed. — "Design Technical Bulletins - 1978 (1980, 1984)" Pub. by INTERNATIONAL SLURRY SEAL ASSOCIATION, Washington, D.C.

Benedict, C. Robert — "An Introduction to the Potential Uses of a Loaded Wheel Tester (LWT) for the Traffic Count Design of "Slurry Seal" Presented ISSA convention Las Vegas, February 3-6, 1975.

Benedict, C. Robert — "Classification of Asphalt Emulsion/Aggregate Mixture Systems by Cohesion Tester Measurement of Set and Cure Characteristics" Presented ISSA convention Phoenix, January 24-28, 1983.

Benedict, C. Robert — "New Trends in Slurry Seal Design Methods" Presented ISSA convention Orlando, February 3-7, 1985.

Benedict, C. Robert — "Uses of the Modified Cohesion Test for Emulsion Formulation and Mix Design of Performance Cold Mix Systems". Presented AEMA convention New Orleans, March 5-8, 1985.

Benedict, C. Robert — "Experiments with Cured Cohesion Testing of Slurry Seals and Thin Layered Cold Mixes". Presented ISSA convention San Francisco, January 28, 1986.

Woodside, Alan — Personal Communication and Methyl Blue Tests. University of Ulster at Jordanstown, Northern Ireland, about May, 1985.

Breuer, J.U. — Dipl.-Ing. "Prufung der Wasserempfindlichkeit von Gesteinsmehlfullern" University/Munich, 1964 - received 1982.

Choyce, P.W., Lammiman, P.A., Taylor, I.F. — "Resistance to Deformation of Hot Rolled Asphalt" Highways and Transportation, No. 1, Volume, 31, January 1984 (J of Inst. of Hgwy. Group and Tptn. and HTTA).

Marklund, Soren — "Measurement of Adhesion and Cohesion Loss by 6-day Soak Wet Track Abrasion Test". Presented ISSA convention San Francisco, January 28, 1986.

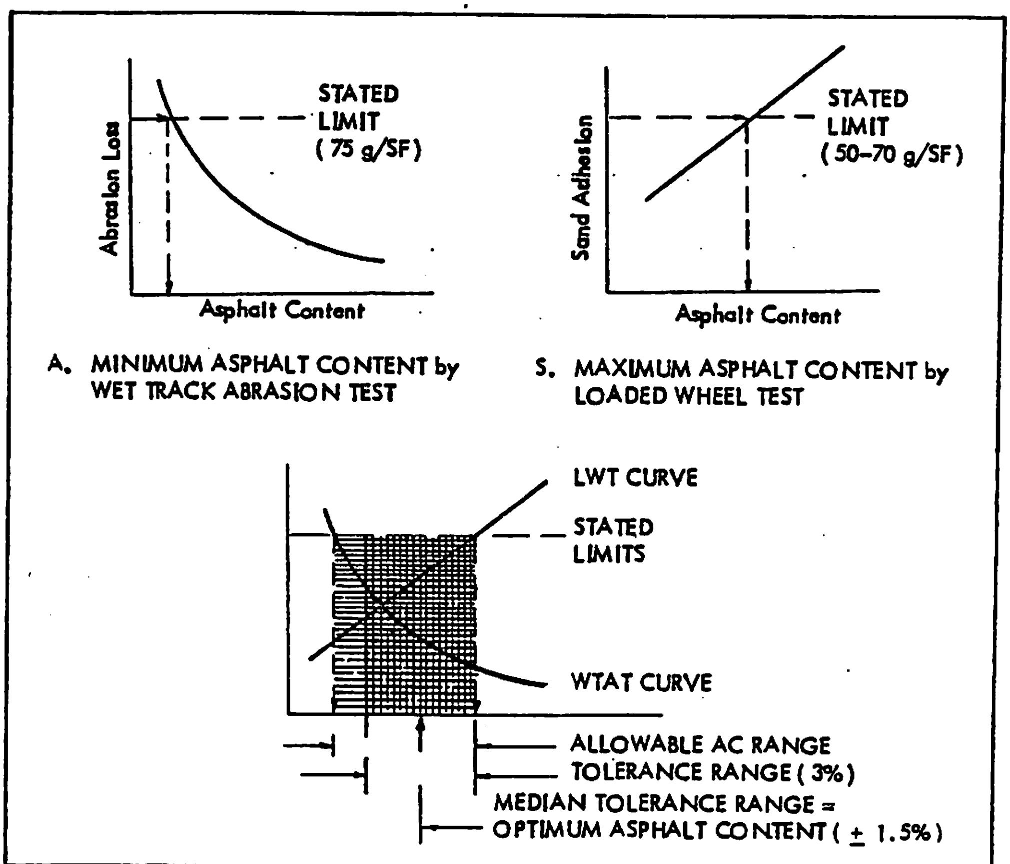
Jacobs, F.A. — Hot Rolled Asphalt: "Effects of Binder Properties on Resistance to Deformation" TRRL Laboratory Report 1003, 1981 ISSN 0305 - 1293.

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

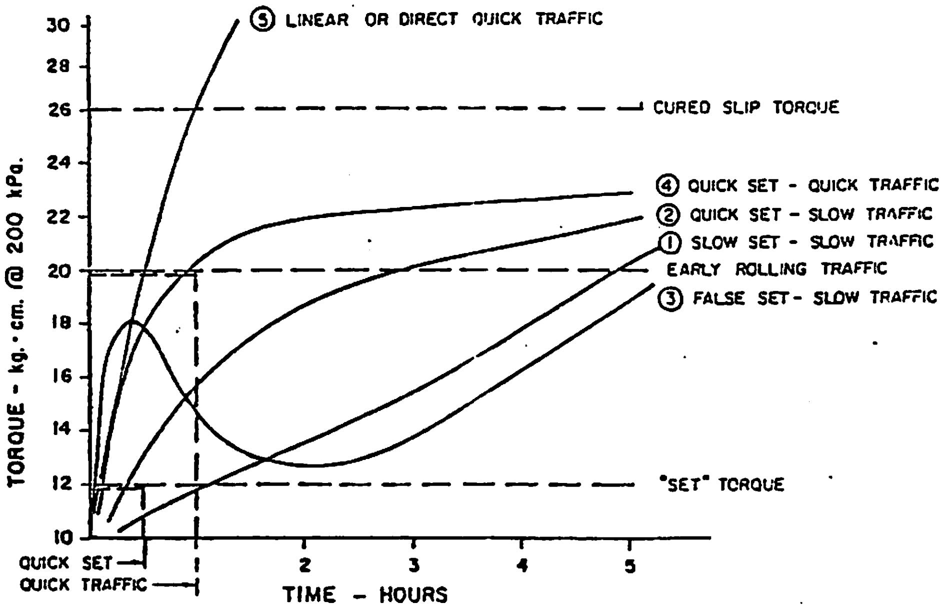
   a. State Maximum limits to WTAT = minimum asphalt content (75g/SF?)
   b. State Maximum limits to LWT = maximum asphalt content or
      State Maximum LWT limits for Traffic Counts
      Light = 0 to 500 ADT (70 g per SF?) sand adhesion, 1000 ¢@125 lbs,
      Medium = 250 to 1500 ADT (60 g per SF?)
      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.



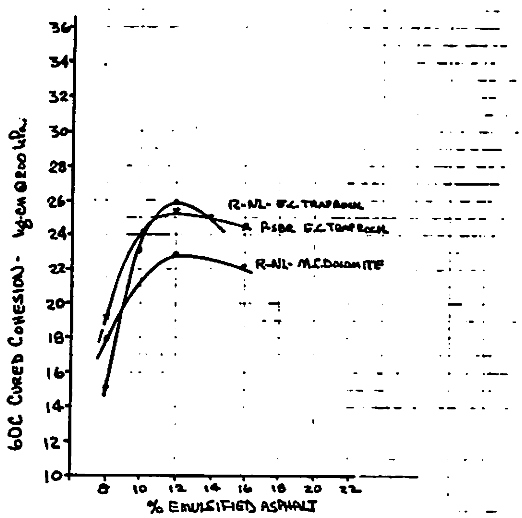
GRAPHICAL DETERMINATION OF OPTIMUM ASPHALT CONTENT

CURRENT SLURRY SEAL DESIGN METHOD

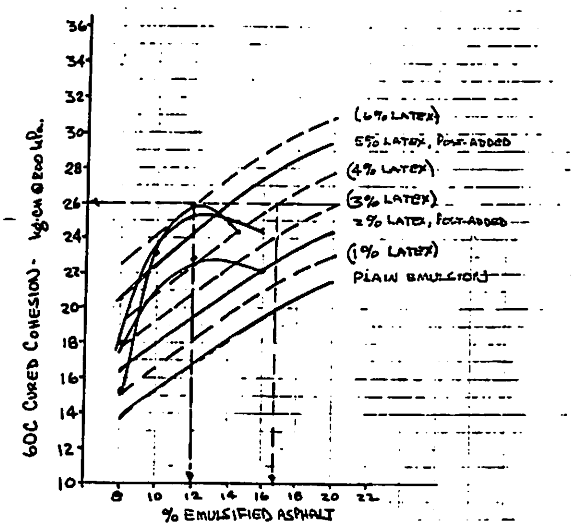
ISSA TECHNICAL BULLETIN NO. 111 – 1978



CLASSIFICATION OF MIX SYSTEMS BY
MODIFIED COHESION TEST CURVES



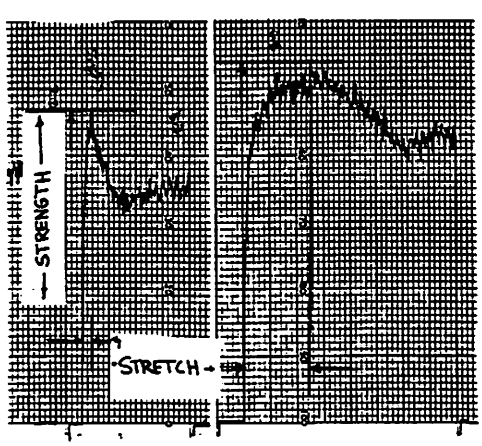
EXAMPLE 5. EFFECT OF LATEX CO-EMULSIFICATION ON CURED COHESION



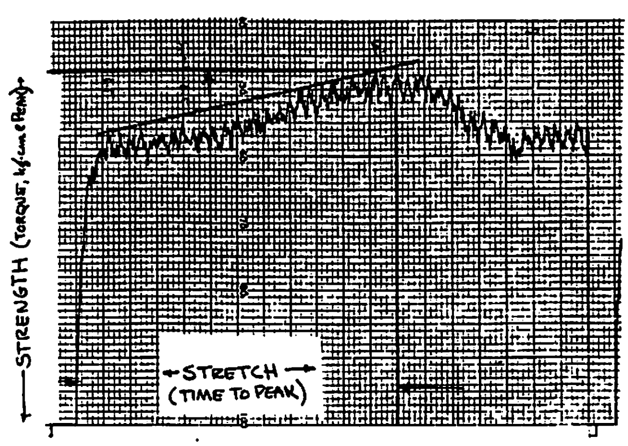
EXAMPLE 6. LATEX POST-ADDITION & CO-EMULSIFICATION EQUIVALENCIES

EXAMPLE 5. THE EFFECTS OF CO-EMULSIFICATION ON CURED COHESION.

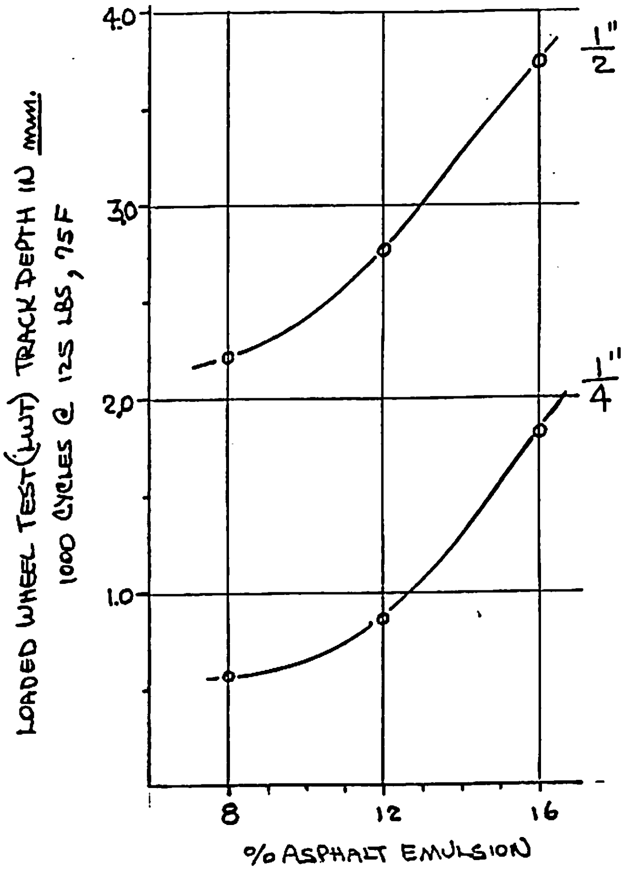
EXAMPLE 6. COMBINED POST-ADD AND CO-EMULSIFICATION CURVES.

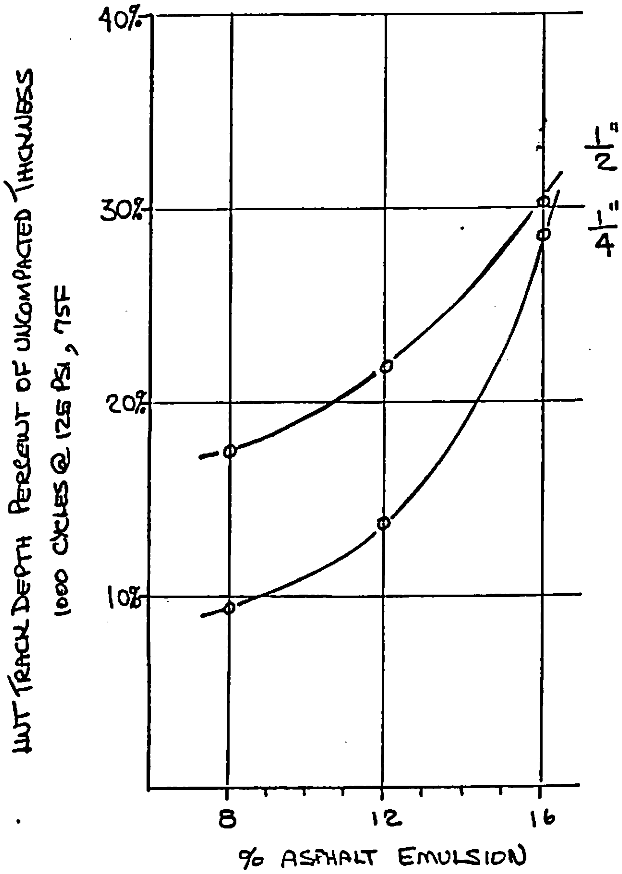


EXAMPLE 10a. STRENGTH AND STRETCH CURVES 60C CURED COHESION



EXAMPLE 10b. STRENGTH & STRETCH (60C-CURED COHESION)





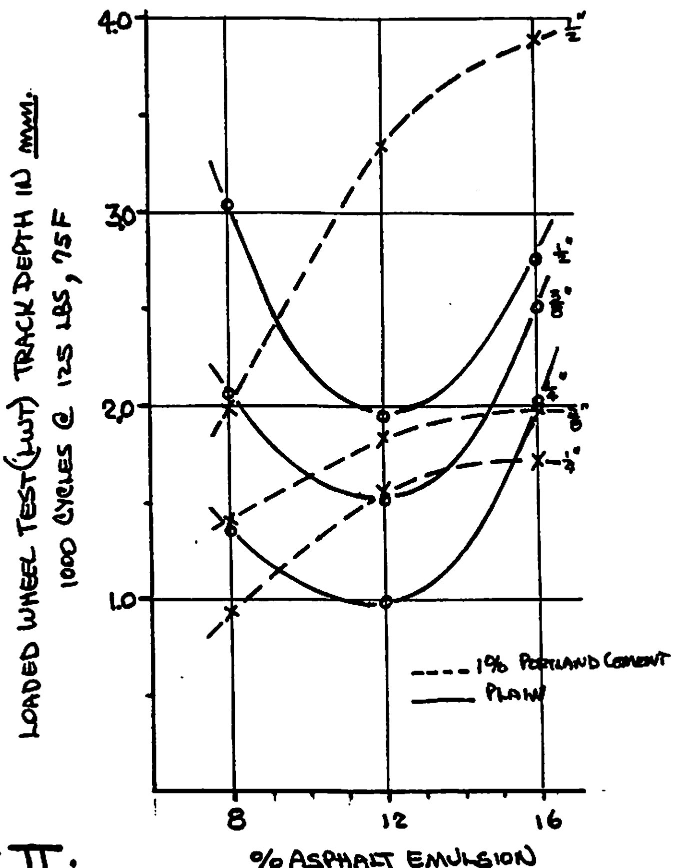
CASE I:

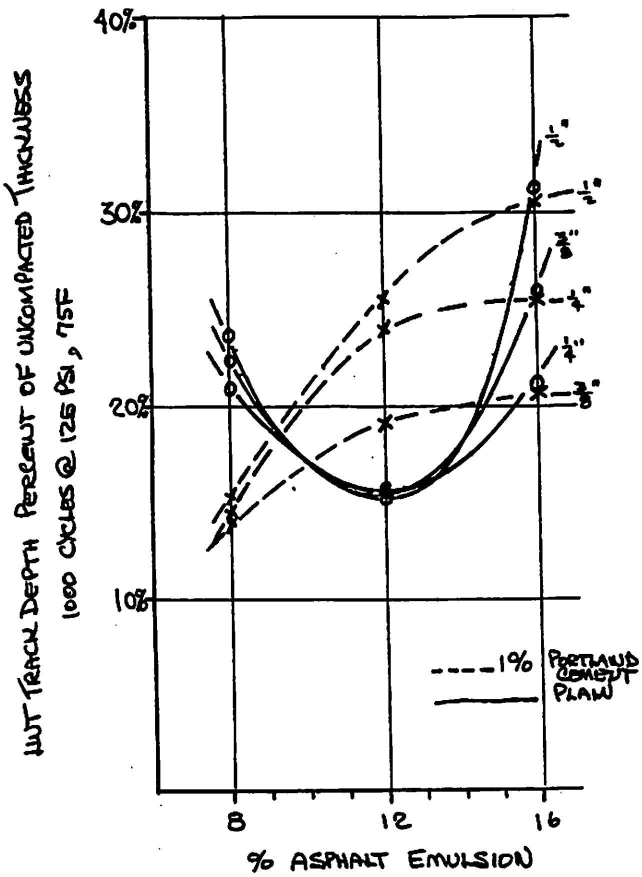
#517K vs. 0/5 mm, 75 SE GRAVEL

TRACK DEPTH vs. LAYER THICKNESS /CRB 5/8

#517K vs. 0/5 mm, 75 SE GRAVEL 7--

% VERTICAL DISPLACEMENT vs. THICKNESS /CRB 5/86





CASE II:

EFFECT OF PORTLAND CEMENT FILLER ON LWT TRACK DEPTH WITH AN UNMODIFIED PERFORMANCE SYSTEM - LOW FINES DOLOMITE VS. CQS VENEZUELAN - PLAIN 11/86

EFFECT OF PORTLAND CEMENT FILLER ON LWT TRACK DEPTH - % OF UNCOMPACTED THICKNESS WITH LOW FINES DOLOMITE VS. PLAIN VENEZUELAN CQS.

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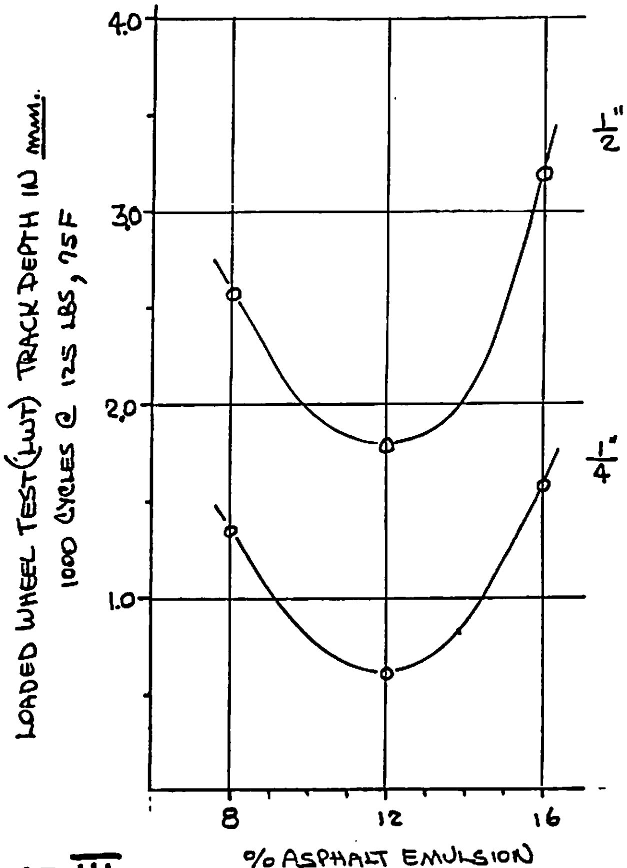
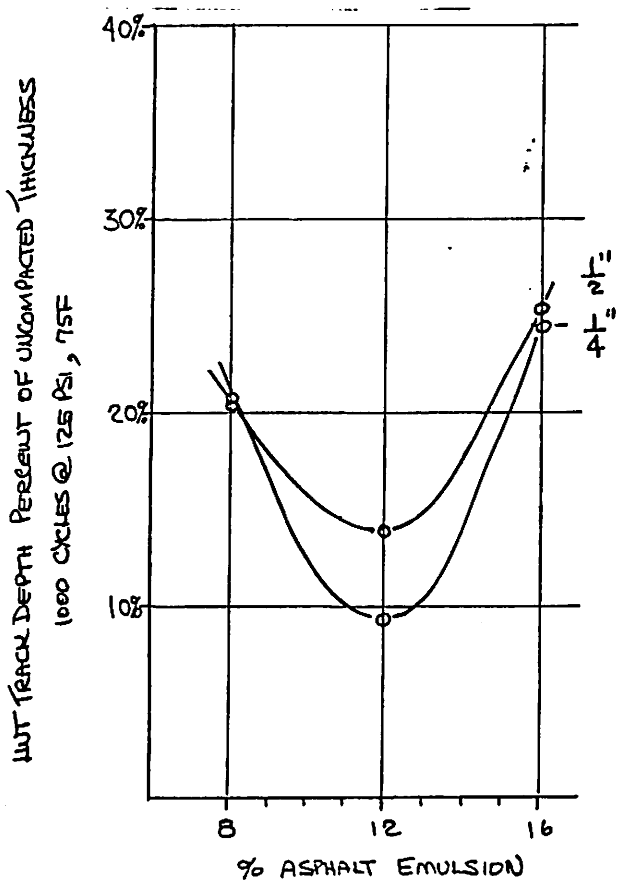




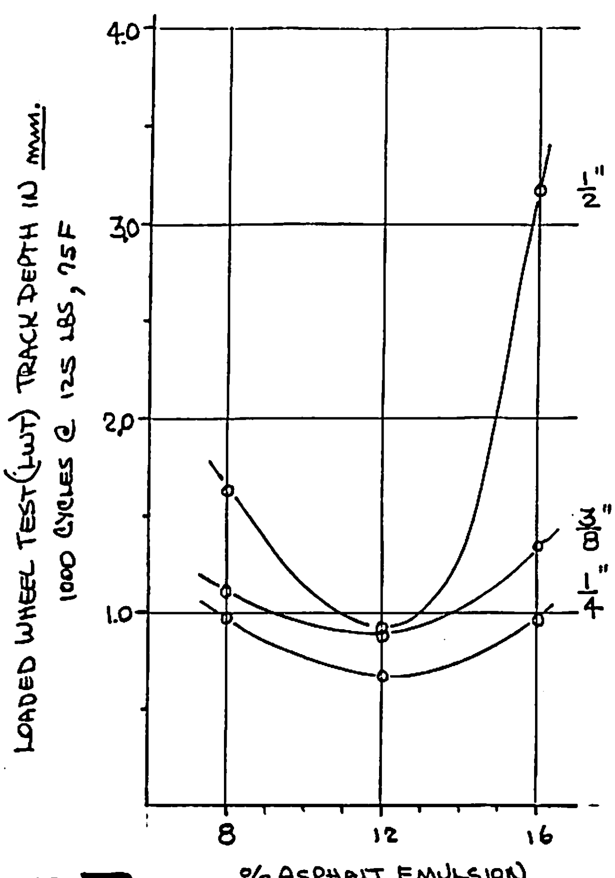
CASE III:

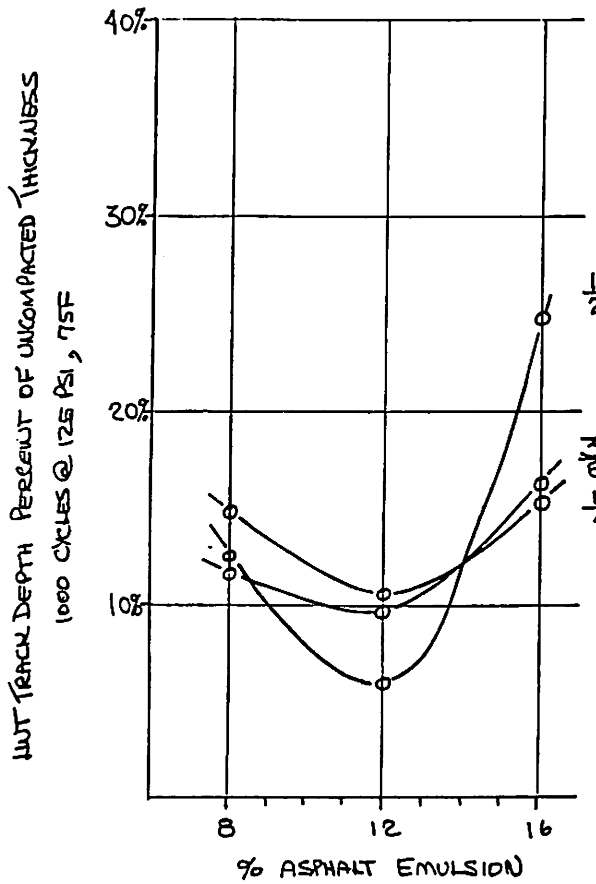
#420-1 vs. 0/5 mm., 75 SE DOLOMITE

TRACK DEPTH vs. THICKNESS /CRB 5/86

#420-1 vs. 0/5 mm, 75 SE DOLOMITE

% VERTICAL DISPLACEMENT vs. THICKNESS /CRB 5/86





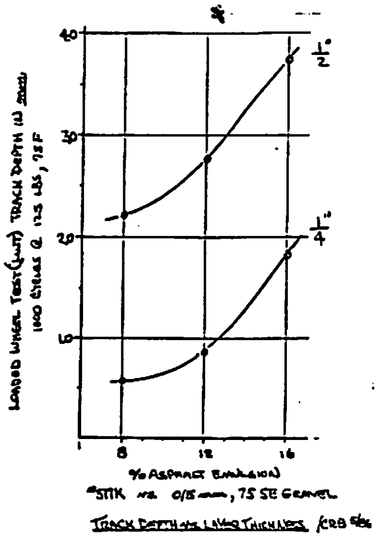
CASE IV:

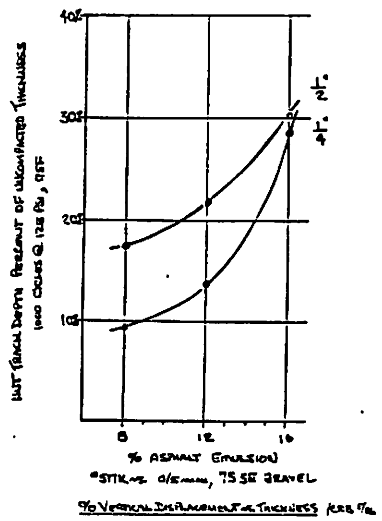
#928 vs. 0/5 mm, 75 S.E. DOLOMITE

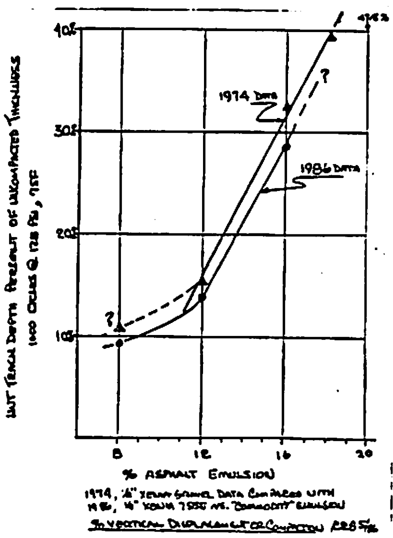
TRACK DEPTH vs. THICKNESS /CRB-5/86

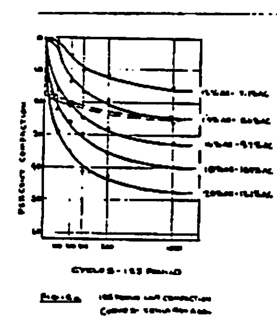
#928-1 vs. 0/5 mm., 75 SE DOLOMITE

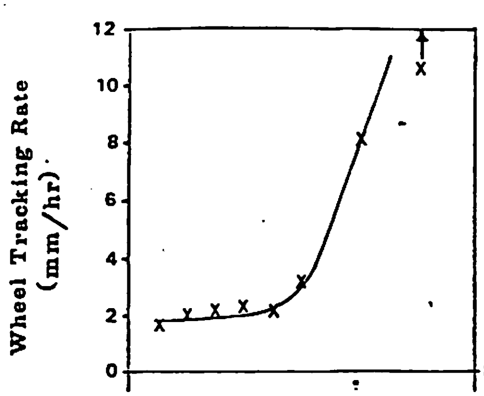
% VERTICAL DISPLACEMENT vs. THICKNESS /CRB 5/86

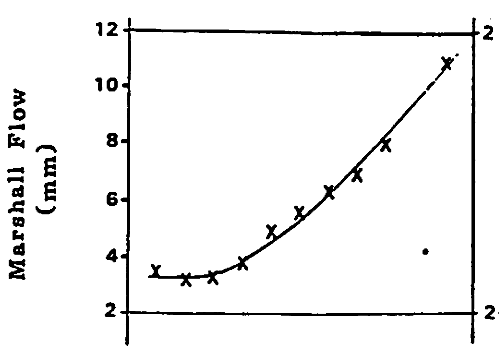




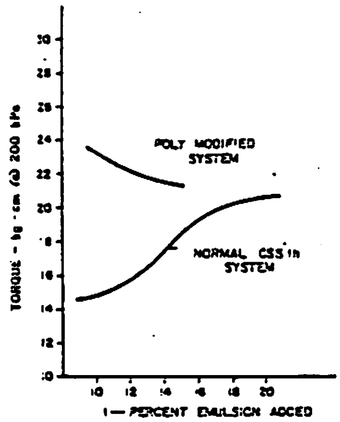


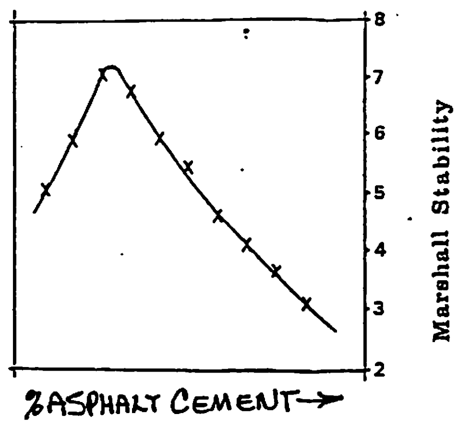






SIMILAR CURVES: LWT TRACK DEPTH, WHEEL TRACKING RATE AND MARSHALL FLOW





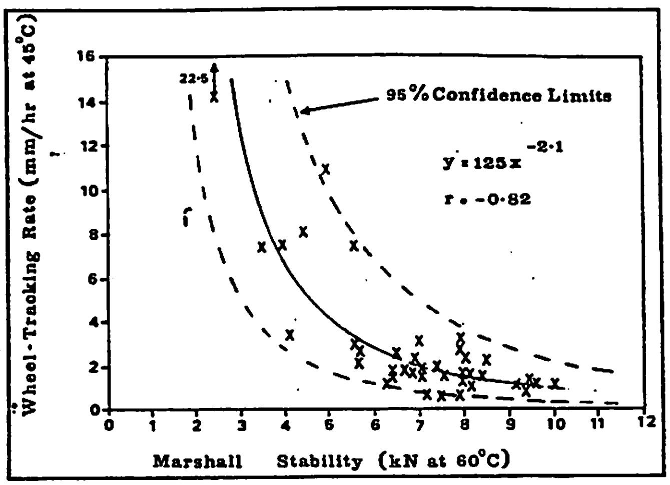


Fig 2 Marshall stability vs wheel-tracking rate.

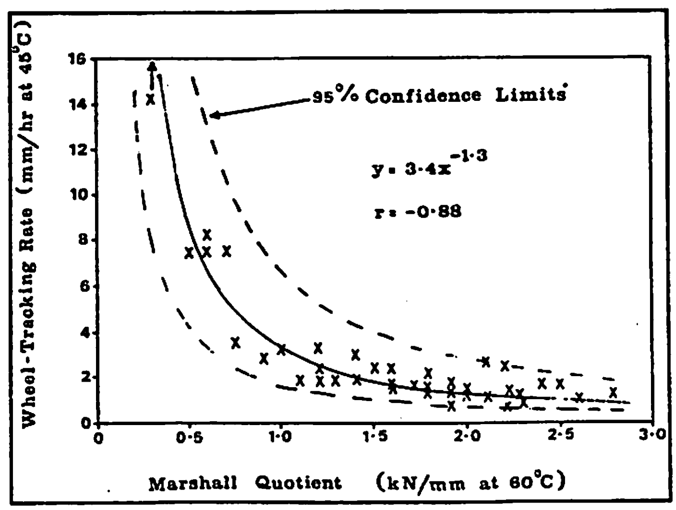


Fig 3 Marshall quotient vs wheel-tracking rate.

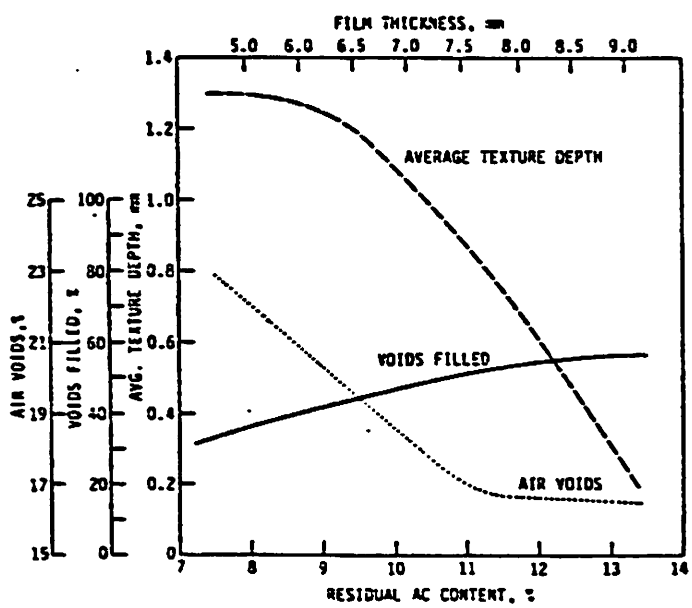


Fig. 4 : Relationship between residual asphalt content, film thickness, air voids, voids filled, and texture depth, Series II, L1.