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LABORATORY MEASUREMENT OF CHIP SEAL CHIP RETENSION STRENGTH BY THE FROSTED MARBLE MODIFIED ISSA COHESION TESTER

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An ancillary paper for a joint presentation "Highway 84 Modified Asphalt Emulsion Test Project" by Gaylon Baumgardner, Ergon, Inc. and Robert Moseley, Mississippi Highway Department at the AEMA/ISSA Users Conference, Atlanta, Georgia, November 14, 1990.

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INTRODUCTION

The problem of chip seal (surface dressing) chip retension or "loss of cover aggregate" is well known. The problem of loose, unbound chips is severe enough in some areas to prohibit the use of chip seals altogether.

The laboratory measurement of chip retension as a predictor of field chip retension then becomes an important tool for the development of rational specifications. Among several methods of laboratory measurement of chip retension now used are:

1. The Vialit test (1) where bitumen and chips are applied to a metal plate, cured and turned over then impacted by a falling metal ball. The number of chips dislodged or retained by impact is taken as a measure of chip retension.

2. The Pendulum test (2) where a single chip is imbedded in bitumen on a raised pedestal. The force of a swinging pendulum (a la golf club) required to dislodge the chip is taken as a measure of chip retension strength.

3. Skewed Tire Wheel Tracking Test (3) where plaque mounted chip seal specimens are subject to side force friction or abrasion of a pneumatic tire in motion. The chip loss is taken as a measure of chip retension.

4. The new "Frosted Marble" Modified ISSA Cohesion Test method. We have adapted the ISSA Technical Bulletin #139 modified Cohesion Tester to test chip retension strength. Simply, the standard cohesion tester foot is replaced with a 50mm "hooked foot" (fig.1) which is rotated horizontally with a torque wrench to dislodge a standard 9/16" (14.3mm) diameter frosted (acid etched) marble or glass bead from bitumen contained in a flat steel trough to a depth of 1.5mm ($1.5/1/ml^2$). The average torque (kg/cm^2) required for dislodgement of 3, 4 or 5 frosted marbles is recorded as the chip retension strength.

Initially, we have used 3 rows of 5 marbles in a single trough plate. Each row was tested at different time periods of curing.

1. 15 hours air curing at ambient
2. 4 hours in a forced draft oven at 60°C (2 hour cool)
3. 15 hours in a forced draft oven at 60°C (2 hour cool)

It was found that most bitumens would "cold flow" into the craters left by previously extracted marbles. This tended to reduce somewhat the immersion depth of the adjacent row of marbles which may introduce inaccuracies. To solve this problem, plates were fabricated with three separate troughs, one for each curing period.

PROCEDURE

1. Replace the 1 1/8" dia. cohesion tester foot with the 50mm hooked foot and adjust to contact the frosted marbles slightly below the center of the marble. Lock in place with the jamb nut.

2. Adjust air pressure to 70kPa or 10psi to minimize friction. The unit may be operated without air pressure at some loss of convenience.

3. Add 9.0 ± .2 grams of chip seal emulsion to each of the 3, 1.55 ± .05mm deep troughs of the trough plate. Place on a level surface and to allow the emulsion to seek its own level.

   When the emulsion is level, place the template directly over the trough plate and add 15 frosted marbles (5 in each trough).The template may be removed in a few minutes or when the initial "set" occurs.

   To get comparable results with pure bitumen, pre-heat the bitumen and trough plate to spraying temperature before adding 6.0 ± .2 grams of bitumen to each trough.

4. Curing times may be varied. It is suggested that the following 3 consecutive periods be tried: (1) 15 hours at ambient, (2) 4 hours at 60C forced draft and 2 hours cool (3) 15 hours at 60°C forced draft and 2 hours cool.

5. After each specified curing period, the trough plate is positioned on the cohesion tester base with the hooked foot for 2-point static contact. The trough plate is held firmly in place while the torque wrench is applied to the upper rod end and twisted with a firm, smooth horizontal motion through a 30 to 45° arc in about 1/2 second. The torque required to dislodge the marble is read by the follow-up pointer and recorded. The average torque values of 5 successive tests in each trough for the curing period stated is recorded as the chip retension strength.

6. After the test, the residual bitumen in the trough may be removed and tested for moisture or solvent content.

FIELD PROJECT CORRELATIONS - MISSISSIPPI

The Mississippi State Highway Department undertook during October 1989 an experimental chip seal project to determine the effectiveness of various polymer modified Chip Seal Emulsions. 2000 gallons each of 10, CRS2 type modified emulsions were placed on MISS SR84. The initial performance and long term performance continues to be evaluated. We were supplied with samples of each emulsion which were subjected to the above procedures; i.e., testing after an overnight air cure, after 4 hours in forced draft oven @ 60C and after an additional overnight oven cure for 16 hours. All tests were conducted at room temperature. Figure 2 graphs our results. The most striking differences in test values ranging from 12 to 33 kg/cm^2) occur after the first overnight ambient cure which indicates the all important initial or early chip retension strength. Figures 3 and 4 arrange the test results in ascending order for clarity. The value of Polymers incorporated into the emulsion becomes quite apparent under conditions of the test. In general, these results reportedly correlate well with field results. The field data is to be presented November 14, 1990 at the Atlanta AEMA/ISSA users conference by Gaylon Baumgardner, Ergon Asphalt and Emulsions Co., and Robert Moseley, Research Dept., MISS SHD.

All CRS samples with the exception of the Ductilad were manufactured by Ergon using the identical base bitumen and emulsifier. It is our opinion that the Ductilad emulsion itself was faulty and test results were much lower than typically found in the field.

SHRP, SPS-3 FIELD CORRELATIONS

Figure 5 graphs the test results of emulsions from 4 SPS-3 regions which were applied during 1990. These are unmodified "generic" CRS-2 emulsions. We await the SHRP SPS-3 field results.

Moisture contents, originally at about 33%, are shown at 3.8 to 6% for the residual bitumen after overnight curing. Moisture contents after 4 hours at 60C are not shown but are believed to be 1 to 2% while moisture contents after the 3rd curing period are (of 16 hours at 60°C) believed to be at or near zero. It is believed that the early retension strength is closely related to amount of water retained in the emulsion residue while the fully cured strength is related to bitumen viscosity and polymer properties..

SUMMARY

A new method has been presented for measuring chip seal chip retension strength using a modified ISSA cohesion tester and frosted glass marbles as a standard-shape reference aggregate. Objective, reproducible numbers are obtained with the test and generally correlate with field results.

Only after refinement and definition of the test will it be possible to set reasonable limits for chip retension strength.

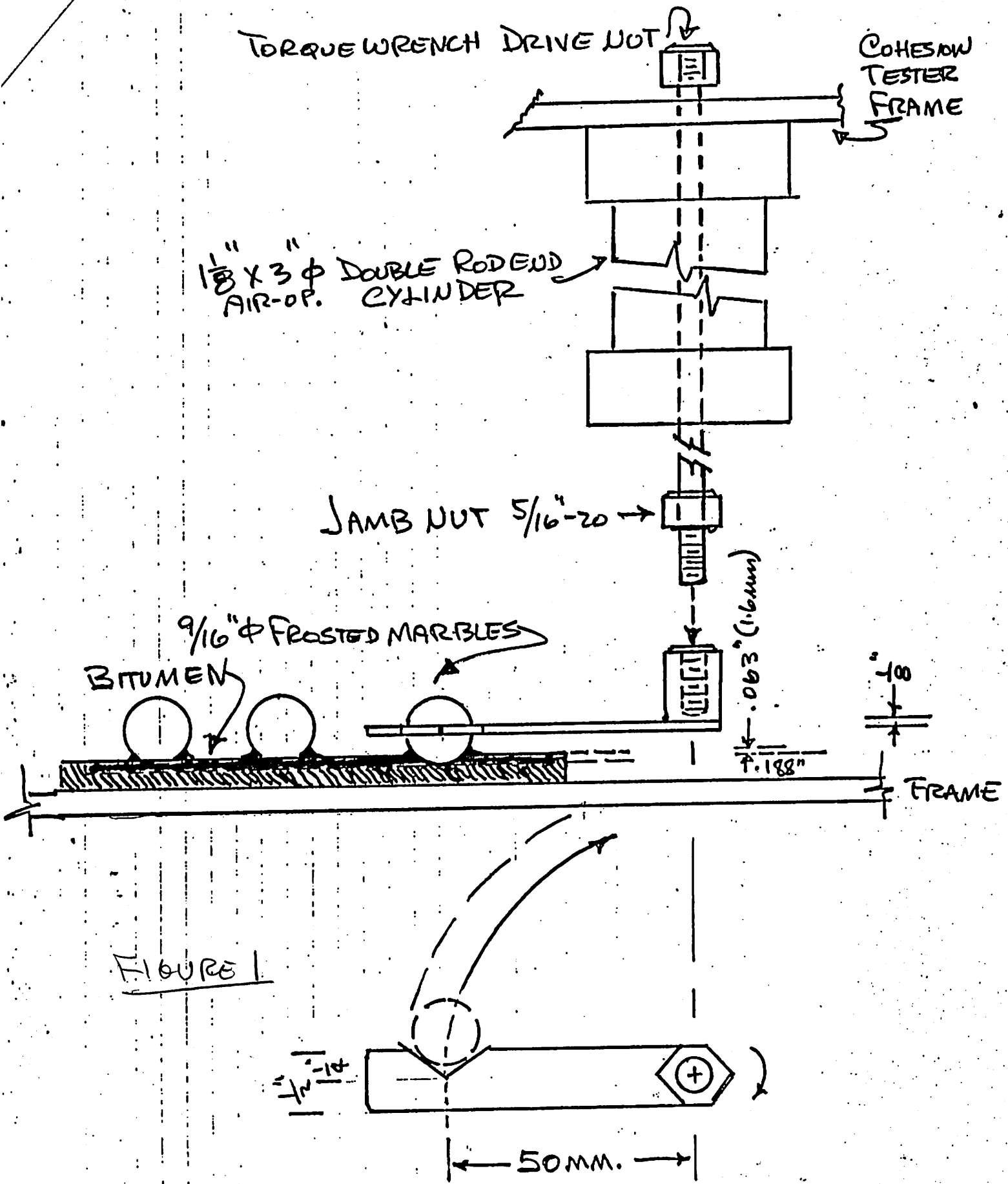
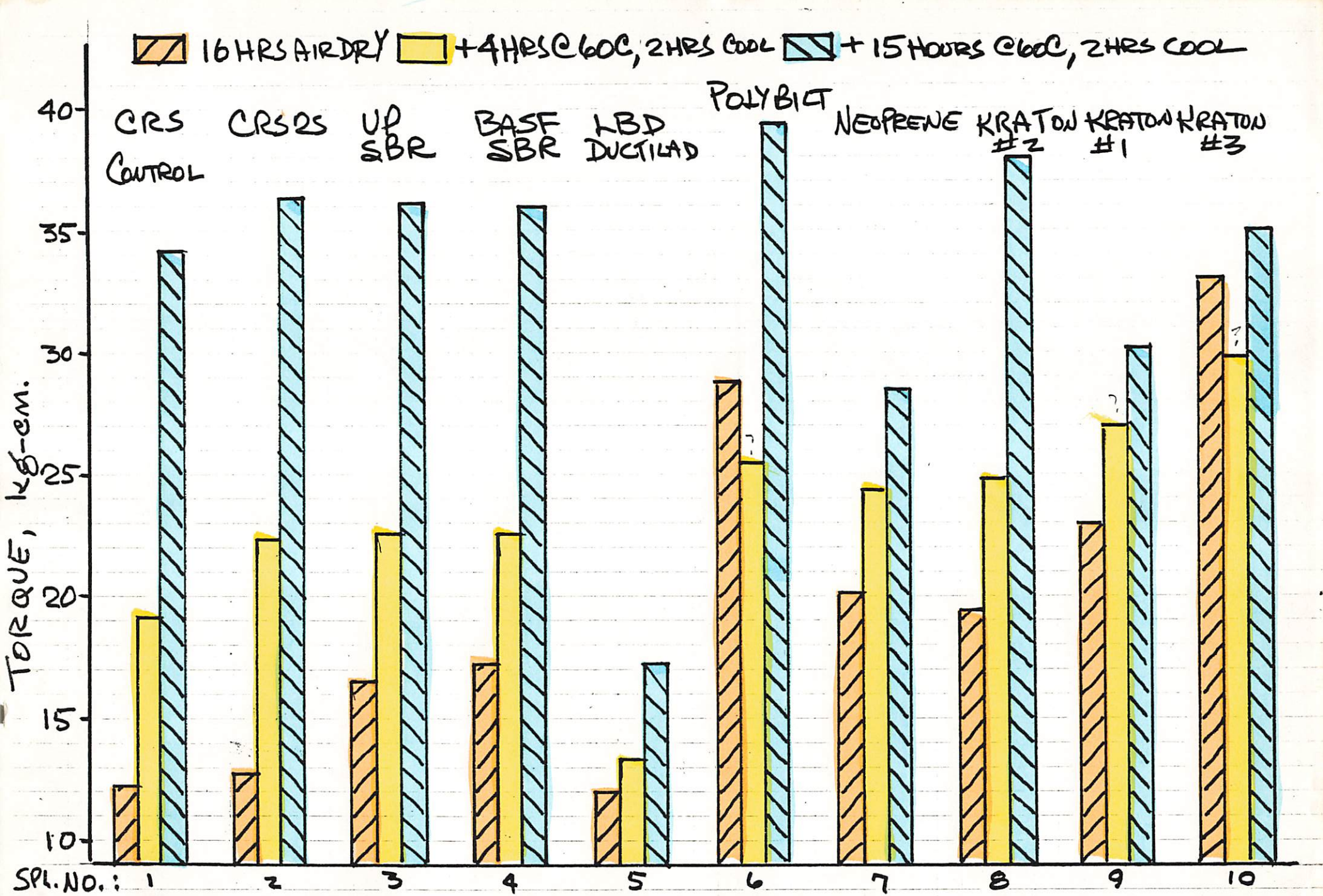


FIGURE 1

CHIP RETENSION STRENGTH TEST

BENEDICT 10/22/89
513-298-6647



MISSISSIPPI DOT CHIP SEAL RESEARCH PROJECT - FIELD TRIAL EMULSIONS 9/11/89 ON-.
LABORATORY MEASUREMENT OF CHIP RETENSION STRENGTH BY MODIFIED COHESION TEST; 1.5 l/m², 9/16" Φ FROSTED MARBLES - 10/22/89 / BENEDICT

FIG. 2

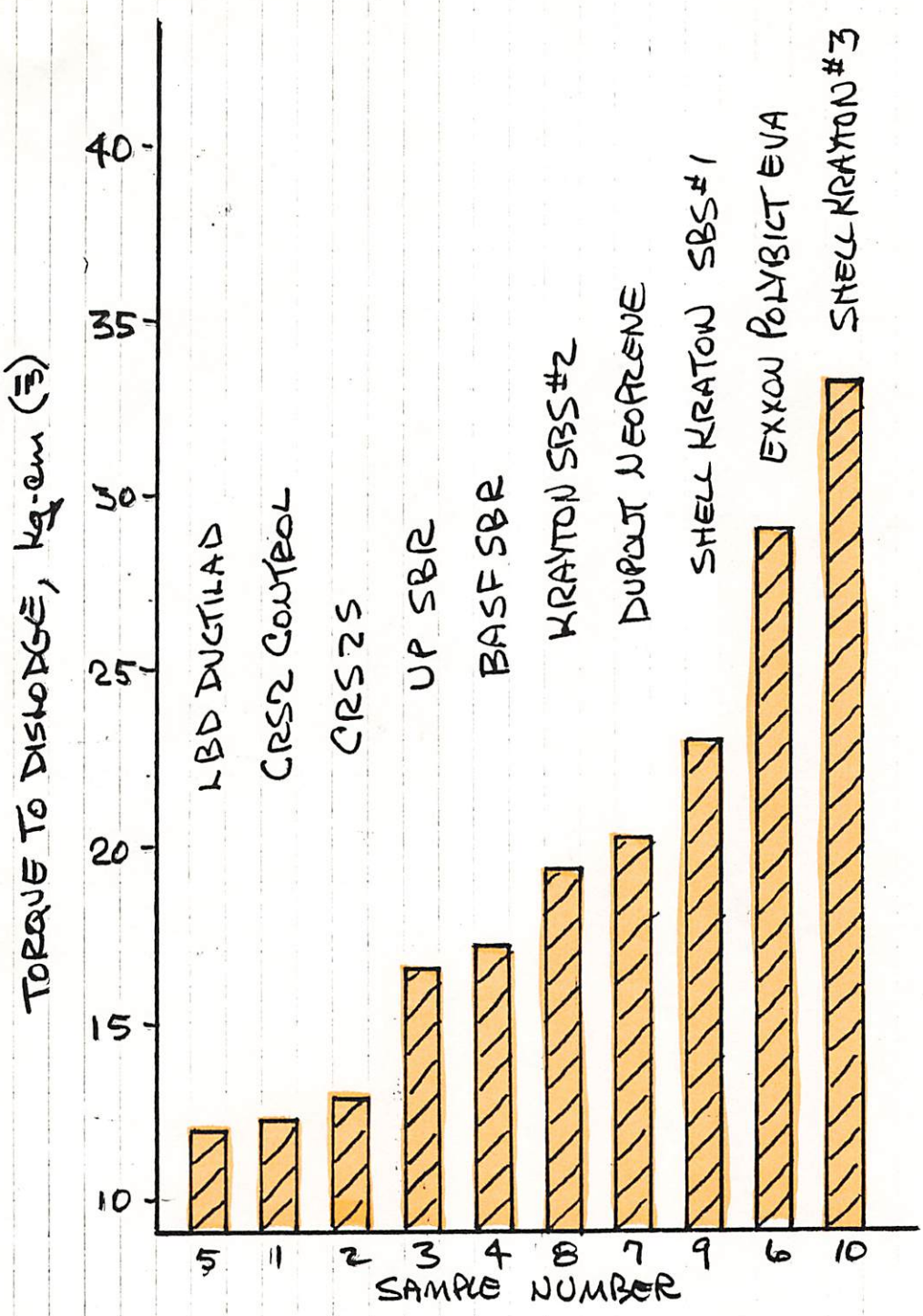


FIG. 3 MISSISSIPPI DOT CHIP SEAL RESEARCH PROJECT 9/11/89----

EARLY CHIP RETENSION STRENGTH MEASURED BY MODIFIED ISSA TECH. BULL. 139 COHESION TEST

1.5 ℓ/m^2 9/16" Φ FROSTED MARBLES
16-HOUR AMBIENT CURE 10/22/89/BENEDICT

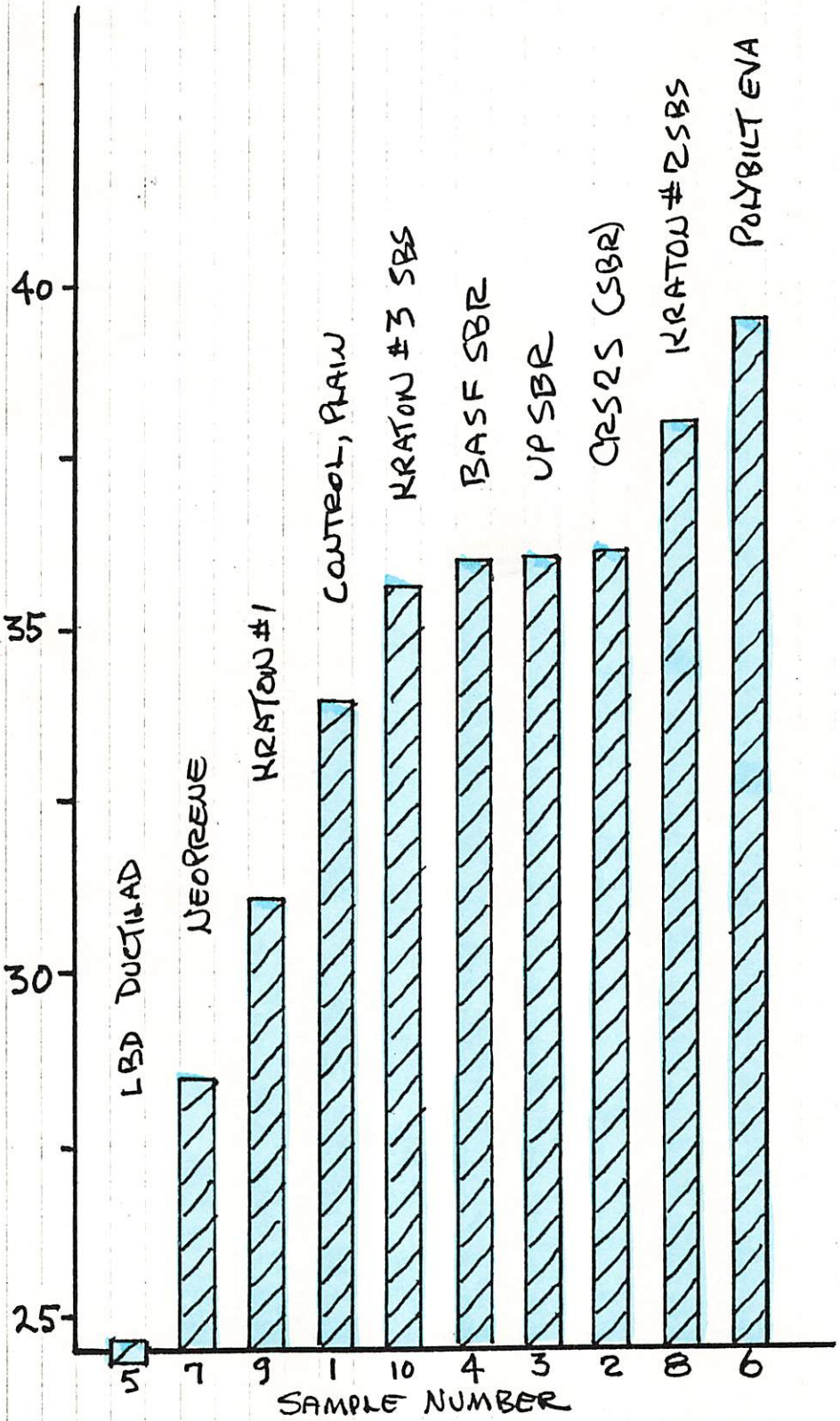


FIG. 4 FULLY CURED CHIP RETENSION STRENGTH MEASURED BY MODIFIED ISSA TECH. BULL. 139 COHESION TESTER

1.5 l/m², 9/16" ϕ FROSTED MARBLES

MISSISSIPPI DOT CHIP SEAL RESEARCH FIELD SPECIMENS 10/22/88 - BENEDICT

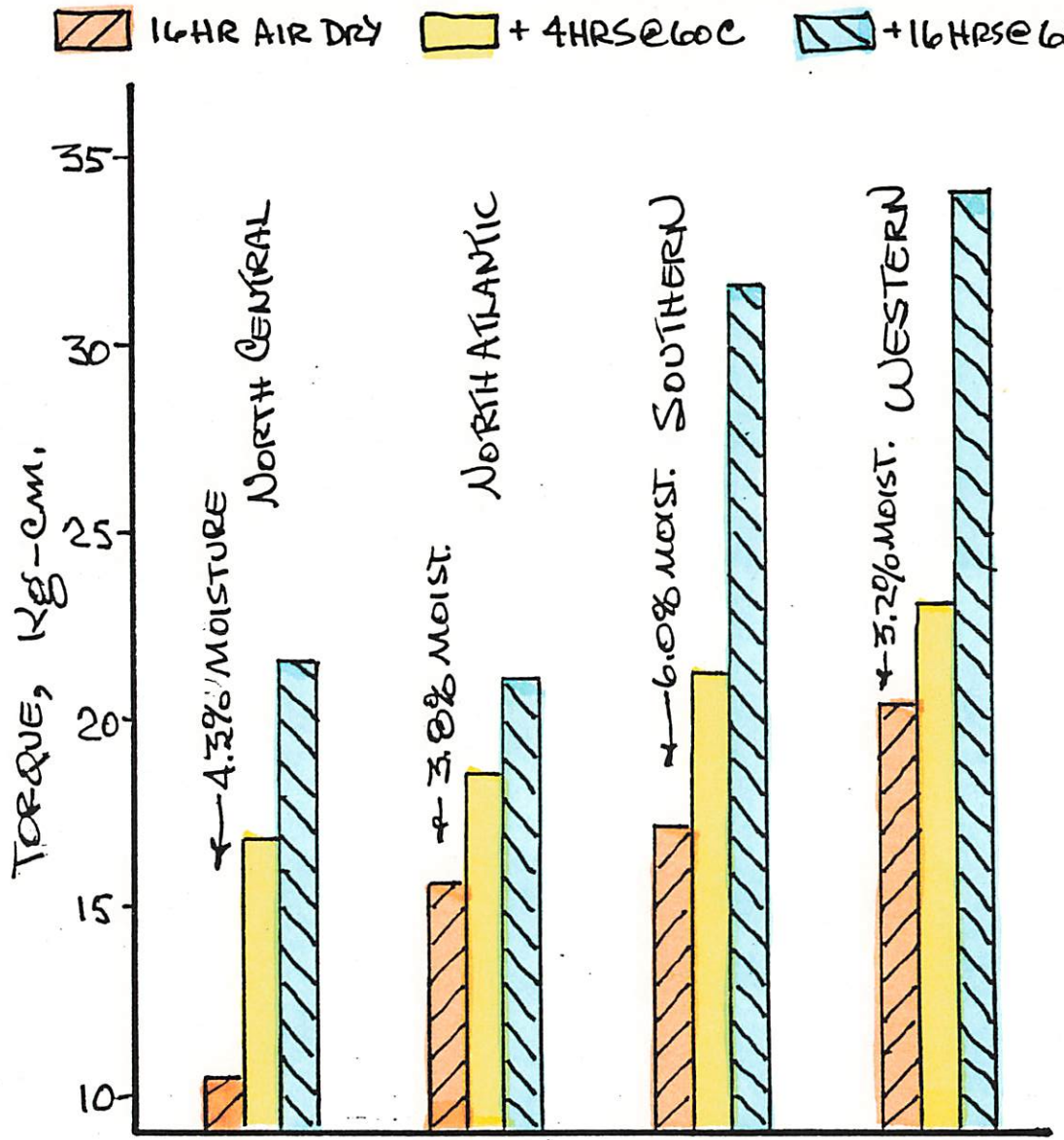


FIG 5 CHIP SEAL CHIP RETENSION STRENGTH TEST
(MODIFIED ISSA COHESION TEST)
1.5 ℓ/m² EMULSION WITH 9/16" ϕ FROSTED MARBLES

SHRP H101, SPS-3 "MAINTENANCE EFFECTIVENESS