MS-1441

DRAFT

USE OF THE MARSHALL METHOD FOR JOB CONTROL TESTING

I AM PRETTY SURE THAT MANY OF YOU WERE A BIT SURPRISED TO SEE A PRESENTATION ON THE AGENDA CONCERNING MARSHALL TEST METHODS. INDEED, IT FEELS A LITTLE STRANGE TO ME TO BE UP HERE TALKING ABOUT IT. HOWEVER, I DID SUGGEST THAT THE TOPIC BE PUT ON THE PROGRAM SO THAT YOU MIGHT BECOME AWARE OF THE EXPERIMENTAL WORK THAT WE'VE BEEN DOING. AS SOME OF THIS WORK HAS BEEN IN THE FIELD ON SOME OF YOUR PROJECTS, WE FELT THAT SOME OF YOU MIGHT ALREADY BE A BIT CURIOUS. AND I'M SURE THAT MOST ALL ARE INTERESTED IN ANY NEW DIRECTIONS THAT THE DEPARTMENT IS CONSIDERING.

I SHOULD SAY FROM THE OUTSET THAT THE WORK WE ARE DOING IS A FEASIBILITY STUDY. WE ARE EVALUATING A VARIATION OF THE MARSHALL STABILITY AND FLOW TESTS TO DETERMINE IF THEY CAN HELP US DO A BETTER JOB OF CONTROLLING MIXTURE QUALITY.

WHY ARE WE CONSIDERING A CHANGE IN OUR JOB CONTROL TESTING? AND WHY THE MARSHALL METHOD? PART OF THE ANSWER TO THESE QUESTIONS GOES BACK SEVERAL YEARS. IT SEEMED TO MANY OF US IN THE DEPARTMENT, AND PROBABLY ALSO TO MANY OF YOU, THAT WE WERE BEGINNING TO HAVE MORE AND MORE EARLY PROBLEMS WITH OUR ASPHALTIC CONCRETE PAVEMENTS, PARTICULARLY WITH RUTTING. AT THAT TIME WE BEGAN A SMALL IN-HOUSE STUDY TO TAKE A PRELIMINARY LOOK AT SEVERAL TESTS WHICH WE DO NOT ROUTINELY USE. WE WANTED TO SCREEN THESE TO SEE IF IT APPEARED THAT ANY OF THEM MIGHT HELP US TO BETTER IDENTIFY POOR QUALITY MIXTURES, EITHER AT

THE MIX DESIGN STAGE OR DURING JOB CONTROL TESTING. WE COMPARED HVEEM STABILITY, COHESION, MARSHALL STABILITY AND FLOW, INDIRECT TENSION, AND RESILIENT MODULUS USING PLANT PRODUCTION SAMPLES FROM A NUMBER OF STATE PROJECTS. WE FOUND THE RESULTS OF THESE TESTS TO BE RATHER INTERESTING. WHILE THE DIFFERENCES IN THE MIXTURE DESIGNS AND INDIVIDUAL MATERIALS MADE THIS LESS THAN A SCIENTIFIC COMPARISON, WE DID CONFIRM SOME OF THE SIMILARITIES AND DIFFERENCES IN THE MIXTURE CHARACTERISTICS BEING MEASURED. CONCERNING MARSHALL STABILITY, THE DATA INDICATED NO DIRECT RELATIONSHIP WITH HVEEM STABILITY, WHICH IS NOT EARTH-SHAKING NEWS. A PARTICULAR MARSHALL STABILITY VALUE DOES NOT INSURE A CERTAIN CORRESPONDING HVEEM STABILITY. HOWEVER, THE COMPARISON OF DATA DID SEEM TO INDICATE THAT MARSHALL STABILITY IS SENSITIVE TO SOME OF THE SAME FACTORS WHICH AFFECT HVEEM STABILITY. FOR THIS REASON, AND BECAUSE MARSHALL IS A NATIONALLY-ACCEPTED JOB CONTROL TEST, WE FELT THAT IT WAS WORTH THE EFFORT TO TAKE A CLOSE LOOK AND SEE IF IT MIGHT HELP US.

ANOTHER REASON THAT WE ARE INTERESTED IN MARSHALL TESTS IS THAT THEY CAN BE PERFORMED AT THE RESIDENCY OR EVEN THE PLANT LABORATORY. THIS CAPABILITY MAKES RESULTS AVAILABLE MUCH SOONER THAN WITH OUR HVEEM PROCEDURES, WHICH IS A MAJOR ADVANTAGE.

WHAT DO WE LOOK FOR IN A JOB CONTROL TEST? FIRST, AND MOST IMPORTANTLY, THE TEST MUST BE SENSITIVE TO CHANGES IN THE MIXTURE WHICH WILL AFFECT PAVEMENT PERFORMANCE. SECONDARILY, IT SHOULD PROVIDE TIMELY RESULTS, BE SIMPLE TO PERFORM, AND BE ECONOMICALLY

PRACTICABLE. HVEEM STABILITY IS EXCELLENT IN SENSITIVITY TO SEVERAL IMPORTANT MIXTURE CHARACTERISTICS, AMONG THOSE BEING AN OVER-ASPHALTED CONDITION, BUT IT IS NOT AS FEASIBLE FOR FIELD USE. THE MARSHALL METHOD WOULD PROVIDE MORE RAPID RESULTS, AS WE SAID, AND THE EQUIPMENT IS MORE REASONABLY AVAILABLE ON THE MARKET. THE KEY QUESTION, HOWEVER, IS WILL THE PROCEDURE BE ADEQUATELY SENSITIVE TO CHANGES IN MIXTURE QUALITY THAT WILL MEAN POOR PAVEMENT PERFORMANCE? BEFORE I GET INTO THE WORK THAT WE HAVE BEEN DOING TO ANSWER THAT QUESTION, LET ME BRIEFLY DESCRIBE THE MARSHALL STABILITY AND FLOW TEST FOR THOSE LESS FAMILIAR WITH IT.

MARSHALL STABILITY AND FLOW TESTS ARE VERY SIMPLE TO PERFORM AND ARE DETERMINED SIMULTANEOUSLY DURING A PROCEDURE WHICH TAKES ONLY A FEW SECONDS TO RUN. THE SPECIMEN IS MOUNTED ON ITS SIDE AND IS LOADED TO FAILURE THROUGH CURVED BEARING HEADS WHICH CONFORM TO THE CURVATURE OF THE SPECIMEN. THE LOAD IS APPLIED AT THE RATE OF TWO INCHES/MINUTE. THE SPECIMEN IS CONDITIONED TO 140°F FOR THE TEST. A NUMBER OF TESTING MACHINES ARE AVAILABLE FOR APPLYING THE LOAD. THEY RANGE FROM MORE SIMPLE VERSIONS WHICH USE A PROVING RING FOR READING LOAD TO THOSE WHICH USE ELECTRONIC LOAD CELLS FOR AUTOMATICALLY PLOTTING LOAD SPECIMEN DEFLECTION.

THIS IS WHAT A TYPICAL PLOT OF APPLIED LOAD AND SPECIMEN DEFLECTION LOOKS LIKE. THIS PLOT ALLOWS A GRAPHICAL DEFINITION OF MARSHALL STABILITY AND FLOW. THE MARSHALL STABILITY IS THE

PEAK LOAD ATTAINED PRIOR TO FAILURE, IN THE UNITS OF POUNDS. THE MARSHALL FLOW IS THE AMOUNT OF SPECIMEN DEFLECTION WHICH OCCURS BETWEEN THE ZERO AND PEAK LOADS, MEASURED IN INCREMENTS OF 1/100 OF AN INCH.

WHEN WE DETERMINED TO EVALUATE THE POSSIBILITY OF USING MARSHALL TESTS, WE DECIDED THAT WE SHOULD RETAIN OUR CURRENT SPECIMEN COMPACTION METHODS. THEREFORE, WE ARE USING SPECIMENS WHICH ARE GYRATORY-COMPACTED AND ARE 2 INCHES IN HEIGHT. MARSHALL PROCEDURES CALL FOR DROP-HAMMER COMPACTION AND 2 1/2 INCH HIGH SPECIMENS. WE BELIEVE, AND WE HAVE HEARD IT EXPRESSED AT THE NATIONAL LEVEL, THAT GYRATORY OR SIMILAR METHODS OF COMPACTION MORE CLOSELY SIMULATE ROADWAY COMPACTION. THE USE OF GYRATORY COMPACTION IS A VERY SIGNIFICANT DEVIATION FROM THE PROCEDURES USED BY OTHER GOVERNMENTAL BODIES USING THE MARSHALL TESTS. TEST RESULTS ARE MOST CERTAINLY AFFECTED, AS YOU WILL SEE A LITTLE LATER.

LET ME HIGHLIGHT OUR WORK PLAN FOR EVALUATING THE MARSHALL METHOD IN TEXAS. WE HAVE, AT THIS POINT, JUST GOTTEN A GOOD START ON THIS WORK. WE'VE BEEN AS BUSY AS YOU HAVE THIS YEAR, AND GETTING TO SPECIAL PROJECT WORK HAS BEEN A CHALLENGE. I HAVE TO GIVE OSCAR RODRIGUEZ, AND UP-AND-COMING YOUNG ENGINEER IN MY SECTION, MOST OF THE CREDIT FOR THE PROGRESS THAT WE'VE MADE. WE HAVE LOOKED AT SENSITIVITY AND REPEATABILITY IN OUR CENTRAL LAB, AND WE HAVE BEEN WORKING WITH SEVERAL VOLUNTEER DISTRICTS WHO HAVE BEEN RUNNING THE MARSHALL TESTS ALONG WITH

THE HVEEM TESTS REQUIRED BY OUR SPECIFICATIONS. LET'S LOOK AT RESULTS FROM SOME OF OUR WORK REGARDING THE TEST'S SENSITIVITY AND REPEATABILITY FIRST. THEN WE'LL REVIEW WHAT HAS COME OUT OF A COUPLE OF THE FIELD TRIALS.

REPEATABILITY HAS BEEN A REAL CONCERN TO US FROM THE BEGINNING. WE NOTED THAT ASTM AND AASHTO DO NOT INCLUDE PRECISION STATEMENTS IN THEIR PROCEDURES. (I HAVE HEARD THAT THE REASON FOR THIS IS THAT REPEATABILITY IS RATHER POOR.) OUR CONCERN WITH REPEATABILITY WAS ONE OF THE REASONS THAT WE DECIDED TO CONTINUE TO USE OUR CURRENT COMPACTION EQUIPMENT. IT IS OUR HOPE THAT REPEATABILITY MAY BE SIGNIFICANTLY IMPROVED BY ELIMINATING VARIABILITY RESULTING FROM DROP-HAMMER COMPACTION. THE RESULTS SHOWN HERE SHOW A SINGLE-LABORATORY, MULTI-OPERATOR STANDARD DEVIATION OF 118 POUNDS. THIS DATA INDICATES A REASONABLE REPEATABILITY, BUT NOT AS GOOD AS WE HAD HOPED. FOR COMPARISON PURPOSES, IT HAS BEEN NOTED THAT THE MULTI-LABORATORY STANDARD DEVIATIONS FOUND BY AMRL DURING THEIR REFERENCE SAMPLE TESTING PROGRAM RUN BETWEEN 300 AND 400 POUNDS. SO IT APPEARS TO ME THAT THE DECISION TO STAY WITH OUR COMPACTION EQUIPMENT PROBABLY HELPED A LITTLE BIT. BY THE WAY, THE TECHNICIANS ARE LISTED IN ORDER OF EXPERIENCE, FROM MOST EXPERIENCE TO LEAST.

THIS PLOT SHOWS THE AMOUNT OF DIFFERENCE IN MARSHALL STABILITY WHICH RESULTS FROM OUR CHOICE TO USE GYRATORY-COMPACTED SPECIMENS OF 2 INCHES. I WAS SURPRISED TO SEE THIS DEGREE OF DIFFERENCE. MY GUESS WOULD HAVE BEEN THAT GYRATORY-COMPACTION

MIGHT HAVE COMPENSATED SOMEWHAT FOR THE DIFFERENCE IN SPECIMEN HEIGHT. NEVERTHELESS, IT IS IMPORTANT TO NOTE THAT USING OUR CURRENT SPECIMEN COMPACTION PROCEDURES GIVES CONSIDERABLY LOWER VALUES FOR A GIVEN MIXTURE. THEREFORE, ACCEPTABILITY VALUES WHICH MAY BE FOUND IN THE SPECIFICATIONS OF OTHERS ARE NOT APPLICABLE FOR OUR TESTS. SHOULD WE DETERMINE TO INSTITUTE A REQUIREMENT, WE WILL BE FORCED TO DEVELOP OUR OWN. THIS IS THE DRAWBACK WHICH WE WILL HAVE TO ACCEPT IF WE DECIDE TO INCORPORATE MARSHALL WITHOUT GOING WITH ITS COMPACTION METHODS.

ON THE OTHER HAND, OUR MARSHALL FLOW VALUES RUN HIGHER THAN VALUES FROM LARGER SPECIMENS PREPARED WITH A DROP-HAMMER.

LET'S LOOK AT HOW VARIATIONS IN THE ASPHALT CONTENT MIGHT AFFECT MARSHALL STABILITY VALUES. WE HAVE ONLY LOOKED AT TWO MIXTURE DESIGNS AT THIS POINT, ONE WITH LOW MARSHALL STABILITY AND ONE WITH RATHER HIGH VALUES. UNFORTUNATELY, WE FAILED TO OBTAIN A GOOD CONTROL MARSHALL STABILITY FOR THE PROJECT 2 MATERIAL. IN THE CASE OF THE LOWER STABILITY MIXTURE, INCREASES IN ASPHALT CONTENT RESULTED IN INCREASED MARSHALL STABILITY. INCREASES IN ASPHALT IN THE PROJECT 2 MIXTURE HAD LITTLE EFFECT ON STABILITY. I WILL NOT BE SURPRISED IF WE ALSO FIND THAT SOME MIXTURES WILL DECREASE IN MARSHALL STABILITY WITH INCREASED ASPHALT, SIMILARLY TO WHAT MOST OFTEN OCCURS WITH HVEEM STABILITY. PERHAPS IT JUST TAKES SOME GETTING USED TO, BUT IT BOTHERS ME THAT MARSHALL STABILITY CAN GO UP WHEN I FEEL THAT THE MIXTURE IS GETTING CLOSER TO FLUSHING AND RUTTING.

THIS IS A DEMONSTRATION OF MARSHALL STABILITY'S SENSITIVITY TO THE BINDER QUALITIES. THE SECOND THING THAT I MIGHT POINT OUT IS THAT ALMOST WITHOUT EXCEPTION, AN INCREASED MARSHALL STABILITY CORRESPONDS TO A DECREASED HVEEM STABILITY VALUE FOR THE GIVEN SAMPLE.

THIS IS THE SECOND FIELD TRIAL PROJECT THAT I WANTED TO SHOW TODAY. THE NOTEWORTHY ITEM HERE IS THAT THE HVEEM STABILITY PICKED UP A SIGNIFICANT CHANGE IN THE MIX DURING THE LAST COUPLE OF DAYS OF PRODUCTION. THE EXTRACTION TEST SHOWED AN INCREASE OF FOUR-TENTHS OF A PERCENT ASPHALT, AND THE LAB DENSITY INCREASED FROM ABOUT 97.6 TO 98.7. THE MARSHALL STABILITY SHOWED A SLIGHT DOWNTURN, BUT NOT UNCHARACTERISTIC OF THE VALUES BEING OBTAINED OVER THE DURATION OF THE JOB. THE HVEEM STABILITY REACTED TO THE CHANGES IN THE MIXTURE BY DIPPING SLIGHTLY BELOW THE SPECIFIED MINIMUM VALUE.

WHERE DO WE GO FROM HERE?

THE INFORMATION THAT WE HAVE GATHERED SO FAR IS CERTAINLY NOT CONCLUSIVE. IT APPEARS THAT THE MARSHALL'S REPEATABILITY MAY BE ADEQUATE, BUT ITS SENSITIVITY TO POTENTIALLY DETRIMENTAL CHANGES IN THE MIXTURE REMAINS THE KEY QUESTION. OUR WORK THIS WINTER WILL FOCUS PRIMARILY ON THIS QUESTION. SHOULD OUR FINDINGS BE THAT THE MARSHALL TESTS ARE SUITABLE FOR JOB CONTROL TESTING PURPOSES, IT WOULD BE OUR RECOMMENDATION THAT THE SPECIFICATIONS BE REVISED TO ALLOW THEIR OPTIONAL USE IN LIEU OF DAILY

WE ALSO TOOK THE SAME TWO PLANT-PRODUCED MIXTURES AND ADDED TO THEM 5 AND 10 PERCENT CRUSHED STONE SCREENINGS. THE ASPHALT CONTENT PERCENTAGE WAS MAINTAINED CONSTANT BY THE ADDITION OF A SMALL AMOUNT OF ASPHALT CEMENT. IN BOTH CASES, THE ADDITION OF SCREENINGS INCREASED MARSHALL STABILITY VALUES. THIS WAS MOST PRONOUNCED IN THE LOWER STABILITY MIXTURES.

WE DID THE SAME THING WITH THE FIELD SAND BEING USED. INCREASING THE PERCENTAGE OF FIELD SAND IN THE LOWER STABILITY MIXTURE DID NOT HAVE A SIGNIFICANT AFFECT. THE HIGHER MARSHALL STABILITY MIXTURE DROPPED OFF IN STABILITY WITH THE INCREASE IN FIELD SAND.

AT THE SAME TIME THAT WE WERE DOING SENSITIVITY WORK IN OUR LABORATORY, SEVERAL DISTRICTS WERE DOUBLING UP ON TEST SPECIMEN MOLDING ON SEVERAL PROJECTS SO THAT HVEEM STABILITY AND MARSHALL VALUES COULD BOTH BE MONITORED. HERE YOU CAN SEE HOW THE TWO COMPARED ON A DAY-TO-DAY BASIS ON PROJECT 7. A COUPLE OF THINGS THAT MAY BE WORTH MENTIONING. DURING THE FIRST HALF OF THE JOB THE MAT WAS SEEN TO STAY SOMEWHAT TENDER, TURNING VEHICLES TENDED TO MARK IT. IT WAS NOT PARTICULARLY TENDER DURING COMPACTION, HOWEVER. THE SECOND HALF OF THE JOB WAS DONE WITH AN AC-20 INSTEAD OF AC-10, AND THE MAT DID NOT SEEM TO BE AS TENDER DURING THE FIRST SEVERAL DAYS AFTER PLACEMENT. THE AVERAGE ASPHALT CONTENTS, LAB DENSITIES, AND HVEEM STABILITIES ACHIEVED DURING THE SECOND HALF OF THE JOB WERE VIRTUALLY IDENTICAL TO THOSE OF THE FIRST HALF. BUT, THE MARSHALL STABILITY INDICATED A 200 POUND, OR 17%, INCREASE WITH THE HIGHER VISCOSITY ASPHALT.

HVEEM STABILITIES. HVEEM STABILITY WOULD STILL BE USED FOR OUR MIXTURE DESIGNS, AND OCCASIONAL FIELD SAMPLES WOULD STILL BE REQUIRED.

A FEW SUMMARIZING THOUGHTS.

OUR JOB CONTROL SET OF TESTS CURRENTLY INCLUDES EXTRACTION, MOLDED DENSITY, AND HVEEM STABILITY. THE EXTRACTION TEST GIVES US A LOOK AT THE AGGREGATE GRADATION AND THE ASPHALT CONTENT (HOW CLOSE ARE WE TO THE MIXTURE DESIGN). THE MOLDED DENSITY IS AN IMPORTANT ESTIMATE OF HOW DENSE THE PAVEMENT MAY BECOME UNDER SEVERAL YEARS OF TRAFFIC. AND THE HVEEM STABILITY INDICATES TO US IF THE FRICTIONAL CHARACTERISTICS OF THE AGGREGATE WILL BE ADEQUATE AT THE GIVEN ASPHALT CONTENT SHOULD THE PAVEMENT BECOME AS DENSE AS THE LABORATORY MOLD. ONE OF THE MOST IMPORTANT THINGS THAT HVEEM STABILITY DOES FOR US IS TELLS US WHEN WE ARE APPROACHING AN OVER-ASPHALTED CONDITION. THIS MAY BE CAUSED BY DECREASED ASPHALT ABSORPTION OR A CHANGE IN AGGREGATE GRADATION JUST AS WELL AS BY THE SIMPLE OVERDOSING WITH ASPHALT. OVERDOSING OF ASPHALT WE WILL CATCH WITH OUR EXTRACTION. A CHANGE IN ASPHALT ABSORPTION, OR A DECREASE IN VMA CAUSED BY A SUBTLE SHIFT IN GRADATION, MAY NOT BE PICKED UP CLEARLY BY ANYTHING EXCEPT THE HVEEM STABILITY. THEREIN LIES THE VALUE OF HVEEM STABILITY. IF THE MARSHALL STABILITY CAN INDICATE TO US WHEN THESE THINGS ARE OCCURRING IN PRODUCTION, THEN WE WILL BE ABLE TO BENEFIT FROM THE PORTABILITY OF EQUIPMENT AND THE TIMELY RESULTS WHICH THIS TEST MAKES POSSIBLE. IF IT

CAN NOT IDENTIFY WHEN THESE CONDITIONS ARE OCCURRING, THEN WE WILL BE BETTER OFF WITH SOMEWHAT DELAYED BUT MORE INFORMATIVE HVEEM RESULTS.

REGARDLESS OF THE OUTCOME OF THIS STUDY, IT WILL REMAIN OUR GOAL TO IMPROVE OUR SPECIFICATIONS AND PROCEDURES AT EVERY OPPORTUNITY.