UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

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Illinois Division
3250 Executive Park Drive
Springfield, IL 62703

Subject: Quarterly progress in the project DTFH61-02-X-00029 between December 02, 2002 – April 02, 2003

Dear Mr. Choudry:

Significant progress has been made on several tasks in the FHWA research study entitled "Investigation of Aggregate Shape Effects on Hot Mix Performance Using an Image Analysis Approach," since the project started almost a year ago. This is a 2-year pool-funded research project having as the participants the following states: Alabama, Georgia, Indiana, Minnesota, Mississippi, Missouri, Montana, and South Carolina, and the Central Federal Lands and Highways Division. This letter is intended to provide information on the quarterly research progress to the FHWA project administrator and the project monitor, the FHWA Illinois Division, for the period of December 02, 2002 – April 02, 2003.

Enclosed in Appendix 4, you will find a progress chart detailing the 2 phases of the project, various task items to be accomplished in each phase, and the corresponding timelines scheduled for the successful completion of the project. Progress will be described based on each phase and the individual task items in each phase as indicated in the chart.

PHASE I: Evaluation of Shape and Size Properties and Validation of the UIAIA

Work Items of Phase I

(1) Acquisition of NCAT Aggregate (March, 2002);

(2) Acquisition of Aggregate Samples from the Participating States (March 2002 – May 2002);

(3) Testing of Participating States' Aggregate Samples with UIAIA (March 2002 – March 2003);

(4) Testing of NCAT Aggregate Samples with UIAIA (May 2002 – May 2003);

(5) Image Processing for Shape Indices (August 2002 – August 2003).

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Progress to Date in Phase I

Items (1) "Acquisition of NCAT Aggregate" and (2) "Acquisition of Aggregate Samples from the Participating States" have been completed. So far, all the aggregate samples requested have arrived. As per the research scope of this project, of all the aggregate samples received, 14 coarse aggregate (retained on No.4 square opening sieve) samples from the National Center for Asphalt Technology (NCAT) and 44 coarse aggregate samples from the participating states were selected as representatives for testing and image processing with the University of Illinois Aggregate Image Analyzer (UIAIA). As requested, coarse aggregate samples received are both light in color and sufficient for image testing and mixture design. For detailed information about the aggregate samples, please see Appendix 1 for aggregate samples from NCAT and Appendix 2 for aggregate samples from the participating states.

Item (3) "Testing of NCAT Aggregate Samples with the UIAIA" has been completed ahead of time. Depending on the average sizes and gradation results, anywhere from 300 to 2500 particles were selected for testing to establish a representative bag sample for each material. For materials having mainly smaller particles, a larger number of particles was typically needed to have anywhere from half a kilogram to 2 kilograms of aggregate by weight. Each aggregate sample was processed through the UIAIA system at least twice to verify the repeatability of the results. Only two of the samples had slightly darker particles, which could not be properly detected by the cameras and therefore were not image processed. In total, images of 15,000 particles from 14 samples were acquired and properly documented for image processing to later obtain their shape indices.

Item (4) "Testing of Participating States' Aggregate Samples with the UIAIA" has been completed ahead of the scheduled time (March, 2003). Out of the 44 selected coarse aggregate samples listed in Appendix 2, 5 samples were identified as too dark to be recognized by cameras of the UIAIA system and therefore could not be processed. So far, a total of 40,000 images have been acquired from the 39 aggregate samples and properly documented for image processing to obtain their shape indices. Note that more materials have been requested from Indiana and Mississippi as stated in the previous progress report. As these materials are expected to arrive soon, there will be additional image acquisition and processing to be conducted on these aggregate samples.

Item (5) "Image Processing for Shape Indices" is currently underway. For the images of the NCAT samples, both the image processing part and the analyses of shape indices for volume and weight (using specific gravities), flat and elongated ratio, angularity, gradation have been completed. The image processing and corresponding analyses of shape indices have also been completed for the acquired images of the 39 aggregate samples from the participating states. Surface texture analyses of all the aggregates, however, are still in progress due to the current research being focused on the finalizing the development of the imaging based surface texture index.

Phase I of this study is about finished for all the 39-image analysis suitable light colored aggregates out of the 44 so far received from the participating states. These aggregates have also been processed for most of the imaging based indices with the exception of surface texture index analysis. To be complete in the research study, we are still in need of more aggregates, materials and information for asphalt mixes and mixture designs as shown in Appendix 2. We have contacted Mississippi and Indiana for additional aggregates, mixture designs, and related materials. Further, we also contacted several other states listed in Appendix 2 for obtaining the missing mixture design information. In summary, the remaining Phase I research activities currently focus on obtaining all the missing information and materials from the participating states, processing of the newly arriving coarse aggregate materials using the UIAIA, and processing of the available and newly arriving aggregates for the imaging based indices.

PHASE II: Evaluation of the Shape and Size Effects on Hot Mix Performance

Work Items of Phase II

(1) Preparation and Laboratory Testing of Asphalt Samples;

(2) NCAT Performance Data Collection;

(3) Laboratory and Field Data Analysis;

(4) Report Preparation.

Progress to Date in Phase II

Phase II of the research study involving laboratory asphalt sample preparation and testing is currently underway at our Advanced Transportation Research and Engineering Laboratory (ATREL) in Rantoul, Illinois. As of April 2003, in accordance with the project timetable (see Appendix 4), we have made progress in task item (1) "Preparation and Laboratory testing of Asphalt Samples." Appendix 3 lists asphalt mixture designs received from the participating states and the asphalt mix specimen preparation and testing progress in the laboratory. So far, out of the 10 participating states, we have received a total of 3 complete sets of mix designs from Federal Lands and Highways Division (NM mix), Federal Lands and Highways Division (OK mix), and Montana ("Design 2"). As also indicated in Appendix 3, we have made 3 gyratory specimens for each of these mix designs in the laboratory. We are now in the process of finalizing test procedures for performance testing. We will very soon start testing of these mixes for resilient modulus and permanent deformation properties.

Many of the states that include Montana ("Design 1"), Minnesota (2 designs), Mississippi (1 design) and Missouri (3 designs) did not report the mixing and compaction temperatures needed for Superpave gyratory specimen preparation. We are in the process of contacting these states to obtain the missing temperature information before we can make asphalt specimens in the laboratory. In addition, we need to obtain more materials and mixture designs from South Carolina (asphalt binder and mixture designs), Indiana (both aggregate and asphalt binder), and Georgia (mixture designs) as indicated in Appendix 2. Further, three of the Alabama NCAT mix designs contain up to 3 of the image processed coarse aggregates in each mix. We are in the process of requesting related materials (asphalt binder and mixture designs) for making gyratory specimens for these Alabama NCAT mixes in the laboratory.

Asphalt mix samples are prepared in the laboratory for resilient modulus and performance testing strictly following the four major testing and analysis steps of the Superpave mixture design procedure:

(a) Selection of materials (aggregate, binders, modifiers, etc.);
(b) Selection of a design aggregate structure;
(c) Selection of the optimum design asphalt binder content;
(d) Evaluation of moisture sensitivity of the design asphalt mixture using AASHTO T283.

Note that the selections mentioned in these steps were already made and presented to us by the participating states for the 10-job mix formulas received so far. For correlating better the laboratory testing results to mix performances from NCAT track test, a typical 7% field air void content was specified as the target air voids content for compacting asphalt specimens in the laboratory. After preparing the samples, resilient modulus and permanent deformation (rutting) tests will be conducted on the specimens. We are currently finalizing the selection of the appropriate test procedures following the AASHTO and recent Superpave recommendations.

The imaging based aggregate shape factors determined in Phase I will eventually be used to quantify the influences of particle shape on asphalt concrete mix performances and establish proper aggregate criteria. For the Phase II work item "(2) NCAT Performance Data Collection," a recent NCAT study report (No. 2002-12, November 2002) has been obtained on "NCAT Test Track Design, Construction, and Performance." This report is presently studied for field performance data fro. Other Phase II work items (3), and (4) have not yet started in accordance with the timetable shown in Appendix 4.

We will soon have to decide on a meeting date, possibly in June or early July 2003, to organize a project progress meeting as suggested in the time table in Appendix 4. This meeting to be held in the campus of University of Illinois will further give a chance to the project monitor(s) and the representatives of all the participant states to evaluate the progress made in this pool-funded study.

I am happy report to you that we are on time with the scheduled tasks and making good progress in the project. Should you have any questions, you can always contact me at (217) 333-8637 or send e-mail to tutumlue@uiuc.edu.

Sincerely,

Erol Tutumluer, Ph.D.
Associate Professor of Civil Engineering

Appendix 1. Aggregate Samples from NCAT

STATE	AGGREGATES	TYPE
Alabama	***Calera 67***	Gravel
	Calera 7	Granite
	Calera 821	Limestone
	Calera 822	Limestone
	Calera 89	Gravel
	Calera 892	Limestone
	Jemison 1/2 Crushed gravel	Gravel
	Jemison 3/8 crushed gravel	Gravel
	Jemison Concrete sand	Sand
	Summit sandstone 8	Sandstone
	Summit sandstone sand	Sand
	Gadsden slag 78	Slag
	Gadsden slag 8910	Slag
Indiana	Indiana 1	limestone
Georgia	***Columbus 6***	Granite
	Columbus 7	Granite
	Columbus 89	Granite
	Columbus M10	Granite
	Columbus W10	Granite
	Lithia springs 7	Granite
	Lithia springs 89	Granite
Mississippi	***Blain 1/2 crushed gravel***	Gravel
	Blain 3/4 crushed gravel	Gravel
	Blain coarse sand	Sand
	Blain 3/8 crushed gravel	Gravel
	Falco agricultural lime	Limestone
South Carolina	Blacksburg regular screens	Granite
	Blacksburg 67	Granite
	Blacksburg 78M	Granite
	Blacksburg manufactured sand	Sand
	Gray court #10 manufactured sand	Sand
	Gray court 6M	Granite
	Gray court 789	Granite
	Gray court regular screenings	Granite

Note: Samples in bold are the selected coarse aggregate samples for image analysis. For the NCAT aggregate samples, image testing and processing for shape indices have been completed.

Appendix 2. Materials and Mixture Designs from the Participating States

State No.	State	Mix No.
1	**Federal Lands and Highways Division (NM)**	1 mix
	**** 7/8" Rock***	
	**** Coarse Aggregate***	
	**** Intermediate Aggregate***	
	Asphalt Binder P6 58-34 (2)	
	Crushed Fines	
	Hydrated Lime	
2	**Federal Lands and Highways Division (OK)**	1 mix
	**** 1" Rock***	
	**** 1/2" Rock***	
	Screenings	
	P6 70-28 Asphalt (2)	
	Sand	
	Stone Sand	
3	**Minnesota**	2 mixes
	Maple Grove Mix	
	Meridian St. Cloud 3/4" Unwashed Sand	
	Meridian St. Cloud CA-50	
	Meridian St. Cloud FA-3	
	Barton Elk River #1 Washed Sand	
	Kraemer Burnsville Washed Sand	
	Meridian Washed Sand	
	Red Rock Mix	
	**** Barton Denmark BA-2***	
	****Kraemer Burnsville 9/16" Chip***	
	****Kraemer Burnsville Class 2***	
	Camas "Shiely" West Lakeland Washed Sand	
	Camas Nelson Man. Sand (Class D)	
	Mn/DOT 58-28 AC	
4	**Mississippi**	1 mix
	Dickerson Bowen Madison Mix	
	****Crushed Gravel (4 bags)***	
	****Crushed Limestone (2 bags)***	
	Agricultural Limestone	
	Asphalt Binder	
	Coarse Sand	
	Hydrated Lime	

5	**Missouri**	3 mixes
	Brickey's Mix	
	**** Brickeys 1"***	
	**** Brickeys 1/2"***	
	**** Brickeys 3/4"***	
	*** Brickeys 3/8"**	
	Burlington Mix	
	****1/2" Burlington***	
	**** 3/4" Joornagan, Joe Howard Qy***	
	****1/4" Chips Tower Rock***	
	1/2" Base	
	Clean Mix	
	****1 1/2" Clean Stone***	
	****1/2" Clean Stone***	
	****3/4" Clean Stone***	
	LOF	
	Man. Sand	
	MOR Life	
	PG 64-22 Asphalt	
	Screenings	
	TRSG Man. Sand	
6	**South Carolina**	N/A
	**** Blacksburg 67 (NCAT)***	
	**** Blacksburg 78M (NCAT)***	
	**** Gray Court 6M (NCAT)***	
	**** Gray Court 789***	
	**** Marlboro 67***	
	**** Marlboro 789***	
	Blacksburg Man. Sand	
	Blacksburg Regular Screening	
	Gray Court Regular Screenings	
7	**Georgia**	N/A
	HMA 12 coarse aggregate	
	****Lithia Springs***	
	****Handson and Candler Coarse aggregate***	
	M10 W10 Lime (binder)	
	Fine aggregate liquid AC lime (binder)	
	Binder	

8	**Indiana**	1 mix
	**** Indiana 1***	
9	**Alabama**	N/A
	**** Calera 7 (NCAT)***	
	**** Calera 89 (NCAT)***	
	**** Columbus 7 Granite 7 (NCAT)***	
	**** Jemison 1/2 crushed gravel (NCAT)***	
	**** Jemison 3/8 crushed gravel***	
	**** Summit sandstone 8 (NCAT)***	
	Calera 821	
	Calera 892	
	Columbus 89 Granite 89	
	Columbus M10 granite M10	
	Columbus W10 Granite W10	
	Jemison concrete sand natural sand	
	Summit sandstone sand	
10	**Montana**	2 mixes
	Crushed Fines	
	Washed Crushed Fines	
	****3/8 Inch Chips***	
	****Coarse Aggregate***	
	Fines	
	****Intermediate Aggregate***	
	****Coarse Aggregate***	
	Asphalt Binder	

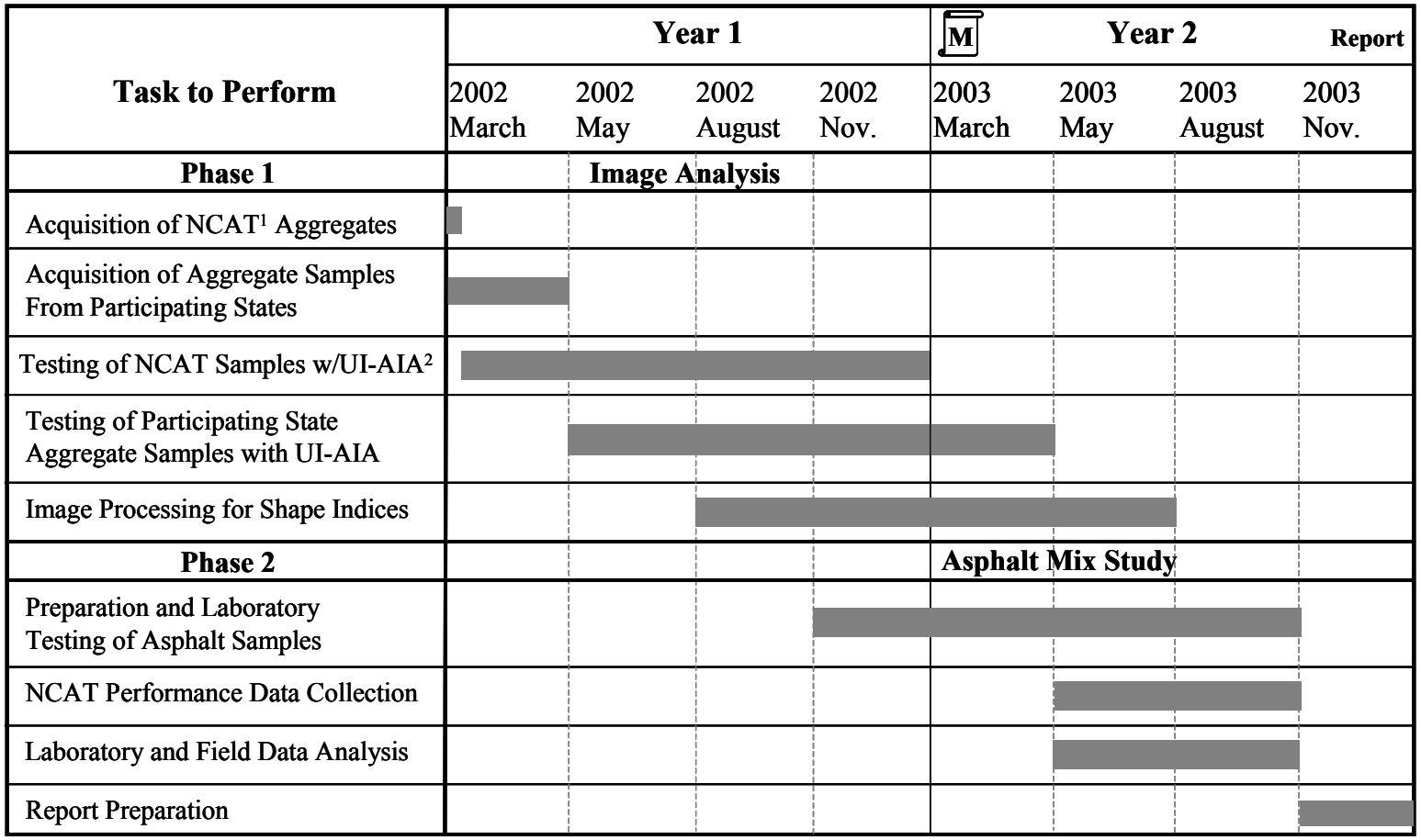
Notes: Samples in bold are selected as coarse aggregate samples.

Image testing and processing for samples beginning with a star have been completed.

Appendix 3. Progress In the Asphalt Testing Laboratory Study

Mixture Designs	ATREL Laboratory Research Progress		
	Gyratory Mix Preparation (3 specimens)	**Resilient Modulus Testing**	**Permanent Deformation Testing**
Federal Lands and Highways Division (NM)	Completed		
Federal Lands and Highways Division (OK)	Completed		
Minnesota Design 1			
Minnesota Design 2	Completed		
Mississippi			
Missouri Design 1			
Missouri Design 2			
Missouri Design 3			
South Carolina			
Georgia			
Indiana			
Alabama			
Montana Design 1			
Montana Design 2			

Appendix 4. Timetable for the Pooled Fund Study on
"Investigation of Aggregate Shape Effects on Hot Mix Performance Using An Image Analysis Approach"



M : Proposed meeting schedule to discuss research progress and results

[1]: National Center for Asphalt Technology pavement test track facility

[2]: University of Illinois Aggregate Image Analyzer