

**State of Wisconsin/Department of Transportation**  
 RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: September 30, 2006

<b>Program: SPR-0010(36) FFY99</b>	<b>Part: II Research and Development</b>
<b>Project Title:</b> Field Validation of Wisconsin Modified Binder Selection Guidelines	<b>Project ID:</b> 0092-03-13
<b>Administrative Contact:</b> James McDonnell	<b>Sponsor:</b> WHRP
<b>WisDOT Technical Contact:</b> Len Makowski	<b>Approved Starting Date:</b> Jan 31, 2003
<b>Approved by COR/Steering Committee:</b> \$125,006.00	<b>Approved Ending Date:</b> Jul 31, 2007
<b>Project Investigator (agency &amp; contact):</b> Hussain Bahia, UW Madison	

**Percent Complete: 76 %**

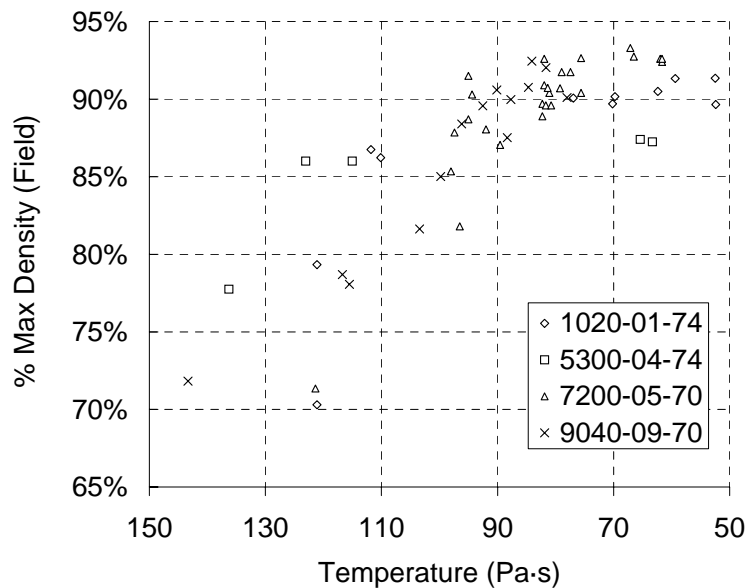
**Project Description:** The study will be conducted over 48 months, and be completed in 5 phases:

- Task 1: Select Field Section and Define Grades to be Compared
- Task 2: Collect Samples and Conduct Testing
- Task 3: Monitor Performance of Sections
- Task 4: Database Development
- Task 5: Reporting

**Progress This Quarter:**

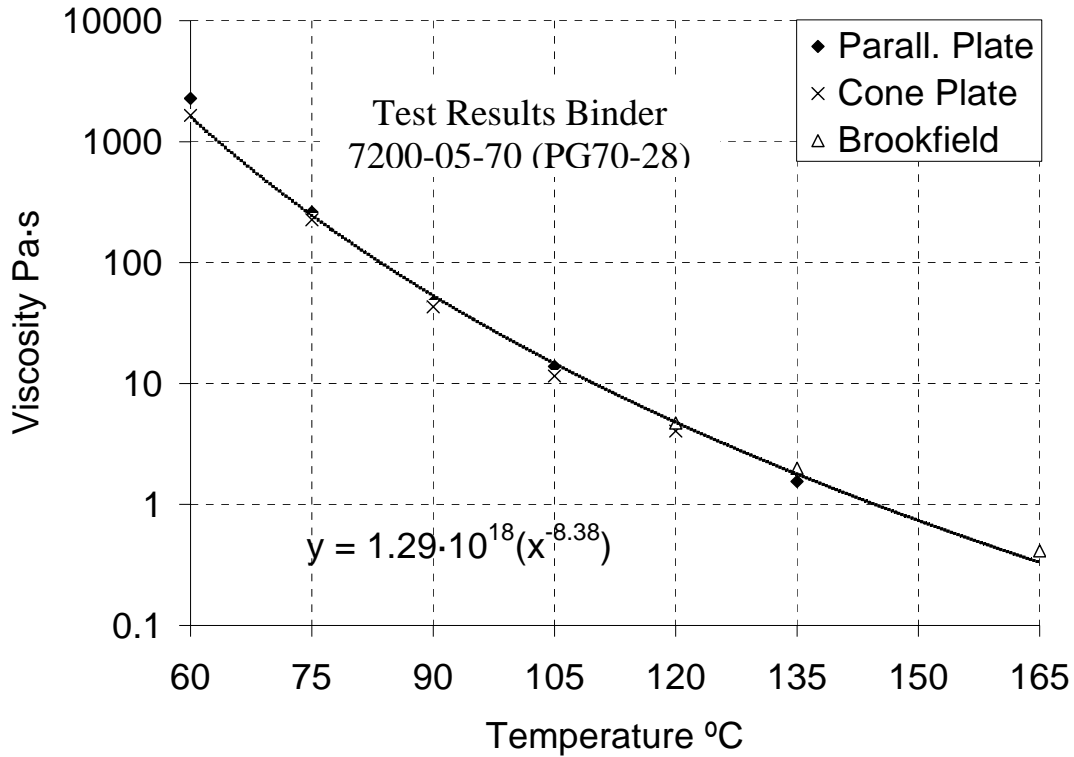
Testing

The research team decided to go one step further into the validation of compaction temperatures for asphalt mixtures. The previous work included laboratory compaction from about 150°C until 90°C. It was concluded that varying the temperature in this range did not have any significant effect in the densification curves during the laboratory compaction. The results and statistical analysis were presented in the previous report. Considering that densification in the field continued for temperatures even below 80°C, two more temperatures were added to the laboratory study: 75°C and 60°C. Figure 1 shows the field data for the four studied projects, with the % Maximum density versus temperature.



**FIGURE 1 Field Density v/s Temperature, All Projects**

The field data indicated that there is a limit temperature, under which no more compaction can be achieved, even when more roller passes are added. The limit temperature varies, depending on the binder viscosity. So, in order to establish criteria based on material properties, the binder viscosities in the 60°C – 90°C range had to be determined. The dynamic shear rheometer DSR was used for this purpose, considering two geometries: cone and plate and parallel plate. The results of both geometries showed good agreement. Also good agreement was found with the results of the Brookfield viscometer. Figure 2 shows the binder viscosities for all four binders.

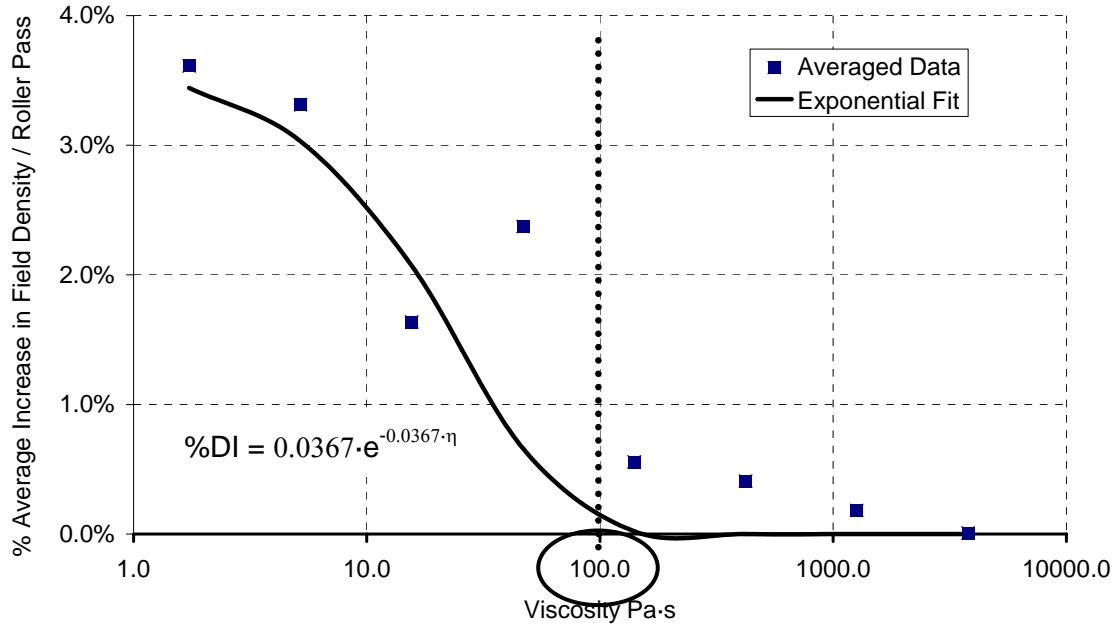


Temperature (T) °C	Fitted Viscosities ( $\eta$ ) Pa·s			
	9040-09-70 (PG58-34) $\eta = 1.43 \cdot 10^{15} \cdot T^{-7.31}$	5300-04-74 (PG64-28) $\eta = 1.09 \cdot 10^{17} \cdot T^{-8.08}$	1020-0174 (PG70-28) $\eta = 2.12 \cdot 10^{18} \cdot T^{-8.55}$	7200-05-70 (PG70-28) $\eta = 1.29 \cdot 10^{18} \cdot T^{-8.38}$
60	144	468	1328	1621
75	28	77	197	250
90	7.4	18	41	54
105	2.4	5.1	11	15
120	0.90	1.7	3.5	4.9
135	0.38	0.67	1.3	1.8
150	0.18	0.28	0.53	0.75
165	0.09	0.13	0.23	0.34

**FIGURE 2 Fitted Viscosities for All Binders**



After determining the binder viscosities, the field data was plotted against viscosity instead of temperature in Figure 3. This plot reflects the average increase in density per roller pass, for the four projects, in each viscosity range. It can be seen that when the viscosity of the binders is below 100 Pa, the increase in density per roller pass is in the range of 1.5% to 3.5%. However, when the viscosity is higher than 100 Pa, the % increase in density per roller pass decreases to levels below 0.5%.



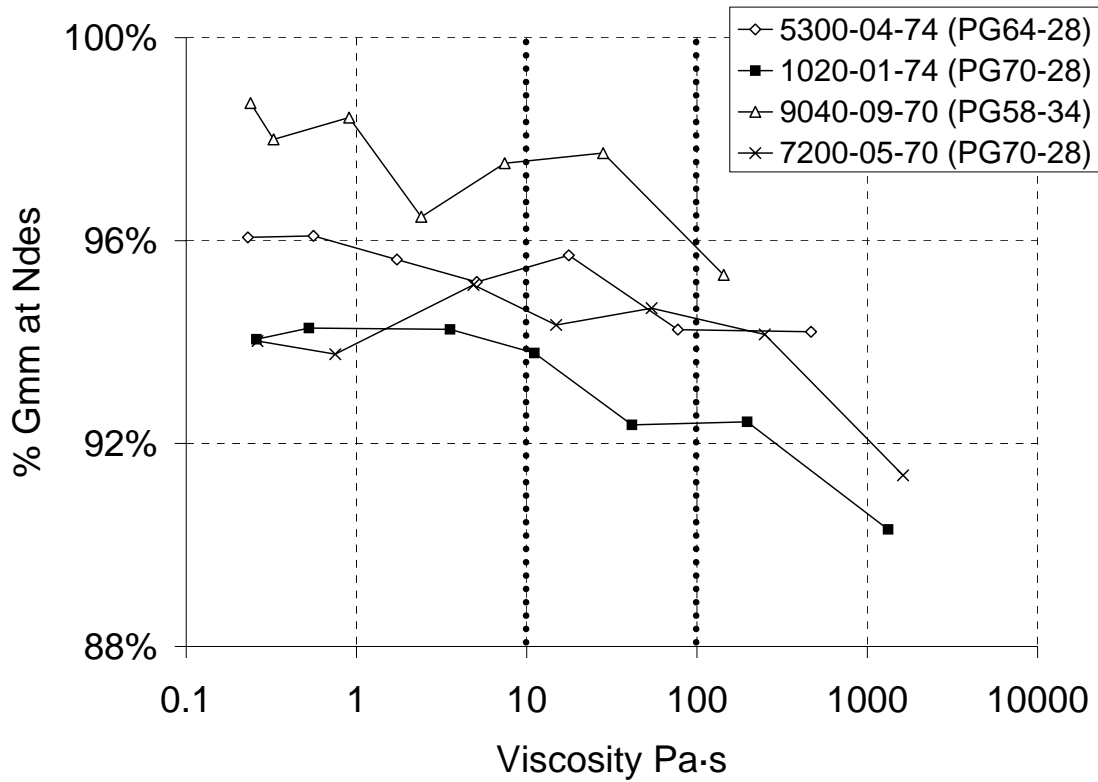
**FIGURE 3 % Density Increase (%DI) versus Binder Viscosity (Field Data)**

The field densification data versus viscosity was then contrasted with the laboratory compaction results using the two new temperatures of 75°C and 90°C. The laboratory data also indicated that when the viscosity increased above certain limit, the densification was affected. Figure 4 shows the %Gmm at Ndes in terms of the binder viscosity for the four projects.

For three of the projects, there was a significant decrease in %Gmm at Ndes when in the 10 Pa·s – 100 Pa·s range. For one of the projects (7200-05-70, PG70-28) the densification only was affected above 100 Pa·s. In order to recommend a viscosity limit for compaction, the temperature limits were calculated using three different viscosities: 10 Pa·s, 100 Pa·s and an intermediate value of 50 Pa·s. The resulting temperatures using these three viscosity values are shown in table 1 for the four projects.

By comparing the different temperature limits from Table 1 with the field compaction data from Figures 1 and 3, the following conclusions were obtained:

- The viscosity limit of 10 Pa·s seem to be too conservative, since it specifies a lower temperature limit for compaction equal to 110 °C for project 7200-05-70 (PG70-28). The field data from table 2 indicates that the breakdown compaction for project 7200-05-70 started around 100°C and adequate compaction was achieved at this range.
- The viscosity limit of 100 Pa·s gives reasonable temperatures for three of the projects, but would result in a temperature limit of 63°C for project 9040-09-70 (PG58-34) which seem too low and somewhat unrealistic.
- An intermediate value of **50 Pa·s seem to be a reasonable choice**. The temperature limits for the four projects obtained based on 50 Pa·s are still high compared with the field data, which makes this number a conservative choice.



**FIGURE 4 %Gmm at Ndes versus Binder Viscosity (Lab Data)**

**TABLE 1: Temperature Limits for Compaction based on different Low Shear Viscosity Limits**

Project	Temperature Limit for Compaction		
	Visc. Limit = 100 Pa·s	Visc. Limit = 50 Pa·s	Visc. Limit = 10 Pa·s
9040-09-70 (PG58-34)	63 °C	69 °C	86
5300-04-74 (PG64-28)	73 °C	79 °C	97
1020-01-74 (PG70-28)	81 °C	88 °C	106
7200-05-70 (PG70-28)	84 °C	91 °C	110

## Meetings

A preliminary report was prepared and presented to Ms. Judie Ryan ( the project oversight representative) on August 18<sup>th</sup>. Also the results from the mixing and compaction study were presented to the flexible pavements TOC meeting held on September 22<sup>nd</sup> at the Marquette Interchange offices. After the meeting, the researchers asked the TOC committee for guidance on the next steps for the project. The alternatives for the future work are:

### Alternative 1

Go deeper into the mixing and compaction temperature study. As suggested by the TOC committee, there could be also mixture effects on densification of mixtures. A more comprehensive validation of the compaction viscosity limit proposed (50 Pa-s) would need to consider more mixtures.

Finish the field validation of the low temperature cracking specifications. This task can be achieved successfully since the field data obtained already considers projects with and without cracking and the binder testing results can be adequately compared and contrasted with the field cracking data.

Do not go further in the field validation of the fatigue and rutting binder specifications. The reason for changing plans from these tasks to the mixing and compaction validation, are the expected results and the field data available. The field data for rutting and fatigue is very limited. The sections where binder and mixture were collected during the duration of the project have shown limited fatigue and rutting damage, making the validation not very meaningful. The results obtained in the mixing and compaction area are, in contrast, very solid and could lead to significant changes in the way, specially compaction temperatures are approach nowadays. The state of Wisconsin could benefit much more from some solid results in the mixing and compaction area than from some meaningless results in the areas of fatigue and rutting.

### Alternative 2

Continue with the project as it was originally. Do not go further into the mixing and compaction temperature validation and finalize the validation of the low temperature cracking, fatigue cracking and rutting specifications.

### Work Next Quarter:

The feedback from the TOC meeting suggested that alternative 1 would be the best one for the remaining of the project work. The researchers are waiting for an official answer about the matter.

For the next quarter, the focus of the work will be finishing the validation of the low temperature cracking specifications, since this task is considered in both alternatives.

**Gantt Chart:**

PROJECT I.D.		STARTING DATE	COMPLETION DATE	MONTH	REPORT #														PERCENT OF						
PROJECT # 0092-03-13		Jan-31-03	Jul-31-07	Sep - 06	15																				
CONSULTANT FIRM NAME		% TIME ELAPSED	TOTAL PROJECT FUNDING	CONTRACT FUNDING															Project Complete	Task Complete Last Report	Task Complete This Report	Project Complete			
UNIV. OF WI - MADISON		83%	125.006	100%																					
NAME OF STUDY																									
FIELD VALIDATION OF BINDER GUIDELINES																									
TASK *	YEAR	2003			2004				2005				2006				2007		Project Complete	Task Complete Last Report	Task Complete This Report	Project Complete			
	MONTH	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 5	Qtr 6	Qtr 7	Qtr 8	Qtr 9	Qtr 10	Qtr 11	Qtr 12	Qtr 13	Qtr 14	Qtr 15	Qtr 16	Qtr 17					Qtr 18		
<b>TASK 1 :</b>																									
Define binder grades		█	█	█																10	8	0	8		
Select field sections								█																	
<b>TASK 2 :</b>																									
Collect samples				█				█	█	█	█	█								50	41	2	43		
Conduct testing					█													█	█						
<b>TASK 3 :</b>																									
Monitor performance of sections												█							█	10	5	2	7		
<b>TASK 4:</b>																									
Database development																			█	█	█	15	4	2	6
<b>TASK 5:</b>																									
Reporting		█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	15	11	1	12
PROGRESS SHOWN																									
SCHEDULED																									
COMPLETED																			100	69	7	76			