CENTER FOR TRANSPORTATION RESEARCH
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Project Summary Report 0-4185-S
Project 0-4185: Correlation of Field Performance to Hamburg Wheel-tracking Results
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February 2006

Analysis of Hamburg Wheel Tracking Device Results in Relation to Field Performance

PROJECT SUMMARY REPORT

To evaluate the laboratory-field correlation for the Hamburg Wheel Tracking Device (HWTD), nine test sections were constructed on IH-20 in Harrison County. This research included a monitoring of the construction of the test sections; the collection of construction data, performance data through a 5-year period, and performance data from laboratory tests using the HWTD; and an analysis of the collected information. Field performance was observed through visual pavement condition surveys and nondestructive tests for 4 years. In this study, similar types of deformation patterns were observed between the field test sections and lab specimens. Thus similar types of deformation patterns were assumed for both. At the end of the study, it was found that the average ratio between wheel pass/ESALs could be assumed to be 37 for the specific mixes utilized for this particular research project.

What We Did...

The HWTD was developed in Hamburg, Germany, in the 1970s by Esso A.G. This machine measures the combined effects of rutting and moisture damage by rolling a steel wheel across the surface of an asphalt concrete specimen that is immersed in hot water. The HWTD test is conducted on a pair of samples simultaneously. The sample is typically compacted to 7±1 percent air voids. The plate type compactor has been proposed for the compaction of specimens. Use of cylindrical specimens, however, makes it possible to obtain compacted specimens very easily with the aid of gyratory compactors. Figure 1 shows the HWTD.

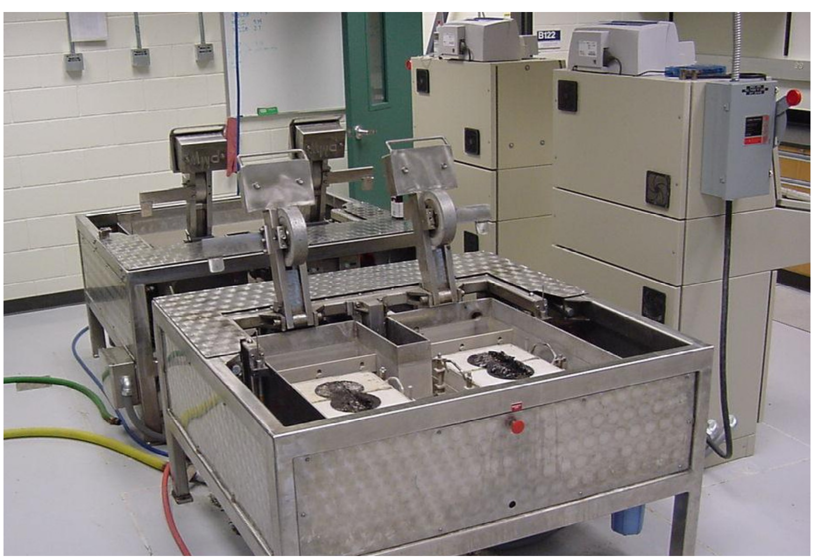

Figure 1: Hamburg Wheel Tracking Device

For this project, nine HMA mixture types were prepared using three different mix designs: Type C, 12.5 mm Superpave, and CMHB-C mixtures. Each mix used three different coarse aggregates: siliceous gravel, quartzite, and sandstone. Pavement overlays were placed on test sections constructed along IH-20 in Harrison County, Texas. The test section included each of the nine different surface mixture types. The base course was the same for all surface mixtures and was designed with 90% limestone and 10% local field sand. For all mixtures including the base course, PG 76-22 binder was used.

Visual pavement condition surveys were conducted on the eastbound and westbound test sections of IH-20 in the Atlanta District throughout the duration of the project and in accordance with the SHRP Distress Identification Manual for the Long-Term Pavement Performance Studies (SHRP 1990). The survey described the severity levels of observable distresses. The survey revealed that most distresses occurred as transverse cracks. Other distresses occurred with less frequency but were also defined, classified, and measured according to the SHRP distress identification manual.

Test sections on both the westbound outside lane and eastbound outside lane of IH-20 revealed mostly transverse crack distresses. The changes in the number of transverse cracks for each test section were recorded for December 2001, January 2002, November 2002, November 2003, and November 2004. It was noted that the initial condition of the continuously reinforced concrete pavement (CRCP) could also affect the formation of distresses on the asphalt pavement. Thus the existing number of cracks that included both transverse cracks and patchings on the CRCP prior to the placement of the asphalt pavement overlay were also recorded and reported.

The International Roughness Index (IRI) was also utilized to monitor the condition of the test sections. IRI(Left) and IRI(Right) values were estimated separately for test sections on both the eastbound and westbound lanes of IH-20. IRI-Finished and IRI-Nov2004 values were compared by performing a statistical test for each section. IRI values collected in December 2001 and November 2004 were compared according to three categories: IRI values collected from the left wheelpaths, IRI(Left); IRI values collected from the right wheelpaths, IRI(Right); and the average of IRI(Left) and IRI(Right) values, IRI(Average). The IRI(Average) values were similar to the IRI(Right) and IRI(Left) values, producing p-values higher than 0.05 and thus showing no significant decrease in value during the three-year span between construction and November 2004.

Final rutting data was collected for each test section along the profile of the roads with a dipstick profilometer on November 9, 2004, for estimating the in-place rutting of the asphalt pavement. In order to make a correlation, the HWTD test was conducted only on the field cores, because only the field cores can match the exact air void contents with the field test sections. For each profile, two rut depths were found that corresponded to the inside and outside wheelpaths. For the outside lanes, the right rut depth corresponded to the outside wheelpath and the left rut depth corresponded to the inside wheelpath. The rutting depth values were calculated using the American Association of State Highway and Transportation Officials (AASHTO) Designation PP38-00. Rutting was observed to be very low overall for all test sections, though it should be noted that the highest rutting data was observed with gravel mixes.

Six separate FWD tests were conducted on the outside eastbound and westbound lanes of sections of IH-20 in Harrison County from March/April 2001 to November 2004, which evaluated the structural performance of the pavement since the total thickness of asphalt surfacing overlaid on the tested CRCP was approximately 100 mm (4 inches). The mean FWD deflection parameters (W1, W7, SCI, and BCI, respectively) and standard deviation of these parameters were calculated for all test sections during each round of FWD tests. The deflections along individual sections are somewhat uniform though the data depicts sporadic jumps and irregularities, indicating regions where repairs had been made or regions with potential structural weaknesses.

The statistical analyses indicated a significant difference in the W1, SCI, and BCI deflection parameters between January 2002 and November 2004. Each of these parameters decreased in magnitude between January 2002 and November 2004. No significant difference in the W7 parameter was apparent. The decrease in SCI indicated a relative stiffening or densification of the surfacing layer or upper pavement structure. This may be the reason for the lower W1, W7, and BCI deflection parameters. No specific trends were evident from the FWD deflection data that may be used to infer the relative performance of the mixes on the different sections evaluated. It was found that construction of the new overlay resulted in a decrease in the magnitude and extent of deflections apparent on the old pavement structure, but the overlay did not appear to contribute significantly to the structural capacity of the pavement.

Four series of PSPA measurements were conducted on IH-20 test sections in Harrison County, with the first series conducted atop the concrete pavement after the milling of the old overlay. The series of tests were conducted in January 2002, November 2002, November 2003, and November 2004, respectively. A statistical analysis of the difference between the modulus measurements in January 2002 and November 2004 was conducted by applying a t-test. The t-test assumed unequal variances and the null hypothesis – that there was no difference between the mean moduli in January 2002 and November 2004 at a 95% confidence level. The null hypothesis was proved for all test sections except Section 9, which consisted of a Type-C design with quartz aggregate. Thus mean moduli values did not change from January 2002 to November 2004 with the exception of Section 9. Also with the exception of Section 9, there was no significant increase in the asphalt modulus for each test section between January 2002 and November 2004.

Seven days of traffic data (24 hours/day) was collected in 2003 for the months of May, July, August, September, October, November and December. The data was not always collected continuously or weekly and does not include the month of June. Each observation consisted of class number, axle weight, and axle spacing. Axle specifications and loadings were converted into normalized ESALs. The eastbound and westbound outside lanes of IH-20 carried many more ESALs than the eastbound and westbound inside lanes.

What We Found...

Data collected in the laboratory showed creep slope but no stripping slope. Parallel to this observation, no stripping deformation occurred in the field either. Therefore, creep slope was used for comparison purposes. The creep slope measurements taken by the HWTD tests were correlated

Table 1. Accumulated ESALs for each lane

Year	Lane 1	Lane 2	Lane 3	Lane 4
2001	53397	8478	10239	64582
2002	111045	17631	21293	134306
2003	173284	27513	33227	209582
2004	240478	38182	46111	290852

to ESALs/mm. First, accumulated ESALs were calculated separately for each lane. Then, the ESALs/mm was calculated for each section, thus establishing the correlation between the data and creep slope. The ESALs/mm for each section is included in Table 1, which also shows the accumulated ESALs for each lane throughout the duration of the project.

Wheel pass/ESALs values were calculated for each test section, and the results are included in Table 2. It is important to note that the ratio between the wheelpass and ESAL is established on the assumption that both field and lab rutting are similar deformations. Based on the data, it was observed that the average wheelpass/ESALs value was 37, the highest value was 107, and the smallest value was 15. The highest value for wheelpass/ESALs was observed for the CMHB Sandstone mixture aggregate combination, which is the only specimen that failed the HWTD lab test. Since HWTD data for the Type C Gravel specimen was not available, Table 2 includes information only from the other remaining eight mixture aggregate combinations. It should be noted that the wheel pass/ESALs presented here are for the mixes included in this study and should not be applied to all mixture types and asphalt contents. It should also be noted that the rutting observed in the field was minor compared to that observed in the laboratory with the field samples.

The Researchers Recommend...

The data showed that the average wheelpass/ESALs value was 37, the highest value was 107, and the lowest value was 15. The fact that the lab specimens exhibited only creep slope and no stripping failure supports the assumption that a ratio between wheelpass/ESALs can be established. Furthermore, parallel to what was observed with the lab specimens, no stripping problem could be observed in the field test sections. Therefore, similar types of deformation patterns could be assumed for both lab specimens and field test sections. However, it should be noted that the rutting observed in the field was very minor compared to what was observed with the lab specimens. Another significant shortcoming of this study was that testing was conducted with a very limited number of specimens for each test section. Therefore, this study should be repeated for different mixes. In addition, all of the nine test sections were located on IH-20 in Harrison County. To understand the correlation between the HWTD and field performance, this study should be repeated in a variety of different environmental conditions.

Table 2. Wheelpass/ESALs for each section

Mix Type	ESALs/mm	Wheelpass/mm	Wheelpass/ESALs
CMHB Quartize	198534	3823	52
Type C Quartize	174163	8348	21
Superpave Gravel	168123	4474	38
CMHB Gravel	136550	6259	22
Superpave Sandstone	125249	4368	29
CMHB Sandstone	130695	1220	107
Type C Sandstone	156155	10172	15
Superpave Quartize	187873	12245	15
AVERAGE	**157243**	**6364**	**37**
STD	**26415**	**3655**	**31**

For More Details...

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The research is documented in the following reports:

0- 4185-1, Correlation of Field Performance to Hamburg Wheel Tracking Device Results
0-4185-2, Hamburg Wheel Tracking Device Results on Plant and Field Cores Produced Mixtures
0-4185-3, Performance Assessment by Using Nondestructive Testing
0-4185-4, Pavement Performance Evaluation by Using Field Data
0-4185-5, Analysis of Hamburg Wheel Tracking Device Results in Relation to Field Performance

To obtain copies of a report: CTR Library, Center for Transportation Research,
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