Rutting of Asphalt Concrete Overlays on Continuously Reinforced Concrete Pavements in Texas

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Rutting history data on asphalt concrete pavement (ACP) overlays on rigid pavements are being collected by the Center for Transportation Research (CTR) to study ACP overlay behavior under the traffic and environmental conditions of Texas. The available data were analyzed recently for this purpose. Overlaid sections located in three counties of the state were selected for this study. These sections were originally built as continuously reinforced concrete pavement (CRCP). Using the limited data available at the present time, it was observed that the rate of rutting was maximum in the first year because of the initial compaction of material in the wheelpath. In the second year, the material between the wheelpaths experienced more compaction than that in the wheelpaths themselves, and therefore rutting was observed to decrease in the second year. However, rutting increased in the years following full compaction of the lanes. A regression equation was developed to characterize the rutting behavior of ACP overlays on CRCP. The analysis of available data indicated that overlay thickness was an important predictor of rutting in overlays. The age of the overlay was not very significant in the regression equation. This may be due to the brief history of rutting data available at the present time. The rutting of the overlays in different counties was affected by the locations of the overlaid sections. Apparently the materials of construction and construction-related items, which may be different in each county, affected the performance of overlays.

The state of Texas has constructed several thousand miles of continuously reinforced and jointed concrete pavements. Some of these pavements were built in the early 1960s, and those pavement sections that have needed rehabilitation have been overlaid primarily with asphalt concrete pavements (ACPs).

The rigid pavement sections that have been overlaid with ACP and thin bonded portland cement concrete (PCC) are being monitored by the Center for Transportation Research (CTR) to study their performance and rutting behavior. The objective of the study described in this paper is to characterize the rutting of ACP overlays on CRCP.

The current data base on the rutting history of the ACP sections was initiated in 1979. Data for a total of about 100 sections have been recorded in the data base so far. A portion of the overlaid section approximately 100 ft in length was selected to represent the entire section, which is of the same thickness. Rut depths were measured at 10-ft intervals along this section and the average of the 10 readings was recorded as the average rut depth for the section. A typical printout of the current data base is shown in Figure 1. The data base contains section identification and average rut depth measurements.

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LOCATION OF OVERLAID SECTIONS

The approximate locations of the ACP overlaid sections that are being monitored by CTR are shown in Figure 2. These sections are located on I-10, I-20, I-35, and I-45. Because many overlaid sections included in the data base did not have enough rutting history, it was decided to analyze the data from overlaid sections located in Walker, Falls-McLennan, and Jefferson counties only. The base slab for all of these overlays was a continuously reinforced concrete pavement (CRCP). A summary of information related to overlaid sections selected for this study is given in Table 1.

COLLECTION OF RUT DEPTH DATA

The rut depths of the ACP overlays were measured with the help of the device shown in Figure 3. This device uses a linear variable differential transformer to measure the rut depth in the wheelpath (approximately 3 ft away from the pavement edge). Measurements were taken at 10-ft intervals on a section approximately 100 ft long, and the average of the 10 readings was recorded as the rut depth for the section. Typical averages of rut depth measurements are shown in Figure 1.

ANALYSIS OF RUT DEPTH DATA

For the data analysis, the rut depth data were summarized and tabulated (Table 1).

Jefferson County rut depth data are plotted in Figure 4. These plots show the relationship between the rutting of overlays and age. Similar plots of Falls-McLennan County data are shown in Figure 5. The effect of overlay thickness on rutting in Walker County is shown in Figure 6.

Because the plots of rut depth data indicated that rutting is affected by the overlay thickness and the age of the overlaid section, a regression analysis of the data given in Table 1 was performed. Rutting data for ages less than 2 years were not included in the analysis because sections located in only one county (Jefferson) were measured at ages 0 and 1 year. The resulting regression equation is

$$Y = 0.009 + 0.021X_1 + 0.014X_2 + 0.091X_3 + 0.141X_4$$
$$(R^2 = 0.72, S = 0.0465) \quad (1)$$

where

y = rut depth of overlay (in.);
X_1 = overlay thickness (in.);
X_2 = age of overlaid section (years); and

X_3, X_4 = county identifiers:

$X_3 = 0$ and $X_4 = 0$, if Walker County,
$X_3 = 1$ and $X_4 = 0$, if Jefferson County, and
$X_3 = 0$ and $X_4 = 1$, if Falls-McLennan County.

The t-ratios for the coefficients associated with $X_1, \ldots, X_4$ indicated that overlay thickness is a significant predictor of rut depth. Also, the rutting in each county (predicted by X_3 or X_4) is significantly different for any given overlay thickness and age. The age of overlay section did not show a significant effect on rutting in the set of data used for this analysis.

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   9    15     2    18   902IH-35 SB     FALLS-MCLENNAN
326+25   267+00
                      MAY 81    .217
                      MAR 83    .275
                      MAR 84    .288
267+00   230+00
                      MAY 81    .306
                      MAR 83    .338
                      MAR 84    .352
230+00   214+50
                      MAY 81    .180
                      MAR 83    .231
                      MAR 84    .210
214+50   189+00
                      MAY 81    .241
                      MAR 83    .306
                      MAR 84    .310
189+00   176+50
                      MAY 81    .348
                      MAR 83    .442
                      MAR 84    .471
176+50   134+00
                      MAY 81    .290
                      MAR 83    .312
                      MAR 84    .298
   9    15     2    18   902IH-35 NB     FALLS-MCLENNAN
140+00   195+00
                      MAY 81    .287
                      MAR 83    .358
                      MAR 84    .375
195+00   326+25
                      MAY 81    .319
                      MAR 83    .369
                      MAR 84    .366
   9    15     3    10   901IH-35 SB     FALLS-MCLENNAN
134+00   110+00
                      MAY 81    .322
                      MAR 83    .399
                      MAR 84    .405
110+00    70+00
                      MAY 81    .241
                      MAR 83    .268
                      MAR 84    .268
 70+00    00+55
                      MAY 81    .313
                      MAR 83    .373
                      MAR 84    .366
   9    15     3    10   901IH-35 NB     FALLS-MCLENNAN
 00+55    55+00
                      MAY 81    .211
                      MAR 83    .255
                      MAR 84    .246
 55+00    68+00
                      MAY 81    .236
 68+00   107+00
                      MAY 81    .323
                      MAR 83    .383
                      MAR 84    .396
107+00   140+00
                      MAY 81    .373
                      MAR 83    .407
                      MAR 84    .432
  17   675     7     4  1701IH 45 SB     WALKER       05/24/79
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FIGURE 1 Typical printout of current data base.

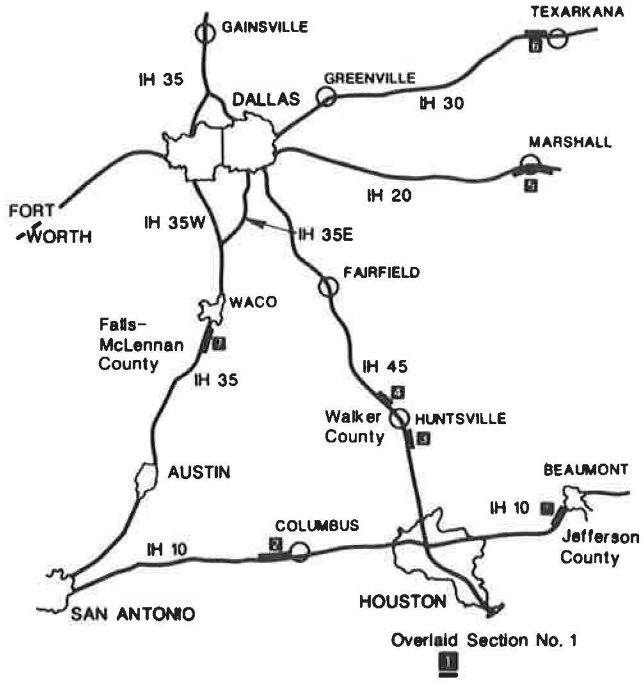

FIGURE 2 ACP overlaid sections monitored by CTR.

DISCUSSION OF RESULTS

Figure 4 shows the rutting history of overlaid sections in Jefferson County. The individual plots of rutting history for overlays of different thicknesses (3.25, 4, and 6 in.) indicate that the rutting in new overlays develops at a faster rate than in older overlays (more than 2 years of age). Also, after the first year's service, rutting tends to decrease before it starts increasing again, after 2 years. A possible reason for this phenomenon is that in the beginning the new overlay is subjected to compaction of material in the wheelpaths under the wheel loads of traffic in addition to the permanent deformation of fully compacted material. Therefore the rate of rutting in the first year is higher than in following years. Because the material in the wheelpath may be fully compacted during the first year, the increase in rut depth during the next year will be a fraction of the total rut depth during the first year. Also, it is likely that the high ridges developed around the center of the wheelpath during the first year may start subsiding because of compaction of this part of the cross section. The major portion of traffic that will cross this part of the roadway is passing traffic, which moves from the outer lane to the inner lane. Although this will happen simultaneously with the compaction of the roadway in the wheelpath, the amount of traffic will always be a fraction of the total traffic passing along the wheelpath. Therefore full compaction of material in the middle of the wheelpath will take place after the wheelpath has been fully compacted. When this happens, the ridges will smooth out and the rut depth will

TABLE 1 SUMMARY OF RUT DEPTH DATA

Section No.[a]	County	First Overlay Thickness (in.)	Overlay Age (years) 0	1	2	3	4	5	6	7
3	Walker	2.5							0.119	0.114
		4.0							0.123	0.136
		5.0							0.256	–
		6.0							0.250	0.302
1	Jefferson	3.25	0.162	0.188	0.179	0.184				
		4.0	0.249	0.258	0.255	0.255				
		6.0	0.248	0.263	0.229	0.259				
7	Falls-McLennan	3.5				0.268	0.339		0.335	
		7.0				0.296	0.333		0.340	

[a]See Figure 2.

actually appear to be less than that measured at the end of the first year.

After a certain period of time (in this case, 2 years), when the entire cross section has been fully compacted by traffic, further rutting in the overlay will be caused by the permanent deformation characteristics of the material. Therefore rutting will increase with time, as shown in Figures 4 and 5 and as indicated by Equation 1 (a positive sign for variable X_1).

It was mentioned earlier that the rut depth data for 0 and 1 years were excluded from the data set used in the development of Equation 1. Because the initial compaction characteristics of materials used in different locations may not be the same, it was decided to use only that portion of the rutting history curve that indicated consistent behavior for all three counties.

Figure 6 shows the effect of overlay thickness on rut depth for Walker County data. An increase in overlay thickness increases the rut depth at any given time. The laboratory studies of permanent deformations in asphaltic mixtures indicated that the permanent strain (ε_p) at the first load application is a function of deviatoric stress (σ_d) and elastic strain (ε_e) *(1)*. Because the rut depth of an overlay is the product of ε_p and layer thickness, it is conceivable that thicker overlays would rut more than thinner overlays of similar materials.

The results of this study, which are based on the analysis of available data, can be summarized as follows:

1. Initial compaction of ACP overlays (by service traffic) produces a high rate of rutting in the first year of service. The rutting of overlays decreases after the first year and starts increasing again after the middle of the wheelpath has also been fully compacted by passing traffic that changes lanes.
2. After the first 2 years of service, rut depth increases with age.

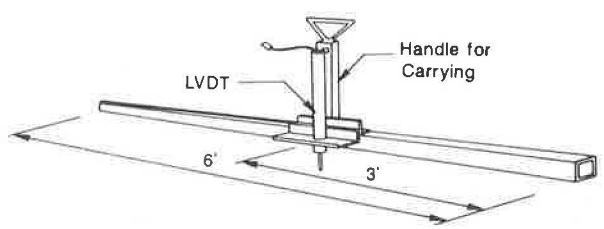

FIGURE 3 Rut depth measuring device.

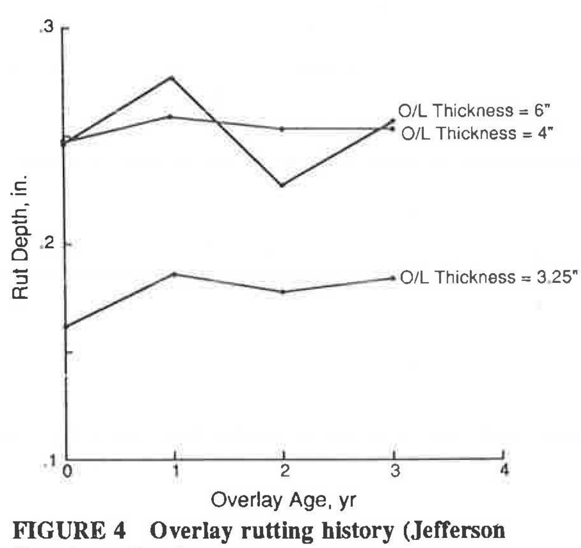

FIGURE 4 Overlay rutting history (Jefferson County sections).

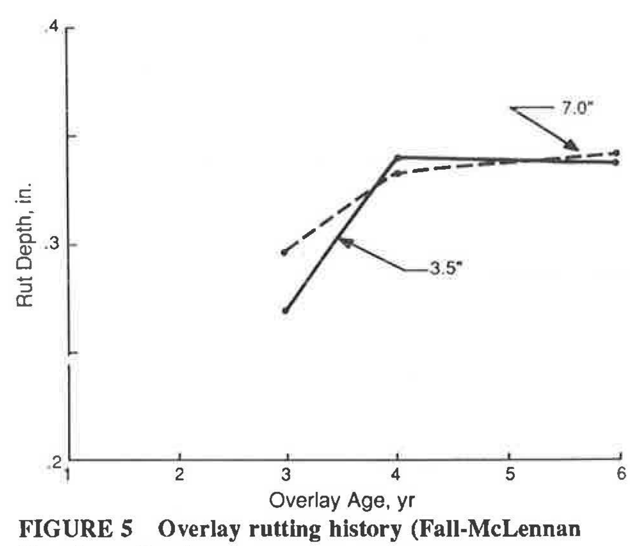

FIGURE 5 Overlay rutting history (Fall-McLennan County sections).

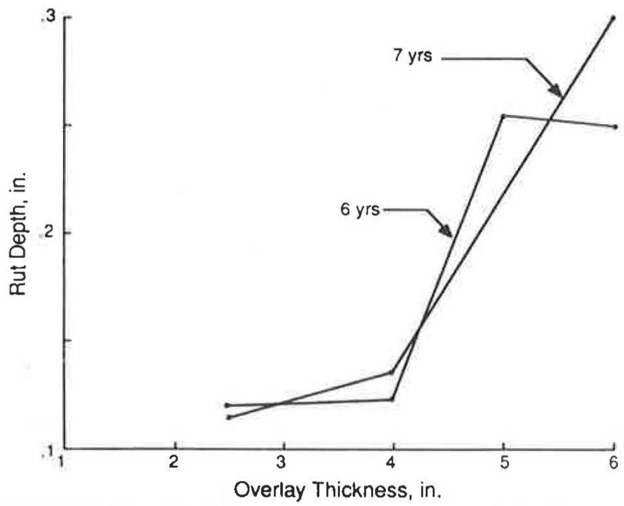

FIGURE 6 Effect of overlay thickness on rut depth (Walker County data).

3. Rut depth increases with an increase in overlay thickness.
4. The materials of construction and construction-related items may control the amount of rutting in overlays.

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