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THE EFFECTS OF RAINFALL INTENSITY, PAVEMENT CROSS SLOPE, SURFACE TEXTURE, AND DRAINAGE LENGTH ON PAVEMENT WATER DEPTHS

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The Effects of Rainfall Intensity, Pavement Cross Slope, Surface Texture, and Drainage Length on Pavement Water Depths

by

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Abstract

Reported herein are the results of a study concerned with determining the amount of water which can be expected to exist on various pavement types under normal ranges of pavement cross slopes, rainfall intensities, pavement textures, and drainage lengths. Equations are developed which relate these variables and their relative effects to water depth. Results are presented in both tabular and graphic form. Background information and pertinent past research pertaining to hydraulics of water flow over paved surfaces are given.

Nine different type surfaces were tested. The surfaces were placed on individual 28 feet long by 4 feet wide, double tee, prestressed, concrete beams. Rainfall or uniform intensity was applied to the surface. Water depth measurements were taken at regularly spaced drainage lengths for various combinations of rainfall intensity and pavement cross slope. Multiple regression analyses were used to determine the best fit of the data.

Pavement cross slope was found to affect water depths significantly. For a rainfall intensity of 1.5 in/hr, a surface texture of 0.03 inches, and a drainage length of 24 feet, increasing the cross slope from 1/16 in/ft (1/192) to 1/4 in/ft (1/48) decreased water depths by 62 percent in the outside wheel path (approximately 21 feet from the top of the drainage area). Correspondingly, increases in surface texture decreased water depths; whereas, increases in rainfall intensity and drainage length increased water depths. The over-all experimentally obtained equation is

$$d = [3.38 \times 10^{-3} (1/T)^{-.11} (L)^{.43} (I)^{.59} (1/S)^{.42}] - T$$

where

d = average water depth above top of texture (in.),
T = average texture depth (in.),
L = drainage-path length (ft),
I = rainfall intensity (in/hr) and
S = cross slope (ft/ft).

The findings and conclusions contained herein will be useful to the highway engineer in determining proper geometric designs and paving materials commensurate with acceptable pavement friction characteristics and service demands. Suggestions for further research are also included.

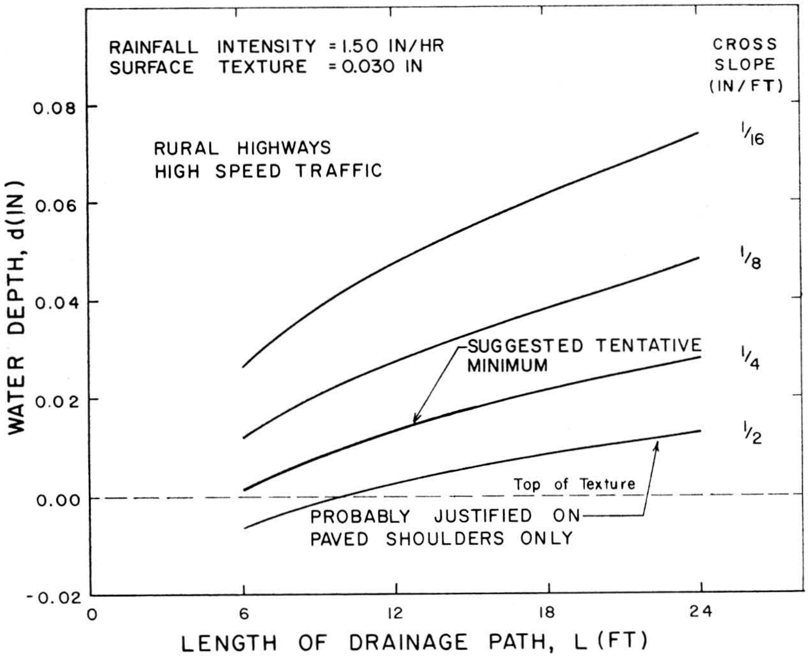

Figure 1. Pavement water depth vs. length of drainage path for different cross slopes.

Objectives

The objectives of this research were:

1. To examine the relative effects of various rainfall intensities, pavement cross slopes, drainage lengths, and surface textures on resultant pavement water depths.

2. To develop an equation relating rainfall intensity, pavement cross slope, drainage length, and surface texture to pavement water depth, and

3. To recommend means by which the findings and conclusions contained herein can be implemented by the highway engineer in determining proper geometric designs and paving materials commensurate with acceptable pavement water depths and service demands.

Summary of Findings and Results

1. The experimentally determined equation relating water depth to surface texture, length of drainage path, rainfall intensity, and pavement cross slope is

$$d = [3.38 \times 10^{-3} (1/T)^{-.11} (L)^{.43} (I)^{.59} (1/S)^{.42}] - T$$

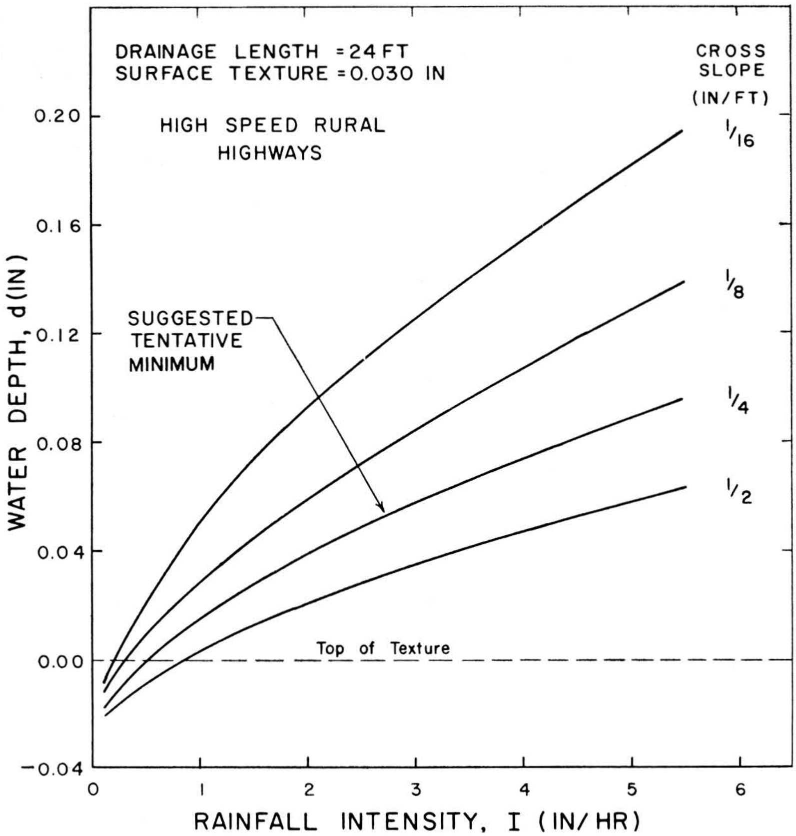

Figure 2. Pavement water depth vs. rainfall intensity for different cross slopes.

where

- d = average water depth above top of texture (in.),
- T = average texture depth (in.),
- L = drainage-path length (ft),
- I = rainfall intensity (in/hr), and
- S = cross slope (ft/ft).

2. Increasing surface texture resulted in a decrease in water depth for a given rainfall intensity, cross slope, and drainage length. This effect was more pronounced at the flatter cross slopes and lower rainfall intensities.

3. Greater drainage lengths increased water depths, however, the rate of increase in water depth became smaller as drainage lengths increased.

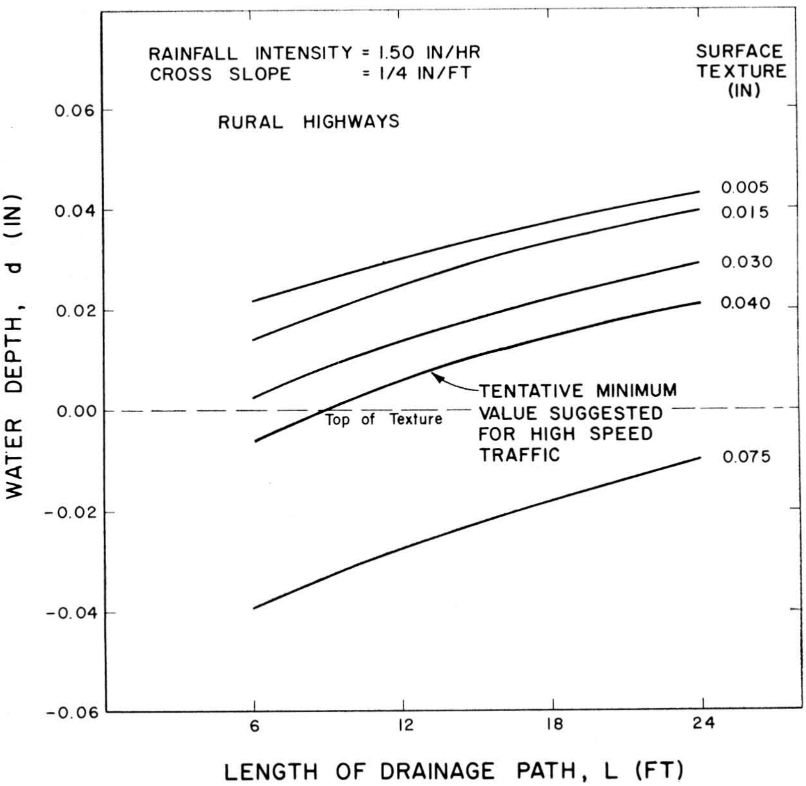

Figure 3. Pavement water depth vs. length of drainage path for different surface textures.

4. Greater water depths were associated with higher rainfall intensities; notwithstanding, the adverse effect of rainfall intensity was quite pronounced, even at the lower rainfall intensities.

5. Increases in pavement cross slope resulted in reduced water depths. This effect was very significant at the flatter cross slopes where a slight increase in cross slope resulted in a pronounced reduction in water depth. The reader is referred to Table 8 and Figure 18 in the full report for a more detailed account of findings 2 through 5.

6. Surface texture, rainfall intensity, and pavement cross slope were found to affect the average detention water* on the surfaces similar to the manner in which these variables affected water depth. Increases in surface texture and pavement cross slope resulted in decreased detention; whereas, increases in rainfall intensity increased detention. The reader is referred to

*The water in question is that water above a calculated median datum line referenced from an average of the tops of the asperity peaks.

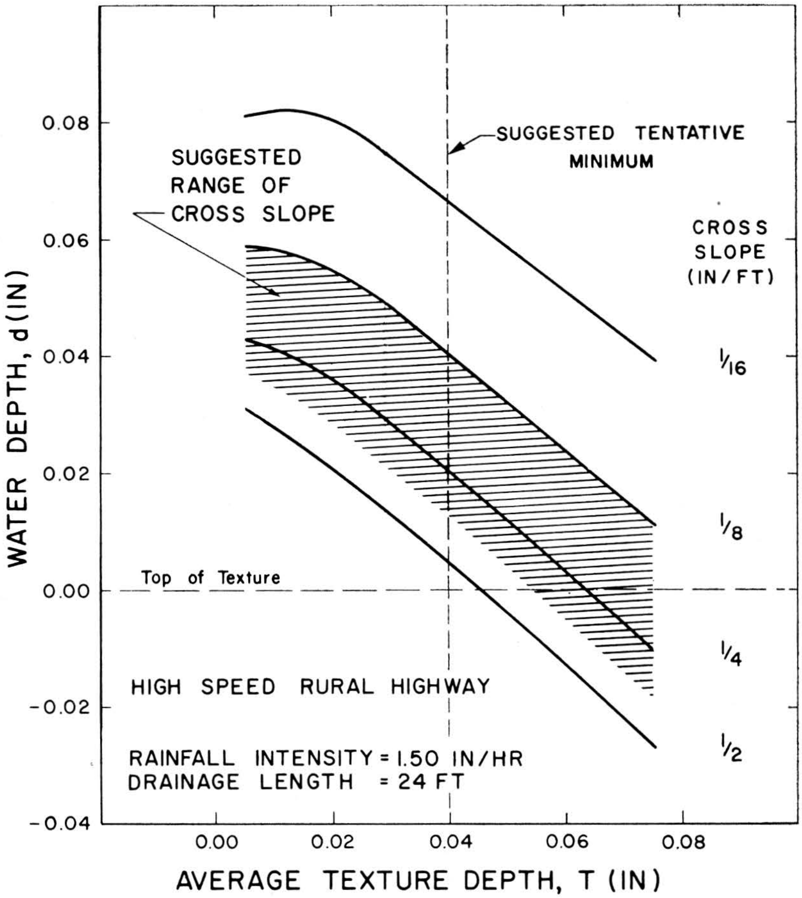

Figure 4. Pavement water depth vs. average texture depth for different cross slopes.

Table 9 and Figure 19 in the full report for more detailed information. The experimentally determined equation was

$$\text{Det} = [11.80 \times 10^{-3} (1/T)^{-.11} (I)^{.57} (1/S)^{.31}] - T$$

where

Det = average water depth detention (in.),

T = average texture depth (in.),

I = rainfall intensity (in/hr), and

S = cross slope (ft/ft).

7. Detailed plots of the findings are contained in Figures 1 through 4.

The published version of the complete report of which this is a summary may be obtained by addressing your request as follows:

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