General Information for Pavement Drainage and Intake Capacity

A. Introduction

Effective drainage of pavements is essential to maintaining the desired level of service and to traffic safety. Water on the pavement can interrupt traffic, reduce skid resistance, increase potential for hydroplaning, limit visibility due to splash and spray, and cause difficulty in steering a vehicle when the front wheels encounter standing water.

Designing pavements to drain requires consideration of surface drainage, gutter flow, and inlet capacity. The design of these elements is dependent on storm frequency and the allowable spread of storm water on the pavement surface.

This chapter presents design guidance for the design of these elements. Most of the information presented is this section is based upon FHWA's Hydraulic Engineering Circular No. 22 (HEC-22), Urban Drainage Design Manual. Designers may refer to this document for additional information.

B. Design Criteria

Two of the more significant variables considered in the design of highway pavement drainage are the frequency of the design runoff event and the allowable spread of water on the pavement. The design criteria for these requirements are summarized in Section 2A-1.

In addition to the storm frequency and allowable spread, the slope of the pavement also directly affects the design of the pavement drainage and the intake spacing.

Together, these three criteria are the key elements in designing pavement drainage and determining intake spacing. A summary of the importance of each is provided below.

1. **Stormwater Spread:** The objective of roadway storm drainage design is to provide for safe passage of vehicles during the design storm event. The design of a drainage system for a curbed urban roadway is to collect runoff in the gutter and convey it to the stormwater intakes in a manner that provides reasonable safety for traffic at a reasonable construction cost. As spread from the curb increases, the risk of traffic accidents and delays increases.

   Due to the increased traffic volume and vehicle speed, water on traffic lanes of higher classification roadways poses more risk than for lower classification roadways. Because of the increased risk, water encroaching into the traffic lanes is less tolerable on these roadways and the additional cost of controlling the spread is justified. This is reflected in the stormwater spread criteria described in Section 2A-1.

2. **Design Frequency:** Stormwater spread should be checked for both the minor and major storm events. As described in Section 2A-1, the minor storm is generally considered a 2 to10 year recurrence event while the major storm is considered a 50 or 100 year storm. Due to the decreased frequency of the major storm, an increased spread into the traveled way is tolerated.

3. **Pavement Slopes:** Both the longitudinal slope and cross slope of the pavement directly impact the width of the stormwater spread and the resulting intake spacing.

   a. **Longitudinal Slopes:** A minimum longitudinal grade is more important for an urban roadway (with a curb) than for a rural roadway (with no curb) since the water is constrained by the curb. However, flat gradients on uncurbed pavements can lead to a spread problem if vegetation is allowed to build up along the pavement edge. This can create a potential for unexpected hydroplaning and loss of vehicle control.

      As recommended in Section 5C-1, the desirable minimum gutter grade is 0.6%. The minimum gutter grade is 0.5%. Grades of 0.4% may be allowed in certain circumstances. While some publications indicates that grades as flat as 0.3% are allowable, constructing pavements this flat becomes difficult and often results in “bird baths” in the pavement.

      Special attention to drainage must be provided at vertical curves. Both crest and sag vertical curves that have a grade change from positive to negative (or vice versa) contain a level area at some point along the curve. Generally, as long as a grade of 0.30% is provided within 50 feet of the level area, no drainage problems develop. This criterion corresponds to a K value of 167. Refer to Section 5C-2 for additional information regarding vertical curves.

   b. **Cross (Transverse) Slopes:** Section 5C-1 provides the minimum cross slope requirements for urban and rural roadways. In general, for streets with three or fewer travel lanes, the cross slope should be 2%. For roadways with four or more lanes, the cross slope of the inside lanes, including left turn lanes, should be 2%. In order to reduce stormwater spread, the cross slope of the outside lanes should be 3%, if both lanes slope in the same direction.

      At intersections and other cross-slope transition areas where the longitudinal grade drains toward the direction of decreasing cross slope, care must be taken to ensure that the transition length is long enough to prevent trapping water or reducing the longitudinal slope below the recommended minimum.

$$TL = \frac{(S_L - S_{Lm}) \times P_w}{\Delta T_s}$$ **Equation 2C-1.10**

where:

TL = minimum transition length, ft
S_L = longitudinal slope of the mainline pavement, ft/ft
S_{Lm} = min. desirable longitudinal slope through transition (typically 0.5% or greater), ft/ft
P_w = pavement width, ft.
ΔS_x = change in cross slope through transition, ft/ft

C. References

U.S. Department of Transportation. *Urban Drainage Design Manual*. Hydraulic Engineering Circular No. 22. Third Ed. 2009.