Local Edition: Vol. 15, No. 10
April 2010

LOCAL HIGHWAY TECHNICAL

NEWS

Local Highway Technical
Assistance Council
3330 Grace Street
Boise, Idaho 83703
208-344-0565/800-259-6841
www.lhtac.org
Edited by: LHTAC Staff

Proper Drainage Reduces Roadway Problems

Inadequate drainage not only causes driving problems, it also causes roads to deteriorate rapidly. Pavement drainage requires consideration of surface drainage, gutter flow and inlet capacity. The design of these elements depends on storm frequency and the allowable spread of storm water on the pavement surface.

Design Frequency and Spread

- The classification of the highway is a good starting point in the selection process because it defines the public's expectations regarding water on the pavement surface.
- Ponding on traffic lanes of high-speed, high-volume highways is contrary to the public's expectations. Therefore, the risks of accidents and the costs of traffic delays are high.
- Design speed is important to the selection of design criteria. At speeds greater than 40 mph, water on the pavement can cause hydroplaning.
- Projected costs of traffic delays and accidents increase with increasing traffic volumes.
- The intensity of rainfall may significantly affect the selection of design frequency and spread.
- Cost considerations make it necessary to formulate a rational design criteria.

Risks associated with the spread of water on pavements may be less in arid areas subject to high intensity thunderstorms than in areas accustomed to frequent but less intense storms.

The elevation of the highway and surrounding terrain is an additional consideration when water can be drained only through a storm drainage system, as in underpasses and depressed sections. Spread on traffic lanes can be tolerated to greater widths where traffic volumes and speeds are low. Spreads of one-half of a traffic lane or more usually are considered a minimum type design for low-volume local roads. The selection of design criteria for intermediate types of facilities may be the most difficult. For example, some arterials with relatively high traffic volumes and speeds may not have shoulders that will convey the design runoff without encroaching on the traffic lanes. The recommended design frequency for depressed sections and underpasses where ponded water can be removed only through the storm drainage system is a 50-year frequency event.

Check Storm and Spread

A check storm should be used anytime runoff could cause unacceptable flooding during less frequent storms. Inlets also should always be evaluated for a check storm when a series of inlets terminates at a sag vertical curve where ponding to hazardous depths could occur. Criteria for spread during the check storm are: 1) one lane open to traffic during the check storm, and 2) one lane free of water during the check storm. These criteria differ substantively, but each sets a standard by which the design can be evaluated.

Hydroplaning
The hydroplaning potential of a roadway surface can be reduced by adopting the following suggestions:

- Design highway geometries to reduce drainage path lengths of water flowing over the pavement. This prevents flow build up.
- An increase of pavement surface texture, such as grooving or grinding, will increase the drainage capacity at the tire pavement interface.
- The use of open-graded asphalt pavements greatly reduce the hydroplaning potential of the roadway surface because this forces water through the pavement under the tire.
- Drainage structures to capture the flow of water over the pavement will reduce the thickness of the film of water and reduce hydroplaning potential.

Design Guidance
The recommended minimum values of roadway longitudinal slope given in the *AASHTO Policy on Geometric Design* include three general guidelines:

1. A minimum longitudinal gradient is more important for a curbed than an uncurbed pavement because water is constrained by the curb. Flat gradients on uncurbed pavements can lead to a spread problem if vegetation is allowed to build up along the pavement edge.

2. Desirable gutter grades should not be less than 0.5 percent for curbed pavements with an absolute minimum of 0.3 percent. Minimum grades can be maintained in very flat terrain by using a rolling profile or by warping the cross slope to achieve rolling gutter profiles.

3. To provide adequate drainage in sag vertical curves, a minimum slope of 0.3 percent should be maintained within 50 feet of the low point of the curve.

Cross/Transverse Slope
Cross slopes of 2 percent have little effect on driver effort in steering or on friction demand for vehicle stability. In areas of intense rainfall, a somewhat steeper cross slope of 2.5 percent may be used to facilitate drainage.

On multi-lane highways where three lanes or more are sloped in the same direction, it is desirable to counter the resulting increase in flow depth by increasing the cross slope of the outermost lanes. The two lanes adjacent to the crown line should be pitched at the normal slope, and successive lane pairs or outward portions should be increased by about 0.5 percent to 1 percent. The maximum pavement cross slope should be limited to 4 percent.

Curb and Gutter
Normally curbs are used at the outside edge of pavements for low-speed highways, and in some instances, adjacent to shoulders on moderate to high-speed highways. They serve the following purposes:

- Contain the surface runoff within the roadway and away from adjacent properties.
- Prevent erosion on fill slopes.
- Provide pavement delineation.
- Enable the orderly development of property next to the road.

Gutters formed in combination with curbs are available in 12- through 39-inch widths. Gutter cross slopes may be the same as that of pavement or may be designed with a steeper cross slope, usually 1 inch per foot steeper than the shoulder or parking lane. The American Association of State Highway and Transportation Officials (AASHTO) geometric guidelines state that an 8 percent slope is a common maximum cross slope.

Channels
Roadside channels are commonly used with uncurbed roadway sections to convey runoff from the highway pavement and from areas that drain toward the highway. Due to right-of-way limitations, roadside channels cannot be used on most urban arterials. They can be used in cut sections and other locations where sufficient right-of-way is available and driveways or intersections are infrequent.

To prevent drainage from the medians from running across the travel lanes, slope medians and inside shoulders to a center swale. This design is particularly important for high speed highways and for highways with more than two lanes of traffic in each direction.

Bridge Decks
Bridge deck drainage is similar to that of curbed roadway sections. Effective bridge deck drainage is important for the following reasons:

- Deck structure and reinforcing steel is susceptible to corrosion from deicing salts.
- Moisture on bridge decks freezes before surface road ways.
- Hydroplaning often occurs at shallower depths on bridges due to the reduced surface.

Bridge deck drainage is often less efficient than roadway sections because cross slopes are flatter, parapets collect large amounts of debris and drainage inlets or typical bridge scuppers are less hydraulically efficient and more easily clogged by debris.

Because of the difficulties in providing for and maintaining adequate deck drainage, gutter flow from roadways should be intercepted before it reaches a bridge. For similar reasons, zero gradients and sag vertical curves should be avoided on bridges.

Additionally, runoff from bridge decks should be collected immediately after it flows onto the subsequent roadway sections where larger grates and inlet structures can be used.

Median Barriers
Slope the shoulder areas adjacent to median barriers to the center to prevent drainage from running across the traveled pavement. Where median barriers are used, and particularly on horizontal curves with associated super elevations, it is necessary to provide inlets or slotted drains to collect the water accumulated against the barrier.

Reference: Tech Note #54 2009, Baystate Roads Program, MASS LTAP