# 5.0 MEDIAN DRAINAGE

The purpose of a median is to separate opposing lanes of traffic. A wide, shallow, depressed median is typically used for rural divided highways. Inlets and/or culverts should be included in the design to drain the median. This section contains guidelines and procedures for the design of median drainage.

## 5.1 TYPES OF MEDIAN DRAINS

Shallow medians, such as those constructed to multi-lane interstate standards, should be drained by a pipe culvert with an appropriate end section or a drop inlet. KDOT has a standard drawing for a concrete headwall and structural steel grate on a 6:1 slope for shallow medians. The structural steel grate is not required for a pipe with a diameter of 24 in. or smaller. A culvert with a different type of end section may be used in a wide, deep median where the end section would not constitute a roadside hazard. In cut sections, the median grade and/or the outside ditch grade may need to be adjusted to provide an adequate slope for the crossroad pipe culvert.

KDOT has standard drawings for three types of drop inlets: a grated manhole (inlet-manhole, special), a concrete ditch inlet (Type I and Type II), and a pre-fabricated interception device (steel). A concrete ditch inlet is a concrete structure with a structural steel cover plate and a grated opening on one or both sides. The Type I concrete ditch inlet is used on grade with a ditch plug to capture flow from one direction. The Type II concrete ditch inlet is used at low points on the roadway profile to capture flow from two directions. A pre-fabricated interception device (steel) is a rectangular steel riser that is attached to a corrugated metal pipe. Prior to selecting this type of inlet, the designer should review KDOT's current policies on appropriate pipe materials for crossroad pipes.

The Type I or Type II concrete ditch inlet is the preferred drop inlet for use in medians. The grated manhole inlet may be used where it is necessary to combine flows from more than one inlet into the storm drainage system. Since the depth of these inlets is variable, the grated manhole may also be used in locations where a deeper inlet would help to reduce the slope of the outfall pipe. Pre-fabricated interception devices may be used for temporary installations and/or locations where steel pipe is permitted by the current pipe policy.

## 5.2 DESIGN CRITERIA

A median inlet should be designed to intercept the total design flow from its drainage area. A ditch plug placed downstream of the inlet enhances the performance of a median inlet.

The median drainage system should be designed to minimize the number of inlets, but a practical maximum spacing of 1200 ft. to 1500 ft. should be considered. Inlets are located at sag points and elsewhere as needed. The spacing between inlets is usually limited by the capacities of the inlets. The cost of erosion protection can also limit inlet spacing.

### 5.2.1 Allowable Water Surface

The design criteria for road ditches are applicable to medians. The allowable water surface (AWS) for the median is the top of the subgrade at the edge of the shoulder.

### 5.2.2 Recurrence Interval

The recurrence interval for the median is 10 years. For median drains at low points on the roadway profile, use the recurrence interval for the highway (see Table 2.4-1).

### 5.2.3 Minimum Grade

The minimum grade of a median should be 0.3 percent to provide for proper drainage. A "saw-toothed" median profile may be used if needed to obtain this grade.

### 5.2.4 Median Cross Section and Depth

The cross-sectional dimensions of the standard median are shown on the standard drawings for Grading, Typical Section (4-Lanes).

The bottom of the median should be at least 6 in. below the top of the subgrade. The maximum depth of the median should be set to accommodate side slopes of 6:1 or flatter.

### 5.2.5 Temporary Erosion Protection

The newly constructed median should convey the 1-year flow without significant erosion. If necessary, a temporary lining should be provided to protect against erosion until the grass lining is established. The designer should determine the locations requiring temporary erosion protection and provide a list of these locations to the Environmental Services Section.

## 5.3 CAPACITY OF MEDIAN DRAINS

The allowable headwater elevation (AHW) for a median drain in a low point on the roadway profile is the elevation of the top of the subgrade at the edge of the shoulder. The AHW for a median drain on grade is the lesser of (1) the elevation of the top of the subgrade at the edge of the shoulder and (2) the elevation of the top of the ditch plug directly downstream of the inlet.

A crossroad pipe culvert with a concrete headwall and structural steel grate should be analyzed as a culvert by the procedures in Section 6.3 to determine its capacity at the AHW. The concrete headwall with the structural steel grate is hydraulically equivalent to the Type IV end section.

The capacity of a median drain with a drop inlet is the lesser of (1) the capacity of the drop inlet and (2) the capacity of the crossroad pipe under outlet control. Use Table 5.3-1 to determine the capacities of the Type I and Type II concrete ditch inlets and the prefabricated interception device (steel). Use Table 5.3-2 to determine the capacities of the standard grated manholes. The capacity of an inlet can be affected if it becomes partially clogged with debris. In order to compensate for the possibility of partial blockage by debris, the designer may consider reducing the drop-inlet capacity by an appropriate percentage (up to 50%), if it is to be located where large amounts of debris are anticipated depending on local conditions and experience. Typically, drop-inlets located in grassed medians are not susceptible to large amounts of debris.

Use Equation 13-1 to compute the capacity of a crossroad pipe connected to a drop inlet. The tailwater elevation (TWE) in Equation 5-1 is the water-surface elevation in the road ditch at the outlet of the crossroad pipe for the appropriate recurrence interval. If this water level is below the crown of the crossroad pipe at the outlet, set TWE equal to the elevation of the pipe crown.

$$Q = 0.0438\, D^2 \sqrt{\frac{AHW - TWE}{1.5 + \dfrac{5060 n^2 L}{D^{4/3}}}} \qquad (5\text{-}1)$$

where: Q = discharge capacity (cfs)

D = diameter of pipe (in.)

AHW = allowable headwater elevation (ft)

TWE = tailwater elevation (ft)

n = Manning's roughness coefficient for pipe (see Table 6.3.4-2)

L = length of pipe (ft)

**Table 5.3-1 Capacities of Concrete Ditch Inlets and Pre-fabricated Interception Device (Steel) [Based on No Blockage]**

| HW above flowline of median (ft) | Q (cfs) | | |
|---|---|---|---|
| | *Concrete Ditch Inlet | | **Pre-fabricated Interception Device (Steel) |
| | Type I | Type II | |
| 0.0 | 0.0 | 0.0 | 0.0 |
| 0.1 | 0.5 | 1.0 | 0.9 |
| 0.2 | 1.5 | 3.0 | 2.5 |
| 0.3 | 2.7 | 5.4 | 4.6 |
| 0.4 | 4.2 | 8.3 | 6.1 |
| 0.5 | 5.8 | 11.7 | 6.8 |
| 0.6 | 7.7 | 15.3 | 7.5 |
| 0.7 | 9.7 | 19.3 | 8.1 |
| 0.8 | 11.8 | 23.6 | 8.6 |
| 0.9 | 14.1 | 28.2 | 9.1 |
| 1.0 | 16.5 | 33.0 | 9.6 |
| 1.1 | 19.0 | 38.0 | 10.1 |
| 1.2 | 21.7 | 43.4 | 10.5 |
| 1.3 | 23.0 | 45.9 | 11.0 |
| 1.4 | 23.8 | 47.7 | 11.4 |
| 1.5 | 24.7 | 49.4 | 11.8 |
| 1.6 | 25.5 | 51.0 | 12.2 |
| 1.7 | 26.3 | 52.5 | 12.6 |
| 1.8 | 27.0 | 54.1 | 12.9 |
| 1.9 | 27.8 | 55.5 | 13.3 |
| 2.0 | 28.5 | 57.0 | 13.6 |
| 2.1 | 29.2 | 58.4 | 14.0 |
| 2.2 | 29.9 | 59.8 | 14.3 |

**Table 5.3-1 Capacities of Concrete Ditch Inlets and Pre-fabricated Interception Device (Steel) [Based on No Blockage]**

| HW above flowline of median (ft) | Q (cfs) | | |
|---|---|---|---|
| | *Concrete Ditch Inlet | | **Pre-fabricated Interception Device (Steel) |
| | Type I | Type II | |
| 2.3 | 30.6 | 61.1 | 14.6 |
| 2.4 | 31.2 | 62.4 | 14.9 |
| 2.5 | 31.9 | 63.7 | 15.2 |
| 2.6 | 32.5 | 65.0 | 15.5 |
| 2.7 | 33.1 | 66.2 | 15.8 |
| 2.8 | 33.7 | 67.4 | 16.1 |
| 2.9 | 34.3 | 68.6 | 16.4 |
| 3.0 | 34.9 | 69.8 | 16.7 |

* See Standard Drawing RD631

* * See Standard Drawing RD640

**Table 5.3-2 Capacities of #Inlet-Manholes, Special**

| HW above flowline of median (ft) | Q (cfs) | | | |
|---|---|---|---|---|
| | 90 x 54 in. | 66 x 54 in. | 54 x 54 in. | 48 x 48 in. |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.1 | 2.1 | 1.8 | 1.6 | 1.4 |
| 0.2 | 6.1 | 5.0 | 4.4 | 3.9 |
| 0.3 | 11.2 | 9.1 | 8.1 | 7.1 |
| 0.4 | 17.2 | 14.1 | 12.5 | 10.9 |
| 0.5 | 24.0 | 19.7 | 17.5 | 15.3 |
| 0.6 | 31.6 | 25.8 | 23.0 | 20.1 |
| 0.7 | 39.8 | 32.6 | 29.0 | 25.3 |
| 0.8 | 48.6 | 39.8 | 35.4 | 28.2 |
| 0.9 | 58.0 | 47.5 | 41.3 | 29.8 |
| 1.0 | 68.0 | 55.6 | 43.3 | 31.2 |
| 1.1 | 78.4 | 64.2 | 45.2 | 32.6 |
| 1.2 | 89.4 | 67.4 | 47.0 | 33.9 |
| 1.3 | 95.4 | 69.9 | 48.8 | 35.2 |
| 1.4 | 98.7 | 72.3 | 50.5 | 36.4 |
| 1.5 | 102.0 | 74.7 | 52.2 | 37.6 |
| 1.6 | 105.1 | 77.0 | 53.8 | 38.8 |
| 1.7 | 108.1 | 79.2 | 55.3 | 39.9 |
| 1.8 | 111.1 | 81.4 | 56.8 | 41.0 |
| 1.9 | 114.0 | 83.5 | 58.3 | 42.0 |
| 2.0 | 116.8 | 85.6 | 59.8 | 43.1 |
| 2.1 | 119.5 | 87.6 | 61.2 | 44.1 |
| 2.2 | 122.2 | 89.5 | 62.5 | 45.1 |
| 2.3 | 124.8 | 91.5 | 63.9 | 46.0 |
| 2.4 | 127.4 | 93.3 | 65.2 | 47.0 |
| 2.5 | 129.9 | 95.2 | 66.5 | 47.9 |

### Table 5.3-2 Capacities of #Inlet-Manholes, Special

| HW above flowline of median (ft) | Q (cfs) | | | |
|---|---|---|---|---|
| | 90 x 54 in. | 66 x 54 in. | 54 x 54 in. | 48 x 48 in. |
| 2.6 | 132.4 | 97.0 | 67.7 | 48.8 |
| 2.7 | 134.8 | 98.8 | 69.0 | 49.7 |
| 2.8 | 137.2 | 100.5 | 70.2 | 50.6 |
| 2.9 | 139.6 | 102.2 | 71.4 | 51.5 |
| 3.0 | 141.9 | 103.9 | 72.6 | 52.3 |

#See Standard Drawing RD648

## 5.4 DESIGN PROCEDURE FOR MEDIAN DRAINAGE

Use the following procedure for the design of median drainage:

1. Determine the appropriate material for the crossroad pipe culvert in accordance with the KDOT's current policies for crossroad pipes.

2. Select an inlet type and a crossroad pipe size that are compatible with the roadway design (Section 5.2). In a cut section, the grade of the outside ditch or the grade of the median may need to be adjusted to provide an adequate slope for the crossroad pipe.

3. Select a trial spacing between median drains based on desirable discharge locations. The spacing between median drains is typically between 500 ft and 1000 ft; however, local conditions may dictate a shorter or longer spacing.

4. Compute the capacity of each median drain (Section 5.3).

5. Compute the design flow for each median drain by the Rational method (Section 3.2).

6. Adjust the locations of the median drains as needed. Ideally, the design flow for each drain should be slightly less than or equal to its capacity. If the design flow exceeds the capacity, relocate the drain to decrease its drainage area. If the design flow for a median drain on grade is much smaller than its capacity, relocate the drain to increase its drainage area.

7. Determine whether the newly constructed median would be subject to erosion by the 1-year flow (Section 4.6.1). If the 1-year flow would cause erosion, protect the erodible section with a temporary lining or reduce the spacing between median drains, whichever is more economical.

### 5.4.1 Example: Design of Median Drainage

Problem:

A shallow median on a fill section of a freeway in Shawnee County is to be drained by Type I concrete ditch inlets with 24-in. RCP crossroad pipes. The grade of this median is 2.0%. The median has 18:1 cross-slopes for 9.0 ft on each side of the centerline. The total width of the median is 60 ft including two 6 ft shoulders. The total width of pavement drained by the median is 36.0 ft. The 100-ft-long crossroad pipes are to be placed on slopes of 0.005 ft/ft. The soil type is a silty soil with high plasticity. Determine an appropriate spacing for the inlets.

Solution:

1. Try a spacing of 1300 ft between inlets.

2. Compute the capacity of the median drain.

   a. Compute the capacity of the inlet.

      The AHW for a median inlet on grade is 1.0 ft, the height of the ditch plug above the top of the inlet.

      Obtain the capacity of the Type I concrete ditch inlet at HW = 1.0 ft from Table 5.3-1.

      Capacity of inlet = 16.5 cfs

   b. Compute the capacity of the crossroad pipe.

      Flowline of pipe at inlet = 3.08 ft below flowline of median (from standard drawing; assumes 3 inch pipe wall thickness)

      Tailwater level in fill section = crown of pipe at outlet

      AHW – TWE = headwater depth + fall in pipe – tailwater depth

      AHW – TWE = 1.00 + 3.08 + 100 (0.005) – 2.0 = 2.58 ft

      Obtain the Manning's n for RCP from Table 6.3.4-2.

      n = 0.012

      Compute the capacity of the crossroad pipe with Equation 5-1.

$$Q = 0.0438\, D^2 \sqrt{\frac{AHW - TWE}{1.5 + \frac{5060 n^2 L}{D^{4/3}}}} = 0.0438(24)^2 \sqrt{\frac{2.58}{1.5 + \frac{5060(0.012)^2(100)}{(24)^{4/3}}}} = 25.3 \text{ cfs}$$

Capacity of crossroad pipe = 25.3 cfs

c. The capacity of the median drain is the lesser of the capacities of the drop inlet and the crossroad pipe.

Capacity of median drain = 16.5 cfs

3. Compute the design flow by the Rational method (Section 3.2).

   Recurrence interval = 10 years (Section 5.2.2)

   Obtain runoff coefficients from Table 3.2.4-1.

$C = 0.40$ for median

$C = 0.90$ for pavement

The composite runoff coefficient is the area-weighted average of the runoff coefficients for the median (48 ft width) and the pavement (36 ft width)

$$C = \frac{48(0.40) + 36(0.90)}{48 + 36} = 0.61$$

Compute the drainage area between inlets for a spacing of 1300 ft.

$$A = 1300\,(48 + 36) = 109{,}200 \text{ ft}^2 = 2.51 \text{ ac}$$

Compute the time of concentration with Equation 11-2. (See Section 3.2.2)

$$T_c = 0.0368 \left(\frac{L}{\sqrt{Sl}}\right)^{0.66} = 0.0368 \left(\frac{1300}{\sqrt{0.02}}\right)^{0.66} = 15.2 \text{ min.}$$

Obtain the rainfall intensity for a duration of 15.2 minutes and a recurrence interval of 10 years for Shawnee County from KDOT's *Rainfall Intensity Tables for Counties in Kansas (2014)*.

By Interpolation i = 4.93 in./h

Compute the design flow with Equation 3-1.

$Q_{10}$ = C i A = 0.61 (4.93) (2.51) = 7.55 cfs (Equation 3-1)

The capacity of the median drain exceeds the design flow, so the inlet spacing of 1300 ft is satisfactory.

4. Determine whether temporary erosion protection is needed.

Compute the 1-year flow by the Rational method with Equation 3-1:

C = 0.61; $T_c$ = 15.2 minutes; A = 2.51 ac (same as for $Q_{10}$)

By Interpolation i = 2.84 in./h

$Q_1$= C i A = 0.61 (2.84) (2.51) = 4.35 cfs (Equation 3-1)

Compute the maximum flow for stability with temporary mulch.

Obtain the permissible shear stress for temporary mulch with silty soil with high plasticity from Table 4.5-1.

$\tau_p$ = 0.25 lb/ft$^2$

Compute the maximum depth for stability with Equation 4-12.

$$d_s = \frac{\tau_p}{\gamma\ S} = \frac{0.25}{(62.4)(0.02)} = 0.20 \text{ ft}$$

Compute the cross-sectional area with Equation 12-2 (B = 0; $Z_L = Z_R = 18$).

$$A = B\ d + \frac{Z_L + Z_R}{2}\ d^2 = 0\ (0.20) + \frac{18 + 18}{2}\ (0.20)^2 = 0.72 \text{ ft}^2$$

Compute the wetted perimeter with Equation 4-4.

$$P = B + d\left(\sqrt{Z_L^{\ 2} + 1} + \sqrt{Z_R^{\ 2} + 1}\right) = 0 + 0.20\ (\sqrt{18^2 + 1} + \sqrt{18^2 + 1}\ ) = 7.21 \text{ ft}$$

Compute the hydraulic radius.

$$R = \frac{A}{P} = \frac{0.72}{7.21} = 0.01 \text{ ft}$$

Obtain the Manning's n for temporary mulch from Table 4.4.3-1.

n = 0.020

Compute the discharge with Equation 4-1.

$$Q = \frac{1.49}{n}\ A\ R^{2/3}\ S^{1/2} = \frac{1.49}{0.020}\ (0.72)\ (0.01)^{2/3}\ (0.02)^{1/2} = 0.35 \text{ cfs}$$

The maximum flow for stability with temporary mulch is less than the 1-year flow, so temporary erosion protection should be specified.