City of Springfield

Drainage Criteria Manual

Open Channels

Adapted from Open Channel presentation by Ian Paton, Wright Water Engineers, 2007

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Overview

- Design Guidelines
- Types of Channels
- Channel Design
- Grade Control Structures

Restored natural channel

Design Probabilities/Flowrates

- 4% AEP Must be contained within the channel
- 1% AEP must be contained within the drainage easement
- Design flowrates assuming fully developed conditions per current zoning
- Upstream detention MAY be considered with approval from Stormwater Services

Upstream Detention

- Upstream detention MAY be considered with approval from Stormwater Services
- Detailed modeling may be required
- Ownership and maintenance must be clearly defined

Flow Regimes

- $F_r < 1.0$ Flow is subcritical
- $F_r = 1.0$ Flow is critical
- $F_r > 1.0$ Flow is supercritical
- F_r for channel design be less than 0.8 or greater than 1.2
- Subcritical channels are preferred
- Check F_r using minimum “n” values for lining material

Table OC-6 Velocity Limitations

Channel Type	Minimum Velocity	Maximum Velocity
Grass, seed and mulch	2 ft/s	4 ft/s
Grass, sod	2 ft/s	6 ft/s
Grass, TRM	2 ft/s	8 ft/s
Grass, pre-vegetated TRM	2 ft/s	10 ft/s
Manufactured hard lining	5 ft/s	12 ft/s
Riprap	5 ft/s	12 ft/s
Concrete	5 ft/s	18 ft/s

Block Lined Channels

Longitudinal Slope

- Acceptable maximum longitudinal slope generally dictated by criteria for:
  - Flow regime (i.e., $Fr < 0.8$)
  - Flow velocity (i.e., type of channel lining)
- Acceptable minimum slope (to minimize ponding):
  - 0.4 percent – for natural linings
  - 0.2 percent – for concrete linings

Slope, cont'd

- Excess velocities require a reduction in slope.
- This may necessitate drop structures
  - Newberry riffle
  - Hard drop
  - Grouted boulder drop

Rock riffle/drop

Concrete vertical drop

Sloping concrete drop

Curvature of Channels

- Minimum radius of three times the topwidth at the design flow (minimum of 100 feet)
- Provide freeboard based on superelevation in curve
- Use minimum ‘n’ value for lining material to determine design velocity

Curvature, cont'd

- Superelevation is computed using:

$$\Delta y = \frac{V^2 T}{2 g r_c}$$

Where:

Δy = superelevation
V = maximum velocity
T = channel topwidth at design flow
r_c = centerline radius of curvature
g = acceleration due to gravity

Freeboard Requirements

- The required freeboard for engineered open channels is dependent on the type of channel:
- Concrete channels, 6 inches above 25-year water surface (subcritical)
- Other types of channels, 12 inches above 25-year water surface
  - (Except for channels where 25-year flow depth is < 12 inches, then freeboard is only 6 inches above 25-year surface)

Other Requirements

- Conditions may warrant additional freeboard
- Low-flow or pilot channels may be required for 2-yr flows > 5 cfs or for unlined grass channels

Riprap Channel Linings

Solve for K value:

$$K = \frac{VS^{0.17}}{(g-1)^{0.66}}$$

Where:

K = Riprap sizing constant

V = Mean channel velocity (ft/sec)

S = Longitudinal slope (ft/ft)

g = Gravitational constant (32.2 ft/sec^2)

Select Riprap D_{50} from table

K Value	Rock Type
< 3.3	VL**(d_{50} = 6 inches)
$\geq$ 3.3 to < 4.0	L**(d_{50} = 9 inches)
$\geq$ 4.0 to 4.6	M**(d_{50} = 12 inches)
$\geq$ 4.6 to 5.6	H**(d_{50} = 18 inches)
$\geq$ 5.6 to 6.4	VH**(d_{50} = 24 inches)

Energy Dissipation

- See FHWA Hydraulic Toolbox for riprap energy dissipation structures such as
  - preformed scour holes
  - Riprap aprons

Summary

- Design flows
- Freeboard
- Velocity Criteria
- Riprap Linings

Questions?