Simple drainage design

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Transverse Slopes

Removes water from pavement surfaces in shortest amount of time possible
Gradient longitudinal direction of highway to facilitate movement of water along roadway
Drains

Collect surface water

A typical intercepting drain placed in the impervious zone
Drainage channels (ditches)

Design

> Adequate capacity
> Minimum hazard to traffic
> Hydraulic efficiency
> Ease of maintenance

Desirable design (for safety): flat slopes, broad bottom, and liberal rounding
Ditch shape

> Trapezoidal – generally preferred considering hydraulics, maintenance, and safety

> V-shaped – less desirable from safety point of view and maintenance
Figure 17.8 Schematic of the Effect of Critical Depth on Flow in Open Prismatic Channels
Flow velocity

- Depends on lining type
- Typically 1 to 5% slopes used
- Should be high enough to prevent deposit of transported material (sedimentation)
  - For most linings, problem if $S < 1$
- Should be low enough to prevent erosion (scour)
  - For most types of linings, problem if $S > 5$
Use spillway or chute if drop in elevation is large.
Rip rap for drainage over high slope
Find expected $Q$ at point of interest
Select a cross section for the slope, and any erosion control needed
Manning’s formula used for design
Assume steady flow in a uniform channel
V = \( \frac{R^{2/3}S^{1/2}}{n} \)

Where:

- **V** is the mean velocity (m/s)
- **R** is the hydraulic radius (m) = area of the cross section of flow (m\(^2\)) divided by wetted perimeter (m)
- **S** is the slope of channel (m/m)
- **n** is the Manning’s roughness coefficient
Side ditch/Open channel design basics

\[ Q = VA \]
\[ Q = \text{discharge (m}^3/\text{s)} \]
\[ A = \text{area of flow cross section (m}^2) \]

US Federal Highways Agency has developed charts to solve Manning’s equation for different cross sections.
Figure 17.6 Graphical Solution of Manning’s Equation for a 2:1 Side Slope Trapezoidal Channel
Open channel - Example

Runoff = 10 m³/sec (Q)
Slope = 1%
Manning’s number = 0.015
Determine necessary cross-section to handle estimated runoff
Use rectangular channel 2 m wide
Open Channel Example

\[ Q = \frac{R^{2/3}S^{1/2}}{n} \]

Hydraulic radius, \( R = \frac{a}{P} \)

\( a = \text{area}, \quad P = \text{wetted perimeter} \)
Open Channel Example

Flow depth = d
Area = 6 m x d
Wetted perimeter = 6 + 2d
\[ Q = \frac{R^{2/3}S^{1/2}}{n} \]

\[ d \approx 1.2 \text{ m} \]

Channel area needs to be at least 1.2 m x 2 m
Find flow velocities?
Alignment and grade of culvert (with respect to roadway) are important
Similar to open channel
Design flow rate based on storm with acceptable return period (frequency)
Any questions?

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