

## Road Drainage

Whether it is concrete, asphalt or gravel, when a road fails, inadequate drainage is often the cause. Shoulders and embankments damaged by heavy rain or floods can allow water to stand on the road or seep back into the base, saturating it. Surface cracks allow water to penetrate and weaken the base. Poor design can direct water back onto the road or keep it from draining away. Too much water remaining in the surface, base and subgrade combine with traffic action to cause potholes, cracks, and pavement failure.

To reduce water damage, build and maintain a good drainage system. **One dollar spent on drainage will save two dollars on maintenance.**

A proper drainage system has four major elements—roadway, shoulders, ditches, and culverts—which you must design, build and maintain.

### Roadway and shoulders

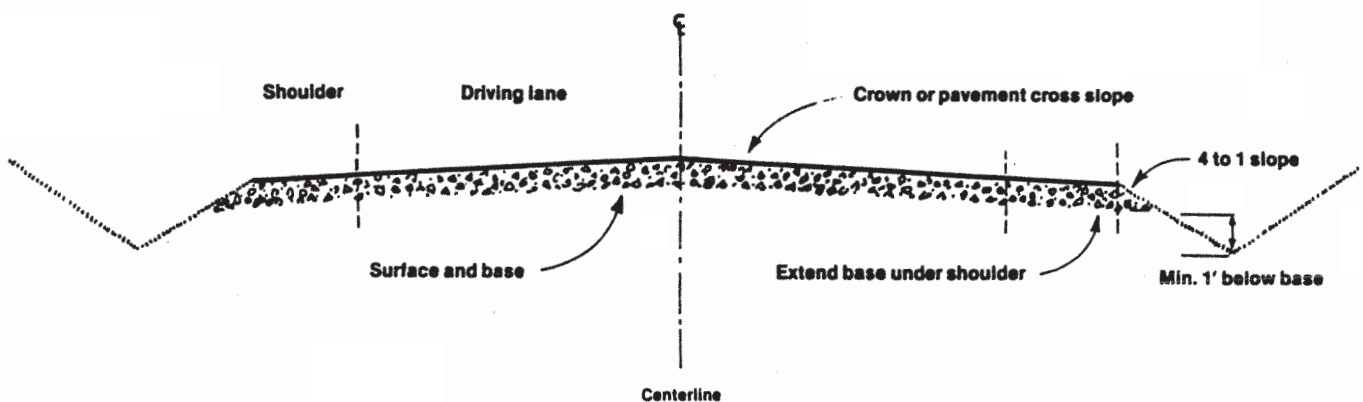
Design and build as a unit the roadway surface, base, and shoulder. One common gravel road construction method, the *trench technique*, causes poor drainage. This technique involves a shallow excavation of just the

intended road surface, then filling it with sub-base and base material. The shoulders are not fully excavated and the original soil is covered with a thin layer of gravel.

The problem is that usually water can't penetrate beneath and through the shoulder subsurface material. These impermeable shoulders keep water from draining out of the roadway's base. Water is trapped and weakens the roadway.

For proper drainage and longer roadway life excavate the shoulders to the same depth as the roadway and make them the same sub-base and base material (see figure below). Use a good draining gravel or crushed rock to remove any water which soaks through the surface or enters the subsurface from ditches.

The road surface should be crowned so water will run off to the shoulders. As a general rule, the roadway crown should be 2½" higher than the shoulder for paved surfaces and 5" to 6" higher for gravel surfaces. Shoulders should slope as much or more than the road to keep water moving to the ditches. For example, a paved roadway with an 11' lane and 4' shoulder should have a total crown (from centerline to outside edge of shoulder) of not less than 3½".



Gravel roads subjected to frequent rains will need higher crowns to prevent the surface from absorbing too much water, becoming saturated, and not drying out. Traffic action on a saturated surface will cause potholes and ruts.

Good quality gravel absorbs only minimal amounts of water, sheds the rest, and dries out quickly. Poor drainage may be caused by gravel with a poor gradation of stones; sand and fines. You can compensate partially for poor quality gravel with a higher road crown.

Steep roads may also require higher crowns since the water will tend to flow down the road flooding traffic lanes, rather than across the crown.

Shoulders extend the road surface, directing water flow to the ditches if they slope as much or more than the crown. If they slope less, water will build up during heavy rain at the join between shoulder and road, flooding traffic lanes. Make sure the shoulder continues the road crown smoothly.

Springs or seepage areas will require special treatment. You can use french drains (rock filled trenches) or perforated pipes to drain this subsurface water into ditches or streams.

## Ditches

Ditches carry water away from the roadway and into streams or other natural waterways. To fulfill this function ditches must be properly shaped for safety, maintenance, waterflow and erosion control. The ditch should be at least one foot below the bottom of the gravel base in order to drain the pavement. Deeper ditches may be necessary to provide positive drainage patterns.

Ditches should extend the shoulders with smooth transition to a shallow foreslope. Sides that are too steep may cause vehicles to roll over and will impede maintenance. Side slopes of 4 to 1 are desirable. 2½ to 1 should be near the maximum slope. A gentle slope makes mowing and ditch cleaning easier, faster and cheaper. Of course flat slopes require a wider right of way.

It's very important that water flow through ditches and not stand. Standing water may saturate the subsurface material beneath the roadway preventing the road from draining during the next storm. Standing water also reduces the ditch's capacity to handle runoff. The next storm could wash out the roadway. Ditches with a 1% gradient are desirable (½% minimum) to insure proper flow.

The flow of water through ditches should not erode the ditch itself or weaken the adjoining shoulder. Vegetation in ditches is necessary to help keep the soil in place and minimize erosion. Use paved ditches if steep slopes cause serious erosion.



**Proper Ditch**

- safe
- higher capacity
- clean with grader
- blends into roadside
- easy to mow



**Improper Ditch**

- less capacity
- must be cleaned with backhoe
- cars can get stuck
- sides cave in

## Culverts

Culverts channel water under the roadway from one side to the other. They help control water flow and slow it down to control erosion. In designing culverts consider: loads and cover, durability and capacity, placement, and gradient.

A culvert must be strong enough to support the fill material above it and the traffic that moves over it. Concrete culvert strength depends on its wall thickness, and the amount of steel reinforcement provided. Steel culvert strength is determined by the depth of corrugations, gauge of steel used, and, to a great extent, on the quality and compaction of backfill material on the sides of the pipe. They should be covered with at least 12" of soil from the top of the pipe to the top of the subgrade. Arch and elliptical pipes or shallow box culverts can be helpful where there is limited depth of cover over the culvert.

A culvert must be durable and have sufficient hydraulic capacity to carry away a predetermined quantity of water in a given time. Design charts are available for each type of culvert. A complete design involves reviewing the topography, predicting runoff, sizing the waterway and culvert, comparing cost to risk of flood



damage. For roadway cross culverts the minimum recommended size is 18". A professional adviser with local experience can save you construction costs and damage claims.

The capacity of a culvert can be improved by altering the entrance configuration. Beveling the edge of the inlet or using side-tapers and slope-tapers can help improve culvert capacity significantly.

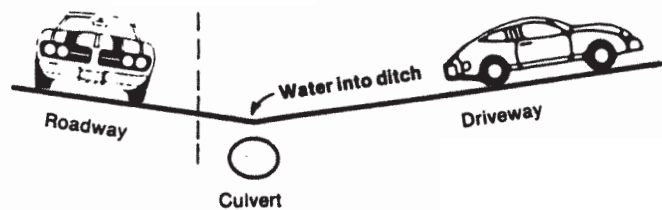
Place culverts so they match existing contours; in the existing channel, if possible. Be extremely careful about changing culvert locations, capacities or drainage patterns. Wisconsin Statutes (88.87) require that highways shall not impede the general flow of surface water. Drainage districts must be notified if any changes or major maintenance work are being planned (Wis. Stats. 86.075). Before replacing culverts located in established flood plains you must also secure prior approval.

They should slope enough so water will flow at about 2½ feet per second. A minimum drop of 6" across the road is desirable. This will keep sediment from accumulating in the pipe but will not cause extensive erosion at the discharge end. Metal aprons or concrete headwalls improve the capacity, reduce erosion and can shorten culvert length.

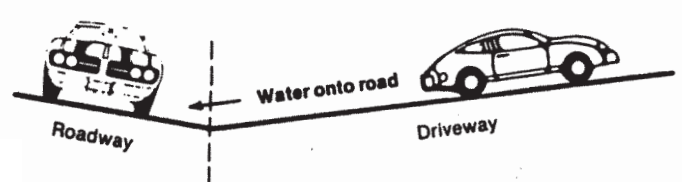
### Driveways

Driveways can block drainage and cause flooding. Culverts should be required to maintain normal ditch drainage. A minimum 18" diameter is recommended.

Driveways should be built so that they either slope away from the road or are graded with the low point over the culvert. This prevents water from washing onto the road from driveways.



Proper Driveway



Improper Driveway

## Maintaining Proper Drainage

Even if a road has been constructed with all the proper drainage design elements, if maintenance is neglected flooding, washouts, and potholes are likely to occur. **To keep a road in good condition, maintain the road surface and shoulders to retain and restore, as nearly as possible, the original design.** This involves smoothing and reshaping gravel roads with a motor grader. Surfaced roads may need periodic patching or overlays.

**Ditches clogged with debris or sediment should be cleaned to avoid overflowing and washouts.** If the ditch has been properly built it will have sides with slopes gentle enough so that a grader can clean it. You will need a backhoe to clear a ditch with steep side slopes. This is more expensive and time consuming than using a grader. Sediments of the same quality as the aggregate mix on the road can be put back onto a gravel road and bladed into the surface.

It's important to mow vegetation and cut brush so it will not obstruct water flow. Also be careful to disturb the vegetation as little as possible when removing sediment from ditches to limit erosion. It may be necessary to re-seed, mulch, or use other erosion protection methods on steep slopes or in areas sensitive to severe erosion. Sediments from eroding slopes can fill other road ditches and culverts or pollute streams and lakes.

**Keep culverts free of sediment to avoid washing out roads and flooding adjacent property.** Preventing sediment from building up in ditches is the best maintenance technique. Clogged culverts can be cleared using hand shovels or mechanized equipment.

Culverts must also be inspected periodically for cracks or corrosion that might lead to failure, and for sediment buildup.

## Summary

Attention to proper drainage design and maintenance on rural roads cannot be over-emphasized. A proper drainage system has four elements—roadway, shoulders, ditches, and culverts—that, working together, prevent water from infiltrating the road surface, remove water from the driving lanes to the side ditches, and carry water away from the roadway. Even roads with all the proper drainage design elements will flood, wash out, and develop cracks and potholes if maintenance is neglected.

- Build and maintain a roadway crown to drain water from the surface:  $\frac{1}{4}$ " per foot of width for paved roads,  $\frac{1}{2}$ " per foot of width for gravel roads.
- Avoid the trench technique of construction. Extend the roadway base to the outer shoulder edge.
- Use ditches with gentle side slopes for vehicle safety, to minimize erosion, and to aid maintenance.
- Design culverts to handle soil and traffic loads and appropriate drainage volume. Good design saves money.
- Maintain the pavement and culverts to perform as originally intended.
- Keep ditches clean for efficient water flow.
- Inspect culverts regularly. Inspection after a heavy rain will give the most information on your drainage problems.
- Maintain natural surface water flow conditions and coordinate improvements with local drainage boards.

*References: Information and figure sources include: Okalahoma State University fact sheet D-1020, Kentucky Transportation Center Link newsletter, and St. Michaels College fact sheet T-610.*

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