One Dollar Spent On Drainage Will Save Two Dollars On Maintenance

Proper drainage is probably the most important element in road design

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 on 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 the roadway surface, base, and shoulder as a unit. One common gravel road construction method, the trench technique, causes poor drainage. This technique involves the shallow excavating of just the intended road surface, then filling the excavated surface with subbase and base material. The shoulders are not fully excavated and the original soil on the shoulder 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 the diagram on this page). 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 two and one-half inches higher than the shoulder for paved surface and five to six inches higher for gravel surfaces. Shoulders should slope as much or more than the road to keep water moving to the ditches. 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 at the joint between shoulder and road during heavy rain, flooding traffic lanes. Make sure the shoulder continues the road crown smoothly. For example, a paved roadway with an 11-foot lane and four-foot shoulder should have a total crown (from centerline to outside edge of shoulder) of not less than three and one-half inches.

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.

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, water-flow, 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 impede maintenance and cause vehicles to roll over. A gentle slope makes mowing and ditch cleaning easier, faster, and cheaper. Side slopes of four to one are desirable. Two and one-half to one should be near the maximum slope. Of course, flat slopes require a wider right-of-way.

It is 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.

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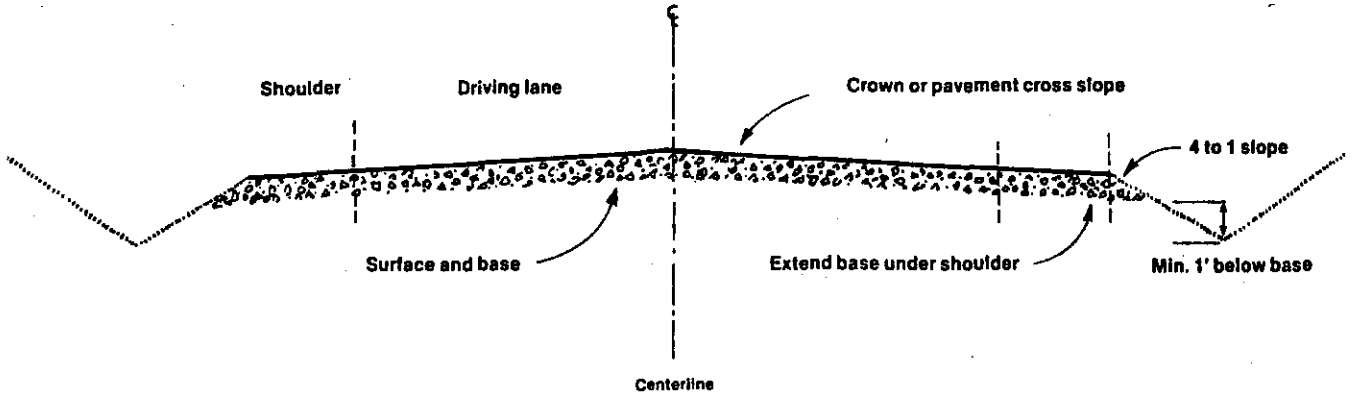

- safe
- higher capacity
- clean with grader
- blends into roadside
- easy to mow

Proper Ditch

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

Improper Ditch

Drainage...
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Standing water also reduces the ditch's capacity to handle run-off; the next storm could wash out the roadway. Ditches with a one percent gradient are desirable (one-half percent 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.

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, cover, durability, 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 wall thickness and the amount of steel reinforcement provided. **Steep culvert strength is determined by the depth of corrugations, gauge of steel used, and, to a great extent, the quality and compaction of backfill material on the sides of the pipe.** They should be covered with at least 12 inches 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, and comparing cost to risk of flood damage. For roadway cross culverts, the minimum recommended size is 18 inches. When you decide to design a culvert, a professional advisor 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. Before replacing culverts located in established flood plains, you must also secure prior approval.

Culverts should slope enough so that water will flow at about two and one-half feet per second. A minimum drop of six inches across the road is desirable. This will keep sediment from accumulating in the pipe at the discharge end. Metal aprons or concrete headwalls improve the capacity, reduce erosion, and can shorten culvert length.

Driveways

Poorly designed driveways can cause drainage blocks and flooding. Culverts should be required to maintain normal ditch drainage. An 18-inch minimum 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 into the road from driveways.

Maintaining Proper Drainage

If maintenance is neglected even on a road that has been constructed with all the proper drainage design elements, flooding, washouts, and potholes are likely to occur. **To keep a road in good condition, maintain the road surface and shoulders as nearly as possible to 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. It's important to mow vegetation and cut brush so that 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 reseed, 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.

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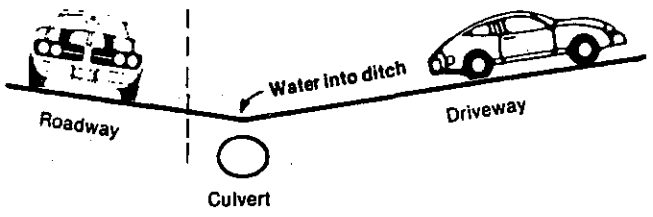
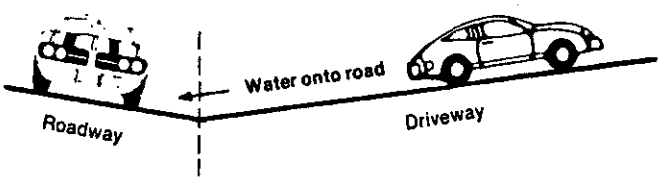


Proper Driveway



Improper Driveway

Diagnostic Aid For Drainage Problems

IF YOU SEE:	IT USUALLY MEANS:	YOU SHOULD:
Scour at Inlet	Pipe too small. Pipe clogged. Poor location.	Schedule for larger pipe. Clean. Relocate. Until corrected, schedule for frequent cleaning and check for rust.
Scour at Outlet	Too much grade. Pipe too small. Pipe in poor condition.	Build stone apron at outlet end. Check invert for wear or rust. Schedule for repair/replacement.
Standing Water	Not enough crown on road.	Clean clogged drains. Remove standing water by brushing. Clean or deepen ditches. Check drains often.
Rusting/Corroding	Water high in acid. Scour from water flow.	Clean pipe. Coat with asphalt. Contact district for acid test for water.
Edge Cracking	Not enough shoulder. Road too narrow.	Cut and stabilize shoulders.
Alligator Cracking	Sub-base is saturated. Too much load on roadway.	Cut and shape shoulders. Schedule for pipe placement. Treat surface.
Trash at Inlet	Pipe clogged.	Clean trash away. Clean ditches for 15 feet on both sides of inlet.

Drainage...
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Summary

Attention to proper drainage design and maintenance on rural roads is crucial and cannot be overemphasized. A proper drainage system has four elements—roadway, shoulders, ditches, and culverts—which, 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. However, even roads with all the proper drainage design elements will flood, wash out, and develop cracks and potholes if maintenance is neglected.

Some quick tips for helping to design and maintain good road drainage:

- Build and maintain a roadway crown to drain water from the surface: one-fourth inch per foot of width for paved roads or one-half inch 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 to minimize erosion, aid maintenance, and improve vehicle safety.
- Design culverts to handle soil and traffic loads and appropriate drainage volume. Good design saves money.
- Maintain the pavement and culverts so they 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: Oklahoma State University Fact Sheet D-1020, Kentucky Transportation Link Newsletter, Vermont Local Roads Program Fact Sheet T-610, and Wisconsin Transportation Bulletin Fact Sheet Number 4.

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