

Gravel Roads

More than a quarter of Wisconsin's local road miles are unpaved. They can be found in agricultural areas and forests, and even in many cities and villages. While they only carry a small portion of the state's traffic, they are a vital first link in the local economy.

A "good" gravel road has a good surface, a proper crown, and adequate drainage. Its good condition is maintained by periodically smoothing and reshaping its surface and shoulders. This bulletin describes the characteristics of a gravel road and how to maintain one.

Surface

A properly blended road gravel will produce a good surface. Good road gravel has three elements: gravel, sand, and fines (clay and silt). A good blend has a mixture of all three sizes.

The **gravel** or stones can be any rock-like material down to ¼" in diameter.

Sands range from coarse, a maximum of ¼" in diameter, down to fine, .074mm in diameter (about the smallest size you can see with your naked eye). Sand is granular and the grains have little attraction to each other.

Silt is actually a very fine sand, the consistency of flour. Silt particles range from 0.074mm down to 0.005mm in diameter. Because it also is granular there is no cohesion between grains. Therefore, silts compact very poorly and have little or no dry strength.

Clay's microscopic particles are cohesive. Moist clay becomes sticky and can be rolled into a ball. It is almost impermeable to water flow and has low strength when wet.

Is your gravel "good" or "bad"?

You can take samples from the gravel pit and submit them to a testing lab to analyze the gradation and amounts of stone and sand. In addition, with some experience you can inspect the samples yourself. Are the stones different sizes or are they all one size? Does there seem to be an equal number of stones of each size? Are there lumps of clay, silt, or other contaminants (like dark, soft organic material)? Do the fines (silt and clay) stick to your hands? If so, it's "dirty" gravel and may not be useful for roads because too many fines will give poor stability and drainage.

Good road gravel needs gravel, sand, and silt in the proper proportions to: support traffic loads, resist abrasion, shed water, and enhance the soil's ability to absorb and disperse water. There must be small sands and fines to fill the voids between the larger stones so the mixture can be compacted.

The percent of each component in good gravel can vary with the source but in general there should be:

- 40%–80% hard stone, uniformly graded from ¼" to 3" diameter;
- 20%–60% sand, smaller than ¼" in diameter; and
- Fines should be 8%–15% of the total gravel weight.

Types of gravel

Pit run gravel has been taken out of a natural deposit, very often an old stream bed. **Screened gravel** is pit run gravel with oversized stones removed. (The maximum size stone in a gravel mixture should not exceed two-thirds of the thickness of the layer being placed on the road.) **Washed gravel** is gravel in which excess fines are removed by water. **Crushed gravel** is made by breaking stones into uniform gradation.

Crushed Rock

In some parts of the state good quality natural gravel is not available. Then crushed rock from a rock quarry is used. Well graded crushed rock will have qualities and performance similar to gravel.

Blending

For a good all-weather surface, road gravel must be properly blended. Blending allows the stones and fines to compact together forming a hard, durable surface crust to carry the traffic load and shed water.

To blend, blade the road surface when it is moist, cutting with a grader to a depth of 2"–6". Moisture makes blading easier, and causes the fines to cement the stones into a crust. Too much moisture during blading will cause the crust to break up, reducing its load-carrying capacity and leading to rapid surface deterioration.

Crown

The crown is the most important design element of a gravel road. A proper crown can enhance a road's usefulness, improve drainage, and ease maintenance.

In a proper crown the center of the road is higher than the shoulders and the road slopes in a straight, uniform line to each shoulder edge. The road center should be $\frac{1}{2}$ " to $\frac{3}{4}$ " higher than the shoulders for each foot of lane width. For example, a 20' wide road (two 10' lanes) would have a 5" to 7" crown. This degree of slope should drain surface water without washing off surface material.

Without a proper crown, water saturates the surface instead of draining off. Vehicles travelling on a saturated, unpaved surface will create ruts. As these ruts increase in number and size, the road will become very

rough, and its usefulness will be diminished. Blading the road with a grader will remove the ruts and restore the crown to its proper shape.

Drainage

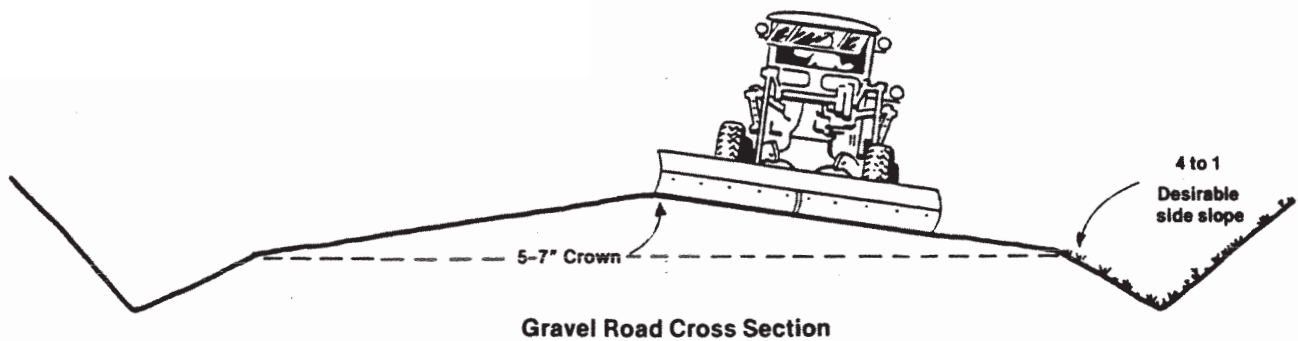
Proper side ditch and cross surface drainage are also important. Without proper drainage, road surfaces become rutted, surface materials wash away, and roads can become flooded and impassable.

Compaction of a proper crown and surface material affects cross surface drainage. If the crown is designed properly, then water will run off and onto the shoulders. Well compacted surface material has fewer voids to absorb water and lets most of it run off.

The shoulders, (see figure) should also be constructed of aggregate. The shoulder must slope as much or more than the crown for good drainage and to prevent water from flowing back toward the road surface.

Ditches collect run-off from shoulders and carry it to streams and other natural drainage locations. The right-of-way usually limits ditch sizes. The most common and economical to build ditch shape is a V. Look at the figure. The foreslope of the ditch (next to the shoulder) must slope at least as much as the shoulder and usually more to prevent water from flowing back onto the shoulder. A slope of between $2\frac{1}{2}$ to 1 and 4 to 1 is desirable. The backslope may be steeper than the foreslope. A good cover of vegetation helps ditches resist erosion, but you should keep at least the foreslope and ditch bottom mowed so water flows properly.

When ditches become clogged with sediments, clean them to avoid overflowing and possible washouts. A grader is most economical if the ditch slopes are not too steep. Some of the fines may be remixed with the road gravel to replace fines that have been blown away.



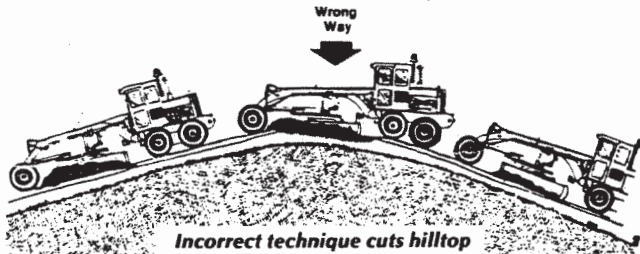
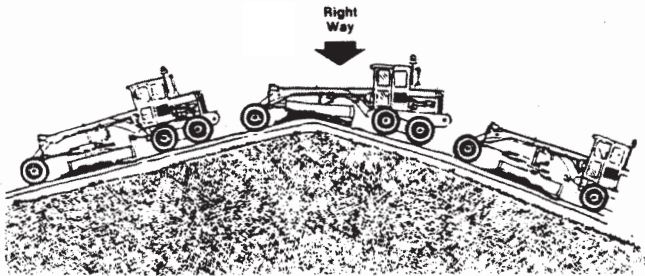
Gravel Road Cross Section

Blade road to maintain smooth riding surface and good drainage

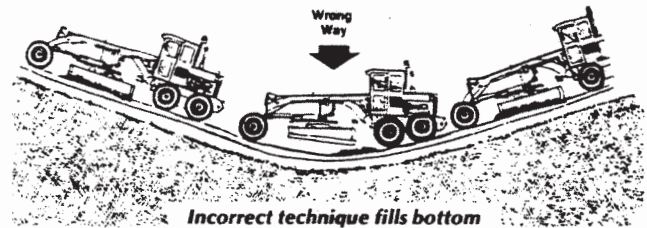
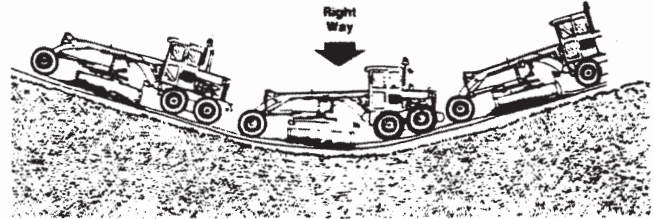


Operator Tips

- When smoothing or dragging the road, tilt the moldboard forward 15 degrees. This will reduce rut depth and help compact the gravel.
- When reshaping, use the moldboard in the upright or cutting position. The gravel must be moist so traffic can compact it.
- To prevent gravel build up, occasionally blade bridge approaches and intersections in the opposite direction. Be very careful and use traffic warning signs.
- To avoid cutting the tops of hills, gradually raise the blade after the front wheels pass over the top of the hill. Gradually lower to normal position as rear wheels pass over the top of the hill.



- Shift into lower gear when going downhill to slow grader and reduce bouncing.
- To avoid filling in the bottoms of hills, gradually lower the blade after the front wheels pass the bottom and start to rise. Gradually raise the blade as the rear wheels reach to bottom of the hill.



- Match driveways with shoulder edges and avoid bumps in the road from driveways.
- Maintain super-elevation (banking) around curves and make the transition to normal crown 50' -100' back from the curve in both directions.
- Be sure the motor grader has a slow moving vehicle emblem and use the revolving cab lights.

Maintenance

Good maintenance is crucial to the life and quality of an unpaved road. Use changes its original shape: the crown is flattened, chuck holes develop, and surface materials are blown, plowed or washed away.

While a correctly designed and built paved road will last for years with little maintenance, an unpaved road must be maintained almost from the beginning. The road surface and shoulders must be smoothed and reshaped, usually with a motor grader, as often as necessary for the amount and kind of use the road receives.

The crown is the most critical design element that grading tries to restore. Every motor grader should be equipped with a level bubble so the operator can correctly judge the crown slope.

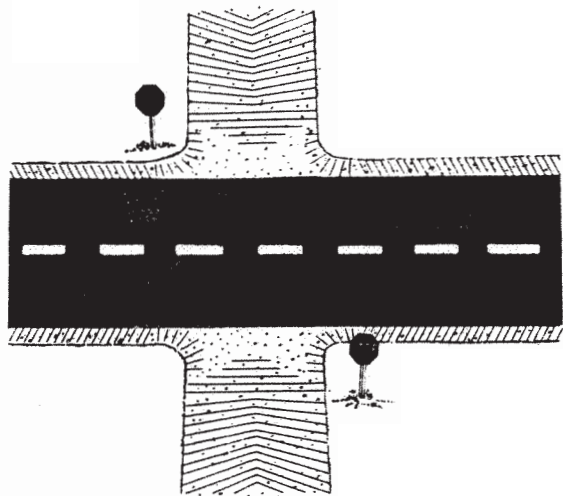
When grading consider the moisture content of the surface and the speed of the grader. Surfaces worked

when they are too dry will not compact and chuckholes will quickly redevelop. Surfaces worked when they are too wet may not be stable. A damp surface is best. If the grader is operated too fast, the blade will bounce, creating a washboard effect on the road surface. Therefore, the operator should keep his speed low enough so the blade doesn't bounce. Three m.p.h. is recommended. The operator should also be careful that the edge of the blade doesn't leave a berm or windrow which will keep water from running into the ditch.

Special grading techniques

A bridge may or may not have a crown shape, but seldom has as much crown as the road. Starting 50' to 100' from the bridge, the operator must gradually reduce the crown to match the bridge and must also avoid dragging surface material onto the bridge.

At intersections with through roads, the through road crown should be continuous. The crown on the side road should be gradually removed on its approach, matching its grade to the shoulder elevation of the through road. At the intersection of two minor roads, the crown is usually removed from all approaches.



Railroad crossings require similar techniques as bridges. It is more critical, however, that surface material not be dragged onto the rails.

Washboards, chuckholes, dust and weeds

Rainwash and vehicle windwash remove the fines from the surface and start washboarding. This can be corrected by reshaping the road surface. Sometimes you must also add gravel.

Improper drainage usually causes chuckholes or potholes. Fix them by filling the holes with a mixture of half sand and half graded gravel up to one-half inch in diameter. Overfill the holes slightly to compensate for compaction and tamp the fill with the wheels of a truck before reopening the road to traffic.

Much of a gravel road's surface can be lost as dust stirred up by wind. Adding calcium chloride to the road surface attracts moisture from the air and helps keep dust settled. It also creates a harder, more durable surface by keeping small particles moist and cemented to the larger ones.

Weeds and grass tend to creep into the road near the shoulder line in late summer and early fall. After prolonged dry weather and with insufficient moisture to blade, these weeds can be a major problem at the first blading. They drag under the blade, making it very difficult to leave a smooth surface, and then end up in a large berm. You may need to blade more frequently or use chemical herbicides to solve the problem.

Summary

Gravel will provide a good all-weather surface when the roadway is properly constructed and maintained. The amount of maintenance needed relates partly to how well the road is constructed.

When building a gravel road, pay close attention to surface material quality, crown design, and drainage adequacy.

No matter how well a road is constructed, it will need some regular maintenance. During maintenance use special techniques for such road features as bridges, intersections, and railroad crossings. Washboards, chuckholes, dust, and weeds are unique to gravel roads and will require particular attention.

- Not all gravel is good road gravel.
- Good gravel is hard enough to resist breaking down under traffic and forming dust.
- Good road gravel contains a uniform mixture of gravel, sand, and fines: 40%–80% stone uniformly graded, 20%–60% sand, and 8%–15% fines.
- For an all-weather road, blend different size aggregates so the pieces can compact into a strong, dense surface crust.
- Proper blending is done by blading the top 2" to 6" of road surface when it is moist. You may need to add aggregate or fines.
- A proper crown provides drainage. The center of the road is higher than the shoulders and slopes straight and uniformly to the shoulder edge on either side. A crown of 5" to 7" is desirable.
- Ditches should have a "V" shape and should be mowed and cleared of sediments and debris to prevent washouts.

References: St. Michael's College fact sheets T-225 and T-510. Iowa D.O.T. slide and tape training series.

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