PennDOT LTAP
technical
INFORMATION
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MAINTENANCE OF GRAVEL ROADS

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A properly constructed and maintained gravel road will provide a good all-weather road in rural communities where traffic is lighter.

What type of material is needed for a durable, low-maintenance unpaved and gravel road? A durable aggregate.

Remember that not all aggregate is good for use as a driving surface. Aggregate used as a driving surface is different than aggregate used as a subbase course. Some aggregates may break down into fine pieces under heavy traffic, break down or swell when wet, fracture when frozen, or be so hard that they are difficult to work.

A good aggregate is hard enough so that it doesn't form dust but loose enough to drain. It supports the weight of traffic and distributes traffic loads sufficiently that it doesn't destroy the subgrade. But is it suitable for a driving surface?

Selecting Material

Some certified aggregates are appropriate for subbase only and will not create a stable matrix that will properly crust. Using these materials on an unpaved or gravel road could cause erosion, potholes, and other damage.

PennDOT 2A aggregate

AASHTO 57 (PennDOT 2B)

Materials such as PennDOT 2A, 2A (Modified), and 2RC are "well graded" and incorporate aggregate of different sizes, including a larger top size material and smaller percentage of fine material. Although they provide good strength and drainage, they were developed to be used as a subbase course and are not intended for use as a driving surface on unpaved and gravel roads.

Likewise, materials such as AASHTO 8, 57, and 67, which are "uniformly graded" and predominantly the same sizes, were developed as structural aggregates for other uses, such as concrete, hot-mix asphalt, and bituminous chip seals. These materials may provide good strength when bound with cement or asphalt, but they also are not for use as a driving surface on unpaved and gravel roads.

When using standard PennDOT aggregate specifications intended for use with asphalt and concrete roadway construction as a driving surface on an unpaved or gravel road, a host of problems can result, including the following:

- The material will not form a surface crust to bind the material together.
- The road becomes difficult to maintain.
- A significant loss of aggregate due to traffic action occurs.
- The material is less durable when exposed to traffic, and dust and sediment result.

Aggregate durability and drainage characteristics are very different for unpaved and gravel roads. For these kinds of roads, Pennsylvania developed a driving surface aggregate (DSA) specification in the late 1990s through early 2000s with minor modifications to the specification continuing today. This specification provides:

- Even distribution of aggregate to achieve density, strength, and durability.
- A smaller top size aggregate.
- Intermediate size aggregates to fill voids.
- More fines to bind the material together and aid in compaction.
- Less aggregate loss due to traffic action.
- A more durable material with less dust and sediment.

DSA and material requirements for unpaved and gravel roads are found in Publication 447, Section MS-0450-0004. The specification provides a blend of different size aggregates, including fines. The different sizes allow the material to lock together, creating a unified mat.

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Municipalities using liquid fuels monies to purchase DSA must obtain the material from a source listed in PennDOT Bulletin 14. All materials require a material certification (MS-447A).

Aggregate gradation must fall within the ranges in the specification.

Aggregate	2"	1-½"	1"	¾"	½"	⅜"	4	8	16	100	200
PennDOT DSA		100%		65-95%			30-65%		15-30%		10-15%

In addition, quality control of DSA is required. All aggregates must meet the following quality control criteria:

Durability (hardness) – Harder aggregates are less likely to break down under traffic and create dust and sediment affecting stream quality.

pH (acidity/alkalinity) – The material's pH can affect water quality of nearby streams. Aggregate must be within the pH range of 6 and 12.45.

Soundness (resistance to disintegration by sodium sulfate) – The soundness test determines an aggregate's resistance to disintegration by weathering and, in particular, freeze-thaw cycles.

The recovery of aggregate from recycled concrete is not allowed; 95 percent of the aggregate mix must be derived from the crushing of clean rock material. If 10 percent of the aggregate mix does not pass the #200 sieve, the quarry can add up to 5 percent external source material, approved by the engineer, to the mix. Neither clay nor silt can be added to the mix, and the material must not exceed the plasticity index (PI) rating of 6.

Placing New Material

To place the DSA on the subgrade of a road, use a paver (the preferred method) or approved spreading equipment that doesn't cause segregation. The aggregate must be placed to a minimum uncompacted depth of 6 inches and a maximum uncompacted depth of 8 inches in one lift.

A paver is the preferred method for placing DSA on the subgrade.

The cross-slope should be placed at 4 to 6 percent or ½ to ¾ inch per foot to facilitate water movement across the rougher surface.

The material is to be delivered and placed at an optimum moisture content of plus or minus 1 percent as determined for that particular source. The optimum percentage moisture is determined using the standard proctor test.

Maintaining Gravel Surfaces

Although unpaved and gravel roads provide excellent service for low traffic and light vehicles, heavy-traffic volumes and loads can cause these roads to fail, even when properly maintained, especially in wet weather.

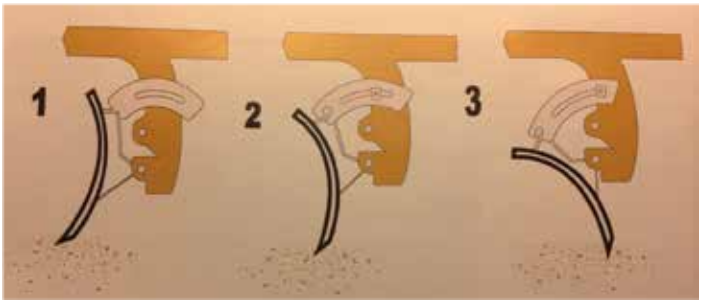
Gravel roads are generally maintained by routine smoothing and reshaping with a grader and adding gravel as needed either by "spot graveling" or regraveling entire sections. However, almost any gravel road gradually begins to show distress over time that requires more than routine maintenance to correct.

At certain intervals, virtually every gravel road requires some major rehabilitation, which involves reshaping the road surface as well as the shoulder area and possibly the foreslope and ditch. This work may be accomplished with motor graders only, depending on the extent of work needed to reestablish a good cross-section on the roadway. Compaction equipment is always helpful. If material must be removed, loaders or excavators and trucks are needed.

Blading/Smoothing – Road surfaces are smoothed by dragging without breaking the hard surface crust. A dragging, rolling action created by the curve of the grader's moldboard helps compact the road as it is blended. Smoothing is done when aggregates and fines are moist.

Properly blended gravel and fines will dry to form a hard crust that provides a wearing surface. The crust carries the traffic load and sheds water until it is broken. Traffic and climatic conditions will completely break the crust over time. Reshaping will be necessary to rebuild the crust.

The speed at which a grader operates or can blade effectively will depend on the type of grader, its tire pressure, and the condition of the road surface. Going too fast will cause the grader blade to bounce, creating roughness in the road surface known as corrugations.



MOLDBOARD PITCH:

1) Blade in upright vertical position provides for aggressive cutting.

2) Blade, slightly angled forward, allows for spreading of material.

3) Blade, angled sharply forward, allows for light blading or dragging.

Smoothing Procedure

1) Determine the road length for smoothing.
2) Place temporary work zone traffic control.
3) Tilt the moldboard forward to create a dragging action.
4) Angle the moldboard at 30 to 45 degrees to spread the loose material.
5) Tilt the front wheels 10 to 15 degrees from vertical in the direction the aggregate is rolling across the blade.
6) Repair minor defects by hand.
7) Consider periodically blading the surface against traffic to eliminate aggregate drift at bridges, culverts, intersections, and railroad crossings.

Reshaping – Unpaved and gravel road surfaces are reshaped to remove surface irregularities, restore roadway cross-slope and drainage, and remix the aggregate to improve surface stability. Reshaping is necessary when the aggregate cannot be smoothed to provide an acceptable riding surface. It should be done when the aggregate and fines are moist. The grader blade should cut well below the potholes and corrugations.

A grader is used to reshape the road surface of an unpaved or gravel road.

Reshaping involves remixing the aggregates to get a proper blend of fines and different size stones and then blading and compacting this blended material into a properly crowned road surface. When remixing, it may be necessary to add more aggregate.

The art of proper blending is not a cut-and-dried proposition. Experience is the best guide to correct blending. The quality of the crust and its length of useful life depend on the skill used in blending coarse and fine materials and moisture to form the desired crust.

A good aggregate is hard enough so that it doesn't form dust, **but loose enough to drain.**

After the gravel is mixed, it is reshaped by blading to restore a proper crown and smooth surface. A proper crown has the center of the road higher than the shoulders and a straight, uniformly sloped line from the center of the road down to the shoulder edge on either side.

Keeping a crown on the road is probably the most important part of blading. Without a proper crown, water will stand and soak and soften the road surface.

Improving Drainage

A properly drained gravel road must have sufficient or adequate crown and shoulders.

The crown is the part of the roadway shape in which the center of the road is higher than the outer edge of the road surface; it is measured in cross-slope. Sometimes referred to as a "straight A shape" or "flat A shape," cross-slope is a measurement of the percentage crown in the road. It is typically displayed in percent or inches per foot. The shoulder is typically graded with a greater cross-slope than the roadway.

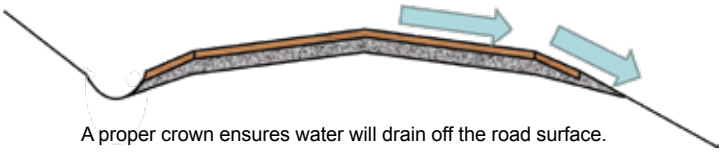
The typical cross-slope of a paved roadway is 2 percent or ¼ inch per foot. In contrast, the typical cross-slope of an unpaved or gravel roadway, which requires additional cross-slope to facilitate water movement across the rougher surface, is 4 to 6 percent or ½ to ¾ inch per foot.

How much crown is enough? Problems develop quickly when a gravel road has no crown. A proper crown ensures water will drain off the road surface. Without it, water will quickly collect on the road surface during a rain event or snow melt and

Reshaping Procedure

1) Determine the road length for reshaping.
2) Check if additional material needs to be added to the roadway.
3) Place temporary work zone traffic control.
4) Tilt the moldboard backward to cutting position.
5) Angle the moldboard at 30 to 45 degrees to spread the loose material.
6) Tilt the front wheels 10 to 15 degrees from vertical in the direction the aggregate is rolling across the blade.
7) Put enough down pressure on the blade to cut shoulders and corrugated ridges.
8) Scarify the surface, if required.
9) Provide additional passes, as needed.
10) Windrow remixed material to the center of the roadway.
11) Add additional material, as needed.
12) Distribute aggregate evenly, blading the material to the proper crown.
13) Grade shoulder with cross-slope equal to or greater than the roadway.
14) Remove excess material, as required (bridges, intersections, etc.).
15) Compact surface aggregate with a roller.

will soften the crust. Water retained in the roadway surface can lead to rutting that can extend down into the subgrade.



A proper crown ensures water will drain off the road surface.

Shoulders, which are the additional width of material along the outside edge of the road, direct water away from the driving surface and provide support and stability for the edges of the roadway. Shoulders also offer additional safety for motorists by providing recovery for vehicles that stray from the roadway.

Shoulders are typically either gravel or vegetated and should be graded at equal or slightly greater cross-slope to facilitate drainage.

As an extension of the road surface, the shoulders allow water to run in sheets from the center of the road, off the sides of the road and shoulder, and into the ditch. When constructing and maintaining roads, be careful not to form a secondary ditch by leaving a ridge of materials between the road surface and the ditch.

Dust Control

An unpaved and gravel road that has dust blowing from it is a form of erosion. Dust occurs when larger material breaks down or existing fines are eroded away by the wind. This means the road is deteriorating.

With an average daily amount of traffic, untreated unpaved and gravel roadways on average lose up to 1 inch of surface per year. This is equal to approximately 500 tons of materials per mile of eroded and lost material. Such loss of aggregate gravel can cost thousands of dollars per mile each year for just materials.

A municipality may find it more economical to stabilize a road with an approved dust suppressant, calcium chloride, emulsion, cement, or other stabilizing agent. Not only is it more cost-effective in the long run, but it also keeps the roads in better condition.

Dust indicates the road is deteriorating.

In addition to stabilizing the roadway and reducing maintenance costs, a dust control program improves safety and reduces harmful effects to crops, the environment, vehicles, and people.

Note: Do not apply used motor oil for dust control as it is toxic and can enter the groundwater.

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Contact LTAP at 1-800-FOR-LTAP (367-5827) or **www.ltap.pa.us** for more information or technical assistance on maintaining gravel road surfaces.

REFERENCE:

U.S. Department of Transportation, "Gravel Roads Construction & Maintenance Guide," August 2015. Available on the LTAP website, www.ltap.state.pa.us.