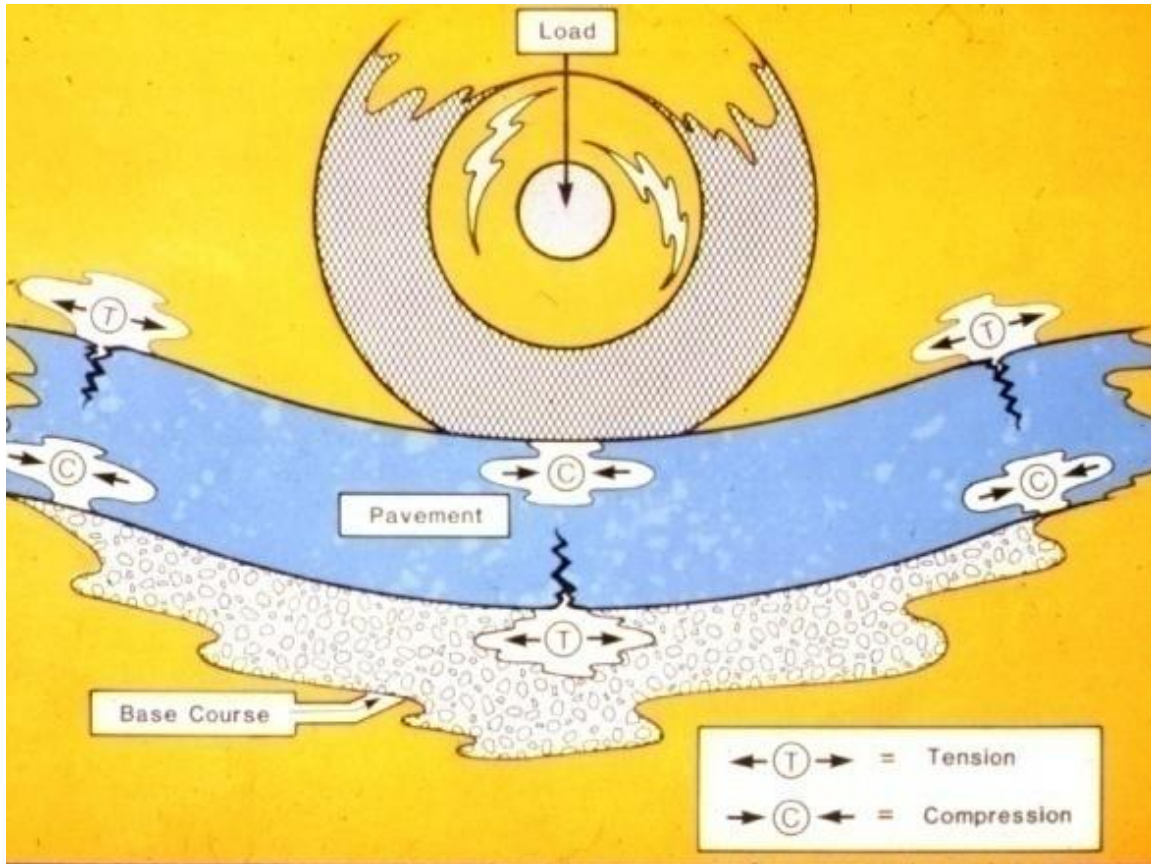


A Common Sense View of Fairbanks, Alaska Gravel Road Problems



FNSB, Rural Service



DOT&PF, RD&T2

A Common Sense View of Fairbanks Gravel Road Problems

This handout helps you recognize gravel road problems and problem causes. It presents information that can help you construct a good gravel road and preserve it's intended as-built condition.

The terminology issue of "construction" versus "maintenance" is avoided. Instead, the term "preservation" or other synonyms are used. In other words:

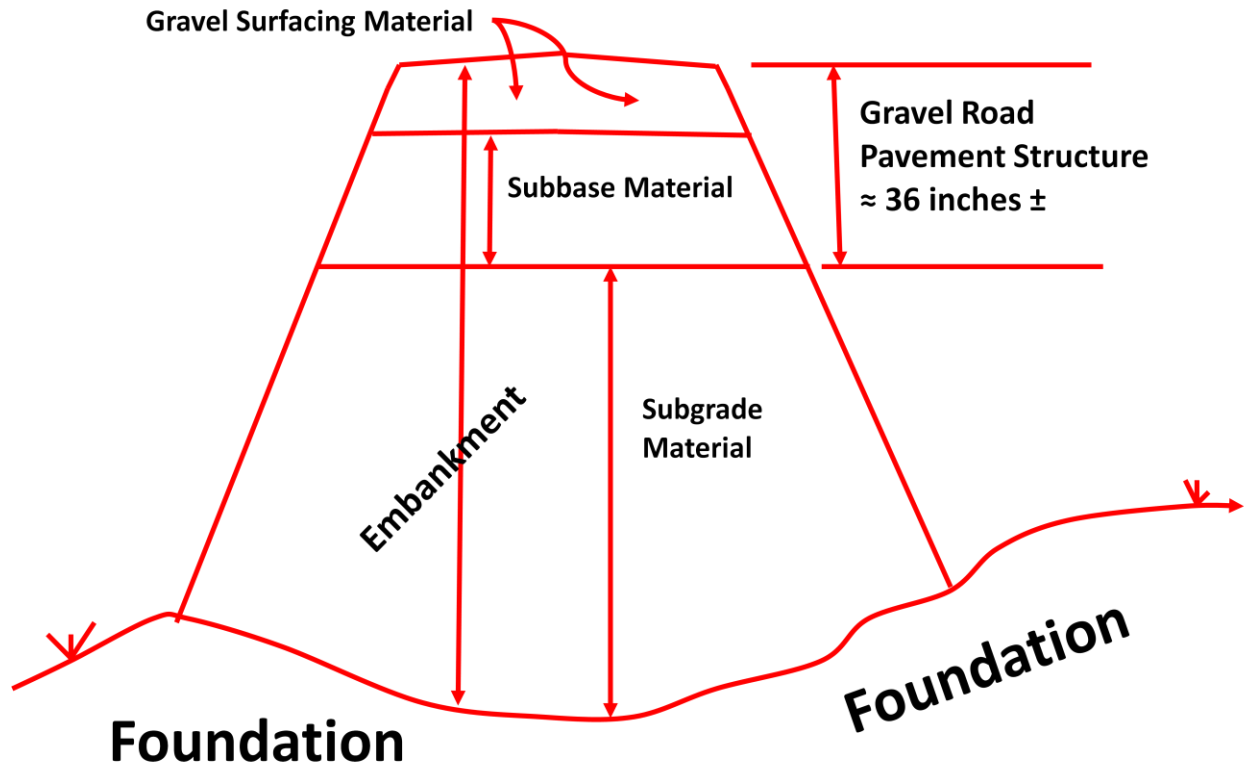
Maintenance + Reconstruction = Preservation, i.e., general upkeep including all types of gravel road repairs.

First rule-of-thumb: Common sense rules, but a little technical background doesn't hurt.

Gravel Road Nomenclature

The diagram on the following page identifies layers of the gravel road's pavement structure (gravel surfacing and subbase material) and the underlying portion of the gravel road embankment (subgrade). The pavement structure is the upper portion of the embankment, and should be constructed from relatively high quality materials that will withstand many live loads imposed by vehicle traffic without significant permanent deformation. As the term indicates, a "live load" is caused by vehicle movement, and includes forces due to acceleration, stopping, bouncing, etc. With respect to gravel road wear and tear, a live load is much more severe than the standing "dead" load of a parked vehicle. Subgrade materials perform a much easier job. They are deep enough in the embankment that they do not "feel" the live load influences of normal traffic loads.

The quality of materials and construction effort put into the pavement structure determines the gravel road's ability to successfully handle a given type and number of vehicles. With reasonable attention to routine upkeep, the gravel road pavement structure discussed in this document is intended to provide 15 or more years of good service for a majority of the Borough's lightly trafficked local service roads.



Gravel Road Problems

Problems can be “built in”

- Poor design-engineering
- Poor construction practices.

Problems can accumulate with time and road use

- Foundation related failures
- Vehicle-caused wear/tear
- Various kinds of drainage deficiencies/malfunctions
- Poor preservation practices.

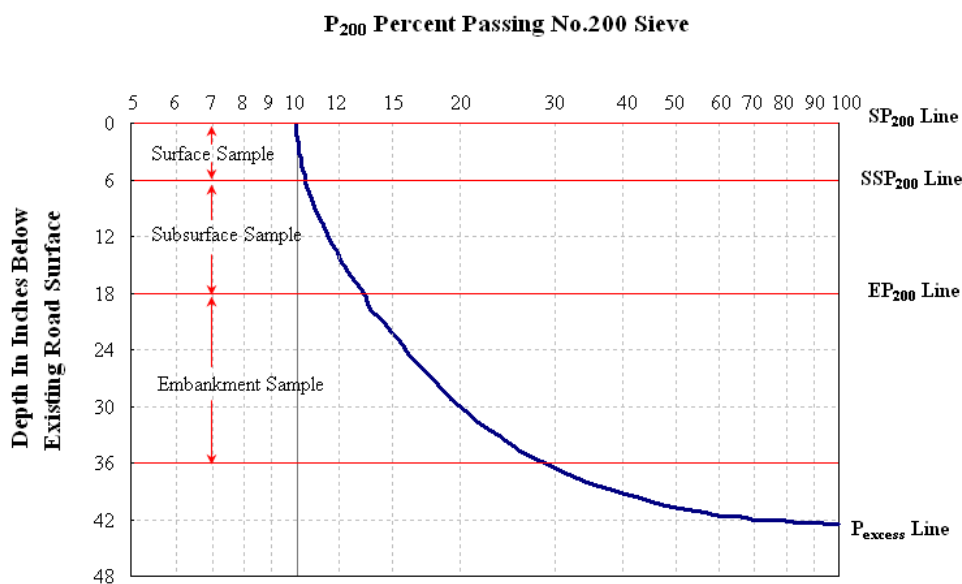
What we need to know about gravel road problems

- How to recognize various types of problems (appearance, morphology)
- How to recognize the cause of each problem type (mechanism)
- Whether to fix a particular problem or fix the cause of that problem (preservation strategy)
 - Preservation strategies are extremely cost-dependent
 - High costs of some work mean you are often forced to repeatedly fix the problem itself and ignore the cause

Simplified Summary of Gravel Road Requirements

For a new gravel road

1. You need a good designer, construction contractor, as well as good quality control during construction
2. Locate road where major foundation problems are not present
 - a. Need good engineering and maybe good luck to boot
3. Plan for excellent drainage of water off of and away from the roadway
 - a. Well engineered ditches and culverts
 - b. 3% crown (FNSB Engineers recommend 4%)
 - c. 18" to 24" of freeboard (nominal vertical distance between road surface elevation and natural ground, ditch bottom, or road-adjacent pond surface)
4. Use 4" to 6" of good surfacing material
 - a. See Appendix section about surfacing material
 - b. Crushed, -1", well graded gravel with enough fines (12 to 14% minus #200 sieve size) to promote good compaction
 - c. Should contain a cohesive binder (most Fairbanks area materials do not)
5. Under the surfacing material—at least 24 inches (ideally 30" +) of readily compactable subbase material that does not exceed the minus #200 limitations at various depths according to the following plot. Non-frost-susceptible fill materials (see Appendix) can be substituted for this requirement. This requirement prevents springtime thaw weakening and is a necessary concession to living in Alaska.
6. Preservation practices that truly maintain all of the above in "as-built" condition



Allowable Fines Content at Any Depth within the Pavement Structure

Minimal preservation for an existing gravel road

1. Pick a good preservation contractor
2. Provide for good drainage of water off of and away from the roadway – to the extent possible
 - a. Reestablish 3% roadway crown
 - b. Evaluate sufficiency of drainage adjacent to the roadway, and repair or upgrade wherever necessary
3. Problem type:
 - a. Springtime soft areas: Consider 18” to 24” existing material removal. Replace with non-frost-susceptible material (see # 5 above) and surfacing material (see # 4 above)
 - b. Summer/fall soft areas: Drainage improvements will likely help this
 - c. Normal rutting: Ruts happen. Periodic grading is required
 - d. Dust: Replace or augment existing surfacing material with better surfacing material (see #4 above). Or consider use of dust palliative with existing surfacing material
 - e. Corrugations: Grade to **below the bottom** of existing corrugations then recompact
 - f. Foundation (permafrost) problems: Add additional material as necessary to relevel the gravel road surface – sometimes this problem decreases or stops with time
4. Reestablish originally designed superelevations (may be expensive)
5. If funds are very scarce, reset speed limit to be compatible with actual safety and material conditions

Most important

- **DRAINAGE, DRAINAGE. DRAINAGE** (Ref: H. R. Cedergren, *Seepage, Drainage, and Flow Nets*, 1977)

Sources of Gravel Road Problems

1. Poorly Design Regarding: Road Alignment/Safety Features (Geometrics, Obstructions, Signs, Lights), Drainage, and Materials
2. Drainage Deficiencies (road surface and roadside)
3. Ice-Rich Road Foundation Conditions
4. Substandard and/or Degraded Road Construction Materials
5. Poor Construction Practices
6. Poor Preservation Practices (Maintenance and Reconstruction Practices)

Classes and examples of common gravel road problems

1. Problems due to poor design

- Accidents
- All problems listed in following items 2 through 4

2. Problems due to poor drainage

- Erosion
 - Rills
 - Gullies
 - Piping
- Potholes
- Ruts
- Soft areas

3. Problems due to foundation settlement

- Bumps/Dips
- Cracks
- Slope failures
- Ruts

4. Problems due to substandard and/or degraded road construction materials

Related to surfacing material

- Airborne dust production (could be in a class by itself)
- Loose surface rock – surface raveling
- Loss of surfacing material (usually to shoulder or sideslope) – surface raveling
- Breakdown of surfacing material (abrasion, crushing, dissolving)
- Contamination (contaminated with underlying material)*
- Soft areas*
- Ruts*
- Corrugations

Related to pavement structure materials below surfacing material

- Soft Areas (often with frost boils and seepage showing up at the road surface)*
- Ruts*
- Ruination of surfacing material by reworking and/or contamination *

5. Problems due to poor construction practices

Specification violations and sloppy materials handling affects all other problem areas

6. Problems due to poor preservation practices

Specification violations and sloppy materials handling affects all other problem areas

Most common

- Contamination (grader operators going too deep)
 - Dust
 - Ruts
 - Soft Areas
 - Corrugations
- Loss of crown (poor control of surface topography))
- Loss of superelevation (poor control of surface topography)
- Loss of adequate road surface drainage (poor general control of surface topography)
- Insufficient late-winter snow pack removal (road surface must readily drain water from thawing snow pack)

** Problems often due to—or accentuated by—Alaska’s seasonal freeze/thaw*

Best times to examine a gravel road

During or immediately after heavy rain event (to evaluate drainage)

During spring thaw (to evaluate drainage and thaw-related problems)

During a prolonged dry period (to evaluate dust)

Examination of the gravel road during all three conditions is necessary for a full evaluation of its condition prior to major preservation efforts.

Minimizing Problems Due to Poor Design and Construction

Poor design can be the root cause of any or all other problems. Verifying poor design usually requires a technical specialist – an independent engineering design review. Minimize design problems by having the design done by a reputable engineering design firm. Hire one that has Fairbanks area gravel road design experience.

Like design problems, poor construction practices can be the root cause of any or all other problems. During or after construction, some aspects of the design can be checked fairly easily by an engineer or surveyor:

- Horizontal alignment
- Vertical alignment
- Superelevation
- Crown
- Safety accoutrements: signs, lighting, etc.
- Drainage features

Of course these items should be checked, as part of good quality control, during construction.

On the other hand, materials specification and handling problems cannot be easily identified immediately after construction. If major problems exist, they will become evident with time. Avoid construction related materials problems from the start of construction. Require and maintain good inspection, sampling, and quality control practices during construction.

Design and construction problems will be very expensive to correct after construction.

Preservation Methods by Problem Type

Corrugations

Comments: Can be dangerous and damage vehicles. Particularly persistent in high speed segments of the road that are both steep and curved. Common and persistent at locations where road changes from pavement to gravel surfacing.

Recommended for Temporary Repair: Grade below bottom of corrugations, and re-compact. Deep corrugations may require addition of new surfacing material (see Appendix, surfacing material).

Recommended for Permanent Repair: If existing materials are to be left in place, first grade to below bottom of existing corrugations, then add soil stabilization agent (see Appendix, soil stabilization) and re-compact. A better alternative is to first grade out the corrugations, and then add 4' to 6" inches of crushed, well graded gravel containing a cohesive binder (see Appendix, surfacing material). In areas where corrugations consistently reappear, permanent repair may ultimately require upgrading the offending roadway segment to asphalt concrete pavement.

Erosion (rills, gullies, piping)

Comments: This includes damage to the road surface as well as the embankment sideslopes. Lack of effective drainage. This problem can be minimized by simply getting storm water or water from snow melt off of the roadway surface as quickly as possible without concentrating the flow.

Recommended: Establish or re-establish 3% crown wherever the road is not in superelevation. Late-winter maintenance should blade snow and hard pack to the embankment's sideslope area prior to Fairbanks' spring "breakup."

Springtime Only, Very Soft Areas and Deep Rutting

Comments: Usually related to loss of pavement structure strength due to thaw weakening during the springtime breakup period. A less serious form (usually less serious) of springtime softening can be caused by poor drainage of snow melt from the roadway surface or ponding of thaw water adjacent to the roadway. Assume that thaw weakening is the culprit if surface drainage or ponding problem is not obvious. Vehicle action on very soft surfacing material will most likely destroy the design properties of that material and require replacement of surfacing material as part of the repair.

Recommended for Snow Melt or Ponding: Improve drainage of road surface by re-establishing crown. Make sure that late winter maintenance clears ice pack and snow from road surface to prevent damming of melt water.

Recommended for Thaw Weakening: Remove approximately 18" of existing material. Replace with new surface course material and the remainder of the 18" thickness with non-frost-susceptible fill material (see Appendix sections on non-frost-susceptible and surfacing material).

Summertime, Very Soft Areas and Deep Rutting — Road Surface Usually Damp or Wet Appearing

Comments: Constant or repeatedly reoccurring damp or wet areas are usually drainage related.

Recommended: Evaluate drainage conditions. Re-establish a 3% crown if it has been lost. Check that existing drainage features are functioning properly in the vicinity of the problem area. Ditches may need cleaning or other repairs. Culverts may need repair or replacement. Ponding adjacent to the roadway should be drained if possible, or the road should be raised to provide a minimum 24" of freeboard between the nominal road and pond surfaces.

Summertime, Very Soft Areas and Deep Rutting — Road Surface Usually Dry Appearing

Comments: Usually related to surface course degradation. Often presents a combination of visually-obvious problems. The following are almost always most noticeable during dry periods:

- airborne dust
- minor rutting of sandy or silty appearing surface material
- loose surfacing material

- loss of surfacing material
- breakdown of surfacing material (abrasion, crushing, dissolving)

Recommended: The surfacing material requires some form of cohesion (glue). The cohesive agent can act temporarily or permanently. Examples of cohesive agents include: water, calcium chloride, proprietary soil stabilization additives, and clays. Replace or augment existing surfacing material with better surfacing material. An alternative is to treat existing surfacing material with soil stabilization additives. See Appendix sections on surfacing material, dust palliatives, and soil stabilization.

General Minor Rutting

Comments: Normal occurrence for most gravel roads.

Recommended: Non-aggressive routine grading when rutting exceeds about $\frac{3}{4}$ "

Potholes

Comments: Usually associated with poor drainage of roadway surface

Recommended: Surface regrading is required that must include re-establishment of 3% crown (and re-establishment of correct superelevation wherever necessary).

Embankment Slope Failures, Cracks, Bumps/Dips

Comments: On flat or gently sloped terrain, usually caused by thawing of ice-rich permafrost foundation soils and subsequent settlements. Settlements are often highly variable in depth and spacing, as is the ice content of most foundation soils before thawing. Less common in the Fairbanks area are embankment slope failures caused when embankments are constructed along steeply sloped terrain and/or if high embankments themselves are constructed with sideslopes that are too steep (usually steeper than 1.5 horizontal : 1 vertical). Very complicated embankment stability problems can sometimes develop that involve both thawing permafrost and embankment construction across sloped terrain.

Recommended: For temporary repairs in relative flat areas where simple permafrost thaw settlements are the culprit, replace settled fill material with suitable gravel fill as needed. Fill used within the critical subbase and surfacing layers must be suitable for those purposes as discussed above. Also see Appendix sections on subbase and surfacing materials. Unless the settlements are very deep, it may be expedient to use subbase material for all leveling except the upper 4" to 6" inches of surface course. This form of temporary repair may eventually become permanent if the thawing process slows considerably or stops. A serious attempt at

permanently stopping thaw settlement problems in areas of newly constructed roads will require additional foundation investigations, engineering design and, likely, a large expenditure.

Very severe, continued settlements and embankment failures (with or without permafrost involvement) on steep slopes require engineering design work, and permanent repairs will be costly.

Minimizing Problems Due to Poor Preservation Practices

Comments: Poor preservation practices can negatively affect gravel road quality in a big way.

Contamination of Surfacing Material:

Sometimes difficult to distinguish between this and breakdown of sub-standard surfacing material. Be alert for changes in gradation of surface course material following maintenance grading. In the Fairbanks area, some Birch Creek Schist aggregate breaks down easily when worked by grading and/or compaction equipment.

Other problems include:

Loss of crown (poor control of surface topography))

Loss of superelevation (poor control of surface topography)

Loss of adequate road surface drainage (poor general control of surface topography)

Insufficient late-winter snow pack removal (road surface must drain thaw water)

Recommended: Monitor maintenance grading, and reduced grading if before/after graded material is different. Material spoiled by the contamination process is not reclaimable without reprocessing (rescreening). The contamination process is not reversible although it may be possible to successfully treat contaminated surfacing material with soil stabilization and/or dust palliative additives — an expensive alternative to monitoring the contractor.

Watch out! Realize that nearly all freshly graded gravel roads look good — and that is itself a problem:

Results of poor preservation practices might not become evident for some time after the work is done. Avoid problems by remaining vigilant while the work is underway. Keep in mind that poor preservation practices can impact your road as much as shoddy design/construction and poor materials.

Combinations of Problems

When you evaluate gravel road condition, you will usually find that more than one problem exists. Common sense rules in deciding what sort of repairs to do. There are no hard, fast rules in this process, except that you are always trying to return the road to an acceptable standard at the least cost. A few examples will illustrate a reasonable viewpoint.

Combination of Observed Problems	Possible Solutions
Summertime dust + springtime very soft	Fixing the soft condition by removing and replacing significant thickness of pavement structure will also require new surfacing material.
Absence of crown + minor potholing + rutting	Reestablishing the crown with addition of new material also gets rid of the potholes/rutting. The new crown keeps water from ponding on the road surface that can lead to more potholes/ruts.
Summertime soft areas (wet) + absence of superelevation + excessive roadside ponding	Add material including new correct surfacing to reestablish superelevation. Provide or improve ditching.
Embankment cracks/ dips/shoulder failures + bad potholes + ruts + summertime dust + loss of crown + springtime softening	Permafrost foundation failure can require an expensive fix. If economically possible, fix the foundation problem and then reestablish road with proper design. If foundation fix is not possible, and foundation deterioration is ongoing, then avoid wasting money by simply adding appropriate fill and regrading the road surface periodically.
Minor rutting + overgrown ditches	Periodically regrade road surface. Also, always keep ditches clean.

Considering Geosynthetics

First, be aware that there are many kinds of geosynthetics that might be usefully applied to construction and/or repairs of gravel roads. Some of the most common types include geotextiles (cloth-like materials), geogrids, geocomposites, geomembranes and geocells. A Google search of the Internet or a recent textbook on geosynthetics (Ref: Holtz, Christopher, and Berg, "Geosynthetic Engineering", 1997) will explain the characteristics and appropriate uses of the various geosynthetic types. With the proper evaluation and engineering design,

geosynthetics can save a lot of money and cure or prevent many problems. Applied improperly, they can be a complete waste of money.

It is recommended that you not use geosynthetics on your gravel road project without consulting an engineer knowledgeable and experienced in the use of those products.

Useful Rules-of-Thumb

An Ideal Gravel Pavement Structure

- 4 - 6 inches of gravel surfacing
 - see rule-of-thumb for ideal gravel surfacing aggregate
- 30 inches Subbase
 - limit minus #200 according to critical fines plot if possible, compacts fairly well
- These materials types should be well compacted when placed.
- Material deeper than bottom of pavement structure can be almost anything that is not muck, highly organic, non-compactable.

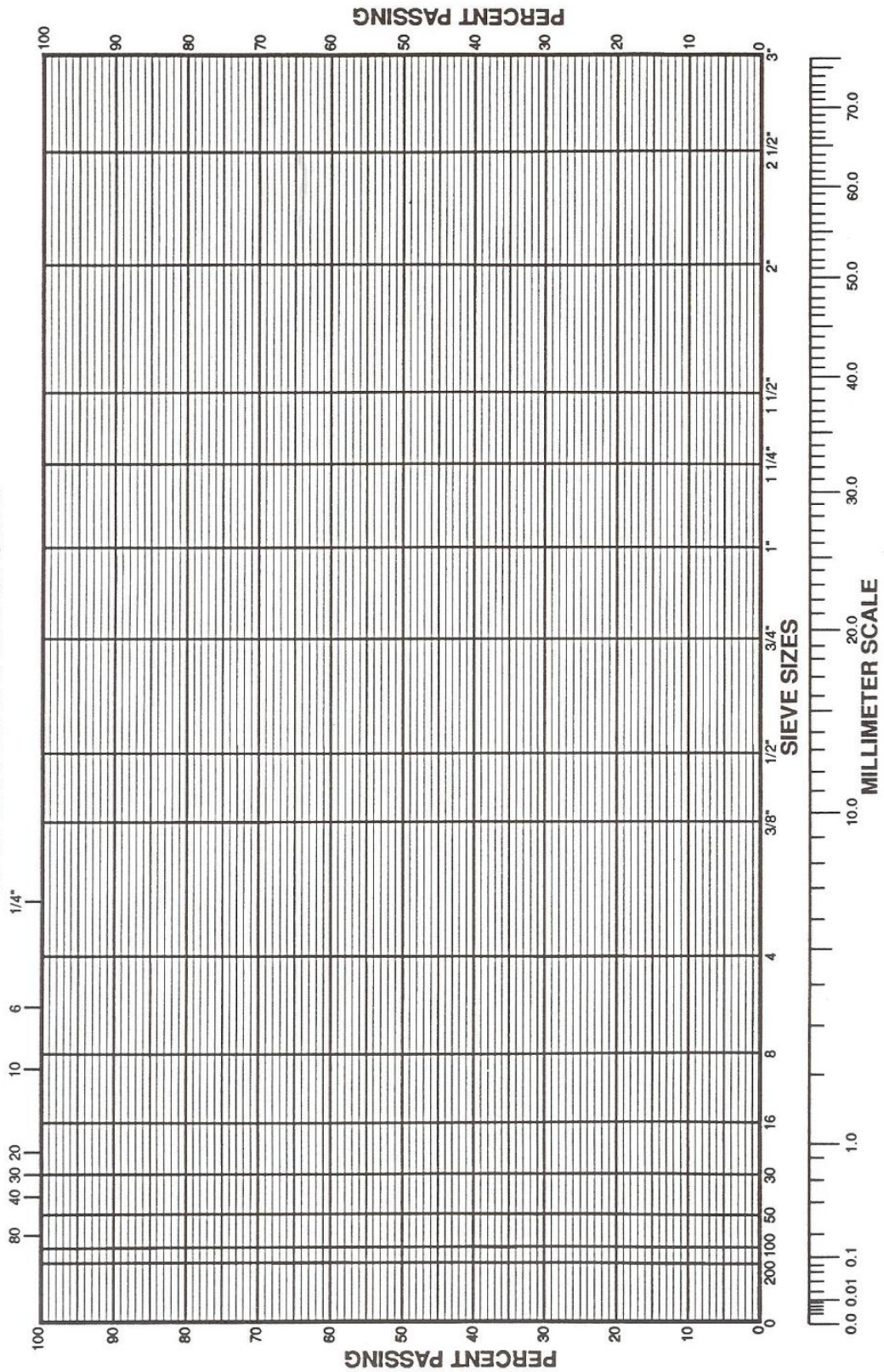
An Ideal Gravel Surfacing Material

- high quality aggregate
- particles not flat or elongated
- 100 % minus 1 inch
- 10 to 14 % minus #200 size
 - (maybe 12 to 14% is best)
- contains up to 3 % clay (minus 0.002 mm) size—or other form of cohesion (glue)
- well graded aggregate (plots as straight line on 0.45 power paper)

Specifications for the Various Layers

- For Surfacing Material: See Appendix for surfacing material specifications
- For Subbase Material: See Appendix for non-frost-susceptible fill specifications
- For Subgrade Material: Use ADOT&PF specification 703-2.07, Selected Material Type A, B, or C (whatever's cheapest)

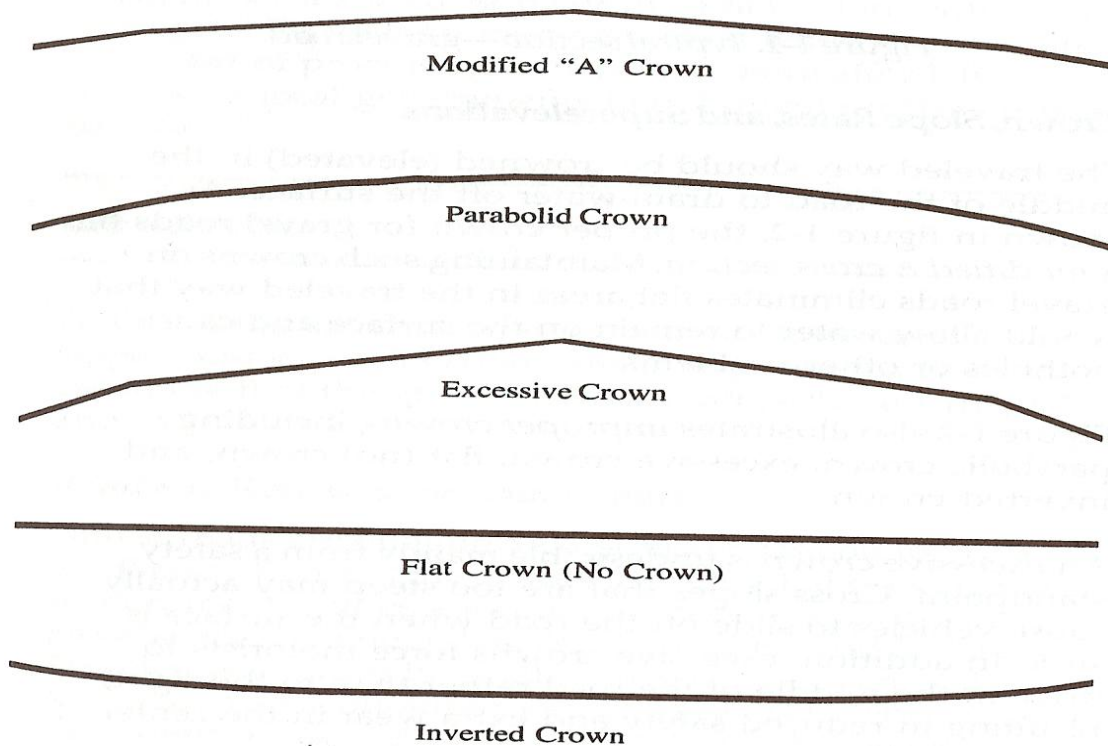
NATIONAL CENTER FOR ASPHALT TECHNOLOGY (NCAT)
GRADATION CHART
SIEVE SIZES RAISED TO 0.45 POWER



Useful Rules-of-Thumb for Getting Water Off the Road Surface

- Proper cross section for road surface
 - “A” crown with 3 % cross slope (FNSB Engineers recommend 4%)
 - what about superelevation?
 - A good crown must always be maintained.
- Allow no berms to form along downhill edges of roadway.
 - summer—for rain
 - spring—for snow/ice melt

Types of Crown

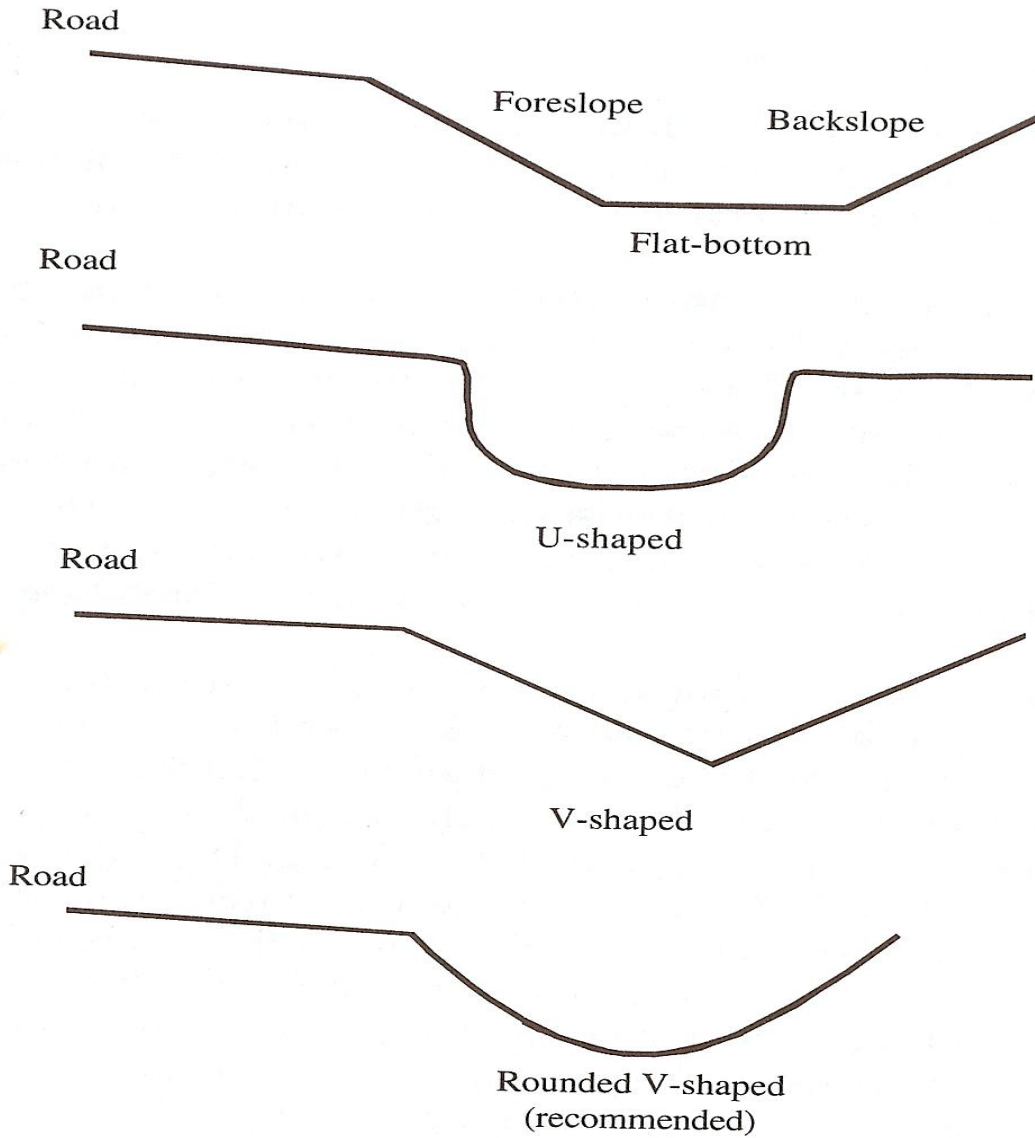


Useful Rules-of-Thumb for Getting Water Away from the Road

- A good ditch is a road’s best friend
- Design to insure freeboard.
 - 2 feet ±
- Select a good ditch shape and maintain it.
 - flat or modified “V” bottom may be best
- Culverts must be compatible with ditch design

- Keep ditches clean
- Be aware of environmental issues with ditch runoff.
 - Whatever the requirements today, they will be more strict tomorrow!

Common Ditch Shapes



APPENDIX

The following information was obtained and modified from: McHattie, Robert L., *Evaluating and Upgrading Gravel Roads for Paving*, Matanuska-Susitna Borough Engineering Guide, 2010.

Upgrading from Gravel to Pavement

From Guide Preface:

*“Fact: Given **sufficient preparation**, nearly any gravel road can be paved with a minimal-thickness hot mix asphalt concrete pavement or even a low cost asphalt surface treatment (AST), and it can be relied on to survive low-volume traffic for a decade or two. What does “sufficient” mean in terms of design and materials? And, perhaps more importantly, how much is “sufficient” going to cost?*

This engineering guide provides tools to aid evaluation, development and management of Matanuska-Susitna Borough’s gravel-to-pavement projects.

The guide serves an additional purpose. It documents the engineering bases for design features and specification requirements used in certain Matanuska-Susitna Borough construction contracts in case of legal disputes.”

The Engineering Guide is a relatively small “PDF” file (less than 1 Megabyte) and is available for download from the Alaska University Transportation Center’s Internet URL:

http://www.alaska.edu/uaf/cem/ine/autc/gravelRoads_finalEval.pdf

Some Specifications for Non-Frost-Susceptible Fill

Very Good Fill:

This is a readily compactable granular material that meets or exceeds the requirements of Alaska Department of Transportation & Public Facilities (ADOT&PF) Highway Construction Specification 703-2.09 for Subbase Course, Gradings A, B, C, or D. Fill material meeting Base Course C-1 and D-1 requirements of ADOT&PF Specification 703-2.03 is acceptable.

ADOT&PF Highway Specifications can be downloaded as a “PDF” file from the Internet:

<http://www.dot.state.ak.us/stwddes/dcspsecs/assets/pdf/hwyspecs/english/2004sshc.pdf>

Some Specifications for Surfacing Material

If a decision is made not to pave the gravel road, the Borough may decide to evaluate and/or upgrade the existing road's gravel surface. In its 2004 Standard Construction Specifications for Highways, ADOT&PF offers two gravel surfacing gradations. These are listed as gradings E-1 and F-1 in Section 703-2.03 *Aggregate for Base and Surface Course*. Surfacing material must also meet the quality requirements for base course in that specification section. There are a few rules of thumb for gravel surface course materials that have worked in Alaska:

- Use well graded gravel with a maximum particle size of 1 inch
- The P₂₀₀ content should probably be in the 10% to 14% range although ADOT&PF allows 8% to 20% depending on grading.
- Require material that compacts well – ideal material will plot as a straight or nearly straight line on 0.45 power paper (obtainable from regional offices of ADOT&PF materials engineers).
- The best surface course materials contain a small percentage of natural clay (not more than 2 to 3%).

Regarding the last item above, there is a problem that is common to most Alaska gravel materials with respect to use as gravel surfacing, i.e., lack of natural cohesion. Lack of cohesion means that even those gravel surfaces made using well-graded, densely-compacted material likely produce a lot of dust. Dust is an environmental problem and the raveling caused by loss of fines leads to considerable material loss over time. Presence of a small amount of natural clay provides cohesion. It is possible to obtain cohesion by adding commercially-available montmorillonite clay or other commercial “stabilizer” additives to existing gravel. Correct dosage rates for clay or any other stabilizers must be determined, by testing, for a specific gravel material.

Information About Dust Palliatives

In today's literature you can find many documents dedicated to the subject of soil stabilization in general and dust palliatives in particular. Keep in mind that dust palliatives are simply a specialized application of soil stabilization technology. For the sake of simplicity, the writer picked two, reasonably definitive, and useful documents for reference in this section.

The Dust Palliative Selection and Application Guide written for the U.S. Department of Agriculture, Forest Service

This manual is available by download from the USDA Internet site:

http://www.airquality.nrcs.usda.gov/Documents/USFS_DustGuide.pdf

Section IV, *Dust Control and Stabilization* of South Dakota's Maintenance and Design Manual. This manual is available by download from the Federal Government's EPA Internet site:

<http://www.epa.gov/owow/nps/gravelroads/>

As of this writing, the Matanuska-Susitna Borough uses calcium chloride (CaCl₂) as a dust palliative for gravel roads with an application rate of about 6 tons per centerline-mile on 2-lane roads.

ADOT&PF's Northern Region M&O uses calcium chloride to treat 2-lane gravel roads with annual application rates usually ranging between 5 and 10 tons per centerline-mile – most commonly 5 to 6 tons per mile. ADOT&PF may use an initial application rate of nearly 10 tons/mile for new gravel road surfaces (surfaces previously untreated with CaCl₂).

Sodium montmorillonite (brand name, Stabilite) was used more than 10 years ago as a surface course stabilizer/dust palliative for the Fort Yukon runway. With occasional grading, it provided more than a decade of acceptable, relatively dust free service. The montmorillonite was added to the surface course gravel at about 3 percent, by total weight, of treated surfacing gravel.

Common materials, such as calcium chloride or montmorillonite clay, may be your safest bet as a reliable dust palliative although many other materials are available. Be aware that proprietary dust palliatives may need extensive testing before they can be accepted for routine use. Be sure to require an MSDS as part of evaluating any proprietary products.

Information About Soil Stabilization

Use methods described in the Alaska Soil Stabilization Design Guide by R.G. Hicks to select a base course stabilization method that is most compatible with the materials you are using. The ADOT&PF's Soil Stabilization Guide is available by download from the Internet site:

http://www.dot.state.ak.us/stwddes/research/assets/pdf/fhwa_ak_rd_01_06b.pdf

The ADOT&PF has found that a mixture of frost susceptible base course and 2 to 3 percent (by total weight of mix) asphalt cement will produce a non-frost-susceptible base course. For this to work, the original base course must be an otherwise acceptable, well graded, compactable gravel material.

Many other stabilizers, including a number of proprietary synthetics, etc., may do a good job of stabilizing a frost susceptible material. Selection criteria:

- Compatible for use with the material to be stabilized (see ADOT&PF Stabilization Guide referenced above)
- Nontoxic, environmentally acceptable, etc., based on information contained in its material safety data sheet (obtain MSDS from Internet)
- Meets or exceeds U.S. Cold Regions Research and Engineering Laboratory (CRREL) “low” heave rate classification (≤ 2.0 mm/day, 48 to 72 hour average heave rate, ADOT&PF frost heave test method)