2019 NTTIIC

Solutions for Gravel Road Maintenance with Linear crushers

Big Sky, Montana
September 18, 2019
THE FIRST 5 DAYS AFTER THE WEEKEND ARE THE HAREST
Brief Background of presenter
Acknowledgements

The original “Gravel Roads Maintenance and Design Manual” was published in 2000. It became an invaluable resource for managing gravel surfaced roads throughout the Nation and in other parts of the world. As in all fields, change occurs and resources need to be updated.

This revised manual has been produced as a joint effort by the Federal Highway Administration (FHWA) and the South Dakota Local Technical Assistance Program (SDLTAP) located at South Dakota State University in Brookings, SD. New information was gathered from local agencies across the United States and from other countries. In addition, current photographs have been included to this update.

Acknowledgment and appreciation is extended to the technical review committee, which helped guide this revised manual.

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Photos:
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Additional Credits:

Managing Gravel Road Maintenance
TRB Webinar – April 10, 2012

Presented by:
Mr. Ken Skorseth, Program Manager

SD Local Transportation Assistance Program (LTAP)
South Dakota State University
Brookings, SD

Plus many other sources....
Gravel Road Maintenance
Addressing the problems
Silk purse  Sow’s ear
Session agenda

• Meet and greet
• What is good gravel?
• Equipment Toolbox
• Maintenance for Drainage
• Innovations
• Wrap up
America is composed of three groups:

1. 30% are pulling the wagon
2. 40% are riding in the wagon
3. 30% are walking behind trying to take the wheels off the wagon

Which group are you in?
What are the Challenges you face?

Equipment
Manpower
Training
Resources
Weather
Other
The #1 Problem With a Gravel Road:

It’s not a paved road!
BUT... gravel roads have an advantage...

They are Not set in concrete!!!!

We can alter.... grades, drainage, alignment and in some cases surface materials with minimal expense. But we usually do not have the funds to do much at all????
“Nearly 80% of the roads in the US have traffic volumes of 400 vehicles per day or less.”!! (quote from Little Green Book)

It becomes very difficult to construct and maintain these very low-volume roads to a high geometric standard.
Rule of 7’s for gravel roads

Annual maintenance frequency

- Dry blading: 49
- Water and roll: 7
- Dust control: 1

ADT’s is a driving number but not always the controlling factor....
OK...What makes good gravel?

Aggregate Size
Aggregate Shape
Aggregate Gradations
Binder
Who Gets Blamed for Poor Performing Gravel?

The Operator

*The Operator cannot make good gravel out of bad gravel*

- Good quality surface gravel may cost more, but it is worth the extra cost
- Quality can only be determined by proper field sample testing in a materials lab
- Approximately $200.00 per sample
Rock crushing “101”
Round and clean is bad

Won’t stay in place

A clean gravel road only “looks” good for a short time.
Dirty and angular... Good

A good gravel road will look dirty!
Objective of Roads

1. Provide access to resources
2. Means for conveyance of goods and products
3. Good roads were called a “Highway” or “Turnpike”
4. Maintained for Primitive (seasonal) or 365 day access?
Drainage, Drainage, Drainage!!!

Managing Gravel Road Maintenance

Shoulder drainage: Outstanding example!

Managing Gravel Road Maintenance

Crown: (con’t)

Clear illustration of 2% crown on road to the left and 4% on the road to the right. Water will not drain off an aggregate surface with only 2% crown. This must be addressed in design and during construction.
Einstein's Theory on Road Maintenance

- Definition of insanity:
  Doing the same thing over and over again and expecting different results!!!

We must....
Take a proactive approach
Design criteria???

Frequent light recreation  
Occasional heavy loads
An important issue is crown on gravel road surfaces. Generally recommended crown for gravel surfaces is 4%, which is double the crown used in pavements.
1.11: High Shoulders (Secondary Ditches)

A condition known as high shoulders can occur along gravel roads almost anywhere people travel. Many slang terms such as “berms” or “curbs” are used in the field to refer to this condition. The engineering term for this condition is secondary ditch and it is a good description of the situation. When a gravel road develops a high shoulder, it restricts the surface water from draining into the designed ditch. This causes several problems.

In relatively level terrain, the water collects at the shoulder line and seeps into the subgrade, often causing the whole roadway to soften. In rolling and rugged terrain, the water quickly flows downhill along the secondary ditch, often eroding away a large amount of gravel and even eroding the subgrade. This also creates a serious safety hazard. There are many reasons to work hard to eliminate the high shoulder or secondary ditch.
The Road Prism Profile

OUTSLOPED
3 - 5%
Typical for temporary roads with dirt surface (no ballast)

IN SLOPED
3 - 5%
DITCH LINE

BALLAST
Typical for permanent roads; with or without ballast or ditch line

CROWNED SURFACE
3 - 10%
DITCH LINE
Fastest water removal.
Requires water control on both sides.
Confused? So is the water!
Geometry of a grader in a corner
Correct tracking around a corner
Mechanics of Corner shoving aggregate segregation
Typical high elevation desert road?

Worn out or just spread out... the spoils of grading
Mechanics of Dust ...
there goes your road!
Mechanics of Washboards

• Washboards are inevitable!
• Controlled by reduced speeds.
• Cutting to the bottom of the wave during grading.
• Using larger angular aggregate with good cohesive binder.
New tools for the toolbox
Innovations to make gravel... on site.
“In place” processing equipment

Many types and many misapplications!

Challenging geology's

Brief History
Strong reasons for using a linear crusher...
Early process were labor intensive!
Innovations
Need to fully penetrate pavement plus 25% avoid large rocks and bedrock

Different sizes Carbide tooling
More robust tooling
best in softer rock types

Heavy cuts
Operate backwards
Different tooling plus additives
What about some of the harder materials

Now we are not only breaking down “cemented” materials, we are actually crushing rock
Some On-Road Rock Processing Terms

- Linear Crushing™
- In-Place Processing™
- On-Road Crushing
- Roto-Milling
- In-Situ Crushing/Processing
- In-line Crushing
- Roto-Trimming
Reconditioning... what is it?

- re-process to a maintainable surface
- utilize existing materials
- minimize imported materials
- improve performance & safety

Other Names: (Not always the same thing!)

- Rejuvenate, refurbish, re-establish....
- “in-place processing”, “road-crushing”
- “rock grinding”, “rock milling”, “linear crushing”
Why is Re-sourcing materials cost-effective?
Comparing technologies

Crushing

Roto-scarifying
Self powered crushers

Linear crusher 1”-4” minus
All rock types

Carbide tools 3-4” minus
Not all rock types
Crushing mechanics makes the difference!!!
Tool spacing controls output

Works good in some cases  Round rocks are a problem
Roto-scarifying

By design carbide tooling will reject harder materials

Can have large volumes of oversized side-cast
Comparing Output (size & blending)

Crushing on top

Roto-scarifying base

Consistent mixture of coarse and fines

Inconsistent mixture of coarse and fines
Harder and round materials don’t “crush” well with carbide tips
## Carbide Material hardness limits

<table>
<thead>
<tr>
<th>HARDNESS OF ROCK</th>
<th>EVAPORATIVE MINERALS</th>
<th>SEDIMENTARY</th>
<th>METAMORPHIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOFT</td>
<td>salt, potash, etc.</td>
<td>soft sandstone, lime rock, gypsum, etc.</td>
<td></td>
</tr>
<tr>
<td>MEDIUM</td>
<td></td>
<td>aggregate pit mining</td>
<td>normal caliche, concrete (non-reinforced), soft ledge rock, anhydrite, trona, etc.</td>
</tr>
<tr>
<td>MEDIUM HARD</td>
<td>medium sandstone, medium limestone</td>
<td></td>
<td>harder ledge rock, coal, etc.</td>
</tr>
<tr>
<td>HARD</td>
<td></td>
<td></td>
<td>hard caliche, quartzite, etc.</td>
</tr>
<tr>
<td>VERY HARD</td>
<td></td>
<td></td>
<td>very hard rock, glacial till, etc.</td>
</tr>
</tbody>
</table>
Linear crushing ... can convert the hardest existing resources

Utilize available raw materials
Crushed to manageable size

Without the added transport expense!
Before & After (basalt)
Before & After (granite)
Before & After (shale meta-seds)
Before & After (glacial mix)
Vanway V600H offers many Solutions!

Fracturing round aggregate
Fracturing & blending the “spoils of grading”
Cleaning overgrown ditch-lines
Reducing oversize from construction
Re-blending existing separated aggregate
Blending in new aggregate.
Blending in additives...Clays, Abatements, Etc.
Pulverizing RAP

Plus... NOT REWORKING THE SAME ROAD EVERY 2-3 WEEKS!
Crushing 10”- Basalt trap rock
### AASHTO T255 Moisture

<table>
<thead>
<tr>
<th>Moisture Content</th>
<th>Coarse</th>
<th>Fine</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of Wet Sample</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass of Dry Sample</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AASHTO T111 Wash

- Mass of Dry Sample After Wash (Mt): 27783.5

### AASHTO T27 Sieve Analysis

#### Coarse Sieve Spec.

<table>
<thead>
<tr>
<th>Sieve Size Spec. (mm)</th>
<th>Multiple Drops (Single)</th>
<th>(A) Accum. Mass</th>
<th>(A/B) Accum. Con. Mass</th>
<th>(B) Total % Rat.</th>
<th>(B) Total % Pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>40.0 (2)</td>
<td>184.7</td>
<td>184.7</td>
<td>0.7</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>37.5 1/2</td>
<td>206.8</td>
<td>238.9</td>
<td>7.5</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>5564.3</td>
<td>5594.3</td>
<td>20.0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>19.0 (4/8)</td>
<td>6375.0</td>
<td>6375.0</td>
<td>30.1</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>11729.1</td>
<td>11729.1</td>
<td>42.2</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>13398.6</td>
<td>13398.6</td>
<td>48.2</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>4.75 (5/32)</td>
<td>16838.3</td>
<td>16838.3</td>
<td>60.8</td>
<td>38</td>
<td></td>
</tr>
</tbody>
</table>

#### Fine Sieve Spec.

<table>
<thead>
<tr>
<th>Sieve Size Spec. (mm)</th>
<th>Multiple Drops (Single)</th>
<th>(A) Accum. Mass</th>
<th>(A/B) Accum. Con. Mass</th>
<th>(B) Total % Rat.</th>
<th>(B) Total % Pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.80 (9/32)</td>
<td>672.0</td>
<td>672.0</td>
<td>60.0</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>0.40 (1/16)</td>
<td>342.2</td>
<td>342.2</td>
<td>30.1</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>0.25 (1/8)</td>
<td>171.1</td>
<td>171.1</td>
<td>20.0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>0.125 (5/32)</td>
<td>85.5</td>
<td>85.5</td>
<td>10.0</td>
<td>99</td>
<td></td>
</tr>
</tbody>
</table>

#### Summary

- Total % Rat. = A / Mt x 100
- Mt = Accum. mass retained on 0.75 (4/16) sieve
- Ns = mass of split minus 0.75 (4/16) (4%) material actually tested
- Ratio of Split = Rs = Ns / Mt (must be calculated to 3 decimal places)
Hardness, Fracturability and % of silica influence on costs
Jefferson County, ID
Republic, WA
Recovering the spoils of grading
Cost comparison Republic WA

Summary of Calculated Volumes

<table>
<thead>
<tr>
<th>Company</th>
<th>Method</th>
<th>Volume (yd^3)</th>
<th>Cost/yd</th>
<th>Output Gradation</th>
<th>Usage</th>
<th>Mat depth (ft)</th>
<th>Distance (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triple-Tree, Inc.</td>
<td>In-place</td>
<td>4900</td>
<td>$6.27</td>
<td>3” minus</td>
<td>Base</td>
<td>0.5</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Processing</td>
<td></td>
<td></td>
<td></td>
<td>Course</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadtech, Inc.</td>
<td>In situ</td>
<td>1500</td>
<td>$14.43</td>
<td>1” minus</td>
<td>Surface</td>
<td>0.15</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>crushing</td>
<td></td>
<td></td>
<td></td>
<td>Course</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: When calculating total cost, linear crushing does result in a higher cost per yard; however, one must remember that this process virtually eliminates the need to back haul ditching material, and it produces a more suitable surfacing material.

Summary of Costs in Time and Dollars

Table 1: Projected

<table>
<thead>
<tr>
<th>Method</th>
<th>Time (day-hrs)</th>
<th>Crew</th>
<th>Cost per mile</th>
<th>Miles</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>12 – 10s</td>
<td>12</td>
<td>$178,781.00</td>
<td>2.5</td>
<td>$446,952.50</td>
</tr>
<tr>
<td>On Site</td>
<td>5 – 10s</td>
<td>12</td>
<td>$50,805.00</td>
<td>2.5</td>
<td>$127,012.50</td>
</tr>
</tbody>
</table>

Table 2: Actual

<table>
<thead>
<tr>
<th>Location</th>
<th>Time (day-hrs)</th>
<th>Crew</th>
<th>Cost per mile</th>
<th>Mile</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herron Creek Rd</td>
<td>5 – 11s</td>
<td>6</td>
<td>$20,953.73</td>
<td>2.5</td>
<td>$52,384.32</td>
</tr>
<tr>
<td>Customs Road</td>
<td>5 – 11s</td>
<td>6</td>
<td>$19,929.18</td>
<td>2.5</td>
<td>$49,822.94</td>
</tr>
</tbody>
</table>

NOTE: These totals combine both county force crew and contractor costs for each project and process, as we experienced them on these roads, in such a way as to protect both contractors from potentially erroneous statements on my part.
Polk County, AR
Reshaping crown from ditchline waste
Pendleton, OR
Long needed cleaning of ditches
Oakley, ID
Base reconstruction with surfacing
All from repurposed native resources
Rose Lake, ID
Crushed surfacing from native rock

16” native quartzite

1” minus crushed wear-course
Nye, MT
“hot crushing” pit-run
Kittitas, WA
Resurfaced with no hauling
Sweet Grass, MT
Hot crushing cliché for a Finished $\frac{3}{4}$ minus
Priest Lake, ID
Access road up grade, Hard granite

Hard out cropping may need a hammer or powder!

Three years later
FDR and base building

Switching Modes to roto-scarifying
Same machine with TWO functions!

**Crusher w/ Chromium carbide hammers**

**Roto-scarifying w/ Heavy carbide conical(s)**

All with bolt on tooling that is easily replaced.
Naches, WA
Surface pulverized and recycled to another location
Farragut, ID
Old mat no longer maintainable, repurposed to gravel surfacing

Requires robust tooling for marginal cushions

Can fracture larger rocks but there are limits!
Colville Nation, WA
FDR with base building additives
Eliminates Rutting Below Surface

Rutting can occur in surface, base and subgrade of unstabilized bases due to repeated wheel loading.

Stabilized bases resist consolidation and movement, thus virtually eliminating rutting in all layers but the asphalt surface.
Colville Nation, WA

Un-maintainable old thin mat surfacing

“Poor mans” asphalt @ 1/3 the price!
Thanks, any questions?