Minnesota Local Road Research Board
Local Operational Research Assistance Program
(OPERA)

November 27, 2012

Development of Aggregate Loss Factors for Rural Gravel Roads

OPERA Project Number: 2011-01
2012 Interim Report

Project Sponsor: Itasca County, Minnesota


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Research Problem

County transportation departments, particularly in Minnesota’s more rural counties, typically manage a mix of paved and gravel roadways. For example, Itasca County manages a transportation system that includes 750 roadway miles of gravel roads. Producing aggregate for these roads, placing the aggregate on the roads, and maintaining the aggregate surfacing can be a significant budgetary challenge. Itasca County typically has a total annual budget of approximately $2 million associated with aggregate production, placement, and maintenance. In today’s local government funding environment, County Boards are requiring a more logical justification for such budgets. It is becoming more and more important for transportation professionals to be able to justify budget requests with “hard” data and calculations. Unfortunately, there is no system on which those professionals can build their aggregate budget requests. Therefore, the purpose of this project is to develop “aggregate loss factors” that can be used to generate estimates of annual gravel needs on a system-wide basis.

Problem Solution

In Itasca County it is presumed that there are three mechanisms for gravel loss. The first would be the gradual loss of fine material created by traffic into airborne dust which then is transported by wind off the roadway. The second would be a function of plowing the road during spring thaw conditions which would potentially move some gravel off the roadway as part of the snow removal. The third would be gravel loss due to storm erosion.

To analyze the loss of fine material due to traffic, 6 gravel roadway segments were selected for study to provide a range of roadway characteristics across parameters such as average travel speed, traffic volume, environmental factors (e.g. roadway shading), and maintenance strategies (e.g. chloride application.) The segments are located relatively close to one another to neutralize weather effects and to utilize a single gravel source for the study. Project investigators will then document the amount of gravel present on the roadway by field measuring a Digital Terrain Model (DTM) at each site. At one month intervals, during the summer, an additional DTM will be generated and compared to the original data so that the volume of gravel “lost” can be calculated. Data collection related to fine material loss will be gathered only during the summer months as traffic impacts during the winter would be assumed to be negligible.

Measurements at the fall and again in the spring of the following year will indicate the gravel loss due to winter maintenance activities.
Gravel loss due to erosion is highly sensitive to terrain. This study may explore the dynamics of gravel movement, but ultimately, may recommend estimation procedures over experimental data analysis.

To address the loss of fine material during the summer, six sites were identified as 1) low speed unprotected (LSUP), 2) high speed protected (HSP), 3) low speed protected chloride (LSPC), 4) low speed protected (LSP), 5) high speed unprotected (HSUP), and 6) high speed unprotected chloride (HSUPC). These generalized identifiers would provide a means to categorize road segments for the development of needs based model of a gravel road system.

The three variables identified are speed, roadway protection from the sun and chloride. The speed of the traffic is directly related to the vehicles ability to move the fine material into the air. Protected roadways are roads that are generally protected from the sun. Shaded roadways protect the loss of moisture from the gravel which tends to retain fine material in the road. Chloride also works similarly to retain moisture in the gravel surface. Figure 1 shows the locations of all six sites.

Due to the relatively small volumes of loss, the project will be phased over a 4 year period to develop a more accurate factor. The goal of the project will then be to convert the field data to “aggregate loss factors” that can be used to predict annual gravel needs for a variety of roadway characteristics on a system-wide basis.
Figure 1: Map of six study sites in Itasca County.
Research Procedure

In May Itasca County maintenance crews placed 6 inches of new aggregate surfacing on all sites. The gravel was produced and transported from a single site known as the Buck Lake pit. Itasca County survey crew began the initial survey of each site using a Lieca robotic total station. Two permanent control points were established at each site. Cross sections were performed at 25 foot intervals. Once the field survey was completed, the information was downloaded and a Digital Terrain Model (DTM) was developed. Each road within the study was surveyed once a month between the months of May through October.

Gravel samples were taken from each site and a sieve analysis was performed to determine material properties and beginning particle size percentages. Sampling steps are in Appendix 1.

A traffic count was performed at each site to aid in the study.

Results

The results of the project at this point have been inconclusive due to the survey procedure.

<table>
<thead>
<tr>
<th>Site</th>
<th>CR 51 Low Speed Unprotected (LSUP)</th>
<th>CR 333 High Speed Protected (HSP)</th>
<th>CR 53 Low Speed Protected Chloride (LSPC)</th>
<th>CR 53 Low Speed Unprotected (LSP)</th>
<th>CR 336 High Speed Unprotected (HSUP)</th>
<th>CR 336 High Speed Unprotected Chloride (HSUPC)</th>
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<tbody>
<tr>
<td>Site 1</td>
<td></td>
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<td></td>
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<td>Site 2</td>
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<td>Site 6</td>
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<tr>
<td>July</td>
<td>-0.39</td>
<td>-5.12</td>
<td>-1.64</td>
<td>-4.97</td>
<td>8.11</td>
<td>78.41</td>
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<tr>
<td>August</td>
<td>-17.54</td>
<td>-15.47</td>
<td>7.49</td>
<td>-1.30</td>
<td>29.07</td>
<td>-49.44</td>
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<td>September</td>
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<td>-4.17</td>
<td>23.48</td>
<td>-9.41</td>
<td>-79.86</td>
<td>16.14</td>
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<td>October</td>
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<td>9.10</td>
<td>-41.88</td>
<td>-4.41</td>
<td>47.37</td>
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<td>Total Change</td>
<td>-21.55</td>
<td>-15.66</td>
<td>-12.55</td>
<td>-20.09</td>
<td>4.69</td>
<td>46.65</td>
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Table 1: Gravel loss (-) or gain (+) compared to previous month from July through October 2012.
Table 2: Length, area, and average daily traffic (ADT) data for each site.

A Sieve Analysis will be performed each year to review if the gradation of the material changes over time. Results from year one is inconclusive.

Table 3: June 2012 Sieve Analysis (% passing)

Table 4: October 2012 Sieve Analysis (% passing)
Implementation

The data collected was not sufficiently conclusive to develop an implementation plan.

Status

The initial data collection for this study has been completed. As was initially anticipated at the end of the first year, data collected did not indicate strong conclusive trends. Looking forward at year two of the study, procedures for collecting and analyzing data will be reviewed and revised in an effort to eliminate the possibilities of error that may have affected the year one data set. The collection of data will restart again in the spring to review the potential loss of gravel from snowplowing operations and begin year two of the study.

Project Duration

Approval of this OPERA research project was transmitted to Itasca County by the OPERA Program Coordinator on March 20, 2012. Surveying and sampling was started by Itasca County in May 2012 and continued until October 2012. Research and documentation was extended until November 20th, 2012. The study will continue between the years 2012-2015.

Project End Date

Surveying and sampling procedures ended within the month of October, 2012. Research and final documentation for year one continued until November 20, 2012. This project will continue for another 3 years with similar end dates. A final submittal will be completed by November, 2015.

Project Costs

Total project cost through 2012 interim report preparation was approximately $17,570. OPERA funds used for the project totaled $3970. The remaining project funding was provided by Itasca County. Itasca County provided approximately $83,000 in gravel, gravel placement and chloride associated with the project. These items were not charged to the project cost as they are associated with normal maintenance operations.

<table>
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<th>Field Survey</th>
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REFERENCES