Iowa Granular Roads

- 60% of Iowa miles
- 66,243 miles
- $270 million/year

Contribution to:

- **Economy:**
  - 1st nationally in Pork, soybeans, corn (2.5 Billion bushels), & eggs
  - Renewable energy – 1st Ethanol, 3rd Wind, & 2nd biodiesel

- **Use:**
  - 2.96 M VMT/day
  - 119 times around earth
  - Over 6 times to moon & back
  - Not Insignificant
Previous IHRB Projects


Ongoing IHRB Projects

- TR-721 - Low-Cost Rural Surface Alternatives: Demonstration Project, Phase III (Treatments)
- TR-725 - Low-Cost Rural Surface Alternatives: Phase IV, Frost Depth Monitoring & Prediction
- TR-685 – Feasibility of Gravel Road and Shoulder Recycling (Gradations)
- TR-704 - Performance Based Evaluation of Cost Effective Aggregate Options (Quality & Econ)
Granular Roads Asset Management System (GRAMS)

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Project IHRB-TR 729
TAC Members

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- Todd Kinney, Clinton County
- John Riherd, Butler County
- Zachary A. Gunsolley, Union County
- Brad Skinner, Montgomery County
- Mark Nahra, Woodbury County
- Eric Cowles, Iowa DOT, Secondary Roads Engineer
National Efforts

• Other States: Wyoming, Utah, Michigan, South Dakota, & New Hampshire
  • Various methods of granular asset management or Best Management Practices
  • Data-Driven condition evaluation or Manuals

• Canada: Forest Engineering Research Institute
  • Condition based management
Objectives of the GRAMS effort

• Develop a user friendly Systemic Risk-Based Asset Management Tool to:
  • Tell the story
    • To identify new ways communicate the dynamics and needs of granular surfaced roads to the public and elected officials.
  • Perform technical analysis
    • Seeking to employ numeric modelling in a meaningful way.
  • Support decisions
    • Exploring to see if decisions can move from rule-of-thumb to evaluation of objective criteria.
  • Seek optimum
    • To explore whether or not one can build a model and use it to find the ‘optimal’ granular surfacing strategy for any given county.
GRAMS Concepts

1. Two structural components
   • Granular Surfacing – Effective “crust” Index or Rock-In-Service (RIS)
     • Gradation – Compactability
     • Material Quality – Type, hardness durability, plasticity
     • Physical conditions – width, crown, drainage, traffic, material loss, thickness
   • Subgrade – Wide range of embankment soils - many undesirable or unsuitable
     • Soil characteristics, drainage, freeze-thaw, seasonal variations
     • Likelihood of wet and weak subgrade conditions
Preliminary GRAMS Tool
   - Dust – 100 tons per 100 AADT / mile / year
   - Roll off – Vehicles and Blading – 15 tons per 100 AADT / mile / year
   - Water Runoff – variable amounts

2. Annual replacement is needed to sustain the system:
   - But, How much? Where? and How does it perform?
Premise

• Develop a probabilistic model to predict system-wide risks and granular needs in TPM to manage the risk
  • Amount of Rock-In-Service (RIS) in the roadway crust, in Tons/Mile (TPM)
  • Reliability of roadway vs. its RIS level
    • Reliability = % chance of good performance under adverse subgrade conditions
    • Risk = % chance of impaired roadway use at times of weak subgrade conditions
  • Premise: For any given effective TPM, there is a matching maximum risk of roadway failure during a freeze/thaw and high precipitation periods → Road Agency need to balance acceptable risk vs. budget needs
    and they can
  • Implement a matching resurfacing program to optimize expected outcomes.
RIS* – or ‘how thick is the crust’

Need to know (as best as one can) how many tons of granular are “in service”

“*ROCK IN SERVICE” – in Tons per Mile

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
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</thead>
<tbody>
<tr>
<td><strong>ACTUAL</strong></td>
<td><strong>ACTUAL</strong></td>
</tr>
<tr>
<td>Top condition achieved currently</td>
<td>Lowest condition level to which roads are allowed to reach</td>
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<tr>
<td>Layer</td>
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<tr>
<td>Top inch</td>
<td>75%</td>
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<td>Equivalent inches of granular</td>
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<td>TPM @ 24 ft</td>
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<tr>
<td>TPM @ avg width</td>
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</tbody>
</table>

TR-685
TR-704
Gradations and Aggregate Quality

Method for estimation of RIS
Reliability vs. crust RIS

Tune a ‘logistics’ curve to model the relationship between RIS(TPM) and Reliability/Risk of the system. Similar to pavement deterioration curve.

“Maximum risk of road impairment during a period of subgrade weakness.”
Single roadway over time

- Risk, although small at first, grows exponentially as the tons per mile of Rock-in-Service declines.

Illustration of life cycle of a granular road segment:
- Y0: 930 TPM, 1:40 risk
- Y1: 810 TPM, 1:20 risk
- Y2: 690 TPM, 1:10 risk
- Y3: 570 TPM, 1:5 risk
- Y4: 450 TPM, 2:5 risk
- Y5: 330 TPM, 3:4 risk

TR-664
TR-721
Granular Surfacing Stabilizing Treatments
Condition of the system

- System status is a composite of the individual statuses of all the encompassed road segments. \( \frac{\sum mi \times \text{risk}}{\text{Total miles}} \)
Sample wave patterns over time

- **Annual seasonal risk of weak subgrade**

- **Combined annual and long term risk**

- **Final risk, adjusted for year to year variance**

TR-725 Frost Prediction Model
Sample plan: 750 TPM max 400 TPM every 3.5 years

RIS based risk hits max every 3.5 years

Resultant max risk, after consideration of point in time conditions
System level optimization

• Criteria
  • Minimize the maximum risk
  • Minimize length of time that risk exceeds target threshold
  • Set risk allowances to fit traffic levels
    • Perhaps a different TPM target for low, medium, high AADT

• Tradeoff between cost and achievement
  • More ‘rock-in-service’ equals less risk – up to a point
  • More RIS requires a higher total investment in material
  • Budget limits may require prioritization
Sample of possible summary sheet
Sample of possible summary sheet
Products & Deliverables

• A spreadsheet-based GRAMS for county engineers to perform local construction and maintenance optimization analyses.

• Validated formulas to predict and estimate the material quality, need for material replacement, and performance of existing aged materials, risk potential for methods applied, and system-wide risk performance over multiple years.

• A web-based GRAMS for state wide assessment and communication of granular roads management needs. This will provide a foundation for building a web-based GIS map and mobile app.
THANK YOU

• QUESTIONS – COMMENTS – CRITIQUE