BRADLEY UNIVERSITY

DEPARTMENT OF CIVIL ENGINEERING AND CONSTRUCTIO

Performance Evaluation of Snow and Ice Plows (R27-94)

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Sponsored by
The Illinois Department of Transportation
Illinois Center for Transportation
TRP Chair – Tim Peters

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Acknowledgements

- Project Technical Review Panel
- Morton, IL IDOT facility staff, mechanic, and drivers
- Drew Dragoo,
  Former Bradley University Graduate Student
- Other Bradley University Students

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Introduction

Removal of ice and snow from road surfaces is a critical task in the northern tier states of the United States

Highways with high levels of traffic are expected to be cleared of snow and ice quickly after each snowstorm

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Objective:

Increase efficiency and effectiveness of snow removal operations

- Conduct a comprehensive study to evaluate performance of snow and ice plows
- Develop an instrumentation and data collection system for IDOT snow plow trucks. Both front and belly mounted plows should be considered
- Develop a Synthesis of Best Practices in Snow and Ice Removal

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Project Tasks

- Literature review and synthesis of best practices
- Develop a performance evaluation procedure including researching instrumentation alternatives and calibration and installation of selected instruments
- Perform field tests
- Develop finite element models to synthesize a comprehensive performance database
- Documentation of project activities and findings

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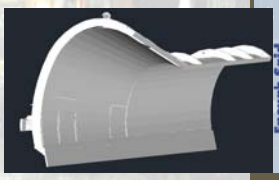
Studied Plows

Valk Alaskan
Front Body Snow Plow



Enough Said.

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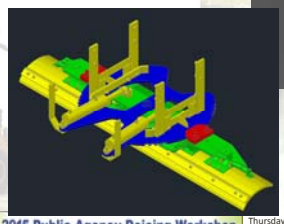
Studied Plows

Monroe Underbody Scraper



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Truck Instrumentation

- Strain sensors wired with three foot SMA male to 10-32 male lead cables connecting to 24 foot SMA male to SMA female extension cables.
  - dielectric grease applied in connections to help prevent corrosion of the connections.
- Extension cables cut to install plug connection
- Cables ran into ¾" liquid tight flexible conduit

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Truck Instrumentation

Daytime Plowing Operation

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Black Box GPS Camera

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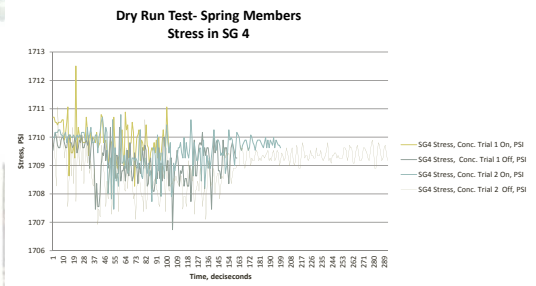
Dry Run

- Data extracted from DAQ logger verifies that the instruments were live



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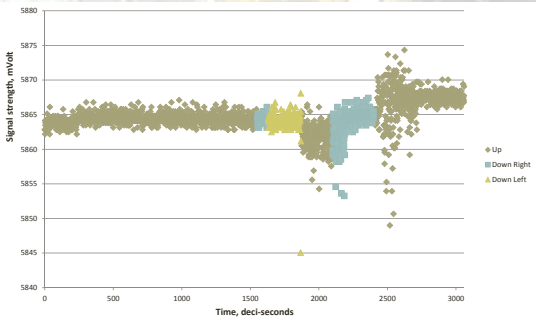
Data Analysis and Validation



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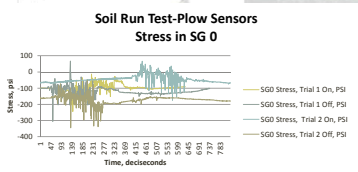
~~Snow~~ Dirt Removal Testing

- Took place at the Morton Truck Facility, Morton IL.
- Two Purposes:
  - Validate data collection procedure
  - Test the instrumentation and data collection procedure under actual plowing conditions



Amplitude of strain data is noticeably larger when blade is down and Blade Saver is Turned Off

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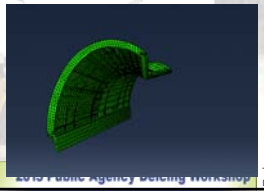
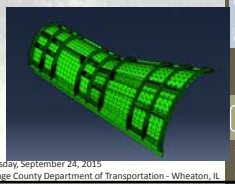
Analysis

- Abaqus is a FEA application that is used to model real world applications
- Ability to change parameters and examine the effects of those changes on analysis results allows to define parameters for optimum operation efficiency.





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Conclusions

- Snow plowing is a messy and dangerous operation
- The instrumentation and data collection system developed for this study is effective in assessing several field factors.
- The Blade saver option reduces stresses in the snow plow and the carrier structure, this was true for three different cases:
  - Dry runs on asphalt pavement,
  - Dry runs on concrete pavement, and
  - Soil-dry runs on concrete pavement.
- Higher stresses are observed when plowing concrete pavements compared to asphalt pavements.

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Conclusions - Continued

- Using the underbody scraper simultaneously with the front body plow during a heavy snow event is an effective way of providing a cleaner driving lane faster.
- Using the underbody scraper simultaneously with the front body plow on a ramp is an effective way to ensure that more ice is removed. The ramp can then be made even less slippery by the addition of salt.
- Snow plow operators need to be very alert and need to have an excellent understanding of the equipment they are working with to reduce hazard to themselves and the public

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Synthesis of Best Practices

- Conducted interviews with agency personnel, DOT engineers, and consultants actively involved in snow and ice plowing
  - Wisconsin DOT, Iowa DOT, Monroe Truck & Equipment, District 1
    - Equipment
    - Material
    - Procedures
    - Policies
- Focus on collecting information related to safety, best practices, and standards for: plow selection, blade selection, installation & maintenance practices.

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Synthesis of Best Practices

- Visited with a national plow manufacturer
- Visited with a blade manufacturer
- Summarizing the best practices in a well organized report based on a classification system and criteria that were developed by the research team

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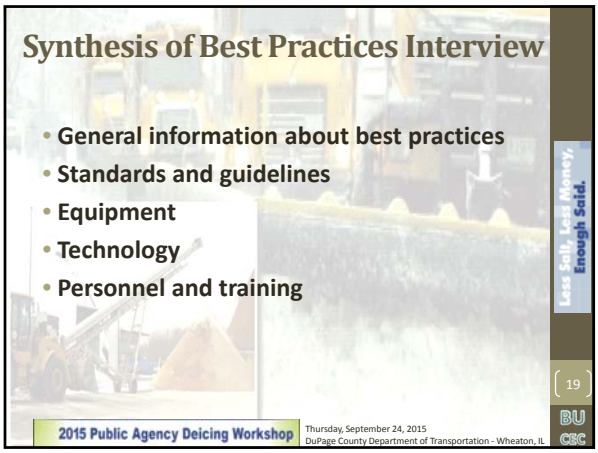
Synthesis of Best Practices Interview
• General information about best practices
• Standards and guidelines
• Equipment
• Technology
• Personnel and training
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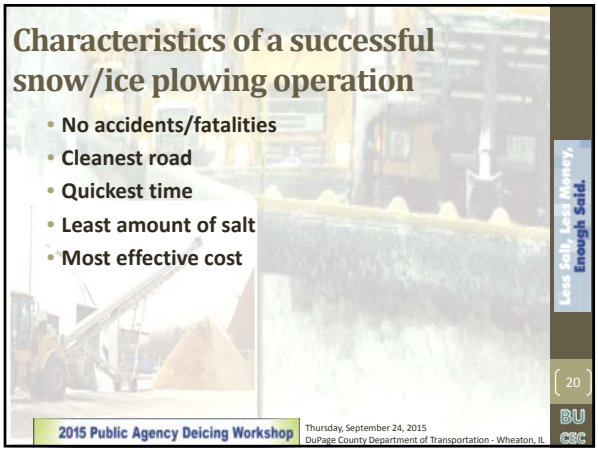
Characteristics of a successful snow/ice plowing operation
• No accidents/fatalities
• Cleanest road
• Quickest time
• Least amount of salt
• Most effective cost
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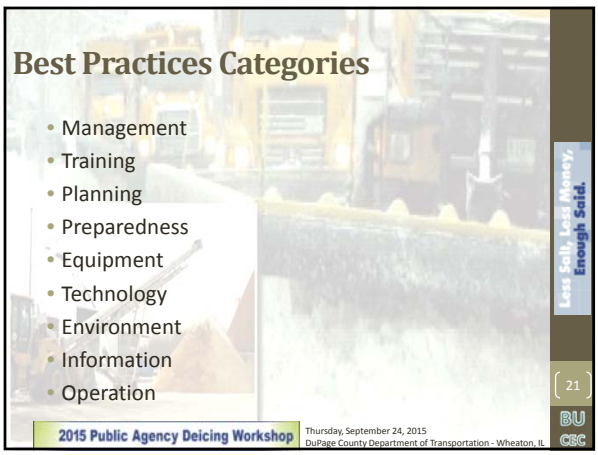
Best Practices Categories
• Management
• Training
• Planning
• Preparedness
• Equipment
• Technology
• Environment
• Information
• Operation
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Best Practices - Management

- Management and field operators need to be flexible in terms of adopting the changing technology and procedures of operations.
- Management and field operators need to make sure equipment is ready and drivers are prepared to respond in a timely manner when the weather condition warrants it.
- The efficiency of ice and snow control operations diminishes when managers focus on reducing hours of operation and use of materials. Operators should be instructed to focus on ensuring the safety of the traveling public first.

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Best Practices - Management

- Management and field operators must watch for changing weather conditions. Sometimes a storm may start with 100% snow but a sudden change in temperature and dew point creates favorable conditions for the sudden formation of black ice, necessitating a change in the treatment approach.
- Plow drivers are first on the road; therefore, they are the best positioned to evaluate the situation and adjust the snow-clearing operation as necessary to ensure successful results.

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Best Practices - Training

- Initial and continual training must be required of all truck operators. Hands-on training is necessary, and job shadowing or riding along during an actual snow- and ice-clearing operation is highly recommended. The Clear Roads Project and AASHTO offer a number of training manuals and videos that can be incorporated in a comprehensive training program.
- Training programs must be updated on a regular basis to incorporate new information and the use of new technology.

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Best Practices - Training

- Over-applying or under-applying salt and other chemicals may create unsafe conditions. Plow operators need to be provided with instructions on when and how much anti-icing or deicing material to apply and also be properly trained to make sure they follow the guidelines.

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Best Practices - Training

- Make procedure manuals and guidelines for application of chemicals and plowing available to operators to ensure they are familiar with the procedures and guidelines and are able to follow the instructions as required and applicable. These guidelines usually include what chemicals to apply under what conditions, how much to use, and how to plow.
- Blowing snow and freezing rain represent challenges that operators need to be well trained and prepared for. For example, anti-icing with liquid chemicals is not recommended during freezing rain or sleet events (NCHRP Report 526).

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Best Practices - Training

- Drivers must perform a walk-around inspection of their trucks every time before they head out. They must be trained on how to look for problems such as loose bolts and cracked blades.

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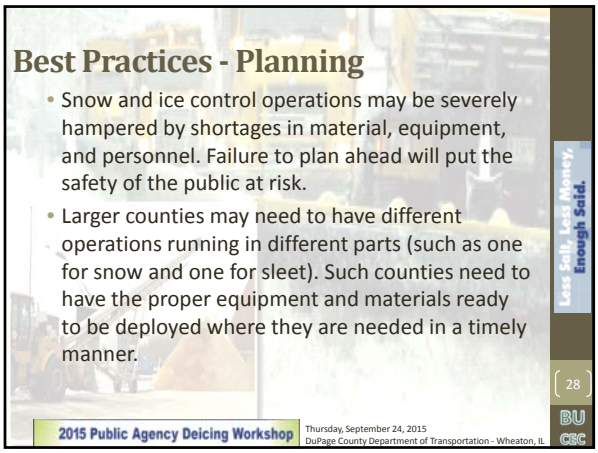
Best Practices - Planning
• Snow and ice control operations may be severely hampered by shortages in material, equipment, and personnel. Failure to plan ahead will put the safety of the public at risk.
• Larger counties may need to have different operations running in different parts (such as one for snow and one for sleet). Such counties need to have the proper equipment and materials ready to be deployed where they are needed in a timely manner.
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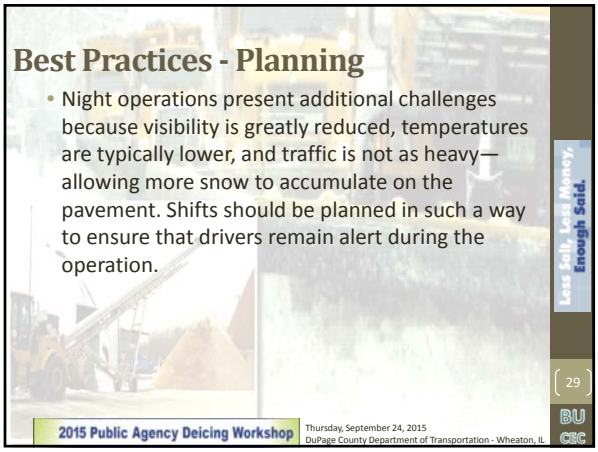
Best Practices - Planning
• Night operations present additional challenges because visibility is greatly reduced, temperatures are typically lower, and traffic is not as heavy—allowing more snow to accumulate on the pavement. Shifts should be planned in such a way to ensure that drivers remain alert during the operation.
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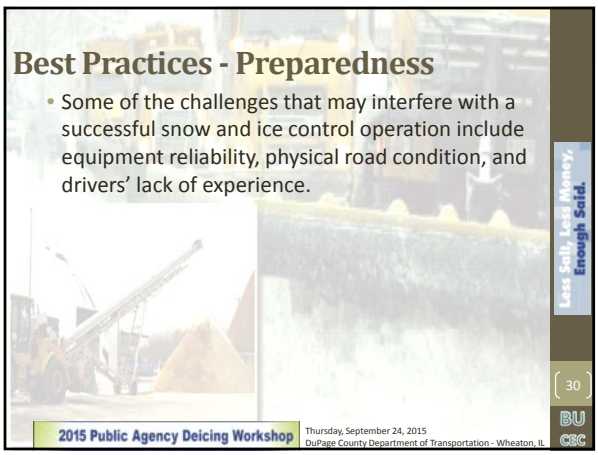
Best Practices - Preparedness
• Some of the challenges that may interfere with a successful snow and ice control operation include equipment reliability, physical road condition, and drivers' lack of experience.
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Best Practices - Preparedness

- It is extremely important for drivers to be familiar with the routes they are assigned to clear snow and ice from. Drivers need to be aware of obstacles on the roadway surface, such as manhole covers, curbs, and joints at railroad crossings and bridges. Driver training programs should include route scouting missions before the snow season, and drivers should be assigned to clear the same route throughout the season.

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Best Practices - Preparedness

- Pre-plowing guidelines: Perform a quick inspection of the equipment (truck and plow) and ensure adequate quantities of anti-icing and deicing materials.
- Make sure there is enough of the blade left to avoid having to change it during the storm.
- It may also be worthwhile to mention here that a more thorough inspection of the equipment is necessary after the current operation is completed to make sure the equipment is ready for the next storm.

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Best Practices - Preparedness

- A safety inspection should be conducted on trucks every 6 months.
- Keep adequate truck maintenance and inspection records.
- Keep adequate blade replacement records.

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Best Practices - Equipment

- Plow trucks should have the adequate capacity to carry the required amount of material, both solid and liquid, for treating their assigned route.
- In connection with knowing when and how much anti-icing or deicing material to apply, trucks should be equipped with sensors to measure road temperature.
- High-output plows, such as the Alaskan plow, should be used in rural areas only. In urban areas, 12-ft-long flush plows are best.

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Best Practices - Equipment

- One-way plows can handle more snow and may be more efficient in clearing large areas such as parking lots and interstate highways. Reversible blades are more efficient for clearing roadways because they can be used to push the snow away to the left or right of the road.
- Use a hydraulic system that limits the down force on the blade when available. It does make a difference.

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Best Practices - Equipment

- High performance blade systems that use multiple materials, such as Joma or PolarFlex, provide improved performance. Some materials may wear out quicker but they are also less expensive.
- Steel blades cut ice better than carbide blades, but also they wear out faster. The best setup is to use a steel blade in front of a carbide-reinforced plate. The steel blade ensures cutting adequacy, while the carbide ensures durability.

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Best Practices - Equipment

- Change blades when less than the width of two fingers is left on them.
- Some plows, such as the Alaskan plow, cause uneven wear on the blades. It is common practice to replace the whole blade set—not just sections of it.

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Best Practices - Equipment

Best practices for installing plow blades:

- Make safety your number one concern. Immediately replace cracked or otherwise broken blade.
- Blades should be replaced by at least two people—and preferably three. Always use jack stands or a hoist.
- It is usually safer and more efficient to torch off old bolts.
- Always use new bolts with each blade replacement.

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Best Practices - Equipment

Best practices for installing plow blades:

- Use an impact wrench to tighten bolts and secure blade in place. The impact wrench should be such that it does not over torque the bolts. An inexpensive ½ inch drive unit is better in this application than a ¾-inch air impact wrench. Torque sticks or torque wrenches are ideal.
- Replace the carbide bits and the blade at the same time. Set the carbide and then install the steel blade.

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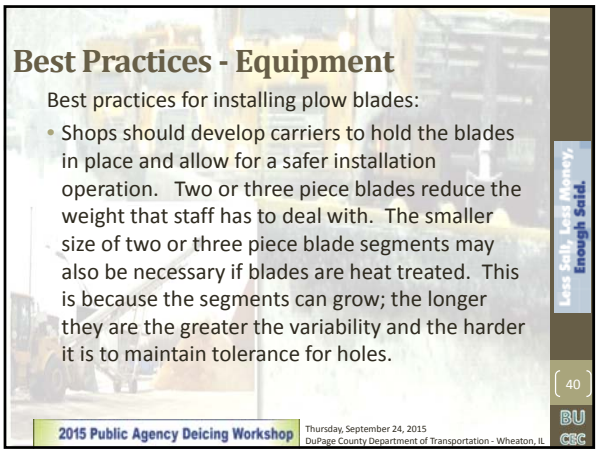
Best Practices - Equipment
Best practices for installing plow blades:
• Shops should develop carriers to hold the blades in place and allow for a safer installation operation. Two or three piece blades reduce the weight that staff has to deal with. The smaller size of two or three piece blade segments may also be necessary if blades are heat treated. This is because the segments can grow; the longer they are the greater the variability and the harder it is to maintain tolerance for holes.
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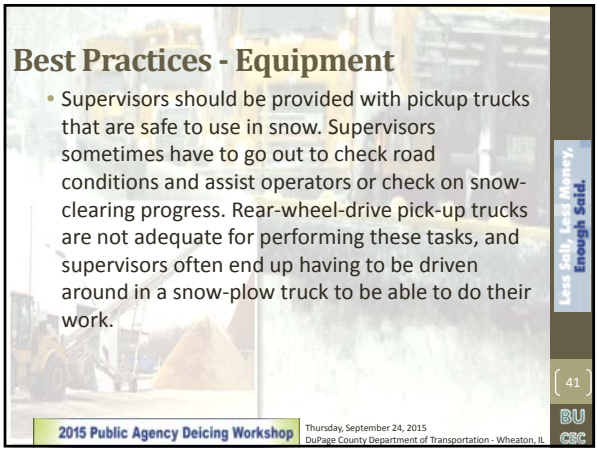
Best Practices - Equipment
• Supervisors should be provided with pickup trucks that are safe to use in snow. Supervisors sometimes have to go out to check road conditions and assist operators or check on snow-clearing progress. Rear-wheel-drive pick-up trucks are not adequate for performing these tasks, and supervisors often end up having to be driven around in a snow-plow truck to be able to do their work.
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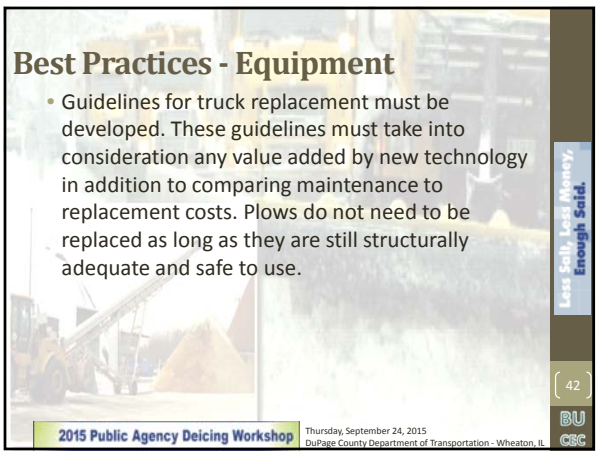
Best Practices - Equipment
• Guidelines for truck replacement must be developed. These guidelines must take into consideration any value added by new technology in addition to comparing maintenance to replacement costs. Plows do not need to be replaced as long as they are still structurally adequate and safe to use.
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Best Practices - Technology

- Technology is improving and can be integrated to make snow and ice control operations more efficient. This includes GPS, weather-monitoring systems, road temperature sensors, computerized salt control and slurry technology, automatic vehicle location (AVL), a maintenance decision support system (MDSS), and mobile apps to keep the public informed about road conditions.

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Best Practices - Environment

- Type of pavement: The dark color of asphalt makes it absorb solar radiation and radiate heat better than concrete, which means that concrete is quicker than asphalt to freeze. Moreover, the permeability of asphalt allows the liquids to dissipate faster and not freeze.
- Bridge vs. roadway: Bridges are more likely than roadways to have ice on them as bridges cool much faster because of the air passing under them. The soil underneath provides thermal mass to roads.

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Best Practices - Environment

- Time of day: Night operations are more challenging and require increased alertness. Also, temperature is typically lower during the night, which increases the probability of ice formation.
- ADT: Affects the priority and timing of snow-clearing operations.
- Topography and trees: They affect snow distribution and the amount of snow accumulated.
- When there is blowing snow, do not get pavement wet because it will build snow packs.

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Best Practices - Environment

- Look out for reflectors ("cat eyes") because hitting them will tear up the carbide, will cause vibrations in the plow, and may cause bolts that are holding the blade to come loose. Raised pavement markers can also be knocked loose and become a dangerous projectile. They tear up the carbide by acting as a ramp and causing the blade to bounce. This is problem is worse for blades with trapezoidal carbide. The material used to hold the carbide in the blade fractures and the carbide is lost in chunks.

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Best Practices - Information

- Pavement temperature: Critical in determining the type of anti-icing or deicing material to use, if any.
- Temperature: The warmer it is, the faster and easier it is to get snow off the pavement.
- Dew point: The higher the dew point, the quicker and more likely ice is to form on the pavement.
- Wind speed and direction: Wind can completely change the operation because it can cause snow drifts and possibly blow the dry chemicals away from the pavement.

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Best Practices - Operation

- Keep communications open with the foreman and report any incidents immediately.
- Monitor temperature and general weather conditions on a regular basis.
- If conditions are favorable, pretreat the roadway before the snow starts to fall. It could take up to four times the amount of salt to remove ice and snow than it it does to prevent it from bonding in the first place.
- Pre-wetting rock salt before spreading it on a dry roadway will prevent it from bouncing. A sodium chloride brine solution will help salt stick to roadway.

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Best Practices - Operation

- When plowing on an interstate highway using the front plow, speed may be as high as 30 to 40 mph. A lower speed should be used on secondary roads. The operator must consider weather and traffic conditions and use an appropriate and safe speed.
- The underbody scraper is harder on the pavement, so a lower speed of 20 to 30 mph should be used.
- When wind is blowing above 10 mph, do not use solid pretreatment on a dry pavement.

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Best Practices - Operation

- Completely clean and adequately inspect trucks and plows after the plowing event.
- Inspect tires, bolts, lights, springs, spreaders, curb guards, liquid tanks, truck fluids, etc.
- All maintenance must be performed if due.

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Pitfalls to watch out for in snow/ice plowing operations

- Changing weather conditions
- Equipment reliability
- Railroad crossing and bridge joints
- Road obstacles: manhole covers, curbs, reflectors
- Inexperienced drivers
- Not knowing proper amounts of salt and chemicals to apply
- Sudden changes in temperature
- Blowing and drifting snow

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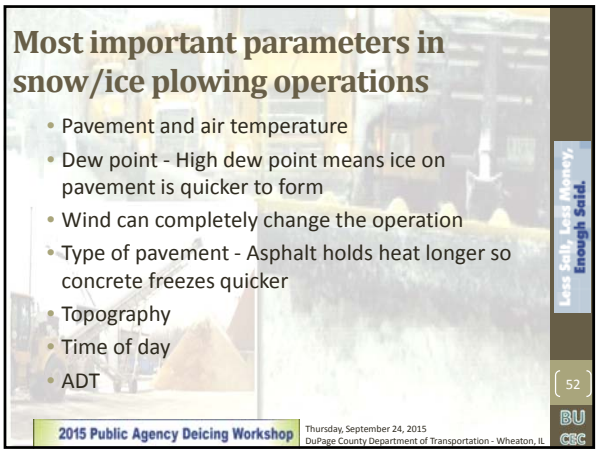
Most important parameters in snow/ice plowing operations
• Pavement and air temperature
• Dew point - High dew point means ice on pavement is quicker to form
• Wind can completely change the operation
• Type of pavement - Asphalt holds heat longer so concrete freezes quicker
• Topography
• Time of day
• ADT
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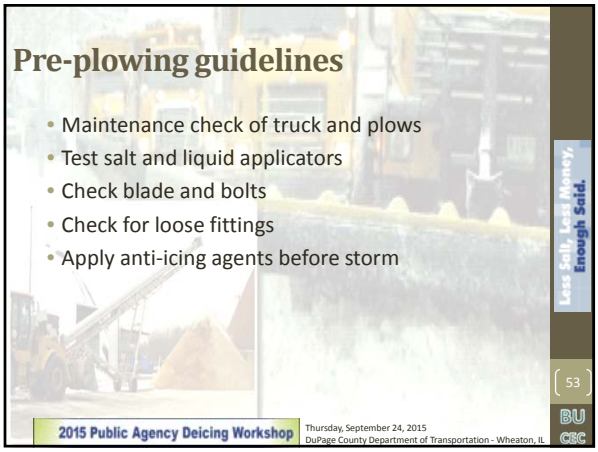
Pre-plowing guidelines
• Maintenance check of truck and plows
• Test salt and liquid applicators
• Check blade and bolts
• Check for loose fittings
• Apply anti-icing agents before storm
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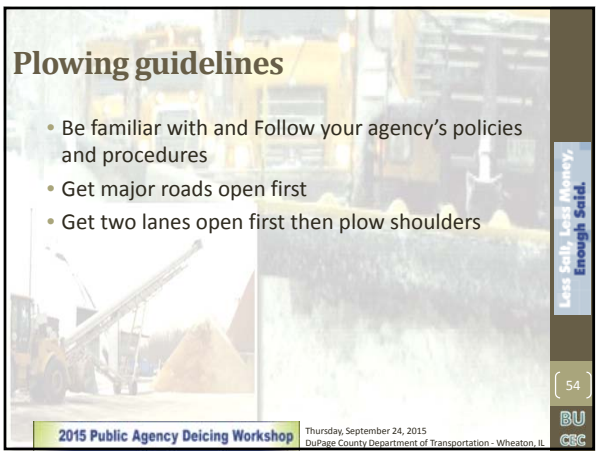
Plowing guidelines
• Be familiar with and Follow your agency's policies and procedures
• Get major roads open first
• Get two lanes open first then plow shoulders
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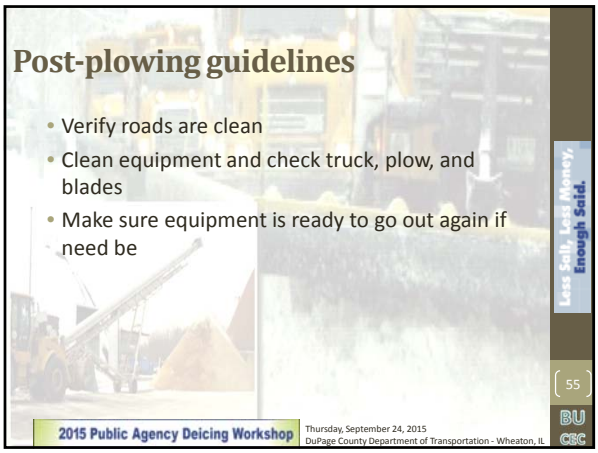
Post-plowing guidelines
• Verify roads are clean
• Clean equipment and check truck, plow, and blades
• Make sure equipment is ready to go out again if need be
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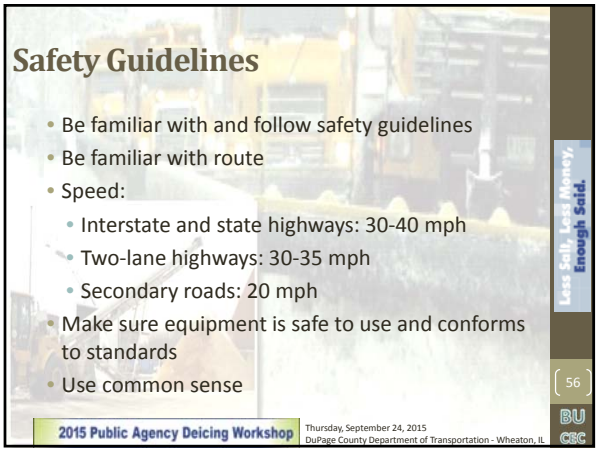
Safety Guidelines
• Be familiar with and follow safety guidelines
• Be familiar with route
• Speed:
  • Interstate and state highways: 30-40 mph
  • Two-lane highways: 30-35 mph
  • Secondary roads: 20 mph
• Make sure equipment is safe to use and conforms to standards
• Use common sense
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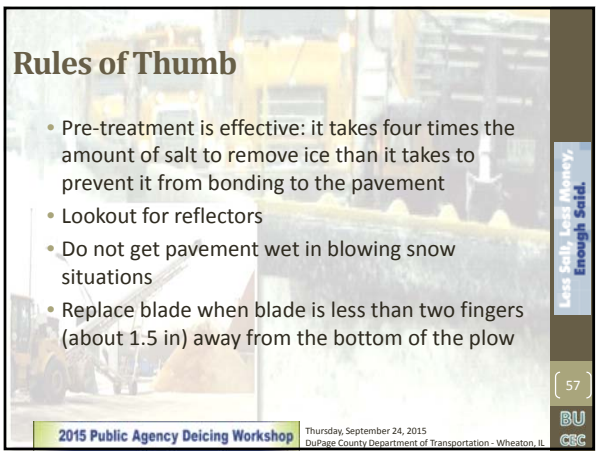
Rules of Thumb
• Pre-treatment is effective: it takes four times the amount of salt to remove ice than it takes to prevent it from bonding to the pavement
• Lookout for reflectors
• Do not get pavement wet in blowing snow situations
• Replace blade when blade is less than two fingers (about 1.5 in) away from the bottom of the plow
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New Technology
• Road sensors have improved quite a bit
• A variety of types of blades are available
• GPS
• Speed controlled salt distribution
• Communications with the public through mobile apps
• Snow plow route optimization
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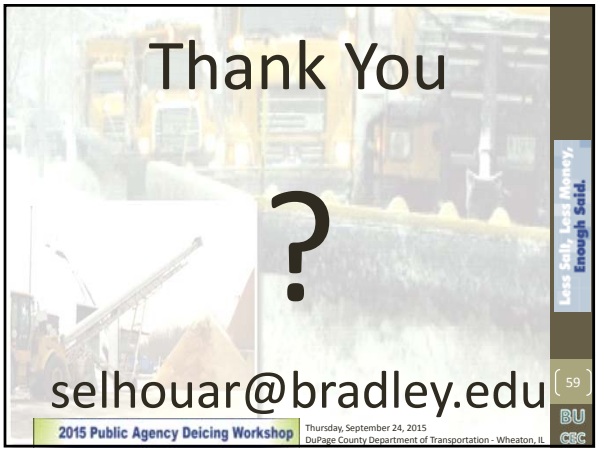
Thank You
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