Seasonal Weight Restriction Implementation

County Engineers' Workshop 2014
February 11, 2014

Bob Lindbeck, P.E.
Engineer-Manager, Alger County Road Commission

Other Countries' and States'

METHODS OF CALCULATION AND IMPLEMENTATION

Methods of Determining Susceptibility

1) Falling Weight Deflectometer (FWD)
2) Benkelman Beam Analysis
3) Frost Tubes (data specific to exact location)
4) RWIS or ESS Frost Depth (typically top 18 inches)
5) Thawing Index of Air Temperatures
6) Test Hole Excavation

FWD Testing

ASTM D 4695

Benkelman Beam

Gilson Company, Inc.

STATE OF MINNESOTA
DEPARTMENT OF HIGHWAYS

in cooperation with

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS *and*
MINNESOTA LOCAL ROAD RESEARCH BOARD

FLEXIBLE PAVEMENT EVALUATION WITH THE BENKELMAN BEAM

INVESTIGATION NO. 603
SUMMARY REPORT – 1968
(1983 Revision)

The Benkelman beam test can be a valuable aid to the engineer in providing a more objective basis for his determination of the requirements for reinforcing and upgrading flexible pavements, evaluating his flexible pavement designs, and in setting spring load restrictions. It is hoped that Minnesota engineers will take advantage of this research and implement a program of deflection measurements to aid them in making engineering decisions in which the strength of flexible pavements is a factor.

MNDOT 1968

It is a general conclusion of this investigation that the Benkelman beam can be a very effective tool for obtaining information which will be a valuable aid in making engineering decisions with respect to the strength of flexible pavements. It is recommended that Minnesota highway engineers strongly consider using a program of deflection measurements as an objective basis for evaluating the strength of their flexible pavements. The procedures to be followed for performing the Benkelman beam test and for estimating load carrying capacity are given in PART II of this report.

MNDOT 1968

10 tests

1 every 500 ft

ESTIMATED SPRING LOAD-CARRYING CAPACITY

The following method is recommended for use to estimate the spring load-carrying capacity of a pavement from deflection tests conducted at any time between May 1 and freezing of the pavement in the fall. The steps are as follows:

1. Obtain at least ten deflection tests (one every 500 feet) in each mile of the road to be evaluated.
2. Average the ten deflections in each mile.
3. The standard deviation, s, for each mile is then calculated using Equation 1 and the uncorrected average, $\overline{BB}_{80}$.

$$s = \sqrt{\frac{\sum\left(BB - \overline{BB}\right)^2}{(n-1)}} \qquad \textbf{Equation 1.}$$

where :

s = standard deviation, 0.001 in.

BB = individual deflections, 0.001 in.

$\overline{BB}$ = average of individual deflections, 0.001 in.

n = number of individual deflections in the mile. of individual tests being considered.

Σ = summation of quantity in parenthesis for number of individual tests being condsidered.

4. If the mat temperature is less than 80 °F correct the average of the individual deflections, $\overline{BB}_{80}$, to a deflection at 80 °F, $\overline{BB}_{80}$, using Table 1. All corrections are added.

MNDOT 1968

Table 1. Benkelman beam deflection corrections to 80°F*

Range of Defl. in Inches	Temperature in Degrees F: to 35	36-45	46-55	56-65	66-75
.000 - .010	.005	.004	.003	.002	.001
.010 - .020	.007	.006	.004	.003	.001
.020 - .030	.010	.008	.006	.004	.002
.030 - .040	.010	.008	.006	.004	.002
.040 - .050	.012	.010	.007	.005	.002
.050 - .060	.015	.012	.006	.006	.003

*All corrections to be added.

Note: For deflections over .060 in. no data have, as yet, been obtained. It is suggested that the corrections for 0.050 to 0.060 in. deflections be used for higher deflections.

5. Calculate the "present design deflection" of the test site by adding two standard deviations to the average deflection corrected for temperature. This value ($\overline{BB}_{80} + 2s$) is the deflection which theoretically is exceeded on 2 per cent of the mile if the deflection at the points tested are representative of the pavement.

6. The next step is to convert ($\overline{BB}_{80} + 2s$) value to "design spring deflections", SBB, which are the deflections which the test load would cause during the critical spring period. Table 2 gives deflection ratios as a function of time of year and surface thickness for three embankment types. At this point it is necessary to know the embankment type of the test site in question. The ratios are representative values for a winter slightly more severe than an average winter considering spring results from 1964, 1965 and 1966. SBB is calculated by multiplying ($\overline{BB}_{80} + 2s$) by the appropriate deflection ratio. It should be pointed out that the ratios in Table 2 were developed from pavements conforming to the Minnesota Highway Department Flexible Pavement Design Standards and, therefore, should only be used for pavements that likewise conform to these standards.

MNDOT 1968

Table 2. Deflection ratios to calculate critical spring deflections from deflections taken during other non-frozen times of the year (Revised1983)

PLASTIC EMBANKMENTS									
Asphalt Surface Thickness	Date of Test								
	5/1 5/15	5/16 5/31	6/1 6/15	6/16 6/30	7/1 7/15	7/16 7/31	8/1 8/15	8/16 8/31	Sept.
≤ 2 in.	1.12	1.29	1.44	1.53	1.60	1.65	1.69	1.73	1.79
> 2 ≤ 3½	1.17	1.34	1.50	1.59	1.63	1.67	1.71	1.73	1.75
> 3½ ≤ 5½	1.14	1.24	1.37	1.43	1.50	1.58	1.64	1.70	1.71
> 5½ ≤ 8 in.	1.17	1.25	1.25	1.25	1.26	1.30	1.41	1.50	1.55
> 8 in. Conventional Construction	1.13	1.18	1.16	1.13	1.15	1.18	1.29	1.37	1.45
> 8 in. Full-Depth Construction	1.12	1.16	1.16	1.10	1.09	1.15	1.33	1.46	1.55

SEMI-PLASTIC EMBANKMENTS									
Asphalt Surface Thickness	Date of Test								
	5/1 5/15	5/16 5/31	6/1 6/15	6/16 6/30	7/1 7/15	7/16 7/31	8/1 8/15	8/16 8/31	Sept.
≤ 5 in.	1.16	1.35	1.40	1.50	1.52	1.51	1.48	1.46	1.45
> 5 in.	1.29	1.40	1.46	1.50	1.54	1.58	1.64	1.69	1.71

NON-PLASTIC EMBANKMENTS									
Asphalt Surface Thickness	Date of Test								
	5/1 5/15	5/16 5/31	6/1 6/15	6/16 6/30	7/1 7/15	7/16 7/31	8/1 8/15	8/16 8/31	Sept.
≤ 2 in.	1.30	1.41	1.72	1.79	1.83	1.83	1.88	1.88	1.88
> 2 ≤ 5½	1.21	1.36	1.47	1.53	1.58	1.56	1.52	1.49	1.44
> 5½ ≤ 8 in.	1.00	1.02	0.98	1.00	1.05	1.05	1.07	1.11	1.11

MNDOT 1968

Repeat for each mile

7. From Table 3 find the allowable spring deflection, ABB, for the pavement in question. At this point it is necessary to know the average surface thickness and traffic level of each mile. The allowable spring deflection is selected from Table 3 for HCADT when this is known. Use ADT only if data on HCADT are not available.

8. Compute the allowable spring axle load for the mile using Equation 2.

$$L_A = L_D \frac{(ABB)}{(SBB)}$$ **Equation 2.**

where:
- L_A = allowable spring axle load, tons.
- L_D = axle load used for deflection testing, tons.
- ABB = allowable spring deflections from Table 3, 0.001 in.
- SBB = design spring deflection, 0.001 in.

Table 3. Allowable spring deflections

	two-way	HCADT*	< 50	50 - 100	100 - 150	> 150
Traffic	two-way	ADT**	<500	500 - 1000	1000 - 3000	>3000
Bituminous Surface Thickness			Allowable Deflection, inches			
less than 3 in.			0.075	0.070	0.060	0.045
3 to 6 in.			0.065	0.060	0.050	0.040
greater than 6 in.			0.055	0.050	0.040	0.035

*HCADT = heavy commercial average daily traffic volume (excludes passenger cars and 4-tired trucks).

**Use ADT only when HCADT is not known.

9. Repeat for each mile in the length of pavement under consideration.

10. Use allowable loads for various miles to aid in setting load restrictions.

MNDOT 1968

Europe

INFRASTRUCTURE NOTES

TRANSPORTATION, WATER AND URBAN DEVELOPMENT DEPARTMENT
THE WORLD BANK

March 1993
Transport No. RD-14

SEASONAL TRUCK-LOAD RESTRICTIONS AND ROAD MAINTENANCE IN COUNTRIES WITH COLD CLIMATE

Jukka Isotalo

Isotalo 1993

- In Finland, use of FWD has recently ousted the use of Benkelman beams.
- In Iceland, the thawing of frost is measured.
- In Norway, most measurements are made with FWDs.
- In Sweden, no quantitative criterion is measured.
- In France, it is difficult to achieve a coherent system because of the large number of decision makers, haphazard approach to meteorological information, and insufficient inter-regional and inter-county cooperation.
- The United States have no uniform formulae on how to apply load restrictions.

Isotalo 1993

Ontario, Canada

Depth of Thawing

Proposed System for Co-ordinating Spring Load Restrictions in Ontario

Max Perchanok, Research Coordinator, Ontario Ministry of Transportation
Heather McClintock, Maintenance Engineer, Ontario Ministry of Transportation*
Steve Birmingham, Maintenance Officer, Ontario Ministry of Transportation
Juan Pernia, Professor, Lakehead University
Robert Timoon, Research Associate, Lakehead University

Paper prepared for presentation
at the Better, Faster, Safer Road Maintenance Session
of the 2013 Conference of the
Transportation Association of Canada
Winnipeg, Manitoba

- A variety of methods and criteria are used to establish restriction dates, creating uncertainty for commercial road users.
- This provides scientifically-based projections to assist decision makers in determining load restriction dates.

- An initial effort developed a degree-day index model to predict the depth of freezing early in winter and the depth of thawing from the top and bottom as the thawing season progresses. The index approach is similar to one developed in Minnesota (Ovik et al, 2000), with the difference that the Ontario model predicts frost and that depth rather than the load restriction start date.

- Tools have been added to the Ministry of Transportation's RWIS web site that provide observations and forecasts of frost and thaw depths, and estimated critical dates for the initiation and ending of Winter Weight Premiums and Spring Load Restrictions.

Isotalo 1993

3.3 Empirical Prediction

In an initial effort to provide a forecast of frost and thaw depths, the University of Waterloo (Tighe et al, 2007) developed a degree-day index model to

4

predict the depth of freezing early in winter and the depth of thawing from the top and bottom as the thawing season progresses. The index approach is similar to one developed in Minnesota (Ovik et al, 2000), with the difference that the Ontario model predicts frost and thaw depth rather than the load restriction start date. Empirical coefficients account for differences in geotechnical characteristics at each instrumented site. It has the advantage of requiring only the time series of air temperatures as input, and can project frost and thaw depths as far into the future as the daily air temperature forecast (Figure 3). Different coefficients are used for the freezing and

4. Conclusions

Tools have been added to the Ministry of Transportation`s RWIS web site that provide observations and forecasts of frost and thaw depths, and estimated critical dates for the initiation and ending of Winter Weight Premiums and Spring Load Restrictions.

With a training program planned for the fall of 2013, the system will provide a sound engineering basis for adjustment of the dates based on varying seasonal weather conditions and will help balance the interests of the Ministry in minimizing thaw-related repair costs while providing improved access to the trucking industry.

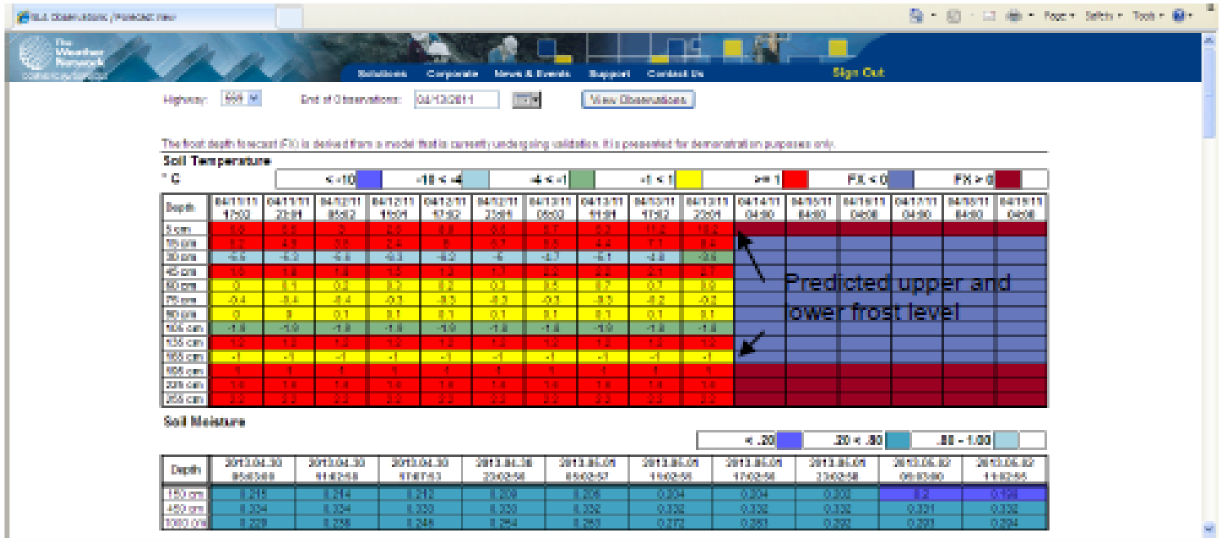
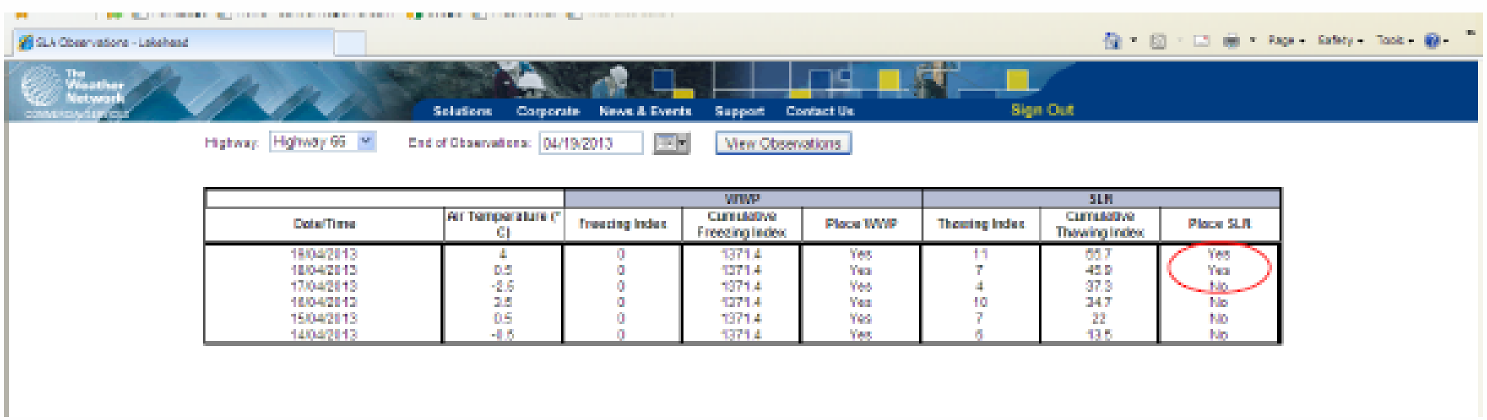


Figure 3. Forecast of Frost and Thaw Depth



		WWP			SLR		
Date/Time	Air Temperature (°C)	Freezing Index	Cumulative Freezing Index	Place WWP	Thawing Index	Cumulative Thawing Index	Place SLR
19/04/2013	4	0	1371.4	Yes	11	55.7	Yes
18/04/2013	0.5	0	1371.4	Yes	7	45.9	Yes
17/04/2013	-2.5	0	1371.4	Yes	4	37.3	No
16/04/2013	3.5	0	1371.4	Yes	10	34.7	No
15/04/2013	0.5	0	1371.4	Yes	7	22	No
14/04/2013	-6.5	0	1371.4	Yes	6	13.5	No

Figure 4. Load Restriction Recommendation from Lakehead Model

Wisconsin

Frost Tube & RWIS
Subsurface data
For State Highways

With

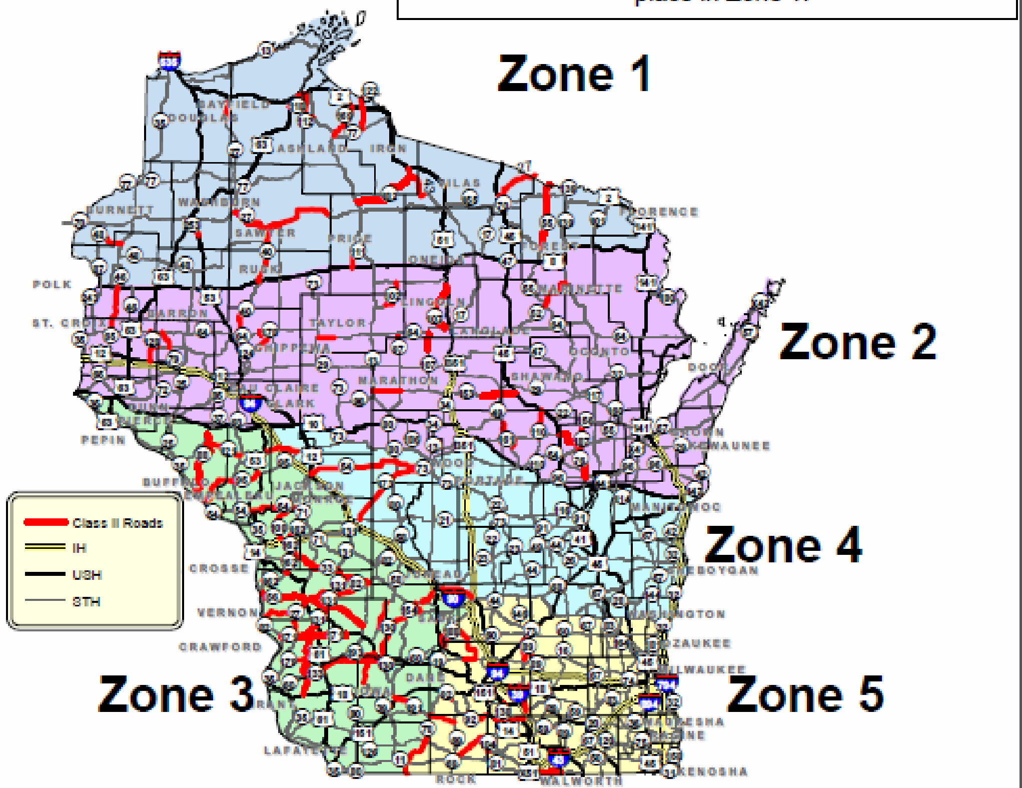
Thawing Index
Recognized For Local Roads

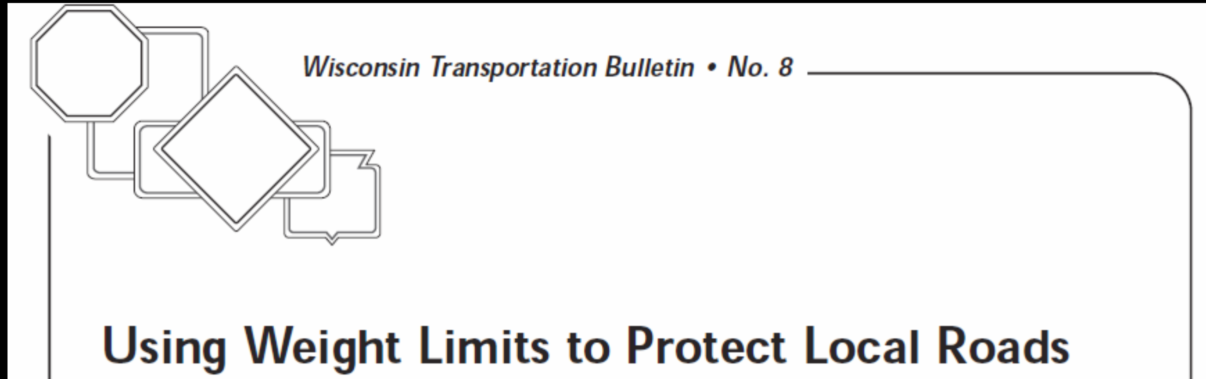
Wisconsin Highway Region Map

2013 CLASS II WEIGHT RESTRICTIONS
FOR NON-DIVISIBLE OVERWEIGHT PERMITS
(PERMITS BEGINNING WITH AA, AP, BH, GG, II, MH, MP, SA, SM, SS, AND ST)

STATE-MAINTAINED HIGHWAYS ONLY

Class II restrictions end in Zone 2 on Thursday, May 23, 2013 at 12:01 CDT.
Class II roadway restrictions previously ended in Zones 3, 4, and 5.
Class II roadway restrictions remain in place in Zone 1.




Wisconsin Transportation Bulletin • No. 8

Using Weight Limits to Protect Local Roads

- Wisconsin's extensive local road system is a lifeline for our state and local economies.
- Local officials have a responsibility to preserve our investment in roads by protecting them from excess damage caused by trucks carrying heavy loads.
- For local roads, you generally must use judgment and experience. However, a Thawing Index (TI)—calculated like heating degree days used by winter fuel suppliers—can help you predict when to begin restrictions.

- Begin using the Thawing Index when the average daily temperature rises above 29° F—chosen as a reference temperature because tests show than an asphalt pavement surface is 32° F when air temperature is about 29° F.
- Pavement thickness determines how many thawing degree days are needed for applying spring load restrictions. The FHWA study *Guidelines for Spring Highway Use Restrictions* has established "should" and "must" Thawing Index levels for thick and think pavements.

- Effective communication with the public, your own agency, and affected haulers is essential.
- Protecting local roads from damage by heavy vehicles is the responsibility of local authorities.

Minnesota

Thawing Index

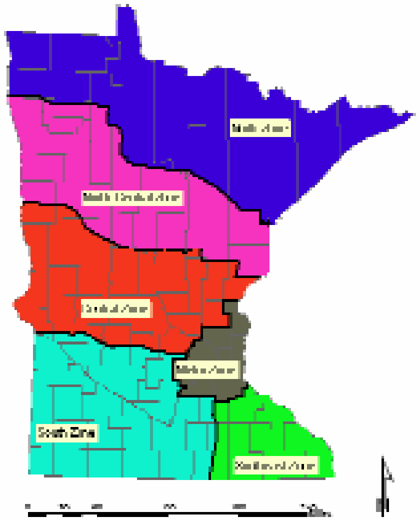
Projected Using RWIS and ESS data

With

Regional Implementation

Minnesota
Regions using Thawing Index

Seasonal Load Limit Zone Boundary Descriptions



North Zone	Extends south from the Canadian border to a line following and **including** TH 1 at the North Dakota state line east to TH 89, TH 89 south to US 2, US 2 east to TH 33, TH 33 south through Cloquet to I-35, I-35 north to the Carlton/St. Louis county line, and then south on that line to the Wisconsin state line.
North-Central Zone	Extends south from the southern limit of the North Zone (TH1 – TH 89 – US 2 – TH 33 – I-35 – Carlton/St. Louis county line – WI state line) to a line following and **including** US 10 from the North Dakota state line east to Motley, TH 210 east to Brainerd, TH 18 east to I-35, I-35 south to TH 48, and then TH 48 east to the Wisconsin state line.
Central Zone	Extends south from the southern limit of the North-Central Zone (US 10 – TH 210 – TH 18 – I-35 – TH 48 – WI state line) to a line following and **including** US 12 from the South Dakota state line to the Hennepin county line.
South Zone	Extends south from the southern limit of the Central Zone (US 12 – Hennepin county line) to the Iowa state line and east to the Metro Zone and then a line following and **including** I-35. This zone includes TH 19 along the southern border of Scott county.
Metro Zone	Minneapolis – St. Paul Twin City Metro Area includes the following counties: Anoka, Carver, Chisago, Dakota, Hennepin, Ramsey, Scott and Washington. This zone does not include TH 19 along the southern borders of Scott and Dakota counties.
Southeast Zone	Extends south from the southern limit of the Metro Zone along, but not including, I-35 to the Iowa state line and east to the Wisconsin state line. This zone includes TH 19 along the southern border of Dakota county.

- Critical time for SLR is when the pavement first thaws, thus proper measurement and prediction of freeze-thaw events is crucial to a successful load restriction strategy.
- Counties, townships and municipalities generally followed state recommendations on load restriction posting and removal dates.

- The current MnDOT policy uses actual and forecasted averages daily temperature to determine when SLR should be placed and removed.

For Minnesota, SLR impacts many more miles of the county township and municipal systems than the state trunk highway system. Damage incurred to the entire road system is quite substantial if SLR are not placed before the critical thaw period.

- SLR are not new to Minnesota. Although changes were recently made in the way SLR are placed and removed, the concept had been around since 1937.
- As the average air temperature decreases, a pavement structure freezes from the surface, down. In the same manner, as the average air temperature increases, a pavement thaws from the surface down.

MnDOT

3-day notice for restrictions

TI based on forecast for 3 days

TI > 25 F

TI =

Explanation of Process

The process used to place SLR is as follows:

1. The Districts submit their restricted roadway segments for the annual *ROAD RESTRICTION MAP* to the Director of the Office of Materials & Road Research by November 30 of the preceding year.

2. The annual *ROAD RESTRICTION MAP* is available electronically at the Office of Materials & Road Research.

3. A toll-free telephone number (1-800-723-6543) and local telephone number (651-366-5400), a web page (Seasonal Load Limits), and by subscribing, an automatic e-mail update have been established to provide information on postings in each frost zone as quickly and conveniently as possible. A 3-day notice of restrictions is provided using a recorded telephone message with more detailed status reports available on the Internet site. U. S. postal service mailings are no longer used, but you can get current and timely notice by subscribing to receive automatic e-mail updates.

4. The start of the load restriction period is determined for each zone using measured and forecast daily temperatures for several cities within each frost zone. The criteria used to determine when the load restrictions will be placed is when the cumulative thawing index (TI) for a zone exceeds 25 F degree-days based on the 3-day weather forecast, with predicted increases well in excess of 25 F degree-days.

   The intent is to use the 3-day advance forecast temperatures to ensure that the postings are on at the beginning of the thaw and at the same time provide 3 days of notice to the public that the posting period is coming. The calculation is made using the following formula:

   TI = Summation (Average Daily Temperature - Reference Temperature)

   The reference temperature decreases 1 degree F per week from 29 degrees F on February 1 to 24 degrees F on March 15.

5. The Internet site, recorded telephone messages, and automatic e-mail updates are the only means of notification provided on a regular basis.

MnDOT

Cumulative Data Available on Web-Site

MnDOT

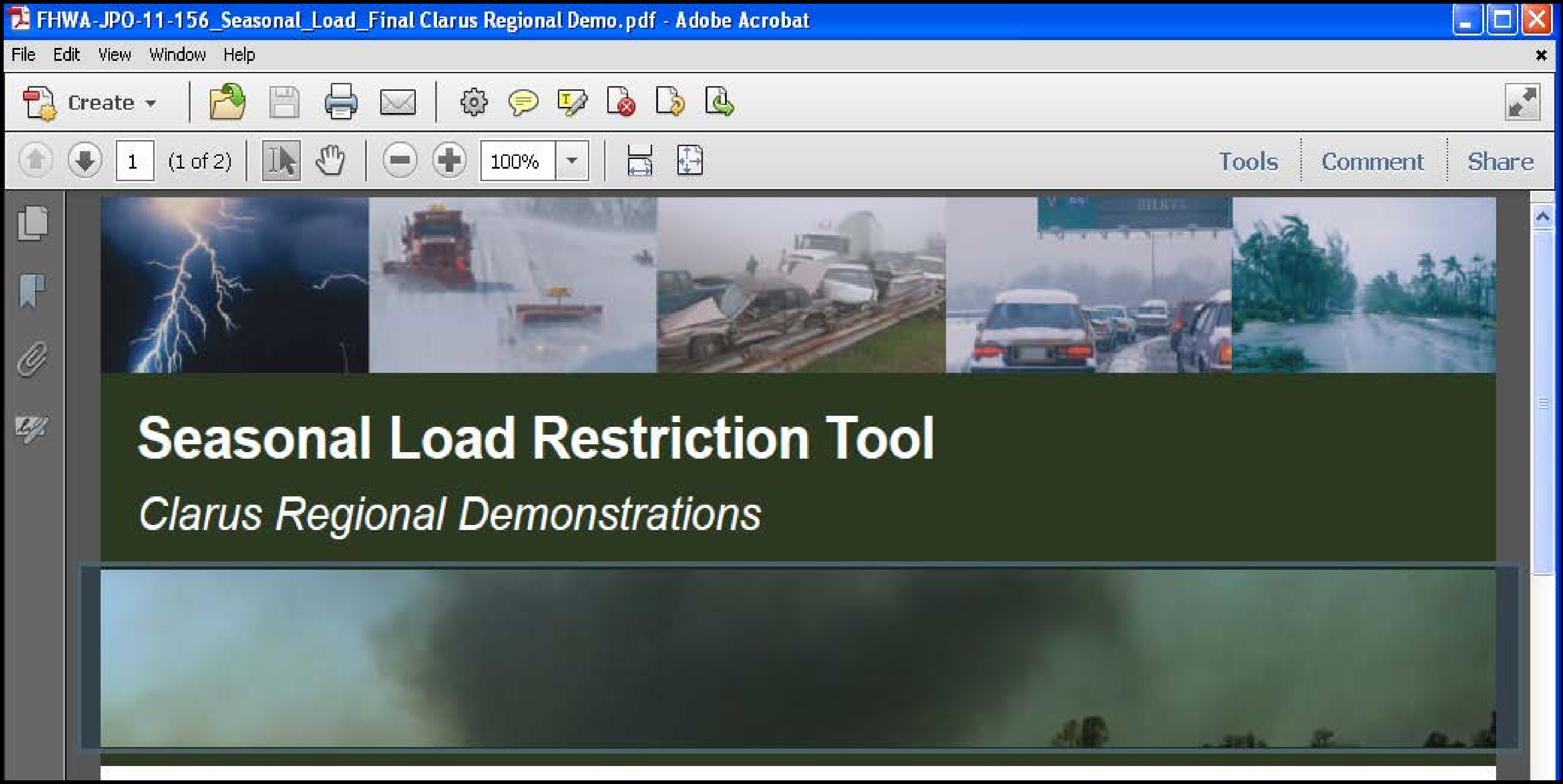
Montana, N. Dakota, S. Dakota

Subsurface Modeling Of Conditions

Based upon

Sub-pavement soil profiles, RWIS data, and weather observations

Clarus (Latin for Clear)



The *Clarus* Initiative, a joint effort of the U.S. Department of Transportation Intelligent Transportation Systems (ITS) Joint Program Office and FHWA's Road Weather Management Program (RWMP), is a six-year effort to develop and demonstrate an integrated weather observation data management system that can reduce the impact of adverse weather conditions on surface transportation.

Participants in the SLR *Clarus* regional demonstration project included State Maintenance Operations personnel in Montana, North Dakota, and South Dakota.

SLR uses *Clarus* and other observation and a numerical model output as input to a subsurface model that generates weight restriction guidance based upon simulated structural stability in the subpavement soil profile. The decision support tool lead also uses past and current weather observations, long-lead time weather forecasts, and characteristics of the subpavement thermal and moisture profiles to create its soil stability assessment.

FHWA, MT, ND, SD

Summary

The Seasonal Weight Restriction Decision Support Tool provides a better understanding of subsurface conditions that may be associated with conditions observed on the surface or tied to existing thaw assessment techniques.

To obtain a copy of this software, please contact Paul Pisano of the RWMP.

All photos courtesy of the FHWA Road Weather Management Program.

U.S. Department of Transportation
Road Weather Management
1200 New Jersey Avenue, E86-205
Washington, DC 20590

Paul Pisano
202-366-1301
E-mail: paul.pisano@dot.gov
http://ops.fhwa.dot.gov/Weather/index.asp

Federal Highway Administration
Research & Innovative Technology Administration

FHWA, MT, ND, SD

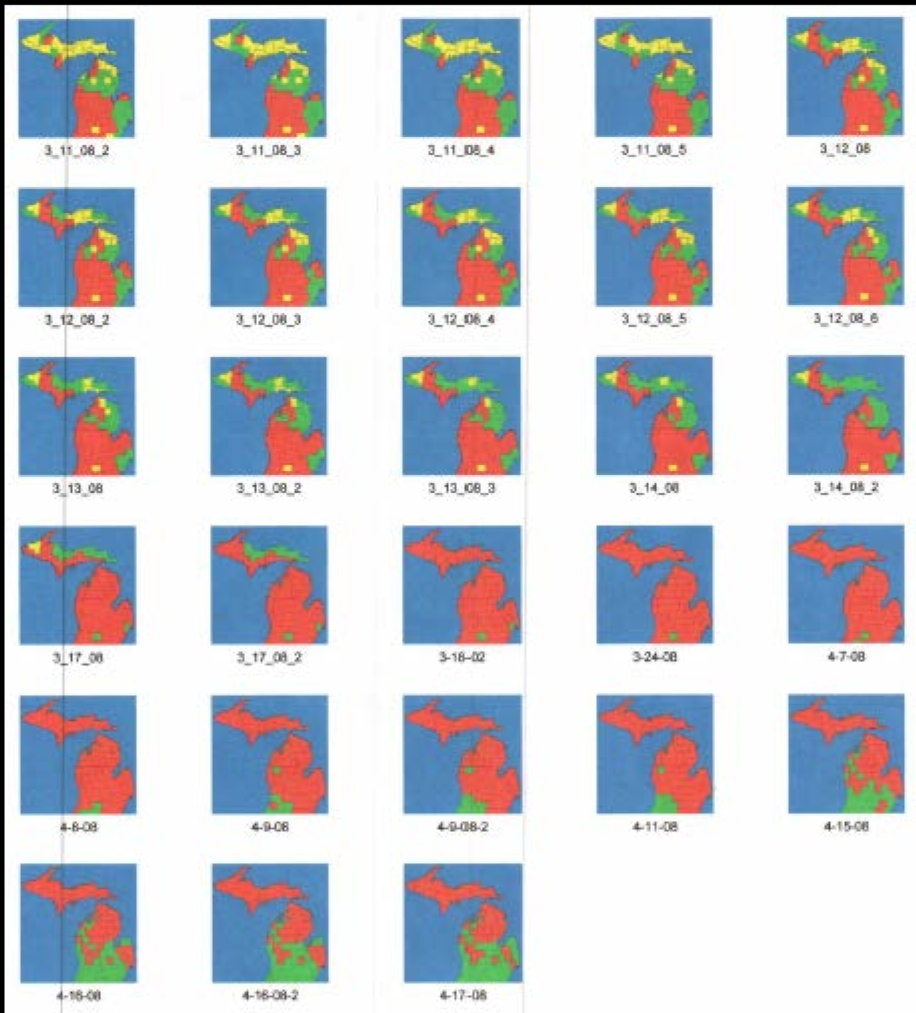
Analysis of
Regional Boundary (Zone) Implementation in Michigan

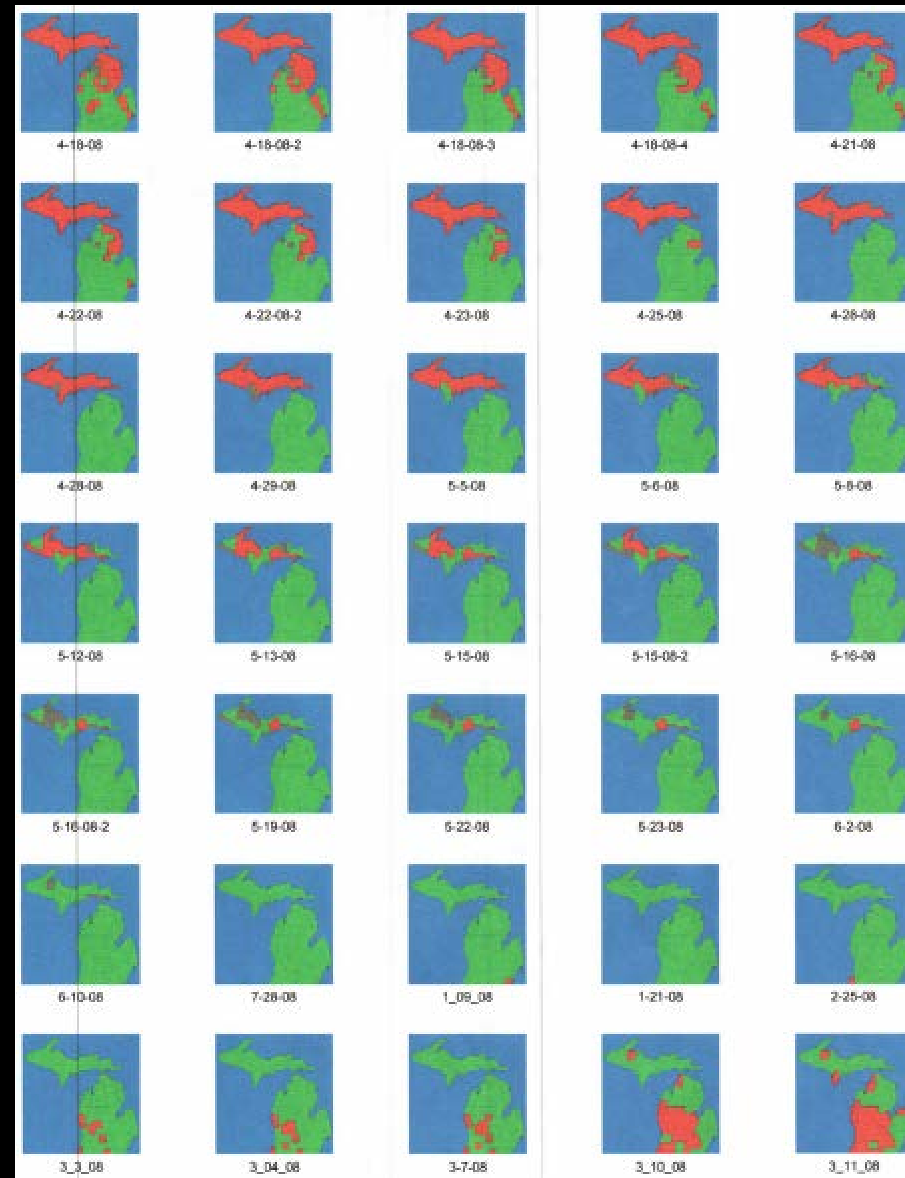
Are Regions based upon historic data a viable option for Michigan?

Potential Michigan Regions Based Upon Historic CRAM Data (2006 - 2012)

Historic CRAM data from all counties has been analyzed by date to construct trends of adjacent counties with similar (or identical) implementation dates……..

Sample of 2008 Data





CRAM

DRAFT Michigan Regions

July 24, 2012

Dear Engineering Committee Members:

Please remember our Committee's goal of presenting the information gathered by the **Uniformity in Weight Restrictions Sub-Committee** at each upcoming Council Meeting.

Mr. Karl Hansen has provided a one-page summary of the Sub-Committee research. The draft Regional Implementation Map will allow for input and explanation of the proposed regions. A copy of the questionnaire summary may also be helpful, when discussing the concept with Council members.

By introducing the concept of Uniformity in Weight Restrictions, at the CRAM Council level, we are hoping to educate all members on the research which has been done and also to discover whether the majority of each Council would support this Regional method.

Following the Council meetings please let me know if support exists for Regionalization, so our Subcommittee may proceed accordingly.

Thank you.

Robert L. Lindbeck, P.E.,
Engineer-Manager,
ALGER COUNTY ROAD COMMISSION

Seasonal Weight Restriction Uniformity

Regional Boundary Analysis

Meeting Date: January 9, 2012
Meeting Location: Otsego County Road Commission

1. Regions based upon historic data **may** be a viable option for Michigan (Similar to Wisconsin and Minnesota)

    A. Michigan Department of Transportation (MDOT) participation in regional boundaries, based upon data may be a key to a successful regional state-wide map. Public education & partnering with MDOT to display information at weigh stations, message boards, development of statewide truck maps, etc.) Data exists through CRAM for the past 5-years.

    B. Region panels would be necessary to establish implementation and removal dates. Panel should be made up of 3 to 5 engineers, with representation from county road commissions and MDOT staff.

    C. Regional panels must have the ability to place restrictions back on, based upon data.

    D. All weight restrictions must be based upon degree-day thawing data using FHWA-TS-87-209 with *average* region data and *"should"* criteria.

2. Permits will be available based upon each road agency's policy – utilizing existing unified permit form CRA 110. Permitting to allow hauling would be the responsibility of each road agency, as it is their asset that would be in jeopardy.

3. Bonding of permitted routes may be done at each road agency's discretion.

CRAM Council Survey

- During the December 3, 2012 Engineering Committee Meeting, Council support OR non-support for a regionalized approach to weight restriction implementation in Michigan was communicated.

Support of a Regionalized Approach To Weight Restriction Implementation In Michigan:

Council	Support Regions (Yes/No)
Blue Water	No
Great Lakes	No
Southeastern	No
Paul Bunyan	Yes
Southwest	Yes
Vacationland	Yes
Straits Area	No
Urban	No
Seven County	Yes

Future

CRAM Engineering Committee decided to:

- Retain Sub-committee to educate members on methods and research.
- Conduct 2013, 2014 test pilot programs throughout the state to re-evaluate regional approach.