Reaching Freeze & Thaw Balance: Combining Institutional Knowledge with Thawcaster



White Paper Center for Technology & Training

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Criticality of Consistency

Michigan road agencies, primarily consisting of county road agencies and the Michigan Department of Transportation (MDOT), along with heavy-weight commerce industries (such as logging, home heating companies, and waste removal agencies) each have a vested interest in keeping roadways open and accessible to traffic. Load restrictions on routes mean lost revenue for commerce industries like logging and increased expenses for many other industries; however, opening routes to heavy-weight traffic too soon often results in pavement "break-up", which requires costly repairs. No roadway surface is indestructible and, by law spring load restrictions (SLR), or seasonal weight restrictions (SWR), are imposed during the months of March, April, and May. Michigan road agencies can enact SWRs outside of these months on any road with the exception of designated "all season roads". Typically, the enforcement of SWRs reduces the maximum axle load allowable on the surface to 25% for concrete surfaces and 35% for all other surfaces.

Restriction guidelines provided by the US Department of Transportation Federal Highway Administration (FHWA) were developed by the Washington State Transportation Center and the University of Washington in their WA-RD 80.1 Report for the FHWA titled "Guidelines for Spring Highway Use Restrictions". The FHWA guidelines advise that applying SWRs depends upon pavement structure thickness, base course thickness, local experience, and the Thaw Index (TI; the TI is the cumulative number of degree-days above a reference temperature during the thaw season). This set of guidelines further differentiate timing of restriction application between "should" and "must" based on the pavement structure and TI:

Thin pavement structure - 2 in. or less surface thickness with 6 in. or less base course Weight restriction application should occur at 10 TI and must occur at 40 TI.

Thick pavement structure - more than 2 in. surface thickness with more than 6 in. base course Weight restriction application should occur at 25 TI and must occur at 50 TI.

For removing restrictions, the FHWA guidelines propose that removal could occur after the TI exceeds 0.3 x the Freeze Index (FI; the FI is the cumulative number of degree-days below freezing during the thaw season).

There must be a balance between the road agencies' needs and the needs of commerce industries. Road agencies strive to protect the service life of their roads while avoiding costly repairs, whereas commerce industries

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seek to mitigate lost revenue and increased expenses that result from imposed SWRs. In northern climates, the central dilemma comes down to keeping routes used by heavy trucks fully open as long as possible when the calendar rolls into spring.

Keeping road users' concerns in mind, road agencies do not wish to implement SWRs any earlier than necessary. Engineers have many different tools and resources available for evaluating the need for applying SWRs and for assessing when to give the "all clear" for removing SWRs.

Tools include the use of visual clues identified on road surfaces (presence of bleeding and pavement deflection), institutional knowledge of road conditions in the past seasons, physical measurements (using frost tubes, strength readings, and/or test holes), and the FHWA Method described in the FHWA's guidelines (i.e., calculation of daily high/low temperatures to obtain the accumulated freeze and thaw indices). The primary concern with relying on visual clues and physical measurements for adding or removing SWRs is that they are reactive rather than predictive assessments of thaw-weakening. Surface characteristics like bleeding are not apparent at the onset, and by the time the surface changes are visible the thaw-weakening has already happened.

The FHWA Method is easy to use but it, too, has other shortcomings such as accounting for differences in pavement designs, differing soil types, and a lack of weather forecast data for each road. Collecting the necessary temperatures over time to support the FHWA Method is relatively easy; however, collecting, entering, and maintaining data (typically in a spreadsheet) is laborious and time prohibitive.

With so many variables for determining SWR application and removal, decision making can appear to be somewhat arbitrary from state to state and even disproportionate from county to county. Perceived inconsistency and lack of transparency in determining application and removal of SWRs across state or even county lines can lead to the frustration of constituents affected by a road's restriction status.

Automating the Tedious

There is a clear need for a consistent and transparent process for applying and removing SWRs across the state of Michigan. In response, the Center for Technology & Training (CTT) focused on the use of the FHWA Method and began development of a web-based application to provide road agencies with a consistent and

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easy method of data collection. Thus, the CTT released Thawcaster, a web application specifically designed to take the tediousness out of data collection, data entry, and data maintenance so road agencies can focus on the business of predicting the SWR implementation and removal dates.

Thawcaster synthesizes two different assessment models, the FHWA Method and the Minnesota Method, into a single resource for data collection and assessment. Both methods use degree days to estimate how much the pavement has frozen as winter progresses and then how much is thawing as spring progresses. For the FHWA Method in Thawcaster, the freezing reference temperature is set at 32 degrees Fahrenheit, and temperature for thawing is 29 degrees Fahrenheit.

On the other hand, the Minnesota Method uses a floating thawing reference temperature in order to account for the increased warming efficiency of the changing sun angle during the spring thaw. This method discounts any early refreezing days, and sets thawing to zero starting on January 1st.

Built on the Microsoft Azure cloud service and using web service APIs, Thawcaster automates the data collection, calculation, and data storage processes by accessing historical, current, and forecast weather data. The weather data comes from a proprietary weather data source that includes weather data reported by the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service agency. The FHWA and Minnesota Method indices calculations are made on the collected data in Thawcaster throughout the season.



Data are accessible in Thawcaster by first selecting a location on the map. Thawcaster displays a full seasonal forecast based on the location.

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Thawcaster provides 10-day and seasonal forecasting of the Freeze Indices and Thaw Indices for 300 locations across the state of Michigan. Locations are based on pre-defined latitude and longitude points which display as the nearest zip code. The locations are spaced 14 miles apart supplying accurate weather data coverage over a broader area than the reporting NOAA weather stations provide on their own.

Thawcaster is a tool for predicting when thaw-weakening will occur based on location selection. By presenting the data graphically, Thawcaster provides road agencies with a clear visual representation of the rising and falling temperatures in conjunction with the calculated Freeze Index, Thaw Index, and indicators for when the application or removal of SWRs should occur according to FHWA guidelines so considerations can be made well before thaw-weakening indicators are determinable by visual clues or pavement measurements.



Thawcaster uses historical weather data to indicate the Thaw Index (TI) and Minnesota Method Thaw Index (MTI) for the entire season. This graph is displaying the TI and MTI in relation to the FHWA guideline for applying SLR on thin pavement.

Combining the Tools

In administering SWRs, there is no single source for determining the right time to apply and remove SWRs. Nevertheless, states affected by pavement freezing and thawing should provide a consistent and transparent

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SWR decision-making process within its borders. During the critical times of the year when some roads are in their most fragile state, Thawcaster is an efficient and predictive tool that compliments the road agency's institutional knowledge for determining application or removal of SWRs with the consistency, transparency, and accuracy necessary to keep a balance between all concerned parties in Michigan.

About CTT

The Center for Technology & Training (CTT) is a research center housed at the Department of Civil and Environmental Engineering at Michigan Technological University. The CTT provides tecnical assistance to Michigan road agencies, the Michigan Department of Transportation, the Federal Highway Administration and other transportation-related organizations through the Local Technical Assistance Program (LTAP). Visit <u>www.ctt.mtu.edu</u> and <u>www.michiganltap.org</u> for more information.



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