Guidelines for Road Restrictions

As many road managers know, pavement damage is most likely to happen during thawing periods. Thawing occurs during late winter and early spring (mud season) and during warm weather periods in the mid-winter months. To prevent potholes and cracks from forming,

1. Apply truck load restrictions during the thawing (or critical) period, or
2. Change the pavement structure to prevent or reduce damage.

Due to budget constraints, many agencies have only the first alternative. This article will discuss regulations and a systematic method for posting roads.

RSA 231:191

When placing load limit restrictions, managers must keep RSA 231:191 in mind. It grants cities and towns the authority to establish "Maximum Weight Limits on Class IV, V, and VI Roads." It allows them to post roads to prevent unreasonable damage or extraordinary municipal maintenance expense. The law states that postings shall be located at all entrances to the highway. Any person violating the maximum weight limit without written permission shall be required to repair damage attributed to his/her vehicle.

The following general guidelines can be used when placing weight restrictions. These guidelines, based on a study performed by Washington State Transportation Center (WSTC), and Douglas Dowey's use in New Hampshire's District 3, provide criteria to help determine:

1. Where to apply load restrictions,
2. The amount of the load restriction, and
3. When to apply and remove load restrictions.

The Problem

Frost action in soils can cause damaging effects. One effect is the frost heave. Another is the loss of ability of the road base to support heavy traffic. Reduced base course strength occurs during thawing periods. Ice melts from the top down, trapping water until lower ice layers melt. Trapped water saturates the wearing and base course layers. This results in more moisture than the pavement was designed for and reduces the strength of the pavement and its supporting base.

Any lowering of base material strength or increase in the number of loads reduces the life of the pavement. Therefore, reducing loads when the strength of the pavement materials is reduced is a reasonable way to maintain the design life and general serviceability of the pavement.

Where to Apply Load Restrictions

In New Hampshire seasonal load limits are usually placed on roads carrying less than 5000 vehicles per day and subject to excessive damage during the thawing period. To select which pavements are candidates for load restrictions, agencies should consider surface thick-ness, the type of subgrade, and local experience relating to observed moisture and pavement distress.

Surface Thickness. Agencies should consider load restrictions if the pavement surface thickness is two inches or less.

Type of Subgrade. Pavements or unpaved roads with a fine-grained subgrade are candidates for load restrictions. Silts and clays, common in New Hampshire, are considered fine-grained soils.

Local Experience. Highway managers should use their own knowledge to determine load limit application. This includes determining the historical performance of the road (i.e. drainage, behavior during thaws, and the structural sufficiency of the road foundation). Roadway usage including frequency, size, and number of trips heavy vehicles make are important considerations. The availability of alternative routes, projected damage, and cost of repairs should also be examined.

Load Restriction Amount

The load reductions used by the agencies interviewed in the WSTC study suggest that reducing the load on individual axles (or tires) by about 40 to 50 percent reduces pavement distress to an acceptable level.

The results generally showed that the more loads are reduced, the greater the increase in pavement life. As shown in Table 1, potential pavement life increases are dependent on load reduction. Thus, if the 44 percent load reduction level is used, this results in a potential improvement in pavement life of about 90 percent.

Table 1

Pavement Load Reduction (%)	Pavement Life Increases (%)
20	62
30	78
40	88
50	95

However, the necessary level of load reductions is not as simple as the table suggests. For example, many thin or generally weak pavement structures need higher levels of load reduction during the thaw periods to prevent significant pavement damage. Unpaved roads, especially those with a poor subgrade, are even more susceptible to damage from heavy vehicles.

The WSTC study showed that, when using load restrictions the load reductions should be a minimum of 20 percent. Load reductions greater than 60 percent appear to be excessive for paved roads. The general national practice for paved roads was to use load reductions ranging from 40 to 50 percent. The WSTC study confirmed this. However, the study lacked the data to make conclusions about unpaved roads. In some situations, many unpaved roads, especially very old roads that were not designed for modern truck loads therefore greater reductions than recom-mended for paved roads might be warranted. Local experience becomes very important with unpaved roads.

Degree Days Log

The WSTC guidelines used to apply and remove load restrictions are based on air

Degree-Days Log

A	B	C	D	E	F	G	H	I	J
Month	Day	High Temp	Low Temp	Avg. Temp (C-D)/2	FDD 32-Avg.	Cumu-lative FDD	MDD Avg.-29	Cumu-lative MDD	Notes
December	1	38	28	33	-1		+4		
	2	34	26	30	+2		+1		
	3	37	30	30.5	-1.5		+1.5		
	4	35	25	30	+2	2	+1		BEGIN CFDD
	5	32	20	26	+6	8	-3		
	6	33	20	26.5	+6.5	14.5	-2.5		
	7	31	19	25	+7	21.5	-4		
February	29					717.0			
March	5	33	24	28.5	3.5	720.5	-0.5		MAX CFDD
	6	38	26	32	0	720.5	+3	3	BEGIN CMDD
	7	39	29	34	-2	718.5	+5	8	
	8	37	25	31	+1	719.5	+2	10	SHOULD POST THIN
	9	41	30	35.5	-3.5	716	+6.5	16.5	
	10	42	33	37.5			+8.5	25	SHOULD POST THICK
	11	43	33	38			+9	34	
	12	41	29	35			+6	40	MUST POST THIN
	13	44	34	39			+10	50	MUST POST THICK
April	20							170.5	
	21	57	40	48.5			+19.5	190	
	22	59	49	54			+25	215	LIFT RESTRICTIONS

Pictured above is a sample Degree-Days Log used to determine when to apply and remove load limits. The following pages explain how to use this log .

temperature. Agencies can determine when to apply load limits by using a Degree-Days Log. A sample of this log is located below. Degree-Days are the number of degrees between some data and the average temperature for a particular day.

In order to use the Degree-Days Log the following factors must be calculated:

1. The average daily temperature.
2. Freezing Degree-Days (FDD), which is the difference between 32°F and the average daily temperature.
3. Melting Degree-Days (MDD), which is the difference between the average daily temperature and 29°F.

To use the Degree-Days Log, first determine the average temperature (this can be obtained from newspapers, government weather stations, private meteorologists, or businesses such as heating oil companies). Enter this number into Column E. If the average temperature is not available then use the sum of the high (Column C) and low temperature (Column D) divided by "2". Enter this value in Column E. The high and low temperature can be obtained in the same manner as the average temperature. If the agency starts this project after freezing occurs, the information is available historically using the same methods mentioned above.

To find the FDD, subtract the average temperature from 32°F. Enter this number in Column F. The summation of the FDD is a measure of the extent to which the road surface and base are subjected to below-freezing temperatures. The Cumulative Freezing Degree- Days (CFDD) in Column G is a running total of FFD.

To minimize errors, indicate positive and negative values for FDD. For an average temperature less than 32°F, the FDD is "+" and the value is added to the CFDD. Conversely, an average temperature greater than 32°F should be recorded with a "-" sign and its value is subtracted from the CFDD. Begin calculating CFDD only when there is a clear pattern of positive values for FDD, see December 4 in the sample log.

The running total of MDD is the Cumulative Melting Degree-Days (CMDD). The MDD for each day is calculated by subtracting 29°F from the average and entering it in Column H.

Be sure to indicate positive and negative values for MDD. When an average for a given day is more than 29°F, the MDD should be recorded with a "+" sign and the value is added to the CMDD from the prior day. Conversely, an average less than 29°F should be recorded with a "-" sign and the value is subtracted from the CMDD from the previous day.

CMDD recording should begin in the spring when there is a clear pattern of positive MDD and there is an average temperature above 29°F. This will indicate a period of consistent melting of the road base.

CMDD are used to determine when to establish load limits. CFDD and CMDD are used together to determine when to remove them. Their applications are described below. Since the data for all of the values must be collected for several months, it is easiest if the tracking is done using a spreadsheet program, which can be obtained from the UNH T^2 Center.

When to Apply Load Restrictions

Load restrictions should be posted at the start of the thawing period. For thin pavements this occurs when 10 CMDD accumulate (see March 8). For thick pavements, load restrictions should begin when they accumulate 25 CMDD (see March 10). These thresholds are estimates of when thawing will be sufficient to reduce pavement strength.

Load restriction must be posted after thin pavements accumulate a 40 CMDD (see March 12) and thick pavements accumulate 50 CMDD (see March 13) following the start of the thawing period. These thresholds are estimates of when thawing will reach approximately four inches into the base coarse.

Users should note in Column J of the Degree-Days Log when values in Column I indicate the road should and must be posted. They should also note road conditions in Column J.

It is recommended that users apply the "should" values during the initial years of application. Then, using the suggested documentation, they can determine the best thresholds for all or groups of their roads.

These criteria are best suited for use during the start of the spring thaw period, generally February through April. A different condition exist for mid-winter thawing cases. A higher base temperature for CMDD (such as 31°F) might better predict mid-winter road restrictions. However, the WSTC researchers did not develop a specific value. Local experience remains the best basis for mid-winter restrictions.

The temperature based Melting Degree-Days criteria are best applied to fine-grained soils, which are common in local roads in New Hampshire. The analysis performed in the study showed more consistent results for this soil type than for course-grained soils.

Placing Load Restrictions

When a highway agency sets a load restriction, it should notify the public through the press or letters. It should place temporary signs on all limited roadways.

It is recommended that agency staff individually notify contractors and loggers who frequently use the affected roads. Because the need for restriction happens quickly, this notification should be by telephone, fax, and/or email. If the agency has a policy for partial road use, such as early morning for certain roads, it should provide affected users with the procedures to apply the policy. The agency should also clearly establish exceptions to the policy; for example, transport of perishable or essential products such as milk or fuel oil.

The agency should keep a record of the effective dates of the posting and the removal for each road or a set of roads. Once it has applied load restrictions, it should monitor roadways to determine when it can remove restrictions. These records will document specific road behaviors, and be useful in applying the guidelines in future years.

Duration of Load Restrictions

The length of the load restriction period should approximate the time required to achieve complete thawing. The WSTC equation to estimate this time is

$$CMDD = 0.3 \cdot CFDD_{max}$$

In the example, the maximum CFDD of 717 occurred on February 29. Using the above equation, 0.3 times this value is 215. Therefore, in the sample Degree-Day log the load restriction should be lifted on April 22. Experience in New Hampshire, however, has indicated that the 0.3 multiplier varies due to a number of factors.

- Variations in road construction--pavement thicknesses, base thicknesses and materials, shoulders and ditches.
- Shaded areas that limit sunlight reaching the road surface.
- Elevation differences sufficient to influence average daily temperatures.
- Water remaining on roadsides due to residual snow and ice.

The suggested procedure is to make dur-ation judgements based on experience during the initial years of applying the guidelines. Users should note the maximum CFDD in Column J. Users should also document road conditions relative to the CMDD for specific road types. After several years, a factor can be determined that applies to road types, and substituted for 0.3 in the above equation.

This article was adapted by Stefanie R. Fishman from *Guidelines for Spring Road Use Restrictions,* which can be obtained from the UNH T^2 Center.

Sources:

Guidelines for Spring Road Use Restrictions, University of New Hampshire Technology Transfer Center, Durham NH, October 2000.
How Vehicle Loads Affect Pavement Performance, Wisconsin Transportation Bulletin, Transportation Information Center, Madison WI, 2000.
Maximum Weight Limits on Class IV, V, and VI Roads, Title 20, Transportation Section 231:191
Procedural Guidelines for Establishing Seasonal Load Limit Regulations, New Hampshire Department of Transportation, March 2000.