Canadian Strategic Highway Research Program (C-SHRP)

Seasonal Load Restrictions in Canada and Around the World

September 2000 **C-SHRP Technical Brief # 21**

In April 2000, the Transportation Association of Canada (TAC) held its annual Spring Technical Meetings in Ottawa, Ontario. During the TAC Pavements Standing Committee (PSC) meeting, a series of presentations were made to discuss policies of seasonal pavement load restrictions in Canadian provinces, the United States and various European countries. This brief has been prepared from those presentations. This brief is the second of its kind, following a similar brief issued in 1999 to summarize another round of presentations concerning pavement smoothness specifications.

BACKGROUND

Frost forms in pavement soil sublayers as the temperature drops below 0°C. As the water freezes, it expands, causing an increase in volume commonly referred to as "heave." Lenses of frozen water forming above the water table draw additional moisture upward through capillary forces, which in turn freezes and expands. The depth of frost penetration depends on the soil type, soil permeability and moisture content. Depending on the susceptibility of the soil to frost (capillarity) and the amount of water present, the formation of frost may not pose serious problem to the pavement structure, or may result in varying levels of damage due to differential frost heave. Unfortunately, the formation of frost and the associated damage imposed to the pavement structure varies from year to year. Variation of the water content in the soil, the height of the groundwater table, the duration and range of temperatures below 0°C and the heterogeneity of the soil allow significant variation in the frost behaviour within a pavement structure.

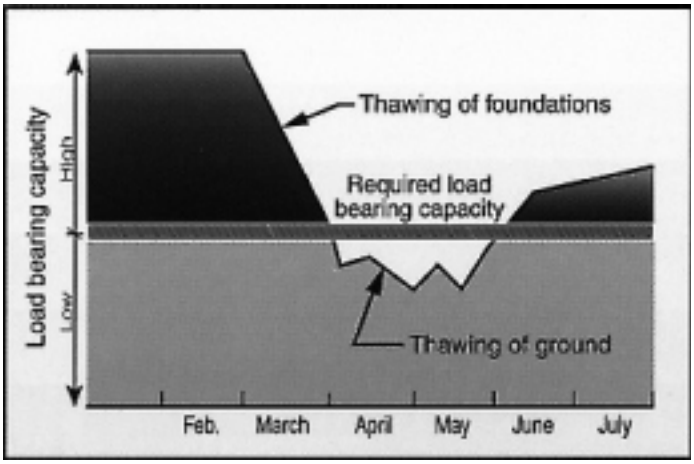
Loss of Strength During Thaw

In the spring, thawing commences from above and below the frozen layer. As the thaw progresses, the water may not efficiently drain out of the soil, as the surrounding soil remains frozen and impermeable. The soil then becomes temporarily saturated with water, which reduces the pavement structure effective strength (bearing capacity) to carry vehicular traffic (Figure 1).

If the surplus water is present immediately under the thawed road surface (in the granular base material), the majority of damage will occur in the asphalt layer. However, if the frost has progressed down to the surface of a frost susceptible subgrade, damage may occur throughout the entire pavement structure. If the road is also subjected to heavy truck loading, the dynamic loading will pump up the saturated fine graded subsoils into the structural layers [1]. Paved roads with thin overlays on top of frost-susceptible

soils may experience a loss of 50% of their normal bearing capacity during spring thaw, while a 70% loss of bearing capacity may be experienced on gravel roads.

Figure 1: Strength Loss During Spring Thaw



(courtesy of the Ministère des transports du Québec)

Financial Implications

In 1992, the World Bank published a report that established the order of magnitude of the benefits to be gained, either from strengthening roads that are sensitive to frost damage or from applying traffic restrictions during an extreme (20 year) winter [2]. A summary of the results from this investigation is shown in Table 1. The estimated savings associated with the implementation of seasonal traffic restrictions are substantial, ranging from 40% up to 92%, with an average of 79% for the countries analyzed. The costs reported in Table 1 include repair of pavements, incremental costs of operating vehicles on roads suffering from frost damage, and the costs resulting from restricting axle loads during thaw periods.

The United States Federal Highway Administration (FHWA) also investigated the benefits of seasonal load restrictions in 1990 [3]. Table 2 displays the expected increase in pavement life associated with varying pavement load restrictions. As with the World Bank study, it is clear that seasonal load restrictions can significantly extend the useful pavement life.

On the other hand, it should be noted that the imposition of seasonal load restrictions affects the productivity of the trucking industry. In 1982, the Alaska Department of Transportation and Public Facilities reported that the statewide loss in revenue to the trucking industry was approximately $100,000 USD per restricted day (1982 dollars). However, the associated damage to state roads imposed when load restrictions were not enforced (but should have been) was approximately $158,000 USD per day [4].

Winter Weight Premiums

Put simply, winter weight premiums are the opposite of seasonal load restrictions. During the winter months when the water in the pavement structure is frozen, some agencies allow increased truck loading under the assumption that the pavement structure has increased bearing capacity and to encourage a shift in the spring loads into winter, thus reducing the overall anticipated damage to pavements. The

Table 1: Cost Savings Associated with Seasonal Load Restrictions (adapted from [2])

Country	Percent of Road Network Sensitive to Frost and Thaw	Annual Daily Traffic	Cost of a Severe Winter With SLR (CAD million)	Cost of a Severe Winter Without SLR (CAD million)	Associated Cost Savings (Percent)
Bulgaria	25	2250	300	3750	92
CSFR	30	2700	450	3450	87
Hungary	40	2900	450	4650	90
Poland	15	2240	600	2400	75
Romania	50	2700	900	6600	86
Yugoslavia	45	2100	1350	8100	83
France	20	4900	7200	12000	40
Average					79

Table 2: Benefits from Seasonal Load Restrictions (from [3])

Pavement Load Reduction During Thaw (Percent)	Expected Pavement Life Increase (Percent)
20	62
30	78
40	88
50	95

magnitudes of these premiums are typically limited by the capacity of bridges and structures, but a range of 10% to 25% is common on some axles, or a reclassification of a secondary highway to permit primary loads during the winter season.

METHODS TO TIME LOAD RESTRICTION IMPOSITION

While it is apparent that seasonal load restrictions (SLR) are needed to prevent excessive damage to road systems during spring thaw, the procedures used to time the imposition of the restrictions vary widely. Direct methods include the use of frost tubes or deflection testing, while indirect methods include the use of historical databases, weather forecasts, prediction models or expert judgement.

Frost Tubes

Frost Tubes, also known as "freeze tubes" or "frost gauges", incorporate a thin transparent tube filled with water or other fluid to measure the depth of frost into the pavement structure. By monitoring the frost tubes, the enforcing agency can determine the beginning of the spring thaw (i.e. when to apply the load restrictions), as well as the end of the thaw when the restrictions may be lifted.

Deflection Testing

The Falling Weight Deflectometer (FWD), Dynaflect and Benkelman Beam are commonly used for deflection testing of pavement structures to capture the seasonal changes in strength.

Historical Databases and Weather Forecasts

Previous physical observations of road conditions and weather patterns are used to generate models that predict weakening periods. Over thirty years of measurements exist in some provinces. Coupled with accurate weather forecasting, this information can trigger the imposition (or lifting) of SLR to protect the road infrastructure before excessive loading occurs.

Thawing Index

Similar to the freezing index concept, the thawing index is the accumulation of degree-days above a reference thawing temperature. The index indicates the penetration of thaw in the pavement structure and the onset of weakening and the subsequent damage. The concept has been adopted by the state of Minnesota and is based on a refined Thawing Index (TI) equation:

$$TI = \text{Average Daily Temperature} - \text{Reference Temperature}$$

The Reference Temperature varies linearly from 29°F (-1.7°C) on February 1 to 24°F (-4.4°C) on March 15. The Reference Temperature method was developed for Minnesota conditions and reflects analysis of air, asphalt and base temperatures collected over a three-year period [7]. The average daily air temperature for days when the asphalt temperature was near 0°C (which indicated thawing of the base) was determined. This analysis indicated that the average daily air temperature that resulted in base thawing conditions decreased from January to March possibly due to increasing daylight hours during the early spring.

Observations of pavement deflection, the thawing index, frost depth and air temperatures at Mn/ROAD test site showed that thawing reaches a critical state at a cumulative thawing index of 25°F-days (13°C-days). Spring load restrictions are posted when the 3-day forecast predicts a cumulative Thawing Index in excess of 25°F-days (13°C-days) and continued increases well in excess of 25°F-days (13°C-days). The duration of the restrictions is the 8-week period following posting. Historically, the posting period has lasted 7 to 10 weeks with an 8-week average duration. A condition-based criterion for lifting the restrictions has yet to be established.

Expert Judgement

Agencies may rely on expert judgement to enact a restriction or a full closure of certain links according to the field conditions. This measure is often taken after consultation with local industry or users and on a case-by-case basis.

SEASONAL LOAD RESTRICTIONS IN CANADA

All Canadian provinces issue public orders that restrict truck loading during the spring thaw period. The policies aim to protect pavements by reducing axle loads that can cause significant permanent damage. The regulations vary not only in duration and extent but also on technical criteria and agency practices. Table 3 is a summary of basic and reduced axle loads from all provincial jurisdictions. It must be stressed that the values in Table 3 are presented for comparative purposes only and do not represent the entire set of basic and seasonally restricted loads imposed by each provincial agency. The reader is encouraged to contact the respective provincial transportation agency for more detailed information.

As shown, most Canadian agencies do not restrict their primary highway network during the spring thaw. Percentage reductions of 90, 75 (or 70) and 50% of the basic allowable weights are typically imposed, based on highway functional class and the reduction in bearing capacity experienced with annual deflection testing. Agencies that normally allow tolerances on their basic allowable weights typically remove those tolerances during the thaw. Finally, some primary highways are temporarily reclassified as secondary highways during the thaw so that they are then subjected to seasonal restrictions.

The respective start and end dates, test methods, exemptions and enforcement information reported by the jurisdictions are presented in Table 4. Although the actual imposition dates vary between agencies and individual seasons, most Canadian agencies impose spring load restrictions during March, and remove the restrictions in May. Deflection testing is used by 7 of the 10 provinces, while frost tubes are used primarily in British Columbia and Quebec. Most provinces allow exemptions to the restrictions for trucks carrying commodities such as milk, grain, forest products and other essential commodities. Most public utility and emergency vehicles are also exempt. Enforcement of the restrictions is typically completed using permanent and portable weigh stations.

Harmonization and Rationalization Study

The Prairie provinces (Alberta, Saskatchewan and Manitoba) and the federal department of Public Works and Government Services have jointly initiated a study to investigate harmonizing and rationalizing spring restrictions and winter load premiums. The study is being conducted by EBA Engineering and the University of Manitoba and will be completed by March 2001. The study established the critical need to rationalize and harmonize the regulation and enforcement practices, as well as to modernize information systems pertaining to the spring weight restrictions and winter premium aspects of truck size and weight (TS&W) limits in the Prairie Region.

INTERNATIONAL SEASONAL LOAD RESTRICTIONS

Practice in the United States

In the United States, 19 states have implemented spring load restrictions [6], however, there have been no uniform or consistent formulation on how to apply load restrictions, where and when to use them or how much to restrict the loads. A survey of the practices of 45 State DOT and 3 forest service regional offices revealed that 24% of agencies use quantitative methods (FWD, frost tubes or thaw index) to impose restrictions, while 52% of agencies used inspection and observation. The remaining 25% relied on a fixed date method. The removal of restrictions was made quantitatively in 14% of agencies, 57% inspection and observation and 29% by date.

The majority of restrictions in the U.S. are applied to asphalt concrete roads, however 10 states reported restrictions on surface treatments and some states also restricted gravel roads. The restrictions ranged from 6 or 7 tons per axle to 50% of the legal load and total shutdown. Restriction levels are typically set sufficiently high to accommodate school buses.

European Practices

Seasonal load restrictions in France and the Scandinavian countries are provided below. Again, these examples do not represent the practices of all European countries and may even vary within the individual countries.

In France, the weight restriction policy [1] is based on frost prevention on primary roads and the application of weight restrictions during frost thaw on the secondary road network. The weight thresholds are based on total weights of 3.5 and 9 tons, which correspond to 2.5, 4, 6 and 8-ton single dual-tire axles.

Table 3: Comparison of Basic and Seasonally Restricted Loads in Canada

Province	Allowable Weights Under Basic Regulations				Spring Load Restrictions			
	Tractor		Trailer		Tractor		Trailer	
	Steering	Drive	Tandem	Tridem	Steering	Drive	Tandem	Tridem
British Columbia[1]	**5500 kg**	**9100 kg**	**17000 kg** (1.2 to 1.85m)	**24000 kg** (2.4 to 3.7m)	• Restrictions imposed only when and where needed through engineering judgement • Overload permits suspended for numbered highways • Other highways restricted at 70% or 50% of basic axle weight (steering axle exempted)			
Alberta[2]	**5500 kg**	**9100 kg**	**17000 kg**	**23000 kg** (3.05 to 3.6m)	• 90%, 75% or 50% of basic axle weights			
					Not Restricted	**8190 kg** (90%) **6825 kg** (75%)	**15300 kg** (90%) **12750 kg** (75%)	**21600 kg** (90%) **18000 kg** (75%)
Saskatchewan[2]	**5500 kg**	**8200 kg**	**14500 kg**	**20000 kg**	• Reduction of load per tire from 10 kg/mm width to 6.25 kg/mm width to a maximum load of 1650 kg per tire • Some primary highways are downgraded to secondary highways during May and June			
					Not Restricted	**6600 kg**	**13200 kg**	**19800 kg**
Manitoba	**5500 kg** (A1 Hwys) **5500 kg** (B1 Hwys)	**9100 kg** (A1 Hwys) **8200 kg** (B1 Hwys)	**16000 kg** (A1 Hwys) (1.0 to 1.85m) **14500 kg** (B1 Hwys) (1.0 to 1.85m)	**23000 kg** (A1 Hwys) (3.05m) **20000 kg** (B1 Hwys) (3.05m)	• No restrictions to primary system or gravel roads • Steering axle not restricted • For other axles: • **Level 1** (beginning of thaw for 14 days): • A1 highways 90% of basic load • B1 highways 95% of basic load • **Level 2** (imposed 14 days after Level 1 and removed 1 week before removal of Level 1): • 65% of basic load			
Ontario[3]	**5000 kg**	**10000 kg**	**17200 kg**	**23000 kg**	• Primary network not restricted • Restrictions on some secondary provincial highways up to 50% of basic load • Commercial vehicles not to exceed 5000 kg • 2-axle tanker truck not to exceed 7500 kg/axle • Maximum of 5 kg/mm tire width			
Quebec	**5500 kg**	**10000 kg**	**18000 kg**	**21000 kg to 26000 kg**	**5500 kg**	**8000 kg**	**15500 kg**	**18000 kg to 22000 kg**
New Brunswick	**5500 kg**	**9100 kg**	**18000 kg**	**21000 kg** (2.4 to 3.0m) **23000 kg** (3.0 to 3.6m) **26000 kg** (3.6 to 4.8m)	• Three restriction levels: • All weather highways, arterials and most collectors allow 100% of basic load • Specific collectors and locals allow 90% of basic load • All other highways allow 80% of basic load • Tolerance removed for all levels			
	Tolerance 500 kg/axle							
Prince Edward Island	**5500 kg**	**6800 kg**	**13500 kg**	**18000 kg (<3.6m)** **19500 kg (>3.6m)**	• All weather highways, Trans-Canada arterials and some collectors allow 100% of basic load • Other highways allow 75% of basic load • Tolerance removed during thaw			
	Tolerance 500 kg/axle							
Nova Scotia	**• Combination 50000 kg + 500 kg/axle tolerance** **• 5-axle Semi-trailer 41000 kg + 2500 kg tolerance (Schedule C highways and some arterials and collectors)** **• Other highways 38500 kg gross vehicle + 500 kg/axle tolerance**				• Tolerance removed during thaw • Max. gross weight 12000 kg for buses			
					Not Restricted	**6500 kg**	**12000 kg**	
Newfoundland	**No formal policy** **9100 kg Single, 12000 kg Tandem**				• Arterial and collector roads are all weather • Local roads monitored and restricted as needed			

1. Trailer weights are based on 10 kg/mm of tire width.
2. Values reported for Secondary highway system.
3. Weights based on tire width. Example given is for width of 279.4mm (11 in.).

Table 4: Seasonally Load Restriction Implementation, Testing and Enforcement in Canada

Province	Start/End Dates	Testing	Exemptions	Enforcement
British Columbia	**Mid-February to Mid-June**	• Frost probes, weather synopsis, Benkelman Beam data for 20+ years, other historical data		• Permanent and portable scales
Alberta	**Start Date:** 30cm thaw and a heat flow model **End Date:** Determined with FWD testing	• FWD	• Milk, farm machinery, bread, water, heating fuel, fertilizer, mail and buses	• 20 staffed weigh scales, 20 self-weighing scales and portable scales
Saskatchewan	**Start Date:** Second or third week in March (weather dependent) **End Date:** Maximum six weeks after start date	• Benkelman Beam		• Permanent and portable scales
Manitoba	**Start Date:** (Level 1) • Southern Zone: March 23 • Northern Zone: April 15 **End Date:** May 31	• Benkelman Beam	• Essential commodities exempted	• Permanent and portable scales
Ontario	• Variable start and end dates. Typically first Monday in March to Mid May (Southern Region)		• Municipal, milk, emergency and public utility vehicles	• Permanent and portable scales
Québec	**North:** March 24 to May 25 **Central:** March 6 to May 12 **South:** March 21 to May 19 • Timing can be advanced or delayed based on frost probe data. Start of restrictions at 300 mm thaw and ending at 5 weeks after 900mm thaw below road surface	• 81 frost probes (1.5m to 3.5m depth) • Measured weekly during freeze, daily during thaw, and then weekly at end of thaw.	• Raw forest products exempted while hauling to primary processing plant. • Single unit trucks with non-detachable dumping mechanism • Road maintenance single unit vehicles	• Permanent and portable scales
New Brunswick	**Southern Zone:** Second week in March to mid-May **Northern Zone:** Third week in March to end of May • Timing varied according to severity of winter and spring conditions	• Dynaflect testing on 40 affected control sections on weekly basis during restriction period.	• Passenger buses and service vehicles.	• Permanent and portable scales
Prince Edward Island	**March 1 to April 30** • Timing varied according to severity of winter and spring conditions	• Dynaflect testing on random sections throughout restriction period.	• Commodities (potatoes, livestock, milk, fish, and live stock feed) .	• Portable scales
Nova Scotia	**Southern Region:** March 2 to April 24 **Central/Northern Regions:** March 2 to April 27	• Dynaflect testing on random control sections (all classes) from mid-February to end of April.	• Public utility and emergency vehicles.	• Portable scales
Newfoundland	**February to April** (Trans-Labrador Highway)			• Permanent and portable scales

In Scandinavia, weight limitation policies are based on a number of standards [1]. First, damage to the roads should be avoided in order to reduce annual road maintenance and rehabilitation costs (Finland, Norway and Sweden). Also, the life span of the road should be extended (i.e. damage avoided) to keep the road passable outside of the spring thaw period (Iceland). Furthermore, the roads should be passable year round for cars and emergency vehicles (Finland and Iceland). The roads should be secured for dairy and food transports, school buses and daily commuting traffic (Finland). Finally, the life span of thin overlays and surface dressings should be safeguarded (Norway and Sweden).

Finland applies vehicle total-weight restrictions. A 4 metric ton restricted limit allows transportation of cars, vans and agricultural tractors with a reasonable load, while an 8-ton limit will allow empty trucks and smaller buses. The limit of 12 tons, which allows large buses and 2-axle trucks, is aimed to prohibit heavy timber and earth moving transports. The local road maintenance supervisor has authority to grant dispensations to critical transports and the dispensation practice has been liberal to date.

Norway classifies all public roads according to the maximum allowed total weight, which depends on the allowed axle loads and the axle distances in the vehicle combination. The classification originated from the capacity of bridges. Since 1979 there has been a new road class, 10 tons with spring thaw restrictions. With the recent knowledge on the bearing capacity of roads, the number of road kilometers in this category has actually increased during recent years. Exemptions are usually granted only for route buses and dairy transports.

Sweden applies a variety of weight restrictions. An axle load of 10 tons may be reduced to 8, 6 or 4 tons. The total weight may be limited to 12, 9, 7 or 4 tons. An average of 150 km is closed annually. The local road maintenance supervisor imposes restrictions and may also grant exemptions. The exempted “necessary” transports include dairy and food deliveries. Cooperation between the road authorities and the traffic police in Scandinavian countries is good, and weight restrictions are controlled using portable scales.

SUMMARY

Seasonal pavement load restriction policies within Canada, the United States and Europe have been presented in this technical brief. The magnitude of these restrictions, as well as the methods to impose, monitor and enforce them vary considerably from province to province and country to country. Nonetheless, the overall goal of the restrictions is the same - to protect pavement structures during the spring thaw. This in turn will prolong the life of pavement and help to provide consistent and safe mobility of people and goods.

REFERENCES

[1] Isotalo, Jukka. "Seasonal Truck-Load Restrictions and Road Maintenance in Countries with Cold Climate." Transport No. RD-14. Transportation, Water and Urban Development Department, World Bank. March, 1993.

[2] Ray, M., Mason, M., Thriscutt, S. and Guerin, M. "Road Rehabilitation and Maintenance in Central and Eastern Europe." The ECA and MENA Technical Department, World Bank. 1992.

[3] Federal Highway Administration (FHWA). "Spring Load Restrictions." Pavement Newsletter No. 17. US Department of Transportation, 1990.

[4] Sweet, L. "Highway Load Restriction Determination." Alaska Science Forum Article #540. Geophysical Institute, University of Alaska Fairbanks. 1982.

[5] USDOT Federal Highway Administration. 1990. "Spring Use Restrictions." Pavement Newsletter No. 17/1990.

[6] Kestler, M., Knight, T., and Krat, A. "Thaw weakening on low volume roads and load restriction practices", Annual Meeting of the Transportation Research Board, 1998.

[7] Van Deusen, D., Schrader, C., Bullock, D., and Worel, B., "Recent research on Springtime thaw weakening and load restrictions in the State of Minnesota", Annual Meeting of the Transportation Research Board, 1998.

This technical brief has been prepared and distributed by:

Canadian Strategic Highway Research Program (C-SHRP)
2323 St. Laurent Blvd.
Ottawa, Ontario K1G 4J8

Tel. : (613) 736-1350
Fax : (613) 736-1395
www.cshrp.org

ISBN 1-55187-059-2