Seasonal Truck Load Restrictions: Mitigating Effects of Seasonal Road Strength Variations

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Roads in cold climates are exposed to seasonal strength variations. A paved road with a thin overlay on top of frost-susceptible soil may lose more than 50 percent of its summer strength. A gravel road built without sufficient base course may lose 70 percent of its strength in spring. In Scandinavia it is estimated that the annual costs of road repair would be $35 million (U.S.) per country without load restrictions. A recent World Bank study in some central and eastern European countries estimated the costs of road strength variations between 1.8 to 14.8 percent of the gross national product. The rehabilitation of some of the most important frost-susceptible transport routes in a particular province of Finland would give a benefit-cost ratio of 1.5. Unfortunately, the scarcity of financial resources seldom allows improvement of all needed roads. Therefore, many countries apply various types of weight restrictions. However, these restrictions are seldom based on accurate measurements and uniform policies. There is a need for more accurate technical and economic methods of deciding truck load restrictions. The complexity of the thaw phenomenon requires more accurate methods of frost measurement and measurement of moisture and other soil properties related to thaw prediction and fast and cheap methods to measure bearing capacity. The World Bank is currently updating its project planning model, HDM III, by including a cold climate submodel.

Roads in cold climates are exposed to seasonal strength variations. Thin road overlays on frost-susceptible soils are susceptible to severe structural damage in spring if the load-carrying vehicles are heavy. There is a wide annual variation in the freezing and thawing mechanism that makes it difficult to predict the extent of loss in bearing capacity in the spring. A paved road with a thin overlay on top of frost-susceptible soil may lose more than 50 percent of its summer strength. A gravel road built without sufficient base course may lose 70 percent of its strength in spring.

The strength variation has the following main cost implications (*1*):

1. Additional costs to maintain and rehabilitate roads. The main part of these costs is related to the volume and weight of traffic. A minor part of the costs is related to the physical damage caused by the freezing and thawing of road structures.
2. Direct costs to road users related to a reduction in speed (Finnish estimation, 10 to 20 km/hr) because of increased unevenness, soft surface, and damage to vehicles.
3. Indirect costs to the economy caused by lower utilizaton of vehicle capacity, reduced loads, extended routes to bypass weak or restricted roads, reloading and

storage of goods to reduce weight, and the amount of totally obstructed transports.

Global View on Economic Implications

Scandinavia

It is estimated (*1*) that the annual costs of road repair in the Nordic countries of Finland, Iceland, Norway, and Sweden amount to an average of $10 million (U.S.) per country under present policies of spring load restrictions. Costs for road repair would be $35 million per country without restrictions. Road user costs because of traffic restrictions were estimated to be $15 million to $20 million per year.

A recent study in a Finnish province (*3*) shows transport and production savings from rehabilitation of 240 km of the most important frost-susceptible transport routes with a benefit-cost ratio of 1.5. Of the 5000 km of public roads in this province more than 25 percent are annually prone to frost-thaw problems.

Central and Eastern Europe

A very severe winter in France in 1962-1963 cost $850 million (U.S.) to reconstruct low-volume roads. The World Bank (*2*) has carried out an initial estimate in some central and eastern European countries in order to evaluate the magnitude of the benefits to be gained either from strengthening the roads that are sensitive to frost damage or from applying traffic restrictions. The cost estimates were based on French data on severe winters. Assumptions were made of the extent of damage to pavements in both normal freezing conditions and in a severe winter, which is assumed to occur every 20 years. The costs without load restrictions could amount to between 1.8 to 14.8 percent of the gross national product in the selected countries (Table 1).

Russia

The author recently visited Vologda Province in the northern part of the Russian Federation. This region covers 145 000 km^2 and has 1.4 million inhabitants. Every spring, all public roads in this province have posted weight limits of 4 or 6 tons. The provincial road administration is using a fixed 45-day weight restriction period extending from April 5 to May 20. To enable the most vital transports, the road administration normally issues 5,000 to 6,000 provisional permits during this period. However, the permits are issued without any fee. The transporters are therefore bearing no burden for the possible damage to the roads. The direct enforcement cost paid by the local road administration to police in spring 1992 was 10 million rubles. The indirect and direct losses to the manufacturing and transport industries in the province are much higher.

TABLE 1 Evaluation of Costs of Severe Winter for East Europe and France (*2*)

Country	% of main road network sensitive to frost and thaw	Cost without truck restrictions as % of GNP	Discounted cost savings with truck restrictions (US$ mill.)
Bulgaria	25	11.9	800
CSFR	30	4.3	700
Hungary	40	14.8	1,000
Poland	15	2.3	500
Rumania	50	10.0	1,400
Yugoslavia	45	11,2	1,700
France (1985)	20	1.8	1,200

United States

In the United States, 19 states have springtime road use restrictions (*4*). FHWA gives the following table for the benefits of using spring load restrictions:

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

Weight Regulation Policies and Practices

General

For economic reasons, it would be ideal to improve and strengthen frost-sensitive roads to a frostproof condition. However, the scarcity of financial resources seldom allows improvement of all needed roads. For this reason, a number of countries with cold climates apply various types of spring load-restriction policies. The following examples reveal the great variety of such policies and practices.

Prediction of the extent of restrictions, correct timing and length of restrictions, and the correct total or axle weight limits are of great economic importance. However, few road agencies follow all indicators needed to predict the severity of the coming frost-thaw period. Current technical devices, such as falling weight deflectometers (FWDs), allow fast measurement of road strength. They are, however, seldom used and are considered too expensive for this purpose.

Scandinavia

In Scandinavia the weight limitation policies are based on the following principles (*1*):

1. Damage to roads should be avoided in order to reduce road maintenance and rehabilitation costs (Finland, Norway, and Sweden).
2. The life span of a road should be extended and damage avoided in order to keep the road passable beyond the spring thaw period (Iceland).
3. Roads should be passable year-round for cars and emergency vehicles (Finland and Iceland).
4. Roads should be secured for dairy and food transport, school buses, and daily commuting traffic (Finland).
5. The life span of thin overlays and surface dressings should be safeguarded (Norway and Sweden).

Enforcement

Cooperation between the road authorities and the traffic police in Scandinavia is good, and the weight restrictions are controlled using portable weigh bridges. However, only Iceland uses special police-highway staff teams to supervise weight restrictions.

Measurements for Weight Restrictions

The Nordic countries have traditionally used measurements for determining the need for weight restrictions. A traditional method applied for many decades is the measurement of frost depth and the followup of the thawing process.

Finnish experience reveals that the following values can be used as threshold values for weight restrictions. These values are based on measurements with a Benkelman beam under a 5-ton double-wheel axle:

Type of Road	*Allowed Deflection S5 (mm)*
Main road with asphalt pavement	1.20
Other asphalt roads	1.40
Surface dressed (oil gravel) roads	1.60
Secondary gravel roads	1.80
Tertiary gravel roads	2.00

The applicable weight restriction is determined from a graph. Use of FWDs has already replaced the use of the Benkelman beam.

Finland

Finland is presently applying vehicle total weight restrictions. A limit of 4 tons will allow transport by cars, vans, and agricultural tractors. An 8-ton limit allows empty trucks and small buses. A 12-ton limit permits normal buses and two-axle trucks and prohibits heavy timber and earth-moving transports. The road authority may issue provisional permits for a fee.

Norway

Norway has classified all public road according to the maximum allowed total weight, axle loads, and axle distances in the vehicle combination. The classification is published annually in a booklet called *Road List* (*Veglisten*) and is distributed to all road users.

Sweden

Sweden is applying a large 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.

France

In France weight restriction policy (5) is based on frost prevention on primary roads and application of weight restrictions during frost-thaw on the secondary road network. It is difficult to achieve a coherent system for all of France because of the large number of decision makers, insufficient knowledge of road behavior under thaw, the haphazard approach to meteorological information, and insufficient intercountry and interregional contacts. 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 twin-wheel axles.

United States

In the United States (4) there is no uniform formula for applying load restrictions, where and when to use them, and how much to restrict loads. FHWA recommends calculating freezing and thawing indices as a guideline for when to apply and when to remove load restrictions. The calculation formula is based on pavement thickness and the accumulation of daily low and high temperatures.

Russia

The author's interviews of Russian highway officials reveal an extensive use of spring load restrictions. It is not known whether the practice in Vologda Province of categorically restricting all public roads in spring applies to the whole Russian Federation.

RECOMMENDATIONS

Need for More Accurate Restriction Practices

In today's practice, most of the truck load restrictions are based on visual inspection and the institutional memory available in road maintenance units. Senior road supervisors familiar with the behavior of various road sections still play a key role in the decision making. More accurate methods to assist decision making are needed, especially for new road managers and supervisors.

Road users need more accurate technical and economical methods of deciding truck load restrictions. Locally, such restrictions have a great negative economic effect. Unnecessary restrictions should be avoided. The fees for provisional permits should reflect the anticipated damage to the road.

Need for Fast, Cheap Methods of Measuring Bearing Capacity

The complexity of the thaw phenomenon requires more accurate methods of measurement of frost and moisture and other soil properties related to thaw prediction. Frost-thaw can be very fast. Fast decisions in deciding on restrictions are needed at the lowest possible administrative level during the peak thaw period. Making these fast decisions requires fast and cheap methods of measuring bearing capacity.

Economic Models of Seasonal Truck Load Restrictions

The data of springtime FWD measurements as well as frost and spring thaw defects should be stored in the road data bank for the use of maintenance management and pavement management systems. The economic impacts of load restrictions should be incorporated in the calculations of benefit-cost ratios and internal rates of return of road development projects. It is encouraging that the World Bank is currently updating its project planning model, HDM III, by including a cold climate submodel.

Other Methods of Mitigating Needs for Weight Restrictions

The economic consequences of weight restrictions can be partly mitigated by allowing additional loading of vehicles during the peak winter period when the subsoil is frozen to sufficient depth. Through active cooperation with industry and transport agencies, part of the transports can be scheduled outside the frost-thaw period. The Scandinavian experience (2) recommends an introduction of low-pressure truck tires to reduce contact pressure on the road surface. Correspondingly, the introduction of wide-thread (super-single) tires would dramatically increase the damaging effect on roads. They could reduce the structural life of roads by a factor of 5. It may also be more feasible to shift the restrictions from the total weight to axle load limitations.

General

The weight restriction system applied in a country should be uniform, understandable to the road user, enforceable, and easy to measure on the spot.

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