CONTROL OF FROST HEAVE

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SYNOPSIS

The author describes the use of salt in the prevention of frost heave on railroad tracks. Frost heave will not take place if the soil water in a susceptible area does not freeze. When salt dissolves in the water, the freezing point is lowered. As it is possible to determine the amount of salt required to lower the freezing point to any desired level, it is only necessary to know the minimum temperatures to be guarded against.

Several methods of applying the salt to the roadbed are discussed, but the important factor is to apply the salt early enough so that it may be thoroughly distributed over the susceptible area by the time freezing starts.

The author suggests the use of salt as an admixture in subbase courses of highways as a frost control measure with no particular reference to stabilization. Such a procedure has been followed in the construction of highways in Nova Scotia during the past two years. The addition of from 20 to 40 tons of salt per mile has been quite satisfactory as frost control.

My subject has to do with certain experiments on the control and prevention of track heaves caused by frost action carried out over the past few years by Canadian railways. Since the control of differential frost heave is a problem in both the railway and highway fields, the information gleaned in the one can be presented with the hope that it will be found interesting and perhaps useful.

It is undoubtedly true that frost heaves on tracks are a much more serious problem to the railways than frost heaves on highways are to highway engineers. Smooth track is not just something desirable from the viewpoints of passenger comfort and economical operation; it is an absolute essential to safe operation of modern high-speed trains. A small heave, that, on a highway might be but a minor nuisance to motor traffic, on a railway track becomes a positive menace calling for immediate correction lest human lives be endangered, to say nothing of potential property damage.

Therefore continuous inspection for track movement and prompt adjustment of same are amongst the most important winter duties of track maintenance crews. Adjustment is accomplished by "shimming" the rails up on an even and gradual approach to and departure from the heave site, using hardwood shims of varying thicknesses in the process. Thus a short heave, if it be of only a few inches, may necessitate "shimming" hundreds of feet of rail, and it will be obvious that a one-sided heave affecting but one side of a track, must call for equal "shimming" of both sides. You will not then be surprised to learn that millions of shims are used annually by our railroads, and that the cost of placing—and later removing them runs into very substantial figures.

The experiments discussed here were promoted by the salt industry and involve the use of salt. May I briefly outline the theoretical basis on which we worked.

It is unnecessary to discuss the etiology of frost heaves,—you are all familiar with their causes. Nor do I need to repeat that adequate drainage, or excavation and back-fill with porous material will in the majority of cases eliminate them. These are well known facts.

But, as these methods are not always applicable for topographical or economic reasons, a cheap chemical control method has some interest.

The theory is simply that frost heave

will not take place if the soil water in a susceptible area does not freeze. There will then be none of the expansive force of ice formation, no migration of water to ice particles in the soil, and no heave.

Now, according to the records of underground temperature gathered by the Meteorological Branch of the Canadian Government it appears that the temperature at a depth of 15 in. to 2 ft., rarely goes below 15° F., in spite of air temperatures as low as 50 to 60 deg. below zero. Therefore, even though frost may penetrate to a depth of 6 or 7 ft., the temperature for most of this depth is within a few degrees of the freezing point. Any intense degree of frost is concentrated in the first foot or so of depth.

When salt dissolves in water, the freezing point is lowered. A 5 per cent salt solution will not freeze above 15° F. Salt might therefore be used to lower the freezing point of soil-water at shallow depths, below any temperature to be normally expected, or to so reduce the amount of freezing and the rate of freezing in a heaving area, as to make its movement uniform with the movement of the adjacent sections of track.

When the track movement is uniform, there is no problem. In the application of salt, the idea is to *make* soil movements uniform, by cutting down on the frost action and ice formation in the soils containing excess moisture, so that they will behave the same as the adjacent soils.

During the past three years our railways have treated some 940 spots that had been subject to recurrent and persistent frost heave, by methods based on the above theory.

Salt has been applied in several ways:

(1) Spread on top of the ballast with just enough cover to prevent it being washed off the ballast section with heavy rains. It is then worked out of sight with standard hoes or shovels.

(2) Spread in the desired thickness on the top of the ballast. The ballast section is boxed by building a lip or dyke at the bottom of the ballast section on the sub-grade approximately on the grass line. The small dyke about 9 in. is built to prevent the salt from being washed away from the ballast section. In this method the salt is not covered.

(3) Remove the ballast between the ties and place the salt at or below the bottom level of the ties. This method places the salt near the source of the heaving. For small thickness of salt, the ballast is replaced immediately, but in heavy applications it may be necessary to replace the surplus ballast left over from refilling the excavation, at a later date.

(4) The fourth method is to dig holes at 2 ft. centers, 6 in. in diameter, and varying in depth from 18 in. to 2½ ft. On the standard ballast section this places five, 6-in. holes across the track, three holes between the rails and two outside. Three inches of salt are placed in the holes and the ballast thrown in on top. The shallower holes are dug with standard tools, but a post hole digger should be used on deep holes to reduce cost.

In all methods of application, the salt must get to the moisture in the soil, and must have time to be distributed over the area before it can be expected to do any work. This means that it must be applied long enough before freeze-up to give it time to be absorbed into the soil moisture. Therefore the best time for application is in the late summer or early fall. Heaving spots treated too late in the fall give no results the first year. In most cases, however, the salt has been effective the next season.

Run-off must be provided in applying salt, the same as when "shimming." This is done by thinning out the application towards the ends. The length of run-off is usually governed by the length of the section which has previously required "shimming." The run-off should be about half of the distance, hence one tapers off the salt gradually to a point about the middle of each previously shimmed section.

If one knew the exact amount of excess water involved in a heave spot and the temperature it would fall to, it would not be hard to calculate the exact amount of salt needed to overcome the tendency to heave. But, since the actual moisture content of the soil may change from day to day, and since the temperature follows the general trend of the weather, exact dosages of salt for treatment of any given heave site cannot very well be determined. Therefore the amount of salt required in each case must be estimated, and we have found that this can best be done by one familiar with local winter conditions, preferably the road master or section foreman.

The following rule has been developed from practical tests:

Apply salt to the hump, not in the area where shims have been installed, and apply in the same thickness as the thickest shim usually used up to a maximum of three inches of salt.

The results of the treatments to date are naturally variable. A reduction in the amount of "shimming" required subsequent to treatment has been reported in approximately 90 per cent of locations, varying from 25 per cent reduction to complete elimination,—the latter in 28 per cent of the treatments. In all cases where cost records have permitted comparison of maintenance costs for successive years, the chemical method of heave control has apparently effected substantial savings. We do not regard this, as yet, as being fully conclusive since different conditions necessarily prevail in successive winters.

When salt is first tried, the user may sometimes get the impression that it produces soft track. This can happen, particularly if too heavy an application is made in clay soils. Upon investigation of many of these situations however it has been found that the so called "soft spots" were places where the salt had done its job, but that it had been cut off too abruptly. In other words, the salt treated spot had stayed down, while the rest of the track had lifted.

The length of time over which one treatment will continue to function cannot be predicted accurately, as soil conditions naturally vary from place to place. Our records support the conclusion that two years is the minimum expectation, as many of our original successful treatments are still functioning satisfactorily.

If the thoughts of this paper were to be translated to the field of road construction, they would support the use of salt as an admixture in the sub-base courses of highways, as a straight out-and-out frost control measure, with no particular reference to stabilization. This procedure has in fact been followed in the construction of Nova Scotia highways for the past two years, where 20-40 tons of salt per mile have been mixed into the sub-bases of newly constructed highways for no other reason than frost action control. The results, we understand, have been entirely satisfactory.