General

A review of the temperature ranges, soil types, and the water sources indicates that frost heave in itself is rearely a problem of great magnitude in Colorado. It does have significance in the fact that those soils having a high percentage of fines and which lie in close proximity to a water source take on sufficient moisture in the form of ice during the freezing periods to become a matter of major concern during the thawing cycle. From the previous discussions, it is noted that in the mountain valley areas, frost penetrations of 4 to 5 ft. are common. This entire frozen area immediately becomes a matter of concern when the thawing cycle starts.

In the fine-grained soils, the amount of moisture present has been found to be in excess of the plastic limit and often approaches the liquid limit during the thawing cycle. Under such conditions, it is obvious that the amount of support provided to any pavement structure could never be adequate to prevent complete disruption. The obvious answer, as we have found it, is to provide sufficient thickness of non-frost-reactive material together with grade lines which provide complete drainage of the roadway prism to a depth equal to the frost penetration. In high mountain areas, where the frost penetration is of a lesser depth, the granular blankets over soils similar to those in the high mountain valleys can be reduced only to the extent that the frost penetration is reduced.

FROST ACTION IN MICHIGAN

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Michigan's cool and moist climate is typical of the Great Lakes Region. The annual percipitation of 35 in. is well distributed throughout the year. The freezing index ranges from about 600 in the southern limits of the State to about 1800 in the Upper Peninsula. The Great Lakes have a moderating influence on temperatures thus preventing extremes of both heat and cold. Under this climatic environment the soils of the state have developed profiles belonging to the Podzol and Gray-Brown Podzolic soil groups. The northern Podzol group grades into the Gray-Brown Podzolic on a line extending across the central portion of the Lower Peninsula of Michigan.

The problem of frost action in Michigan is usually discussed under the headings of frost heaves and spring breakups. Common usage defines a frost heave as a bump or series of bumps high enough to be damaging to pavement and often dangerous to traffic. The term spring breakup is used in referring to the detrimental softening of the subgrade and associated surface failures which occur during spring thawing periods. Such softening is often most destructive when it occurs during a sudden January or February thaw.

Frost Heaves

Differential frost heaving is a spectacular expression of frost action now seldom seen on the main roads because of corrective measures consistantly applied. It occurs when certain soil textures, certain drainage conditions or a combination are found within the subgrade frost zone. Silts and very fine sand are soil textures commonly referred to as frost-heave materials. It would be more correct to say that a frost-heave material is a soil texture in which silt and fine sand are the dominating constituents or soil fractions. These materials are easily identified in the field visually and by feel. They have the capacity for moving large quantities of capillary water rapidly through the soil to points where such water is being removed, as, for instance, by evaporation or by the formation of ice crystals in the soil. Silt pockets do not necessarily depend on some water table as a reservoir for capillary water. Water stored in the body of the deposit as capillary water is normally sufficient in quantity to form ice layers and detrimental heaving.

Figure 1. Pavement Broken as a Result of Differential Heaving.

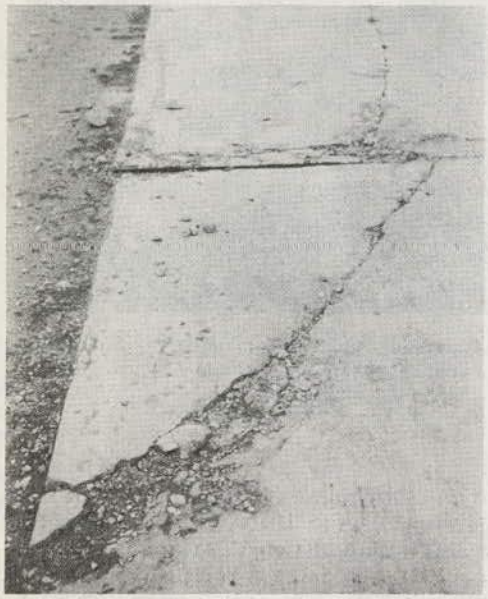

Figure 2. Differential Heaving Diagonal Cracking Parallel to Old Road Fill Crossed at Grade.

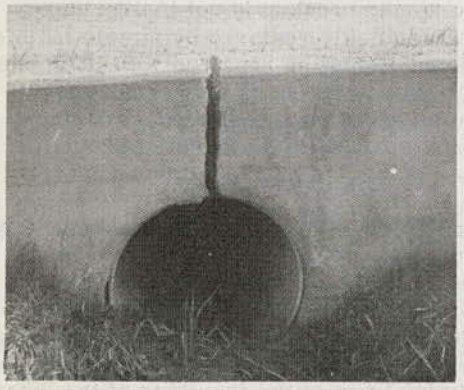

Figure 3. Cracked Headwall Caused by Frost Heaving of Shallow Culvert Pipe.

Figure 4. Frost Boil - Mud Breaking Through the Surface at the Shoulder.

Figure 5. Granular Lift Necessary Before a Bituminous Surface Can Survive a Spring Breakup.

Figure 6. Spring Breakup on Heavy Soils-Bituminous Surface Treatment on Gravel.

Minor heaves may also be caused by sudden and wide changes in the texture of the subgrade soil. Clay pockets in an otherwise sandy subgrade, the weathered horizons of certain soils and marl layers within the frost range illustrate textural variations which will cause heaving.

There are certain drainage situations which also cause heaving. Ground water seeping into the zone of freezing, for instance, will cause layers of ice to build up in any soil texture through which gravitational moisture can move. On the other hand, a stagnant water table in a clean and unfirmly granular soil will not cause serious heaving even when occurring within a few inches of the pavement.

There are a number of special situations which can result in winter heaves. Sewer and tile trenches in heavy soils backfilled with sand and gravel will result in bumps at each side of the trench. Crossing old road fills at grade in finely grained soils will often result in a heave at point of transition from old fill to new fill. Rock knobs within the range of frost penetration can cause extremely irregular heaves as the soil between the rock and pavement varies in depth. Small culvert pipe placed within 2 ft. of the surface have a tendency to heave out of the ground in certain soils and thus cause summer heaves in highway surfaces. Such heaves become more serious with each succeeding season until rebuilding the culvert becomes necessary.

Figure 7. Subgrade Softening - Rutting - First Step in Bituminous Mat Failure.

Spring Breakup

The spring breakup is a maintenance problem on older highways which have not been built to modern standards of design. Construction previous to 1935 did not provide for subgrade strengthening over soils which become soft during thawing periods. In areas of cohesive soils, therefore, most of the land access roads and a large proportion of the state trunkline mileage suffers considerable breakup damage each spring. Gravel, bituminous seals, and other flexible surfaces are most sensitive to the loss of subgrade support. Portland cement concrete pavements may reach middle age before serious failures begin to appear, provided the volume of truck traffic is not so great as to induce pavement pumping. For gravel surface the spring breakup is not too serious a problem since the road's original usefulness can be quickly restored by simple maintenance operations. The surface can be reshaped and otherwise repaired with little hand labor as soon as the frost is out and good drying weather removes the excess water. It is the bituminous surfaces which suffer most from lack of subgrade support during a winter or spring thaw. When these surfaces punch through to the extent of about 10 percent of the surface area the entire road begins to take on an appearance of general failure.

Michigan has extensive areas of sandy soils not susceptible to spring breakup. Areas where road construction is relatively simple and cheap. Unfortunately from a road foundation point of view, most of the people do not live on these sands. They live in regions of good farm land, areas of finely grained soils, good for farming but poor for building roads. It is a rare neighborhood, on the other hand, which will not yield some good construction materials if, in addition to upland sources, underwater deposits are also considered. To locate such suitable materials is one of the functions of the detailed soil surveys carried out for all projects on a state wide basis. Present design standards have been developed to satisfy requirements necessary to build a highway system capable of uniform service throughout the year: A system which will carry normal traffic of legal loads without pavement destruction.