

# A QUALITATIVE APPROACH TO MINIMIZING DIFFERENTIAL HEAVE

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## INTRODUCTION

Because differential heaving may lead to roadway hazards and costly repairs, designers must determine if inexpensive and simple techniques exist for reducing this problem. By considering three specific examples, one can examine the effect of varying subgrade soils on road and utility construction; this allows a qualitative approach to minimizing or eliminating differential heave.

Frost heave occurs when certain fine-grained soils, during the freezing process, attract water to the gradually deepening "freeze front" through wicking action. As the water freezes, it expands and increases the overall soil volume. Because it is confined below and laterally, the soil can only heave upward.

## EXAMPLES

Silty, frost susceptible soils in South Fairbanks range anywhere from four to twenty feet or more in depth and lay in and above a relatively high water table. Consequently, one would anticipate substantial ground heave in this area.

The Army Corps of Engineers (USACE) and the City of Fairbanks Engineering Division recently let contracts for work in South Fairbanks. Seasonal differentials in the finished surface elevations sparked an interest in the causes and effects of "differential heave". Because correction of deficiencies after project completion is costly, engineers should consider such standard options as minimizing excavation of poor soils, reducing the quantities of imported NFS material, or insulating the poor soils to slow frost penetration. Drainage and other, more costly standard alternatives exist, but one should first determine if the simpler methods will provide adequate and perhaps more desirable results.

The projects reviewed here are the USACE's culvert drains on Peger Road and the City's Discount Truck Stop sewer service and Twenty-third Avenue Reconstruction Project. Although the basic problem is a matter of materials, the results and effects vary.

In 1983, the Corps of Engineers completed the construction of a drainage ditch south of Fairbanks. At the Peger Road crossing, their contractor installed several 36" culvert pipes. Because the existing subgrade soil was highly frost susceptible silt, engineers directed the contractor to excavate eight feet below the pipe and replace the silty soil with NFS gravel<sup>1</sup>. They also bedded the pipe with gravel and though the existing road contained only two feet of NFS material, replaced the entire excavated portion of the roadway with gravel. The contractor paved the road that fall.

During the spring of 1984, this one-hundred foot section of roadway subsided nearly 15 inches. The abrupt change in profile forced the 35 mph traffic to slow to less than 10 mph to safely negotiate the area<sup>2</sup>. Initially, Corps engineers worried that the 36" culverts had collapsed or settled. These fears were quickly dispelled when the spring thaw revealed no conduit damage or deflection. Subsequent survey measurements revealed that the "subsided" roadway was actually stable; the surrounding ground and roadway had heaved up! The section evened out over the summer and the same sequence of events occurred during the winter and spring of 1985.

As part of a sewer interceptor repair project in the fall of 1983, City engineers directed the installation of a new sewer service to the Discount Truck Stop. Because the work was performed during sub-freezing, snowy conditions, the project engineer directed the contractor to backfill the excavation with NFS material. The contractor paved over the ditch flush with the surrounding asphalt in early May 1984<sup>3</sup>. Almost immediately, the business owner complained that the contractor had left a hump over the service ditch. At first, this hump was barely noticeable, but as summer progressed and the sur-

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rounding silt thawed and settled, it grew to be a substantial bump.

The final example is the mile long 23rd Avenue Reconstruction Project. This included replacing the existing six-inch gravel road with a 2 1/2 foot paved section and installation of a subsurface storm drain system. A thousand foot section of the new road lies on a very thick layer of highly frost active silt. During construction, the project engineer directed an additional 12 inches of unclassified excavation and backfill with NFS gravel. Time constraints, combined with a lengthy City Council approval process, precluded a more extensive effort<sup>4</sup>. Further, water, sewer, and storm system mains and services lay throughout the area, compounding difficulties in removing the silt. Each spring since project completion, this section of roadway has heaved several inches. Minimum gradients in the storm conduits (which freeze) and surface features result in substantial ponding "upstream" of the heaved area. Further, the heaving is so great that several feet of the concrete sidewalk vaulted the first year: the City replaced these sections at substantial cost. Finally, the subsurface drainage system has had no apparent affect as the magnitude of differential heave has remained constant. This isolated belt of silty-clay extends into the water table and is therefore relatively unaffected by surface runoff.

#### ANALYSIS

Overexcavation in a limited area may result in hazardous grade changes. The 15 inch elevation difference at the Army Corps' drainage ditch on South Peger Road forced vehicles to greatly reduce speed. This effect could have been minimized in two ways:

1. Don't remove the poor soils. Reuse existing materials and replace the roadway to match the adjacent embankment, thereby allowing a more uniform heave.

2. Overexcavate to thaw stable ground below the conduit as was done. However, transition to the surface--transverse to the excavation--at a shallow (4 to 1) gradient<sup>5</sup>. This way the elevation differential will extend over a great distance, thereby minimizing the hazard to traffic.

Complete overexcavation and replacement with NFS material is expensive and often impractical. The 23rd Avenue heave rests atop a deep layer of highly frost susceptible silt and carries several underground utilities. Political expedience and lack of readily available funds necessitated a minimum of subgrade replacement. While the engineer had hoped that drainage improvements would minimize the effect, there has been little noticeable change in the magnitude of the frost heave. Though also very expensive, placement of polystyrene insulation might be a more practical alternative to overexcavation in similar cases. The insulation increases the effective cover over the poor soils, thereby reducing frost penetration.

Reuse of in situ material tends to minimize differential heave. Placement of an isolated trench of NFS material will result in differential heave: a springtime dip, as on South Peger Road, or a later summertime bump, as at the Discount Truck Stop. The engineer's good judgment and the contractor's careful backfill and compaction may result in a safer, more aesthetic product.

#### REFERENCES

<sup>1</sup>Interview with Dale Johnson, Project Engineer, U.S. Army Corps of Engineers, Fairbanks, AK, 6 November 1985.

<sup>2</sup>Interview with Carol Adameczak, Project Engineer, City of Fairbanks Engineering Division, Fairbanks, AK, 28 October 1985.

<sup>3</sup>Interview with Rick Hand, Assistant Project Engineer, City of Fairbanks Engineering Division, Fairbanks, AK, 29 October 1985.

<sup>4</sup>Interview with James E. Vick, Project Engineer, City of Fairbanks Engineering Division, Fairbanks, AK 28 October 1985.

<sup>5</sup>Berg, R., and T. Johnson, "Revised procedure for pavement design under seasonal frost conditions," CRREL Special Report 83-27, 1983.