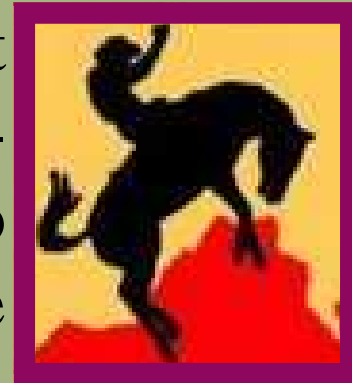


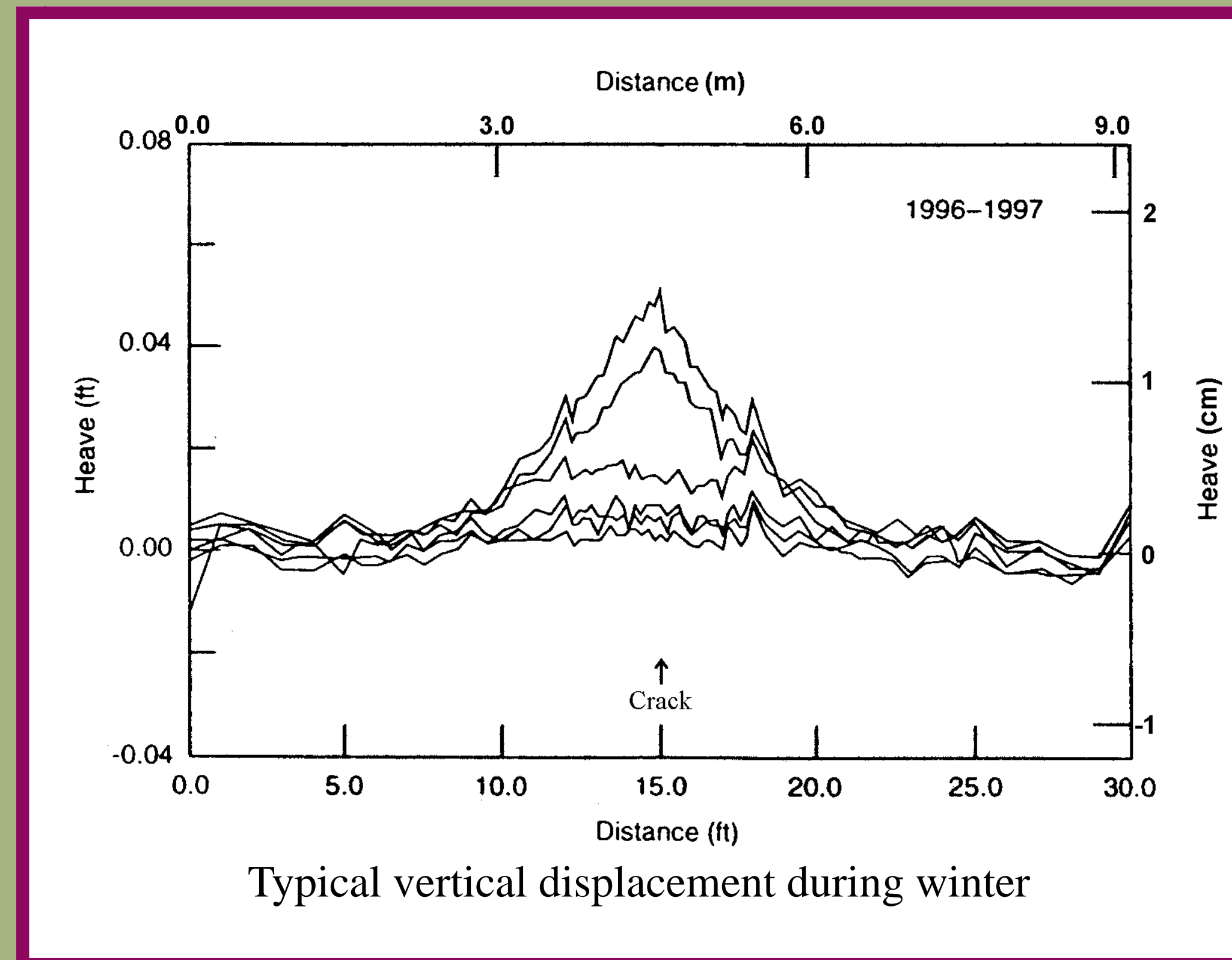
# UNDERSTANDING TENTING OF HIGHWAY PAVEMENTS



**Tenting**, also known as lipping, consists of localized heaving in the immediate vicinity of transverse pavement cracks. It typically produces a highly irregular riding surface, particularly toward the end of the winter season, and can lead to rapid premature deterioration of the pavement surface in the areas adjacent to the crack.



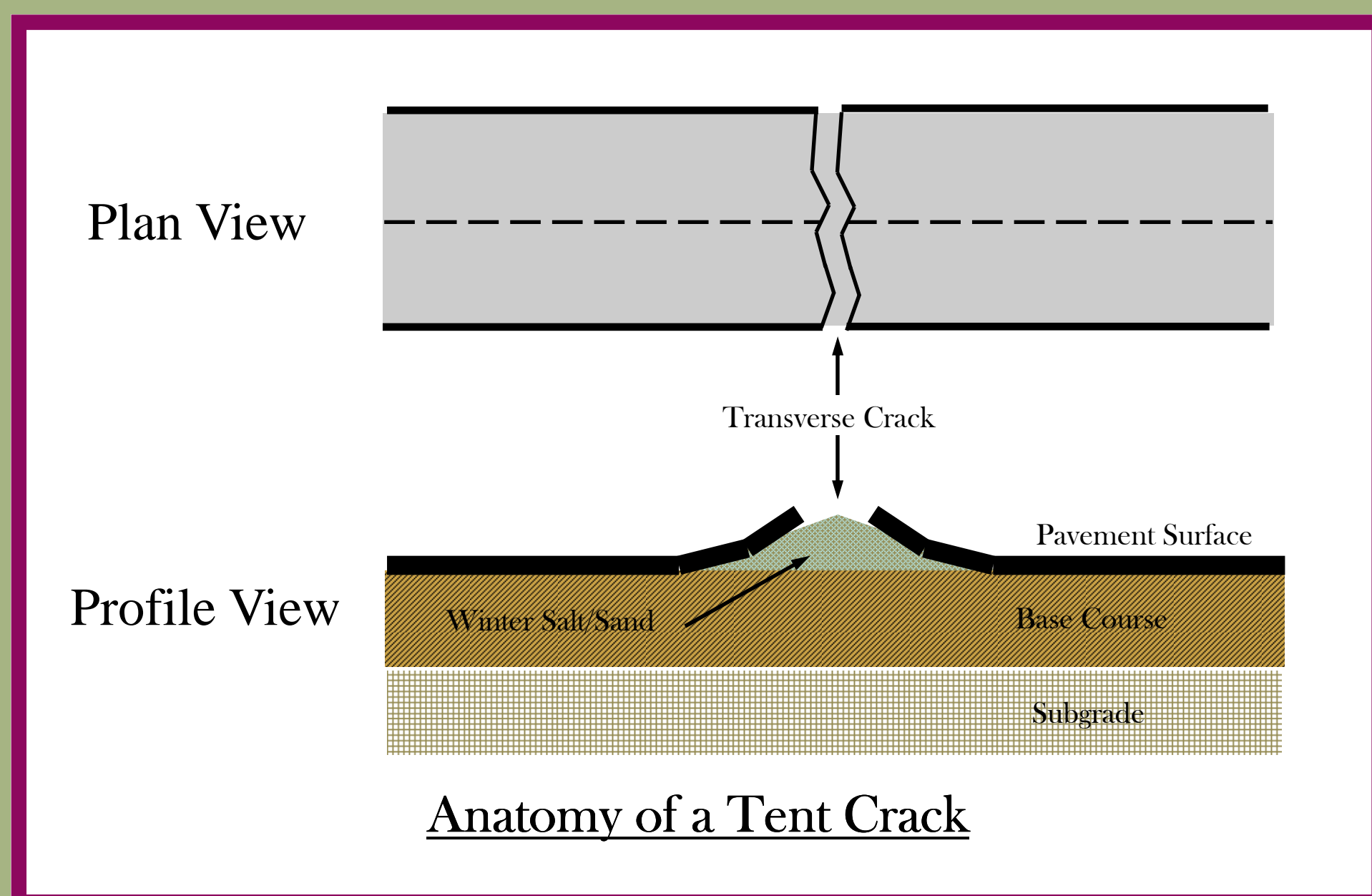
In contrast to most frost related distresses, tenting is not unique to low volume roads; it occurs just as frequently on high traffic highways that have been designed to withstand freezing and thaw weakening. Furthermore, it is frequently exhibited by pavements that are in otherwise good condition.



## Summer Tenting

The following theorizes why tenting does not always fully disappear during the summer: In the presence of fluctuating air temperatures and changing concentrations of road salt through repeated application for snow and ice control, the HMA to either side of the crack is lifted by ice pressure. Sand from the road salt-sand mix continually enters the crack as thaw cycles occur. This exacerbates the localized heaving problem if the salt-sand mix for ice control has a high percentage of fines. This also increases the amount of material, as well as the frost susceptibility of sand immediately beneath the HMA crack.

- 1) This could explain the higher percentages of fines in the immediate vicinity of the crack during pit excavations.
- 2) It could also explain why tenting is generally worse in the passing lane and shoulder than in the travel lane. Constant traffic may accelerate/hasten settling and conformance of the HMA slab to underlying base course before sand can make its way into any void between the HMA and base course at the crack.
- 3) Finally, it could explain why tenting does not always completely disappear during the summer.

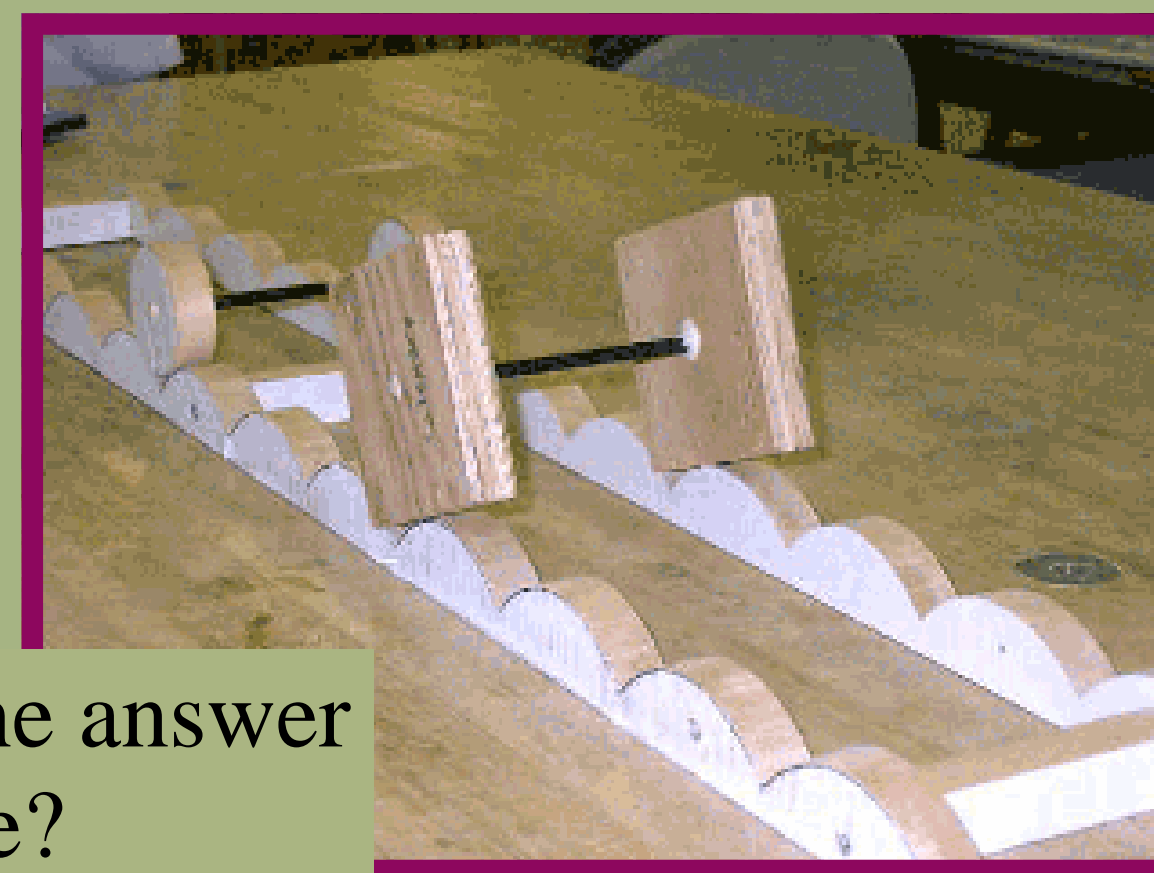


## Analysis

Correlations between occurrence of tenting and frost penetration indicate that tenting is a near-surface phenomenon related to the road salt-sand mix getting into the base course material. In contrast to conventional frost heaving that occurs when groundwater and cold temperatures reach the frost susceptible subgrade, tenting occurs while the frost is contained within the upper reaches of the pavement structure.

Tenting has also been observed more frequently in longitudinal slope sections than on level road sections. Salt-rich surface water flow is intercepted by transverse cracks. Longitudinal cracks also intercept surface water, but the drainage area is appreciably smaller. This is reflected in the reduced occurrence and magnitude of tenting observed along longitudinal cracks.

At the end of the observation period, arrays of base course samples were collected immediately beneath and adjacent to several of the cracks for subsequent laboratory analysis including salinity, moisture content and grain-size analysis.

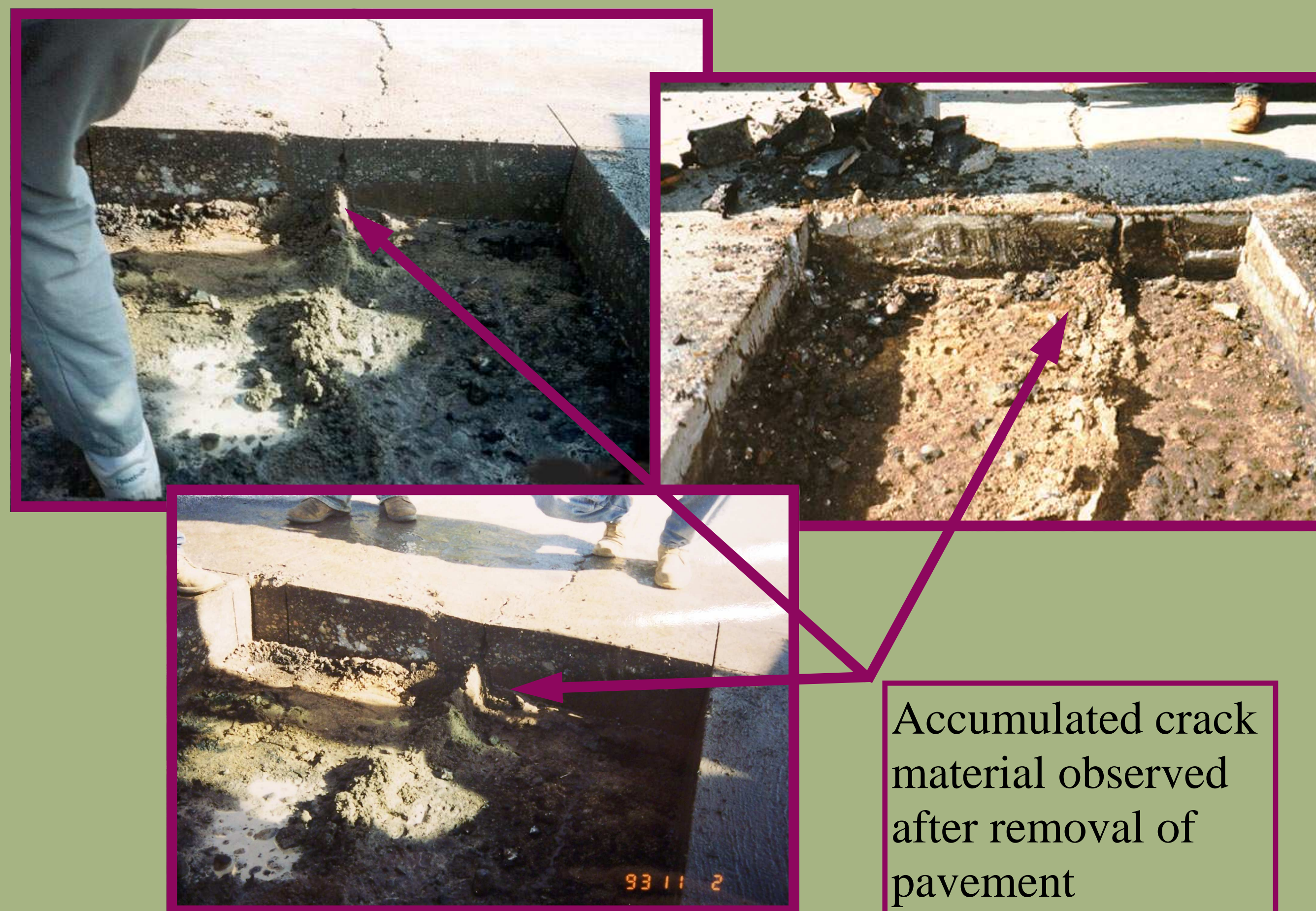


Could this be the answer to a smooth ride?

## Observations

The New Hampshire Department of Transportation (NHDOT) employed the efforts of the US Army Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, NH to investigate the causes and mechanics of the phenomenon.

Because the distribution of road salt within the base course was suspected to be a primary contributor toward tenting, about a dozen transverse cracks in New Hampshire were monitored throughout several winter/spring seasons. Sensors were installed to monitor salt concentration, moisture content, subsurface temperature, and freezing point. Pavement elevation surveys were conducted throughout the freeze-season to monitor tent formation.



Accumulated crack material observed after removal of pavement

## More Theories on Tenting

Taking these theories yet a step further, an independent, similar study has also been conducted in Quebec, Canada, where some highways exhibit as much as 70 mm (3 in.) of tenting by the end of a typical winter. Researchers there hypothesized that:

- 1) Salt concentration gradient and the resulting freezing point depression gradient can take the place of thermal gradient (Konrad and Morgenstern 1980) required for ice segregation (i.e., frost heaving) to occur in salt free frost susceptible soils (in full conformance with above theories), and
- 2) Salt concentration gradient can also contribute to increasing frost susceptibility of non frost susceptible granular materials.

## Recommendations

The research confirms the benefits of timely crack sealing to hinder the ingress of fines. Even after the onset of tenting, crack sealing and overlays at least prevent *additional* salt water intrusion. However, when pavements are overlaid, reflection cracking often occurs, and the cycle of intrusion of road salt into cracks continues. For tenting pavements, mitigating measures include removal and replacement of salt-contaminated base course or mixing/grading salt-contaminated base course, then re-surfacing.

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