LRRB

Mitigating Seasonal Movement at Culvert and Utilities

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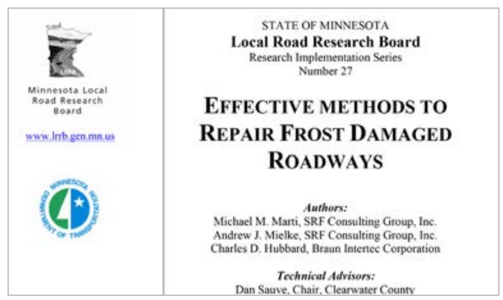
Overview

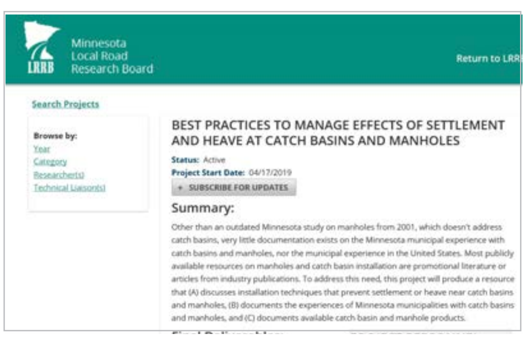
Over the past years, the Local Road Research Board (LRRB) has developed several resources to address and mitigate issues associated with seasonal movement (heaving and depressions). The focus of this document is to specifically address **seasonal movements at culverts and utilities**. This document synthesizes several of the earlier resources:

Frost Damage in Pavement: Causes and Cures (video)

Effective Methods to Repair Frost Damaged Roadways

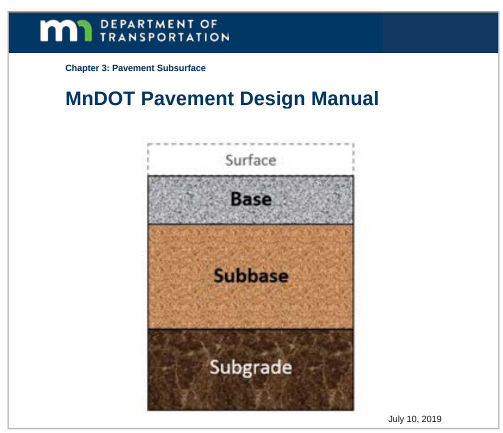


Best Practices to Manage Effects of Settlement and Heave at Catch Basins and Manholes



(Ongoing LRRB research project schedule to conclude summer of 2021)

MnDOT Pavement Design Manual



(Section 360: Culvert and Storm Drain Bedding and Backfill and Section 380: Frost Effects)

Factors/Conditions Causing Seasonal Movement

- Water in or near the soil
- Freezing temperatures
- Frost-susceptible soils (soils that “hold/absorb” water, which expands when frozen).

Differential movement typically occurs where there are unconformities (either natural or constructed) within the composition, consistency and or drainage characteristics of the subgrade soils.

Susceptible Soils

Fine grained soils with poor drainage characteristics that tend to “hold” water

- Lean and fat clay, silty clay, fine sand with silt, elastic silt (FHWA 7.5.6)
- Soils >6% passing 200 sieve (US Army Corp, Table 2.1)
- Areas of non-uniformity (i.e. “good” material placed above a culvert with poor insitu material.

Potential Issues/Evaluation

Besides insitu soils that are susceptible to seasonal movement, construction materials and practices also contribute seasonal movement around culverts/utilities. Prior to mitigating, it is important to evaluate and understand the site conditions:

Construction/Maintenance History

Site history information will help put field observation and test results in perspective. Pertinent information may include grading and as-built plans, construction notes and maintenance records for the area(s) where differential frost occurs.

Visual Observation

A reconnaissance to define the limits of the repair, reveal the contributing factors of the seasonal movement and possibly expose specific features (such as insufficient drainage ditches) that have contributed to the damage.

Subgrade Evaluation

Several methods exist to evaluate subgrade materials and determine the range of significance in any inconsistencies in their composition, strength and moisture. The following two methods, done in combination, are an efficient way of determining insitu material composition and strength:

1. Penetration test borings or auger borings to obtain material samples for classification and laboratory testing to determine the relative density and stiffness of the subgrade materials.
2. Dynamic Cone Penetrometer (DCP) testing provides relative insitu density and stiffness of the subgrade materials.

Details are listed in the MnDOT Geotechnical and Pavement Manual (Section 4.2).

MN DCP compliments of Pavement Interactive website

Mitigation Construction Practices

- Good design can alleviate problems. MN Local Technical Assistance Program (LTAP) provides an online course for Culvert Installation and Maintenance for Local Agencies
- MnDOT Pavement Design Manual (Section 360: Culvert and Storm Drain Bedding and Backfill and Section 380: Frost Effects) provides specific details for culvert and storm drain bedding and backfill.
  - **Treatment #1** - Applies to all flexible culverts with existing granular soil (Figure 360.10)
  - **Treatment #2** - Applies to flexible culverts with existing non-granular soils where the frost depth is above the center of the pipe (Figure 360.11).
  - **Treatment #3** - Applies to flexible culverts with existing non-granular soils where the frost depth is below the center of the pipe (Figure 360.12).
  - The manual also has designs for rigid culverts (Figure 360.2, 360.3 and 360.4)

Material

- Optimally any subgrade material that is added would “match” the existing insitu material.
- Often when the insitu material is non-granular, granular material is used as bedding and backfill to facilitate compaction and provide support around the culvert/utility. Medium-coarse grained granular material has minimal seasonal movement when compared to other soil types. Granular material can be used alone or blended well with on-site, non-organic soils to create a uniform cross section and tapered as noted below.

Transition

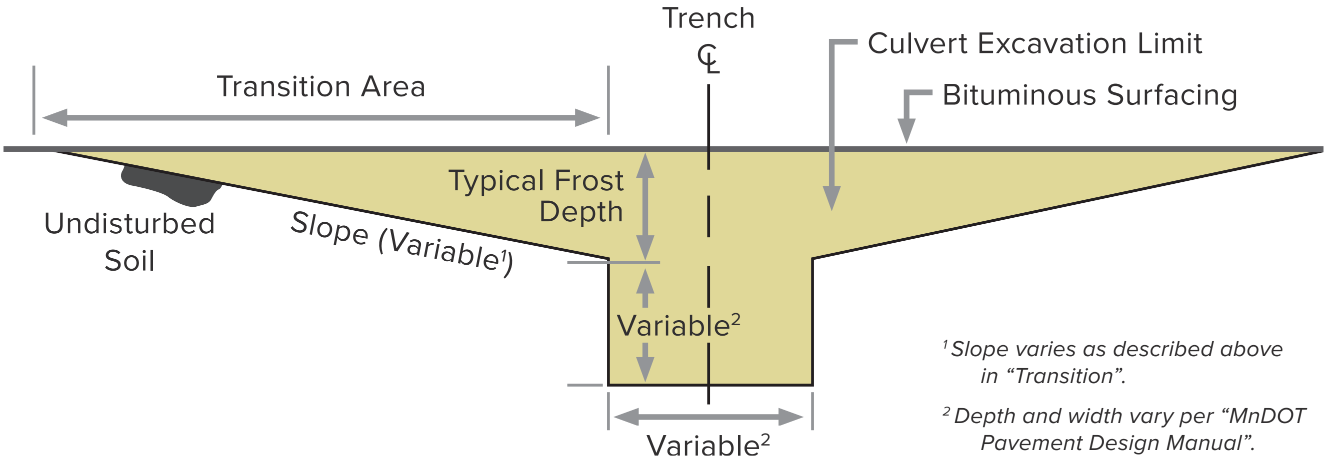
When installing or conducting repairs around culverts/utilities, it is very important to taper/transition into and out of the repair areas. From a recent survey of MN counties, the transition/taper ranged from 1:5 to 1:20. **The longer the transition area the better.**

The transition area (and subsequent slope) is dependent on:

- Frost depth (the transition area should extend below the frost line; if this depth is not known check with your District’s Material Engineer)
- Length of the taper varies due to:
  - roadway speed *(typically, the higher the roadway speed the longer the transition)*
  - surrounding geometrics conditions *(e.g. the presence of utilities, curb and gutter may confine the transition area)*
  - difference between insitu and backfill material *(when using similar materials, it may be possible to have a shorter transition)*
  - available budget

The following figure shows a typical trench detail.

Utility Trench Treatment



- The taper shall be constructed in the direction of traffic full width of each lane disturbed and backfilled with excavated materials and to depths equal to surrounding conditions with a minimum of six inches of aggregate base and four inches of bituminous surfacing.
- The soils shall be uniformly distributed in layers not to exceed twelve inches in thickness (loose measurement) and thoroughly compacted.
- The aggregate base materials shall be uniformly distributed and compacted in layers not to exceed three inches in thickness (compacted thickness). The layer thickness may be increased to six inches if a vibratory steel wheeled roller is used. The addition of water may be required to achieve acceptable compaction if the material is dry.

Backfilling/compaction

Achieving good compaction reduces settlement. As mentioned above, if insitu material is non-granular, it may be necessary to replace it with imported material to achieve acceptable compaction around the culvert/utility. Compaction to 100% of standard Proctor density is generally recommended to comply with MnDOT Specification Section 2105.3F, Specified Density Method procedures. A cost-effective alternative for remote sites or for projects with limited service requirements is to simply compact the scarified, moisture-conditioned subgrade materials "until there is no evidence of further consolidation," in general conformance with MnDOT Quality Compaction Method procedures.

MnDOT Standards

In addition to the design templates listed with the MnDOT Pavement Design Manual (Section 360: Culvert and Storm Drain Bedding and Backfill and Section 380: Frost Effects), the following link provides access to MnDOT's Design Detail/standard plates

1. Click on "Main Menu" in upper left
2. Click on "Design Details", bottom of list

Backfilling transition zone (blending new with insitu material)

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