Best Practices for Improving Subgrade Drainage

Options to mitigate roadway distress or failure

LRRB
LOCAL ROAD RESEARCH BOARD

START

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How to use the Tool:

This Tool serves as a guide to assist agencies in understanding drainage problems and options to consider for mitigating structural damage to pavements due to moisture. The weather and soil conditions vary drastically across Minnesota. Engineers should use their engineering judgment and seek expert guidance when necessary.

Questions on drainage and improving subgrade designs can be forwarded to MnDOT's Grading and Base team at https://www.dot.state.mn.us/materials/gradingandbasecontacts.html.

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This Guide includes:

- Understanding the Need for Better Drainage
- Design
- Construction
- Maintenance Needs
- Frequently Asked Questions
- Other Considerations
- Typical Sections & Specifications
- Resources

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Understanding Drainage

Pavement design benefits of better drainage

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How much would you spend on drainage if it doubles the life of your pavement?

> *A study conducted by the National Cooperative Highway Research Program (NCHRP) estimated that* ***excess water reduces the life expectancy of pavement systems by more than half*** *(Christopher and McGuffey, 1997). Cedergren (1974a) predicted a* ***reduction of 50% in the pavement service life if a pavement base is saturated as little as 10% of the time***

...Incorporating subgrade drainage can double the pavement life and performance!

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Who needs better drainage?

My County has sandy soils (cleaner granular soil subgrade) – do I need drain tile?

- Maybe not – check for past pavement failures, paying attention to the bottom of vertical curves.

Drain tile doesn't seem to work in the southern MN clays?

- Drain tile alone does not work in southwestern Minnesota's heavy clay soils.
- This may be exactly the location for installation of a permeable base with drain tile to move water out of the pavement section as soon as possible.

Is the investment in tile and good drainage worth it?

- Roads with good drainage recover faster when experience spring freeze thaw conditions, making the pavements less vulnerable to premature distress as a result of heavier loads.

There is a research report that stated tile can cause pavement failure, why would I do it?

- Poorly installed tile or tile systems that are not maintained can consolidate free water and trap it in the pavement section, creating saturated weak soils – do it and do it right!

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What do I need to know?

This manual will tell you everything you need to know for improving subsurface drainage for pavements in Minnesota. There are three main factors impacting when, where, and how to design and construct a better draining pavement.

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Factors impacting the structural integrity of pavements

Soils

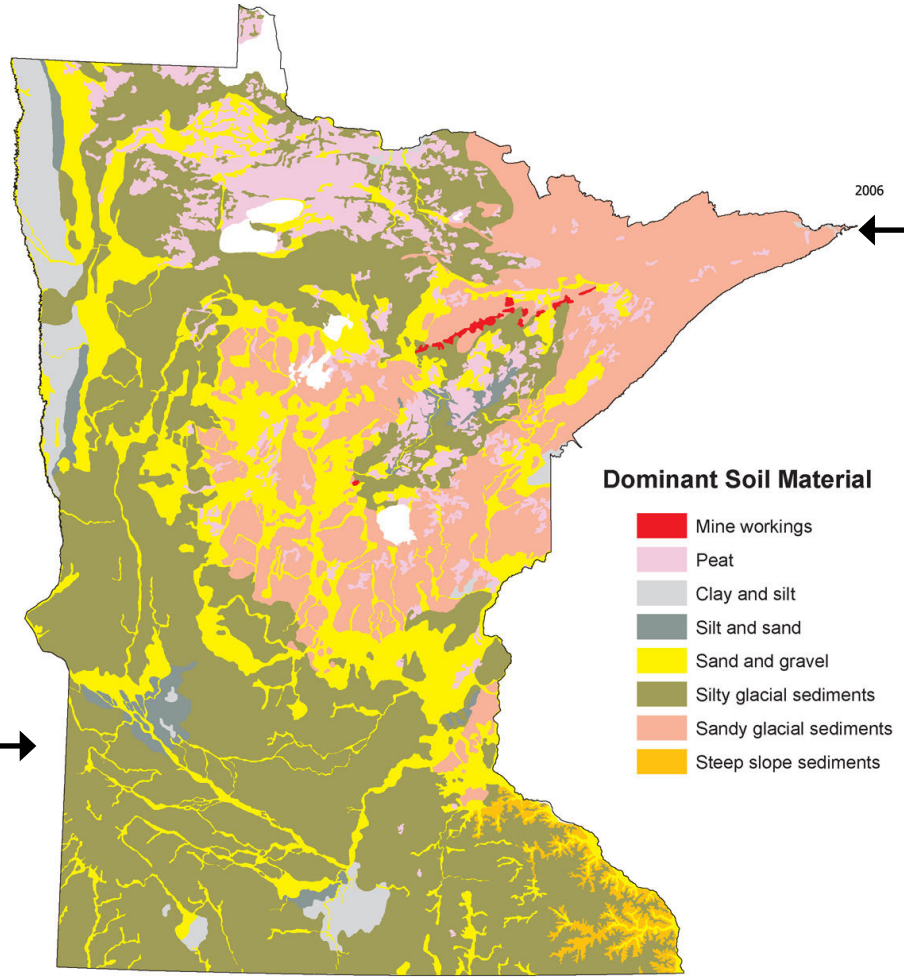
Water

Freeze/Thaw Action

Understanding Minnesota's Diverse Soils

Understanding soil subgrade conditions are important when considering subsurface drainage for roadway project. With subgrade soils consisting of free-draining granular soils, subsurface drainage may not be warranted.

However, where subgrade soils consist of finer-grained soils which are susceptible to frost action and are moisture sensitive such that they are susceptible to subgrade weakening when exposed to excess water, some sort of subsurface drainage should be considered.



Area Consist Primarily of Frost Susceptible - Silty and Clayey Soils

The FIX: Encourage including permeable base and edge drains

Area Consist Primarily of Free-Draining Granular Sands/ Gravels

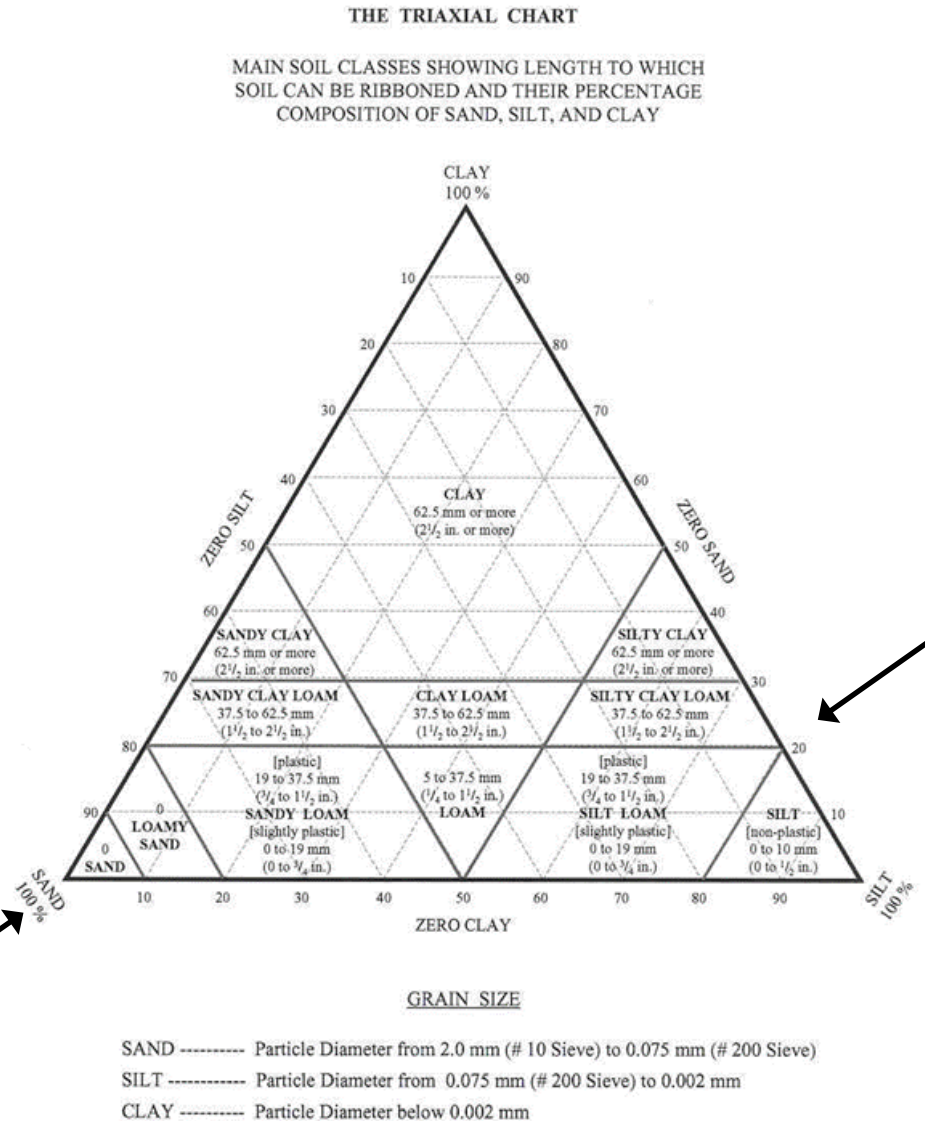
The FIX: Possible use of tile in low points (sag of vertical curves where drainage may accumulate)

Identifying Frost Susceptible Soils – Unified Soil Classification (NCHRP 1-37A)

Frost Group	Degree of Frost Susceptibility	Type of Soil	Percentage Finer than 0.075 mm (# 200) by wt.	Typical Soil Classification
F1	Negligible to low	Gravelly soils	3-10	GC, GP, GC-GM, GP-GM
F2	Low to medium	Gravelly soils	10-20	GM, GC-GM, GP-GM
		Sands	3-15	SW, SP, SM, SW-SM, SP-SM
F3	High	Gravelly Soils	Greater than 20	GM-GC
		Sands, except very fine silty sands	Greater than 15	SM, SC
		Clays PI > 12	-	CL, CH
F4	Very high	All Silts	-	ML-MH
		Very Fine Silty Sands	Greater than 15	SM
		Clays PI < 12	-	CL, CL-ML
		Varied clays and other fine grained, banded sediments	-	CL, ML, SM, CH

Source: https://www.fhwa.dot.gov/engineering/geotech/pubs/05037/07c.cfm

If you don't know your soils, reach out to a geotechnical expert for soil borings or talk with our MnDOT experts



Silty and Clayey Soils highly frost susceptible

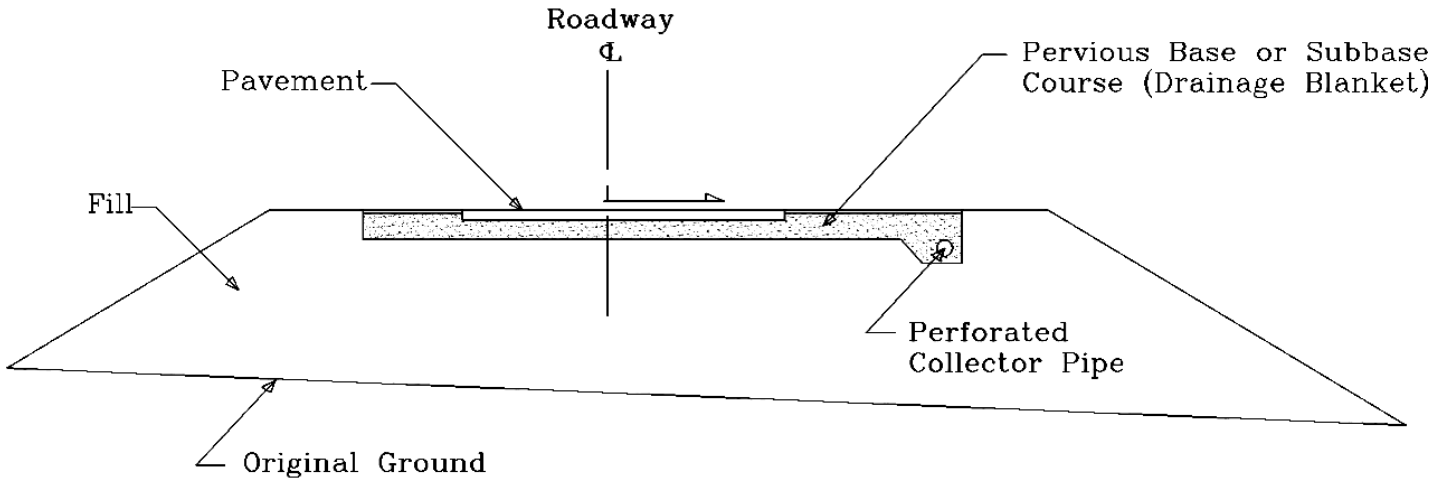
Solution: Consider including permeable base and edge drains

Well Draining Soils

May consider the use of tile in low points (sag of vertical curves where drainage may accumulate)

DID YOU KNOW?

Frost Susceptible Soils



Source: Figure 2.15 https://www.lrrb.org/pdf/200917.pdf

DID YOU KNOW?

Non-Frost Susceptible Soils with High Water Table

inadequate separation between groundwater table (hydrostatic condition) and pavement surface

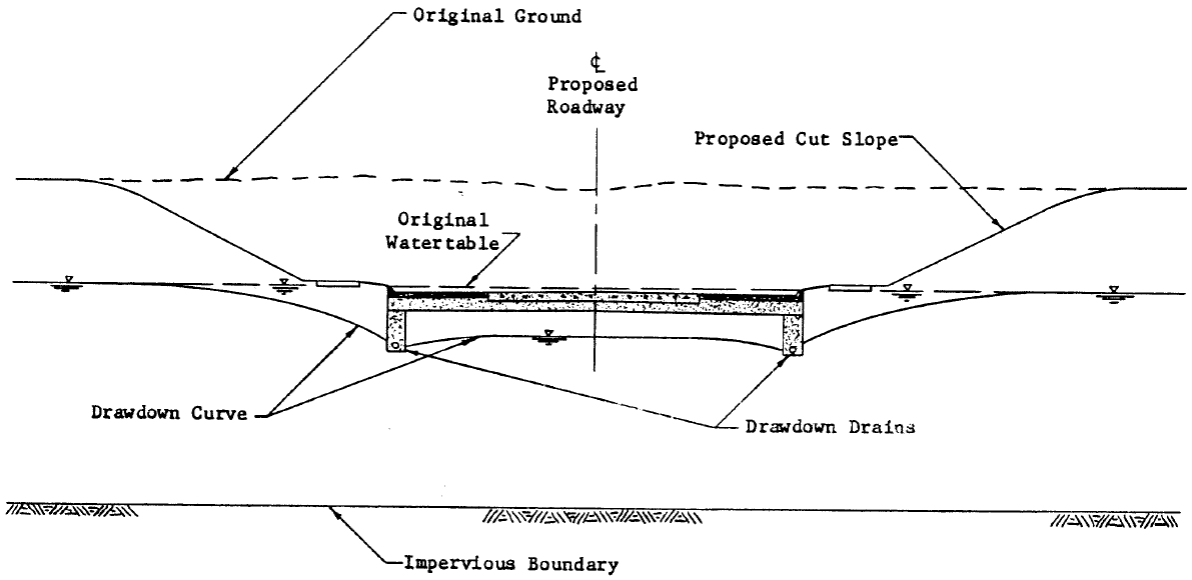


Figure 2.12. Symmetrical longitudinal drains used to lower the groundwater table and to collect water infiltrating the pavement (Moulton, 1980).

Source: Figure 2.12 https://www.lrrb.org/pdf/200917.pdf

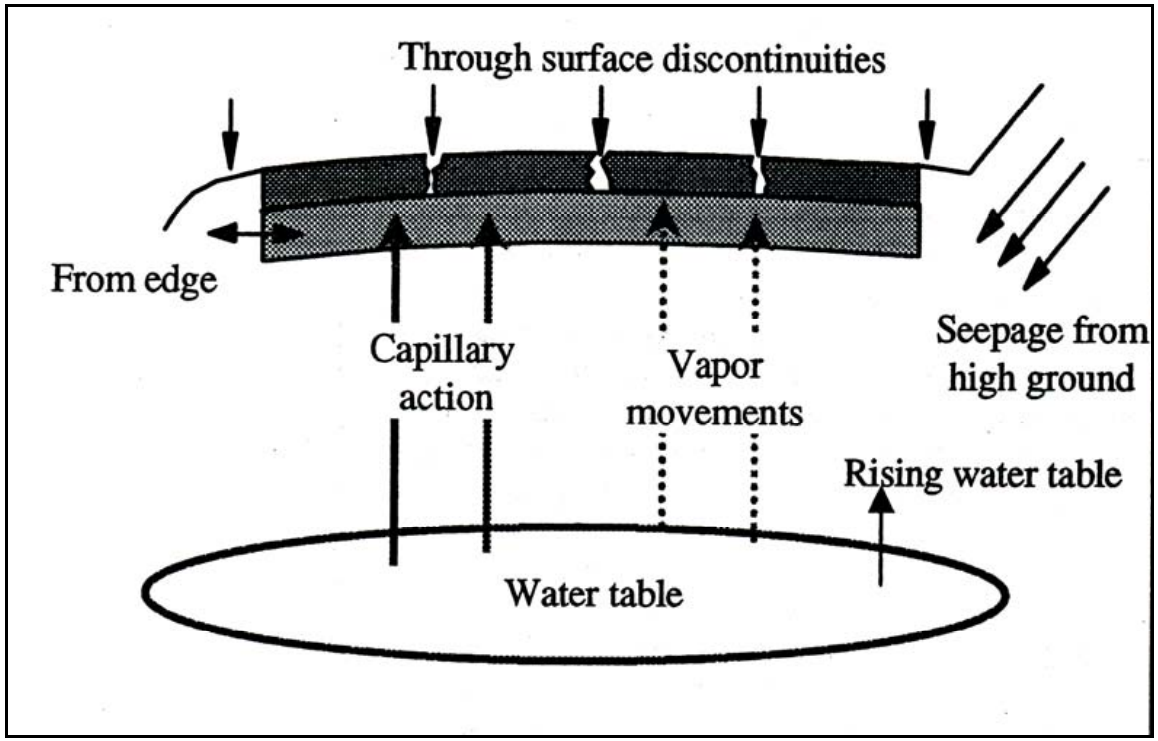
Soils in Summary

If subgrade soils consist of cleaner sands or gravels with less than 20 percent fines passing a #200 sieve (similar to MnDOT Granular Material), the subgrade soils are judged to be negligible to low in susceptibility to frost action or sensitivity to moisture related subgrade weakening. With those subgrade soils, assuming hydrostatic groundwater levels are located well below the pavements, costs of adding subsurface drainage is typically not warranted.

For subgrade soil conditions which consist of highly plastic clays (PI greater than 12) or courser silty sands/gravels, those soils are moderately to highly susceptible to frost action/subgrade weakening. With those conditions, providing subsurface drainage is important and, at a minimum, those roadways should contain a drainage ditch system and/or draintile to drain the pavement base and subbase of excess moisture.

For subgrade soil conditions which consist of very fine-grained silty sands, low plastic clays and silts, those soils are highly to extremely highly susceptible to frost action/subgrade weakening. With those conditions, not only should subsurface drainage be provided, but the pavement design should incorporate a subbase consisting of drainage aggregate or clean free draining sand (such as MnDOT Select Granular Material).

Understanding what is the main water source impacting roadway



Source: Figure 2.1 https://www.lrrb.org/pdf/200917.pdf

DID YOU KNOW?

Evaluating the need for drainage improvement

How much free water is permeating the pavement subbase and base layers?

Can this water be removed timely and cost effectively?

Can this water be removed timely and cost effectively?

DID YOU KNOW?

Determine the net inflow of water that must be removed by drainage system

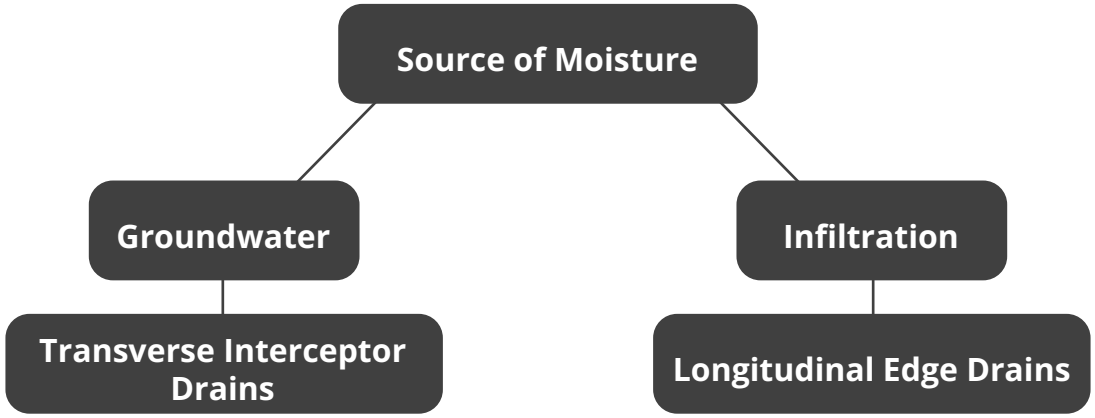
- groundwater
- infiltration and
- melt water from thawing ice lenses
- capillary water, see page

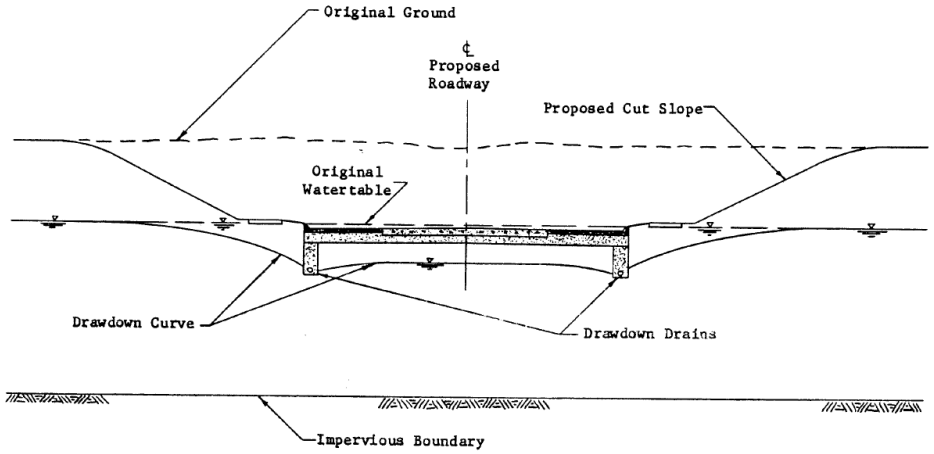
Analyze and design pavement drainage layers to provide for rapid removal of net inflow. Evaluate the need for filter layers or special treatment of the subgrade

Analyze and design collection systems to provide for disposal of water removed by the pavement drainage layers. Included: location and sizing of longitudinal and transverse collector drains, selection of filter material, determination of outlet spacing, removal of frost susceptible soils, construction of better designed ditches

Conduct a critical evaluation

of the results previous steps with respect to potential long-term performance, construction, maintenance and economics of the new designed system





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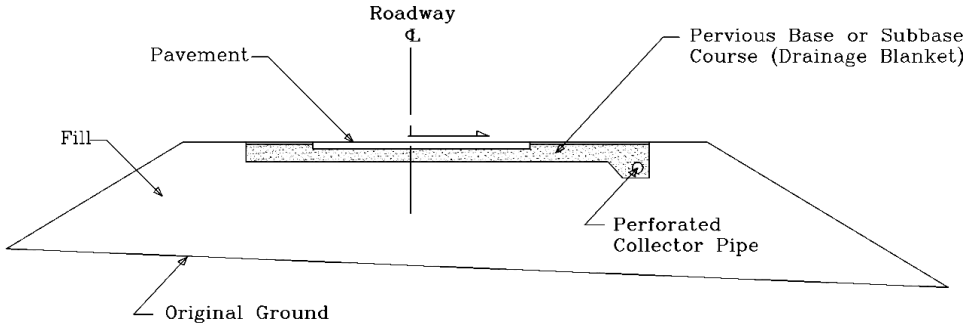


Source: Figure 2.15 https://www.lrrb.org/pdf/200917.pdf

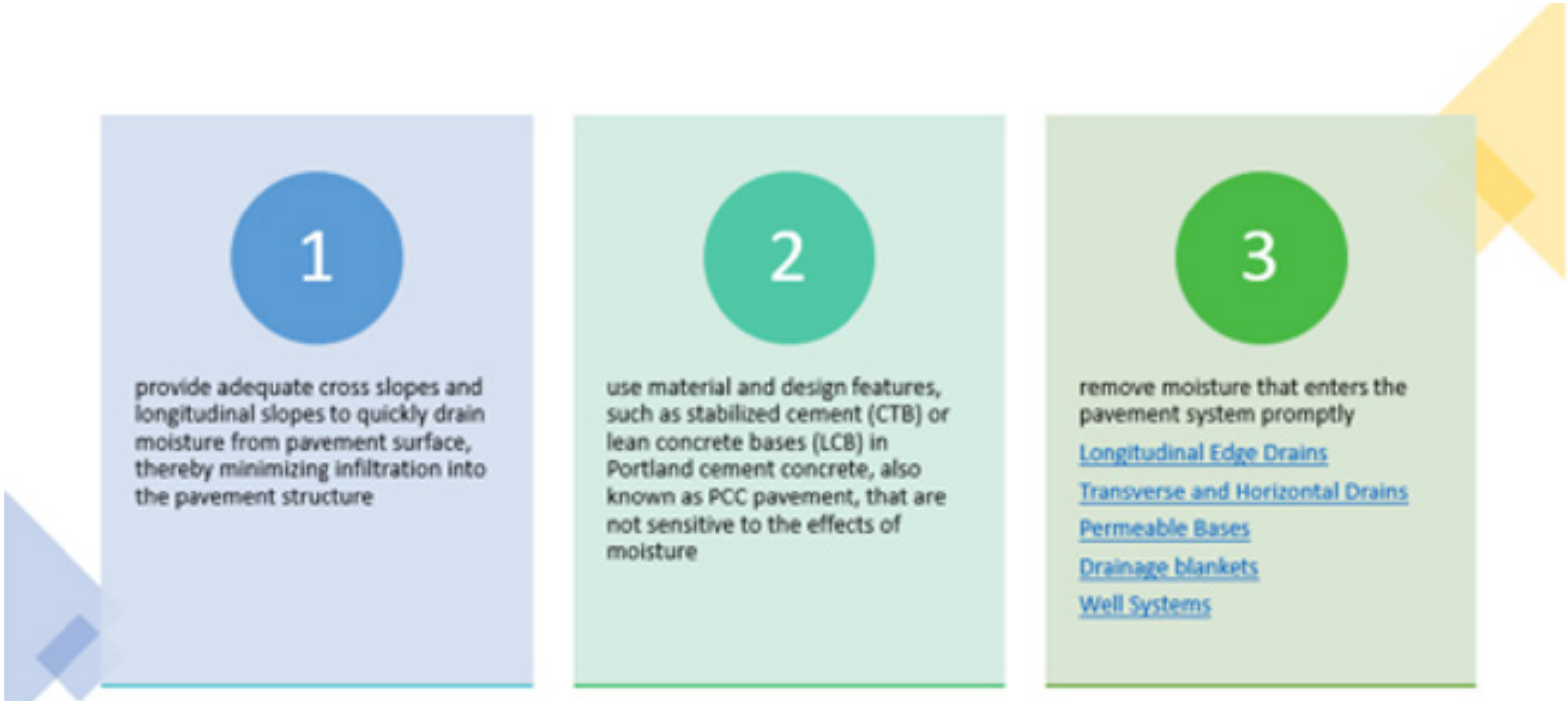
Water in Summary

Infiltration from snow melt or rain is the most common source of water found in pavement sections. Designing pavement sections with positive slope of the pavement surface to well draining roadside ditches can minimize infiltration. Well draining soils minimize the impact of infiltration; however clayey soils will trap infiltration and further weaken the pavement structure increasing susceptibility for pavement failures with heavy loads.

Groundwater in the form of trapped or perched water can sometimes form ice lenses in freezing conditions, damaging pavement structure. Other forms of groundwater such as high-water tables and artesian springs contribute to supersaturated soil conditions also weakening the pavement structure.

Infiltration

Snow melt or rain



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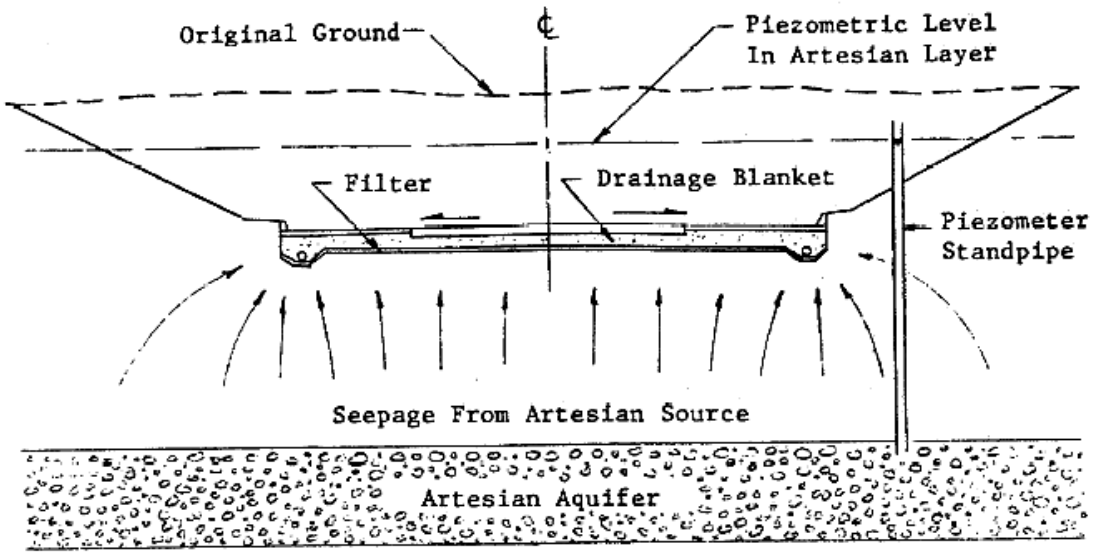
Groundwater

- High water table
- Trapped or perched water (forms ice lenses)
- Artesian Springs

Consult Experts



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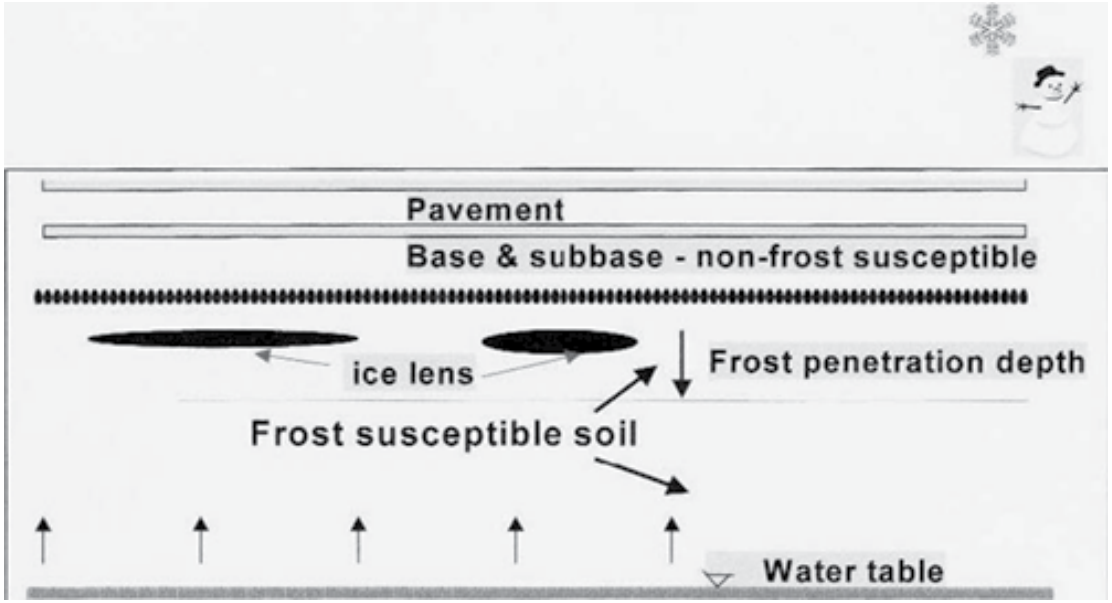
"Yep, we have freeze/thaw action"

Frost Damage in Pavement: Causes and Cures

https://www.youtube.com/watch?v=fkrrSys03qQ



Source: Figure 7-19 [https://www.fhwa.dot.gov/engineering/geotech/pubs/05037/07c.cfm Figure](https://www.fhwa.dot.gov/engineering/geotech/pubs/05037/07c.cfm)

Design Options

Targeted solutions

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Design Options to Improve Drainage

Longitudinal tile

(most common – collecting and conveying water from drainable pavement system)

Permeable base

(create more separation from water table, saturated soils, moisture sensitive or frost susceptible soils where subgrade weakening occurs)

Drainage Blankets

(used in unique circumstances for high flow situations or fluctuating water tables)

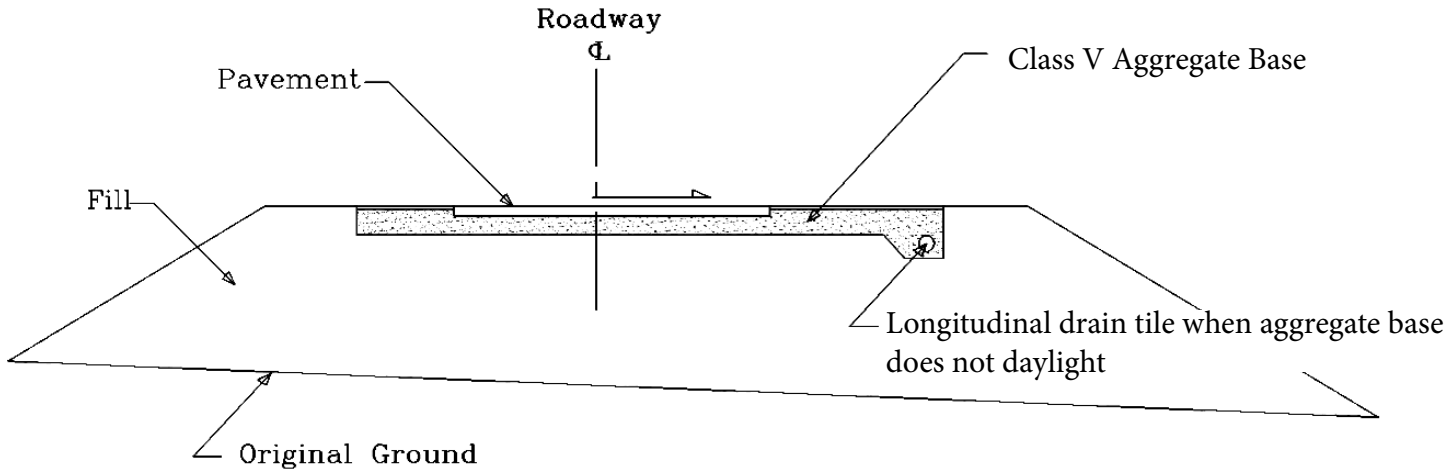
Transverse tile (interceptor drains)

(interceptor drains to draw water down below the top of subgrade elevation; possibly for perched or trapped water)

Well systems

(rarely used; wick drains to help consolidate soils; possibly for perched or trapped water)

Longitudinal Edge Drains



DID YOU KNOW?

Longitudinal Edge Drains

A well-designed system would posses the combination of pipe diameter and outlet spacing, able to provide adequate drainage capacity to handle the design flows.

Pipe Diameter (in)	Pipe Conveyance, ft^3/day^*	
	Smooth Pipe (n = 0.012)	Corrugated Pipe (n = 0.024)
3	4,900	2,450
4	10,557	5,279
6	31,120	15,560

**Pipe conveyances computed using minimum recommended grade of 0.35%.*

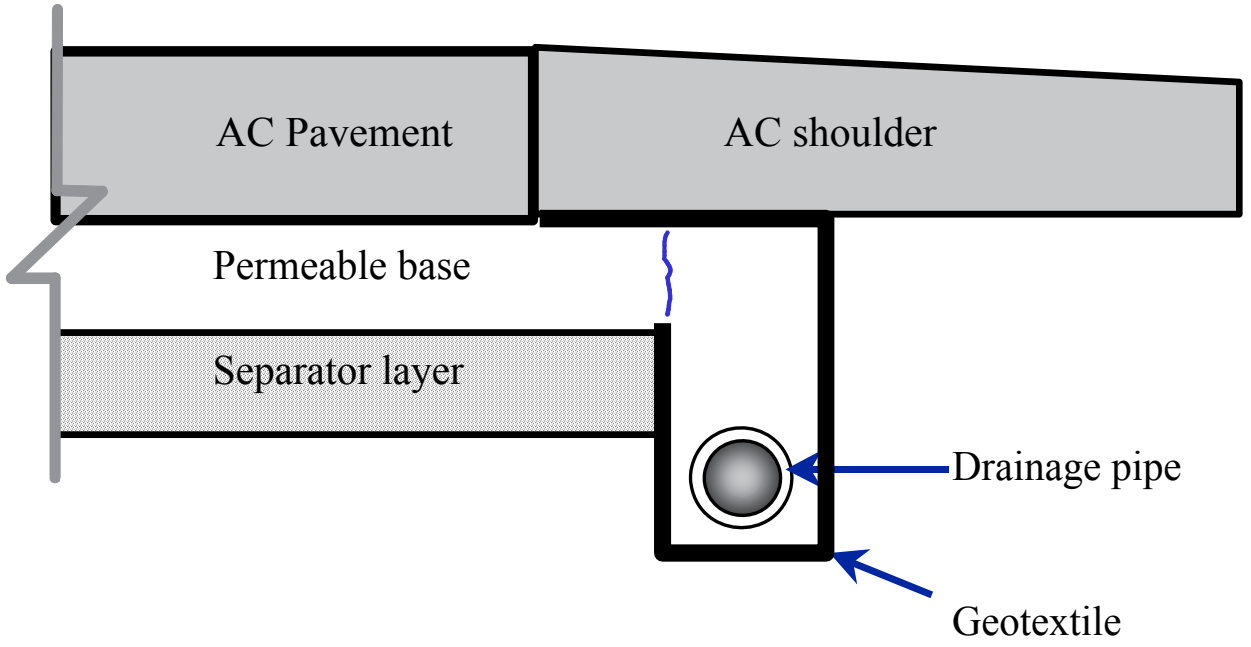
DID YOU KNOW?

5 year usage of pavement drain tile

Drain Tile Usage on Fed and State Aid Projects

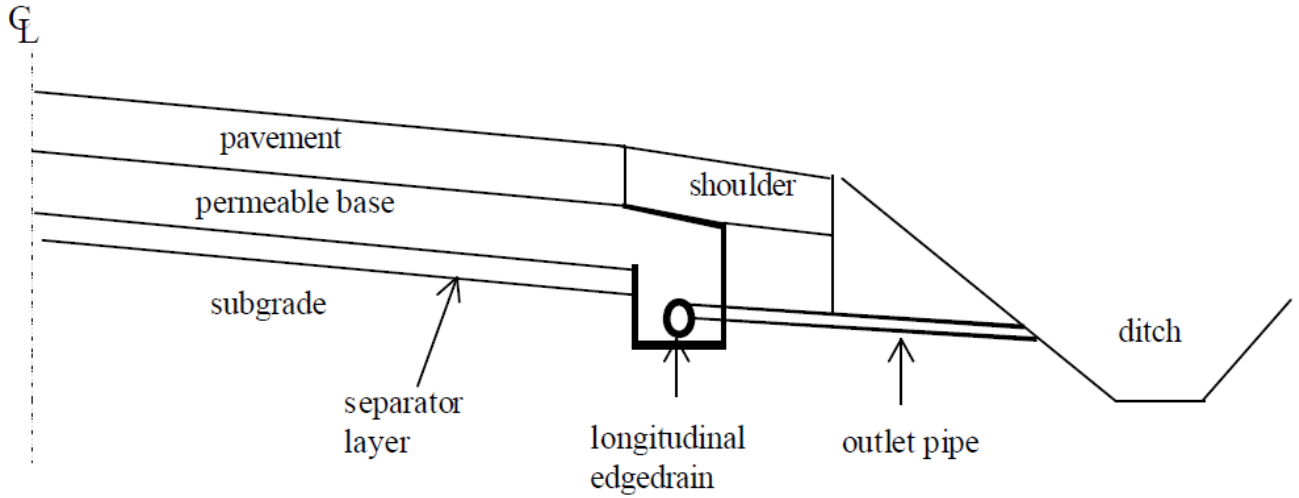
Year	SP/SAP #	Item Number	Description	Est. Quantity (lf)	Unit Cost
2020	007-614-013	2502.503	4" perf PE Pipe Drain	56,304	$ 5.95
2020	009-090-004	2502.503	4" PERF PE PIPE DRAIN	2,200	$ 6.60
2020	009-608-018	2502.541	4" PERF PE PIPE DRAIN	8,500	$ 7.81
2020	025-621-013	2502.503	4" PERF PE PIPE DRAIN	41,726	$ 6.00
2020	027-648-007	2502.541	4" PERF PE PIPE DRAIN	8,850	$ 6.80
2020	040-605-009	2502.503	4" PERF PE PIPE DRAIN	42,454	$ 2.52
2020	040-626-045	2502.541	4" PERF PE PIPE DRAIN	57,296	$ 1.85
2020	040-628-030	2502.503	4" PERF PE PIPE DRAIN	21,300	$ 3.75
2020	043-594-002	2502.503	4" PERF PIPE DRAIN	4,040	$ 8.85
2020	062-696-030	2502.541	4" PERF TP PIPE DRAIN	8,372	$ 8.75
2020	066-676-002	2502.503	4" PERF PE PIPE DRAIN	21,385	$ 4.65
2020	073-592-004	2502.541	4" PERF PE PIPE DRAIN	4,200	$ 1.60
2020	074-612-038	2502.503	4" PERF PE PIPE DRAIN	24,730	$ 5.50
2020	082-617-013	2502.541	4" PERF PE PIPE DRAIN	1,600	$ 7.00
2020	086-612-021	2502.541	4" PERF PE PIPE DRAIN	7,013	$ 5.00
2020	087-594-001	2502.603	4" PERF PE PIPE DRAIN	5,000	$ 14.00
2020	111-233-005	2502.503	4" PERF PE PIPE DRAIN (W/ SOCK)	3,796	$ 5.25
2020	133-108-006	2502.503	4" PERF PVC PIPE DRAIN	7,106	$ 6.00
2020	134-113-006	2502.541	4" PERF PE PIPE DRAIN	4,503	$ 3.00
2020	134-122-005		4" PERF PIPE DRAIN	2,304	$ 2.00
2020	134-126-002	2502.541	4" PERF PE PIPE DRAIN	2,981	$ 3.00
2020	137-102-001	2502.503	6" PERF PVC PIPE DRAIN	4,408	$ 12.45
2020	148-114-004	2502.541	5" PERF CORRUG PE TUBING	3,083	$ 3.99
2020	149-105-003	2502.503	4" PERF PE PIPE DRAIN	2,691	$ 9.00
2020	170-114-012	2502.503	4" TP PIPE DRAIN	5,747	$ 5.15
2020	171-080-002	2502.503	4" PERF PE PIPE DRAIN	4,456	$ 9.00
2020	196-101-008		4" PERF PVC PIPE DRAIN	140	$ 9.00
2020	196-117-003		4" PERF PVC PIPE DRAIN	575	$ 30.00
2020	196-122-001		4" PVC DRAIN TILE	4,400	$ 5.00
2020	196-123-002		4" PERF PVC PIPE DRAIN	250	$ 7.00
2020	196-123-003		4" PERF PVC DRAIN TILE	200	$ 10.00
2020	207-594-001	2502.503	6" PERF PE PIPE DRAIN	1,665	$ 7.00
2019	007-614-011	2502.541	4" PERF PE PIPE DRAIN	37,593	$ 3.99
2019	021-682-015	2502.521	3" PERF PE PIPE DRAIN	14,540	$ 6.00
2019	021-761-003	2502.541	4" PERF PE PIPE DRAIN	5,433	$ 5.50
2019	024-609-009	2502.503	4" PERF PE PIPE DRAIN	51,600	$ 2.42
2019	024-622-010	2502.541	6" PERF TP PIPE DRAIN	1,850	$ 14.85
2019	025-625-025	2502.503	4" PERF PE PIPE DRAIN	44,480	$ 3.40
2019	034-630-012	2502.521	4" PERF PE PIPE DRAIN	4,818	$ 4.00
2019	035-632-001	2502.503	4" PERF TP PIPE DRAIN	2,606	$ 7.00
2019	036-707-001	2502.541	4" PERF PE PIPE DRAIN	10,980	$ 1.50
2019	052-610-015	2502.503	4" PERF PE PIPE DRAIN	10,020	$ 4.70
2019	055-604-017	2502.541	4" PERF PE PIPE DRAIN	22,204	$ 5.41
2019	066-601-020	2502.503	4" PERF PE PIPE DRAIN	15,605	$ 5.30
2019	066-646-005	2502.541	4" PERF PE PIPE DRAIN	8,350	$ 4.75
2019	070-627-029	2502.541	4" PERF PE PIPE DRAIN	5,079	$ 8.65
2019	077-622-013	2502.503	4" PERF PIPE DRAIN	9,402	$ 6.25
2019	086-612-020	2502.541	4" PERF PE PIPE DRAIN	14,933	$ 2.95
2019	101-128-005	2502.541	4" PERF PVC PIPE DRAIN	4,203	$ 7.50

Permeable Base with Longitudinal Edge Drains



DID YOU KNOW?

Permeable Base with Longitudinal Edge Drains



Notes: not to scale; the drainage design used in Iowa is slightly different

DID YOU KNOW?

Drainage Blankets

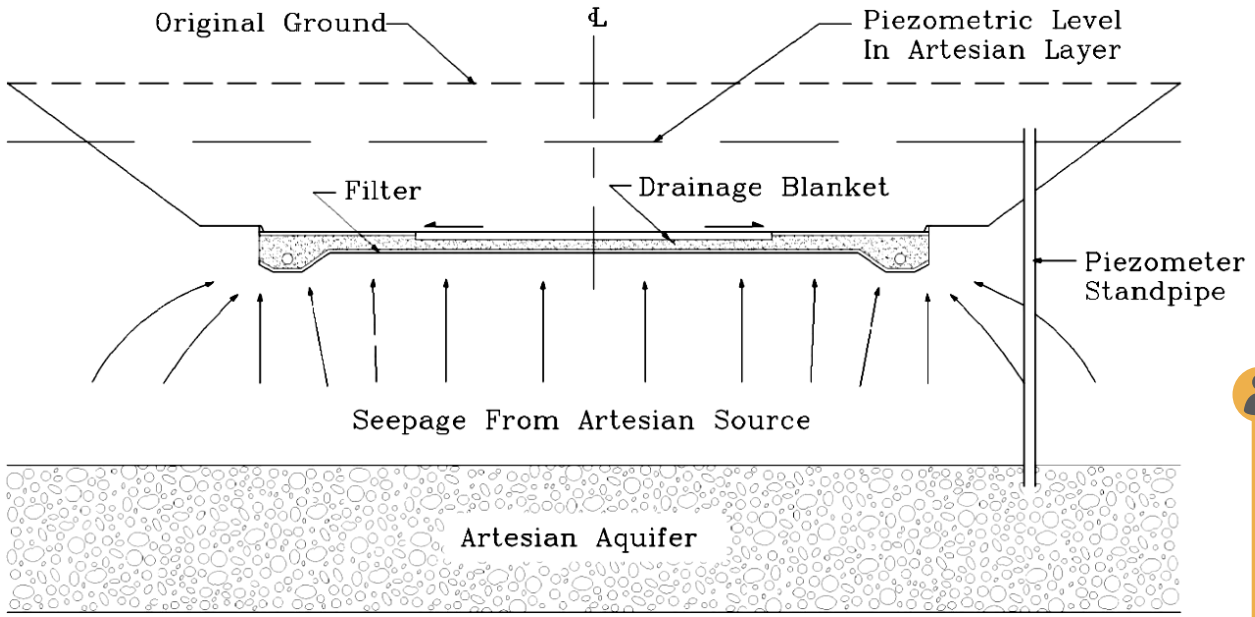
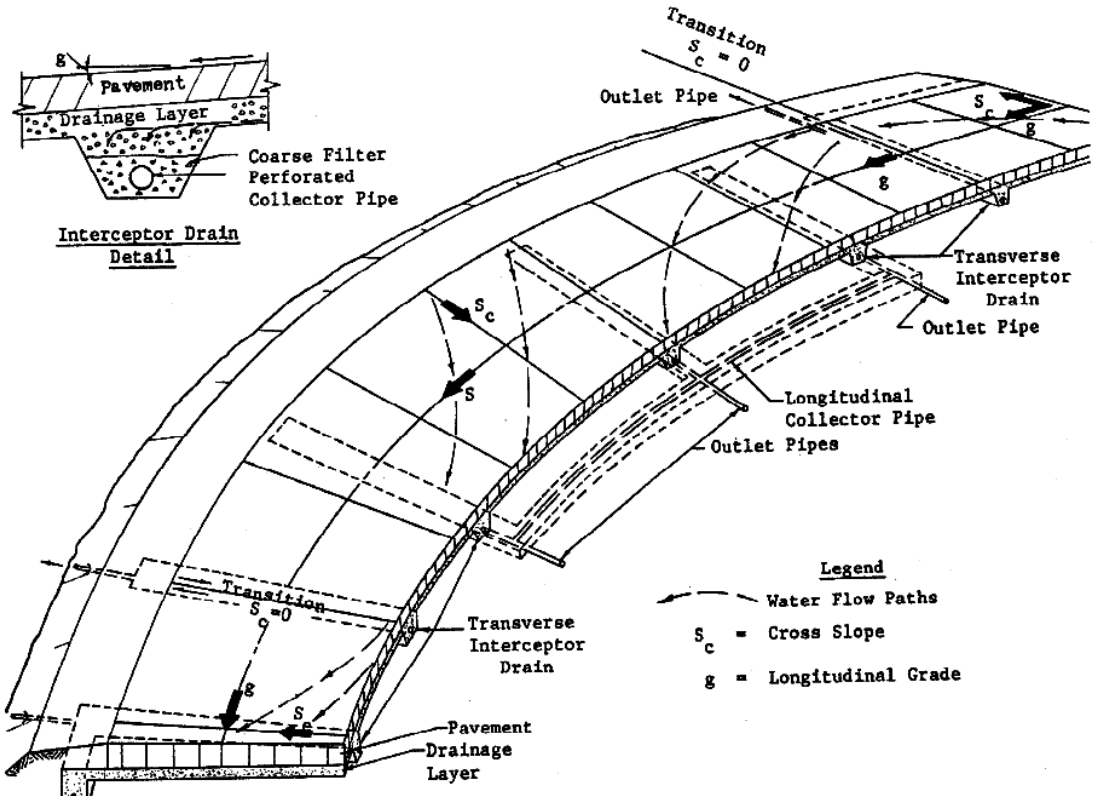


Figure 2.20. Applications of horizontal drainage blankets (redrawn from: Moulton, 1980).

Used in unique circumstances, typically with the involvement of geotechnical expertise.

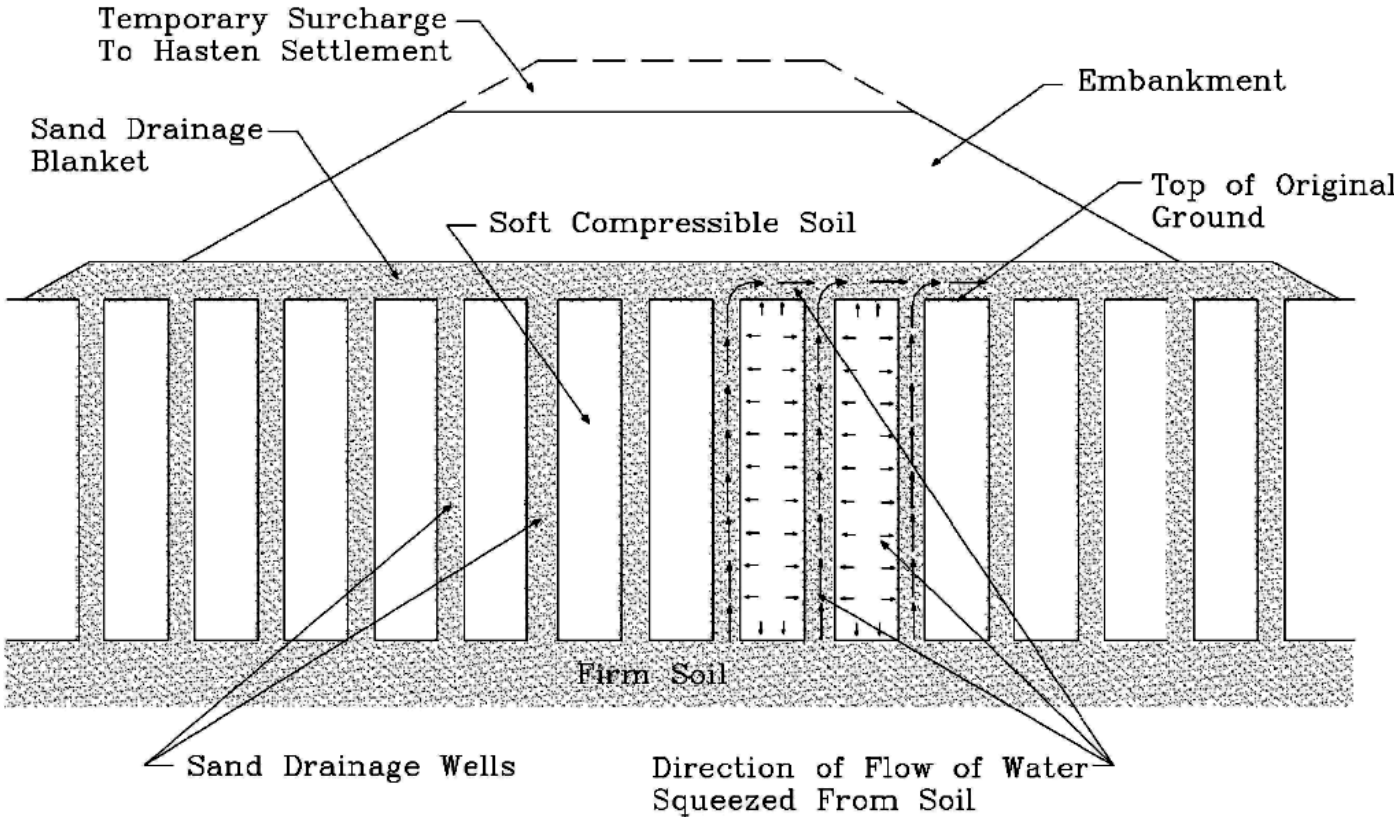
DID YOU KNOW?

Transverse (or Horizontal) Drains



DID YOU KNOW?

Well Systems



DID YOU KNOW?

Construction Solutions

What agencies do best

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New Construction

- Adequate compaction of subgrade materials
- Excavate the collector trench and outlet trenches
- Place open graded bedding material in trenches
- Install perforated pipe and outlets
- Backfill and compact trenches
- Then, place and compact the base drainage layer (aka permeable base)
- Finally, install outlet treatments (headwalls/filter aggregate/markers)

Rehabilitation of Existing Pavements

- Review history of the existing road
  - » variable frost heaving or frost boils
  - » higher than normal pavement distress or rutting
  - » erosion or loss of soils into ditches
  - » trapped water adjacent to pavements
- Establish alignment and grade for edgedrain
- Determine optimal locations for outlets (high spots to low spots)
- Ensure that outlets have good positive drainage (slope) to daylight
- Tile outlets sometimes curl and trap water – use concrete headwalls to prevent this (or rigid pipe outlets)
- Compact trench backfill (prevent deterioration of shoulder structure)

Rules of Thumb for tile

- Bottom of trench should be excavated to follow grade of road at consistent depth
- Top of perforated tile should be no less than 2 inches below the bottom of the drainable base
- Bedding material should be open graded filter aggregate

I.1 Medium Filter Aggregate

Provide naturally rounded and 100 percent virgin medium filter Aggregate meeting the requirements of Table 3149.2-10 and the following.

Table 3149.2-10
Medium Filter Aggregate Gradation Requirements

Sieve Size	Percent Passing
3/4 inch	100
3/8 inch	50 - 100
No. 4	10 - 60
No. 10	0 - 15
No. 40	0 - 4
No. 200	0 - 2.5

(1) The maximum shale and soft rock content of the Material retained on the No. 4 Sieve is 5.0 percent.
(2) The maximum Carbonate content is 55 percent.
(3) The maximum crushing content is 15 percent. Material crushed from quarries is considered crushed Material.

I.2 Fine Filter Aggregate

Provide 100 percent virgin fine filter Aggregate meeting the requirements of Table 3149.2-11.

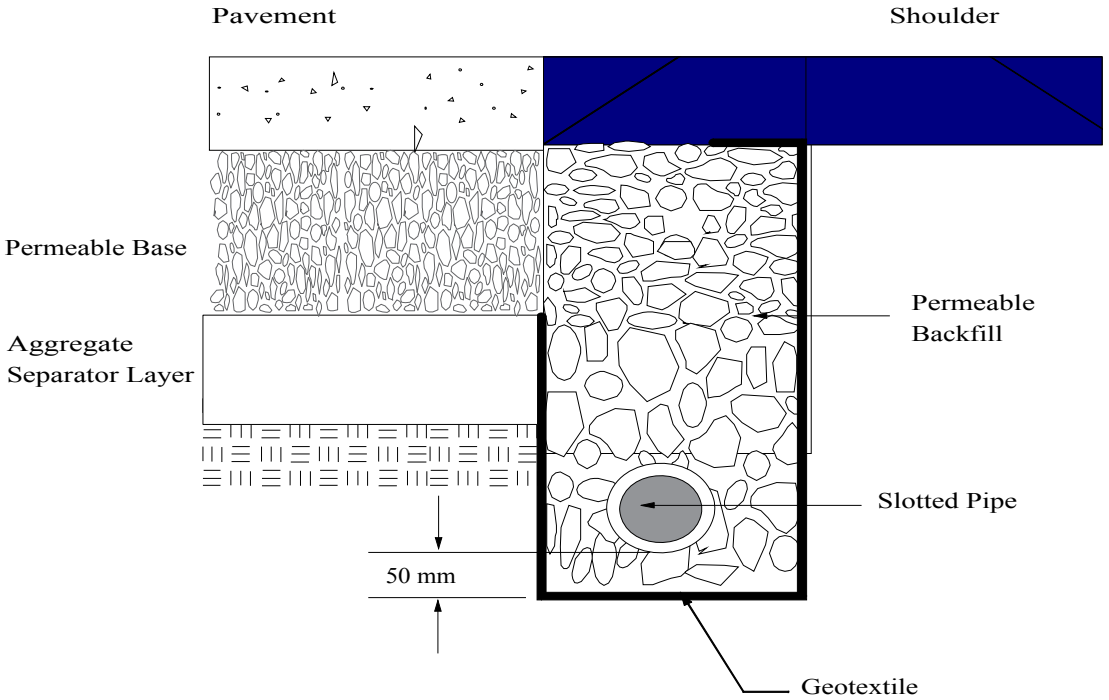
Table 3149.2-11
Fine Filter Aggregate Gradation Requirements

Sieve Size	Percent Passing
3/8 inch	100
No. 4	90 - 100
No. 10	45 - 90
No. 40	5 - 35
No. 200	0 - 3.5

Source: Minnesota 2020 Standard Specifications

Sock is most common (use of geotextiles)

- Where fines are prevalent, trenches can be lined with geotextile material, but this is not an economical solution for mainline of highway.
- Use of a sock on perforated tile may also be a solution where crushed rock is used for back fill in the presence of fines. Caution regarding soil types (clay silts) that can clog sock materials.
- Carbonate sand backfill or crushed concrete are also detrimental to optimal drainage with drain tile, and therefore should not be used as permeable backfill as part of the drain tile. Crushed concrete aggregate base should also not be placed any closer than 3 feet to drain tile.



Maintenance Needs

Taking care of business

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Maintenance Best Practices

- Marking tile outlets at location or on pavement. Also, wise to have GPS locations of tile outlets
- Inspection during construction and after (ensure pipe was not crushed during construction and final seeding)
- Some agencies use concrete headwalls with or without rodent guards
- Some agencies use aggregate filter outlets to avoid mower damage and critter intrusion
- Inspect annually, if possible, for blockage from erosion, vegetation, rodent damage, mower blight

Urban responses:
Jetting, televised inspections, use of designed cleanouts

Rural responses:
Check outlets
occasionally-maybe or maybe not-depends on other work

DID YOU KNOW?

Lack of Maintenance

Consequences of NOT taking care of business

The results of a survey conducted by Harrigan(2002) reported **high failure rates of constructed subsurface drainage systems**, showing that only one-third of the edge drains in existing pavements are functioning properly.

Prioritize outlet inspection for rodent nests, vegetation, and sediment preventing drainage

DID YOU KNOW?

FAQs

Frequently asked questions

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Are tree roots a problem in edge drains in an urban area with a lot of trees?

Tree roots can be a problem in urban areas. Designers can switch to non-perforated tile through treed areas and transition back to perforated tile beyond the root zone.

Should tile be in the center of the road or along the edges?

2009-08 Research Report titled Evaluating Roadway Subsurface Drainage Practices indicated that the edgedrain treatment is recommended, but in some specific instances, particularly if the source of water is an artesian ground water source the centerline drains could have an advantage over the edgedrain treatment. Whether urban or rural, edgedrain systems are most beneficial with impermeable soils and when it is desired to drain the base and subbase materials.

What is the typical size of bedding aggregate?

Agencies may use Fine (MnDOT 3149.2-11), Medium (MnDOT 3149.2-10) or Coarse (MnDOT 3149.2-9) filter aggregates depending on experience.

Table 3149.2-11
Fine Filter Aggregate Gradation Requirements

Sieve Size	Percent Passing
3/8 inch	100
No. 4	90 - 100
No. 10	45 - 90
No. 40	5 - 35
No. 200	0 - 3.5

Table 3149.2-9
Coarse Filter Aggregate Gradation Requirements

Sieve Size	Percent Passing
1 inch	100
3/4 inch	85 - 100
3/8 inch	20 - 60
No. 4	0 - 10

Table 3149.2-10
Medium Filter Aggregate Gradation Requirements

Sieve Size	Percent Passing
3/4 inch	100
3/8 inch	50 - 100
No. 4	10 - 60
No. 10	0 - 15
No. 40	0 - 4
No. 200	0 - 2.5

Do municipalities use sump pump interceptors behind the curb section for drainage benefit?

Generally, agencies using tile as interceptors for sump pump drainage utilize solid tile as in many cases, boulevard trees can wreak havoc with performance of perforated tile. In some cases, perforated tile can be used for added drainage benefit where the depth of installation can serve both purposes.

What is better – plowing or trenching?

Local agencies use both methods with trenching noted in just over half of the survey respondents.

Does tile reduce or eliminate frost boils on gravel roads?

The use of tile can mitigate frost action. In heavy clay soils, improving subgrade soil materials with permeable soils may also need to be considered in combination with subsurface tile.

What is the preferred outlet end treatment?

Concrete headwalls are the preferred outlet as they prevent ‘tile curl’ at the outlet and can be seen more easily by maintenance. Aggregate outlets are another option. In both cases, regular inspection to ensure the outlet is not blocked is critical to ensure the system is working properly, and to eliminate damage to the pavement section due to trapped water in the pavement.

Is there a minimum grade for tile?

2% is desirable but may not always be achievable. Designers should be cautious to avoid trapping water in the pavement section in ‘flat’ areas with little grade. Decreasing the outlet spacing to ensure water is not trapped in zero grade areas can prevent trapped water.

Does tile provide any benefit in areas that don't appear to have any water issues, to prolong the life of a road?

Some areas of Minnesota have the good fortune of sandy, well-draining soils. There will be very little benefit from the installation of drain tile if the soil conditions are ideal and the area is well drained.

What is the typical cost per linear foot?

Costs vary based on quantity of material. For more information, see historical city and county bid tabulations summarized.

Drain Tile Usage on Fed and State Aid Projects

Year	SP/SAP #	Item Number	Description	Est. Quantity (lf)	Unit Cost
2020	007-614-013	2502.503	4" perf PE Pipe Drain	56,304	$ 5.95
2020	009-090-004	2502.503	4" PERF PE PIPE DRAIN	2,200	$ 6.60
2020	009-608-018	2502.541	4" PERF PE PIPE DRAIN	8,500	$ 7.81
2020	025-621-013	2502.503	4" PERF PE PIPE DRAIN	41,726	$ 6.00
2020	027-648-007	2502.541	4" PERF PE PIPE DRAIN	8,850	$ 6.80
2020	040-605-009	2502.503	4" PERF PE PIPE DRAIN	42,454	$ 2.52
2020	040-626-045	2502.541	4" PERF PE PIPE DRAIN	57,296	$ 1.85
2020	040-628-030	2502.503	4" PERF PE PIPE DRAIN	21,300	$ 3.75
2020	043-594-002	2502.503	4" PERF PIPE DRAIN	4,040	$ 8.85
2020	062-696-030	2502.541	4" PERF TP PIPE DRAIN	8,372	$ 8.75
2020	066-676-002	2502.503	4" PERF PE PIPE DRAIN	21,385	$ 4.65
2020	073-592-004	2502.541	4" PERF PE PIPE DRAIN	4,200	$ 1.60
2020	074-612-038	2502.503	4" PERF PE PIPE DRAIN	24,730	$ 5.50
2020	082-617-013	2502.541	4" PERF PE PIPE DRAIN	1,600	$ 7.00
2020	086-612-021	2502.541	4" PERF PE PIPE DRAIN	7,013	$ 5.00
2020	087-594-001	2502.603	4" PERF PE PIPE DRAIN	5,000	$ 14.00

Other Considerations

Ways to improve drainage without tile installation

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Other Options if tile is not feasible

The PERFECT ROAD

An open graded aggregate base with pavement sloped toward optimally designed and well-maintained road ditches provides the most cost-effective solution

Challenge

No outlet for the water

- Shallow ditches
- High water tables
- Flat topography

Options to Consider

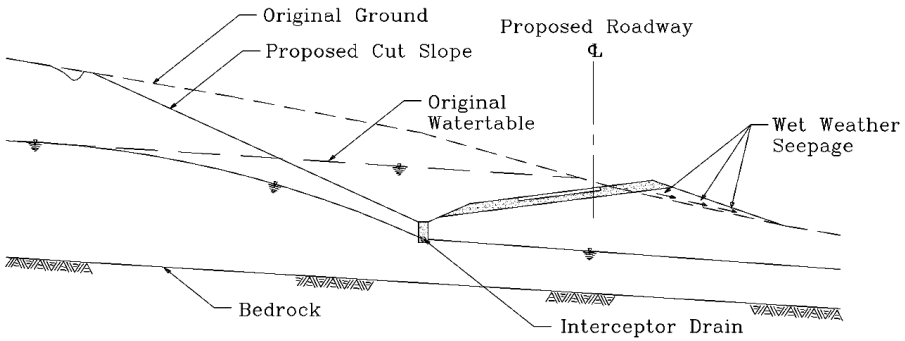
- Deepen ditches
- Raise road (more separation from water table)
- Construct interceptor drain
- Create daylighted outlets

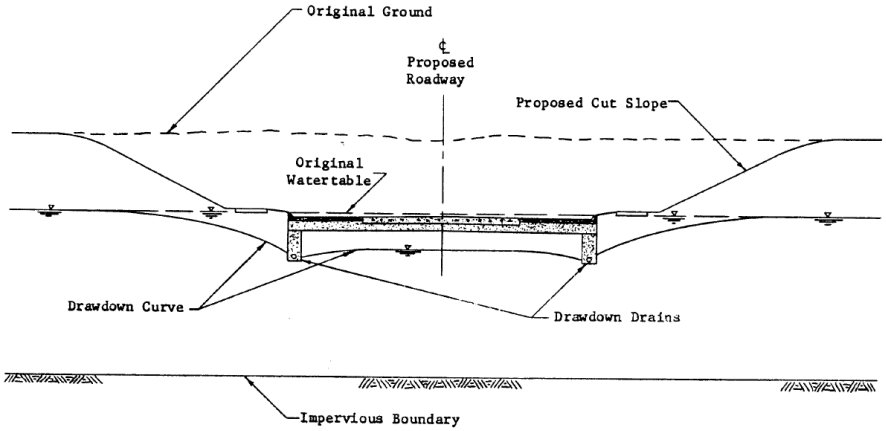
Other Options with Poor Soils and Poor Drainage

Use of interceptor drains

Inability for adequate drainage ditch design
- » shallow ditches
- » high water tables
- » flat topography

Inadequate separation between groundwater table (perched or trapped) and pavement surface





DID YOU KNOW?

Typical Sections & Specifications

Agency examples

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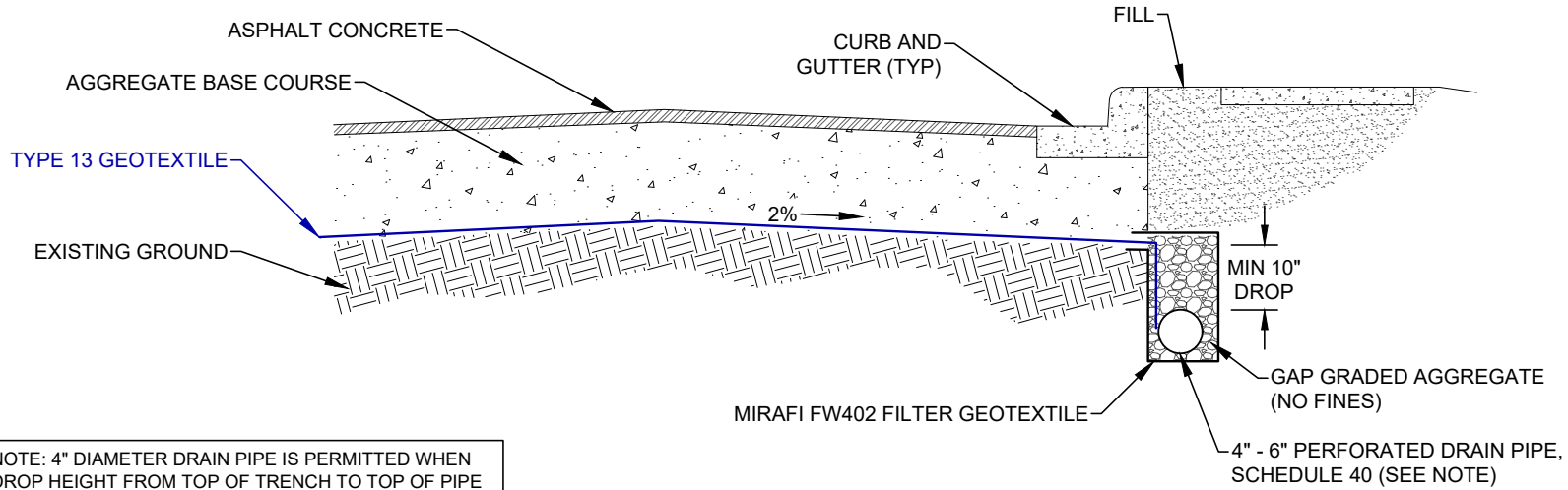
Typical sections/specs



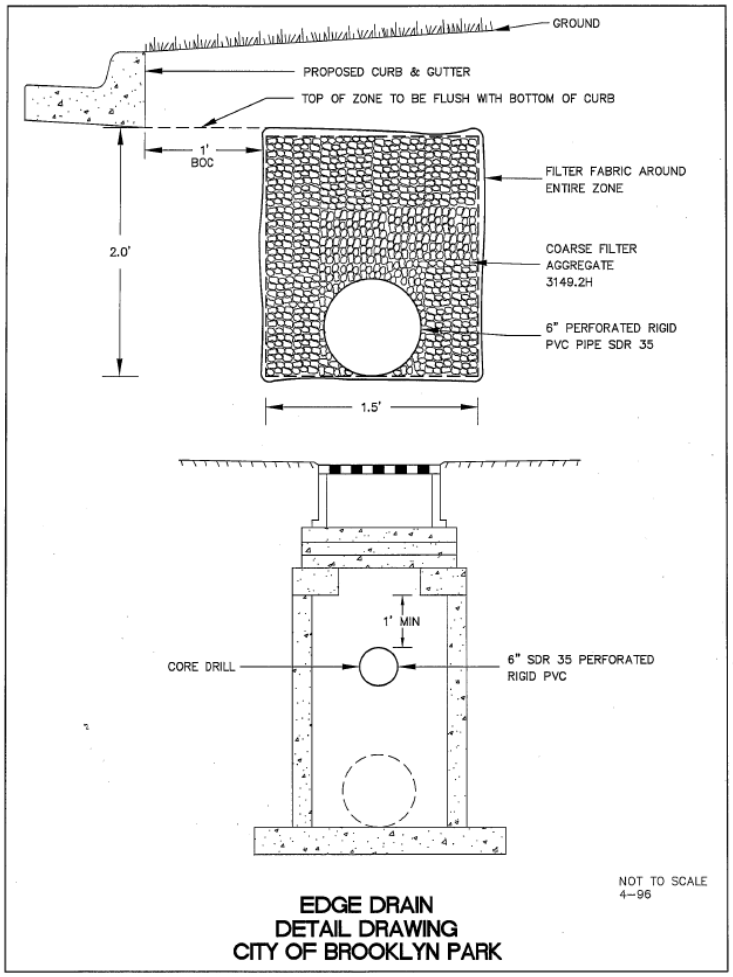
NOTE: 4" DIAMETER DRAIN PIPE IS PERMITTED WHEN DROP HEIGHT FROM TOP OF TRENCH TO TOP OF PIPE IS GREATER THAN 10". A 6" OR GREATER PIPE IS REQUIRED FOR DROP HEIGHTS LESS THAN 10". DRAIN PIPE SHOULD BE DAYLIGHTED FREQUENTLY TO ALLOW FOR INCREASED AIRFLOW WITHIN THE PIPE.

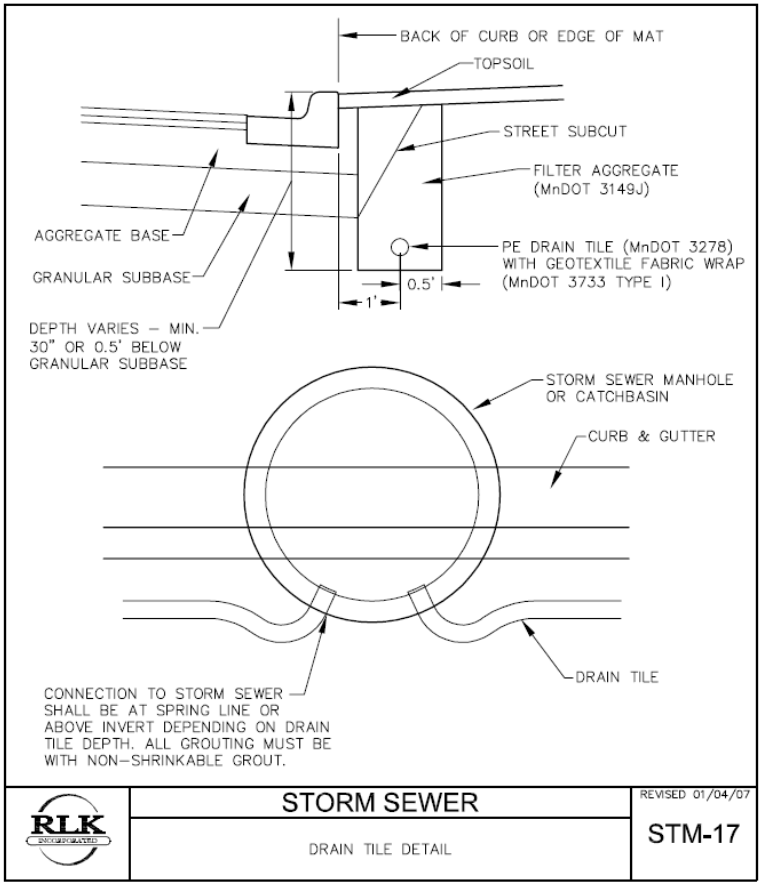
TYPE 13 GEOTEXTILE INTO EDGE DRAIN
NOT TO SCALE

Typical sections/specs

[2502 of Mn/DOT Standard Specifications for Construction]

Urban typical section (behind curb)





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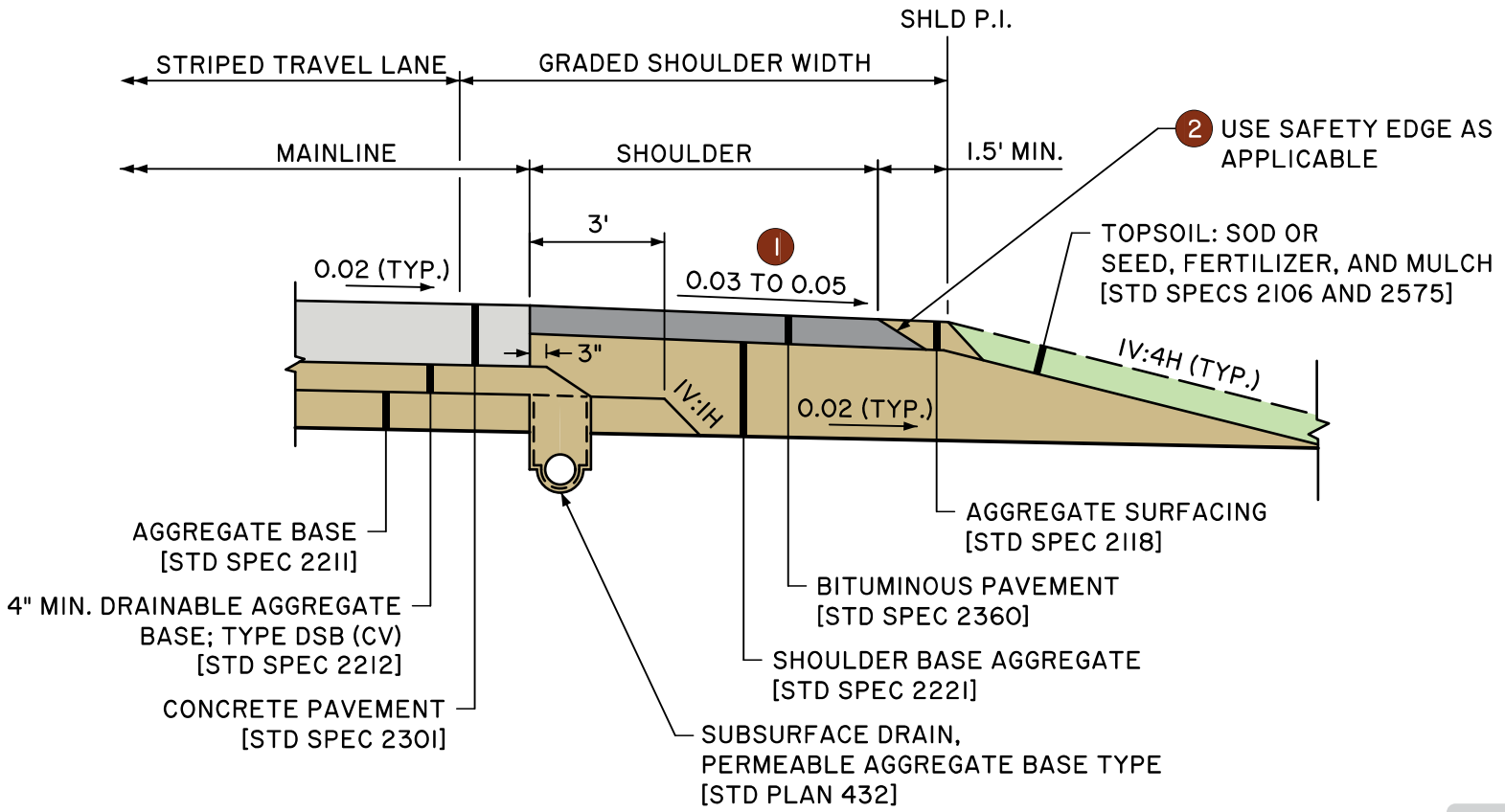
Typical sections/specs

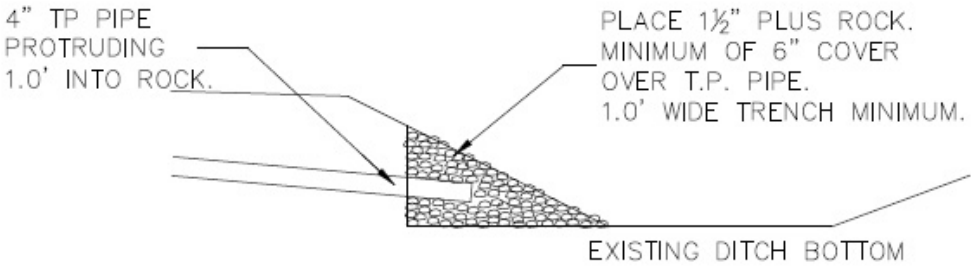
See also: 2502 of Mn/DOT Standard Specifications for Construction

Bituminous Shoulder for Concrete Pavement with Drainable Base



Typical sections/specs

OUTLET TYPICAL



TILE TYPICAL

4" PERFORATED PE PIPE DRAIN SHALL BE PLACED
RIGHT AND/OR LEFT AS DIRECTED BY THE ENGINEE
TRENCH EDGE TO BE A MINIMUM 14.5 ft. FROM C/

PERFORATED PIPE DRAIN INSTALLATION

TRENCH TO BE: WIDTH = 7" MIN. TO 10" MAX.
DEPTH = 3.0' OPTIMUM, 2.0' MINIMUM TO 4.0' I

BOTTOM 1.5' BACKFILLED WITH COARSE AGGREGA
REMAINDER BACKFILLED WITH EXCAVATED MATERIA

PLACE 4"CORRUGATED PERFORATED PE PIPE DRAIN
WITH GEOTEXTILE FILTER WRAP

ESTIMATED TILE OUTLET LOCATIONS			
STATION	LOCATION	STATION	LOCATION
0+50	LT/RT	206+00	LT/RT
10+50	LT/RT	216+00	LT/RT
37+00	LT/RT	232+00	LT/RT
47+00	LT/RT	239+00	LT/RT
66+00	LT/RT	247+00	LT/RT
76+00	LT/RT	251+00	LT/RT
86+00	LT/RT	264+60	LT/RT
96+00	LT/RT	279+00	LT/RT
111+50	LT/RT	289+00	LT/RT
121+00	LT/RT	299+00	LT/RT
136+00	LT/RT	309+00	LT/RT
146+00	LT/RT	319+00	LT/RT
153+50	LT/RT	329+00	LT/RT
160+00	LT/RT	340+00	LT/RT
178+50	LT/RT	360+00	LT/RT
187+50	LT/RT	371+00	LT/RT
		TOTAL	64

Resources

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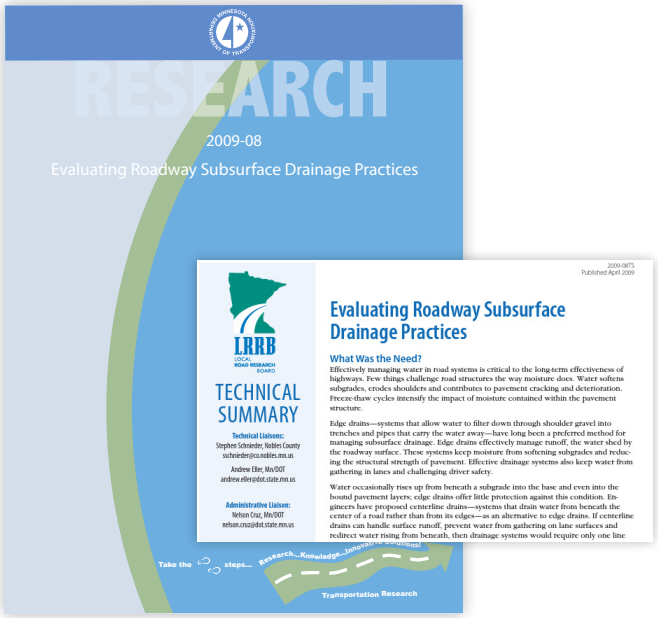
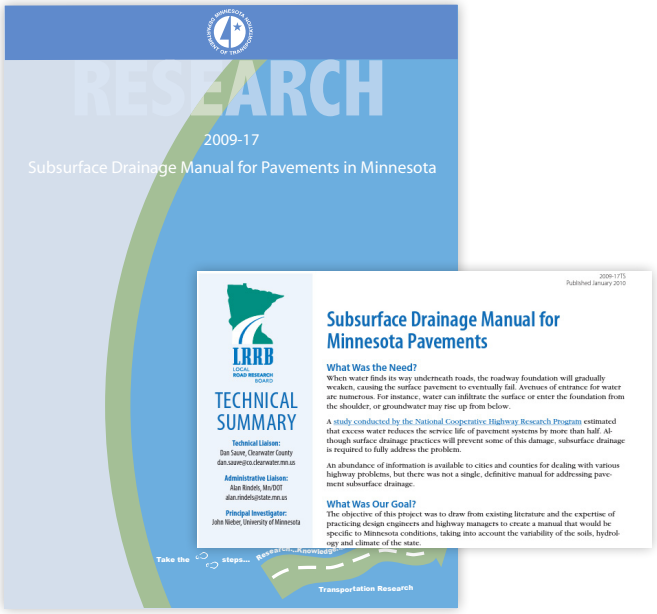


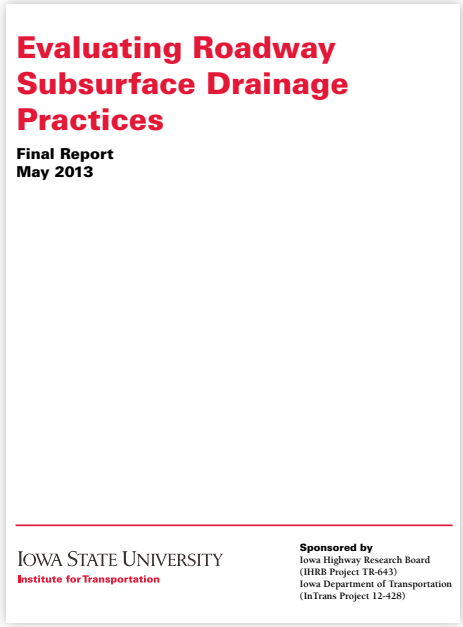
2009-08 Evaluating Roadway Subsurface Drainage Practices

- Technical Summary
- Full Report



2009-17 Subsurface Drainage Manual for Pavements in Minnesota

- Technical Summary
- Full Report



Evaluating Roadway Subsurface Drainage Practices

- Final Report