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1. Introduction

In March 1977 the Joint Highway Research Advisory Council of CONNDOT and the University of Connecticut sponsored a research project in the Department of Civil Engineering to develop methods of reducing highway maintenance through drainage.

The four Districts of CONNDOT were contacted through Mr. R. Zupina, Director of Maintenance. Each district was interested in our investigating several projects. Separate meetings were arranged with each district to visit the site of each problem. Plans of existing roadway and structures were provided by the districts. A tentative schedule was worked out for each project subject to the work load and priorities of the appropriate district. Each problem was studied, then drawings and other information pertinent to the solution were prepared for each site and sent to the district concerned.

Reported herein are the solutions developed for each site. Not all the installations have been made due to scheduling difficulties in the districts.
2. Groundwater Seepage at Exit 92 (Rt. I-86)(Manchester)

A. General

In the vicinity of the west abutment at Exit 92 (Rt. I-86), water seeping from the slope to the north of the abutment and through cracks in the abutment flows onto the pavement. This seepage occurs throughout most of the year. In winter, the seeping water freezes on the pavement surface causing hazardous driving conditions.

Plans of the abutment and existing drainage facilities were supplied by District 1 CONNDOT. This site was first visited by UConn personnel in April 1977. There was evidence of water behind the west abutment and in the slope to the north. A subsequent visit in early June 1977 revealed that the slope on the north side of the abutment had dried, but water was still seeping through cracks in the abutment wall. During this visit, manhole B (see Figure 1) was inspected and found to be carrying water from the catch basin above it. Manhole A could not be located. It has apparently been covered with blacktop by previous paving operations.

Soil samples were recovered from the slope. The grain-size distribution of a typical sample from two (2) feet below the ground surface is shown in Figure 2. The amount of fine particles present indicates a low permeability. Most of the water must therefore be moving in the upper two-foot horizon where frost has loosened the soil structure.

B. Recommended Action

To drain the water from the slope, a prefabricated underdrain\(^{(1)}\) can be buried as shown in Figure 1. The top of the underdrain fin should be close to the bottom of the topsoil. The underdrain could be connected to manhole A or to the pipes between the manholes.
PROPOSED SLOPE DRAINAGE
EXIT 92   I-86

FIGURE 1
Figure 2  Grain Size Distribution of Soil Sample Taken from Slope at Exit 92, Rt I-85
There are several possible solutions to eliminate the water seeping through cracks in the abutment. The plans of the abutment show a drainage pipe behind the wall surrounded by pervious soil. Manhole A should be opened and inspected. If the underdrain pipe is clogged at the manhole, simply cleaning it out periodically may solve the problem.

If the problem is due to a more extensive clogging of the system the following solutions are possible:

1. Drill several small holes about six inches into the abutment. Cement short pipes into the holes. Attach pipes to a header and run header to manhole A. Then place sufficient insulation around pipes to keep from freezing.

2. Make a horizontal hole from the north side behind abutment with flash-joint casing. Place a fabric enclosed pipe or a pipe with narrow, closely spaced slots into the casing. Then withdraw casing leaving pipe in place. Attach pipe to present drainage system.

3. A combination of one horizontal pipe as described in 2 and vertical pipes placed in vertical holes drilled from above. The vertical holes must reach the horizontal pipe so that the flow paths for the water are connected. Vertical holes would be on three foot centers across the back of the abutment.

4. Remove soil behind abutment down to drainage pipe. Reconstruct filter material around pipe and backfill.

These solutions are arranged in order of increasing cost. Solution 1 is the cheapest but also the least reliable since it assumes that the water will continue to seep through the cracks presently carrying water. The insulation would also be vulnerable to damage during snow plowing operations. Solution 2 has a good probability of working. Some subsurface information is needed to insure that the water table is not perched. If the water table is perched Solution 3 may have to be used. Solution 4 is the most expensive.
Solutions 2 or 3 appear most reasonable if the pipe and underdrain system cannot be cleaned from the manhole. Subsurface information is needed and continuous samples should be recovered from borings.

C. Disposition

The proposed solutions covered in item B above were sent to W. Whitman at District 1 on June 1, 1977. We were informed by phone later that the widening of I-86 within the next two years precluded the need for a solution to the abutment problem. However, the underdrains in the slope should be considered when the pavement is widened.
3. Frost Heave on Rt. 52 (Near Exit 80) (Norwich)

A. General

The location of this area experiencing frost heave is at the bottom of a cut section, just south of the overpass carrying Maplewood Avenue across Rt. 52 near Exit 80. This condition may be aggravated by water flowing under the pavement to the area where the frost heave occurs. The pavements of both lanes showed the effects of frost heave. In June 1977 samples of soil from the distressed pavement were recovered. One of the field crews from District 2 excavated the samples. The soil in the subbase has fifteen (15) percent by weight finer than 0.02 mm, indicating that this soil is susceptible to frost heave. (See particle-size distribution curve Figure 3.)

B. Recommended Action

The solution recommended to District 2 is shown in Figure 4. The section of pavement that experiences frost heave is to be removed, the top four (4) inches of subbase to be removed in the middle of the distressed area, and replaced with soil not susceptible to frost heave. A transition zone is provided at both ends of the excavation to reduce the possibility of differential heave by adjacent slabs. A section of prefabricated underdrain is to be placed as shown in Figure 4 and exited to the existing paved drainage ditch. The effect of this solution is to replace the heaving soil with a soil not susceptible to frost heave and provide an exit for water flowing under the pavement.

C. Disposition

The underdrain installation described above was originally scheduled for the middle of July 1977. A portion of Route 52 including this site was
Figure 3: Grain size distribution of soil sample taken from Route 52 near Exit 98.
PLAN

PROPOSED SECTION

FIGURE 4
PROPOSED REPAIRS FOR ROUTE 52
scheduled to be overlayed with asphalt sometime after the underdrain installation. The asphalt overlay was rescheduled for the end of June 1977 on short notice. There was not enough time to install the underdrain before the overlay was placed. As an alternate we proposed cutting through the pavement with a ditch witch and installing the underdrain in the Fall of 1977. To date the underdrain has not been installed.
A. General

This site is the incomplete housing subdivision on the east side of Route 30 about 1.5 miles north of the intersection with Route 74 in Tolland, CT. The area is generally wet and icing conditions on Route 30 are aggravated in this vicinity by flow from the abandoned project. A dirt access road has been cut into the area from Route 30. This road collects and channels water and silt to the highway causing the hazardous driving conditions. Several drop inlets and a partially completed piping system were constructed along the access road before the developer declared bankruptcy. The land is now held in receivership. During the Summer of 1977, it was not clear as to whether CONNEDOT or the bank would undertake construction after calling the bond.

B. Recommended Solution

Although the permanent solution for this site was beyond the scope of this project, a temporary remedy was outlined using a series of small earthen dams three (3) ft. high to contain the runoff. The area behind each dam would act as a retention pond. It was suggested that drainage for the ponds be provided by a system of prefabricated underdrains contained within the dams and the existing, operative catch basins.

C. Disposition

The site was visited in July 1978. The holding institution apparently hired a contractor who built some small retention ponds. However, the basins are not positioned properly to be completely effective.
5. Wilbur Cross Parkway (Hamden)

A. General

The southbound lane of the Wilbur Cross Parkway just north of the Wintergreen Avenue overpass in Hamden experienced severe icing conditions each winter. The ice resulted from water supplied by a swampy area on the west side of the highway. Water from this area could be seen running along the shoulder of the road even during the summer months.

Conn DOT proposed an underdrain at this location, using Typar, a non-woven spun bonded fabric made by DuPont. Inspection of the area however indicated that the problem was primarily one of the surface water, with some contribution from water moving through the upper 6-12 inches of till. This upper layer of till has probably been loosened by frost action.

B. Recommended Solution

The recommended solution controlling both surface flow and ground water is shown in Figure 5. Two small earthen berms were proposed to contain the surface water. A catch basin at the intersection of the berms allows the surface water to drain through buried pipe into the existing system near Wintergreen Avenue. A prefabricated underdrain installed in each berm as shown in Sec. A-A Figure 5 collects any ground water moving through the soil.

C. Disposition

The installation was made essentially as recommended in June 1978. The pipe from the new catch basin to the existing system was Advanced Drainage corrugated pipe. This pipe, which usually comes in lengths of over 100 ft. wound on a roll, had been precut to 20-foot lengths and arrived without couplings. A construction expedient was developed by slitting the ends of the pipe for about 9 inches and forcing the ends together. Figure 6 shows the corrugated
SECTION A-A

Figure 5 As Built Drawing for Kilbur Cross Parkway
near Wintergreen Ave. Overpass
Figure 6  Connecting Drain Pipe to Existing System
(Wilbur Cross Parkway)

Figure 7  Installation of Underdrains
(Wilbur Cross Parkway)
pipe connected to the existing drainage system near the catch basin shown on
the sketch (Figure 5). Installation of the underdrains is shown in Figure 7.
Figure 8 shows the catch basin and the area between the berms after backfilling
was completed. Final grading and seeding had not been completed. A view of
the project toward the Wintergreen Overpass is shown in Figure 9. This project
is complete.

D. Remarks

Several wet soil seams were uncovered during the trench excavation.
The water from these seams caused some problems in backfilling the pipe. One
connection separated and had to be excavated again and rejoined. Wet seams
are common in glacial till. CONDOT might consider stocking a perforated
pipe covered by fabric for these areas. One example is Drainguard which is
also manufactured by Advanced Drainage Systems.
Figure 8  Catch Basin Between Berms
(Willbur Cross Parkway)
Figure 9  View of Completed Drainage Project (Wilbur Cross Parkway)
6. Intersection of Routes 243 and 114 (Woobridge)

A. General

The intersection of Routes 243 and 114 experienced icing problems for the greater part of each winter. CONDODOT suspected the water on the shoulder of the northeast corner of the intersection to be, at least partially, due to ground-water seepage and decided that the non-woven fabric "Typar" could be utilized on this project.

Inspection of the site indicated that the major problem was surface water drainage under a stone wall to the north of the intersection with some additional water seeping out of the shoulder. Examination of the soil beneath the pavement and an open excavation at the south side of the intersection indicated a high ground-water table, but little seepage occurring 1 ft. below the ground surface.

B. Recommended Solution

An installation was designed to collect all sources of water. A catch basin was recommended to collect the surface water. A stone-filled trench surrounded by "Typar" running from the new catch basin to existing drainage facilities at the intersection was also recommended. The proposed solution is shown in Figure 10a. Figure 10b shows a cross-section through the pavement.

C. Disposition

The catch basin and trench were installed in May 1978. At the time of installation there was not as much "Typar" available as originally indicated. At the south end, the trench was half filled with stone before the "Typar" was laid. After a conference with the foreman, it was decided to make the excavation shallower at the north end in an effort to best utilize the available fabric. The remaining fabric was insufficient to properly
Figure 9  View of Completed Drainage Project
(Wilbur Cross Parkway)
INTERSECTION OF ROUTES 114 & 243

ROUTE 114

ROUTE 243

TRENCH

DRIVE

STONE WALL

NEW CATCH BASIN

SURFACE DRAINAGE

CHANNEL

3" WEAR SURFACE

7"-8" OILED

2" SANDY GRAVEL-SOME FINES
TILL WITH SOME SAND LENSES

PAVEMENT SECTION

(b)

NOTES: ROAD IS ABOUT 1' BELOW GRADE AT FIRST POLE.

FIGURE 10
AS BUILT SOLUTION FOR DRAINAGE PROBLEMS, INTER-
SECTION OF ROUTES 243 & 114
enlarge the north end of the trench and the fabric was placed on the road side of the trench only. Inspection two weeks after completion indicated that the soil is penetrating the stone at the north end where there is insufficient fabric. The catch basin was partially full of sand that had washed through the stone and into the basin through the culvert pipe.

Figure 11 shows the "Typar" placed in the trench and the trench being backfilled with stone. Figure 12 shows the completed stone backfill covered by lapping the edges of the fabric. The connection to the existing drainage facilities is shown in Figure 13. A short length of pipe into the stone backfill allows the water to escape into the catch basin. Figure 14 is a view of the completed project looking toward the intersection of 11b and 243.
Figure II  Typar Fabric in Trench and Being Backfilled with Stone
Figure 12: Stone backfill complete and covered with fabric.
Figure 13  Outfall from Stone Backfill
Figure 14  View of complete project along Route 243
7. Route 118 Litchfield

A. General

Route 118 between East Litchfield and Litchfield experiences severe frost heave each winter in numerous locations. This investigation was to determine if improved drainage might alleviate the problem.

The Soils Section of CDOT supplied reports and data from their investigations. These reports from 1957, 1960 and the data from 1977 show that the area is wet and that soils susceptible to frost heave are included in the pavement foundation. The earlier reports addressed sloughing slopes due to excess water. The data gathered in 1977 on the particle size distribution of the soil indicate the susceptibility of the foundation soils to frost heave. Borings were made by CDOT in March of 1977 when the frost had penetrated four (4) feet or more into the soil.

Additional grain size distribution tests were run on samples of the broken-base filler. This grain size distribution is shown in Figure 15 and the filler does not appear to be susceptible to frost heave.

The only certain solution to frost heave problems is to remove the soil to a depth of twenty inches below the top of the pavement and construct a new subbase with soils not susceptible to frost heave. A reduction of frost heave by controlling the amount of water retained in the pavement foundation appeared possible. Past frost heaves caused many cracks in the present pavement. Water entering these cracks during rainstorms either percolates into the subbase, or flows under the pavement and exits at a lower elevation. Proposed installations were designed to collect most of the excess water entering the pavement foundations in the vicinity of the drains.
Figure 15: Grain Size Distribution of the Soil Used as Filler for Broken Stone Base (Rt. 118)
B. Recommended Action

Several site visits were made to Route 118 between Litchfield and East Litchfield. During these visits four (4) areas in the Eastbound Lane were selected for trial installations. These four sites are listed below. The distances were measured eastward from the intersection of Routes 254 and 118:

Site No. 1 - 0.6 mi.  Site No. 3 - 1.7 mi.
Site No. 2 - 1.1 mi.  Site No. 4 - 2.2 mi.

The object of each installation was to provide a region of drainage in an area of pavement that has experienced frost heave distress in the past.

Drawings detailing the installation of prefabricated underdrains were prepared as shown in Figure 10. Each drain was to be installed transversely in a narrow ditch made with special trenching equipment such as a "Trench Witch." Backfilling with clean sand was recommended. The underdrain pipe to be connected to an existing catch basin or drainage pipe, whichever was closer.

C. Disposition

Two installations were made during the fall of 1977: one at Site 3 and one at Site 4. Figure 17 shows the roadway at Site 3 after completion of the installation. The underdrains are beneath the dark transverse patches. Figure 18 shows the outlet to these drains at the side of the fill.

The sites were inspected during the winter of 1977-78. The frost heave in the vicinity of the drains was not noticeably smaller than in non-drained areas. The installations showed that the frost heave experienced by Rt. 118 can not be eliminated without replacing the soil presently in the foundation.
PROPOSED INSTALLATIONS FOR ROUTE 118

FIGURE 16
Figure 17  Site 3 Rt. 118 (Litchfield)
Figure 18  Drain Outlet Site 3  Rt. 118
(Litchfield)
or treating it with some additive. Either method requires extensive reconstruction.

A field device, developed several years ago, would prove helpful in attempting to eliminate frost susceptible soils from pavement foundations. This device is designed for field use and helps identify problem soils rapidly so that they can be excluded from the pavement foundation.
B. I-84 Middlebury

A. General

The slope on the south side of Route I-84 in Middlebury just east of the arch bridge is sloughing in several areas. The biggest sloughs are shown in Figures 19, 20 and 21. The light areas in the photographs have become unstable due to ground water seeping to the face of the slope. Other areas show local downward movement of the slope face. The instability leads to the erosion of the soil into catch basins at the toe of the slope.

Several underdrains were installed in the slope at the time it was cut. These have become ineffective due to the sediment that clogs several catch basins and the soil movement that has destroyed some of the lines.

B. Recommended Solution

A technique of stabilizing this type soil slope has been developed and used before. Although this slope in Middlebury was a project involving major reconstruction that could not be undertaken at this time, a scheme of drainage was developed and submitted. This scheme is shown in Figure 22. The solution requires prefabricated underdrains. More than 2000 ft. of underdrain with a seven ft. high fin are required at the top of the slope to collect water causing the instability high on the slope. Lengths of drains having fins 5 ft high are required about the middle of the slope to contain local instabilities.

C. Disposition

The possibility of including the slope stabilization as part of the improvements to I-84 in this area was investigated. However, this instability is not a threat to safety and is therefore considered outside the scope of the improvements.
Figure 19  Slope on South Side of Rt. I-84
MIDDLEBURY (EAST)

Figure 20  Slope on South Side of Rt. I-84
MIDDLEBURY (CENTER)
Figure 21  Slope on South Side of Rt. 1-84
Middlebury (West)
Figure 22  Proposed Drain Installations to Stabilize Slope
on South Side of Rt. 1-84, Middlebury

LEGEND
- EDGE OF ROAD
- RUNOFF DITCH
- PREFABRICATED UNDERDRAIN (PROPOSED)

SCALE: 1 IN. = 200 FT
9. Summary and Discussion

The maintenance problems investigated on this project can be divided into two categories: seepage and frost heave. Both conditions may cause hazardous driving conditions in winter.

Seepage problems often develop in cuts after the construction is well along or completed. In many cases, it is difficult or impossible to predict where the problem will occur due to the stratification of the glacially deposited soils. The requirement of remedial measures for seepage areas should be anticipated whenever a cut is made in till.

Another difficulty with stratified soils is the unexpected wet excavation. An example of this was observed on the pipe excavation at the Wilbur Cross Parkway. The trench became wet about half way between the existing catch basin and the proposed location of the new catch basin between the berms. (See Figure 5) The water seeped from a pervious layer that had been exposed by the excavation. This is a common problem when excavating in glacial till. To handle this condition, the field crew should have alternate materials available. In this case the use of a perforated pipe enveloped with fabric would have been preferable to the solid pipe. Perforated pipe with a fabric sleeve is available commercially. One example is Drain Guard manufactured by Advanced Drainage Systems.

The problem of frost heave results from three conditions:

1. the presence of a soil susceptible to frost heave in the pavement foundation;
2. an adequate supply of water to the susceptible soil;
3. subfreezing temperatures.

Ground water is close enough to supply moisture to the freezing zone in many parts of Connecticut and each winter brings temperatures below the
freezing point. The only positive method of preventing frost problems is to eliminate soils susceptible to frost heave from the pavement foundation.

The susceptibility of a soil to heave under freezing conditions correlates with the percent particles by weight smaller than 0.02 mm. Under a previous project, a rapid field test was developed to identify frost-susceptible soils \(^2\). Proper use of this device to test the soils during construction would assist in excluding poor soils from pavement and shoulder foundations.
References
