

SUBDRAINAGE — ITS PURPOSE — DESIGN AND RESULTS OBTAINED *

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Earth is the one item that is used to the greatest extent of any item that enters into the construction of a road. It is made up of natural materials varying both in physical and chemical characteristics with no possible control in their creation. Knowledge of their proper use in highway construction was very limited until the modern concept of soil mechanics was introduced into the field of highway construction some thirty years ago. The first major strides forward in the use of soils was in dams and levees. Methods have been developed, as you all know, so that earth will sustain greater loads than in its original condition.

Used as roadbeds and foundations for modern highways and structures, the soils must be strong. Strength can be increased and controlled by

- 1 — Regulation of water content.
- 2 — Chemical Additives.
- 3 — Proper gradation of natural soils.
- 4 — Compaction.

However, regardless of the treatment chosen, the intrusion of excessive water after construction will weaken or even destroy the desired foundation in reference to proper supporting strength.

Back in the early eighteen hundreds a Scotsman by the name of Telford believed road foundation was the most important single item and he developed the Telford Base type of field stone foundation. Along about the same time, another Scotsman by the name of MacAdam believed surface was the answer and we had the beginning of the waterbound macadam surface. Then in 1823 came the Englishman by the name of John Smith who promoted the idea that drainage was the important item. Certainly no one of them alone was able to obtain the complete and proper results. We know that subdrainage and foundation have to go along side by side in the design and construction of every road in order to have the satisfactory subgrade on which to put the wide relatively thin ribbon we call surface.

This statement has been made by more than one experienced engineer. "A good road is like a house, it needs a tight roof and a dry cellar." These men knew the value of good drainage.

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Unfortunately, we still find the maintenance men patching the effects rather than treating the cause of the pot holes or road breakups. Truly it is in the subgrade and subbase where most pavement failures get their start. Research has emphasized the fact that excess moisture in subgrade soils is, in most cases, the cause of unsatisfactory or varying support and the subsequent failure of road surfaces.

Subdrainage is the method of “dehydrating” the subgrade and subbase.

Soil moisture is of two major kinds.

Gravitational or free water

Capillary

Gravitational water is free to move under the influence of gravity. It is the kind that can be removed by drainage, either surface or subsurface.

Free water, as stated, enters or leaves the subgrade by the action of gravity. The porosity of the soils controls to a large extent the rate of flow.

We all know that gravels and sands afford excellent underground channels if there is any slope to the top of the impervious underlying soil, and providing they are not hemmed in by a barrier of impervious soils. However, these same underground channels which will carry away ground water will also serve to bring unwanted water to the subgrade. We often see this just below the crest of a hill or where the road section changes from cut to fill.

Another condition you have all seen is the “pumping” by passing traffic of the subsurface water through the cracks and joints of the pavement or through the surface itself.

As previously stated, this water is harmful not only in that it lowers the bearing power and stability of the subgrade, but because it may freeze on the surface and create a hazard to traffic.

Capillary Water

Capillary moisture clings to the soil particles by surface tension and reaches the particles either when the free water passes through the soil or by capillary attraction from a wetter to a drier stratum. It is not affected by gravity, being able to move upward as well as in any other direction, and cannot be removed by drainage; but can be controlled by keeping the water table low enough so it does not threaten foundation areas.

Soil Studies

Recognizing that soils are a raw construction material, the Highway Departments have made soil studies a required part of their survey and in-

vestigational design work. The location, source and direction of flow and the fluctuation of the ground water table is studied. Auger borings are or should be made on all jobs. The data obtained prior to design and contract of the job should be checked during the progress of the construction work with additional subdrainage installed where determined necessary from the "on the job" tests.

Soil Surveys

Soil surveys will usually indicate one of the following conditions:

Side hill seepage

Level water table

Surface leakage

The following slides illustrate these conditions and a remedy.

Side Hill Seepage

Water should be intercepted before it reaches the roadway area, as is illustrated in the slide. The pipe should be located, if possible, at an elevation that is below the seepage zone.

Capillary water — where there is a need for controlling the water level well below pavement elevation is illustrated by this slide. Obtaining a proper grade for the pipe plus a satisfactory outlet is often a problem. In some locations, raising the road grade is a very satisfactory solution.

Water pockets is another condition often found.

Rock Cuts

In a large percentage of our ledge cuts, the ledge holds pockets of water increased in volume and flow by the construction blasting. This condition results in the foundation material becoming saturated, with resulting heaving. Design of subdrainage along the shoulders is the correct answer in many cases.

The use of subdrains is not restricted to highways. They are employed wherever problems related to ground water occur; highways, airports, dams and levees, golf courses, shopping centers, housing developments, athletic fields and railroads.

Subsurface runoff and required size of pipe does not lend itself to the use of empirical formulas as is the case with surface drainage. Experience and common sense are the best guides to work by.

The minimum size of pipe should be 6" diameter. Some engineers prefer to use 8" diameter as minimum. Since the number and size of the holes in the pipe walls are the same for both 6" and 8", the use of the larger size has to be based on other reasons.

The minimum grade should, in my opinion, be 0.5 percent with 0.2 percent the absolute minimum.

Before discussing the types of pipe, let me review the history of Sub-drains.

Some of the early subdrains were trenches filled with brush and rocks, with the idea of providing plenty of voids for the water to flow through. Naturally these were effective for only a limited time because of silting up.

Then the so-called French drain. That was a step in the right direction. Size of filter was reduced but no adequate method of removing the water collected in the trench was provided.

Then came the use of a tile pipe with open joints every two feet to carry the collected water. I remember the first underdrain that I saw installed was back in 1922. I remember others in Vermont where clay pipe was used that was dug up either to be replaced or because of the rebuilding of the road. They all had long ago lost all value as a pipe because of filling of the pipe through the open joints.

In 1925 Perforated Metal Pipe was fabricated. The pipe was the standard corrugation with the holes located in four rows grouped in the bottom of the pipe.

In 1934 the Helical corrugated pipe was developed and, as a result of the Vicksburg Tests, the size and location of the holes was established.

In more recent years, cast iron skip pipe, perforated tile, concrete, fiber and asbestos cement pipes have been developed.

Pipe

What is required of the pipe used in an underdrain trench, having in mind that any subdrainage system to be economically sound must continue to function year after year. Since water carried in subdrainage systems normally originates from underground sources, it is not normally corrosive. Likewise, erosive sediment is not present to any extent. For these reasons, structural integrity is of prime importance.

Discussing pipe requirements we have

1. *Strength of Conduit*

Ability to withstand the dead load plus live loads that more often than not are on the trench during construction.

2. Ability to hold alignment and grade. Ability to retain alignment when the backfill is placed. Ability to bridge low spots in the trench bottom and not break or have the joint pull apart.

3. Joints that are positive in their holding the sections of pipe together and preventing infiltration of the filter backfill.

4. Perforations that are correctly sized and properly located in the pipe to pick up the accumulated water, yet not large enough to allow too many fines to enter the pipe. There are engineers who believe that the thicker the pipe wall the more it is possible that, during the times of intermittent flow, the fines dry or harden in the perforations and lead to a permanent clogging of the infiltration areas. This statement was written by Phil Keene in his paper at the 24th Annual Meeting of the Highway Research Board.

Filter Material

The purpose of the filter material is to permit the intercepted water to change direction and drop down in the trench to be picked up in the pipe, and equally as important to prevent the infiltration of the clays and silts in the adjacent soil from being washed into the filter material and thereby clog the voids in the crushed stone or sand backfill. Two Slides on Gradation Broken Stone or Screened Gravel and Graded Sand.

The Connecticut grading specification is, in my opinion, a very satisfactory one. Crushed stone all passing $\frac{3}{8}$ " and maximum of 2% passing No. 100 mesh. Sand all passing $\frac{3}{8}$ " sieve and maximum of 10% passing No. 100 mesh.

Filling the Trench

The trench should be dug to a width sufficient to permit proper shaping of the subgrade and placing of the pipe and connecting collars.

Connecticut's specification covers this very satisfactorily in specifying a width of two feet greater than the diameter of the pipe.

Regardless of the type of pipe used, care must be exercised to prevent clay or other impervious material from inadvertently entering the trench. This can cause clogging of the filter material or the conduit. Slide — Route 15 in Conn. 1958

Outlets

Outlets are of major importance. Any subdrainage system to be economically sound must continue to function efficiently year after year. Outlets should be located where the minimum of maintenance is required to keep them clear. Too often an outlet is carried into an excavated ditch which will be filled to above the flow line of the pipe before the first year of operation has passed. Slide — Outlets into a manhole or catch basin should be at a higher elevation than the flow line of the cross pipe. Inspection of

existing underdrain outlets that have had years of service will too often show these errors of design:

Slides of Underdrains with long years of service.

Bridgewater, Vt. — built 1927 — Picture 1954

Wallingford, Vt. — built 1930 — Photo 1960

Lowell, Vt. — built 1941 — Photo 1960

Columbia, Conn. — built 1933 — Photo June 1957

Woodstock, Vt. — built 1956 — Photo Spring 1958

Combination Drain — 1400' of 12" diameter

In summary of what I have discussed —

Subdrainage installations fit into the same requirements as for all other construction items, namely, carrying out of the plans and specifications.

Installed at proper depth to be sure the water is intercepted, which after all is the purpose for which the installation is made. Proper laying of the pipe to obtain the required flow line grade. Connecting bands properly placed to insure tight rigid joints. Correctly graded backfill material properly placed for the full width and depth of the trench.

Maintenance free outlets.