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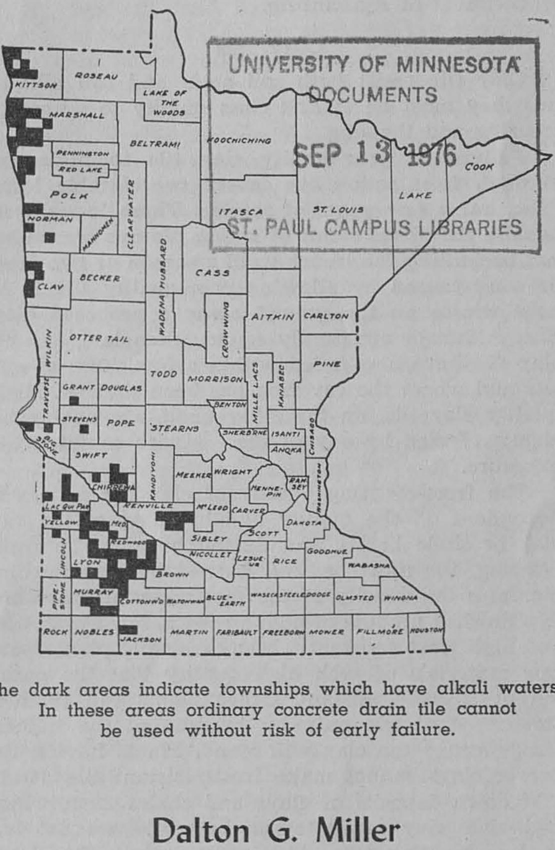
Choosing Drain Tile to Fit Your Soil



The dark areas indicate townships which have alkali waters. In these areas ordinary concrete drain tile cannot be used without risk of early failure.

Dalton G. Miller

UNIVERSITY OF MINNESOTA
Agricultural Extension Service
U. S. DEPARTMENT OF AGRICULTURE

THE performance and life of a tiling system will be greatly affected by the kind and quality of tile used. It is therefore important for the farmer to consider first the three natural agencies that tend to make drain tile go to pieces: (1) freezing and thawing, (2) soil alkalies, and (3) soil acids. The clay or shale tile and concrete tile commonly used in Minnesota are of distinctly different types, with distinctly different strong and weak points, which the farmer should understand before he buys.

Many special studies have been made by the drain tile laboratory at University Farm in order that the resistance of drain tile to these natural agencies may be increased. This work has been conducted under a joint agreement of the University of Minnesota, the Minnesota State Department of Conservation, and the Soil Conservation Service of the U. S. Department of Agriculture.

Clay Tile

Clay tile resist both soil acids and soil alkalies but they must be of first class quality to withstand freezing and thawing.

Failure of poor-quality clay tile in Minnesota through frost action has caused considerable losses after but a few years of service. These losses were usually the direct result of laying tile one season but not backfilling the trench until a season or two later, or were caused by allowing poor-quality tile to lie over winter on the ground along a proposed ditch line. Although apparently sound when laid, inferior clay tile have also failed within a few years at outlets and where the covering has been shallow. High-quality clay tile, on the other hand, are not appreciably affected by any of these severe conditions of exposure.

The frost-resisting quality of clay tile is largely dependent on the quality and handling of the raw clay or shale before and during burning. To resist freezing, tile must be well burned because burning increases the density of the raw materials, resulting in a finished product of high strength, low absorption, and high frost resistance. Many clay-tile plants have raw materials of such high quality that the entire output is frost-resistant. Other plants can produce frost-resistant tile only by burning at the highest temperatures the clay will stand. Plants having the poorer clays cannot make frost-resistant tile at all.

Known deposits of clays and shales from which high-class clay products can be made are not numerous in Minnesota. At present, only eight plants make any type of clay product; only those at Red Wing and Willmar make drain tile. The Red Wing plant makes a limited number of high-quality hard-burned shale tile in sizes from 4 to 20 inches, while the Willmar plant makes a limited number of medium and soft-burned 6- and 8-inch surface clay tile.

Upper Limits of Absorption Indicated for Different Classes of Drain Tile As Determined for Minnesota and Iowa Plants by Freezing and Thawing Tests

Plant and location		Raw material	Per cent absorption: Classes of drain tile: Standard	Per cent absorption: Classes of drain tile: Extra quality	Per cent absorption: Ordinary plant output
A	Iowa	Shale	14.0†	14.0†	9.0
B*	Minnesota	Surface clay	14.0	13.0	22.0
C*	Minnesota	Shale	14.0	13.0	9.0
D*	Minnesota	Surface clay	......	......	34.0
E	Iowa	Shale	13.0†	13.0	6.0
F	Iowa	Shale	13.0†	12.0	10.0
G	Iowa	Shale	12.0	12.0	11.0
H	Iowa	Shale	11.0†	11.0†	9.0
I*	Minnesota	Shale	14.0	13.0	9.0
J	Iowa	Shale	16.0	16.0	16.0
K*	Minnesota	Shale	15.0	15.0	15.0
L*	Iowa	Shale	15.0	15.0	13.0
M	Minnesota	Shale	16.0†	16.0	11.0
N*	Minnesota	Surface clay	15.0	15.0	32.0
O	Iowa	Shale	8.0†	8.0†	4.0
P	Minnesota	Shale	11.0	11.0	8.0
Q	Iowa	Shale	20.0	19.0	13.0
R	Iowa	Shale	21.0	21.0	22.0
S	Iowa	Shale	8.0†	8.0†	5.0
T	Iowa	Shale	11.0	11.0	8.0
U	Iowa	Shale	13.0†	13.0†	9.0
V	Minnesota	Surface clay	20.0	19.0	24.0

* Plant has discontinued business.

† Higher absorption limit permissible for this plant but no tests made of tile having a higher absorption.

To simplify future tile testing and to obtain specific information as to actual quality of clay tile put out by Minnesota plants, as determined by standard tests of the American Society for Testing Materials, samples were collected from stock piles of 14 operating and nonoperating plants. Tile were also collected from 13 Iowa plants that furnish nearly all the clay tile now available for use in Minnesota.

Fifteen tile were tested from each plant. Five were selected from stock piles as representative of the average output, the plant superintendent usually assisting in this selection. Then five harder-burned and five softer-burned tile were picked with the idea that the 15 tile would represent fairly well the whole range of quality for the plant so far as burning was concerned. These tile were then tested for breaking strength, absorption, and frost resistance according to standard specifications for drain tile laid down by the American Society for Testing Materials. These specifications require thawing in water at a temperature of 65° to 70° F. Thirty-six freezings and thawings without visible damage are required for standard drain tile, and 48 such reversals for extra-quality drain tile.

Following each reversal, the individual pieces were examined and where no evidences of failure were found the test was continued until the specimen had passed double the requirements for extra-quality tile, that is, 96 reversals in accordance with the standard specifications. **It was found that of the 1,140 individual pieces, from 26 plants, which passed the extra-quality requirements, 83 per cent also passed the test of double that requirement. The results clearly emphasize that extra-quality tile are all that the name implies so far as resisting frost action is concerned.**

Results of Clay Tile Testing

This testing work showed that the amount of water tile will absorb is a rough index of their frost resistance. This fact is important mainly because the absorption test can be made much more quickly and easily than the freezing-and-thawing test. The accompanying table shows that with but a single exception the only tile plants now in business are those having shales for raw materials. The table also shows that, judged by the absorption test, the tile from some plants now in business are uniformly more frost resistant than the products from other plants. If the absorptions of the ordinary output from any plant are well below the permissible maximum limits shown in the table, it is evident that the general run of products from that plant will be highly resistant to frost action. On the other hand, when the absorptions of the output from any plant closely approach the maximum limits indicated for that plant, care needs to be exercised to obtain the harder-burned products if they are to be exposed to even moderately severe frost action. If the absorptions of the ordinary output from any plant greatly exceed the indicated maximum limits of the table, then none of the products from that plant should be used where exposed to even moderate frost action.

In any case, it is good insurance to install all clay tile without subjecting them to undue abuse. Never allow them to lie on wet ground for long periods of time during cold weather. Such exposures will not appreciably affect high-quality clay tile but are disastrous to borderline tile that otherwise might give many years of satisfactory service.

Concrete Tile

Concrete drain tile, of sizes ordinarily used in farm drains in Minnesota, are dry-mixed products, and such products, when fairly rich in cement, satisfactorily resist frost action under all ordinary conditions of exposure. Concrete drain tile, however, are attacked by soil alkalies, such as magnesium and sodium sulfate, and by soil acids such as occur to a greater or less degree in most of the Minnesota peats.

The map of Minnesota on the cover of this folder shows the areas in which were found shallow ground waters carrying relatively high concentrations of various salts. In these areas, ordinary concrete drain tile cannot be used without serious risk of early failure.

Naturally no map of this kind can be exact, but it will serve as a fairly reliable guide to the sulfate-water areas. Water containing 0.15 per cent magnesium or sodium sulfate will be slightly bitter to the taste and the degree of bitterness will intensify with increase of these sulfates.

The acid soils of Minnesota are not so well localized as those containing sulfates. However, peats are generally the only acid soils in Minnesota that need cause concern regarding the use of concrete drain tile. The peats of Minnesota cover a wide range in acidity but, for the most part, those that are drained for agricultural uses are of low acidity.

In studies aimed at improving the resistance of concrete drain tile to soil sulfates and soil acids, the drain tile laboratory has made up more than 125,000 experimental specimens, including drain tile, cylinders, briquets, and bars. Around 15,000 of these specimens were used in the acid tests, all the others being used in the sulfate tests. Many of these specimens have been exposed to artificial solutions in the laboratory and many to soils and natural waters in field tests. By far the most specimens at any single field location were submerged in Medicine Lake some 20 miles northwest of Watertown, South Dakota. This is a 300- or 400-acre body of clear water, some 35 feet deep near the center. The water of this lake carries from 5 to 15 per cent total salts, depending on the water stage, consisting of about two-thirds magnesium sulfate and one-fourth sodium sulfate, the same salts that were found in the subsoils of western Minnesota where concrete tile had disintegrated.

Following are some of the conclusions that have been reached, based on long-time exposures, a large number of which have exceeded 20 years.

Results That Apply to Concrete Drain Tile

1. Under identical conditions of exposure to soil sulfates, concrete made of a highly resistant Portland cement may last 10, or more, times as long as that made of a cement of low resistance. Therefore, the first consideration for all concretes to be subjected to sulfate action should be the cement itself. Cement of low resistance should be avoided. It has been proved that a sulfate-resisting Portland cement will contain not to exceed 5.5 per cent of the calculated compound tricalcium-aluminate. Cements that meet this requirement will ordinarily have around 4 per cent each of iron oxide and aluminum oxide. Such cements are described as "Type V cement," Standard Specifications of the American Society for Testing Materials. A cement that conforms exactly to Type V requirements is ordinarily stocked only on special and relatively large orders. However, the standard Portland cements manufactured in Iowa, at Davenport and Des Moines, have some of the sulfate-resisting characteristics of Type V. They should therefore be given preference for subsoil construction in the alkali areas when a true sulfate-resistant product cannot be readily obtained and exposure conditions are not too severe.

2. Resistance of concrete products may be markedly increased by curing in water vapor at temperatures of 212° to 350° F. In fact, with enough curing time allowed, the resistance may be brought almost to the point of immunity, 6 hours at 350° giving results equivalent to 8 days at 212°. Resistance is not increased by temperatures under 212°, and no concrete tile plants in Minnesota are equipped to cure their products at the temperatures required.

3. Based on tests of nearly 9,000 cylinders, each 2 by 4 inches, exposed in peat for periods upward to 20 years at six locations and in mineral soil at two locations, it may be said that the degree of peat acidity is a fair indicator of the degree of corrosive action to be expected on concrete. It must be said, though, that practically all concrete specimens so far examined have shown some evidence of deterioration in all the peats where the exposure periods have been around 20 years, and it is doubted that it is good practice to lay any concrete tile of the smaller sizes, as ordinarily made, in the more acid peats. However, if the following recommendations are carefully followed, concrete drain tile should give reasonably satisfactory service when laid in the low acid grass and sedge peats that favorably respond to cultivation in southern Minnesota without much liming. The degree of acidity of such peats when expressed by the hydrogen ion scale will have a *p*H value of 6.0 or more. For such peats, concrete in the walls of the finished pipe should have 28-day compressive strengths upward from 3,500 pounds per square inch. For drain tile of the smaller diameters this will mean a minimum average breaking strength of 1,600 pounds per foot of length and a maximum average absorption under 8 per cent, after boiling 5 hours following oven drying.

4. Finally, make sure to obtain tile of the highest strength that it is feasible to make with any cement and any condition of curing. Strength is a valuable index of the permeability and sulfate and acid resistance of products made of any given cement and by the same manufacturing methods. This is particularly true with rich mixes such as used in really high-quality drain tile.

UNIVERSITY FARM, ST. PAUL 8, MINNESOTA

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