A LABORATORY TEST OF SOME DRAIN TUBE FILTER MATERIALS

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INTRODUCTION

Drainage systems frequently fail in fine sandy soils because of particles entering drain tiles in sufficient quantity to block the drains. Attempts have been made to employ filters outside tiles to allow only soil-free water to enter the system. Filtering materials have included straw, fiberglass sheet, polyester fiber sheet, nylon fiber sheet, coconut fibers and others. Some field experience has shown that the flow of water can decrease over the years through filters, especially in iron-rich soils (2, 6). However, no laboratory tests have been performed to note the effect of months of water-flow through filters, and the relative amounts of sand entry through filters over a long period.

The purpose of this study was to test some commercially available or promising filters for corrugated plastic drain tubes and to assess their effect on water and soil entry into tubes over approximately 2 mo of continuous operation.

PREVIOUS WORK ON COMMERCIAL FILTERS

Experiments by Overholt (5), Nelson (4) and Hore and Tiwari (1) have shown fiberglass filters to be quite effective in short-term observations of tile performance in sandy soils. When placed over and around tiles, these filters reduced the rate of siltation inside the tiles and increased water flow.

Merva (3) examined the relative transmissions of water and sand into plastic drain tubes by a variety of drain tube filtering materials over periods of 6-12 h. These materials included two dacron weaves, fiberglass yarn, orlon-bulky nantuck and hemp baler twine, wrapped into the grooves of a helically corrugated plastic drain tube, as well as a fiberglass mat placed around the outside of the tube.

The results of Merva's study indicated that in a coarse sand most of these filters worked acceptably well, with the baler twine, 18,000 denier dacron, fiberglass mat and orlon being superior with respect to water flow and reduction of sand entry. However, in separate tests on a fine sand, water flow was so slow as to prevent the removal of soil entering the tubes in all cases. Also the permeability of the soil-filter combinations decreased rapidly with time during the series of 6- to 12-h tests that were run on each material. The recommendation was that drainage not be attempted in such a fine sand because of these problems.

CHOICE OF MATERIALS

In this experiment a fine sandy soil, which has been known to be troublesome in existing drainage systems, was used. A good example of such a problem was found in the Lancaster-Bainsville area at the extreme eastern end of Ontario about 50 miles from Montreal, where some 4-inch plastic drain tube and clay tile systems have been completely blocked by fine sand. A grain size analysis of this Bainsville fine sandy loam (Figure 1) showed that it is a uniform fine sand having a 10% effective grain size of 0.06 mm. The Grandby and Colwood soils, marked with a diamond in Figure 1, are from Merva (3) for comparison.

The filter materials chosen were fiberglass weave, polyester weave stocking filters supplied by Daymond Company of Rexdale, Ontario, and jute twine and hemp baler twine wrapped in the helical grooves of Daymond 4-inch (102-mm) corrugated drain tubing. The first two materials are currently available to drain tube users from Daymond Company, as are fiberglass and nylon stocking filters from other manufacturers in Canada and the United States. Twine materials, wrapped in the tube grooves, were potential commercial products in that they would provide a filtered tubing that would be less likely to have the filter damaged during handling and installation than some of the available stocking filters.

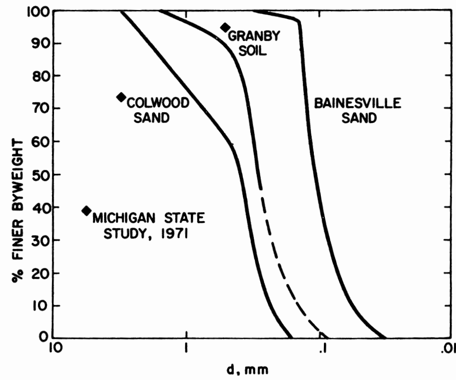

Figure 1. Grain size distributions of test soils.

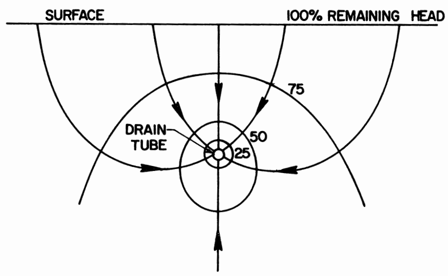

Figure 2. Water flow to drain tube.

EXPERIMENTAL SETUP AND PROCEDURE

Figure 2 shows the theoretical flow of water from a surface-saturated soil to a typical tube position. The last equipotential lines near the tube are nearly circular and the flow lines are nearly radial. Hence, a cylindrical soil volume in the laboratory would represent the conditions of flow near the drain tube. Twenty galvanized 20-gauge steel cylinders 15 inches (38 cm) in diam and 12 inches (30.5 cm) long were fabricated with wooden end-caps, as shown in Figure 3. One end-cap had a hole for the 4-inch (102-mm) diam drain tube to project out of the chamber while the other was solid. A porous fiberglass mat was placed between the compacted soil sample and

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the container wall to allow an equal dynamic water head outside the soil and to cause radial flow lines. Waterproof seals between the wood caps and the drain tube and outside cylinder were made with a bead of silicone sealing compound. Using 20 test chambers, four replicates were established for each of the following five filter treatments: full wrap fiberglass mat, polyester weave stocking, hemp twine wrapped in grooves, jute twine wrapped in grooves and no filter material. Both the hemp and jute twines were initially soaked in a 30% copper-8 quinolinolate preservative solution.

All the chambers were placed upon a long table, and polyethylene funnels, fitted with conically folded milk filters, were placed below the projecting drain tube ends to catch the water and solid matter effluent. A constant water head of 12 inches (30.5 cm) above the drain tube centerlines was applied to the chamber inlet pipes and the system allowed to flow.

Water flow measurements were taken daily for all chambers and solids transmission by the filtered drain tubes was periodically measured by washing the solids resting at the bottom of the drain tubes into the funnels, drying and weighing.

The duration of testing of each set of drain tube filters was continued until a consistent behavior was observed. This length of time varied from 10 d for the jute and hemp twine materials to 60 d for the fiberglass, polyester and no filter combinations.

RESULTS

The tests on treated jute and hemp twine filter materials resulted in nearly complete stoppage of water flow within 7 and 10 d, respectively. The copper quinolinolate solution was suspected of contributing to the blockage since it was seen to flow out of the tubes as a yellow suspension and to form a hard gum on the funnel filters. Thus, these two test series were stopped and reassembled with untreated jute and hemp twine wrapped filters to eliminate the copper quinolinolate.

The average water flows following the beginning of flow tests are shown in Figure 4. While individual test chambers sometimes produced flows differing by considerable amounts from the group average, the trends of rise and fall of flow rates were consistent within groups and the averages are representative of the group performances.

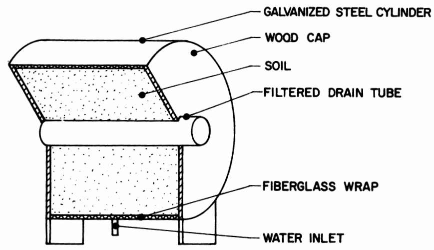

Figure 3. Apparatus for testing filtered drain tubes.

The flow through the fiberglass and polyester stocking filters was even or at increasing rates for the first 20 d of testing, while the flow from the treated hemp and jute wrapped twine filters slowed to almost negligible flows within 10 d. The second tests on untreated hemp and jute twines did not show as rapid a blockage as those treated with preservative. However, they did show flow rates decreasing to very small amounts by 25-30 d of running. The tubes with no filter began with high rates of flow, caused by some piping of water through channels in the soil, but soon exhibited slower flow rates than either stocking filter.

The amounts of soil introduced into the drain tubes during testing are shown in Figure 5. The amounts of sand passing through all the filter materials are very small compared to those collected from the non-filtered tubes. The flow of soil was approximately proportional to the flow of water for unfiltered tubes, and reached rates of over 200 g/h for short periods of time. This result was consistent with problems of actual drain tube blockage observed in this type of soil.

DISCUSSION

From these results, and observations of the tubes after testing, it is believed that the twine and jute filter materials suffered from sand entry between the material fibers and a great reduction in the area of free drainage into the tubes. Water could no longer travel freely around the tube corrugations, but must pass through the plugged materials near the open holes in the tube. Thus a large reduction in the open cross-sectional area was effected and flow rates dropped. To some extent, the same process must occur around the tubes with no filter. Fine sand entered the corrugations to slow water flow into the tube perforations. The fiberglass and polyester stocking filters, stretched over the tube corrugations, give a much larger area for water to enter and flow freely in the grooves to enter the tubes. The results with the fiberglass wrapping and polyester stocking compare favorably with Hore and Tiwari's results

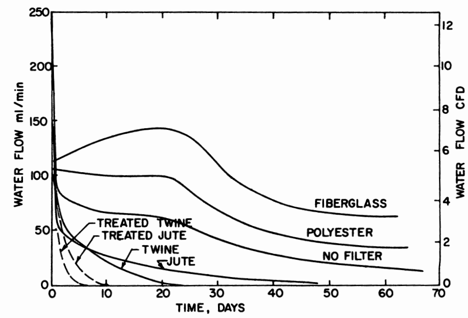

Figure 4. Average water flow measurements with time.

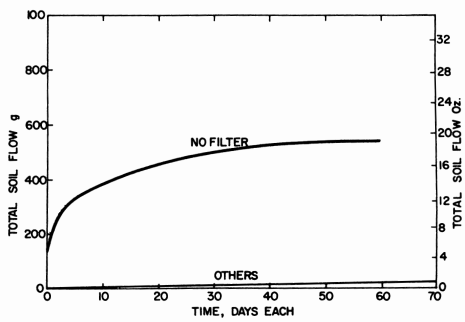

Figure 5. Average soil flow through tubes.

with fiberglass "tile guard" above and below clay tiles, (1).

After 20 d all the tubes began to exhibit slower water flow, accompanied by the appearance of a pungent organic slime in the tubes, indicating probable microbial action near the tube filters. A fine coating probably develops in the filters and soil, gradually reducing the area open to water flow. Also, some reduction in flow rate could be due to small bubbles of air coming out of the water as it passed through the soil in the cylinders and reducing the internal flow area.

Drainage of 50 ml/min from 1 ft (0.30 m) of drain tube is equivalent to a drainage rate of 0.305 inches/d (7.7 mm/d) from a field with lateral drains spaced 100 ft (30.4 m) apart or drainage rate of 0.50 inches/d (12.7 mm/d) from lateral drains spaced 60 ft (18.2 m) apart. A filter at least as good as the polyester filter appears to be required for the soil tested. Some fine sandy soils have low hydraulic conductivities that restrict flow to drains regardless of the filter used, and for such soils, spacings between drain laterals may need to be less than 60 ft (18.2 m) to achieve an adequate drainage rate.

CONCLUSIONS

The full-wrap filter materials, fiberglass and polyester weave, provided good filtering of sand flow and consistently high water flow over the 60 d of continuous operation of this study. They gave a much superior performance in this fine sand, which would be classified as difficult to drain. An unfiltered tube would provide a reasonable flow of water, but this would be accompanied by a large entry of soil into the tubes, which would almost certainly block a drainage system. The wrapped hemp twine and jute became too plugged with fine sand to be effective as water conveyors, and could not be recommended in such a soil.

SUMMARY

Laboratory tests were performed to test the suitability of four filter materials for the prevention of soil entry into corrugated plastic drain tubes. Filtered tubes were placed in the centers of cylindrical containers filled with a fine sandy soil, and pressurized water introduced around the outside of the soil. Compared with unfiltered tubes, those with polyester weave stocking filters and fiberglass sheet showed very little soil entry and a good continued water flow over two months. Hemp and jute twine materials wrapped in tube corrugations also prevented sand entry, but plugged up with soil and prevented a reasonable water flow.

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