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Plastic Drains and Their Installation

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PLASTIC materials are now showing notable promise for use in subsurface agricultural drainage, even though the material costs for some types of suitable plastic tubing are higher than for ceramic or concrete tile. This is because recent research has provided knowledge of materials-handling and placement techniques for the rapid installation of flexible plastic drain tubes. The new methods will require a lower unit installation charge, and thus result in a lower total cost for the complete drainage system.

Types of Plastic Drains

Two basic types of plastic drains are being evaluated in current research and development programs: (**a**) formed-in-place drains in mole drain channels and (**b**) preformed smooth or corrugated wall tubing in coilable lengths or in 20- and 30-ft straight lengths that can be pulled into a mole channel or laid in a narrow trench.

This paper is concerned primarily with flexible plastic drain tubes. A flexible drain conduit gains part of its vertical soil load-carrying capacity by lateral support from the soil walls of the mole-drain channel or compacted soil sidefill. This lateral support (passive resistance of the soil) occurs as the drain tube deflects outward (flattens) against the soil at the sides of the tube. The use of flexible-tube principles for designing these drains results in a more efficient use of expensive plastic material than relying completely on bending resistance in the pipe sidewalls, as is done with rigid or thick-walled tubes. In general, the experimental plastic drains in the United States have been 2 to 3 in. in diameter when installed by a mole plow, and 4 in. when installed in a trench.

Plastic Sheeting for Mole Liners

Research in Ohio led to the development of a "zippered" plastic mole-drain liner (3, 4)*. This is thin-walled drain 3 in. in diameter which is formed from a 0.015-in.-thick by 10-in.-wide sheet of polyvinyl chloride (PVC) plastic that has interlocking tabs prestamped along both edges. Fig. 1 shows the special floating-beam mole plow and mole-lining implement developed for installing the zippered plastic lining. The sheet plastic material is fed from the roll, guided into the ground by the special hollow-blade tool, then formed and "zippered" into a circular tube by the installation tool to form a structural liner for the mole-drain channel. During installation of the plastic mole liner, a soil-compaction wedge on the rear of the mole-lining implement (Fig. 1) closes the plow blade slit immediately above the drain. This completely surrounds the plastic mole liner with soil. The replacement and partial compaction of soil surrounding the liner is important so that soil loads are applied uniformly around the flexible drain tube. If the soil is too dry it cannot be recompacted properly above the drain. The structural stability of the zippered liner depends to a large extent on the moisture condition of the soil at the time of installation and on the inherent stability of the soil surrounding the liner.

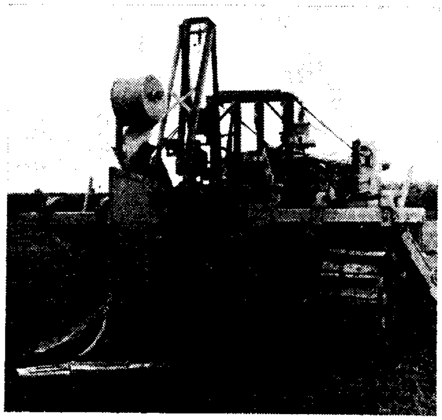

FIG. 1 Floating-beam mole plow with attached mole-lining implement to install zippered plastic lining in the mole drain channel

The normal speed of drain installation with this equipment is about 125 fpm (ground speed) for drain depths of 30 to 33 in. in clay soils. Under these conditions, a track-type tractor capable of developing up to 30,000 lb of drawbar draft is often required to pull the equipment. About 2,000 lineal ft of plastic-lined mole drains can be installed per hour under good field conditions. The use of coiled-sheet plastic as a drainage material, rather than preformed drain-tube sections, greatly reduces the time, labor, and cost for materials handling from the supplier to the field and during installation. The cost of completely installed zipper-lined drains is estimated at 10 to 12¢ per lineal foot, with about 8¢ of this to cover the cost for the plastic-lining material. The greatest cost savings are derived from the method of installation and not from materials.

Similar types of "zippered" plastic, mole-drain liners have been developed in England (1, 2).

During the past five years in the United States, the zippered plastic mole-lining material has been extensively field tested. These experiments have shown that the circular cross-sectional shape of the mole liner gradually deformed; a pointed-on-top and an inward buckling of the upper sidewalls were typical deformations. Two prime factors were believed to have caused this gradual collapse: (**a**) nonuniform closure of the slit opening above the mole liner, which resulted in localized deformed sections in the drain tube, and (**b**) localized "kinks" in the walls of the plastic liner which were caused during installation by apparent changes in drain line direction or gradient. These initially localized deformed places in the drains seemed to propagate in both directions in the drain line, thus causing the gradual collapse of large segments of drain. This progressive channel collapse is indicated in Fig. 2.

These results are from a field test in Ohio and show the percent of total drain length through which 1½ and 2-in. diameter wooden plugs could be pulled for successive years. The data represent a total of 1200 ft of zippered plastic-lined mole drains, and access to the drain was possible once every 200 ft for internal gaging with the wooden plugs. These experimental results show the need for use of stronger wall material in the zipper liner; also longitudinal flexibility of the zippered tube is needed to permit more freedom in going around gradual bends in the drain line, and in making gradient changes. As suggested by Edminster in his paper in this conference the use of shallow ridges or corrugations across the plastic sheet may solve these problems, but it might be added that the plastics industry's help is needed in this refinement.

The field test results in Ohio have also shown that zippered plastic-lined mole drains should be installed at a depth of 30 in. or greater to prevent damage by deep plowing when the subsoil moisture content is high. In general, more deformations of the mole liner walls occurred during periods of high water-table conditions than dur-

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* Numbers in parentheses refer to the appended references.

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ing normal farm field operations when the soil was drier. This I believe means that loads imposed on the plastic mole liners by saturated soil may be more severe than those imposed by surface traffic above the drain.

Plastic-lined mole drains were as effective as conventional draintile for lowering the water table in the soil. The deformations of the plastic mole liners over the 5-year test period did not appreciably affect their functioning as a subsurface drain channel. However, the structural stability of the zippered plastic mole liners, as presently designed, leaves much to be desired.

Preformed Flexible Plastic Tubing

Smooth-wall tubing — Although smooth-walled plastic tubing is generally considered expensive, there are certain applications where it can be used effectively and yet remain competitive with conventional drainage materials. This plastic tubing is generally best handled in either large diameter coils or in straight lengths of 20 to 30 ft each. Since this material does not have good characteristics for coiling or for feeding around sharp corners, its major drawback is handling during the installation operation. If the smooth-walled tubing is to be installed by the mole plow method, the most satisfactory procedure is to pull it into the mole channel behind the plow from the outlet end of the drain. Actually, this technique of installation was used by Schwab (6) in the 1940s; this early research was the first of many plastic drainage approaches which have followed. This method of installation is probably limited to maximum drain lengths of 400 to 600 ft in most soils.

If the tubing is installed in a trench, the bottom of the trench should be shaped into a semicircular cradle to support the walls of the flexible plastic tube. Research has been conducted in Texas to properly install such a tube by a modified trenching machine. The machine digs a narrow trench so that the installation operation can be speeded up. By connecting 30-ft lengths into a continuous tube, the installation can be accomplished with fewer crewmen. The high rate of installation with less labor reduces the total cost even though the plastic tube itself is generally more expensive than the same diameter conventional draintile. This method of drainage with suitable plastic material has been well accepted by various groups and agencies in the lower Texas area, and is now a certified practice which qualifies it for cost-sharing between the farmer and the government.

The kind of plastic used for the smooth-walled tubing is quite important. The material should have good creep resistance so that the tube will not gradually sag (or deflect) under soil loading. For example, low-density polyethylene plastic generally does not possess good creep resistance; PVC and high-density polyethylene are much better in this regard. From a cost standpoint, for the smooth-walled tubing, the wall thickness should be as thin as possible to obtain the required soil-loading capacity so that the cost is held to a minimum.

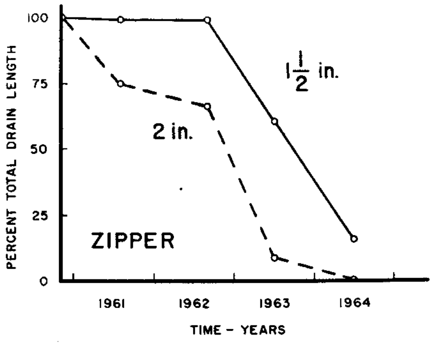

FIG. 2 Percent of zippered plastic-lined mole drain length through which 1½ and 2-in. diameter wooden gage plugs would pass in successive years (northern Ohio)

Corrugated-wall tubing — When compared to smooth-walled plastic pipe, a corrugated tube-wall provides equal crushing strength with much less plastic material per unit of tube length. Since the cost of plastic tubing is almost directly related to the amount of material used, the corrugated tube would be considerably lower in cost. The corrugated plastic tubing can also be coiled for shipment and handling on smaller diameter spools than smooth-walled pipe without kinking problems. The corrugated tubing can be installed with either a trencher or a mole plow, but the mole-plow method of installation seems most promising because of its faster field operation. Since the corrugated tubing can be easily fed around sharp curves, it can be installed with a hollow-bladed tool pulled directly behind the mole plow (Fig. 3). Such an installation tool guides the tubing through a sharp curve to insert it in the mole drain channel. The blade of the tool must be slightly thicker than the tube diameter, which may limit maximum drain size with this method to less than 4 in. It has been demonstrated in field trials that the soil erupted by the passage of such a thick blade during installation of corrugated plastic pipe can be adequately recompacted with two passes of a crawler-tractor track, one pass on each side of the soil slit.

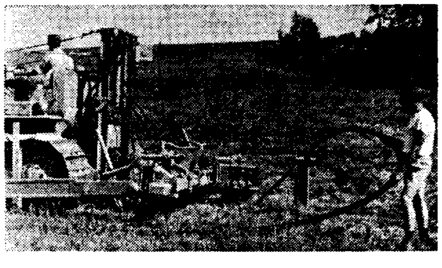

FIG. 3 Corrugated plastic drain tubing being installed with hollow-bladed tool drawn behind a mole plow. This material could be fed from a coil mounted on the equipment

If the corrugated plastic pipe is fed from a coil mounted on the tractor, the installation of this material is even easier and faster than that of the zippered plastic mole liner. Also, a valuable feature is that either perforated or nonperforated corrugated plastic tubing can be installed — the zippered plastic mole liner material requires perforations and slits to provide flexibility during installation. More than one diameter size of corrugated plastic tubing can be installed with the hollow-bladed tool (Fig. 3), but with the zippered tube only one diameter size can be used in any given tool. These are practical considerations that have been taken into account when evaluating the various drainage methods and materials.

The speed of installation is not governed by materials handling for the corrugated tubing, but rather by the maximum machine speed for which adequate depth and grade control can be maintained. This latter item will be discussed below in more detail.

Foamed-Plastic Drain Tube

Preliminary research results have shown considerable promise for foamed polystyrene plastic material for use as plastic mole liner or plastic drain tube. In a recent patent disclosure by Dow Chemical Co.†, a possible method was illustrated for installing a foamed-plastic mole liner by in-place extrusion within the mole drain channel directly behind a mole plow. This idea would conceivably involve pumping a heated polystyrene plastic "gel" down a tube and through an extruder die mounted behind a mole plow. Within the mole channel, the "quick-setting" plastic would expand (foam) into a finished drain tube, and then it would be perforated for water entry by some device behind the extruder die. It is reasonable to expect that this method of installation would be possible in today's technological world; however, specialized equipment needing very precise operation and control would be required. For the present, more practical promise is offered for a preformed foamed-plastic drain tube installed in a trench.

If the foamed-plastic drain tubing is preformed (manufactured), it offers several advantages. For example, it is lightweight and the material cost would

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† Company names are included for the benefit of readers and do not imply product endorsement by the USDA.

be considerably less than for other plastic-drain materials discussed in this paper and even less than the cost for conventional tile. A 10-ft section of 4-in.-diameter tube with ½-in. wall thickness, made from standard density expanded polystyrene, would weigh only about 3 lb. Sections of the tube 10 to 15 ft long would be rigid but could be carried on the ditching machine and placed in the trench mechanically or by hand. For such trench-laid foamed-plastic drains, the backfilling operation would have to be performed with care to prevent damaging the drain tube.

Since this foamed-plastic drain is made of relatively low-strength material, special attention must be given in its installation to insure a structurally successful drain. The bottom of the trench should be shaped to provide a semicircular cradle of support for the flexible drain tube as was discussed for the smooth-walled plastic pipe. The density of the foamed plastic material in the tube wall is also important in determining the amount of deflection the drain can undergo without rupture of its walls. If the plastic density is too high, the foamed plastic tube will be brittle and only a slight tube deflection can cause the wall to rupture.

Drainage Equipment Innovations

With new drainage materials coming into the picture, new and modernized methods of installation are also essential to provide for a faster installation at a lower cost. The use of the mole plow for installing several types of plastic drain tubes is showing very impressive advantages in drainage equipment innovations. A mole plow which can be operated with a floating-beam principle and/or constant depth operation using depth gage wheels provides the versatility to meet a variety of field conditions. The mole-plow method of installing plastic drain tubes has been satisfactory even under such adverse field conditions as 20-percent sideslopes with large sandstone rocks beneath the soil surface. Such conditions of excessive slope and rocks in the soil make the use of conventional tile-trenching machines impractical. When numerous rocks are present, a preliminary pass of the mole plow is made to break or move the rock. The plastic drain is installed during the second pass of the machine.

At the high ground speeds possible with the plastic mole-lining equipment, grading by manual control is not adequate. An automatic depth- and grade-control system is needed for the drainage method to be put into practical use. A grading system is needed that will greatly reduce or even eliminate the required multitude of grade targets or string references characteristic of most grading systems presently used. If such grading references were needed, it could take up to three teams of three men each to set grade string (or wire) references fast enough to keep ahead of the plastic mole-lining equipment.

One system of automatic grading that has been tested on a floating-beam mole plow and a wheel trenching machine was based on a fluid-damped pendulum (5). The pendulum device was mounted on the mole plow beam (Fig. 1) or trencher frame to detect changes in its slope. It operated similarly to an automatic leveling system in that it maintained the plow or trencher beam at a nearly constant slope (parallel to the desired drain gradient) regardless of the ground-surface irregularities the tractor or machine passed over. This grading device functioned quite well on the slow-moving trenching machine under a variety of field operating conditions. The use of the pendulum automatic system on the high-speed mole plow gave better drain grades than those accomplished by manual control; however, it was not dependable under many field conditions. Since the pendulum was an on-machine referencing device, its dynamic stability and its tendency to make accumulative errors were its major limitations. Research is continuing in the United States to develop a grading system based on an off-machine referencing device. An example of such a device is a narrow light beam projected across the field and detected by an instrument mounted on the plow beam. In this system the grading reference (the beam of light) would not be subjected to machine vibrations and motions, as with the pendulum device. A gas laser light beam, which has received much publicity lately, may be applicable in this system. A light-beam grading system has already been successfully developed and tested in England, and in another paper during this conference Dr. Ede discusses its features. It is well to point out that automatic grading on any drainage machine is not merely accomplished by hooking up some new pendulum or light-beam device. The hydraulic depth-control mechanism, its speed of response and sensitivity, and other factors must be considered in the design of the grading system for the drainage machine. Conceivably many present-day trenching machines would require alterations in their hydraulic-control components before acceptable automatic grade control could be achieved, regardless of the grade-referencing device.

Comments

These new materials and methods for subsurface drainage offer but a sample of the developments possible under intensive research and development programs. Structural stability of the plastic drains is the prime concern —most of the plastic materials under consideration are inert to microorganisms and chemicals found in the soil.

For the small-diameter plastic drains, grade control is probably more important than hydraulic capacity. This is particularly true in areas requiring intensive drainage when close lateral drain spacings are needed; the closer the laterals are spaced, the less water each drain must carry for a given drainage coefficient. In many clay soils, the hydraulic conductivity of the soil rather than the hydraulic capacity of the drain limits outflow of the drain. Most of the experimental plastic drainage materials discussed in this paper would only serve as lateral drains; sizes large enough for mains would not be practical or economically feasible for many of these materials.

In the area of drainage equipment developments, the modified mole plow shows good potential because it can be operated at higher speeds than conventional trenching equipment. If the mole plow method of installation is to receive acceptance for practical use, a foolproof and economical automatic grading system must first be developed for the mole plow. For drain depths greater than 4 ft in very heavy soils, the mole plow method may not be so practical because of excessive draft requirements.

References

1 Boa, W. Developments of a machine for laying plastic drains. Journal of Agri. Eng. Res. 8:(3)221-230, 1963.

2 Ede, A. N. New methods of field drainage. Agriculture 70:(2)82-86, 1963.

3 Fouss, J. L., and Donnan, W. W. Plastic-lined mole drains. **Agricultural Engineering** 43:-(9)512-515, September 1962.

4 Fouss, J. L., and Schwab, G. O. Research on plastic-lined mole drains in the United States. VIth International Congress Agricultural Engineering Proceedings II. (Subj. 1—Sect. 2). 150-158, 1964.

5 Fouss, J. L., Holmes, R. G., and Schwab, G. O. Automatic grade control for subsurface drainage equipment. **Transactions of the ASAE** 7:(2)111-113, 1964.

6 Schwab, G. O. Plastic tubing for subsurface drainage. **Agricultural Engineering** 36:(2)86-89, 92, February 1955.