INTERIM REPORT ON
PREFABRICATED SUBTERRANEAN DRAINS

by

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Project 67-2   JHRC PR 70-28
March 1970

PREFABRICATED SUBTERRANEAN DRAIN

INTRODUCTION: Subterranean drains have been used for many years to remove excess water from the ground, to improve crop growth, reduce pumping, icing and frost heave of highway pavements, stabilize slopes and reduce water pressure against retaining walls. A subterranean drain consists of a filter that allows water to flow freely out of the soil yet prevents movements of the soil grains, and an outlet for the water, commonly a gravity flow pipe.

MINERAL AGGREGATE FILTERS: Drain filters in the past have generally consisted of a carefully selected granular soil, coarse enough to allow the entering water to flow through freely yet fine enough to prevent intrusion of the soil being drained. The requirements of a mineral aggregate filter for the drainage of soils with relatively constant grain size distribution were established by the Vicksburg Waterways Experiment Station in 1941. Briefly stated, it was established that:

1. to prevent erosion of the soil being drained, the filter aggregate pore size must be less than the size of the coarsest 15% of the soil being drained.
2. To ensure free movement of water, the permeability of the filter aggregate must be 20-30 times that of the soil being drained.

Aggregate filters designed and constructed according to the above criteria have proven reliable in homogeneous soils. The filter must be at least 6" thick for ease of placement and stability and a perforated pipe is usually provided to remove water from the filter. The size of the openings in the pipe and their spacing often makes an additional aggregate layer necessary. The function of the additional filter layer, which is coarser than the first, is to allow the water to flow freely to the holes in the pipe but prevent the filter layer from eroding. Typical installations are shown in Fig. (1). Many field failures of drains can be traced to improper placement of the aggregate filter.

Many natural soil deposits do not have a constant grain size distribution but contain numerous lenses or channels of soil coarser than the surrounding soil. To be effective the filter must contain enough fines to prevent erosion of the fine soil and also be sufficiently permeable to allow free flow from the coarser soil. An aggregate filter generally cannot satisfy the requirements in such a case. A compromise design often results in both soil erosion and blocking of the natural drainage channels. A common example of non-homogeneous soil is glacial till which is, on the average, fine grained and impermeable but may contain numerous permeable channels formed over the years by frost and water action. These channels, if allowed to drain freely, will in turn drain the entire deposit increasing the effectiveness of the drainage system, but a different type of filter is required for these soils.

PREFABRICATED DRAINS: A prefabricated drain as shown in Fig. (2) was developed to overcome the disadvantages of conventional drain with aggregate filter by

1. Increasing efficiency in non-homogeneous soils.
2. Reducing placement difficulties.

The fine mesh synthetic fabric covering the flexible core must be chosen carefully. Of the many fabrics tested, a polyester chiffon appears most suitable. This fabric prevents erosion in even fine sand and silt, yet is as permeable as a coarse gravel, allowing free drainage from natural channels.

Consolidation test and direct shear tests on saturated disturbed samples indicated a $C_v = .05\ ft^2/day$ and an effective stress friction angle of 41°. The natural undisturbed soil is slightly cemented and contains numerous small channels parallel to the surface which weep water, below the water table, at a rate of approximately .05 gal/min per square foot of exposed soil in a test pit. The channels are more numerous within 4-5 feet of the surface but are present to at least 6 feet below the surface. The effective horizontal permeability within the upper 4-5 feet is approximately 10^{-4} ft/min or 1000 times more permeable than the matrix or a disturbed sample.

The slope was formed when the side of the drumlin was cut back from a natural angle of 1 on 3.3 (17°) to a 1 on 2 slope to allow placement of a sanitary line and sidewalk. The slope started sloughing during the first wet spell and it had been a continual maintenance problem to keep the walk clear of mud in the spring and ice in the winter.

In July 1969 two lines of prefabricated drains were installed along the slope as shown in plan in (fig. 3). (Fig. 4) shows a typical cross section, and the sequence and method used to place the drains.

In the fall of 1969 heavy rains caused surface erosion and in two areas, marked A and B in Fig. 3, the natural drainage channels were such that water was exiting below the drains during periods of heavy rain causing sloughing below the upper drain. An additional 20 foot section of drain was installed at the south end of area B halfway up the slope and this portion has been stabilized. Sixty more feet of drain will be installed in area B and 20 feet in area A.

Daily measurements of the water flow in the drains have been made since their installation. During and after periods of heavy rain water flowed out of the upper drain at a rate of up to 5 gal/min. This indicates an average permeability of the soil of approximately 3×10^{-4} ft/min.

The slope appears to have been stabilized except in the areas mentioned and an additional line of drain and grass should stabilize these areas.

The total cost of the installation, exclusive of hand labor, provided by the Civil Engineering Department, can be broken down as follows

600 feet of drain installed		
Drain Material		
cloth	-	$ 466
expanded aluminum sheet	-	1136
4" plastic pipe	-	302
		$1904
Equipment time and sand	-	$ 906
		$2810

The installed cost was $4.70/foot.

The upper drain was installed where it would have been nearly impossible to install a conventional trench drain so that cost comparisons are difficult but the prefabricated drains appear competitive with conventional drain systems. Recent experiments indicate that the material cost of the prefabricated drain can be reduced to less than $2.00/ft for a four foot deep section by using different materials. The main drainage core can be provided in almost any height and length for a cost of approximately 30¢/ft^2.

FUTURE WORK: The configuration of the prefabricated drain sections allows placement methods which are not now possible with aggregate filter drains. The narrow cross section of the drains permits the use of trenching machines in light soil and the rapid placement of drain sections allows installation in wet areas where trenches can be kept open for only a short while. Shallow sections can be installed with a plow in a manner similar to that used for pipe. A bulldozer can be used to cut a berm on a side hill for drain installation, and then be used to backfill against the drain with the native soil.

Work is continuing in order to develope the most economical manufacturing and installation methods and more field installations are planned, to allow observation of the performance of the prefabricated drains under all conditions.

CONCLUSIONS: Laboratory and field tests indicate that prefabricated subterranean drains are more easily installed and provide, in many situations, more effective drainage than conventional aggregate filter drains.

ACKNOWLEDGEMENTS: This research was carried out in The University of Connecticut Civil Engineering Deaprtment and has been sponsored by The Joint Highway Research Advisory Council of The University of Connecticut and The Connecticut Department of Transportation, The Connecticut Public Works Department, and The University of Connecticut Physical Plant Department.

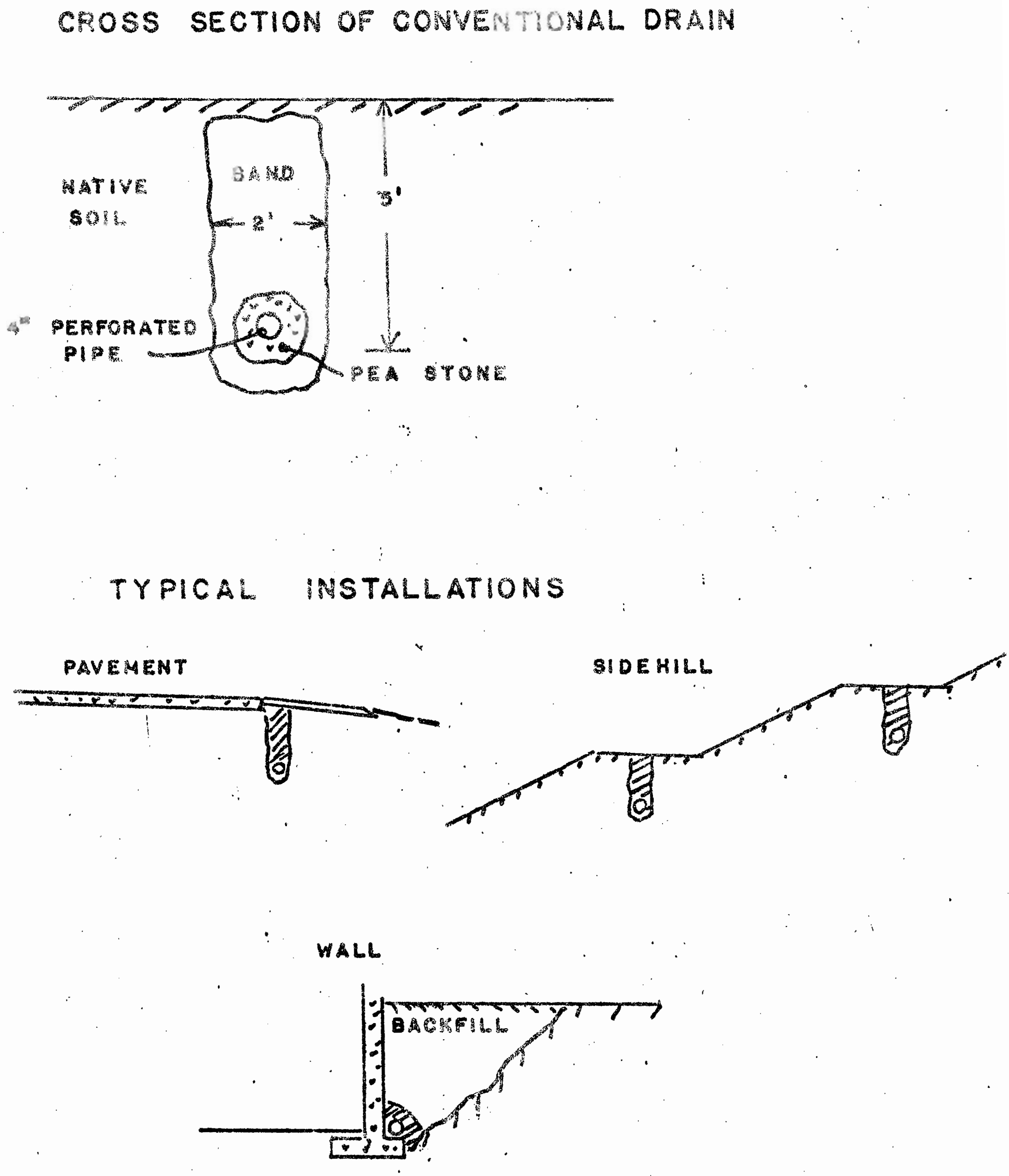
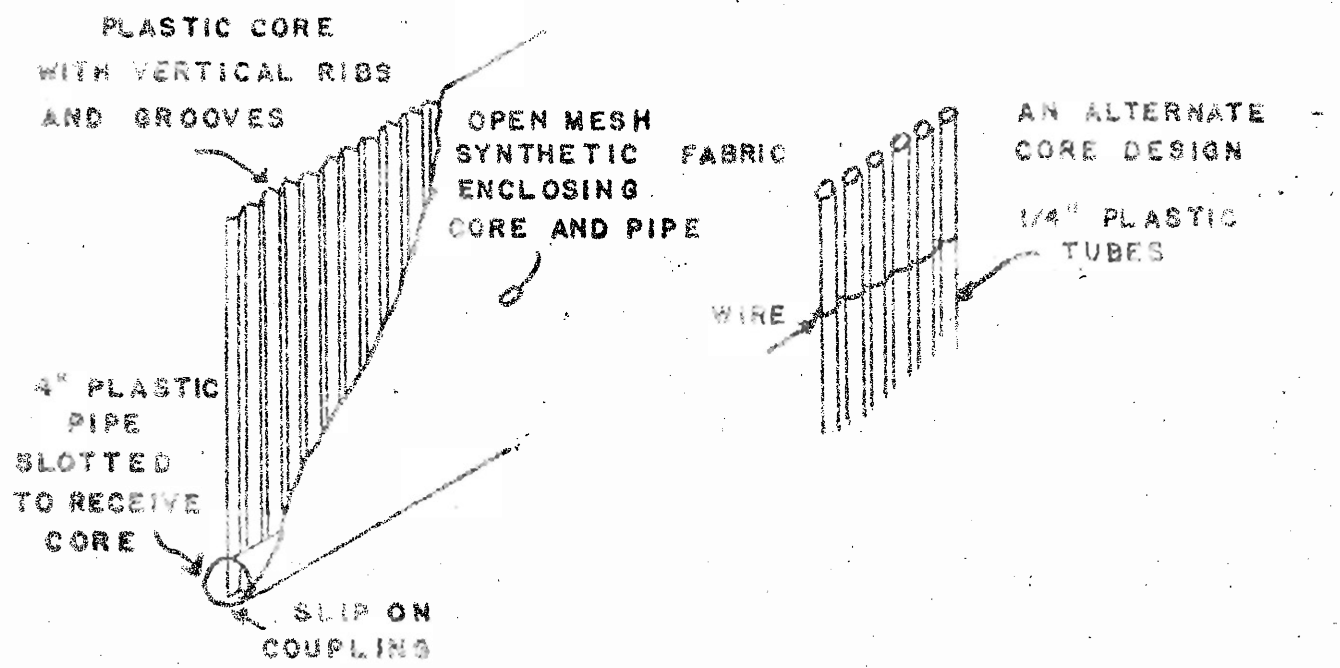


FIG. 1 - CONVENTIONAL DRAIN

CUTAWAY VIEW OF PREFABRICATED DRAIN



TYPICAL INSTALLATIONS

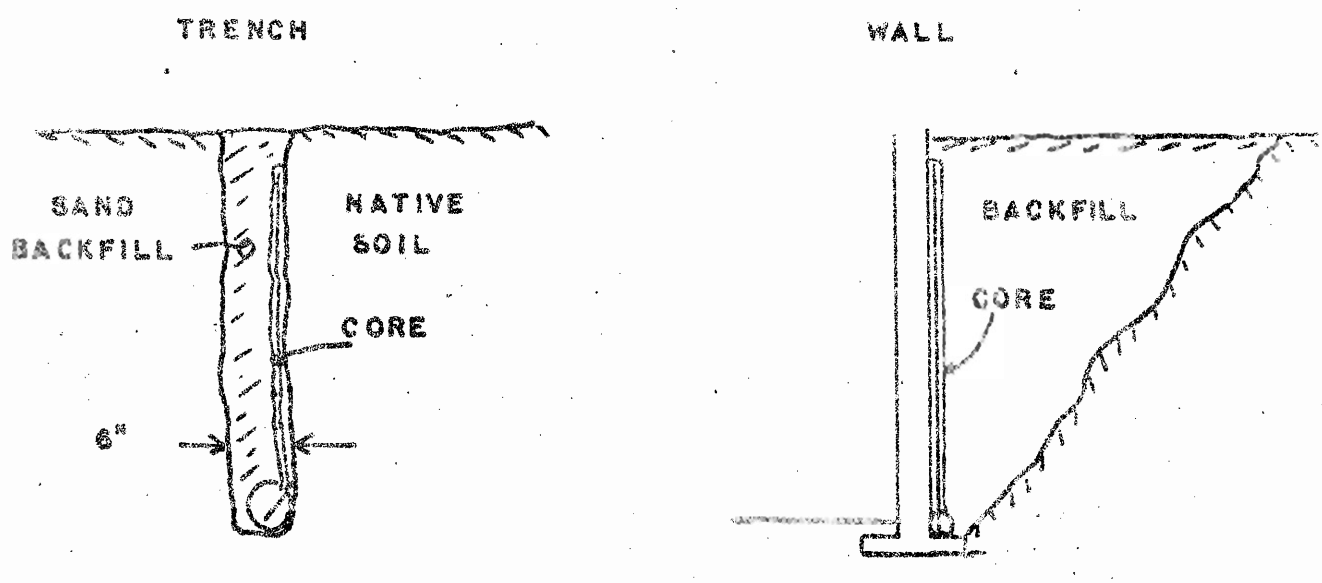


FIG. 2 - PREFABRICATED DRAIN

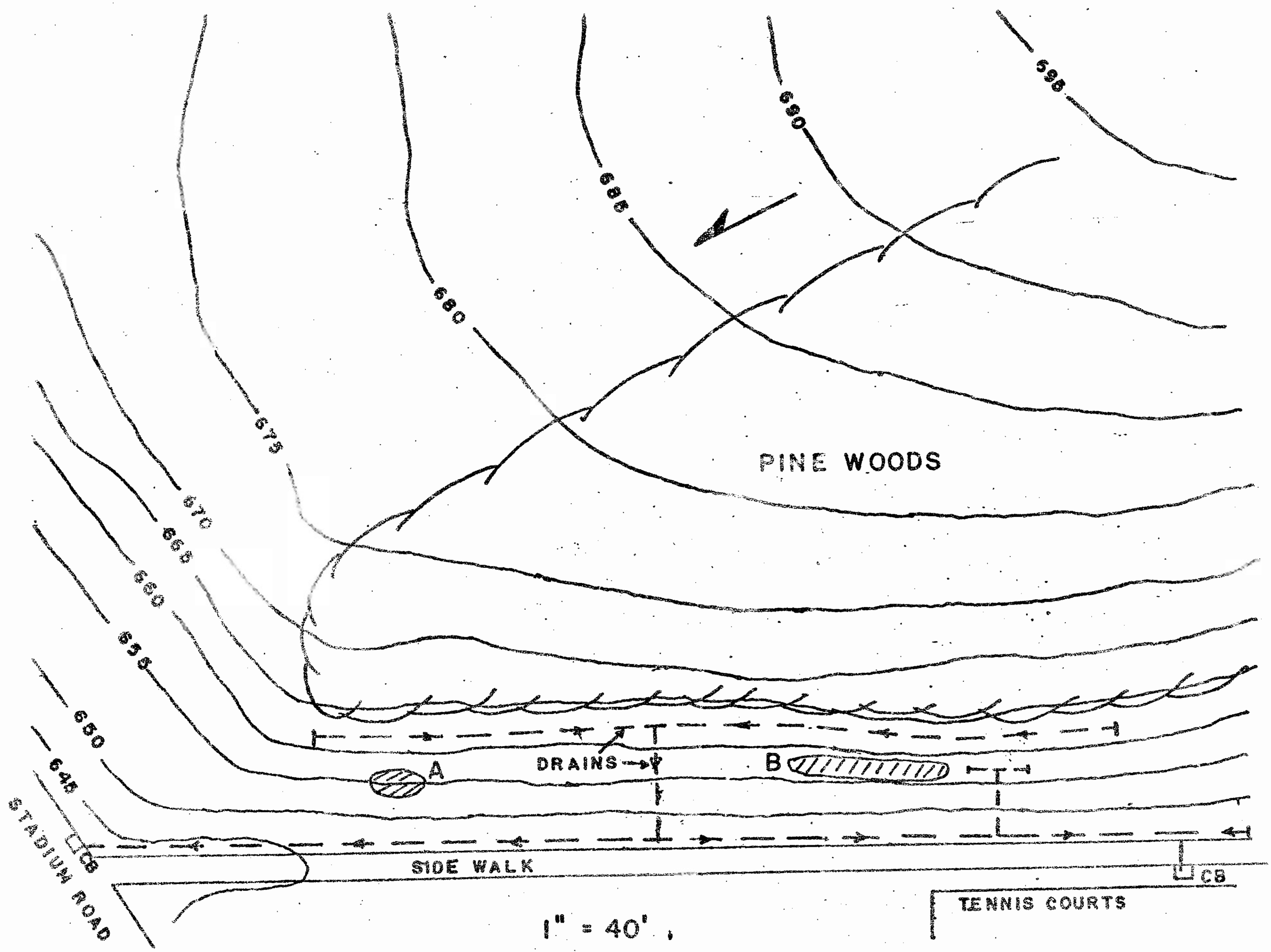


FIG. 3 STADIUM ROAD DRAIN INSTALLATION

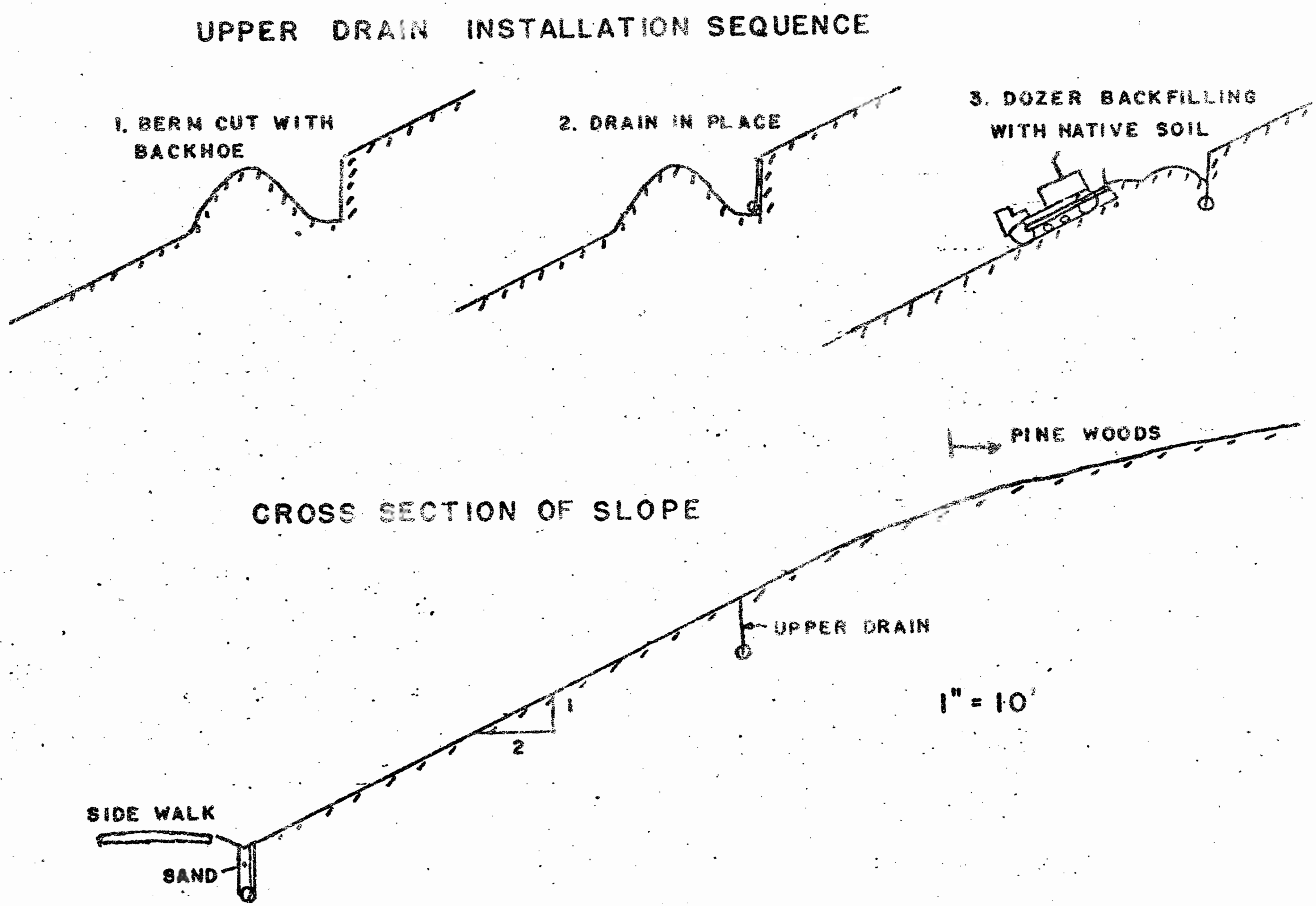


FIG. 4 INSTALLATION OF PREFABRICATED DRAINS