AN EVALUATION OF THE USE OF SYNTHETIC ENVELOPE MATERIALS FOR SUBSURFACE DRAINS IN WESTERN DELTA SOILS

BY

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF

THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

AGRICULTURAL

(SOIL SCIENCE)

DEPARTMENT OF SOILS

FACULTY OF AGRICULTURE

AIN SHAMS UNIVERSITY

1993

APPROVAL SHEET

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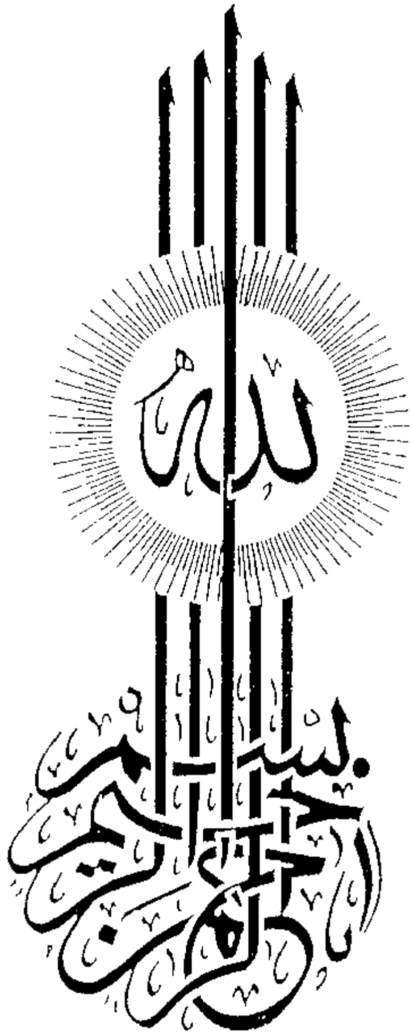
Date of Examination :19/6/1993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Abstract

This study was carried out and continued five years in Harrara pilot area, Western Delta of Egypt to evaluate the use of synthetic envelope materials in tile drainage systems constructed. The obtained results revealed that the sedimentation tendency was low when envelope materials were used. Most of sedimentation inside drain pipes occured just after very short time from constructing tile drainage system and no great variations were found in sedimentation depth after one or five years from installation the drainage system. Soil stability has been improved due to the construction of tile drainage system and the use of envelope materials . The properties of both soil and synthetic envelope

materials showed a high effect on envelope performance and soil stability.

Polyester and Typar as a thin sheet envelope materials showed a high entrance resistance than the other envelopes due to their low hydraulic efficiency . The results of laboratory tests showed that the tested envelope materials were performed satisfactory as found under field conditions .

KEYWORDS:

Tile drainage, envelope materials, polyester, polyproplene, polyachrelic, Typar, socks, Drainage efficiency, Drainage performance, sedimentation, entrance resistance, Western Delta, soil properties, Hydraulic gradient, Hydraulic failure gradient.

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation and gratitude to his promoter prof. Dr. Moneer Abdu Aziz, professor of Soil Science,Fac.,Agric.,Ain Shams University for his conduct, supervision, helpful advices, continous encouragements and constructive criticisms.

Sincere thanks are also extended to prof. Dr. Abdel Ghany El Gendy, Professor of Agricultural Engineering ,Fac.,Agric., Ain Shams University, and to Dr. Mohamed Safwat Abdel Dayem, Director of Drainage Res. Inst.,for their active supervision ,advises and constant guidance , valuable suggestions and splended assistances throughout the completion of this work.

Grateful thanks are also due to Dr. El Tony M.A. and Dr. Galal M.E., Fac. of Agric., Ain Shams University, and Dr.M.B.Abdel Ghany, head of covered drainage division (DRI) for their advices , and providing facilities throughout this work.

Thanks also for all staff members of Drainage Research Institute for their help during carring out this work.

CONTENTS

1. INTRODUCTION

Envelope materials have been used in problem soils of Egypt such as fine sandy,silty soils,and unstable subsoil under high watertable.Gravel envelope material is still the most popular type of envelopes for tile drainage in arid and semi-arid irrigated areas,because it is available at resonable cost as well.If gravel well graded and properly installed,it provides an effective and durable envelope material.The use of gravel remains a diffecult operations resulting in an unequal distribution around drain pipes. Particularly,in Egypt, gravel becomes more and more expensive.
The developement of effective low cost Synthetic envelope materials is a major factor affecting the use of them. Potentially suitable materials should be subject initially to a strict quality control and laboratory testing. Permeameter and sand tanks could be used for this purpose. The results of these tests could be then compared with those obtained from field trials under real operational conditions.

The purpose of this research is to evaluate the performance of some envelope materials used in subsurface drainage systems which constructed in the unstable soils of Western Delta of Egypt.

Harrara Pilot Area, Behira governate,was chosen to test the performance of some envelope materials and to evaluate the envelope mechanical and hydraulic functions. The results of laboratory tests and field trials on the selected envelope materials emphasise the need for these materials and in the meantime, the identification of the most promising envelopes.

2. REVIEW OF LITERATURE

Clogging of drains with sediments is an important problem in the design and maintenance of subsurface drainage systems.The main aim of envelope materials is the protection of drains from soil particle invasion which reduces their water transport capacity.The use of an envelope material depends on availability,cost,and soil properties.

2.1 Effect of soil properties on the performance of envelope materials

2.1.1 Soil physical properties

2.1.1.1 Particle -size distribution.

Olbertz(1965) determined the stability of cohesive soils by the ratio between the percentage of clay particles (< 0.002 mm), and the sum of silt (< 0.02 mm) and clay %. He stated that,if this ratio is less than 0.5, the cohesive soil should be considered unstable.

Trafford et al.(1974) found that the uniformity coefficient and the ratio of clay content to the amount of clay plus silt can be used as criteria to determine the soil silting potential. In the same time, Knops and Zuidema(1976) suggested the limits of 20% to 30% for clay content.

Dieleman and Trafford (1976) mentioned that the real problems in soils are found when the majority of soil particles lie in the range of 50 to 100 um,and siltation problems can be predicted from the values of particle size distribution. They stated that, increasing clay content makes a soil more resistant to particle drift due to cohesive forces of the clay particles. They classified the soils which tend to cause silting in pipes and envelopes by using the parameters of mean particle size,clay content, and uniformity of grading.

Broughton et al.(1977)reported that many installations of perforated drain pipes and clay tiles have demonstrated poor operation in fine sandy soils. Sand particles have been washed through the tube perforations or the tile joints in such quantity which block the drains in several places and resulting in the failure of drainage system .

Knops et al.(1978)reported that soil particles of 0.05 to 0.15 mm diameter which enter the drain pipe and deposit inside it are very difficult to be removed, while particles smaller than 0.05 mm can hardly be kept out by envelopes. Any envelope fine enough would eventually become clogged. Besides, such particles (0.05 mm) are usually remain in suspension and carried away by water flow. Particles larger than 0.15 mm present few problems, because the velocities and hydraulic gradient of the flow in the vicinity of the pipe are insufficient to transport them. They found also that cohesive soils with a clay content of about 25% or more, do not usually demonistrate instability problems. These soils are not particularly sensitive to structural deterioration of the trench backfill as a result of wet laying conditions. Soils with a clay content of 20 to 25% may be subject to temporary instability as a result of wet conditions. Also, Knops et al.(1978)showed that voluminous and thin synthetic materials are suitable for moderatly

fine to coarse sandy soils and loamy sand which did not cause any problems of chemical deposits such as iron, sulphate, calcium carbonate, and manganese or magnesium compounds caused by chemical and bacteriological processes.

Bloemen(1980) proposed to express the particle size distribution of a soil by using a grain size distribution index(f). He mentioned that, the alay content has a large influence on (f) value, i.e., (f) increases with decreasing clay content. Furthermore, (f) increases with a smaller variety of particle sizes (i.e.a lower uniformity coefficient). Thus, the siltation tendency of the soil increases by increasing the values of (f). The effect of mean particle size (D50) (D50 = means that 50 % of soil particles are less than certain diameter, in mm) is introduced by a factor (g) to form a dimensionless siltation index (S) as follows :

$$S = f \ . \ g = f \ . 2^{-(1-0.01 * D_{50})} \qquad (1)$$

The factor (g) is a variable which decreases with increasing deviation of the mean particle size of the soil from 100 um, being the particle size washed out most frequently into the envelope material and pipe. The value of (S), or the siltation tendency increases by decreasing both clay content and uniformity coefficient and when the mean particle size approaches a value of 100 μm.

Lagace and Skaggs(1982) mentioned that envelope materials are needed when clay content is less than 20% and the drain slot width is smaller than two times the D85 diameter of the soil (D85 = means that 85 % of soil particles are less than certain diameter, mm).

Stuyt(1982)concluded that silt and fine sand are, generally, caused problems in the drained soils. On the other hand, the use of particle size distribution only is not sufficient to define the problem soils. Generally, characteristics like D50,D10, and D60 are used. The first is known as the median particle size, the latter two values give an indication of the particle size range of the soil. These values are indicative for the danger of clogging. In the same time, Broadhead et al.(1983) stated that, the ratio W/D60 must not exceed than 2.4.

DRI(1985) recommended, on the basis of field investigations, that most of the soils of Egypt are not need envelope materials for drain pipes, as far as the clay content of the soil equal to or more than 30%, provided a good soil structure. In the same concern, Cavelaars(1987) recommended the value of 30% clay content. However, this percentage does not necessary apply to alkali soils, in which dispersion of clay particles may cause siltation. When alkalinity is found to be a problem in the project area, the safe boundary above which no protection is needed has been raised to 40% of clay. In the areas of clay content lower than 30%, no envelope is needed when a given ratio between the drain slot width (W), and the characteristics size of soil particles (e.g.D85,D60, and D50) is not exceeded. The D85 diameter means that 85% of particles (on weight basis) are smaller than this diameter, and similarly the D60 and D50 are defined.

2.1.1.2 Structure, aggregate stability, and soil moisture content.

Sherard(1953) introduced that soil stability has been expressed in the past by the uniformity coefficient(U),:

$$U = D60/D10 \qquad (1)$$

Where:

D10. mesh width letting through 10% of soil particles by weight (mm).

D60. mesh width letting through 60% of soil particles by weight (mm).

He introduced the measure for aggregate stability by using the concept of plasticity index (Pi) as following :

U	Pi	Soil Stability
< 5	< 6	low
5-15	6-12	medium to high
>15	>12	high

The concept of plasticity index have been defined by Hofstee and Fien(1971) as the difference in moisture content between the upper and lower limits of soil plasticity.

Zaslavsky and Kassiff(1965) reported that the use of thin and coarse envelope materials is effective and economic if the soil contained a large enough particles or aggregates which can form the inverted soil filter with little silting into the drainage pipe. The above finding may be achieved when the soil has stable aggregates such as clay soils with high cohesion.

Ziems(1969) found that the movement of soil particles at