Physical Properties Of Different Egyptian Soils And Need Of Filter Materials For Covered Pipe Drains

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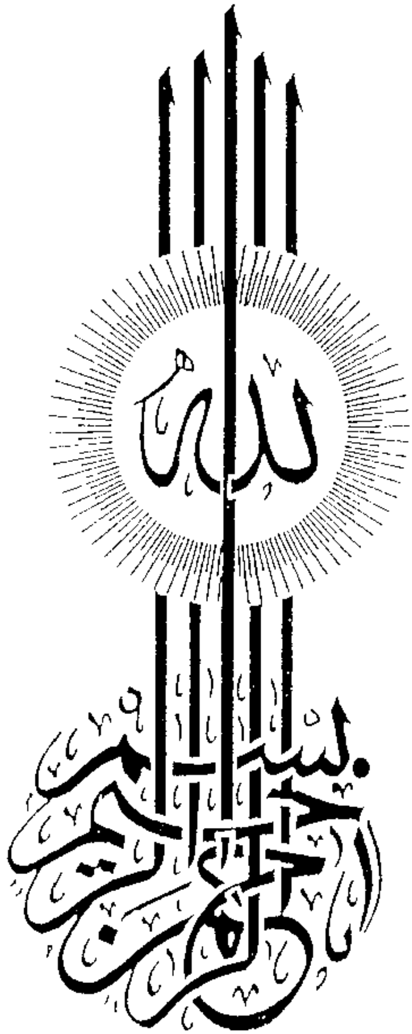
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CONTENTS

(1) To exclude sediments from the drain that may cause clogging

(2) To prevent sealing at drain openings

(3) To increase the rate of water movement into the drain

(4) To serve as a stabilizing foundation for the drain .

The current work was planned to formulate sound criteria for using envelope materials around the subsurface drain pipes in some Egyptian soils. The required criteria should specify first of all soil types which require the use of envelopes whether to act as a filter materials to prevent fine particles from entering into the pipes or to act as hydraulic surround to improve the performance of the drain. The study aims also to find a relationships between different soil physical Properties and the need of envelope materials in different Egyptian soils.

II. Review Of Literature

Mineral envelope materials which used to prevent the enterance of soil materials into the drain and to improve flow properties in the area immediately around the drain include sand, gravel, crushed stone, slag , cinders, and other materials. Probably the most effective envelope is sand - gravel selected from pit - run sources. The functions of envelope materials around subsurface drains are one or more of the following : to prevent soil materials from entring the drains, to improve flow properties in the area immediately around the drain, and, to provide a stable foundation for the drains. Therefore, by filter action, soil sediments are restrained for entring drain pipes. Soil sediment into the drain pipes is very important factors which refer to the need for the envelope materials or not.

Knops (1978) and stuyt (1981) reported that, the functional requirements of a drain envelope are, selective filtering function and hydraulic function. The material should maintain or create a highly permeable layer around the drain, thus improve the rate of water entry into the drain. Also, the envelope must prevent the entry of soil particles that can silt up the tube or block its perforations. When soil particles sedimentate in the envelope; its permeability will decrease drastically within a short period. Therefore, particles that remain suspended even under low flow conditions may enter the drain as they will generally be washed out again. Hence the envelope must filter out soil particles up to a certain size but let pass smaller ones so that, it does not block itself due to the filtering action. Concerning the hydraulic function of the drain envelope, they reported that the envelope must create and maintain a relatively high permeable zone around the drain, which improve the water entry conditions. Whereas, fine structured materials are preferred for the filter function, voluminous coarse-structured materials are preferred for the hydraulic function. Obviously, the requirements are contradictory in their demands on the composition of the envelope.

II.1 FACTORS AFFECTING SEDIMENTATION INSIDE DRAIN PIPES

II.1.1 ENVELOPE THICKNESS :

Kirkham (1949), has shown theoretically that, increasing drain diameter will increase inflow. If the permeable envelope material is considered to be an extension of the pipe diameter, then the larger envelope is better. But there are practical limitations to increase envelope thickness. The perimeter of the envelope through which the flow increases is related to the first power of the envelope diameter, while the thickness of envelope material requires increase the square of the diameter. Doubling the diameter of the envelope and consequently decreasing the inflow velocity at the soil - envelope interface by half, would require "4" times the volume of envelope material.

Recommendation for drain envelope thickness have been made by various agencies. Maierhofer (1965), recommended 10 cm as a minimum thickness around the pipe. The soil conservation service (1971) recommends an 8 cm as a minimum thickness.

Willardson (1974) reported that, the increase in permeability along the pipe that enables water to flow more freely to the cracks or perforations is one of the benefits of envelope placement. This effect is similar to the convertion of the pipe from one with limited openings to one that is completely permeable. This increased permeability can probably be obtained with an envelope of 1.5 cm thick. Increasing the diameter of the envelope reduces the water flow velocity at the soil - envelope interface, thereby decreases the probability of soil particles movement.

Dieleman and Trafford (1976), studied the principles of a filter and stated that filter should have successive layers and the inner one being the most coarse and holding back slightly less coarse particles, which in turn hold back slightly less coarse particles, which in the end hold back the parent material of the soil. Such filters are, however, quite impractical to lay. All practical drain filters work by having a particle size distribution which allowsa graded filter to develope.

II.1. 2. SOIL TEXTURE :

The committe of drainage materials (1967) mentioned that, the use of envelope materials is often restricted to specific areas and soils such as :-

1. Coarse silts and sandy soils : Soil particles of these soils which lack cohesion, but they are sufficiently small to be moved by low velocities of flow. Also,theire instability increases with uniformity.

2. Soils of low hydraulic conductivity.

3. Heavy soils that tend to seal drain joints or perforations.

4. Soils with unstable foundations like fine sands in a "quick" condition.

Dieleman and Trafford (1976) reported that, the first and most obvious question is that, whether or not the soil properties are such that they require a filter to prevent the movement of finer particles into the pipe of tile drainage. To date, there is no universally accepted criterion which defines the requirement of the soil to a filter. However, there are a number of indications which are helpful in making a decision. Soil particles are moved by flowing water at a particular velocity, i.e. the critical velocity at which particles of this size start to move. Gravels require very high water flow velocities, but this velocity becomes less as the particle size becomes smaller. This remains true down to the fine sand particles. However, as soon as there is a significant element of clay in the soil ; the surface active nature of the clay particles and the cohesive forces so generated come into play. Hence increasing percentages of clay make a soil more resistant to the particles movement. They also, examinated many drain pipes with a sediment of sand and reported that, a great deal of sand entered at the time of installation or soon after. This may be deducted from the lower part of the pipe deposit being solid with a structureless mass of sand, wher-eas above this, the material is very finely layered. Dieleman and Trafford (1976) found that, the particle diameters from 50 to 150 um. washed out most frequently by the flowing water. Kellett and Armstrong (1980) studied, the effect of particle size distribution on sedime-ntation into the drain pipes. They mentioned that, the sedimentation into drain pipes is more likely to occur in sandy and silty soils than in clay ones. Coarse textured soils as sandy, loamy sand or Sandy loam accounted for more than 68 % of the cases of high sedimentation, although nationally they represent only 9 % of the drainage work. However, the problem is not restricted to light soils, and a certain amount of sedimentation can be expected in pipes installed in other soils if other conditions permit.

Bloemen (1980) proposed to express the particle size distribution of a soil in a grain size distribution index "E". To obtain "E", the tangent of accumulative distribution curve between each two successive size interval limits is calculated using log scales with the size inte-rval limits "di" on the abscissa and the cumulative weight percentages "P_i" on the ordinate. The slope between any two limits is :

$$\tan i = \frac{\log(P_{i+1}/P_i)}{\log(di+1/di)}$$

Any slope tan i contributes to "E" proportionally to the corresponding weight percentage Ei.

$$Ei = (P_{i+1} - P_i) \tan i \qquad i = 2,3,\ldots.$$

The grain size distribution index E is the mean value of Ei hence

$$E = \frac{\sum_{i=2}^{n} Ei}{\sum_{i=2}^{n} (P_{i+1} - P_i)}$$

The clay content of the soil has a large influence on the values of E, i.e., the value of E increases with decreasing clay content. Furthermore, E increases with a smaller variety of particle size (i.e., a lower uniformity coefficient). Thus , the siltation tendency of a soil increases as the values of E increase. The effect of the mean particle size D_{50} is introduced by a factor g to from a dimensionless siltation index S :

$$S = E.g = E.2^{[1.0-0.01\ D_{50}]}$$

Where, g is a variable value which decreases with increasing the deviation of mean particle size of the soil from 100 um. This value represents the particle size which washed out most frequently into the envelope and pipe. Thus, the value of S, i.e., the siltation tendency, increases if :

a) The clay content decreases ;

b) The uniformity coefficient decreases, and

c) The mean particle size approaches a value of 100 um.

Le Grice and Armstrong (1981) studied the effect of soil texture on the sedimentation amounts. They mentioned a relationship between the amount of sediments and texture for hand texured samples separated from analysed samples. He stated also with very few exceptions, that the texture of the sediments is identical to the subsoil adjacent to the pipe.

Stuyt (1982) mentioned that, soils tending to cause silting of pipes and envelopes are usually classified by three parameters : mean particle size, clay content, and uniformity of grading. Increasing clay content makes a soil more resistant to particle drift due to the cohesive forces of the clay particles. Siltation tendency is correlated with the uniformity coefficient ; i.e, $U = \frac{D_{60}}{D_{10}}$ where : D_{60} and D_{10} are the particles at which 60 % and 10 % by weight passes through a sieve, respectively. In order to find the siltation tendency of a soil from its texture, the parameter of soil texture and the siltation index S, and the soil particle size distribution should be determined.

II.1.3. SOIL STRUCTURE :

Stuyt (1982) stated that, envelope researches must include soil structure. In this respect, the role of porosity as a conductive and storage net work is essential. Soil particle, accumulation in trenches, envelopes and pipes can be explained at least partly by the porous system and its development in time and space. Immediately after installation, a backfill macropore system safeguards favourable flow conditions near the pipes and causes, the primary siltation. Primary siltation is enhanced by either extremely dry, or excessively wet backfill material. He added also that, subsequent siltation is determined by changes of the pore system in time and space. As soon as, the macropore system in the trench is changed due to consolidation ; the probability of secondary siltation is low. Although the trench macropore system tends to disappear with time, the local piping near the pipes might occur due to the development of steep gradients. If the initial structural porosity of the backfill remains or re-establishes, it may provoke vertical fissures linked with the upper soil layers. The distruction of the soil structure, or the erosion of the upper soil layer by heavy rains cause a severe risk of permanent silting-up. Sole (1979) emphasizes the importance of non-saturated downward flow in the trench which is partly responsible for envelope and pipe clogging.

II.1.4. Uniformity Of Grading (U) :

Dieleman and Trafford (1976) reported that, the uniformity of grading has a marked effect on the silting tendency. The uniformity of grading "U" is represented by :

$$U = \frac{d_{60}}{d_{10}}$$

Where ; d60 is a particle size at which 60 % passes through a seive and d10 is a particle size at which 10 % passes through sieve.

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They classified the influence of the uniformity of grading on the silting tendency, as follows :-

$U \geqslant 15$	no tendency to silting
$U = 5 - 15$	Limited tendency to silting
$U \leqslant 5$	high tendency to silting

On the other hand, Feichtinger and Leder (1978) found that, the uniformity grading $U > 5$ is set as a limit to prevent sedimentation , while $U \leqslant 5$ indicates a strong tendency to the formation of deposits.

Stuyt (1982) mentioned that, siltation tendency is correlated with the uniformity coefficient, i.e, $U = \frac{D_{60}}{D_{10}}$ and he classified the influence of the uniformity coefficient on the silting tendency, as follows :-

$U < 5$	high siltation tendency
$U = 5 - 15$	medium siltation tendency
$U > 15$	low siltation tendency

II.1.5. THE CLAY/SILT RATIO :

Dieleman and Trafford (1976) found that, if the clay/silt ratio exceeds 0.5, silting is unlikely to be a problem. While, Feichtinger and Leder (1978) reported another limit indicating a strong tendency for the sedimentation of deposits from a clay (T)/Silt (Z) ratio of $\leqslant 0.5$. For this purpose the limit diameter between silt and sand (d) was 0.063 mm. By moving this limit 0.02 mm, the T/Z - values would grow, thus showing a better correspondence with the results of other rules.

1.6. THE PLASTICITY INDEX (P.I) :

Plasticity of the soil is represented by the amount of water which must be added to change a soil from its plastic limit to its liquid limit (Lambe 1951). The soil plasticity is measured by the "plasticity index".

Plasticity Index = Liquid limit - plastic limit .

Where : The liquid limit is the water content at which the soil has such a small shear strength (this strength is a definite value) that it flows to close a groove of standard width when jarred in a specified manner. The plastic limit is the water content at which the soil begins to crumble when rolled into threads of specified size.

Nelson (1960) ; studied the forces causing particle movement and he mentioned that, the influence of plasticity index is indicated by :

Greatest piping resistance	P.I. > 15
Intermediate piping resistance	6 < P.I. < 15
Least piping resistance	P.I. < 6

On the other hand, Dieleman and Trafford, (1976) Found that, the critical limits for the relation between the plasticity index (P.I.) and silting