Drainage
FACTSHEET

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DRAIN FILTERS AND ENVELOPES

INTRODUCTION

Drain envelopes and filters are two different techniques used to solve different problems. Drain envelopes are permeable materials, such as gravel place around the drains for the purposes of improving flow conditions. Filters for drains are permeable materials, such as geotextiles, placed around the drains for the purpose of preventing fine-grained materials in the surrounding soil from being carried into the drain by groundwater. Table 1 can be used to initially estimate the requirements for further investigation on filters or envelopes.

Table 1 DRAIN FILTER AND ENVELOPE RECOMMENDATIONS

Soil Texture	Envelope or Filter Recommendations	Degree of Urgency
Gravel	None	
Gravelly Coarse Sand	None	
Very Coarse Sand	None	
Gravelly Fine Sand	Filter	Moderate
Medium Sand	Filter	High
Fine Sand	Filter	Very High
Loamy Sand	Filter	High
Sandy Loam	Filter	Moderate
Loam	Filter	Low
Silt	Filter	Moderate
Silty Clay Loam	None	
Sandy Clay	None	
Silty Clay	Envelope	Moderate
Clay	Envelope	Moderate
Peat	None	

FILTERS

Filters can be either geotextile or well graded gravel and sand.

Filters are necessary only where there is something in the soil that needs to be filtered out, namely fine sand. If sand is not present, filters are not necessary. Not only do filters add to the cost of drainage but they also constitute an additional barrier to inflow of water and can, therefore, reduce the effectiveness of the drain. Few soils present the danger of sand particles clogging the drainage system.

Most soils contain sufficient amounts of clay or organic matter to form relatively stable aggregates of individual soil particles. Filters in these soils are of no benefit and may of reduce drain performance. Instead of filters, a porous envelope is appropriate to ensure good flow conditions at all times at the interface between drain and soil. Drain rock, pea gravel and similar materials meet these requirements and are used extensively in some drainage applications.

The first step in the design of a proper filter system, either geotextile or sand and gravel, is to perform a particle size analysis of the soil at the drain depth in the field. Using these results and Table 2, the need for a filter can be determined. Usually soils with more than 30% clay content do not require a filter.

GEOTEXTILE

Geotextile filters have been available since the mid 70’s. Corrugated plastic drainage tubing is available with factory pre-wrapped synthetic filter materials. The filter materials are applied to the drain by the drain manufacturer and are installed in the same manner as a filterless pipe, albeit at an additional cost.

Since most groundwater enters the drain from below, there is great advantage to a completely wrapped pipe, especially in soils with poor cohesion.

Suitable filters may be used to restrict fine particles of silt and sand from entering the drains. A properly designed filter stabilizes the soil around the drain and allows free entry of water. There are two basic types of geotextile filters, knitted and non-woven.

Knitted geotextiles are usually made of polyester or polypropylene filaments that are knitted or woven together. The most common type has a thickness of 1 mm, a weight of 150 g/m^2 and an Apparent Opening Size (AOS) of 300 microns. For applications requiring more filtration capacity, a sock knitted with velour or pile on one side, that is thicker ($\leq$ 2 mm), heavier (250 g/m^2) and has an AOS of about 100 microns is available.

Non-woven geotextiles are made from several layers of randomly distributed fibres that are rolled pressed and usually interconnected by needle punching. Research has shown that fabrics that are about 2 mm thick are very good for silty soils.

The following equation can be used as a general guide for designing a geotextile filter.

$$\frac{O_{95}\text{ Fabric}}{D_{85}\text{ Soil}} \leq 2.5 \qquad \textbf{(EQ 1)}$$

where O_{95} is the apparent opening size (AOS) of the geotextile filter
D_{85} is the size of which 85% of the particles are finer.

Table 2 FILTER RECOMMENDATIONS

Clay %	D_{85} of Soil	Recommended Filter
Less than 30%	$D_{85} \geq 400$ µm	- Any type in which AOS* $\leq$ 800 µm - Pin hole pipe (opening $\leq$ 800 µm)
	$400 \geq D_{85} \geq 120$ µm	- Woven or non-woven 25 $\leq$ AOS $\leq$ 350 µm
	$120 \geq D_{85} \geq 2$ µm	- Minimum thickness 1.9 mm - Pile or velour surface (density $\geq$ 140 g/m^2) - 25 $\leq$ AOS 200 $\leq$ µm or - Non woven when AOS $\leq$ 3 times D_{85} of the soil
More than 30%		No filter needed (may need envelope)

* AOS, EOA and O_{95} are equivalent terms often used in manufacturers specifications

Gravel and Sand Filters

In arid areas **sand and gravel** filters are used to some extent instead of geotextile filters. Drains usually run deeper and the sand and gravel filters also act as an envelope to improve bedding and permeability characteristics. Filter materials should be well graded. If more than one gradation is used, the layers should be from coarsest to finest material, starting at the pipe.

A minimum thickness of 100 mm is recommended for each layer of the filter.

Limits for the filter material should be established using the following equations:

$$\frac{D_{50}\text{ Filter}}{D_{50}\text{ Base}} = 12 \text{ to } 58 \qquad \textbf{(EQ 2)}$$

$$\frac{D_{15}\text{ Filter}}{D_{15}\text{ Base}} = 12 \text{ to } 40 \qquad \textbf{(EQ 3)}$$

From these equations, D_{50} (the size of which 50% of particles are passing through the screen) of the base material times 12 and 58 will yield the lower limit and upper limit for D_{50} filter. Provided the filter has no more than 5% finer than 0.074 mm and is relatively well graded. The chosen filter material should be checked against the following equation for stability.

$$\frac{D_{15}\text{ Filter}}{D_{85}\text{ Base}} \leq 5 \qquad \textbf{(EQ 4)}$$

The D_{85} size of the filter material with respect to the opening of the drainpipe should be verified using the following equation:

$$\frac{D_{85}\text{ Filter}}{\text{Maximum drain pipe opening}} \geq 2 \qquad \textbf{(EQ 5)}$$

It is crucial for filters that the material be well graded. A filter material is considered well graded when all particle sizes from the largest to the smallest are present in a balanced way. Once particle size tests are done, it is simple to verify how well graded the material is. The coefficient of uniformity can be calculated using.

$$C_u = \frac{D_{60}\text{ Filter}}{D_{10}\text{ Filter}} \qquad \textbf{(EQ 6)}$$

where C_u = Coefficient of uniformity

$$C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})} \qquad \textbf{(EQ 7)}$$

where C_c is the coefficient of curvature

Equations 4 and 5, in conjunction with Table 3, should be used to verify the material is well graded.

Table 3 Requirements for "Well Graded" Filter Material	
Maximum Size of Aggregates	**38 mm**
D_{90}	$\leq$ 19 mm
D_{10}	$\geq$ 0.25 mm
C_u	Sand $C_u > 4$ Gravel $C_u > 6$
C_c	$1 \leq C_u \leq 3$

GRAVEL ENVELOPES

The basic functions of a drain envelope is to improve permeability in the zone surrounding the drain. For this reason, the envelope material should have a hydraulic conductivity 7 times higher than the base material. Since envelopes are not designed for their filtration capacity, they do not need to be well graded.

The thickness should be the same as the sand and gravel filter (i.e. 100 mm around the pipe). All the envelope material should be smaller than 38 mm, $D_{90} \leq 19$ mm and the $D_{10} \geq 0.250$ mm.

WOOD WASTES

In past years, drains were installed with a covering layer of organic material such as hog fuel, wood chips, sawdust and straw. The long-term effectiveness of these envelope filters are doubtful. **The use of wood waste materials such as hog fuel, chips and sawdust are not recommended due to environmental contaminants from leachates produced by them.**

See the BC Agricultural Drainage Manual for more information on filter design and soil sampling.

EXAMPLE: Filter Material

A local drainage contractor wants to find a local source for a material to use as a filter for a drainage project.

1. The first step is to sample the soil at drain depth on the project site and determine the base material. This establishes the base material characteristic curve.
2. The next step is to sample the potential materials from different local pits. Particle size analysis of the pit material is sometimes available from the pit owner.
3. The lower and upper limit for the filter material is calculated from results of the particle size analysis of the base materials.

   D_{85} = 0.07 mm
   D_{50} = 0.025 mm
   D_{15} = 0.006 mm

From EQ 2

D_{50} (Filter) $\geq$ 12 (0.025) Lower Limit
D_{50} (Filter) $\leq$ 58 (0.025) Upper Limit
$0.3 \leq D_{50}$ (Filter) ≤ 1.45

From EQ 3

D_{15} (Filter) $\geq$ 12 (0.006)
D_{15} (Filter) $\leq$ 40 (0.006)
$0.072\ D_{15} \leq$ (Filter) ≤ 0.24

4. Once both limits are calculated, the results from the particle size analysis of the three local pits are overlaid to determine the best filter material.
5. From the following figure, it is apparent that the material from Pit #2 is the best suited for a filter material. If more than one layer is required the first layer then becomes the base material and the process is repeated.

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