WORK INSTRUCTIONS FOR ENGINEERS

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OP-019. FILTER DESIGN

19.0 FILTER DESIGN

19.1. INTRODUCTION

Filter is designed to permit free discharge of seepage water (permeability criterion) but to prevent the movement of fines of the adjacent base material (stability criterion).

19.2. FILTER TYPE

The following types of filter can be used:

- Granular filter – well-graded soil material
- Geotextile filter

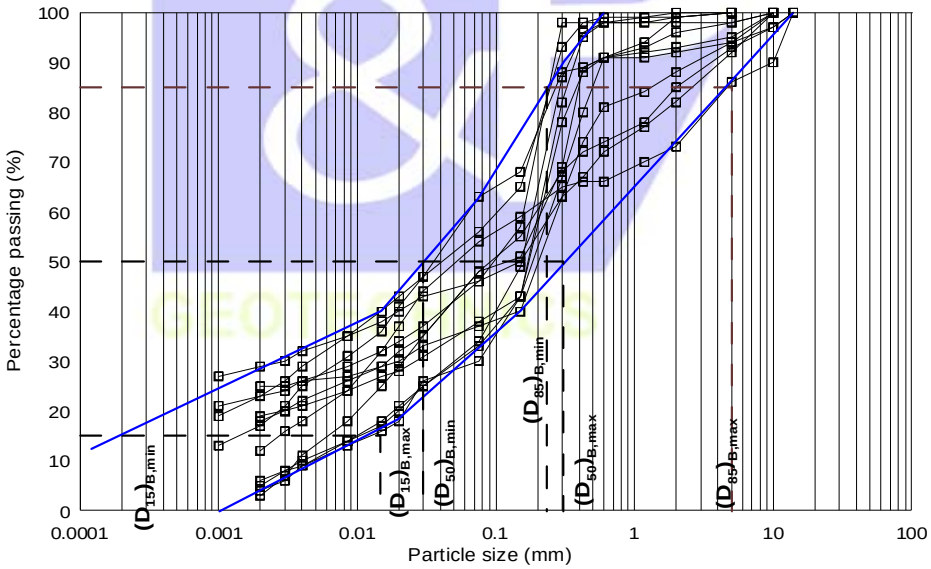
19.3. FILTER DESIGN PROCEDURE

1) Plot all the sieve analysis results of the base material in a SINGLE graph.
Note: Base material is soil/ rock layer to be protected by filter

2) Draw a grading envelope for base material.

3) If granular filter is used, obtain the following values from the envelope:

$(D_{15})_{B,min}$, $(D_{15})_{B,max}$, $(D_{50})_{B,min}$, $(D_{50})_{B,max}$, $(D_{85})_{B,max}$, $(D_{85})_{B,min}$
Note: $(D_{15})_{B,min}$ denotes the smallest size of sieve allows 15% of base material to pass through it.



4) If geotextile filter is used, obtain $(D_{90})_{B,min}$ value.

5) Design the filter according to the design criteria as listed in Section 19.4. If there is more than one layer of filter, each layer should be designed to satisfy these design criteria.

19.4. DESIGN CRITERIA

19.4.1. Granular filter

- Granular filter is specified by using its grading envelope and thickness.

- General design criteria to determine grading envelope of the filter are listed as follows:

Rule 1: $(D_{15})_{F,max} < 5 \times (D85)_{B,min}$ Rule 2: $(D_{50})_{F,max} < 25 \times (D50)_{B,min}$ Rule 3: $(D_{15})_{F,max} < 40 \times (D15)_{B,min}$ for soil with $(D_{60})_B/(D_{10})_B \geq 4$, or $(D_{15})_{F,max} < 20 \times (D_{15})_{B,min}$ for uniform soil ($(D_{60})_B/(D_{10})_B < 4$) Rule 4: Filter materials should not be gap graded, and the grading curve should be similar to that of the base material.	Stability Criterion (to prevent infiltration of base material)
Rule 5: $(D_{15})_{F,min} > 5 \times (D_{15})_{B,max}$ Rule 6: Filter contains not more than 5% of particles passing 75mm sieve, and the fines should be cohesionless	Permeability Criterion (filter to be much more permeable than base material)
Rule 7: Maximum size of particle < 75mm Rule 8: Uniformity Coefficient $4 < (D_{60})_F/(D_{10})_F < 20$	To prevent segregation

- For filter to protect gap-graded soil, the design shall be based on finer base material only.
- Guideline to determine filter thickness:
  - Thickness of filter layer shall not be less than 150mm, less than $(D_{100})F$ or less than $1.5 \times (D_{50})F$.
  - Minimum thickness of granular filter placed by machine is recommended to be 450mm.
  - If the filter also acts as drain, filter thickness shall be sufficient to carry the maximum groundwater flow.
- If perforated or slotted drains are provided within granular filter, the filter grading shall satisfy the following criteria:
  - $(D_{85})_{F,min} > 1.0 \times$ hole diameter (for perforated drain)
  - $(D_{85})_{F,min} > 1.2 \times$ slot width (for slotted drain)
  - $(D_{85})_{F,min} > 2 \times$ maximum opening (for pipe drain)

19.4.2. Geotextile filter

- Design criteria:

Rule 1: $k_g \geq M\ k_B$ M = 10 for woven geotextile, M = 50 for nonwoven geotextile Note: kg is permeability of geotextile; k_B is permeability of base materials; M is a constant (depends on type of geotextile)	Permeability Criterion
Rule 2: $O_{90} < 2.5\ (D_{90})_{B,min}$ for woven geotextile $O_{90} < 5\ (D_{90})_{B,min}$ for nonwoven geotextile Note: O_{90} is opening size of geotextile which 90% of the pores are smaller.	Stability Criterion
Rule 3: $O_{95} \geq 3 \times (D_{15})_{B,\ max}$ for less severe condition Gradient-ratio test (ASTM D5101) is suggested to assess compatibility of soil and geotextile for severe condition	To prevent clogging (Holtz, 1997)

19.5. REFERENCES

1) Geotechnical Manual for Slopes by Geotechnical Control Office, Hong Kong
2) Geosynthetic Engineering by Holtz, R.D., Christopher, B.R. & Berg, R.R. (1997)
3) River and Channel Revetments: A Design Manual by Manuela Escarameia (1998)
4) Seepage Control for Tailings Dams by Earle Klohn (1979)