**Table (1) Base soils and filters properties, and the Assessment of the current model.**

| Base | Filter | $Rd$ | porosity ( $n_f$ ) | porosity ( $n_b$ ) | self-filtration layer | | $d_{85}^*$ | $D_{c35}/d_{85}^*$ | assessment | Laboratory assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $D_{c35}$ | $D_{c95}$ | | | | |
| **B1** | F1 | 0.04 | 0.255 | 0.490 | 0.018 | 0.074 | 0.048 | 0.380 | E | E* |
| | F2 | 1.00 | 0.213 | -- | **No S.F.L.**** | -- | -- | -- | -- | I* |
| | F3 | 0.84 | 0.296 | -- | **No S.F.L.** | -- | -- | -- | -- | I |
| | F4 | 0.70 | 0.333 | 0.492 | 0.481 | 1.752 | 0.130 | 3.702 | I | I |
| | F5 | 0.98 | 0.337 | 0.509 | 0.636 | 2.136 | 0.162 | 3.922 | I | I |
| **B2** | F2 | 0.24 | 0.306 | 0.480 | 0.136 | 0.352 | 0.140 | 0.972 | E | E |
| | F3 | 0.65 | 0.316 | 0.492 | 0.228 | 0.845 | 0.275 | 0.831 | E | E |
| | F4 | 0.80 | 0.324 | 0.496 | 0.391 | 1.373 | 0.416 | 0.941 | E | I |
| | F5 | 0.92 | 0.342 | 0.507 | 0.657 | 1.894 | 0.552 | 1.190 | I | I |
| **B3** | F2 | 0.23 | 0.307 | 0.483 | 0.072 | 0.262 | 0.141 | 0.511 | E | E |
| | F3 | 0.24 | 0.355 | 0.490 | 0.277 | 0.918 | 0.310 | 0.893 | E | I |
| | F4 | 0.57 | 0.345 | 0.494 | 0.432 | 1.375 | 0.371 | 1.164 | I | I |
| **B4** | F2 | 0.00 | 0.331 | 0.478 | 0.098 | 0.418 | 0.144 | 0.681 | E | E |
| | F3 | 0.52 | 0.329 | 0.375 | 0.276 | 0.981 | 0.271 | 1.019 | I | E |
| | F4 | 0.54 | 0.348 | 0.491 | 0.570 | 2.148 | 0.995 | 0.572 | E | I |
| | F5 | 0.79 | 0.352 | 0.505 | 0.811 | 2.873 | 1.388 | 0.584 | E | I |
| **B5** | F3 | 0.66 | 0.315 | 0.492 | 0.215 | 0.802 | 0.369 | 0.583 | E | E |
| | F4 | 0.73 | 0.331 | 0.494 | 0.437 | 1.616 | 0.652 | 0.671 | E | E |
| | F5 | 0.73 | 0.357 | 0.504 | 0.877 | 3.092 | 1.140 | 0.769 | E | I |
| **B6** | F2 | 0.32 | 0.297 | 0.485 | 0.075 | 0.343 | 0.181 | 0.417 | E | E |
| | F3 | 0.63 | 0.318 | 0.494 | 0.214 | 0.815 | 0.274 | 0.784 | E | E |
| | F4 | 0.48 | 0.353 | 0.492 | 0.567 | 2.387 | 0.407 | 1.393 | I | I |
| | F5 | 1.00 | 0.335 | 0.509 | 0.578 | 1.688 | 0.347 | 1.664 | I | I |
| **B7** | F2 | 0.00 | 0.331 | 0.479 | 0.100 | 0.435 | 0.283 | 0.352 | E | E |
| | F3 | 0.34 | 0.346 | 0.489 | 0.327 | 1.308 | 0.740 | 0.442 | E | E |
| | F4 | 0.65 | 0.338 | 0.493 | 0.473 | 1.785 | 0.992 | 0.477 | E | I |
| **B8** | F2 | 0.01 | 0.330 | 0.479 | 0.097 | 0.436 | 0.299 | 0.325 | E | E |
| | F3 | 0.67 | 0.314 | 0.494 | 0.208 | 0.767 | 0.478 | 0.435 | E | E |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | F4 | 0.51 | 0.350 | 0.491 | 0.547 | 2.195 | 0.951 | 0.575 | E | E |
| | F5 | 0.53 | 0.373 | 0.501 | 1.115 | 4.029 | 1.380 | 0.808 | E | I |
| **B9** | F2 | 0.16 | 0.314 | 0.483 | 0.074 | 0.349 | 0.256 | 0.325 | E | E |
| | F3 | 0.08 | 0.369 | 0.491 | 0.370 | 1.468 | 0.577 | 0.640 | E | I |
| | F4 | 0.54 | 0.348 | 0.493 | 0.506 | 2.036 | 0.618 | 0.819 | E | I |
| | F5 | 0.46 | 0.378 | 0.500 | 1.252 | 4.408 | 0.710 | 1.765 | I | I |

* E= Effective; I=Ineffective
** No S.F.L.= no self filtration layer is formed

A typical example of the analysis is base soil B8 with filter F5 as shown in the Figure (6). $D_{c35}$ and $D_{c95}$ of filter F5 are 2.875 and 6.384 mm respectively. The latter two values also represent respectively the minimum ($d_{min}$) and maximum ($d_{max}$) diameter of the base soil particles that are accumulated in the self-filtration layer. Applying the method of Aberg (1992) to the latter soil particles gives the void ratio, hence the porosity can be calculated, $n_b$=0.501. The porosity of filter can be calculated as $n_f$=0.373 from the data presented by Lafleur et al. (1989) assuming the specific gravity of the soil Gs=2.65. Accordingly we found $P_F/P_B$=3.32 which means the percent of filter particles in the self-filtration layer is $P_F$=77% and the percent of erodible soil particles $P_B$=23%. Knowing all these values enables us to determine the GSD of the self-filtration layer, as shown in Figure (6). $D_{c35}$ and $D_{c95}$of the self-filtration layer are 1.115 and 4.029 mm respectively, which is obtained from the CSD of the self-filtration layers. The ratio ($D_{c35}/d^*_{85} = 0.808$) so the soil is predicted to be stable. The results of all the filters and base soils are shown in Table (1), it can be seen that there are 10 cases where wrongly predicted, 9 of which are ineffective filters but predicted as effective filters. For this reason we think it is unsafe to design a filter based on the GSD curve of the self-filtration layer, where a lot of ineffective filters will be assessed as effective. For these ineffective filters, the calculated $D_{c35}$ of the self-filtration layer is less than $d^*_{85}$ of the base soil which means that the filter must be effective, although that these filters were found in the lab to be ineffective filters. Which may mean that formation of the self-filtration layer in these soils is very slow which allows washing out of large amount of the base soil before formation the self-filtration layer.

For the analyzed soils in this paper, the porosity $n_b$ is found to be about 0.5 as shown in Table (1), so the assumption of nb=0.4 is not accurate. It is worth to mention that for base soil B1 with filters F2 and F3, no self-filtration layers are expected to be formed, because that the values of $D_{c35}$ and $D_{c95}$ lies within the gap of these two soils.

We believed that the filters' efficiency will be improved with time, where the interaction layer will be able to capture smaller particles. But this needs more detailed experimental study.

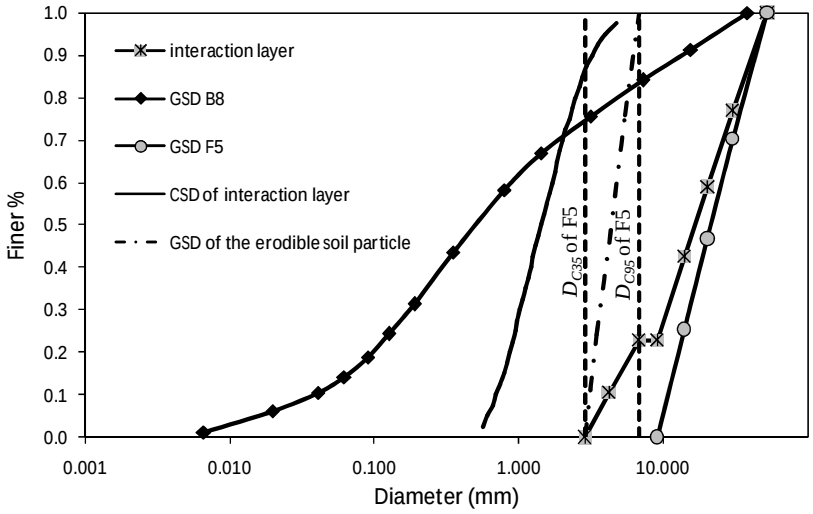


**Figure (6) a typical example of the analysis (Base soil B8 with filter F5).**

## CONCLUSIONS

The following conclusions can be obtained.

1. For gap-graded base soils, if the value of ($D_{c35}$ and $D_{c95}$) of the filter lies within the gap of the base soil then no self-filtration layer will be formed at all.
2. Some filters have $D_{c35}/d_{85}^{*} < 1$which means that they must be effective, although that, these filters were found in the lab as ineffective filters. Which may mean that formation of the self-filtration layer in these soils is very slow which allows washing out of large amount of the base soil before formation the self-filtration layer.
3. The value of the porosity of base soil particles that washed inside the self-filtration layer is about ($n_b$ =0.5) for the data analyzed here.
4. The method of Indraratna and Raut (2006) underestimates the effectiveness of the filters.
5. Prediction the effectiveness of the filter based on the self-filtration layer is unreliable.

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