# Evaluation of geotextile filter application in embankment dams with artificial neural network

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ABSTRACT: In the past three decades Geosynthetics have been widely used for many different civil engineering applications. Geotextiles are flexible permeable geosynthetics used in geotechnical and hydraulic engineering structures. First use of geotextile in embankment dam was in 1959 in Cotrada Sabetta, in Italy (FEMA, 2011). But first use as filter was in Valcoros dam in France in 1970(Faure, et. Al. 1999). In this paper using geotextile as filter in embankment dams is evaluated, using 384 Geostudio SEEP W models and analyzing the results with artificial neural network in MATLAB. Input parameters are: crest of dam, height of dam, bottom width of dam, reservoir water level, permeability of core, top and bottom thickness of dam core, numbers of geotextile layers, and PP geotextile type (200, 400, 500, and 800gr⁄m^2 and the target function is the ratio of the flux with geotextile to flux for those without geotextile in the middle of dam foundation. Using ANN (Artificial Neural Network) helps us to simulate the flux. For any other embankment parameters or other geotextiles without using different permeability of geotextile in different pressures. Calculating the minimum error (MSE) for ANN with two layers and different number of neurons, the simulations are in a good agreement with the model results.

*Keywords: embankment dam, filter, geotextile, geostudio, artificial neural network.*

## 1 INTRODUCTION

Distinguish drainage and filtration systems are complicated. In drainage systems, the main concern is the water flow, but in filtration not only the water flow is important, but also keeping the soil aggregate is of a great importance (FEMA. 1999). In some cases using filtration in embankment dams are necessary and aggregate is the most common material to apply. Geotextile is an alternative choice, especially when appropriate filter material sources are so far or expensive. So the utilization of geosynthetic materials is particularly interesting since increasing construction speed (Plameira. et al. 2009). Geotextile have been used in embankment dams for over 58 years. Used as filter in Valcoros dam in France. The geotextile placed in the ground for a period of twenty one years has not been subject to any significant change in behavior since its installation (comparison of 1976 and 1992 tests) the flow rate measured downstream of the drain in 1992 is similar to the value measured in 1976. The outflowing water does not carry any soil particles. No seepage has been observed on the downstream facing of the dam and this implies that the entire downstream drainage system is working properly. In view of some imprints caused by the angularity of the drainage gravel, it would seem advisable to prescribe a puncture strength criterion further to thickness criterion as proposed by Heerten (1992) for certain applications. (Faure et al. 1999). So it is necessary to evaluate the behavior of geotextile in embankment dams.

## 2 METHODOLOGY

The embankment dam with different properties and different geotextiles are modeled in GeoStudio (SEEP W) software (384 different dams). In this study crest, height of dam, permeability of clay core, reservoir water level, width of core, number and type of geotextiles are variable parameters. The target is the flux with geotextile to flux without geotextile. Qizlar dam is chosen as the case study for this discussion.

To verify the results of the model, they are compared with documented results of the same study with the dam consultant specification. Finally the results are analyzed using Artificial Neural Networks (ANN), and a smart designing procedure is obtained. To check the precision of ANN-based model the results are assessed manually for a specific problem and the model is proved to be appropriate. With ANN in 2 layers with different numbers of neurons and calculate the minimum error (MSE), the simulation result is very close to the model. The characteristics of Qizlar dam are shown in the figure 1.

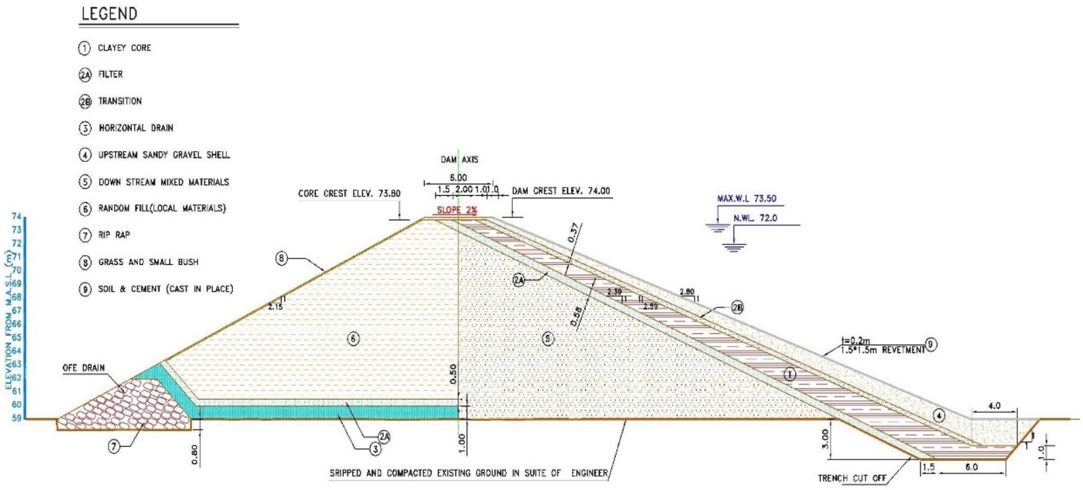


Figure 1. Qizlar dam characteristics

And the permeability of dam body materials are shown in table 1.

Table 1. permeability parameters of Qizlar dam

| $K_y/K_x$ | $K_y(cm/s)$ | $K_x(cm/s)$ | Material |
|---|---|---|---|
| 1 | $1/0 \times 10^{-3}$ | $1/0 \times 10^{-3}$ | Upstream layer |
| 0/1 | $1/0 \times 10^{-7}$ | $1/0 \times 10^{-6}$ | Core |
| 1 | $1/4 \times 10^{-2}$ | $1/4 \times 10^{-2}$ | Filter |
| 0/1 | $1/0 \times 10^{-5}$ | $1/0 \times 10^{-4}$ | Downstream layer |
| 0/1 | $6/0 \times 10^{-7}$ | $6/0 \times 10^{-6}$ | Silty layer |
| 1 | $5/0 \times 10^{-4}$ | $5/0 \times 10^{-4}$ | Foundation |

As the geotextile is under different pressures in this study, using the laboratory data of permittivity and calculate the permeability in 0-50-150-300 Kpa form Pak, A., Zahmatkesh, Z. 2010 study. Table 2

Table 2. geotextile parameters

| Pressure(Kpa) | Thic.(m) | Ψ(1/S) | | | | Kx(m/s) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 800 gr/Cm² | 500 gr/Cm² | 400 gr/Cm² | 200 gr/Cm² | 800 gr/Cm² | 500 gr/Cm² | 400 gr/Cm² | 200 gr/Cm² |
| 0 | 6.60E-03 | 1 | 1.3 | 1.5 | 2.2 | 6.60E-03 | 4.94E-03 | 5.25E-03 | 1.76E-03 |
| 50 | 3.80E-03 | 0.5 | 0.8 | 1 | 1.4 | 3.30E-03 | 3.04E-03 | 3.50E-03 | 1.16E-03 |
| 150 | 3.50E-03 | 0.4 | 0.5 | 0.7 | 1 | 2.64E-03 | 1.90E-03 | 2.45E-03 | 8.00E-04 |
| 300 | 8.00E-04 | 0.3 | 0.4 | 0.5 | 0.7 | 1.98E-03 | 1.52E-03 | 1.75E-03 | 5.60E-04 |

According to Nikkhah et al, 2010 study the ratio of Ky=0.026Kx is used for geotextiles.

## 3 VERIFICATION

The model is verified with the consultant specifications. The evaluated consultant flux is 1.9*E-06 (figure-3) and this study model flux is 1.8966*E-06(figure -2) in the middle of the foundation.

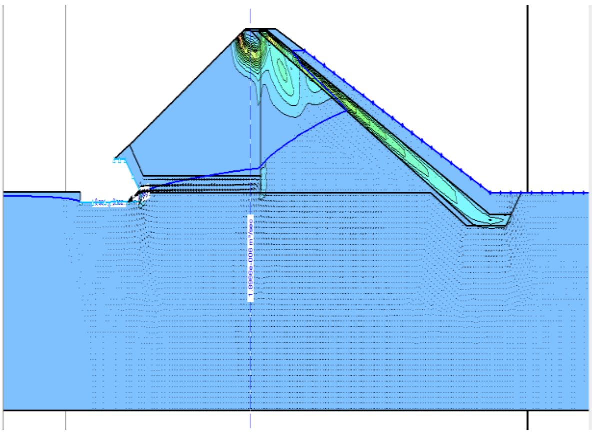

Figure 2. this study model 1.8966*E-06

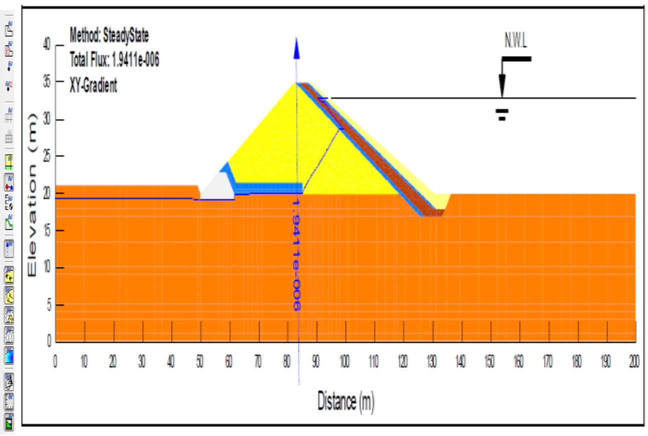


Figure 3. Consultant model 1.9411*E-06

## 4 CONCLUSION

In Figure 4 the results of “flux (with GT/without GT)” using 4 type of geotextile (200, 400, 500, and 800$^{gr}/_{m^2}$ ) in 1, 2, 5, 10, 20, 50 layers are shown. The parameters of certain dam are: C (crest) =6 m, B (bottom of dam) =86 m, h (height of dam) = 15 m, H (water height) = 10 m, Kx core= 1*E-08 m/s, Width of core= 5 m. in Figure 5, H= 13 m, in the figure 6, width of core= 7.5 m,

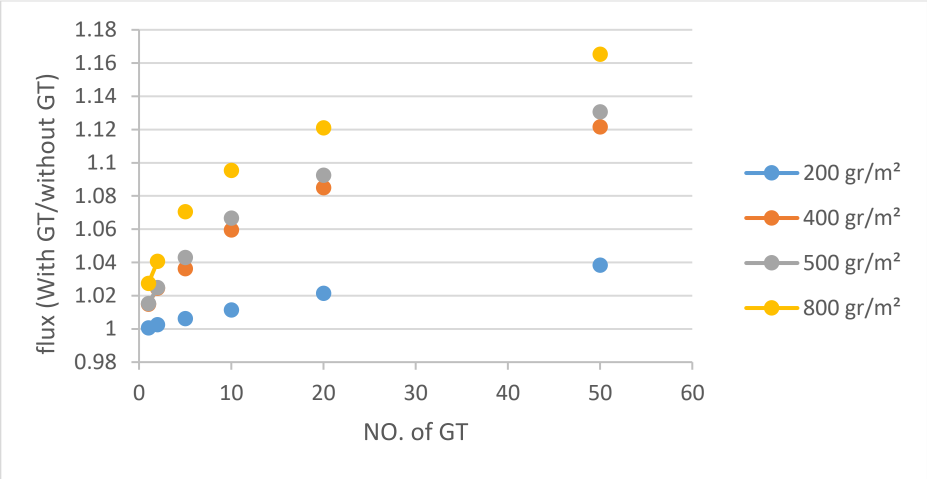


Figure 4. comparison of the flux for different GT layers and GT types in the same condition

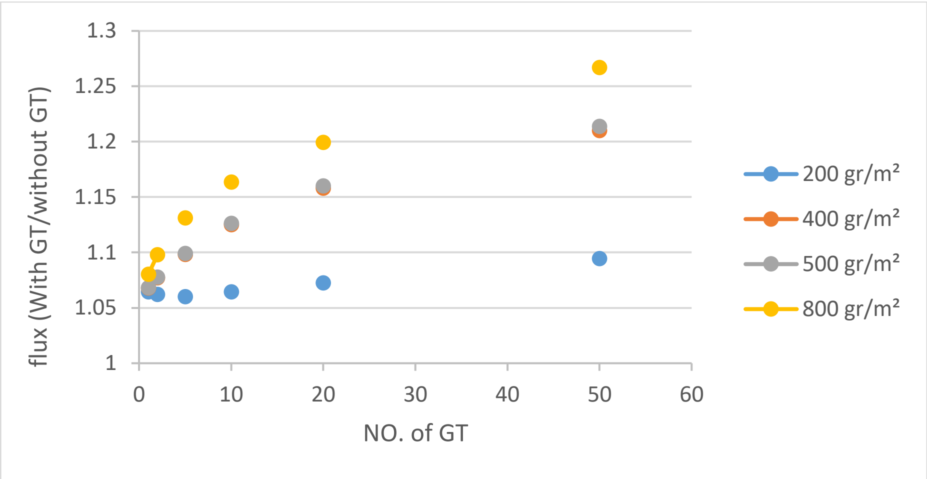


Figure 5. H=13 m

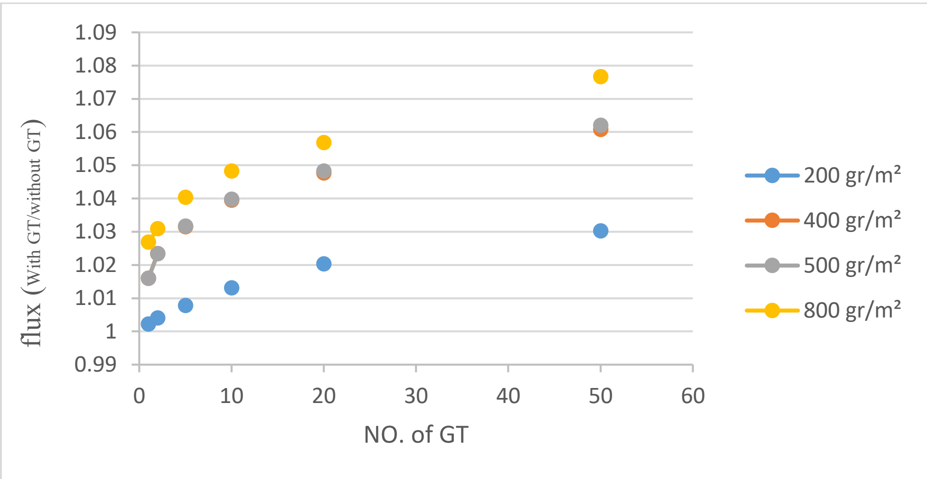


Figure 6. width of core= 7.5 m

As shown if figures 4, 5, 6 the effect of different types of geotextiles are more significant for 50 layers of GT, so it is recommended to use more than 20 layers to compare the results. The effect of GT 400 is more than 2 layers of GT 200 in all layers. The important point is 20 layers of GT 400 that is equal to GT 800 but in less layers GT 800 is more than 2 layers of 400 effect. So the effect of GT 400 is not the same as 2*GT 200, however sometimes is equal. This matter can be used for 400 and 800 GT too. In figure 7, the dam with c=16 m, B= 240 m, h= 40 m, H=10 m, Kx core= 1*E-08 m/s, and 1*E-07, Width of core= 14 m, is shown.

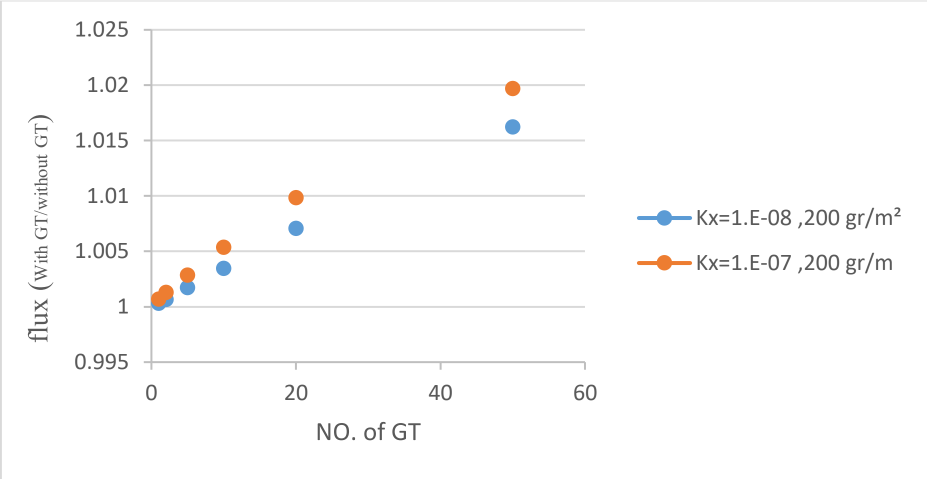


Figure 7.

In figure 8, the effect of core width is illustrated. C=6 m, B=86 m, h=15 m, H=10 m, Kx core=1*E-07 m/s, Width of core= 5, and 7.5 m.

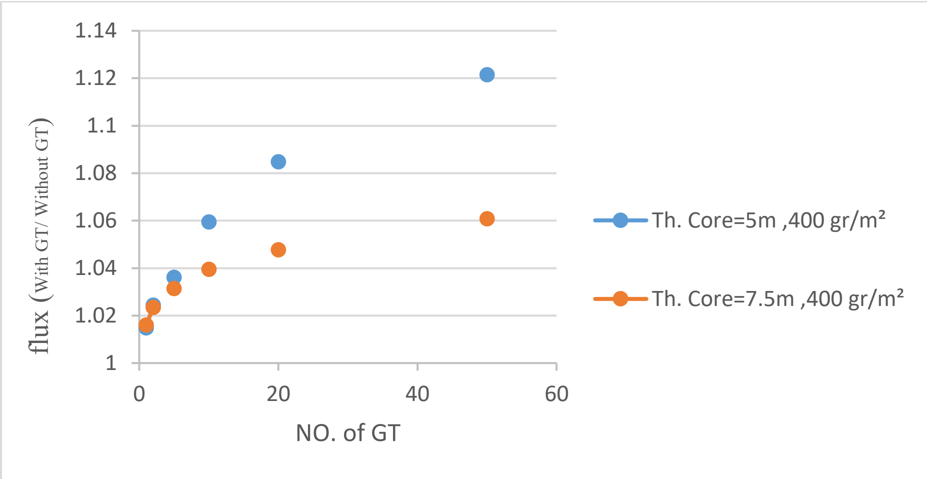


Figure 8.

Using ANN with 2 layers, that input data is C, B, h, H, Kx core, Width of core, NO. Of GT, Kx GT @2KPa and the target in the flux ratio (after/before). With using codes to determine the MSE (mean Square Error) and different numbers of neurons. The simulation is reliable:
The model: 1.07125583
The ANN: 1.0710
However a line is fitted to the results with WEKA software using liner regression, as shown below, with RMSE= 0.0424

Flux ($\frac{With\ GT}{Without\ GT}$) = -0.0015 *[Crest of dam (m)] + 0.0007 * [H (water level (m))] - 153525.14 *[Kx (core (m/s))] - 0.0045 * [Up thick. (m)] + 0.0016 * [NO. Of GT (psc)] + 594.2554 * [Kx GT @2KPa (m/s)] + 1.0098

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