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Professional practice paper

Lessons learned from geotextile filter failures under challenging field conditions☆

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ABSTRACT

This paper reviews sixty-nine (69) field failures involving geotextile filters which performed unsatisfactorily and are categorized herein as failures. They are grouped into four categories; inadequate design, atypical soils, unusual permeants, and improper installation. In the first category are poor fabric selection, poor fabric design, socked drainage pipe and reversing flow conditions. In the second category are fine grained soils, gap-graded soils, dispersive clays and ochre. In the third category are sludges, turbid water, alkaline water, leachates and agricultural waste liquids. In the fourth category are lack of intimate contact and completely adhesive clogging of surfaces. While not the topic of the paper, it should be noted that, most of these same conditions are known to be troublesome to sand filters as well as to geotextile filters.

1. Introduction

Geotextile filters were first used in the USA in the early 1960s (Barrett, 1966) and then technically advanced by the U. S. Army Corps of Engineers who experimented with and specified plastic filter cloth (Calhoun, 1972). Early terminology used the term *filter fabric* which still persists to the present although the term geotextile filters is preferred. The geotextiles evaluated at that time were of the woven monofilament type which were in sharp contrast to European experiences which generally used needle punched nonwovens for the same filtration purposes (Bourdillon, 1976; Giroud et al., 1977). While these two types of fabrics continue to be presently used for geotextile filters, there are also woven slit film and nonwoven heat bonded types. The four geotextile filter types are shown in Fig. 1.

In regard to geotextile filter design, there have been a progression of approaches focusing on both excessive clogging and adequate flow. Considerable past research has been directed at the avoidance of excessive clogging whereby some soil particle size is compared to the opening size of the geotextile. At this time the charts by Leuttich et al. (1992) for both unidirectional and reversing flow have gained considerable recognition. The adequate flow aspect of a geotextile filter design is based on a flow rate or permittivity factor-of-safety and is illustrated in Koerner (2012) among others.

The information gathered for this paper on 69 case histories of geotextile failures was obtained as follows:

- forty-five are from published papers by others (they are referenced accordingly),
- twelve are from published papers or reports by the authors (most are referenced), and
- twelve are from unpublished investigations by the authors and others.

Rather than present them individually (which is not possible due to space limitations) they will be addressed in groups consisting of the following four sections.

- design related failures
- a typical soil related failures
- unusual permeant related failures, and
- installation related failures.

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0266-1144/

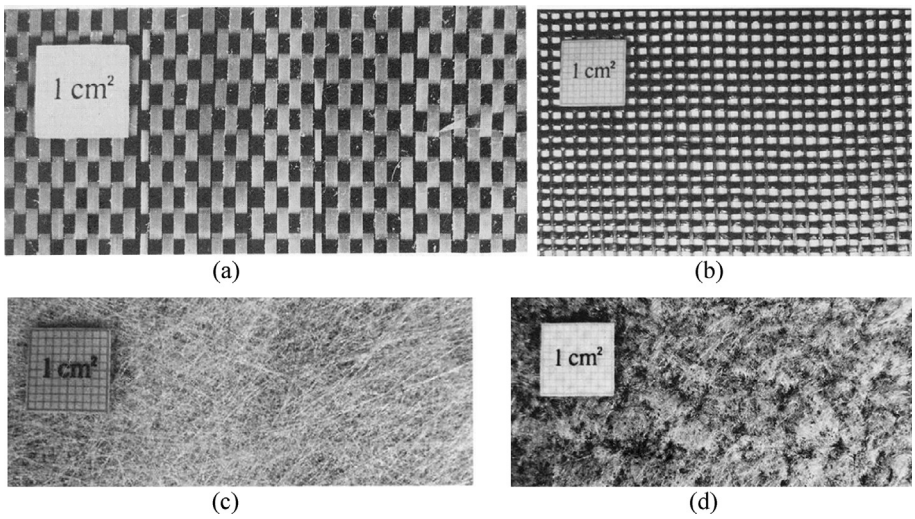

Fig. 1. Various types of geotextiles used as filters; all at 40 magnification. (a) Woven slit (split) film, (b) Woven monofilament, (c) Nonwoven heat bonded, (d) Nonwoven needle punched.
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Note that the word "failures" is used throughout signifying unsatisfactory performance of either the geotextile filter or the accompanying drainage system, the difference sometimes being unknown or difficult to determine in the context of this overview type of paper.

It should be mentioned at the outset, however, that there are hundreds-of-thousands of worldwide successful geotextile filter applications. Geotextile filter applications are even known to be successful with no design, per se, and also with relatively casual installation procedures. What the success-versus-failure rate is for geotextile filter applications is not known but is felt to be extremely high. That said, this paper aims to draw attention to those geotextile filter failures which could have been avoided with proper attention to design, testing and construction.

2. Design related failures

There have been several geotextile filter failures which can be ascribed directly to oversights on the part of the designer (if indeed a design was present to begin with).

2.1. Poor fabric selection

Poor fabric selection has been the cause of at least one failure evaluated by the authors. It was the filter used behind a small gabion wall as seen in Fig. 2a. In this case the geotextile selected was a woven slit film type, recall Fig. 1a, which has poor control over its opening size due to nonbonding of its intersecting fibers. Data from the 2014 proficiency testing program of the Geosynthetic Accreditation Institute's-Laboratory Accreditation Program (GAI-LAP) shows that the statistical coefficient of variation (c_v) is 33% for the permittivity of this type of geotextile (mean value is 0.21 s^{-1} and standard deviation is 0.07 s^{-1}). This relatively high value was the average of twenty participating geosynthetic testing laboratories. Note that at the minimum (e.g., $\mu - 3\sigma$), the permittivity is negligible and, as such, this type of fabric is often used as a silt fence (thereby trapping turbid water to form a small dam) as shown in Fig. 2b. The *lesson learned* in this regard is one of poor fabric selection highlighted by the use of woven slit film fabrics which should not be used for critical filtration applications.

2.2. Excessive coverage of geotextiles

Excessive blockage of the downstream, or exit, surface of geotextile filters has mobilized hydrostatic pressure causing system failures in several cases. van Zanten and Thaket (1982) were the first to recognize the problem (Fig. 3). This same situation has occurred with paving blocks, rock rip-rap, and most recently with roller compacted concrete on the geotextile's surface. This latter case resulted in a major lawsuit (authors file). In each case it is the sudden drawdown of the water in the facility due to tide decreases,

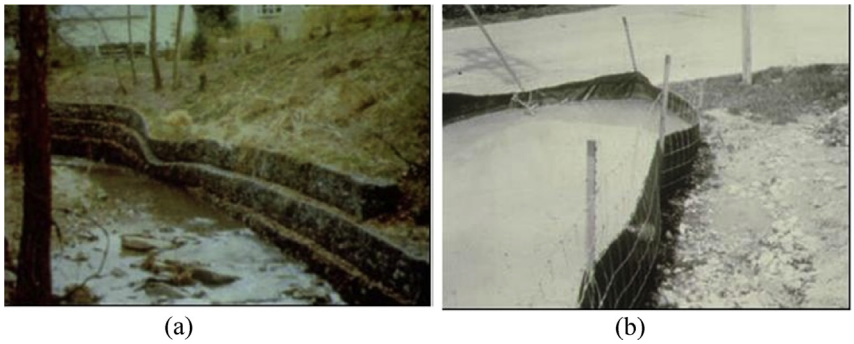

Fig. 2. Improper and proper use of woven silt film fabrics (GSI photos). (a) Gabion wall failure, (b) Silt fence success.