"Criteria for Geotextile and Granular Filters"
by Dr. J.P. Giroud, 2004 IGS Award Recipient

Editor's Note: Dr. J.P. Giroud received a 2004 IGS Award for his contribution to "Criteria for Geotextile and Granular Filters." The following article was contributed by Dr. Giroud upon request. Rather than summarizing his award-winning work, Dr. Giroud explains below his motivation for working on filters and concludes with remarks on research and awards.

I was lucky in 1970 when I made the first filter application of a nonwoven fabric (the word geotextile did not exist at that time). Elementary prudence would dictate that this first application was in a simple project without risk, such as a gravel trench for temporary drainage. But it was in an earth dam, not even a small one: with a height greater than 15 m, Valcros Dam is in the category of "large dams". Clearly, the first time a nonwoven was used as a filter, it was used in a challenging situation.

I had never used "geotechnical fabrics" before. Discussions with my friend Etienne Leflaive, a pioneer in the use of nonwoven fabrics in geotechnical applications, with two years of experience at that time, had convinced me that this new material, which he had used for separation, could be used as a filter. Adequate sand (the granular material traditionally used for filters) was not available at the site and I decided to design the downstream drain of Valcros Dam with a nonwoven fabric as a filter.

For readers who are not familiar with dams, the downstream drain is essential to the performance of an earth dam. Since the soils used to build earth dams are not totally impervious, some water seeps through these dams. The function of the downstream drain is to prevent water that seeps through the dam from accumulating at locations where it would impair the stability of the dam. Numerous failures of earth dams have been attributed to the absence of a downstream drain or to the malfunctioning of the downstream drain. Fortunately, the downstream drain of Valcros Dam and its filter worked well and Valcros Dam is still operating, with a trickle of clean water at the outlet of the drain, as designed.

In 1976, six years after construction, I visited the dam. With me were Jean- Pierre Gourc (then a member of my research team and formerly one of my students) and Philippe Delmas (then one of my students). Both are now very well known in the field of geosynthetics. Together, we inspected the dam, performed a small excavation near the toe of the dam, and took samples of the geotextile filter. We presented a paper on Valcros Dam at the 1977 Paris Conference (eventually recognized as the first International Conference on Geosynthetics). It was well received: the attendees were more impressed by the fact that a geotextile had been used in a dam than by the fact that it was the first nonwoven filter (even though nonwoven filters would be the filters of choice since then). This successful application contributed to the promotion of geotextiles by lending credibility to these new construction materials.

Clearly, the first nonwoven geotextile filter was a success, but over the years, I realized I had been lucky with Valcros Dam. The filter had not been selected using a design method. I only had indications from earlier applications as a separator that this nonwoven fabric would work as a filter for the soil used to construct the dam. Because I had been lucky, I felt compelled to contribute to the advancement of knowledge in filter design. As I started thinking about filtration, I became fascinated by the amount of intelligence involved in the development of this discipline.

At the origin of the concept of filtration, was the invention of the sieve. I deeply admire the unknown man or woman who invented the sieve. The fact that thousands of years ago someone could conceive that discrete particles or grains could be classified by size is remarkable, and the degree of intelligence that was required to develop a tool, the sieve, to implement this classification is amazing.

Understanding that the particles that pass through the openings of the sieve are smaller than the openings must have been an intellectual feat at that time. Then, it took thousands of years to understand the difference between a sieve and a filter. More specifically, it took thousands of years to understand that particles smaller than the openings of a filter (i.e. particles that would pass through a sieve) can be retained by a filter. Separated by these thousands of years were two giants: the intellectual giant who invented the sieve, and the other intellectual giant, Karl Terzaghi, who understood the filter.

Terzaghi worked with granular (e.g. sand) filters. New challenges came with geotextile filters. Particularly challenging was the fact that geotextile filters are very thin compared to granular filters. Thanks to its thickness, a granular filter has many opportunities to stop a moving soil particle. In contrast, a geotextile filter has limited opportunities, a situation that demands rigorous design criteria. Clearly, with the advent of geotextile filters, more work was needed on design criteria for filters. Having no inclination for experimental work, no patience for long testing programs, I was left to my own devices: pen and paper.

As I was thinking about filtration mechanisms, Valcros Dam was often present in my thoughts. As I started understanding how filters work, I realized that, ironically, it was fortunate that I did not design the Valcros Dam geotextile filter. If I had known in 1970 that some people were designing woven "filter fabrics" with an opening size smaller than or equal to the d_{85} of the soil, and if I had used this criterion, it would have been a disaster. As I have demonstrated in several papers, this criterion is inadequate for soils with a large coefficient of uniformity, such as the soil used in Valcros Dam and in many other earth dams. The use of a filter thus designed in Valcros Dam would have resulted in internal erosion ("piping" in the jargon used in dam engineering), and the dam would have failed.

As a result of these thoughts, I was even more committed to develop rational criteria for geotextile filters. The model to follow was obviously Terzaghi's criteria for granular filters. Terzaghi's criteria for granular filters are remarkable because they were developed on the basis of a rational approach at a time when geotechnical engineering was still in limbo. During Terzaghi's time, the temptation was great to use empirical criteria, especially in a case, such as filtration, that seems to defy analysis.

Terzaghi's criteria for granular filters are also remarkable because they are expressed very elegantly. Terzaghi used the fact that the permeability and the opening size of a granular material are related to the particle size distribution of the material to express both the permeability criterion and the retention criterion in terms of particle sizes. Essentially, Terzaghi used a common language for two criteria that are somehow opposite: permeability and retention. However, elegance has a drawback: the smoothness of the presentation tends to hide the hard reality of the physical mechanisms, just like the body of a car hides the engine. As a result, many users tend to forget that the criteria correspond to two basic mechanisms, retention and permeability.

Developing criteria for geotextile filters required going back to basics because there are no simple relationships between the structure of a nonwoven filter and its permeability and opening size. This was a blessing because, by rethinking the mechanism of soil retention, it was possible to develop a retention criterion for geotextile filters that was more advanced than the classical retention criterion for granular filters. Essentially, departing from Terzaghi's expression (but being consistent with Terzaghi's approach) made it possible to make progress. Furthermore, what was necessary for geotextile filters appeared to be also applicable to granular filters.

As a result, a unified retention criterion was established for geotextile and granular filters, thereby making obsolete one of the most awkward practices in geotechnical engineering, the practice that consists of arbitrarily eliminating particles greater than 4.75 mm when using the retention criterion for granular filters. This practice is inelegant and cumbersome; it is, at best, approximate and, in some cases, it leads to errors. The work that started as technology transfer from geotechnical engineering to geosynthetics engineering ended as technology transfer from geosynthetics engineering to geotechnical engineering. As indicated in the citation at the beginning of this article, the development of unified criteria for the two classes of filters, geotextile and granular, is a key aspect recognized by the IGS for this award.

Writing this article leads me to wonder who deserves awards. I would deserve an award if I had developed filter criteria. In reality, I only discovered them. There is a major difference between developing and discovering. The fact that just brain, pen, and paper can lead to equations that elegantly express physical phenomena should inspire great humility to all of those involved in the discovery of equations. Indeed, if equations can be found just by thinking, this means that they were not very far, perhaps just slightly hidden by a veil of habits. The person who happens to write the equation for the first time has in fact a limited role. One should not say that the equation was “developed” whereas it was in fact merely discovered, unveiled. These two words clearly indicate that the equation was there, simply not visible because it was hidden by a cover or veil. I believe that all equations exist even before they are known. They are only hidden (or hiding), waiting to be discovered, not invented. We do not create equations. More modestly, we simply facilitate their birth. Professor Patrick Fox gave me an illustrious example that brilliantly expresses a similar philosophy: Michelangelo said that “every block of stone has a statue inside it and it is the task of the sculptor to discover it”.

Therefore, this IGS Award is more an award for filtration than an award for me, and I am pleased with this recognition by the IGS of the importance of filtration. In the past decade, we have seen many awards and keynote lectures on soil reinforcement. This is, of course, understandable, considering the remarkable achievements in that field in the past few decades. However, it is appropriate that, at last, two IGS Awards are given for filtration (this award and the award given to Ennio Palmeira and Maria das Graças Gardoni). After all, geotextiles were called “filter fabrics” at the time of Valcros Dam design.

The reference of the award-winning paper is:

Giroud, J.P., 2003, “Filter Criteria”, pp. 221-259, in *Jubilee Volume, 75th Anniversary of K. Terzaghi’s “Erdbaumechanik” (“Soil Mechanics”),* H. Brandl, Editor, Reports of the Institute for Soil Mechanics and Geotechnical Engineering, Technical University of Vienna, Austria, 378 p. To learn more about the Jubilee Volume, see *IGS News* Vol. 19, No. 2, p. 1.