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A study of geotextile filter usage in the embankment dams

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Abstract
Geotextile filtration systems have shown several decades their behavior in dams one of the most important factors in the degradation and eventually, destruction of embankment dams is leakage from different parts therein. In embankment dams under normal conditions, employing grain filters is often proposed as the first option. The first large earth dam using geosynthetic materials was built in 1970 in France. At that time the geotextile acts as a filter on the upstream slope between the rocks and the earth fill and on the downstream slope around the main drains. Since this date, a lot of dams were built using geotextile filters. Also, in the last decades, several studies on the long-term behavior of the used geotextiles were carried out to improve both filtration design rules and products. From this long return of experience, filtration design rules have been improved, and new filtration systems with optimized properties have been developed. As a complement to these filtration systems, a new monitoring solution based on optical fibers has been developed to detect and localize the early signs of malfunctioning, such as leaks or instability, to enhance the long-term performance of the dams. . In the paper, the existing geotextile filter design criteria are shown for the retention criterion and the permeability criterion; the influence of the main factors affecting the filtration design is illustrated and the recent methods to evaluate the internal stability of granular soils are analyzed**.**

Keywords: Energy efficiency, green building, sustainable building, Green Building Index (GBI)

1. Introduction

Geotextiles are one of the most prevalent types of geosynthetics that have been used in at least 80 applications thus far. As mentioned earlier, one of the main applications of geotextiles is sought infiltration. But in most cases, geotextiles are employed to simultaneously address several needs. For example, infiltration applications, and geotextiles are also involved in reinforcement [1]. Therefore, to select geotextile materials for their filtration capacities, it is essential to satisfy the maintenance and permeability requirements. Geotextile in the past decades, it has been widely applied globally and in embankment dams. Their main application in dams is an alternative to seed filters. Geotextile is an effective use in the separation of layers and layers of erosion, protection of rivers, etc. It has had good stability and robustness against destructive agents and hydrostatic forces, the geotechnical applications are suitable and recommended, provided that the limits and design criteria as described below [2]. In the case of seed filters carefully controlled, it applies to these substances. 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. The first use of geotextile in the embankment dam was in 1959 in Contrada Sabetta, Italy (FEMA, 2011). But first use as a filter was in the Valcoros dam in France in 1970(Faure, ET. Al. 1999) [3]. The discharge capacity of a tunnel drainage system generally decreases with time because of the hydraulic deterioration of the geotextile filter. Hydraulic deterioration restricts groundwater flow into a tunnel and increases water pressure resulting in detrimental effects on the tunnel lining [4]. Examines a filter cake formation test method in which a geotextile is used to replace the sand stratum. The results show that the infiltration process of slurry in sand and geotextile was similar, and slurry infiltration occurred both with and without filter cake. The filter cakes on the sand stratum and the substituted geotextile had similar properties, such as thickness and water content [5]. The number of constrictions of nonwoven geotextile samples was determined to verify the existence of a correlation between the geotextile structure and the filtration behavior of soil-geotextile systems. The compatibility between an internally unstable soil and a nonwoven geotextile filter was evaluated using the gradient ratio test and the results obtained can also be the basis for modifying the geotextile filter design and selection criteria [6].

Landfills are an example of an environment that contains highly complex communities of microorganisms. To evaluate the microbial community structure, four stainless steel pilot-scale bioreactor landfills with single-and double-layered geotextile fabric were used. Thus, provides insights into the population dynamics of microorganisms in geotextile fabrics used in bioreactor landfills [7]. The use of geotextile filters is very common in engineering applications, such as reinforced soil walls. The main aim is to prevent the movement of fine particles from the bare soil, allowing the liquid to flow as freely as possible. The existing geotextile filter design criteria are shown for the retention criterion and the permeability criterion; the influence of the main factors affecting the filtration design is illustrated and the recent methods to evaluate the internal stability of granular soils are analyzed [8]. The influence of the main factors affecting geotextile/filter long-term behavior which are generally neglected in current design criteria, such as vertical effective stress, partial clogging, flow conditions, type of contact at the interface, and type of permeate, is examined. Furthermore, various performance tests to evaluate the long-term soil-geotextile filter behavior and the reliability and limits of different design criteria for cohesion-less soils are discussed [9]. A theoretical model of the hydraulic deterioration of tunnel geotextile filter has been proposed considering the mechanical and hydraulic behavior of blinding, clogging, and squeezing. A parametric study was carried out to evaluate the performance of the model. An experimental study has been conducted to investigate the clogging behavior of the tunnel drainage system and validate the theoretical model. The findings suggest that the in-plane permeability of the geotextile filter decreased by approximately 90%. The proposed model corroborated the experimental results [10]. The discharge capacity of a tunnel drainage system generally decreases with time because of the hydraulic deterioration of the geosynthetics filter. The hydraulic deterioration of the geosynthetics drain material causes an increase in the water pressure, leading to structural damage to the tunnel lining. In this study, the deterioration mechanism of the tunnel drainage system was investigated [11].

2. Filter

A major filtration concept was to choose the size of the largest pore in the geotextile filter smaller than the larger particles of the soil. As with graded granular filters, the larger soil particles will. The first German recommendations on geosynthetic filters have been released in 1986 followed by a revision in 1992 with some modifications but the same filter rules. In those days, the geosynthetic fabric was still. Therefore the hosting associations - the German Geotechnical Society (DGGT) and the German Water Association (DWA) – agreed on revising the 1992 recommendations, taking into account [12].

To design a filter, four criteria have to be fulfilled:

- The finer material has to be retained (a marginal loss may be allowed)
- Permeability must not decrease significantly in order to avoid a build-up of pore water pressure. On the other hand, the design should be kept as simple as possible
- Further criteria necessary for a successful filter design are:
- Clogging resistance and
- Survivability

German recommendations on geosynthetic filters for hydraulic and geotechnical applications have been released in 1986 when such fabric was still young and research was done in many places. A revision was issued in 1992 with some modifications but the same filter rules (DVWK 1992) The German approach (DVWK 1992) recommends for soils with $d40 > 0,06$ mm to consider the uniformity:

$$O_{90} < 5.d_{10}\sqrt{C_u} \quad (1)$$

There is a second criterion $d_{90} < 1..2.d_{90}$ which is in most cases overruled by the above criterion. For soils with d_{40}< 0, 06 mm also constant threshold values are given, which results in a discontinuity at $d_{40} = 0.06$ mm and contradictory results for a particle size distribution (PSD) bandwidth that reaches both sides of that value. Additionally, this discontinuity is in the middle of the "problematic grain size area" (13) of USCS classes ML, SM, SP, and GM. That's why these recommendations are under revision.

2.1 Definition filter

One of the most common functions fulfilled by geotextiles in dams is filtration. The filtration function, which involves intricate interaction mechanisms between soil particles and geotextile fibers, is certainly one of the most complex among all the functions fulfilled by geotextile products. A lot of studies and research have been carried out around the world to evaluate the behavior of geotextiles used for the filtration function, both in the laboratory and in the field, and to improve design criteria. From these studies, a new geotextile filtration concept was developed, including deep analysis of works after several years of use, sampling of products, theoretical modeling, and laboratory and on-site testing. After presenting these improvements and describing several earth dams built with geosynthetic filter systems, the paper will present a new monitoring solution combining filtration systems and optical fibers able to detect and localize the early signs of malfunctioning, such as leaks or instability, to finally improve the long term performance of the dams. One of the most common functions fulfilled by geotextiles in dams is filtration. The filtration function, which involves intricate interaction mechanisms between soil particles and geotextile fibers, is certainly one of the most complex among all the functions fulfilled by geotextile products. A lot of studies and research have been carried out around the world to evaluate the behavior of geotextiles used for the filtration function, both in the laboratory and in the field, and to improve design criteria. From these studies, a new geotextile filtration concept was developed, including deep analysis of works after several years of use, sampling of products, theoretical modeling, and laboratory and on-site testing. After presenting these improvements and describing several earth dams built with geosynthetic filter systems, the paper will present a new monitoring solution combining filtration systems and optical fibers able to detect and localize the early signs of malfunctioning, such as leaks or instability, to finally improve the long term performance of the dams. Factors Influencing Leakage and Piping Piping and foundation seepage can lead to high hydraulic gradients across core or shell material, which requires protection to avoid contributing to a failure. This protection is provided by way of a filter and drain in most instances. In some cases, impermeable barriers including geomembranes are used [14]. The filter materials are materials that are at the boundary between the two layers that are different in terms of distribution of granularity, they are put in place. The main role of the filter is to prevent the washing and moving of the dust from the soil structure. Its application is where the hydraulic gradient effect is [15].

2.2 Filter performance

One of the most common functions fulfilled by geotextiles in dams is filtration. The filtration function, which involves intricate interaction mechanisms between soil particles and geotextile fibers, is certainly one of the most complex among all the functions fulfilled by geotextile products. A lot of studies and research have been carried out around the world to evaluate the behavior of geotextiles used for the filtration function, both in the laboratory and in the field, and to improve design criteria. From these studies, a new geotextile filtration concept was developed, including deep analysis of works after several years of use, sampling of products, theoretical modeling, and laboratory and on-site testing. After presenting these improvements and describing several earth dams built with geosynthetic filter systems, the paper will present a new monitoring solution combining filtration systems and optical fibers able to detect and localize the early signs of malfunctioning, such as leaks or instability, to finally improve the long term performance of the dams. When the permeation current is made from the soil with relatively small grains (such as the drain) the Embankment Dams toe comes in, and there is a risk that the particles of the earth are washed up inside the material. If this is done over a long period, the fine particles are possible to keep the spaces between materials cut the cut and cut it up. To resolve such a problem, the two layers of filter and the filter layer are used as a protector. The filter and drain allow the flow of seepage from the soil to the time the filter is filtered. It doesn't exist, get out faster. Therefore, the filter material should be based on the soil (Protected soil). Should have been more open and open. The flow of fine grain from the grain to the filter may be washed away, accompanied by being washed away. And the motion of the particles of the soil is based on the pores of the filter material, causing damage to the soil structure. That will happen. It may be due to loss of density and lack of density materials, or the result of the blocking of the filter and the creation of high hydrostatic pressure in the rear of the filter material. In any case for any reason, the safety of the structure is threatened and the structure will be destroyed over time. Filter it will prolong the life of the structure with the least risk [16].

$$Piping \rightarrow (1)\, D_{15(filter)}/D_{15(soil)} \prec= 4-5 \qquad (2)$$

$$Permeability \rightarrow (2)\, D_{15(filter)}/D_{15(soil)} \succ= 4-5 \qquad (3)$$

And the US Army's engineering department also recommends that:

$$Piping \begin{cases} 1 \rightarrow (3)\, D_{15(filter)}/D_{85(soil)} \prec 5-6 \\ 2 \rightarrow (4)\, D_{15(filter)}/D_{15(soil)} \prec 20-40 \\ 3 \rightarrow (5)\, D_{15(filter)}/D_{15(soil)} \prec 25 \end{cases} \qquad (4)$$

$$Permeability \rightarrow (6)\, D_{15(filter)}/D_{15(soil)} \succ 4 \qquad (5)$$

D_i That is a diameter of the material 1% the material is smaller than that and the US Army's Office of Engineering also explains the scope of the proposed. The larger (the recipe to prevent the seeds in the filter) 76 mm filter materials should not be imported from Qatar. To prevent the internal erosion of microparticles and sufficient permeability, it should not be much smaller than sieve size Number 200 in the filter material is larger than 5%. With set limits, the filter can still be layer cover. Determined to filter the protected soil into the filter as well as filter materials to prevent it. It should be noted that the thickness of the filter layer must be determined by Darcy's law.

3. Geotextile

The use of geotextile filters is very common in engineering applications, such as reinforced soil walls. The main aim is to prevent the movement of fine particles from the base soil, allowing the liquid to flow as freely as possible. As a result, the geotextile filter design is based on the retention and permeability criteria. Generally, the retention criterion that a geotextile filter must satisfy is expressed in terms of geotextile characteristic opening size and an indicative soil particle diameter. The criterion works if the filter's larger pores retain the smaller particles of base soil. In fact, the base soil could be subjected to an internal erosion phenomenon if the geotextile filter characteristic opening size is too large and if the larger particles retained by the filter are not able to retain the smaller particles of the base soil under the dragging hydraulic flow [17].

3.1 Definition

It is one of the types of Geosciences. In the general definition, the geosynthetics of textiles or clothes. Of petroleum fibers, whose main property is Corruption against destructive elements in the soil? In this study, many applications in soil engineering and quality improvement have soil properties. Geosynthetics It has a variety of variations, such as geotextiles and geomembrane and geographies, and one. There are many applications. So, based on the qualities that have been in engineering, the domain is widely used. Are generally more permeable than fibers. Synthetic oil derivatives such as polyester, polyethylene, and polypropylene.it is worth mentioning that the manufacture of these textiles is made of natural materials due to corruption. That they can't be. Geotextile can be woven or woven into woven, Geotextile the woven can be perpendicular to each other, as well as the Woven of two parallel threads, perpendicular to each other, made of thread rings. In the woven fabric of the fibers, together with each other, they are positioned and integrated with the help of chemicals, heat, or mechanical [18].

3.2 Types of geotextile

As mentioned, geotextile is woven on two type's wovens and not woven of course. And their property in the face of the soil is their separating property and filtration. Also in protection, it is widely used to cause erosion and against turbulent flows.

3.3 Geotextile Application in Engineering

3.3.1 Drainage

Underground water can flow well on the surface and can be directed to the exit points

3.3.2 Filtering
If the permeable geotextile layer between the two coarse-grained soil layers and thinned, the drainage is easily carried out from the fine layer to the coarse layer and the penetration of the fine grains into the coarse layer prevents.

3.3.3 Separation
Using geotextiles, different layers of soil can be separated for example, in the construction of highways, the clay substrate can be separated from the subsoil by a geotextile.

3.3.4 Reinforcement
The high tensile strength of geotextile increases the loading capacity of the earth

3.4 Use geotextile as a filter
Due to its superiority in terms of performance, its economical optimality, its proper characteristics, and its ease to use using their success in many drainage and geotechnical projects, the materials are replaced with filtered filters. Therefore, geotextile materials should have the same function as grain grains [19].

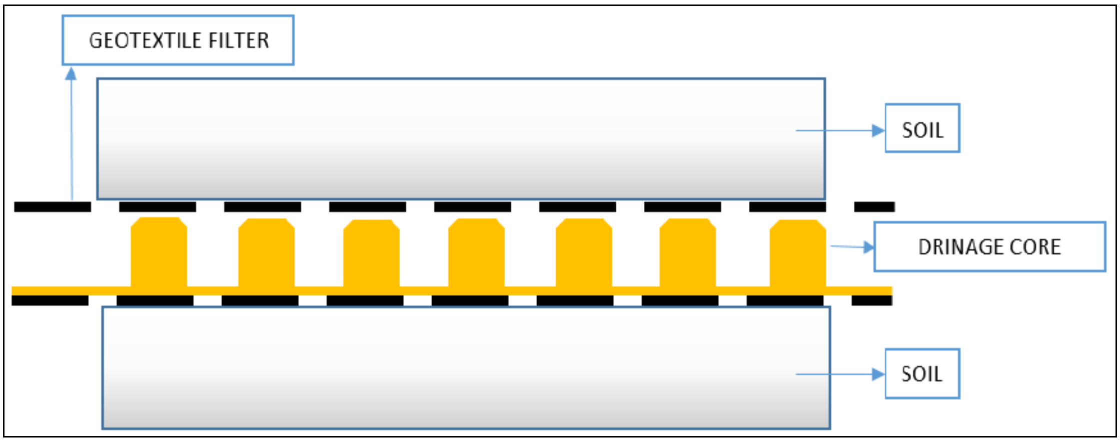

Fig 1: Schematic Geotextile Filter and Drainage core

- Allow excess water to drain and direct it to drains and continue to do so during operation
- Keep soil particles in place and prevent the occurrence of internal erosion (piping)
- Geotextiles also remain in the form of filtered filters requiring a design and a series of properties engineered, otherwise, they cannot function as an efficient system
- Among the geotextile advantages it can be made and the rapid deployment, the economy, and the resistor. The chemical, durability, and the absence of separation between the seeds, which are made in seed filters during construction point out a drop in the amount of drilling.
- compared to the unsuitable filter materials, such as the grains with discrete particle distribution
- (Broad-Graded) which is bad for the filter and the use of it is definitely out of range hydraulic pressure formation (piping) causes bad effects in terms of internal erosion phenomena He did. Geotextile can play a part better.
- In special conditions, such as divergent soils, the occurrence of Turks and conditions of saturated geotextile is better.
- The thickness of the geotextile layer is much smaller than the grain aggregate layer, and this is due to theoretical analysis and executive is important

3.5 Geotextile filter design
Geotextile design is as essential as designing grain filters. Geotextiles in terms of the soil particles are very similar to the building of the soil and, similarly, the empty spaces of the soil In geotextiles, due to the complexity of the soil, it has to be carefully designed More to do [20].

There are three fundamental steps in the design of Geotextile filters:

a) If the pore size is smaller than the size of the soil particles, the soil is based on the filter it is maintained and prevents internal erosion.
b) If the pore sizes are large enough to equal the particles of fine soil particles if there is no obstacle, then Geotextile will prevent the pressure of hydrostatic pressure.
c) Geotextile should be the amount that can always pass the flow of water. This will be determined by the design range of the Geotextile filters. The Geotextile should resist the soil particles. (Storage area) The Geotextile should have a free and free water transition from its own. (Penetration Range)
d) Geotextile should be used as a useful life filter and sufficient capacity. (Range Flow capacity) In particular, in many situations in particular and critical situations, using Geotextile with precision should be the best option, and it should be noted that the selection of Geotextile should not only be based on its price. Though price and cost are generally lower compared to other drainage systems.

3.5.1 Limited design

$$Storage\ area \rightarrow O_{e_{(geotextile)}} \leq B.D_{(soil)}$$

$$Effective\ size\ of\ geotextile\ is\ usually \rightarrow O_e \rightarrow O_{90} or O_{95}$$

$$Dimensionless\ ratio \rightarrow (0.5 - 5.0)$$
$$The\ average\ size\ of\ the\ soil\ particles\ B \rightarrow B = D_{(soil)} \rightarrow D_{85} or D_5$$

B= Function

D_e =Type and soil loss basis

D_{85} Or D_{50} =Geotextile type and the current state (slowly turbulent)

$$Permeability\ range \rightarrow K_{(geotextile)} \geq FS.K_{(soil)}$$
$$for\ the\ normal\ situation \rightarrow K_{(geotextile)} \geq K_{(soil)}$$
$$for\ the\ critical\ situation \rightarrow K_{(geotextile)} \geq 10K_{(soil)}$$

As mentioned earlier, the capacity of the drainage system should not be a problem in the performance of the filter and the water absorption capacity of the iodine filter is larger than the soil [18].

$$q_{(required)} = q_{(geotextile)}\{A_g/A_t\}$$

A_g =Level available for flow

A_t =General area of Geotextile

$$Current\ flow\ capacity\ ranges \rightarrow O_e(geotextile) \geq 3D_{15}(soil) \rightarrow cu > 3$$

If $C_u \leq 3$ the range of maintenance in this case suffices. In situations where the issue If there is water blocking, the following ranges need to be considered.

$$for\ non-wovens \rightarrow\rightarrow n \geq 50\% - 70\%$$
$$for\ wovens \rightarrow\rightarrow POA \geq 4\% - 10\%$$

Porosity (n) and in a hundred open areas Geotextile is percent open area (POA). It should be noted, however, that the specifications are Geotextile not woven and woven into the.

3.5.2 Other limits to designing a Geotextile filter

Some research Geotextile sources in the field of action investigate and provide specifications and design limits. Others say they are briefly mentioned [21].

Q_e =Effective size of geotextile

$U = \frac{D_{60}}{D_{10}}$ =Coefficient of uniformity

O_{max} =Maximum Geotextile Cavity Size

Table 1: Results of researchers' experiments

Mckeade (1977) ICI Fibers(1978)	Geotextiles are unwoven and one-dimensional flow		$d85 \succ 0.25mm$ $d15 \succ 0.05mm$ $O_{50} \leq d85$ $0.02 \succ d85 \prec 0.25$
Calhoun (1972)	Geotextiles are unwoven and one-dimensional flow	Granular soil	$d50 \succ 0.074mm\ (NO.200)$ $O_e \leq d85$ $\%open-area \prec 40$
		Silt soil	$d50 \prec 0.074mm\ (NO.200)$ $O_e \leq 0.21(NO.70-UK-sieve)$ $\%open-area \prec 10$
Raguztki (1973)	Geotextiles are woven and one-dimensional flow		$0.09 \prec d50 \prec 0.34mm$
	Sand soil		$O_{\max} \leq 2.7d50$
	Load-loaded filter(so that they wouldn't 't be displaced)		$Woven \rightarrow O_{\max} \leq 1.3d50$ $Unwoven \rightarrow O_{\max} \leq 1.5d50$ $Filter\ without\ load\ effect \rightarrow O_{\max} \leq 0.7d50$
Zitscher (1975)	Geotextile woven only for sand soil		$U \prec 2, 0.1 \prec d50 \prec 0.3$
	One-dimensional flow		$O_e \leq 2.7d50$
	One-dimensional flow		$O_e \leq 1.0d50$
Schober & teindl (1979)	Sand soil		$0.01 \prec d50 \prec 0.3 \rightarrow 1.5 \prec U \prec 5$
Heerten (1981-1982)	Non-sticky soil of a one-dimensional flow*		$U \geq 5 \rightarrow O_{90} \prec 10d_{50}, O_{90} \leq 10d_{90}$ $U \prec 5 \rightarrow O_{90} \prec 2.5d_{50}, O_{90} \leq 10d_{90}$

	The non - dimensional flow*	$O_{90} \prec d_{50}$
	The sticky soil of all flow states	$O_{90} \prec 10d_{50}, O_{90} \le d_{90}, O_{90} \le 1mm$
Heerten (1981-1982)	Non-sticky soil of a one-dimensional flow	$U \ge 5 \to O_{90} \prec 10d_{50}, O_{90} \le 10d_{90}$ $U \prec 5 \to O_{90} \prec 2.5d_{50}, O_{90} \le 10d_{90}$
	The non - dimensional flow	$O_{90} \prec d_{50}$
	The sticky soil of all flow states	$O_{90} \prec 10d_{50}, O_{90} \le d_{90}, O_{90} \le 1mm$

Table 2: One-dimensional flow of woven and thick geotextile*

1	2	3	4	5	U base
2.4	3.8	4.4	4.3	4.2	O90/d50

Table 3: One-dimensional flow of woven and thick geotextile*

1	2	3	4	5	U base
4.5	6.6	7.4	7.4	7.4	O90/d50

Table 4: One-dimensional flow of woven and thick geotextile*

1	**2**	**3**	**4**	**5**	**U base**
The non - dimensional flow					O90/d85

3-6. User geotextile as a filter in the Embankment Dams

Geotextile applications in soil and gravel dams as a filter are as follows:

A. The erosion of downstream slope relative to the erosion
B. conduction surface runoff and leakage downstream
C. Mains slope protection establishing an internal drainage system
D. The creation of the filter under the Thorpe cover was to prevent internal erosion and washing material on the downstream side of the canal to better study the applications of Geotextile in the embankment dams, several world dams as used as filters, the Geotextile is listed in Table 5:

4. Conclusions

Geotextile filtration systems have been shown for several decades their behavior in dams. Based on this long feedback, filtration design rules and products have been optimized to increase their long-term performance. In this study, the effect of the geotextile filter on the performance of the downstream filter area of embankment dams was examined. One of the most important factors in the degradation and eventually destruction of embankment dams is leakage from different parts therein. In embankment dams under normal conditions, employing grain filters is often proposed as the first option. In case access to granular materials is challenging or economically unfeasible, using a plethora of geosynthetics, especially geotextiles, which alleviates almost all the disadvantages of the traditional method, is highly recommended. In the paper, the existing geotextile filter design criteria are shown for the retention criterion and the permeability criterion; the influence of the main factors affecting the filtration design is illustrated and the recent methods to evaluate the internal stability of granular soils are analyzed.

- Deformations of geotextiles at the contact points may amount to 20–35% reducing the drainage capacity of geotextiles.
- when designing a Deviation tunnel made of rock, such as dams, it is required to increase the design height of geotextiles drainage by 15–25% taking into account macro contacts with rocks.
- -Adding some considers the weight geotextile per unit area (DVWK) to be a significant parameter in most cases means adding only very little money but will increase robustness significantly.

Table 5: Use in Geotextile the dirt dams in the world

Country name and dam name	The height of the dam from the foundation	Year of Construction	Filter location and function	Filter Level
Australia/Loy yang	17m	1979	Under the cover of riprap (in the head)	2900
Czechoslovakia/Nove mlyny	-	1974-79	Internal filter between the nucleus and the sandy shell	10372
Federal Germany/Frauenau	86m	1978-80	The erosion of downstream cover was from internal and internal erosion. Protection of the vertical drain	27000
France/Longefan	-	1977	Sealing shutter hole in Mirage	-
France/Verney	42m	1983-83	Protection for horizontal drain	62000
India/Dharoi dam	-	1981	protection of the downstream and downstream pressure Domestic erosion and the resulting forces	450
Italy/Simbirizii	22m	1983-85	The downstream side of the canal.	40000
Nigeria/Goronyo	21m	1980-83	The downstream drain and the horizontal filter layer	300000
South Africa/Elandspruit	95m	1978-85	below the cover of riprap , and around the inner and outside world	145000
England/Copland	19m	1879	Around the drain for protection	6600
United States/sam Rayburn	-	1982	Hip - bed repair and cover riprap	-

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