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Geosynthetics impact on Environment, a European experience

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ABSTRACT
The scope of this paper is to highlight the challenges and the opportunities represented by the use of geosynthetics in a civil engineering approach, when the environmental issues have a priority.
The problems to front are a big opportunity for geosynthetics, both in the perspective of adaptation to the changing environmental conditions, with a particular focus on the global warming phenomenon, and in the perspective of the possible contribution to the mitigation of the undesired changes.
The ambition of the European Institutions to build a comprehensive normative system does not always fit with the quick answers required by the market, so the national authorities of each country are moving forward independently.
The scale of the problem and the limited availability of data do not allow yet to quantify the possible contribution of geosynthetics to the improvement of the environmental impact of the construction works.
Quantitative analysis are needed to sustain the intuitive benefits and for matching the only apparent contradiction between circular economy and durability of the products.

1. INTRODUCTION

1.1 Global and European warming

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In Europe most of the governments and political parties admit global warming as a real problem to front, and this attitude includes the European Union institutions (Fig.1).

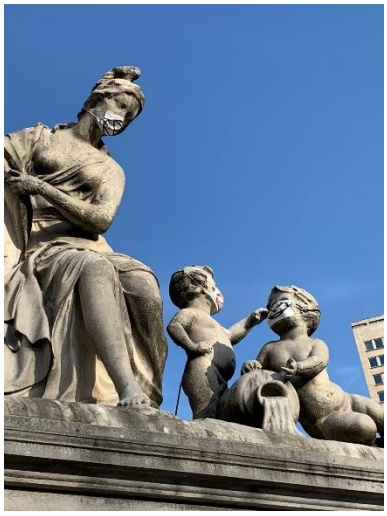

Figure 1 Brussels Jan 2020

Let me point out that I come from a country, Italy, with more than 620.000 (six hundred-twenty-thousands) registered active landslides, about two thirds of the total in Europe (ISPRA 2020), and where the glaciers in the mountain range of the Alps reduced their extension by 30% in the last 60 years (Smiraglia 2016).

The images of the exceptional high waters in Venice with a max of 187cm over the sea level on November 2019 rang a bell all around the world, and gave an idea of what could happen to many low lands around the world.

In recent years we also have more and more storms with unprecedented strength Fig.2.

Figure 2 Marcesina Italian East Alps Nov 2018

So I hope it is clear the reason why in Europe we feel the urgency to pay the maximum attention to any possibility to reduce the impact of the global warming and the climate change.

1.2 What to do

The case of Italy already shows the entity of the actual and possible damages due to the variation of the climatic phenomena and let us focus on the huge demand for construction works oriented to prevent and repair the effects of the environmental issues. Let me mention the well-known and over discussed Module for the High Tides Prevention project in Venice.

Even for skeptical people, the efforts to reduce the environmental impact of the human activities should be already and widely justified by the added value represented by having a cleaner planet, and by the economic issue to allocate the resources in the most efficient way, besides any ideological point of view.

2. TECHNICAL DEVELOPMENT OF GEOSYNTHETICS

2.1 Economic benefits of geosynthetics

The impressive growth of the application of geosynthetics around the world in the last 40 years has been determined by the self-evident economic advantages for the industrialization of the construction processes, especially with infrastructures, and the huge savings due to the lower need of gravel, stones, sand and other materials coming from excavation (not easily renewable by the way).
From the Eighties to the end of last century, the technical and scientific approach of the international geosynthetics community has been oriented mainly on a purely geotechnical engineering level, trying to elaborate theories and calculations for the dimensioning of the works. This is still completely valid and it is the topic of most of the sessions of any international conference.

2.2 Environmental benefits of geosynthetics

Only more recently a due attention has been paid to the environmental benefits determined by the adoption of the geosynthetics technology.
Due to the service life expected for infrastructures and buildings, it came quite soon the question about the durability of this kind of products, in order to evaluate their possibility to be used in projects destined to a long term service, like roads, walls, dams and similar infrastructures.

3. DURABILITY OF GEOSYNTHETICS

This need to forecast the service life has led to a number of studies and experiments, that increased dramatically the know-how in the application of geosynthetics. Knowledge and awareness have taken advantage also from some failure cases, where wrong choices determined the collapse or simply the malfunctioning of a system. A typical and general example about environmental consequences of the misuse of geosynthetics is the application of polyester products in contact with high pH environmental materials, such as fresh concrete castings. In this case the chemical structure of the polymer determines the hydrolysis of the molecule itself, determining the dispersion of nano-plastics.

By the way, unfortunately there are still specifications taking not into account the durability of the products, not their end of the life disposal or dispersion. I mention a current specification asking for a polyester geotextile for the protection of the waterproof geomembrane in a landfill in Rumania, when the hydrolysis if polyester in determined pH environments is a well known phenomenon.

This development in the designing approach was still focusing the technical solution for the particular project, with the aim to choose the most economical solution in relation with the expected duration time of the specific work, so, e.g., for a temporary road even a product with a short expected service life used to be considered good enough, independently from any evaluation of the end of the life of the product.

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In the first decade of the 21st century, an increasing environmental sensitivity spread over the world, and it became more and more clear the ecological opportunity represented by the use of geosynthetics.
Only in the last decade a significant scientific approach has been dedicated to the quantitative measurements of the advantages offered by geosynthetics.

4. LEGAL DIRECTIVES

4.1 World documents

Together with the technical development, also the sphere of the standardization and legal systems started to produce guidelines and rules about environment and sustainability.
It's necessary to mention here the United Nations 2030 Agenda for sustainable development set up in 2015. The relation of the 17 key Sustainable Development Goals (SDG) to geosynthetics has been very well pointed out by the Giroud lecture held by Nathalie Touze at the 11th IGS conference in Seoul 2018 (Touze 2018).
SDG13 is very explicit about our main topic as it asks to "take urgent action to combat climate change and its impacts". This is the goal where geosynthetics can contribute with the mitigation of the impacts, but I like to mention also the SDG9 asking to "build resilient infrastructures, promote inclusive and sustainable industrialization and foster innovation": at the point 4 of this SDG we find the recommendation for the "adoption of clean and environmentally sound technologies". This is where the role of geosynthetics can match the adaptation to the climate changes with the less possible impact of the necessary protection works.

4.2 European rules

Within the growing sensitiveness of the international approach to environmental issues, since the year 2011 the European Community has included sustainability by law (Regulation for Construction Products 305/2011, shortly CPR305) as one of the seven basic requirements to be taken into account for any material for construction.

The total list of basic requirements is:

1. Mechanical resistance and stability
2. Safety in case of fire
3. Hygiene, health and the environment
4. Safety and accessibility in use
5. Protection against noise
6. Energy economy and heat retention
7. Sustainable use of natural resources

The mentioning of environment at the point 3. mostly has to do with the use of dangerous substances and it was there already in the previous Directive dating back to 1989, so the focus for our purposes is on point 7 about sustainability, where three main features are mentioned:

a) Re-use or recyclability
b) Durability of the construction works
c) Use of materials ecologically compatible

Of course geosynthetics fall within the field of materials for constructions, and this rule must be applied to them. CEN TC-189 is the committee of the European Standardization Institute taking care of standardization of geosynthetics since more than 30 years, in coordination with ISO TC/221.
Geosynthetics do meet all the three indications of requirement 7 of CPR305.

5. GEOSYNTHETICS AND SUSTAINABILITY

5.1 Re-use and recyclability

About the point a), being plastic materials, they can generally be cleaned and recycled at the end of their service life. Sometimes for specific purposes and when appropriate in relation with the requested durability of the works, geosynthetics can even be totally or partially obtained from recycled raw materials, both post-industrial and post-consumer. The emphasis should be put on recyclability, rather than on recycled materials. Circular economy is a nice concept, but an economy without wastes to recycle would be even better. On top of this it is necessary to appropriately choose the correct polymer in relation to the chemical situation where the geosynthetic has to be positioned.
In this way also the possibility of releasing pollutant substances can be prevented.
About the use of recycled polymers, it is important to take into account the specific application. By definition a product obtained from recycled polymers cannot perform all the time in the same way, nor its durability can be guaranteed for the long term service life requested by construction works. It means a circularity with a cycle of 50 or even 100 years is by far preferable compared to a cycle of few years as a recycled product can guarantee.
There is a specific rule with a classification of durability in the so called Harmonized European Standards.

5.2 Durability of construction works

About the point b), it comes to evidence an apparent contradiction, as the attitude of geosynthetics to be durable in the time, rings the bell of the diffusion of plastic in the environment. This is a result of a very important and worthy campaign against the mis-use and the abuse of plastic materials, especially in packaging. What is necessary to prevent is a distorted and emotional reaction, considering in the same way also the correct use of plastics, because the correct use of plastics is a solution, not a problem. At point 9. I will return on this topic in relation with geosynthetics. In the case of geosynthetics, their use allows to save a lot of other materials, and they do not have to be confused with the single use plastic products. The long term chemical resistance of plastics is in this case a good feature, enabling to guarantee the durability of the geotechnical work.
Gravel and sand take literally ages to be renovated, and their use has a lot of undesirable implications, such as the consumption of the territories in term of landscapes, excavations of river beds, huge emissions of Green House Gases for extraction and transport, enormous consumption of fresh water for the production of concrete.
It is clear that even the production of geosynthetics has an environmental impact, everybody has to be aware the way to impact zero is an asymptotic line: the matter is to measure and weigh the pluses and minuses, compared to the alternative solutions.

5.3 Use of materials ecologically compatible

This consideration leads to the point c) mentioned by the European law, as the matter of compatibility always implies an assessment. Geosynthetics often allow the use of the in situ soil even if these materials by themselves would not be the best to fit to the geotechnical purposes.
More and more national and local regulations in Europe require or give priority in bids to the designing with the use of the same soil of the excavations, e.g. for the building of a road. Such a result can be reached only by inserting reinforcing or containing structures within the soil, typically represented by geosynthetic products.

6. STANDARDIZATION ACTIVITIES

The current effort of the standardization activities of CEN, the European Normative Committee, an institute which is totally independent from the European Union institution, being a free association of the national normative institutes, is devoted to the definition of an environmental assessment able to establish comparisons between alternative technological solutions, so to encourage and enable more and more the environmental responsibility rather than an utopic total sustainability.
To this purpose it is necessary a coordination with other products rules, and for this reason it is considered appropriate to look not simply to the single product Environmental Performance, but to the whole solution to the designing problem to solve, such as a Life Cycle Assessment.
The wish to find a comprehensive method, valid for any product and situation, does not fit with the need of quick tools to make available for the designers. Because of this situation some European countries are developing internal rules for the sustainability assessment, so that many acronyms are springing.
This is not a bad phenomenon, as far as it will give multiple contributions to adopt the best fitting proposal. For this reason is so important to share experiences with the best practices also from the other continents.
A global cooperation have the chance to lead to ISO standards valid all around the world.

7. ENVIRONMENTAL PRIORITIES

In the general picture of the environmental scenario, sometimes it is necessary to decide not only the methods for assessments, but the priorities themselves.
When we are talking about the global warming effect, with its consequences on the climate change, the quality of the atmosphere seems to deserve a priority over other environmental aspects, such as the dispersion of microplastics in the waters.
If this would be the choice, some demonstrations of the effectiveness of the geosynthetics application are necessary, besides the intuitive advantages, and they are able to corroborate what is already evident from the economic point of view, i.e. the big benefit coming from the sue of geosynthetics technologies compared to traditional solutions.

8. QUANTITATIVE EVIDENCES

It's worth here to mention the results of a very deep and wide study (Stucky et al. 2011-2019) commissioned by EAGM, the European Association of Geosynthetics Manufacturers to ETH Zürich (Swiss Federal Institute of Technology) and ESU-services Ltd. This is a thorough study to quantify the environmental performance of geosynthetics in comparison with some traditional products, such as concrete, sand and similar.
Four different common cases has been examined:

Filter layer

Foundation Stabilization

Landfill construction

Soil retaining wall

The study has been accurately revised in 2019 and led to the measurement of an average saving on the emission of greenhouse gases in the rate of 75%, compared to traditional concrete technologies.

This study can be added to the list mentioned by the accurate presentation held in ICG11 Seul by Dixon (Dixon2018).

A very interesting and specific study has been presented by David Shercliff (Shercliff 2019) on a drainage system built on an English highway, showing an amazing saving of GHG emission, by the use of a geosynthetic composite.

9. ENVIRONMENTAL SURPRISES

In exploring the studies available in the literature, it can happen to find also some surprises.
Beer et al. (2017) conducted a study about the presence of microplastics during the last 30 years in the Baltic sea. The last three decades have seen a huge development of the use of geosynthetics in general, and in coastal protection in particular, especially on the shores of countries like Finland, Sweden, Germany and Dennmark, where the use of geosynthetics is very developed. Also the Russian coast has been interested, as it is shown by Esiukova (2017). Looking to this Russian paper the geosynthetics could contribute to the dispersion of plastics in the sea, but actually this study is interesting because it shows that only the misuse of these product would lead to a result like this, as, notwithstanding the bad Russian experience, the surprise consists in the fact that the presence of microplastics in the Baltic sea did not increase in the last 30 years.
On top of this, another study by the Danish Environmental Protection Agency, Lassen et al. (2015) set the ranking of the presence of plastics in the same Baltic sea: the main source is tires, the second is ship paintings, the third is shoes. According to this study, only for 10% of the analyzed plastic wastes the origin was not possible to determine, and it was

virtually all PVC. So, apparently no impact of the extensive use of geosynthetics in one of the few situations where it has been measured.
What we can learn by this official measurements is that the correct use of any technological tool is the key for environmental safeguard. It is not a product, or a material which is good or bad, but it is the use we make of it, it's the human behavior.
Not even a need then to make a choice between environmental priorities: geosynthetics win in any case.

10. CONCLUSIONS

Of course further evidences must be investigated and hopefully extended to all continents, but the Western European experience encourages to correctly use more and more geosynthetics, knowing they are part of the solution of the environmental problems, global warming over all.
So, will geosynthetics save the planet? Certainly not, but I agree with Dixon and Postill (2018): none of us will save the world by himself, but each small contribution will help, and so it is for products and technology.

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