Development of a design guide for geosynthetics barriers, as part of the ISO design using geosynthetics development.

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Abstract: The principles and practices of design using geosynthetic barriers take into account a number of different parameters considered by professionals engaged in the process. The design guide aims to assist the process by identifying the various characteristics of barrier types and comparing them with the requirements of a variety of different applications. The document has been developed as part of the ISO project “Design using geosynthetics” which offers design advice to professionals involved in the design of civil engineering and construction solutions using geosynthetics materials. Overall the intent is to encourage appropriate selection of materials and design methods to suit particular applications, rather than to redesign projects to suit predetermined materials. Many aspects of the design process have been considered, as well as the particular parameters of various sites and applications. The development has followed the ISO process of development via a committee of international experts over a period of 24 months and with presentations at various international conferences to ensure buy in from the international community. This paper will describe both the process and outcomes as well as describing some of the challenges faced and overcome.

1 INTRODUCTION

The development of a suite of design guides for using geosynthetics, is a project currently being undertaken by ISO TC221 WG6. These design guides are intended to offer advice to designers as to what to consider when using geosynthetics in a particular civil engineering or construction design. As such, they need to cover a range of applications, materials types, climatic and geological issues; as well as covering likely expertise in installation and site preparation / completion in sometimes difficult to access sites. Geosynthetic barriers offer their own challenges to the designer with a plethora of different geosynthetics barrier types as well as materials. Any guide therefore, has to offer a combination of advice as to what might be most suitable as well as how to ensure that the chosen geosynthetics barrier type is able to perform as it is intended. The emphasis is on choosing the most appropriate type(s) of material(s) for the application rather than changing the design to suit a particular material.

2 PROCESS

As with any project of this type, the project team started by looking at what practices were followed in different parts of the world. A scoping document was drawn up and this was presented to an International meeting of experts held in Philadelphia USA. An approach was agreed which listed the types of applications for Geosynthetic Barriers:

2.1 The various applications were described and allocated a two/three letter acronym as follows:

- Containment application, non-landfill (CA)
- Chemical containment, non landfill (CC)
- Construction Waterproofing (CW)
- Landfill base lining (LBL)
- Landfills caps (LC)
- Secondary containment (SC)
- Transport infrastructure applications (TIA)
- Tunnels (Tu)
- Water retaining structure (WRS-e), e.g. balancing ponds, dams, dykes and canals (usually empty)
- Water retaining structure (WRS-f), e.g. reservoirs, canals (usually full)

Then the main characteristics of the barrier were tabulated against each application, with levels of importance given to each of the characteristics often considered for design purposes. These are of course subjective, but again were extracted from the experience and opinions of a number of experts.

Characteristic Parameter		CA	CC	CW	LBL	LC	SC	TIA	TU	WRS-e	WRS-f
Chemical resistance		2	1	3	1	2	1	1	2	3	3
Physical properties											
Hydraulic resistance	permeability	1	1	1	1	1	1	1	1	1	1
Mechanical property	tensile, puncture, tear strength	1	1	2	1	1	2	1	1	1	1
	uni- and multi-axial elongation	2	2	3	3	2	2	2	3	2	2
Abrasion resistance		4	4	4	4	4	4	4	4	2	2
Durability		50 yrs	25 yrs	50 yrs	100 yrs	50 yrs	25 yrs	25 yrs	100 yrs	25 yrs	25 yrs
Installation		1	1	1	1	1	1	1	1	1	1

1 - important 2 - project dependent requirement 3 – rarely required 4 not relevant

2.2 Next, particular characteristics of the main types of geosynthetics barrier were considered and the main types listed with a brief explanation of the material type and constitution listed. Once again, a table was developed using the application types against main types of geosynthetics barriers and considering their acceptance across the main world markets (again subjective, but the opinion of experienced practitioners):

Barrier Type		CA	CC	CW	LBL	LC	SC	TIA	TU	WRS-e	WRS-f
GBR-P	HDPE	1	1	2	1	1	1	1	2	1	1
	LDPE	1	2	2	2	2	1	1	1	1	1
	PVC	3	4	3	4	3	4	3	2	2	1
	EPDM	3	4	3	4	3	4	3	3	1	1
	PP	3	3	3	4	2	3	2	3	2	2
GBR-C	Single-component	2	3	2	2	1	3	1	3	2	2
	Muli-component	2 (A)	2 (A)	2 (A)	2 (A)	1 (A)	2 (A)	1 (A)	2 (A)	2 (A)	2 (A)
GBR-B		3	3	2	4	3	3	2	2	2	2

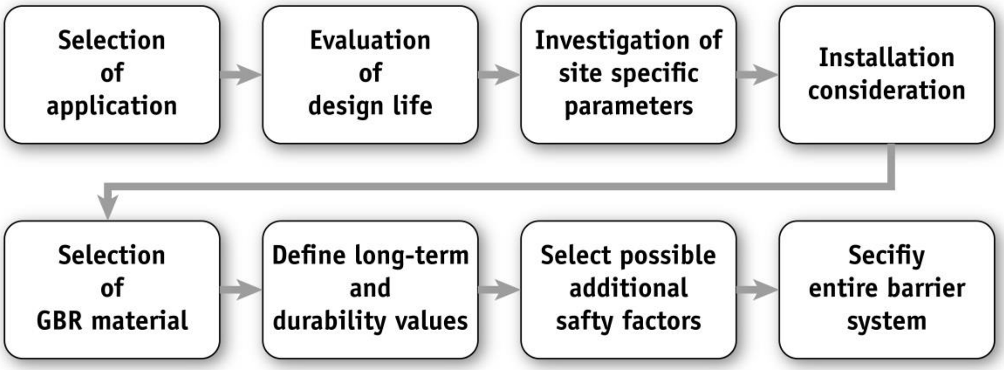
1 – world-wide acceptance 2 – general acceptance 3 – rarely used 4 not recommended

(A) – compare with the relevant combined component

2.3 Then the properties relevant to the design are considered. This is a complicated part of the process as each property needs to be considered in the light of the material and service conditions. This area typically considers elements extraneous to the material but considers the application parameters in which the material and design must work so consideration is given to chemical and physical resistance, weathering and degradation, physical properties of the supportive substrate etc. Unusually for a "standard" no answers or opinions (subjective or otherwise) are given in this section, simply a whole raft of considerations (or questions) are asked requiring the user to take consideration of each of the parameters in their ultimate design combinations.

2.4 The penultimate section covers the basic principles of design, covering such areas as substrate preparation, stability, climate and temperate conditions, quality control and jointing techniques and testing. Here parameters are discussed with opinions and recommendations offered. These are taken from an extensive review of recommendations made by material manufacturers, industry experts and committee members. Again areas such as subgrade preparation, slope stability , climatic conditions, protection and hydraulic uplift. Installation parameters and types of CQA are also considered as to what effect these may have on the DESIGN as well as what additional factors of safety they may offer.

2.5 Finally this whole process was organised into a basic flow chart, to guide designers through the process of choices which need to be considered when designing with a geosynthetics barrier.



Because this work was done as part of an ISO project the work has been done in a structured format dictated by the ISO process and meetings schedules. Whilst the two Project Group leaders (the authors of this paper) have coordinated and originated some of the text, inputs have been received from a number of individuals who form part of the project team. There were a number of meetings held early in the process to determine both the scope and likely approach for the document.

3 CHALLENGES

Any document prepared by a committee is fraught with the difficulties that multiple authors and views can expose. In order to satisfy the requirements of the ISO standards process, as well as having a satisfactory continuity and clarity of content, the chairs of the committee (the authors of this paper) took time to explore carefully the scope and approach, before putting substantial work into content.
One of the initial concerns was, that perhaps predictably, the danger of producing a document that TOLD engineers what to do was voiced. Engineers and professionals and as such are paid for their design input, expertise and experience. The quandary comes with varying levels of all of thee, particularly experience; so it was clear from the beginning that the document should offer advice, areas for consideration and show existing "common practice" based on years of experience in the sector. Any implication of "best practice" was to be avoided, as there are so many parameters to be considered that the combination of areas of consideration will be infinite and as a result, the key to the document was to ensure that it identified "areas for consideration" as well as advice on the individual parameters for each.

At least 12 months of work and consideration via two ISO meetings were needed in order to agree the format for the standard. One of the issues being that committee meetings are held infrequently and pressure of work means that only limited work is done between meetings. Once the scope was decided however the progress has been substantial. This “standard” sits in a suite of nine design standards and was somewhat long in producing its first draft, BUT has been completed to draft for review standard quite quickly, overtaking some of the others in the process. Much credit must go to Kent Von Maubeuge for setting a strategy and timetable relatively early on, ensuring that the initial concept was discussed at international conferences and ensuring that meetings of international experts were held outside the normal ISO meeting schedule to ensure that progress was maintained and in a collaborative environment.

4 PEER REVIEW

Whilst all ISO documents go out as draft for comment, this design standard was mentioned at two initial international conferences, drawing input from international experts, as well as being presented in early draft stage at the Edinburgh soil mechanics conference in Sept 2014. Here a great number of useful expert opinions were available to shape the final document.

5 CURRENT STATUS

The draft for comment was made available at the end of 2014 and is now out for consultation. The authors are receiving a number of comments under the ISO standard format which will help shape the final document. There is a meeting set in November 2016 to discuss these comments and incorporate those the committee feel add to the document, after which a final document will be provided for international acceptance by vote.

6 CONCLUSION

The development of any standard for design is a challenge for any group of professionals, as the document produced must add supportive text and areas for consideration to a process which is in its very nature one of professional judgement by professionals. Geosynthetics barriers are a complex area for design and given the large variety of barrier types, as well as material differences within each type, mean that sooner or later a decision is made comparing a great number of variables. Good design utilises the best possible combination of materials, site preparation, installation and checking in line with the intended end use, expected longevity and “local” constraints which may be functions of geography and climate as well as political, labour availability and access constraints. As such, no design guide or standard can hope to solve the complex combinations of each individual site circumstances and as such it is aimed at professionals making such decisions and helping to ensure that each of the many variable factors have been considered both individually and collectively

7 OMISSIONS

One area which the standard does not try to address is costs, not because these are not important BUT they can vary enormously according to the availability of types of materials, transport distances and costs, installation expertise etc. Good quality design needs to consider the cost effectiveness of any solution but must first qualify and meet all technical and service expectations of the stakeholders in the end use. All engineers must have a current working knowledge of the sort of costs incurred by their designs but the view was taken that to try and incorporate such parameters into the standards would be virtually impossible and almost certainly inaccurate.