Constraints and Barriers to the Application of Geosynthetics

J. Raja, N. Dixon, J. Glass and M. Frost, Department of Civil and Building Engineering, Loughborough University, UK. Contact details: J.Raja@lboro.ac.uk,

I. Fraser, Tensar International Ltd, Shadsworth Business Park, Blackburn, BB1 2QX, United Kingdom. Contact details: IFraser@Tesar.co.uk,

G.Fowmes, Waste Recycling Group Limited, Ground Floor West, 900 Pavilion Drive, Northampton, NN4 7RG. Contact details: Gary.Fowmes@wrg.co.uk

ABSTRACT

This paper outlines the current state of practice in the UK with regard to the use of geosynthetics in construction projects. It examines the awareness that geotechnical engineers possess about the technical and sustainability (i.e. reduced CO_2) advantages that geosynthetics can provide over traditional construction techniques, and the barriers to their increased use. A survey of UK International Geosynthetic Society (IGS) Corporate Sponsors was carried out to understand the perceived constraints and barriers to increased early stage inclusion of geosynthetic based design solutions, and to obtain views on the current awareness of the UK construction industry of the sustainability benefits. The findings from the survey highlight a lack of clarity in the guidance on fill material provided in the literature. The survey results also showed that main barriers to the use of geosynthetics were education and the conservative approach of consultants.

1. INTRODUCTION

With the increasing number of geosynthetics and the hundreds of potential applications geosynthetics are becoming a very important part of the construction industry. Geosynthetics provide a number of benefits and it is these benefits that are attracting more clients and construction professionals to their use. Geosynthetics often reduce the amount of fill material required, and can allow the re-use of lower grade site material. They also provide a number of design benefits both technical and aesthetic. These benefits can have an effect on the cost of a project, and many solutions using geosynthetics as opposed to more traditional methods have resulted in reduce costs by significant amounts. In addition to cost, sustainability of a construction solution is also very important. With recent government targets and legislation, companies are being driven towards reducing their carbon footprint and carbon emissions. Alongside the design benefits provided by geosynthetics they have also been shown to reduce the carbon footprint of a number of construction projects.

In the UK, work has recently been carried out by WRAP (Waste and Resources Action Progamme) to help promote the sustainable benefits of geosynthetics. WRAP is a not-for-profit company established in 2000 and funded by the UK Government. They work to help businesses and individuals gain the benefits of reducing waste, develop sustainable products and use resources in an efficient manner. They produced a report (WRAP 2010) titled ‘Sustainable Geosystems in Civil Engineering Applications’ aimed at demonstrating the beneficial use of geosynthetics to reduce the environmental impact of construction projects. Production of the report was supported by UK geosynthetics companies who contributed to a series of case studies. A research project is currently being carried out at Loughborough University sponsored by the International Geosynthetic Society (IGS) UK Chapter to extend the work carried out by WRAP and further investigate the sustainable benefits of geosynthetics. A Loughborough University

engineering doctoral student is being funded for four years by IGS UK Chapter to carry out the research, with joint supervision by academics and geosynthetic industry representatives.

This paper reports an initial part of the ongoing research and aims to provide an insight into the constraints and barriers being experienced by geosynthetics manufacturers, distributors and consultants to the use of geosynthetics in construction projects. A small survey of IGS UK chapter corporate sponsors was conducted. This survey allowed the corporate sponsors to express their views on a number of issues and provide feedback on key topics such as sustainability, competition and constraints.

2. DESIGN OF SURVEY

In order to develop a survey that would fulfil the aims of the project, research was carried out into appropriate survey methodologies. To draft and form questions it was important to understand what each question would achieve and whether it would provide quantitative or qualitative research outputs. Guidance was taken from a number of sources and in particular from Fink (2005). Due to the broad nature of the survey and the range of information required, it was decided that a mixture of both qualitative and quantitative questions would be used. The survey questions were split into a number of sub-sections that covered different areas of interest, which included personal information, sales, sustainability, considerations/inputs and design. A project meeting involving the industry members of the supervision team was used to present and review the draft survey. This allowed valuable feedback and was an important process in ensuring that the questions addressed the key issues in a way that was clear and accessible to companies. Seventeen survey questions were produced which included questions that were both closed and open ended in nature. After running a test of the survey it was found that participants should only require a maximum of 15 minutes to complete the survey, hence an advisory time of 10-15 minutes was given to those participating in the survey. The survey was administered using an online web tool and was emailed to the 29 IGS UK Chapter corporate sponsors.

3. RESULTS AND ANALYSIS

The survey results gained are from a smaller sample size than expected with ten responses received giving a response rate of 34%. However this was still a large enough group of responses to make a number of conclusions. The answers received showed that a wide range of sectors and services were represented among the participants and this help to establish the relevance and validity of the results. The questions were set out in areas of interest or topics (Section 2) in order to gain a range of information on specific topics such as sustainability. The results and analysis of the survey have been presented in these sections.

3.1 Design and Services

The participants that were involved in the survey and provided valuable feedback and response came from a variety of sectors and services within the geosynthetic industry. Figure 1 presents the representation from different sectors.

The range of sectors represented also resulted in a wide range of products and solutions being included. The majority of companies provided design services, both as technical assistance and fully indemnified. There were also a small number of companies that provided construction solutions; hence both the design and construction sectors were included in the survey. This indicates that as a result of competition, manufacturers provide support activities such as design and construction to help sales and to win contracts. The products that these companies provided covered the whole range of geosynthetics including specialist products such as soil erosion mats. Overall these results showed that the answers received in this survey were representative of the geosynthetics industry and not biased towards any one sector or product.

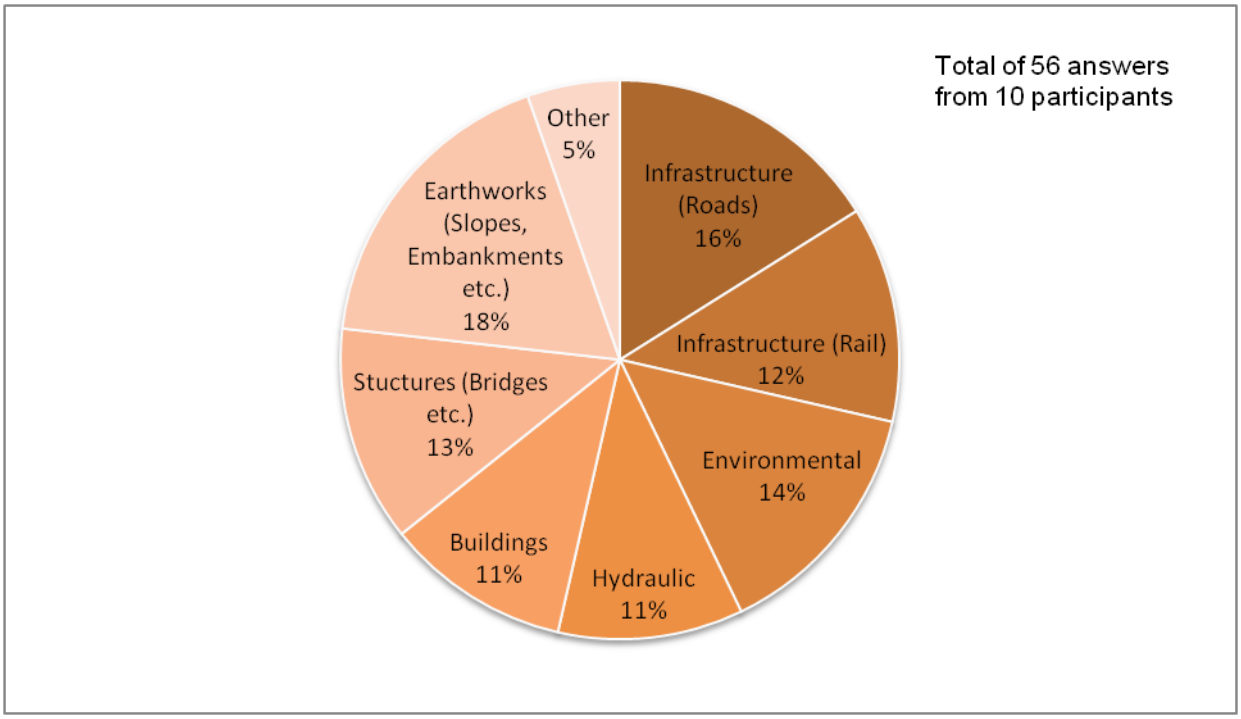

Figure 1. Sectors represented in the survey

The survey was also used to gather information about design documents and guidance that is used by the companies. Key documents identified included BS 8006 (2010), BS EN 14475 (2006) as well as a number of AASTHO and ISO documents.

3.2 Competition and Sales

The survey provided a number of useful results and helped to gain information about the current market, size and growth of companies. Growth in the geosynthetics industry was supported by the survey results which showed that 70% of participants had seen an increase in the sale of geosynthetics in the past five years. With the current poor economic situation this was a very positive response suggesting that the geosynthetic industry has remained strong through these difficult times. The answers to a question on amount of growth showed a wide of range of percentages from 10% to 300%. However, linking this to the sales figures, a correlation could be seen between the size of the company and its growth. Company A with a 300% growth has the smallest sales turnover of less than £1million, with Company C which had a growth of 10% having a turnover of over £20million. This suggests that smaller companies have seen a much bigger growth. However this may be due to them being a recent/new entry to the market in which case these are normal correlations. If new businesses are showing such a positive growth this indicates that there is still a gap in the market for companies to exploit.

When looking at the topic of competition the results suggested that companies perceive a fairly even mixture of competition from within and outside the industry, marginally more towards within the industry. This helps to indentify that a lot of companies see their main competitors as those providing more ‘traditional’ solutions as compared to solutions involving geosynthetics.

3.3 Promotion and Advertising

One of the issues covered in the survey was that of promotion and advertising and it is important to understand how and what methods are being employed by companies to promote and raise awareness of geosynthetics. Participants were asked to rate the effectiveness of different promotional tools or methods and this has allowed significant conclusions to be made from the results. 89% of participants thought that promotional literature was an effective method with no one considering it ineffective (Table 1). Another significant finding was that presentations (conferences) also found 89% of participants rating

it effective/very effective, again with no one finding it ineffective. The respondents provide clear views on the relative effectiveness of the techniques available with promotional material, training workshops, websites, involvement in technical committees and presentations being considered the most useful. The results covering all the promotional tools are summarised in Table 1.

Table 1. The effectiveness of different promotional tools

	Very Effective	Effective	Neutral	Ineffective	Responses
Advertising	11%	22%	56%	11%	9
Promotional Literature	11%	78%	11%	0%	9
Training and Workshops	33%	44%	22%	0%	9
Website	22%	44%	22%	11%	9
Presentations (Conferences)	56%	33%	11%	0%	9
Exhibitions/Events	11%	44%	22%	22%	9
Corporate Entertainment	0%	11%	56%	33%	9
Social Media	11%	0%	33%	56%	9
Involvement in Technical Committees	22%	44%	22%	11%	9

When looking at existing client awareness about the benefits and uses of geosynthetics, the survey results showed that 30% of participants believe that 40 to 60% of all new clients were new to the geosynthetics industry. This helps to highlight that there is still a big group of clients, designers and contractors who are unfamiliar or have little experience with geosynthetics. This could be related to a lack of education (see Section 3.5).

3.4 Sustainability

A key driver for change worldwide is the need for improved sustainability in all aspects of business practice. With the possibility of new UK government legislation introducing CO_2 reduction targets, this survey was an opportunity to investigate the impact that the sustainability agenda was having on the use of geosynthetics. It would also give an insight into the importance sustainability issues are given in the design process. The participants were asked whether sustainability is the primary parameter considered in any design, 50% selected ‘Occasionally’ and 40% ‘Frequently’. None of the participants selected ‘Always’ and 10% or in this case 1 participant selected ‘Never’. This shows that although important, sustainability is not the main consideration. However these results are still encouraging, as 40% of respondents stated that sustainability issues would frequently be considered. The second part of the question asked the participants how often their company offers/highlights sustainability as a benefit to their solution. 60% of participants answered ‘Frequently’ with 10% answering ‘Always’. This shows that as a marketing tool, sustainability is being used as a positive project outcome. However it is important to realise that although the majority of companies highlight sustainability benefits they do not necessarily actively seek to include sustainability considerations specifically in their designs.

The last part of the question asked the participants how often clients/customers ask for a design that is more sustainable. In this case 22% answered ‘Never’ with 56% answering ‘Occasionally’ and the remainder answering ‘Frequently’. This demonstrates that clients are not specifically requesting a more sustainable solution with the key driver being cost. When responses to the three parts of the question are taken together (Table 2) it can be concluded that although cost is still the main consideration when developing a solution, sustainability is playing an increasing role. However companies are not considering sustainability as the primary parameter, as they are more focused on providing a solution that is cheaper than their competitors both geosynthetic and traditional.

Table 2. The use of sustainability in the design process

	Never	Occasionally	Frequently	Always	Responses
Sustainability is the primary parameter considered in any design	10%	50%	40%	0%	10
We offer sustainability as a benefit of our solution	0%	30%	60%	10%	10
Customers/Clients ask for designs that are more sustainable	22%	56%	22%	0%	9

It would be very hard to persuade a client to adopt a costlier solution just because it was more sustainable until stricter government rules and legislations are imposed. However if enough evidence is gathered to prove that a more sustainable solution would help the client increase its green credentials and in return lead to more work, they may be more likely to consider this solution. The influence of cost in design was also considered by asking the participants to rate cost and sustainability in terms of relative importance, the results show that all the participants consider cost to be of primary importance compared to 40% who consider sustainability more important.

Research has shown that a geosynthetic solution can not only increase the sustainability of a project but also reduce the costs (WRAP 2010). Participants were asked if their company had examples that favourably compare the benefits of geosynthetic solutions with 'traditional' construction approaches in terms of both cost and sustainability. A total of nine responses were received for this question with six participants responding with a yes. This was a positive response, highlighting the fact that industry is researching and developing examples that will help to promote the use of geosynthetics. These examples could be used in further research. Having a large number and range of examples will help to validate research findings (e.g. WRAP 2010).

When looking at sustainability in the construction industry, the major consideration is often the carbon footprint of a construction project. When comparing the sustainability benefits of a 'traditional' method against a geosynthetic method, it is common to compare the carbon emissions or embodied carbon between the two approaches. In order to compare the carbon footprint of a project or method a number of carbon calculation tools have been developed. Results from the survey show that only 44% of the companies work with carbon calculation tools to support the design/assessment of a project. This means that a number of companies cannot provide a calculated comparison of the different levels of CO_2 emissions produced between a geosynthetic and 'traditional' method. WRAP (2010) includes a number of case studies that show for a range of specific construction applications, CO_2 emissions for a solution based on geosynthetics are significantly lower than that of a 'traditional' method. In most cases this is a result of using on site materials (i.e. soil fill) in the geosynthetics solution in comparison to the traditional solutions that required the import of high quality fill and removal of site soils as waste. A significant number of companies are currently unable to promote the CO_2 benefits and hence they are missing out on an important marketing advantage. The survey suggests sustainability is not given the same importance as cost by the client. However if companies could show that a geosynthetic solution could reduce the CO_2 emissions by a large amount even if the cost saving is relatively small, clients may be more likely to consider the geosynthetic solution. Leading on from this it was important to find out the views of the participants on whether a tool comparing the sustainability of a geosynthetic and 'traditional' methods would be useful. The tool mentioned would be used at a very early stage of any given project. It is anticipated that such a tool would be able to identify which method could produce the smallest carbon footprint for any specific project. The results were positive with 80% of participant stating a tool like this would be useful or even very useful, and no participants suggested it would be useless. This helps to highlight that companies realise that there is a need for increased sustainability and to promote this to the clients. A tool that could be applied at a very early stage of any project could help in winning more clients and increase the use of geosynthetics.

3.5 Barriers to the use of geosynthetics

The clearest answer received to a question asking for factors preventing increased use of geosynthetics was cost. This has been discussed previously and although in some cases a geosynthetic solution may be more costly, there are a number of examples and case studies available that show for certain projects

a geosynthetic solution is actually far more economical (WRAP 2010). Often a geosynthetic solution can be shown to save costs on extra material, reduce the amount of waste material and transportation needs are much lower. There is a clear need for further research and development of tools that not only compare sustainability but also costs of a project that may be carried out with a 'traditional' or geosynthetic solution.

Education was raised by more than 50% of participants and answers suggested that a lack of education in the general civil engineering industry and amongst designers, engineers and contractors is limiting the use of geosynthetics. There is a view that there is currently insufficient education on geosynthetics in degree courses in the UK, and that this is creating a lack of awareness of potential construction solutions involving geosynthetics. This is valuable feedback as a lack of education can lead to engineers and designers continuing to use 'traditional' tried and tested methods even though geosynthetic based solutions might be cheaper and more sustainable. This means that geosynthetic solutions do not get the exposure they warrant. It is also suggested that often consultant engineers take a conservative approach to design and stick to the 'traditional' methods that they are most confident in applying. With many clients not aware of the geosynthetic based options available, consultants are often not challenged to explore alternative options including using geosynthetics. The majority of the answers received in this section revolve around cost, consultants and education, with all three connected to each other. However the main way of dealing with this problem and increasing the use of geosynthetics is by educating all those concerned, but in particular the clients. If the client is made aware of the potential benefits of using geosynthetic solutions they are more likely to question consultants as to whether alternative designs with geosynthetics are a better option. A key area that requires further work is the need to improve coverage of geosynthetic materials, design methods and construction practices in civil engineering undergraduate degree courses. If geosynthetics are taught to the undergraduate engineers, then they will feel at ease working with them in the future. It may also lead to young graduates questioning their senior engineers on why geosynthetics are not being employed for certain projects and in return they would be acting as an educational tool. Some of the other issues raised in this section included concerns about the current financial market situation, oil market instability and the durability of geosynthetics. The current market situation and the oil market instability are issues dependant on a number of financial inputs, so there is nothing the geosynthetic industry can do to influence these. With regards to durability, this is something that can influence design decisions, and can be addressed by carrying out the relevant testing and analysis. There is worldwide experience of using geosynthetics in a range of applications for in excess of 30 years and many tens of thousands of successful projects, which can be used to demonstrate performance to clients. Concerns were also raised about poor geosynthetic copies infiltrating the market and not meeting the design requirements, ultimately damaging the image and reliability of the industry as a whole.

The survey also provided useful feedback about the guidance documents and literature being employed by those involved in the UK geosynthetic industry. Response from the survey suggested that certain documents such as BS 8006 (2010) and those mentioned in Section (3.1) lack clarity on selection of acceptable fill material. Documents like BS 8006 (2010) along with BS EN 14475 (2006) were reviewed further in order to fully understand the views of the participants with regards to guidance documents. The documents provide considerable guidance on the design processes and steps and they also provide information about how to obtain design parameters, testing requirements and selection of partial factors. However the main problem is the lack of clarity on the fills that can be used. They appear to propose a very strict approach to the mechanical characteristic of the fills that can be used. It may be argued that in some cases the standards are employing over-cautious criteria for some applications. It is here where the main challenge arises as geosynthetics are often at their most economical when being used on projects involving non-standard fills, or fills that could not be used in 'traditional' methods, and hence would have to be removed from site. If the standards are overly prescriptive on the range of fill materials that can be used, this will reduce the number of potential applications. It also leads clients to believe they would be taking a risk when employing a fill material that is not recommended by the documents. There is extensive experience and published case studies demonstrating the successful use of marginal fill materials in conjunction with geosynthetics (i.e. in reinforcement solutions). Greater effort is required to disseminate this practice and experience to designers and clients.

3.6 Selection of Solutions

To understand the process of how and why a client may decide between geosynthetic and 'traditional' methods in a design process, a specific question was asked. The question considered instances where a client has been introduced to a geosynthetic method and they have opted to go for this, over the 'traditional' method they had originally proposed to use. This question had to be designed to evaluate the client's selection process, and whether companies could market the benefits of a geosynthetic to an extent where a client changes their mind about going with a 'traditional' method. All the answers received focused on cost. The respondents stated that the client has often been persuaded by the significant cost savings of a project to employ a geosynthetic method. The number of participants providing positive responses suggests that clients can be converted to using geosynthetic based solutions. However, cost is the major factor in selection of a solution, although there are still a number of cases where a geosynthetic solution may be less economical, yet provide other benefits. Reduction of construction time is one of these benefits and this was raised in the responses. One of the participants also mentioned interaction of the construction project with the landscape. Often in construction the aesthetics of the finished project are very important. Geosynthetics allow for vegetated retaining walls and other solutions that incorporate the landscape and interact well with the natural environment far better than a 'traditional' method could (e.g. reinforced retaining structure).

The second part of the question asked the participants to provide examples and the reasons behind a client's choice where they have refused the geosynthetic solution and stuck to the 'traditional' solution. The participants provided a range of answers, many closely tied in with responses to previous parts of the survey. The participants stated that the client's lack of experience of working with geosynthetics is often why they choose not to proceed. It is also reported that clients often perceive geosynthetics as new technology and prefer to stick to the tried and tested approach, showing significant conservatism and lack of confidence in geosynthetic solutions. This reinforces the conclusions in Section 3.5 that a lack of education and experience in the clients is leading to geosynthetics not being utilised as much as they could be. Feedback from the respondents has highlighted the need for the geosynthetic industry to work closely with potential clients in educating and removing their fears or concerns about geosynthetic solutions.

3.7 Survey Feedback

Participants were asked to provide feedback on the survey and to suggest questions that they feel could have been asked in the survey. The responses focussed on the subject of quality control, substandard materials and imitations. There is concern that cheap inferior geosynthetics are finding their way in to the market and that this is having a damaging affect on the geosynthetic industry. The results from this survey suggest that companies would like more work done to form stricter regulations to prevent the use of cheaper less effective copies of geosynthetics, which are tarnishing the reputation of the more established geosynthetic manufacturers.

4. CONCLUSION

The survey invitation was emailed to 29 participants with 10 responses being received. The feedback and answers from the survey can be used to help understand the view of the geosynthetics industry on why geosynthetics are not being used in preference to 'traditional' methods. The answers provide an insight into a number of key topics ranging from sustainability to the current market situation.

The most important aim of the survey was to understand the barriers to increased use of geosynthetics. The feedback from the survey suggested that education was the biggest barrier to the increased use of geosynthetics. Client's lack of education and awareness of geosynthetic solutions means that they are unable to challenge consultants about possible alternatives to traditional solutions. In order to remove this barrier more needs to be done to increase the awareness of clients and consultants to geosynthetic options; suggestions included an increased emphasis on geosynthetics in civil engineering undergraduate programmes so that all students are exposed to uses and potential benefits. The survey also identified that poor quality geosynthetics were entering the market and damaging the credentials of

the industry. Clearer specifications and rigorous quality assurance procedures are required. It was noted that the current financial market instability and oil prices also have an influence on geosynthetic costs, but that this is outside the control of the geosynthetics community.

The survey demonstrates that sustainability is being considered in many designs and that numerous case studies have shown that geosynthetic solutions can provide significant reductions in CO_2. However, clients are still using cost as the main criteria for selecting solutions. This is unlikely to change unless stricter legislation and/or targets for reduced CO_2 are brought in. The survey did show that there were many situations were cost of a geosynthetic solution was lower than a 'traditional' solution, proving scope for increased marketing on this basis.

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REFERENCES

BS 8006 (2010). Code of practice for Strengthened/reinforced soils and other fills. *British Standards Institution*, London, UK.

BS EN 14475 (2006). Execution of special geotechnical works – Reinforced fill. *British Standards Institution*, London, UK

Fink, A. and Kosecoff, J.B. (2005). *How to conduct surveys: a step-by-step guide,* 3rd ed., London: Sage.

WRAP (2010). *Sustainable Geosystems in Civil Engineering Applications*, WRAP, Project code MRF116-001