The Use and Effectiveness of Geotextiles on Road Projects in Scotland

M. G. Winter
Transport Research Laboratory, Scotland, UK

J. C. Cross & J. Oliphant
Heriot-Watt University, Edinburgh, UK

ABSTRACT: A database of geotextile use on Scottish trunk roads has been compiled for the period 1980 to 1992. Information contained on the database indicates that, on thirty-three projects, approximately 600,000m^2 of geotextiles were used in subgrade separation and drainage & filtration applications. It is considered that there is scope for increased use of geotextiles on Scottish road projects. Cost-effectiveness ratios of 2.56 and 2.31 are found for subgrade separation and drainage & filtration applications respectively, when compared to alternative solutions. These values are consistent with those reported in the literature, which are in the range 1.5 to 8.1. Problems identified in relation to the use of geotextiles are limited and are reported in this paper. These problems emphasise the importance of correct design and specification, of careful installation, and of adequate site drainage. There is no evidence of claims associated with the use of geotextiles.

1 INTRODUCTION

Highway projects provide a wide range of potential geotextile applications. These include drainage and filtration, subgrade separation, retaining walls and bridge abutments, and slope steepening and pavement reinforcement. The primary objective of the use of geotextiles in such applications is to achieve improved cost-effectiveness over more conventional construction techniques. The use of geotextiles can also result in time savings, by rapid construction techniques, and environmental benefits, by reducing the quantities of imported fill materials and land take.

The UK national roads programme, announced in 1989 (Anon 1989; 1993a), includes plans for motorway schemes costing some £12bn at 1993 prices. In Scotland, capital and current expenditure on trunk roads and motorways was £231m in 1992/3 (Anon 1993b). Client bodies require maximum value for money from such construction works (Johnson 1993). The present study was designed to identify the current level and cost-effectiveness of geotextile use on Scottish road projects. It was also designed to allow any problems associated with the use of geotextiles to be reported.

This paper concentrates on the use of geotextiles in subgrade separation and drainage & filtration applications. The use of geotextiles in retaining wall and bridge abutment, slope steepening, pavement reinforcement and other applications on Scottish road projects will be reported separately.

2 DATA ACQUISITION

A database of geotextile use on Scottish road projects was compiled for the period 1980 to 1992. Information for the database was obtained from questionnaires sent to highway designers in both the private and public sectors. Data from these questionnaires was supplemented with information from interviews.

Questionnaires were sent to fifty-five organisations. Of these, twenty forwarded the questionnaires to a parent office. Thus, thirty-five questionnaires were effectively targeted. To date, nineteen organisations have responded with details of geotextile use on thirty-three road projects. This corresponds to a response rate of 54%. Responses are being pursued from the sixteen organisations who have not yet returned questionnaires.

3 RESULTS

Project costs were obtained for each scheme in the year of

Table 1 Results from questionnaire responses.

Application	Total Number of Projects	Quantities, Costs and Unit Rates (Number of Projects)						
		Unit	Geotextile Solutions			Alternative Solutions		
		Quantities* (m^2 or m)	Geotextile Quantities (m^2)	Total Costs (£)	Average Unit Rate** (£/m^2 or £/m)	Project Details Available	Total Costs (£)	Average Unit Rate** (£/m^2 or £/m)
Subgrade Separation	27	379,634 (25)	394,718 (25)	182,973 (21)	0.55 (21)	- (6)	130,115 (3)	1.94 (3)
Drainage & Filtration	27	132,503 (21)	197,386 (21)	107,582 (15)	1.85 (12)	- (2)	33,600 (1)	112.00 (1)

* Unit quantities are m^2 for subgrade separation and linear m for drainage & filtration applications.
** Unit rates are £/m^2 for subgrade separation and £/m for drainage & filtration applications.

opening. These were converted to equivalent 1991 prices (Anon 1993c) using the Road Construction Price Index (RCPI). This base year was selected as the most recent year for which full RCPI data was available. The use of the RCPI allows the effects of market fluctuations to be eliminated. A valid cost comparison can thus be made. It should, however, be noted that the RCPI does not account for anomalous unit rates introduced by the contractor's decisions on the distribution of risk over the items in the contract bill of quantities.

The results from the questionnaires for subgrade separation and drainage & filtration applications are summarised in Table 1. Geotextiles were reported as having been used in subgrade separation and drainage & filtration applications on twenty-seven projects each.

3.1 Subgrade separation

Of the twenty-seven subgrade separation projects, unit quantities and total costs for the geotextile solutions were obtained for twenty-one giving a range of unit rates between £0.29/m^2 and £1.30/m^2, with one high value of £5.00/m^2. The high unit rate may be due, at least in part, to the very small quantities of geotextile (60m^2) used, which would mitigate against any economies of scale in the purchase of the geotextile. The effect of this unit rate on the average unit rate for geotextile solutions is negligible. The average unit rate for subgrade separation applications was £0.55/m^2. (Unit quantities and unit rates for subgrade separation refer to the area, in square metres, of subgrade treated with geotextiles.)

Although alternative solutions were considered for six projects, costs were estimated for only three. The average unit rate for the three alternative solutions was £1.94/m^2. Alternative solutions included the excavation of unsuitable subgrade material, the use of a thicker capping layer and using geotextiles in selected areas only. On one project the use of geotextiles in selected areas would have entailed 29,700m^2 of material, compared to 82,000m^2 for the adopted solution of treating the entire area with geotextile. Although costs for the alternative solution were not obtainable, the alternative may have had a lower cost, despite the greater excavation and capping layer quantities. However, the amount of testing required to select the areas to be treated would have been considerable. This would not only add to the total cost, but also introduce the possibility of delays to the construction work due to testing activities.

Unit quantities and total costs for both geotextile and alternative solutions were obtained for three projects. These three projects included the treatment of a total of 66,966m^2 of subgrade with geotextiles. Total geotextile solution costs were £50,850 and total alternative solution costs were £130,115. The cost-effectiveness ratio was 2.56, in favour of the geotextile solutions.

3.2 Drainage & Filtration

Of the twenty-seven drainage & filtration projects, unit quantities and total costs for the geotextile solution were obtained for thirteen. From the thirteen data sets, two very high unit rates (£21.00/m and £48.59/m) and one very low unit rate (£0.01/m) were calculated. The latter was excluded from the calculation of average unit rate as a statistical outlier. The remaining ten unit rates varied between £0.45/m and £4.48/m.

The high unit rates may reflect prices for the entire drainage system while the lower unit rates may reflect prices for the geotextile filter only. However, provided that geotextile and alternative solution costs are given on the same basis then the derived cost-effectiveness ratio remains unaffected. It should also be noted that for drainage & filtration there is a wide range of potential geotextile use. A wide range of unit rates might therefore reasonably be expected. In comparison, subgrade separation applications are relatively simple, geotextiles being generally used in place of a thicker capping layer or instead of removing a weaker layer of soil.

The remaining 12 projects gave an average unit rate of £1.85/m for drainage & filtration. (Unit quantities and unit rates for drainage & filtration refer to the length, in linear metres, of drainage constructed with geotextiles.)

Although alternative solutions were considered on two projects, costs were estimated for only one. The unit rate for the alternative solution was £112.00/m. The alternative solution was excavation of the entire volume of material to be drained. This goes some way to explaining the high unit rate of both the geotextile solution (£48.59/m) and of the alternative solution.

The total drainage provision was 300m (4,080m^2 of geotextile). The total cost of the geotextile solution was £14,577. For the alternative solution the total cost was £33,600. This single project has a cost-effectiveness ratio of 2.31, in favour of the geotextile solution. It should be noted, however, that this project has high unit rates for both the geotextile and the alternative solution. The above cost-effectiveness ratio should thus be treated with some caution.

The other alternative solution considered involved the use of a granular filter.

4 PROBLEMS ENCOUNTERED

In the thirty-three projects detailed in the questionnaire returns, four included reports of problems related to geotextile use.

The problems reported on two projects related to the use of fin drains. Both installations were in road verges. On the first project undermining of the carriageway was observed during installation. This appears to be due to inadequate trench support during drain installation. Installation of the fin drain on the second project had little effect on the drainage of a flooded verge. This suggests either an under-estimate in the design capacity of the drain or contamination of the geotextile filter media.

The remaining two problems related to subgrade separation applications. The first involved the failure of a turning area for earthworking plant. A 400mm layer of sub-base material was placed above the geotextile separator. The failure occurred after a period of high rainfall and the failure was attributed to inadequate drainage. The second also emphasised the importance of adequate site drainage. On this site the installation of the geotextile was hindered by the ingress of both surface and ground water, particularly in areas of highly compressible subgrade. Additionally, some areas of geotextile were punctured by the underlying rockfill. This could have been due to either inadequate design against puncture or to construction practices outside the terms of the specification.

The problems experienced with the use of geotextiles highlight the importance of correct design and specification, careful installation and of the provision of adequate site drainage.

There was no evidence of claims in connection with geotextile use.

5 DISCUSSION

The data reported in this paper should be treated as a relatively small sample of the population of data from Scottish road projects. However, the number of geotextile applications was considered sufficient to allow a valid analysis to be performed.

Geotextile use totals approximately 400,000m^2 on twenty-five projects for subgrade separation and approximately 200,000m^2 on twenty-one projects for drainage & filtration (Table 1). It is considered that there is scope for increased geotextile use on Scottish road projects.

Although there is no known cost-effectiveness data relating to subgrade separation, a limited amount is available for drainage & filtration applications. For highway edge drains, Finazzi and Thomson (1984) reported a cost-effectiveness ratio of 1.8 for geotextile filters compared to conventional aggregate filters. The cost-effectiveness ratio for fin drains was reported as being up to 2.0 when compared to conventional french drains (Webb 1991). Wall drainage system cost-effectiveness ratios are reported in the range 1.5 to 8.1 (Thomson et al., 1984), for a comparison between geocomposite drainage systems and aggregate, porous concrete and porous block drains.

The cost-effectiveness ratios in the present study are consistent with the limited data in the literature.

The number of alternative costs available is small, a total of four for subgrade separation and drainage & filtration combined. This may have resulted from geotextile solutions having been used to solve technical problems without alternatives solutions being considered or, once considered and rejected on technical grounds, alternative solutions not being costed. If the increasing use of geotextiles on Scottish road projects is to be properly justified economically, then alternative solutions need to be considered and their costs determined.

6 CONCLUSIONS

Based on the quantities of geotextiles used in the projects reported in this study, it isconsidered that there is scope for increased geotextile use on Scottish road projects. An estimated 250 projects were active in Scotland during the period considered by the study compared to the thirty-three projects for which data has been obtained.

The data presented yield cost-effectiveness ratios for subgrade separation and drainage & filtration of 2.31 and 2.56, respectively. These values are consistent with those found in the literature.

Relatively little data were obtained on alternative solutions. If the increasing use of geotextiles is to be properly justified economically, then alternative solutions need to be considered and costed.

Problems identified in relation to the use of geotextiles emphasise the importance of correct design and specification, careful installation, and of adequate site drainage.

The is no evidence of claims associated with geotextile use.

ACKNOWLEDGEMENTS: Crown Copyright 1994. The views expressed in this paper are not necessarily those of the Department of Transport or of the Scottish Office Industry Department.

The work described in this paper forms part of a Scottish Office Industry Department research programme conducted by the Transport Research Laboratory, Scotland (Director, Dr G.D. Matheson), and the paper is published by permission of the Scottish Office Industry Department and the Chief Executive of TRL.

The authors wish to thank the Consulting Engineers and Regional Councils who provided information for this study.

REFERENCES

Anon (1989) *Roads for prosperity*. Department of Transport, Cm 693, Her Majesty's Stationery Office, London (May).

Anon (1993a) *Paying for better motorways*. Department of Transport, The Scottish Office, The Welsh Office, Cm 2200, Her Majesty's Stationery Office, London (May).

Anon (1993b) *Transport statistics Great Britain, 1993 Edition*. Department of Transport, Scottish Office Industry Department, Welsh Office, Her Majesty's Stationery Office, London (September).

Anon (1993c) *Road Construction Price Index*. Department of the Environment, London (March).

Finazzi, M. and Thomson, S. (1984) *Geotextiles 2000: Techno-economic analysis of the use of geotextiles; Volume III Technical study*. Battelle, Geneva Research Centres, Geneva.

Johnson, P. (1993) The way forward: the Client's view. *Geotextiles in Drainage and Filtration*, pp. 131-137, Thomas Telford, London.

Thomson, S. A., Chevaillier, J. P. and Finazzi, M. (1984) *Geotextiles 2000: Techno-economic analysis of the use of geotextiles; Volume I Economic study*. Battelle, Geneva Research Centres, Geneva.

Webb, C. (1992) Changing attitudes. *Highways*, pp. 11-13 (May).