Teaching of geosynthetics in UK Universities

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ABSTRACT: The contact time assigned and the methods used to teach geosynthetic topics at undergraduate and postgraduate levels in universities in the UK are reviewed. The development of geosynthetics teaching is described and the suitability of available text books briefly considered. Results of a questionnaire completed by 21 universities in May 2000 are summarised in tabular form with comment from individual respondents. Current teaching typically involves between 2 and 6 contact hours on geosynthetics usually within 2nd and 3rd year applied geotechnics modules with greater times assigned in more specialized postgraduate modules. An 'ideal' contact/teaching framework is suggested for undergraduate and postgraduate courses. Teaching methods are reviewed together with the role of laboratory based sessions. Learning based on complete case studies is considered to be a most appropriate method to help students to appreciate and understand particular geosynthetic applications.

1 INTRODUCTION

The use of Geosynthetics within the Civil Engineering and geo-environmental construction industry has increased dramatically over the last 10 to 20 years such that today there are few construction projects which do not include some use of geosynthetic materials in the permanent or temporary works. It is perhaps inevitable with such a rapid growth that the teaching of geosynthetics in academic institutions has lagged somewhat behind the current level of use within industry. This Paper reviews the current situation with regard to the teaching of geosynthetics in the UK. It draws on the views of academic colleagues to suggest an appropriate strategy for further development of the teaching programme and the support which might be offered by the geosynthetics industry and the International Geosynthetics Society (IGS).

2 METHODOLOGY

In order to assess the current position, 40 universities with Engineering Departments were invited to assist by completing a questionnaire on their current approach to the teaching of geosynthetics. Twenty one universities replied to the questionnaire and this information has been used to prepare the summary, as shown in Table 1, and help form a view on the future direction that the teaching of geosynthetics might take.

The Author is most grateful to those academic institutions as listed in Table 1 who were able to help with the review. The analysis of any questionnaire can only be based on the replies and comments received and inevitably the results reflect a certain bias generated by the nature of the questions. For example, it may be that the universities which replied are more likely to have developed their geosynthetic teaching than those who did not reply.

3 DEVELOPMENT OF GEOSYNTHETICS TEACHING

There have been various initiatives to introduce the subject of geosynthetics into the teaching curriculum. In the past, the subject has been very much industry led with research commissioned from specific universities. The research interests have in turn sometimes led to the provision of short courses for industry, for example on reinforced soils. The academics involved have, through their own enthusiasm and interest, often covered the subject alongside the conventional approaches without any particular syllabus revision.

The major geosynthetic manufacturers have often been prepared to give talks to university students where the in-house lecturers have not had sufficient knowledge of the subject or a practical/commercial view point was required. Manufacturers have generally been willing to organise site visits to demonstrate practical applications of their products. The fact that manufacturers have often produced comprehensive design manuals around the use of their propriety products may, to some extent, have inhibited development of the academic approaches by restricting academic exposure and familiarity with the topics except for those commissioned to assist with the manual preparation.

In North America, the perception from the UK is that organisations such as the North American Geosynthetics Society (NAGS) together with the IGS initiatives have provided substantial base reference material to help universities plan their courses. Specific 'professor' training Programmes sponsored primarily by the National Science Foundation and the Industrial Fabrics Association have been available to support teachers of geosynthetics in the USA.

As Masters programmes are developed or revamped in the UK there is sometimes the opportunity to include a greater element of geosynthetics (as reported at Glasgow Caledonian, Bolton, Imperial college, Portsmouth, Leeds, Manchester, Glamorgan and Glasgow universities) or to include a full module on geosynthetics (as at Nottingham Trent University).

The module at Nottingham Trent is run as one of 10 taught modules forming the Part time MSc in Construction / Geotechnical Engineering Design and Management. The module runs over a 6 or 7 week period with a combination of home learning from a comprehensive study guide and university attendance for 2 weekends. Weekend attendance is preferred by delegates to avoid time away from the workplace. The syllabus takes delegates through a basic understanding of the polymer materials and on to review the various geosynthetic applications with testing, specification and compliance requirements to provide a practical framework for the practicing engineers taking the course. Site visits are included where possible (Figure 1). The course contributors are industrial specialists /leaders in the particular topic area (rather than academics) with the academic rigor and assessment controlled by the writer as course leader. This combination of industrial and academic involvement proves very popular with the delegates who report a high level of satisfaction with the course

3.1 *Text books and Reference Material*

One factor which often inhibits the teaching is the lack of appropriate textbooks. A basic textbook was prepared by N.W.M John (John 1987) to help lecturers and students but it became dated and does not seem to have gained general acceptance.

The comprehensive texts by Koerner (1994) and Ingold (1992) and the more specialised text by Jones (1996) are valuable reference documents but costing £70 - £90 are beyond the means of most students and are too comprehensive for an initial introduction to the subject. With the lack of curriculum time to introduce a full course on geosynthetics teachers are unlikely to require the student to purchase a text book just relating to 1 or 2 lectures.

Publishers are currently exploring the possibility of preparing an up to date modestly priced general text on geosynthetics. This would be valuable as the growing coverage of geosynthetics would merit an accessible text book in the £20 - £30 price bracket. Alternatively it may be possible in revised editions of current soil mechanics textbooks to include a reasonably substantial section on geosynthetics.

Other reference material is available such as that prepared by NAGS to assist teachers in putting courses together and videos and slides are available through the IGS. These are of some assistance but still depend on the curriculum slot being available.

4 THE RESULTS OF THE QUESTIONNAIRE

4.1 *Currrent level of geosynthetics teaching*

The 21 universities report typically 2 to 4 hours of contact time for the teaching of geosynthetics, mainly within the 3rd and 4th year undergraduate modules (Table 1). Three universities, Sheffield Hallam, Leeds and Loughborough, reported final year geotechnical modules with 6 contact hours relating to geosynthetics. The picture is slightly complicated by more emphasis on the teaching of geosynthetics in specialist optional modules such as Waste management and Geohazards where students may be introduced to further applications of geosynthetics. Students often have the option to study geosynthetic applications within the individual projects prepared during their final year.

At Masters level, the subject is receiving reasonable coverage (typically 2 – 6 hrs) within modules such as Solid waste management, Retaining walls, Coastal engineering, and geotechnical processes (Reinforced earth). Only Nottingham Trent University is at present providing a full Masters module with 24 contact hours devoted to geosynthetics.

Most universities reported the inclusion of geosynthetics questions in assignments and examinations at both undergraduate and Masters levels.

4.2 *Ideal contact time*

Most respondents would prefer to see further expansion of geosynthetics as indicated in the right hand column of Table 1. A progressive approach is favoured by many including the writer. The following suggested framework emerges from the comments:-

Year1 BSc/BEng/MEng	Mention in passing but no specific tuition	
Year 2	Introduce to Geosynthetic materials and properties	4 hrs
Year 3/4	Core coverage in related subject areas (Retaining walls, drainage, containment etc)	6 hrs
	+ specialist elective modules including geosynthetic applications	10 hrs
MSc	Depends on nature of the programme.	
	Specialist module on geosynthetic applications	24 hrs
	Or inclusion as section alongside 'conventional' subject teaching in modules covering Retaining structures, Remediation, Waste management, Geotechnical processes, Environmental engineering etc.	say 6/24 hrs

The provision of a full Masters module on geosynthetics is regarded by the writer to be of value although its content may change as undergraduate coverage increases. The need for a practically oriented module at Masters level may diminish as the applications would be partly covered within the undergraduate programme. The full geosynthetics Masters module should perhaps then be oriented towards research and development of geosynthetic materials, design applications, specification and testing rather than routine applications.

Table 1. Questionnaire Response - Teaching of Geosynthetics in UK universities -Typical and 'Ideal' contact hours

	Univ/College	Course/level	Contact hrs /Total. hrs	Module name	Assessment	Ideal contact time?
1	Aston	Undergrad/3	Not formal-ised	Highway Des +final yr topics		20% of final yr as-sessment
2	Bolton	BEng/3 MSc	3/60 3/45	? Geo-env.geotechnol	1 exam Q 1 Exam Q	BEng/1 - 6hr MSc(geo)- 6hr
3	Exeter	MEng/3	0.7/86	Geotech. Eng	None	2 hr (lot more if 'op-tion' available)
4	Glasgow Cal.	BSc /3 BSc (env)/3 BSc (env) /4 MSc (waste man)	5-7/78 4/12 4/24 5/48	Geotechnics II Solid waste man.	1 or 2exam Q 1 or 2 exam Q 1 or 2 exam Q 1 or 2 exam Q	N/A
5	Imperial	MSc	<3/18	Geotech. Processes (reinf earth)		
6	Liverpool J M	HNC/D /1	4/48	Civ eng (retain. Struct.)		Final year option de-sirable
7	Loughborough	BEng/MEng	6/33	Ground Engineering	Exam Qs	33 hr –full module
8	Mid Kent	Nat. Cert /2 HNC/D /1	1/540 2/540	Materials Civil Eng Const.		
9	Portsmouth	BEng,MEng2/3 BEngMEng/3 MSc/MEng/4	3/45 3+/45 3/45	Geotechnology Civ.Eng Des. Geotech+ coastal		Yr13hr base theory Yr2 – 6hr (practical application) Yr3/4 – Many (as part of integrated des.)
10	Sheff. Hallam	BEng/3	6/36	Geotechnical Eng. (option)	No Exam Tutorial	Yr 2 – 2 (intro) Yr 3 – 4 (core) Yr 3 –6 (option)
11	Hertfordshire	BEng/3 BEng/3	1/50 2/50	Geotechnics Geo-environ. Eng.		Yr 3 (final)-4hr
12	Leeds	BEngMEng/ 3 MSc /4	6/22 5/44	Geotechnics Soils Eng.	+lab/des. Pro-ject	Yr2 – 5 (basics) Yr3 – 10 (detail)
13	Manchester	BEngMEng3 Civ BEngMEng3 Struct. Eng & Arch. MEng,BEng Civ +MSc Env Eng +MSc pollution and Env. control	Not de-fined/24 Not de-fined/24 3/24	Design in Geotech-nics Design in Geotechnics Solid waste man-agement	No formal tui-tion Some exam Qs	Yr 2 'in passing' in each engineering topic Yr3 - 6hrs in Grnd.Eng. mod
14	Nottingham Trent	BEng/3 BSc/3 BSc (Env. Eng/3) MSc	2/24 4/24 4/24 24/24	Geotechnics Geotech. Enginring. Waste disp/land rec. Geosynth Mod.(opt)	1 exam Q 1 exam Q assignment	Yr 2 intro –4 hr Yr 3 core – 6hr + poss option –10 hr MSc full option 24 hr
15	Sheffield	Civil /Struct/3	4/36	Geotech. Des. +const.	Part of examQ	Yrs 2/3/4 4-8 hrs ideally within particular applications
16	Bristol	MEng/4	4/20	Geotechnics 4	1or 2 exam Qs	Current is ok for Civ Eng degree courses
17	Abertay Dundee.	BEng /3 BEng /4	1/60 2/60	Geotechnics 3 Geotechnics 4		Yr 4 4hrs (emb des + reinfcmnt.
18	Dundee	BEng/4 BEng/4	2/40 3/25	Adv. Geomechanics Design Project		OK as is
19	Glamorgan	BEng 2/3 BSc 2/3 MSc	4-6/60 4-6/60 6/60	Geotechnics Geotechnics Grnd. Eng.I and II	assignments Ditto Poss. exam Q	As extension of fun-damental and specific topics

Table 1. Questionnaire Response - Teaching of Geosynthetics in UK universities -Typical and 'Ideal' contact hours (continued)

	Univ/College	Course/level	Contact hrs /Total. hrs	Module name	Assessment	Ideal contact time?
20	Glasgow	MEng/BEng/ 2 MEng BEng /4 MEng/5 MSc	2/30 2/30 case studies 2/30 2/30	Highway Eng 2 Geotech Eng 4 Elective studies Retaining struct. Environ. Geotech.	1 exam Q + coursework. Part of exam Q or crswork	Recently increased hence ok. Possible expand MSc coverage
21	Portsmouth	Eng Geol/2 App Env. Geol /2 Geol. Haz /3	3/33 3/33 3/33	Geomaterials Geomaterials Geohaz.Remediate.		Yrs 2/3 Approx 6-10 hrs

Table 2 . Questionnaire Response - Use of Laboratory Sessions on Geosynthetics

Do you have any laboratory sessions relating to geosynthetics? (please give details)
• No (x 16) • No, except simple demo of retaining wall • Demonstrations in labs +PhD students lab. Work • Yes- lab tests of properties • Yes- model retaining wall, computer based slope stability projects, reinforced earth etc.
Do you consider any particular laboratory sessions would be valuable to students given availability of appropriate equipment (and curriculum time)?
• Yes (x 4) • Yes – any ideas? • Yes interface testing, protection, filtration, drainage • Lab sessions of use in understanding mechanisms of geogrids in retaining structures and slope stability. • Simple material testing would be informative but not high priority. • No (x 2) • Not at this level • Not particularly, more case study based. • Not at undergrad level • No, but site visits needed • Unsure • Issue of time restriction – comparison shear box with /without geotextile could be helpful • Maybe – not really sure what. • Possibly but so could other geotech. techniques/ procedures.

Table 3 Questionnaire Response – Teaching methods

Teaching methods might include:- lectures, case studies, tutorials(working through a problem), group project work, lab.work, model tests, site visits etc. Do you have any comment on the relevance of these for teaching geosynthetics?
• Site visits where suitable project in close vicinity, IT video clips, library of practical clips? • Model tests would be relevant. • I use excellent quality video tapes and slides, digital camera images from past industrial experience, • Tutorials, lab demonstrations, site visits, and visits from geosynthetics companies. • Case studies always valuable, as are site visits • All are relevant • Personally favours case studies • All are relevant – previous very good external lecture by Peter Rankilor • Currently use case studies and tutorials only – site visit would be beneficial but time restraints. • Lectures and case studies • All useful especially case studies with back up material. • Videos are very useful and time/cost effective • Relevant case studies useful, slope stability coursework incorporating reinforcement and commercial slope software package. • Currently restricted to lectures – probably appropriate for the topics covered • Case studies – Web?

Table 4. Questionnaire response - Restraints on Increased Coverage of Geosynthetics

What are the main restraints to increasing coverage of geosynthetics in your courses (assuming you feel it should be increased)?
• Time pressures on syllabus, particularly due to modularisation • Not convinced it needs increasing, time restraints main issue • None • None - we will introduce more on our new Sartor 3 courses (commenced 1999) • N/A (x 2) • lack of time (x 5) • Time :no specialist knowledge • Time- No way at present a new module could be introduced • Wide content and reduced time • crowded curriculum • We are trying to reduce contact time and increase student learning • Time, availability of teaching resources-eg slides, design calcs tend to be somewhat involved, limited coverage in udergrad text books. • Main difficulty is vast range and scope –our 4 introductory lectures aim to give broad overview and a few topics in detail. • Too specialised for undergraduate level • At undergrad level geosynthetics is introduced as extension to the teaching of fundamental and specific topic areas –movement of water, retaining structures, slope stability etc –time is governing factor. However MSc modules do deal more specifically with the use and application of geosynthetics especially reinforced earth where design is covered in detail.

Table 5. Questionnaire response - Topics that might be reduced and expertise to teach Geosynthetics

Are there any topics you feel might be given less coverage in favour of more time on geosynthetics?
• Possibly seepage ? • Concrete • All topics important, balance about right considering evolution over years • Not at moment • Not sure. • No (x 7) • ED EXCEC are currently reviewing the whole HNC/D structure so comment here probably premature • Personally in favour of less of the old theoretical subjects and more useful practical, but there is so much to do (see JBM) • No, all subjects are developing - requiring more time • Difficult to think of any • No- geosynthetics is an 'extra'- would like to cover more as it is 'core' in industry.
Do you have sufficient 'in-house' expertise to teach geosynthetics at the level you consider appropriate to your course(s)?
• Yes (x 10) • yes, just • just (not strongest area) • OK at basic level • No • Just about – design / construction experience would certainly be an asset. • Yes (expert opinion may be sought and guest lecturer/ presentation) • In house expertise is 'second hand' OK for undergrads but limiting for MSc level • Only on the construction side

Table 6. Questionnaire Response -Support that IGS might offer to academic institutions

Could the IGS provide any additional expertise to help with your teaching ?
• Yes- slide sets, samples, simplified design examples • Yes – good case study information; Simple design examples - possible design competition similar to those run by SCI • Yes, content list, expertise, personnel to run seminars for undergrad and post grad courses to cover design processes and case studies + information for project work. • Past video tapes were helpful – some additional expertise welcomed • Almost certainly if there was the time and energy • Illustrated case histories • Case studies in downloadable format • Loan copies of 2 videos very helpful. – it would be good to have permanent copies (A copy of the US FHA manual was kindly provided by IGS) • Visiting lecture (Tour around Universities) • Yes (x 2) • Teaching aids, case study material • More videos • Not until more time available • Not sure • You tell me! • Possibly • Possibly, Prof. Rankilor addresses needs as visiting professor

Table 7. Questionnaire response - IGS Introductory lecture

The IGS has experimented with a trial 'one-off' lecture as an introduction to Geosynthetics. Is this of value to you ? please comment on how you see it complementing your teaching programme.
• Could be a useful precursor/introduction to geotechnical processes • Would be of great value to myself and my students • Have an external (visiting) lecturer programme where this might fit • Visiting lecturers welcomed to bring variety • Yes, visiting lecturer • Yes it could be weaved into our programme –possibly in design project. Netlon have given seminars in the past. • More likely to be used either in Design Class or for Student Geotechnical Society • Yes, (x 2) • Yes as a 1 hour introduction • Yes –have hosted one(very well received by students) -Could only ever act as an introductory taster.- We would host one again – but problem is following it up coherently with more detailed coverage. • Yes, I use specialist lecturers from industry when I can- Guest lecturer would have up-to-date case records. • We always encourage industrial input- this type of activity would be very helpful. • Yes, particularly for final year projects (often linked to an industry based scheme) which involve the use of geosynthetics (Case study lectures) • Yes – a 'one-off' lecture would be useful for 4th year or MSc level • Not of value at moment • Need to assess the content of the lecture. • Guest lectures possible – it depends on the content • Possibly • It would be interesting to know it's content (what photographs etc. were used)

Table 8 Questionnaire Response - Other comments

Please provide any thoughts/ comments/ proposals to help form a direction for future input by the IGS (if needed?)
• Video clips available on the web server + interactive software for project work. • Case studies comparing ground loading and costs with say concrete retaining wall. • More info on erosion protection/ mats and design would be helpful. • If IGS provided information we might be able to use it , but problems of time pressures • Main scope for more geosynthetics in post graduate courses rather than undergrad. which are already bursting at the seams. • As noted above, some form of design example or simple competition would be of use. • Video, CD, web site • Teaching aids, case study material • A good example to follow would be as provided by British Steel (now Corus)- They hosted an 'education day' for lecturers, provided a series of lectures / case studies on designing with steel, workshop discussing needs etc. Also supplied comprehensive slide sets, B.S. piling handbook, Project guides, etc Also ran (with Steel construction institute)an annual Steel piling design competition which several undergrads enter each year. –similar venture would raise the profile of geosynthetics teaching in the universities • More dialogue on one-off lectures would be helpful. • Develop a web site • OTHER ISSUES: • Perhaps get more students to do research projects

4.3 *Use of laboratory sessions*

At present, very little laboratory testing experience is offered to students (Table 2). Opinions vary, but the feelings are that some laboratory testing sessions would be of value. The writer would like to see a simple 'hands on' programme in year 2 or 3 which demonstrated:-

a) Strength (Stress/Strain) characteristics
b) Filtration (permeablility/permittivity) characterictics
c) Friction/Interface characteristics

These could be covered at basic level by 1 or 2 laboratory sessions and would provide valuable insight into the nature of the materials and their required properties. Ideally the tests would be simplified versions of the BSEN/ISO standard tests.

4.4 *Teaching Methods*

Most respondents agreed that a variety of teaching methods should be used (Table 3) with particularly strong support for teaching around case studies. Manufacturers are very willing to provide case histories of projects involving their products but they do not always provide the right insight into the preliminary design processes where the use of geosynthetic solutions are considered alongside 'conventional' solutions nor do they necessarily point out the risks that may be associated with a geosynthetic based option. The design view is best provided by independent design consultants, but of course many projects are taken forward based on 'proprietory designs' and therefore an independent view is not always available. As time goes by, it is hoped that university lecturers will have access to an increasing number of independent, complete case studies. It may well be that manufacturers and installers, having the practical expertise, will still prepare certain case studies but with added comment or critique from an independent design consultant to avoid any apparent bias by the manufacturer/installer.

4.5 *Restraints on increased coverage*

The obvious restraint of 'time' within a full curriculum was highlighted by most respondents (Table 4). There were few suggestions for areas that might receive less coverage in favour of more geosynthetics (Table 5.). It is of interest to note that the bodies responsible for accreditation of degree courses (JBM for Chartered Engineer and JAP for technician qualifications) tend not to be specific in the coverage of topics such as geosynthetics within their guidelines for university courses. This sensibly leaves scope for universities to make adjustments to the syllabus as they feel are merited by changes in industrial practice and concerns.

Most universities feel confident that they now have sufficient expertise to teach geosynthetics at basic undergraduate level but recognise the need to supplement the teaching with 'expert' guest lectures in specialised topics (Table 5.)

4.6 *Additional Support for Academic Teachers*

When asked what additional support the IGS might provide for teachers (Table 6.), the greatest plea was for case study information. The videos produced by the IGS (on Landfills, and Transportation applications) have been appreciated and more are requested. Many see the Web as a means of conveying information by use of video clips and case history information.

The experimental 'one-off' lecture programme prepared with the assistance of Professor Peter Rankilor (Table 7.) proved to be of value to certain institutions although there was some criticism about the details of the content. More work is needed to refine and update the content but in principle, the availability of an independent introductory lecture is appealing to both the universities teachers and students. Ideally the lecture should be followed up by the in-house lecturer to consolidate and enlarge upon the topics introduced.

4.7 *Other comments*

The general suggestions offered to help the IGS and others to form a support programme for the future may be read in Table 8. The suggestion of an 'education day' for lecturers is well worth progressing. This may be linked to the Meeting of Teachers of Geotechnical Subjects (MTGS) held in the UK in September each year.

5 CONCLUDING COMMENTS

The teaching of geosynthetics now forms a part of the curriculum for most UK universities. Having taken this first step to introduce the subject it should be relatively straightforward to reconsider the scale of teaching as course teams review the course content on a regular basis.

It is desirable that the main thrust of geosynthetic teaching should be in the 2nd and 3rd (or 4th) years of undergraduate degree courses with the material properties and characteristics covered initially followed by a study of the applications alongside conventional solutions in each subject area. Complete case studies are regarded as the most appropriate way of learning the practical applications.

It is unlikely that full modules on geosynthetics would be developed at undergraduate level although the subject could well be assigned a high proportion of the available time in modules covering waste management, retaining walls and slope stability.

At postgraduate level complete specialist modules on geosynthetics will have a place to help those in industry who did not receive the basic training at undergraduate level and for more specialised study of the design, specification, testing, and applications of geosynthetics.

ACKNOWLEDGEMENTS

The writer is most grateful to colleagues in the universities listed in Table 1 who were able to respond to the questionnaire and provide helpful views and comment. The figures used in the tables are intended only as a general indication of the position on the teaching of geosynthetics in May 2000. At all universities the level of teaching in a particular subject area is reviewed as courses are re-modelled and re-validated. It is recommended that individual universities are contacted for full details of geosynthetic teaching currently being offered.

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Figure 1. Students assess a temporary steep reinforced slope during the Masters module on Geosynthetics at The Nottingham Trent University.