Safety engineering programme: a partnership development between academics, engineering practitioners and professional institutions

Professor Amir Alani
Department of Civil Engineering
University of Greenwich

Abstract
Safety training is a key element of the industrial training provided by engineering employers to employees at all stages in their careers. Safety engineering is also an integral part of the curriculum of courses recognised by the Engineering Council and its affiliated professional bodies. Evidence shows that high quality teaching and training are essential to maintain high standards of safety within industry. Employers who have invested in safety training have demonstrated much reduced levels of injury, accidents, damage to property and “near misses”.

The main aim of this project was to engage academics and employers within the civil engineering and construction sector (as well as mechanical, manufacturing and petroleum engineering) with a view to identifying appropriate content/curriculum and structure for an undergraduate programme in safety engineering.

Results and findings of this investigation provided knowledge and information for developing an undergraduate safety engineering programme within the civil and construction engineering discipline at the University of Greenwich (using the overall structure of a three year BEng (Hons) programme). Based on the findings of this project in collaboration with industry, it is envisaged that a suite of continuing professional development (CPD) programmes, aimed at professionals and practicing engineers within the sector, will be developed.

Engagement of academics and engineering practitioners of different disciplines within the civil and construction engineering industry has been of paramount importance to this project. The project provided an opportunity for close interdisciplinary interaction within the School of Engineering at the University of Greenwich, between the relevant industries and beyond.

This project could be considered as the first stage of a useful case study in the context of employer engagement in curriculum design, development and delivery.

Results and findings of this project will be integrated into the full development of an undergraduate programme (programme, course and module specifications) at a later stage. There is a strong possibility that the developed programme could introduce different pathways covering a wide range of disciplines within the civil and construction engineering field.

Keywords: safety engineering, employer engagement, programme development, professional institution

Background
Safety engineering in civil and construction engineering is a niche and much-needed area of development in terms of the training of our future engineers. A gap in provision for this particular area of engineering has been visible for many years. The factors that highlight the authenticity of such a programme are listed below. More precisely, the following bullet points describe the existing issues and points of focus for this project:
• There does not currently exist a single course/programme on safety engineering at undergraduate level in the UK

• In the UK each year, a significant number of people are killed (in the construction industry: 254 in 2001, 75 in 2006 and 69 in 2007) or seriously injured during the course of work within different engineering disciplines. This figure has been reported as 50 fatal injuries, with a rate of 2.4 deaths per 100,000 workers for the year 2010/11 (Health and Safety Executive, 2011). This compares to an average rate of 2.8 for the previous five years. This unwelcoming statistic is partly related to a lack of appropriate education and training and partly due to a lack of implementation of the existing Health and Safety regulations

• This is a niche engineering area with high demand from engineering industries as well as professional institutions and statutory organisations

• In terms of accidents, deaths and injuries, civil and construction engineering has the highest rate of reported incidents in the engineering disciplines in the UK

• Imminent major development projects within energy and power engineering require a significant number of new, well-trained and well-educated safety engineers in the near future (Cogent, n.d.). This new cohort of engineers, in terms of quality and quantity, does not currently exist

• Safety specialists tend to develop within the individual industries “by default” and do not have a specialist academic safety engineering background, but instead a more general academic engineering background supplemented by ad hoc training and courses

• European directives are moving towards a common certification approach to safety practitioners (e.g., Road Safety Auditors, Construction, Design and Management Coordinators-CDMCs, etc.) and this programme would meet the likely future need for safety engineers to demonstrate a common and certified academic base

• There is little or no interdisciplinary sharing of safety knowledge between specialist areas, whereas topics such as risk management are in fact common to all areas of engineering. Research and theory could be taught and applied more effectively across all engineering disciplines.

The recent introduction of the Vision Zero Initiative by the highway and transportation engineering sector (one of the major branches of the civil and construction engineering discipline) has emphasised the importance of safety engineering and safety management and education and training therein (Vision Zero Initiative, n.d.).

Very briefly, the Vision Zero Initiative reflected upon the fact that existing transport and management operation systems are traditionally designed for maximum capacity and mobility and not safety. This means that road users are ultimately held responsible for their own safety. The Vision Zero Initiative takes the opposite approach, instead recognising human weaknesses and low tolerance to mechanical force and thus placing the main burden for safety on system design; ultimately, no one should die or suffer serious injury in traffic. In engineering terms, and within this context, the word “traffic” includes the road design and operation in its widest sense, encompassing all of the engineering, technical and management aspects of the transport system. This visibly highlights the role of well-trained and well-educated engineers and their understanding of safety and safety management within the discipline.

Benefits to industry/society

• Educated graduates ready for employment in a much-needed engineering discipline
• Engage industry in development of a programme which is directly relevant to the sector’s needs
• Address the severe shortage of safety engineers in the job market at both national and international levels
• Contribute to fostering a culture of hazard identification and risk management across the engineering sector
• Ensure resources are focused on activities that are most likely to generate safety benefits and cost-effective solutions

• This project highlights a significant and current gap in the engineering sector as a whole and the civil and construction engineering industry in particular.

**Benefits to student learning**

This project directly served the needs of the higher education (HE) STEM sector as it focused on tackling and addressing a major gap in knowledge sharing in an innovative and effective manner. This development provided ample opportunities for students and educators within the HE sector, as well as professionals in industry, to benefit from a well-structured and fit-for-purpose course/programme in the much-needed field of engineering and technology. In no particular order this project:

• contributed to the education and development of graduates ready for employment in a much-needed engineering discipline

• engaged industry and professional bodies in developing a set of courses/programmes directly relevant to their needs

• addressed the shortage of safety engineers in the job market at both national and international levels

• contributed to fostering a culture of hazard identification and risk management across the engineering sector

• ensured that resources were focused on activities that were most likely to generate safety benefits and cost-effective solutions.

**Rationale**

As stated earlier, the main focus of this project was to investigate and quantify the level of need for safety engineering specialists within the civil and construction engineering sector. Based on earlier market research and feedback from industry (construction, civil, nuclear power and petroleum engineering), the project’s aim was to develop an undergraduate programme which would fulfil the identified gap.

Increasingly, employers all over the world in various engineering and related fields are seeking staff members who are proficient in safety and risk management (American Society of Safety Engineers, 2011). There is a strong demand for skills such as hazard identification, risk analysis, risk management, communication and mediation, design for safety, construction for safety, repair and maintenance for safety, strategic and organisational change management, behavioural change management and cost-effectiveness in the wake of the current economic recession and beyond (Office for National Statistics, 2012). This demand is likely to remain high during periods of future economic growth as the safety management discipline builds its professional reputation and adapts to climate change, natural and manmade disasters and increasing pressure on infrastructure due to increasing population density.

There is a well-documented shortage of engineering skills in the construction industry, including health and safety and management of risk (Office for National Statistics, 2012). As more focus is placed on these areas through cost-effective risk management and “zero harm” approaches, there will be an increasing demand for these skills within the industry. This demand is likely to be especially intense in parts of the world without an established track record in advanced construction safety. Part of the growth will be fuelled by the generation approaching the age of retirement, as well as by companies vigorously emphasising safety and efficiency in the post-recession economy.

This degree will build on the school’s existing MEng/BEng civil engineering suite by adding additional safety and risk management-focused courses and, where appropriate, enhancing existing modules with case study material and learning opportunities themed around safety engineering topics.
The programme will diversify the MEng/BEng offered by the university and strengthen the existing MEng, MSc, BEng and BSc by attracting students who recognise the need for safety engineering professionals and want to be able to meet the emerging needs of the industry and support a career path as a safety engineering professional.

The approach

In order to realise the objectives of this project, the team paid particular attention to working with professionals within the civil and construction engineering industry. It was of paramount importance to establish information and knowledge reflecting the opinions of these practitioners at all levels.

The representatives of the participating industrial partners are all accomplished and established professionals, well-placed within their organisations (Chief Executive, Director, Project Director and Manager), who in the first instance will take the findings and achievements of the project back into their organisations. The Department of Civil Engineering’s Industrial Advisory Board at the University of Greenwich consists of 14 members who represent their respective companies and organisations within the civil and construction engineering sector in their capacity as consulting engineers, contractors and design engineers and cover a wide spectrum of disciplines (structures, highway and transportation, aggregate and materials, environmental and water engineering and geotechnics and foundation engineering). Right from the outset, the project engaged the Industrial Advisory Board, seeking members’ opinions and experiences on the subject.

Three main strands of activities were followed in achieving the objectives of this project:

1. Developing a dedicated steering committee, comprising two academics and four engineering practitioners

2. Designing a questionnaire to be distributed amongst civil and construction engineering professionals in order to establish their views on the viability of a three/four-year undergraduate course on safety engineering

3. Organising dedicated interviews with professionals, seeking their advice and experiences in designing a fit-for-purpose programme.

Concerning the first activity, four Industrial Advisory Board members were actively involved with the proposal and gave their respective company’s commitment to support the project throughout.

A questionnaire was then designed and distributed amongst civil and construction engineering professionals (see Appendix). A population of 200 was targeted. At the time of writing, a limited number of completed questionnaires have been returned. The team anticipate a significant number of returns within the following few weeks. On a positive note, the team received a substantial amount of information and comments from the Industrial Advisory Board and were able to interview a number of professionals and experts within the field.

Based on the feedback and comments received (mainly through ten interviews with professionals in the field and a limited number of completed questionnaires), a draft programme structure has been proposed. Table 1 provides a summary of the proposed programme structure at different levels (with reference to the existing University of Greenwich programmes and/or courses). This table forms part of the submitted document for internal validation by the university’s Learning and Quality Office. Feedback from the university’s Programme Validation Committee has been received, including a number of comments and suggestions. The team has already reflected on these comments and an amended version of the course documents will be submitted for consideration in early June 2012.
### Table 1. Draft programme structure, indicating new and existing courses within the proposed programme

<table>
<thead>
<tr>
<th>FHEQ level</th>
<th>Course title</th>
<th>New/existing</th>
</tr>
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<tbody>
<tr>
<td>4 (year 1)</td>
<td>Communication, Social &amp; Legal Studies</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Mathematics 1A/1B</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Hydraulics</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Structures 1</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Engineering Surveying</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Civil Engineering Technology and Design (CAD)</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Principles of Health &amp; Safety Management</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Management for Civil Engineering Projects</td>
<td>New</td>
</tr>
<tr>
<td>5 (year 2)</td>
<td>Engineering Analysis and Applications 1A/1B</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Construction Management &amp; Technology</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Structures 2</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Design &amp; Materials</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Geotechnics &amp; Geology</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Statistical Analysis</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Civil Engineering Construction Methods</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Sustainability in Construction – Materials and Sources (option)</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Fire Safety Engineering (option)</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Disaster Risk Management (option)</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Maintenance and Quality Control in Construction Projects</td>
<td>New</td>
</tr>
<tr>
<td>6 (year 3)</td>
<td>Individual Project</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Project Management &amp; Appraisal</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Structures Health Monitoring Assessment</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Water and Environmental Management (option)</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Bridge Design &amp; Assessment (option)</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Design of Concrete Structures (option)</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td>Safety &amp; Risk Management in Offshore Infrastructure (option)</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Nuclear Power Construction and Safety (option)</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Highway and Transportation and Safety (option)</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td>Construction Safety Law and Practice</td>
<td>New</td>
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The initial programme structure was based on the feedback received during the interviews with professionals within the discipline, as well as the author’s 20 years of industrial and academic experience. The author has been working on the subject of safety engineering in close interaction with a number of major civil and construction engineering consultants and contractors (e.g. Atkins and EnterpriseMouchel), as well as a major international oil company which has more than 100,000 employees across the world (Saudi ARAMCO Oil Company).
Discussion, summary

- The proposed degree programme in Safety in Civil and Construction Engineering provides an innovative curriculum that focuses on achieving a balance of practice and theory in safety management.

- The curriculum has been carefully compiled to develop intellectual capabilities based on the skills and competencies that safety engineers will need to enable them not only to deliver value for employers at the outset, but also to continue to develop lifelong learning in the field as it evolves.

- The proposed programme structure combines successful delivery of the Department of Civil Engineering’s BEng (Hons) Civil Engineering degree programme with specific safety engineering aspects that will appeal to a broad spectrum of professionals working in safety engineering management areas within the construction field. The curriculum will encompass a range of specialist civil engineering disciplines, including highways, nuclear engineering, power, earthquake construction management and petroleum engineering infrastructure (offshore and onshore oil rigs and platforms), enabling students not only to gain a good general grounding in the subject area of safety engineering and risk management, but also to specialise in their preferred area of interest.

- Given the complexity and uncertainty that characterises large construction projects (as well as their business environments), the industry needs a higher level of professionalism and meta-cognitive abilities that are not normally catered for in traditional degree courses. To this end, the management of complexity and change will form a core theme which will run throughout the programme.

- Contemporary engineering practice demands that professionals not only master management concepts, but also have a strong background in combining engineering and management methods. Emphasis is placed on new technologies and developments that support such projects.

From a marketing point of view, the main features of the proposed programme are:

1. Planned accreditation by relevant professional bodies, with the opportunity for students to achieve external certification (Joint Board of Moderators (ICE, IStructE, IHE and CIHT)). There may also be an opportunity to develop this course as an Engineering Gateway (Engineering Council, n.d.)

2. The ability of graduates to apply a significant number of practices and techniques in safety engineering and management of risk.

3. The ability of graduates to analyse, plan and undertake effective leadership and executive decision-making for innovation in safety-related engineering and technology fields.

4. Key lectures by top managers of highly successful international companies and organisations.

5. A competency-based curriculum which offers opportunities to focus on differentiated enquiry, assessment and student project activity.

One of the strengths of this project was the development of a dedicated steering committee composed of academics, industrial partners and practitioners. The Department of Civil Engineering’s Industrial Advisory Board is supportive of this programme and will continue to advise and support it. To that effect, Board members engaged with this project in a constructive and caring manner and it was evident that they were concerned about the industry’s need for such a programme.

Overall, the team believes that this project has successfully addressed a very evident gap in the UK’s civil and construction engineering sector.
Further development

As stated earlier, this is the first stage of the development of this programme. In order to finalise a purposeful and effective programme structure, the team requires continued consultation with relevant industrial contacts and experienced academics. Furthermore, detailed programme and course specifications (covering all of the proposed new courses) must be developed. Further support (financial and professional) is required to complete these tasks. As stated above, it is the intention of the team to fully develop and validate the suggested programme in time for the 2013/14 academic year.

It should be emphasised that the results of outstanding questionnaires, when completed and fully analysed, will provide extra endorsement and support to the already presented and discussed programme structure. It is planned to disseminate the above information, when completed, in the form of an article/paper to be submitted, for example, to the Journal of Engineering Education. The findings of this project will also be the subject of posters and presentations at events organised by The Royal Academy of Engineering and the National HE STEM Programme. It is important to emphasise that, in the process of engagement with the civil and construction engineering industry, a positive impact was made in terms of increasing discipline professionals’ awareness of the existing situation. The assumption was that full awareness previously existed, but our experience clearly showed that, by bringing the subject to their attention, the focus and awareness of professionals and practitioners were significantly raised.

Acknowledgement

The author wishes to express his gratitude to the National HE STEM Programme and The Royal Academy of Engineering for their help and support throughout the project. The author also would like to extend his thanks to members of the Industrial Advisory Board of the Department of Civil Engineering at the University of Greenwich for their dedication and support during this project.

References


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