Strengthen the Formal Education of Construction Safety for Civil Engineers – Bridging the Gap

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Abstract

The prior safety knowledge of civil engineers, who perform both technical and managerial responsibilities for job site execution, supports to understand, develop and implement the safety programs effectively. Increasing injuries and fatalities at construction sites raised the need of formal safety education (courses) essential for students of civil engineering studying in the engineering universities. There is deficiency found for OSH education degree program of civil engineering in all universities. Peer review of research has been done to extract major applied areas for occupational safety and health education (course contents). Level for induction, strong validation and high practical approach are major characteristics of proposed OSH course. Specific contents have been recommended to bridge the gap of basic safety knowledge for fresh civil engineers on the basis of current research with core needs of construction sites.

Keywords

Safety education, engineering universities, curriculums, Pakistan.

INTRODUCTION

Construction is among the growing industries in Pakistan and play significant role for its development (PBS, 2012). There are around twenty thousand contracting and five hundred and fifty consulting firms related to construction industry (PEC, 2012). Annually, around two thousand students graduate in civil engineering from twenty public/private sector universities (HEC, 2012). Fresh civil engineers join client/consultant/contracting firms who are involved in the execution of construction/infrastructure projects. Mostly civil engineers perform technical and managerial duties while diploma holders/technicians perform supervisory duties. According to Pakistan Bureau of statistics (2011) construction industry stand at third most hazardous and vulnerable industry. Civil engineers may be held responsible for such an alarming situation. In this research is primarily based upon the safe work practice and the knowledge of construction safety to practicing engineers. Lack of accredited bodies for continuing professional development in the country magnifies the importance of formal education of new induction in construction market. Current study aims to assess the deficiency of safety education provided in engineering universities aligned with international standards and according to local safety demands

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and fill the gap of knowledge. This study strives to develop awareness for engineering faculty, students and practitioners with many facets of safety and health applicable to civil engineering through formal education.

SCENARIO FOR CONSTRUCTION SAFETY IN PAKISTAN

Pakistan construction industry is contributing to national economy with 2.3 percent of GDP (Ahmad, 2012) and attributed as labor intensive comprising 15.5 percent of workforce with 10.77 percent (PBS, 2012) are from rural areas and 51.41 percent of them are illiterate (both civilian and non civilian labour force) (PBS, 2012). Large human workforce engagement in construction has intensified the need of safety on sites.

Implementation of a safety, health, and environmental management system is no widespread in developing countries (Koehn et al., 1995). General Labour Laws of Pakistan (MOLM, 2012) mainly emphasizes on industrial safety yet no proper legislative rules and regulations have been defined for construction sites. A gradual increase has been found in percentage for occupational injuries and diseases (PBS, 2012), from 12.54 (2002) to 13.10 (2011), which is evident of poor safety practices.

There is consensus found among Construction Managers that substantial importance is given to site safety and considered as prime priority for execution; Managers considered themselves as knowledgeable and experienced to identify the hazardous situations. Moreover managers also admit that regular reporting of safety performance helps to improve safety on site. Managers confirmed that every accident/near miss happened on site is reported but workers revealed that every accident/near miss is not reported (Choudhry et al., 2011). Civil engineers are managers and responsible for safety aspects on construction sites. Construction within developing countries often fails to meet the needs of modern competitive businesses in the marketplace and rarely provides the best value for clients and taxpayers (Ali, 2006).

Only few major construction firms in the country provide professional training for safety to fresh engineers and supervisors because there is no regulatory body responsible for implementation of safety on construction sites. Safety course in frame of continuing professional development (informal) are expensive and not offered consecutively by training institutes. Major responsibility falls on engineering universities/polytechnic institutes to consider safety education and risk management a part of formal engineering education.

CIVIL ENGINEERS RESPONSIBILITY FOR CONSTRUCTION SAFETY

Construction industry is among the most hazardous industries all over the world (Suao and Jaselskis, 1993; Hinze, 1997; Sawacha et al., 1999; Carter and Smith, 2000; Whitlaw, 2001 and Choudhry et al., 2008) and construction site safety is an area of concern for employers of construction workers (John et al., 1997). Construction sites are hierarchically organized with site managers, supervisors, foremen, and construction workers. The construction industry is characterized by traditional masculine values such as freedom, independence, resourcefulness, and toughness, with an often informal and oral culture of risk in which safety knowledge is tacitly understood without being openly expressed (Wadick, 2007; Baarts, 2004).

Insufficient Health and Safety Knowledge held by construction workers is a significant factor prone to severe accident or injury (David and Gary, 2008). One of the characteristics of the Chinese construction industry is the existence of large number of peasant workers, who received little education and are unskilled, untrained, and
inexperienced (Tam et al., 2004). Lack of safety knowledge is one of the causes behind accidents on Hong Kong (Rita and Sun, 2009) and Japan (Tetsuo, 2009) construction sites. Knowledge of and attitudes toward safety often vary from worker to worker, and safety practices, norms, and attitudes are continuously negotiated between workers and foremen/supervisors (Baarts, 2004).

Worker having the competency to identify the hazardous conditions/situations, cultivate with concern for safety and priority. Moreover if worker asked to share experience to align the safety planning then a relative responsibility felt by the worker to improve safety on site. Safety communication has been increased with the engagement induced from manager and supervisor (Kines et al., 2010). Supervisor perceived quick response from managers regarding safety problems, help to develop trust and confidence upon management. In other words, top managers are concerned with policy-making and the establishment of procedures to facilitate policy implementation, while at lower organizational levels supervisors execute these procedures by turning them into predictable, situation-specific action directives (identified as supervisory practice) (Zohar, 2010). Engineers (managers) have a professional and moral obligation to take safety, health, and welfare under consideration (Joe et al., 2000). Safety education is an essential aspect of an engineer's obligations and responsibilities; however, the availability of scientific safety training may be limited (Gross and Jovanis, 2008). Irrespective of professional area of Civil Engineering such as OSHA emphasized on contractors, Hinze et al. (1992) indicate important role of designers, and Suraji et al. (2001) refer construction managers must have prior safety knowledge and enact understanding while, designing, implementing, monitoring and controlling the safety programs.

According to Figure 1, managers develop policy and design safety programs, supervisors execute the procedures and instructions through workers on a typical construction project, It is worth mentioning here that basic knowledge for safety of supervisory level (manager and line staff) is essential to improve safety practices.

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<th>Manager (Civil Engineer)</th>
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<td>Engineering education</td>
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<th>Supervisor (Civil Technician)</th>
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<td>Technology education</td>
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<th>Worker (Skilled/Unskilled)</th>
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<td>Literate/iliterate</td>
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**Figure 1. Construction project hierarchy**

There is need for appropriate arrangement of formal and/or informal education and training (Farooqui et al., 2008) which will enhance safety knowledge leading towards safe work. Educationalists have recognised that incorporating practical training with the rationale of providing technical expertise (Young, 1989) and that for a management course to have value and meaning in any sector it must embrace operations in the field.
The embedded knowledge developed during formal education provides basis for adaptation of advance practices and integration for complex jobs.

According to research study done in Spain by Rubio (2008) the most important obstacles that still must be overcome so that the work of the Civil Engineer as Coordinator of Safety and health (CSH) can be maximally effective? This question is precisely one of the principal objectives of our study. The results obtained show important deficiencies regarding the actual CSH profile, the time CSHs are able to spend on each construction project, as well as the resources allocated for effective health and safety monitoring and management during the construction process. Regarding the deficiencies found in the CSH profile, it is important to point out the following:

- The requirements regarding CSH qualifications are not the same as those for the project manager or project director, even though for the projects in our study, current regulations specify that a CSH should be a civil engineer. Nevertheless, the number of CSHs who lack this qualification is considerably higher than the corresponding number of project managers or project directors who do not have it.
- Training in health and safety is essential for CSHs, however, a great problem lies in the fact that such training is currently not offered at engineering schools, and thus CSHs are obliged to acquire such knowledge only through practice.
- CSH is a responsible and demanding job. For instance they may have to decide how to go about totally or partially halting work at the building site when worker safety is at risk. For this reason, it is crucial that they have sufficient experience in the construction of infrastructures. However, of all of the people interviewed in our study (project director, project manager, CSH), CSHs were the ones with the least experience which proves to be an obstacle for optimal job performance.

Furthermore, the working hours of CSHs are insufficient in most cases for the amount of work that must be done. Current regulations do not specify that CSHs must work full time at each work site. However, considering the evident importance of their work, the photography of such constructions, as well as difficulties inherent in the construction of tunnels and other high-risk structures, CSHs need to be at the site full time. Whereas, results show that 44.8 percent of the companies subcontracted have no record of a CSH at the construction site, and indeed, in many of the projects in our study a full-time CSH would be more than justified. It is the developer who should be aware of the need to hire more CSHs so that their work can be carried out as specified in the regulations.

FORMAL SAFETY EDUCATION IN PAKISTAN

Pakistan Engineering council (PEC) is the regulatory body to accredit the engineering universities (public/private/affiliated) upon quality technical education on regular basis. PEC has approved the curriculum designed by Higher Education Commission (HEC) with updated revisions extracted from regular meetings in which all the representative of engineering universities participate.

According to revised version (2008) of HEC, curriculum adopted for civil engineering at bachelor level, is comprised of 65-70 percent (Engineering courses) and 30-35 percent (Non Engineering courses). Construction management course under which safety education can be considered is related to knowledge area of Management Sciences and sub area of professional practice. This course has 3 credit hours and 3 contact hours per week.

Construction Management course aims to develop ability of students in planning and management techniques for various projects and to provide basic concepts of economic
analysis of different projects. Major elements of curriculum based on detailed introduction to construction industry; project planning, scheduling and controlling by deterministic and probabilistic models; fundamentals of engineering economics and alternative projects. Safety domain of construction project is not clearly addressed in the curriculum which is the main reason that this aspect is often skipped by the teachers. Moreover, there are no practical demonstrations of construction machinery or equipment to the students neither visit to real life construction project are arranged.

Risk prevention in the workplace is not a compulsory subject in the majority of civil engineering schools (Carpenter et al., 2001), despite the repercussions that inappropriate safety conditions may affect health and safety of workers. Risk prevention in the workplace is normally taught in specialized or postgraduate courses, if it is taught at all (Rubio et al., 2005). It is difficult to find civil engineers with the necessary training in risk prevention in the workplace, with knowledge of the different processes within construction, and experience in the execution of these processes (Toole, 2005). Graduate students are not even familiar with the personal protective equipment used on construction projects and are unaware of the safety risk involved in construction process which indicates the major gap of safety knowledge and lead to alarming situations.

PROPOSED CONTENTS FOR SAFETY EDUCATION COURSE

Following are proposed contents developed on the basis of research done to identify the need of safety education in context of Pakistan and provide orientation to emphasize on specific topics which should be inducted in civil engineering course;

- **Introduction to occupational safety and health.** Farooqui et al. (2008) found that basic practices required for safety are not present at most construction sites with a mean value of Safety Performance Index of 0.52. Employees are not familiar with the safety aspects and related associated with construction process. Most of them assume that incidents or accidents with the will of God and ignore personal mistakes and lack of knowledge of safety.

- **Roles and responsibilities of all stake holders and specific positions.** Owners are considered to be the key initiators for project safety; without owner commitment to safety, contractors not accept major responsibility for safety and hence their lack of commitment. Contractors, generally, are not required by project owners to maintain a safety program on projects. As such, many contractors do not follow formal safety management practices. Consequently, procedures for accident reporting and investigation, mechanisms for implementation of safety work rules, processes for safety record keeping and logging, methods for accident response, and practices for safety performance evaluation are not suitably applied by majority of contractors. However, – more because of a practice – jobsite safety inspections, site layout planning and provision of first aid facilities on site are relatively stronger implementation areas of safety (Farooqui et al., 2007). Role of owners, contractors and designers are extremely important to implement safety rules and regulation on site in true means. A construction contract contains safety clauses which bind the contractors for safe work and safe environment on site. Civil engineer who is working with any stakeholder must know the specific responsibilities for safety according to contracts. He/she can urge the fellow civil engineers in contractor to follow the safety clauses such as safety program and control measures. Designers need to recommend that construction method which should not create hazardous condition while performing work.
Introduction to Legal frame works like Factories Ordnance 1934, Hazardous Occupation Rules of 1978, Mines Act 1923, Workmen’s Compensation, Dock Labourer Act 1934, Social Security Ordnance 1965 and Shop and Establishment Ordnance 1969. Foundation for revised and updated common law. Regrettably, the health and safety measures prescribed in most of the laws have not kept pace with the rapidly changing times, conditions or industry requirements. Many of the sectors, with serious OHS hazards (including those with most of the workers) are not covered by these laws, even though they contain very few technical standards. These laws urgently require revision and updating (Awan, 2001; Ali, 2006). It has been deduced through this research that the prevailing laws related to occupational safety and health are too broad to be applied directly for construction safety in Asian developing countries. These are only general guidelines that do not specify the concrete measures needed. So there is a dire need to realize the importance of construction safety by increasing the coordination between all the stakeholders including workers. This can be done by establishing a strong legal and administrative safety infrastructure. Another suggestion is to form an umbrella organization related to construction safety in developing countries that can provide a platform to these countries to address the collective safety issues for improving safety culture in this region. This can be helpful in improving the individual construction industries as well as overall regional economy in the longer run (Raheem et al., 2011).

Health, Safety and Environment management system and policy making. Well-documented policies on safety, established disciplinary process for enforcement of safety programs, management commitment, safety responsibility structures and layered organizational support for safety implementation do not exist with majority of contracting firms. Major consequences have been inappropriate budget allocations for safety implementation, poor worker and subcontractor safety performance, and responsibility shifts (Farooqui et al., 2007). Some of the major improving safety tools and procedures are safety policy/manual, safety reporting, safety checklist, safety inspection (Saqib et al., 2010). The safety management survey explored seven aspects of construction site safety, including health and safety policy, safety organization, safety training, safety inspections, safety promotion, personal protection program, and documentation and accident prevention. The following points require attention that top management needs to implement a safety management system. The safety organizational chart needs to be displayed on site. Competent safety staff needs to be appointed to be responsible for the implementation of safety on site. The concept of the submission of a site specific safety plan by the subcontractors needs to be implemented in the construction industry. Health and safety training plans, induction training of new employees and a dedicated budget for safety is to be in place for implementing the safety management system. Safety performance needs to be checked at regular intervals by management by means of conducting safety audits. Safety bulletins need to be provided and different award or recognition schemes need to be introduced to motivate and increase the safety awareness of workers at project sites. The documentation of the safety record and accident prevention policy and plans require attention by top management (Choudhry et al., 2012).

Safety Culture, safety climate and safety behavior
A cultural and behavioural shift is needed in the contractors’ perception about safety management implementation and improvement on projects; most contractors currently perceive proactive approaches in safety as not being much useful. The major obstacles faced by contractors to the implementation and improvement of safety include – in decreasing order of significance – absence of the following: worker cooperation and behaviour, familiarity and expertise with safety management
techniques, safety awareness and knowledge, owner commitment, and a safety regulatory framework (Farooqui et al., 2007).

The major steps necessary for developing a safety culture on construction worksites, in descending order of perceived effectiveness, have been found as: regular safety meetings, periodic inspections, the belief of top management and work force that is company’s business priority to maintain a safe workplace, owner participation in safety, and worker safety training (Saqib et al., 2010).

Stakeholders’ awareness on construction safety culture and safety climate plays an important role in making construction sites a safer and healthier place to work. From Factor Analysis, two principal components were established and they are namely: (1) management dedication and (2) employee involvement. These two factors are regarded as the most embracing attributes for this research in construction site environments. These factors have been regressed with the perceived safety performance scores to establish the causal relationship between safety climate and perceived safety performance. During the multiple regression analysis, the two underlying factors were used as independent variables in evaluating the relationship with perceived safety performance. All two factors were identified as significant in explaining the perceived safety performance in Pakistan from the multiple regression results. The regression results showed that “management commitment and employee involvement” were the most significant factors relating to perceived safety performance because it contributed the most for establishing positive safety climate on construction sites. Finally, the findings of this study may be useful in creating safer construction sites (Masood et al., 2011).

Positive relationship between workers’ participation and workers’ engagement and accident reporting exhibit that if workers’ participation is needed to be high then they must be engage in safety related activities and motivation is required to report any accident/near miss/incident on site. Further, workers’ engagement found to be more strongly related (Sig. value <0.01) with accident reporting. This result confirmed the vitality of safety communication especially addressing the accident reporting to high level (supervisor or manager). This help to avoid system failure and such events lead to improve safety with the concern of management dedication (Choudhry et al., 2011a).

- Hazard and risk control for construction, work equipment, electrical safety, fire safety, chemical and biological health, working at height, excavation work and confined spaces. Personnel protective equipment

Construction safety risk is highlighted by contractors in terms of loss of human life, accidents on sites and inadequate safety measures (Masood et al. 2010). This risk is shared 25 percent with owners as effective risk control measure is safety control program/insurance (Farooqui et al., 2010).

Major causes of injuries cave-in due to less shoring during excavation; falling from scaffolding while working on high levels; damage to eye while cutting wood or steel; lack of care and maintenance to tools as welding plants, electronic equipment, and temporarily laid power lines (Qazi et al., 2006).

According to Farooqui et al. (2008), the top three safety non-performance practices at building construction work sites are:
- Ear defenders not worn (while using noisy equipment)
- Protective footwear not worn
- Face masks not worn (in dusty conditions)
Most of the safety non-performance issues belong to self protection category. This shows that the site workers themselves are either unaware of the importance of personnel safety practices or they do not want to wear protective gears and kits as they consider it as a hindrance in their work productivity. Also, it was observed that the site management seemed non-interested in emphasizing the need of personnel safety practices among their workers.

- **Safety practical training**
  Few companies have a mechanism of on-the-job trainings for the workers, there is a general lack of commitment from majority of contracting firms toward conductance of safety related orientation and training. Establishing safety cell in the site office will be an important step towards improving safety on the job site (Farooqui et al., 2007). Practical training for safety is very essential for fresh civil engineers at construction site such as wear PPE, know about sign/instructions etc.

**STRUCTURE FOR SAFETY EDUCATION COURSE**

The course should be at least of two (02) credit hours and not be induced with other civil engineering courses like construction management. Half credit should be given to practical hands on training for safety. There should be thirty two lectures in the last semester of degree program. Any degree program relevant to civil engineering discipline should induct safety and health course such as bachelors in transportation, urban planning, architectural engineering, construction management etc other than particular civil engineering.

**DISCUSSION AND CONCLUSION**

This research study is pioneer effort to address the need and importance of formal occupational safety and health education in civil engineering degree program. Lack of practical training for OSH to new civil engineers on construction sites by stakeholders (owner, contractor and designer) emphasizes the formal education (including training) during university education.

Civil engineers hold technical and managerial positions (both for execution and inspection of construction work) and mainly responsible for safety issues on construction sites. Civil engineers are coordinator for safety and health on construction site to manage safety system, develop safety culture, develop safety program and control measures, take critical decisions on spot, develop safety trainings and being resourceful person to resolve safety problems, which need in-depth knowledge about safety to civil engineers.

There are minimal considerations to OSH contents in civil engineering courses and almost neglected by public/private engineering universities throughout the country. As far as continuing professional development is concerned registered engineers are bound to earn credit points in shape of workshop/seminars/conferences as opportunities are limited. On other hand, most of the certificate courses provided by public and private institutions are costly and scheduled on timings not suitable to civil engineers.

It has become a requirement to consider the inclusion of OSH aspects relevant to construction in the degree program. More specifically the contents are solicited on the basis of research already done for OSH in the context of Pakistan. Major constituents of OSH course are introduction, stakeholders’ roles and responsibilities, legal framework (laws), Safety management system (including policy making), safety culture (climate and behavior), hazard and risk control, and safety training. Main provision for curriculum
design and structure are provided which can be modified according to need of degree program or source available.

This study is a hit start for researchers and academicians to highlight need and importance of safety education for civil engineers. It is strongly discourage that the institutes (other than universities) earning huge amount to deliver fascinated courses regarding construction safety and unfamiliar with the need of time. It is ultimate responsibility of universities to provide formal safety education to their students and make essential part of civil engineering degree curriculum. This study provides the main contents which need to be considered for design and development of safety education course.

SCOPE

This research study is effective for civil engineering programs at undergraduate level both for public and private universities. Proposed course contents are the minimum requirement and need to be modified according to suggestions of professionals and academicians. Detail description under each content element can be taken from sources available by Occupational Safety and Health Administration (OSHA), Health and Safety Executive (HSE), National Engineering Bureau of Occupational Safety and Health (NEBOSH) etc.

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