Need for Qualified Workforce in Industrialized Building Systems

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1 Abstract

The use of precast concrete technology offers several significant advantages. In spite of the advantages they offer, the use of these systems is still very low in Turkey as well as many other developing countries. It is commonly claimed that the lack of workforce, which comprises both professionals and labourers, specialized in precast concrete systems is one of the major factors that prevents the extensive use of these systems in Turkey. The main objective of this study is to explore the level of expertise in precast concrete systems currently available in the Turkish precast concrete industry. For this purpose, a short questionnaire was designed and conducted among 36 manufacturers, 41 designers and 57 contractors (erectors). According to the survey results, the academic curricula in Turkish universities do not provide adequate education about precast concrete systems from structural, architectural and managerial standpoints and there are not enough qualified labourers specialized in precast concrete systems. The qualifications of workforce in the Turkish precast concrete industry can be improved by establishing not only new elective courses but also mandatory courses in the current undergraduate and graduate curricula in architecture and civil engineering programs, by changing those courses' contents to a new form which provides practical experience as well as theoretical knowledge, and by providing continuous education programs for the benefit of the active professionals. Moreover, initiating extensive training programs such as apprenticeship programs and establishing technical schools would help in increasing the number of qualified labourers.

Keywords: Precast concrete systems; Workforce; Qualifications; Survey; Developing countries

2 Introduction

Precast concrete technology is recognized worldwide as offering significant advantages including easier and quicker erection of the building structure, lower project cost, achieving tighter control over quality, enhanced durability, fewer material waste, high levels of design flexibility, better sustainability, enhanced occupational health and safety, better architectural appearance, and improved standardization and modularization of reinforced concrete components compared to on site produced components (Sacks *et al*. 2004, Kale and Arditi 2006, Manrique *et al.* 2007). In spite of the advantages they offer, the use of precast concrete systems in Turkey is still very low compared to in many European countries. Indeed, the share of reinforced concrete construction supplied by precast producers is only 2% in Turkey (YEMAR Report 2006). The average share of precast concrete systems in the construction industry across the European Union is 20-25%, whereas it goes up to 40-50% in the northern European countries (YEMAR Report 2006). In contrast, precast concrete systems' share of the overall building construction market is approximately 6.8%, whereas their share of the overall Turkish construction market is nearly 8% (Tokman and Eryilmaz 2004).

It is commonly claimed that the lack of workforce, which comprises both professionals and laborers, specialized in precast concrete systems is one of the major factors that prevents the extensive use of these systems in Turkey (Agrali 2006, YEMAR Report 2006). However, no scientific study has been conducted to test the accuracy of this assertion. On the other hand, it is acknowledged that the current civil engineering and architecture curricula rarely provide a thorough coverage of these systems in Turkey as well as in many other countries. Thus, there are few professionals who are specialized in the analysis, design, production, and organization of these systems. Moreover, there are not many construction laborers who have adequate experience in the erection of precast concrete structures (Agrali 2006, YEMAR Report 2006). Lack of expertise in these systems may lead to poor design, poor plant management and production, and poor erection practices (Arditi *et al.* 2000).

Structural analysis and design of precast concrete components may not be much different from those of reinforced concrete structures, but the foremost issue in these systems is the analysis and design of connections (Arditi *et al.* 2000). Moreover, forming proper connections is critical for the performance of these structures, especially under seismic loads (Sezen and Whittaker 2006). A significant number of precast concrete industrial buildings showed enormous deformations and underwent severe failures during the 1992, 1995 and 1999 earthquakes occurred in Turkey due to distress in the connections (Celep and Kumbasar 2004). The widespread damage to those industrial facilities had a significant impact on the economy of Turkey in terms of both direct and indirect losses (Sezen and Whittaker 2006).

Arditi *et al.* (2000) found in their study that the scarcity of designers with expertise in precast concrete systems compels design firms to prevent the use of these systems, and also, lack of expertise in concrete design may foster severe conflicts between manufacturers and designers. These problems may mainly result from inadequate formal education received by these professionals. They also stressed that while lack of competence on the part of the manufacturer can cause failures in the production stage that may in turn cause delays in the erection schedule and prevent the contractor from gaining the expected cost savings through speedy erection, lack of competence on the part of the contractor can bring about delays in the erection schedule, even if components are delivered to the site on time. Obviously, the level of expertise in precast concrete systems is critical for structural, architectural, and managerial performance of precast concrete building projects.

Since nearly 93% of Turkey is located in the heart of an active seismic zone, major earthquakes frequently strike. Hence, the performance of precast concrete structures under seismic loads, which is directly related to the expertise level of workforce in this technology, is one of the most important factors in the Turkish construction market participants' decision-making process regarding using these systems in their building projects or not.

The main objective of this study is to explore the level of expertise in precast concrete systems currently available in the Turkish precast concrete industry, whose main participants include precast concrete manufacturers, design offices and contractors (erectors). Labor unions and owners may be two of the main participants of the precast concrete industry and they should have been surveyed in order to identify to which extent the lack of expertise in precast concrete systems prevents the extensive use of these systems in the Turkish construction industry. However, in Turkey, unionization is very low compared with developed countries and the rate of unionized construction is even lower than other industries (Polat and Arditi 2005). Therefore, labor unions were left out of the survey. Akin to the construction labour, construction owners are not unionized in Turkey as they are in the U.S. (i.e., Construction Owners Association of America), either. Since it was impossible to contact the owners of precast concrete systems given these circumstances, they were left out of the scope of this study. In order to achieve the goal of this study, a short questionnaire, which consists of eight questions, was designed and conducted among manufacturers, designers and contractors. Having identified the expertise level in the Turkish precast concrete industry, some suggestions for improving the qualifications of workforce in the precast concrete industry were proposed in order to promote the extensive use of precast concrete systems in Turkey.

3 Methodology

Using the information collected in the literature survey and presented in the preceding sections, a short questionnaire, which consists of eight questions, was designed to explore the level of expertise in precast concrete systems currently available in the Turkish precast concrete industry. Those questionnaires were mailed to 100 contractors, 100 design firms and 95 precast concrete manufacturers.

The questionnaire consisted of two sections. The first section included three questions, which inquired about the context of the respondent company. The second section comprised five questions. These questions were meant to explore the level of expertise in precast concrete systems in the Turkish precast concrete industry.

The first question of the second section of the questionnaire asks if the respondent organization employs qualified professionals (i.e., structural engineer, architect, site engineer, site manager, production engineer), who can claim to be experts in precast concrete systems. The second, third and fourth questions respectively ask if they believe that the academic curricula in universities provide adequate education about precast concrete systems from structural, architectural and managerial standpoints. The fifth question asks if they conduct training programs within their organizations in order to provide their employees with adequate knowledge about precast concrete systems.

4 Discussion of findings

Of the 295 questionnaires that were mailed, 134 were answered. The response rates by type of respondent are presented in Table 1.

Table 1 Response rates of surveys Number of Questionnaires

Type of recipient	Mailed	Answered	Rate of response (%)
Contractors	100	57	57
Design Firms	100	41	41
Manufacturers	95	36	38
Total	295	134	45

In the study of Arditi *et al.* (2000) the highest rate of response (59%) was achieved in the survey of precast concrete manufacturers. However, in this study, the lowest rate of response (38%) was achieved in the survey of manufacturers. It appears that the Turkish precast concrete manufacturers are not very interested in promoting their products. If they had seen the survey as an opportunity to express their ideas about the systems they produce, the response rate of the manufacturers would have been much higher.

Of the respondents, 24 of the 57 contractors were the member of the Turkish Contractors Association (TCA), 20 of the 41 designers were the member of the Association of Turkish Consulting Engineers and Architects (ATCEA), and 21 of the 36 manufacturers were the member of the Turkish Precast Concrete Association (TPA). According to the figures obtained from those associations' official web sites, the TCA has 136, the ATCEA has 122, and the TPA has 25 members, strictly speaking, the respondents constitute 18% of the TCA, 16% of the ATCEA, and 84% of the TPA.

Of the respondents, 17 of the 57 contractors (30%) and 9 of the 41 designers (22%) reported that they had never used precast concrete systems in their building projects. Of the respondents using precast concrete systems in their building projects, 12 of the 40 contractors (30%), 9 of the 32 designers (28%) and 9 of the 36 manufacturers (25%) indicated that public sector clients owned the building projects in which they use precast concrete systems. According to the respondents' answers to this question, public sector clients created 28% of the demand for precast concrete products whereas private sectorclients created 72% of this demand. This finding is nearly same as the 2004 figures provided by the Turkish Precast Concrete Association (TPA), which reveal that private sector clients created 71% of the demand for precast concrete products.

In order to explore the level of expertise in precast concrete systems currently available in the Turkish precast concrete industry, the contractors, designers, and manufacturers were asked if they employed qualified professionals specialized in precast concrete systems. Of the respondents using precast concrete systems in their building projects, 32 of the 40 contractors (80%), 25 of the 32 designers (78%) and 32 of the 36 precast concrete manufacturers (89%) reported that they employed qualified professionals, who can claim to be experts in precast concrete systems, within their organizations. Since most of the respondents (83%) reported that they employed qualified professional within their organizations, it can be inferred that the academic curricula in universities provide adequate education about precast concrete systems.

As opposed to this finding, when the respondents were asked if they believed the academic curricula in universities provided adequate education about precast concrete systems from structural, architectural, and managerial standpoints, most respondents reported that they believed that the architecture / engineering curricula are lacking in Turkish universities as shown in Table 2.

Table 2 How adequate is education in precast concrete systems?

Type of recipient	Structural Aspects			Architectural Aspects		Managerial Aspects	
	Adequate (%)	Inadequate (%)	Adequate (%)	Inadequate (%)	Adequate (%)	Inadequate (%)	
Contractors	7	93	4	96	23	77	
Design Firms	10	90	7	93	27	73	
Manufacturers	11	89	3	97	19	81	
Total	9	91	4	96	23	77	

96% of the respondents believe that the architecture curriculum does not provide adequate knowledge about the precast concrete systems from architectural standpoints, 91% of the respondents believe that the engineering curriculum does not provide adequate knowledge about the precast concrete systems from structural standpoints whereas 77% of the respondents believe that the architecture / engineering curricula do not provide adequate knowledge about the precast concrete systems from managerial standpoints. Based on the answers to those questions, it appears that the respondents believe that while managing the erection of precast concrete structures is not very different from managing the construction of other types of buildings, the analysis and design of precast concrete structures require specific knowledge, and the architecture / engineering curricula are deficient from these standpoints. This result is consistent with the findings of the studies by Arditi *et al.* (2000) and Endicott (1997) as they stated that the architecture / engineering curricula in U.S. universities do not provide adequate knowledge about the nature of precast / prestressed concrete, its capabilities, and its wide range of applications. Based on the survey results, it can be inferred that there is no room in the current state of the architecture / engineering curricula to teach the know-how of precast concrete systems. However, architects' and engineers' awareness of precast concrete systems can be increased by providing them with adequate knowledge about these systems in universities.

According to the official figures provided by the Higher Education Institute (YOK), there are 88 universities in Turkey, and 47 of them have civil engineering department and 40 of them have architecture department. In the academic curricula of the 14 of the 47 (30%) civil engineering departments and 3 of the 40 (8%) architecture departments, there are undergraduate courses regarding precast concrete systems. Moreover, the academic curricula of the 12 of the 47 (26%) civil engineering departments and 4 of the 40 (10%) architecture departments cover the courses regarding precast concrete systems. It should be noted that all of these courses are elective and they provide students with theoretical knowledge rather than practical experience. Elective courses are definitely useful, however only limited number of students can take advantage of these courses. On the other hand, all of the students in architecture and civil engineering programs should be familiar with the

nature, capabilities and wide range of applications of precast concrete, and this can be achieved only through mandatory courses. Apparently, there is a need for reconsidering and restructuring typical academic curricula. This can be attained by establishing not only new elective courses but also mandatory courses in the current undergraduate and graduate curricula in architecture and civil engineering programs, and by changing those courses' contents to a new form which provides practical experience as well as theoretical knowledge.

Within the context of those courses, three main activities should be carried out, which are: 1) Educational trips: Educators may organize educational trips to precast concrete manufacturers' production plants and construction sites so that the students can observe not only technical features and production process of precast concrete components but also their capabilities, wide range of applications, and management of the precast concrete components supply chains, 2) Case Studies: The case study method has been proven to be a very useful learning tool and it can be further enhanced with the use of multimedia and the World Wide Web. Case studies may create an educational tool that brings into the classroom a "real-life" design and construction problem, including the construction field, operation of equipment, and details of construction methods. This enables students to better understand the details of the planning, design, and construction of a complicated precast concrete building project (Golias *et al.* 2005), and 3) Assignments: After the educational trips and case studies, giving students an assignment on designing a complicated precast concrete building project would play a significant role in providing adequate knowledge about precast concrete systems. The performance of those courses can be measured via evaluation tests that aim to determine how much the students became aware of technical features and capabilities of precast concrete systems and how much they were good at designing a complicated precast concrete building project.

As well as prospective engineers and architects, active professionals' familiarity with the nature of precast concrete, its capabilities, and its wide range of applications would also help in disseminating the use of precast concrete systems in Turkey. In the U.S., the Precast / Prestressed Concrete Institute (PCI) gives active professionals continuing-education credits via lunch box programs, seminars, plant tours in order to give building owners, developers, and designers a new resource to learn about the many ways that precast concrete can meet construction challenges. These programs follow American Institute of Architects (AIA) accreditation curriculum and they are designed to fit into a busy professional's schedule and take 1 ½ - hour lunch break at the professional's office. The PCI Student Education Committee also provides more than 2,000 copies of the PCI Design Handbook for use as textbooks in schools of architecture in the U.S., provides students with the Architectural Precast Concrete Handbook, and also supports the Association of Collegiate Schools of Architecture Materials and Technology Institute summer workshop program for professional educators who teach in the schools of architecture (Endicott 1997).

The TPA also organizes training seminars, symposiums, conferences and workshops; however, the scope of these activities is very narrow compared with the educational efforts of the PCI since these activities are organized for only the personnel of the member firms. Akin to the PCI, the TPA should expand the scope of these activities and act on behalf of the Turkish precast concrete industry through cooperating with universities, students, professional educators who teach in the schools of architecture and engineering, and professionals by means of consulting for universities in forming new architecture and engineering academic curricula, providing students with free of charge textbooks, providing professors, who teach those students, with information on what's new from architectural, structural and managerial standpoints, and giving professionals continuing-education credits.

While lack of professionals in precast concrete systems results in inadequate analysis, poor design and substandard production practices, lack of qualified laborers in precast concrete systems bring about poor erection practices, which ultimately lead to severe problems such as inferior performance due to distress in the connections. Although precast concrete components are prefabricated in precast concrete manufacturers' plants, they are assembled and erected on site by construction laborers. Since improperly formed connections result in poor performance in precast concrete frame structures under extreme vertical and horizontal accelerations (Iverson and Hawkins 1994), expertise level of the laborers responsible for the erection of precast concrete structures is vital for the performance of these structures under high seismic loads.

For this purpose, the respondents were also asked if they believed that the number of qualified laborers, who have adequate experience in the erection of precast concrete structures, was sufficient. Of the respondents, 48 of the 57 contractors (84%), 31 of the 41 designers (76%) and 29 of the 36 manufacturers (81%) reported that the number of qualified laborers, who can be claimed to be experts in the erection of precast concrete structures, was not satisfactory. In other words, the large majority (81%) believe that there were not enough laborers, who are specialized in precast concrete systems, in Turkey. This finding is not surprising as it is commonly acknowledged that laborers are uneducated, unqualified, and unprofessional in the Turkish construction industry, and their skills are not satisfactory (DPT Report 2004). Precast concrete industry is a part of the construction industry, thus, it isinevitable that unqualified laborers is a severe problem in the precast concrete industry too. Unqualified labour force in the precast concrete industry is an unpreventable result of the wrong policies prevailing in Turkey. In order to improve the qualifications of the labourers in the precast concrete industry, both the precast concrete industry participants and government should do their parts.

Government and relevant ministries and/or institutions, i.e., the TPA, may initiate extensive training programs for all unqualified labourers in the precast concrete industry, and give certificate to the successful attendants, which prove their level of education in this technology. Apprenticeship programs, which are held in most European countries and the U.S., may be a good example of that kind of extensive training programs. Apprenticeship is distinguished from other methods of training by the reciprocal rights and obligations it imposes on the provider and the receiver of training. The provider agrees to teach a broad range of skills required practicing an occupation and, in return, the apprentice agrees to work for the provider at a wage lower than that of a skilled worker (Bilginsoy 1998). In addition to the absence of extensive training programs, the number of technical schools is not sufficient (DPT Report 2004). Although there are numerous architecture and civil engineering faculties that mainly provide their students with theoretical knowledge, there are few technical schools that mainly educate their students with practical knowledge and graduate qualified labourers. The Turkish education system should be reconsidered and restructured in order to initiate new technical schools and promote those technical schools to graduate well qualified labourers endowed with both practical and theoretical knowledge.

Since precast concrete industry participants rarely have a chance to recruit qualified workforce, who can claim to be experts in this technology, then they have to conduct training programs within their organizations on their own in the current state of the Turkish precast concrete industry. The contractors, designers, and manufacturers were asked if they conducted training programs for their employees, including both professionals and labourers, in order to provide them with adequate knowledge on precast concrete systems. Of the respondents, 39 of the 57 contractors (68%), 31 of the 41 designers (75%) and 32 of the 36 manufacturers (89%) reported that they conducted training

programs for their employees. These programs aim at teaching the know-how of analysis and design of precast concrete structures in the design offices, production of precast concrete components in the manufacturers, and erection and organization of precast concrete structures in the contractors. Obviously, the majority of the precast concrete industry participants (76%) conceive conducting training programs within their companies as a way to overcome the unqualified workforce problem in the market. Undoubtedly, that kind of individual initiatives is not adequate to increase the number of qualified workforce and there is an urgent need for the industry wide and nationwide movements.

All of these things can be done and all will help. However, the best solution may be a national initiative led by the government. Improving the qualifications of workforce in construction is a matter of national importance and both deserves and requires government leadership in the formation of a government/university/industry initiative. The Movement for Innovation in the UK (Egan, 1998) is one example of such an initiative.

5 Conclusions

Precast concrete technology offers significant potential advantages. While precast concrete systems have been extensively used in many eastern and northern European countries, the use of these systems in Turkey is very low. It is commonly claimed that the lack of workforce specialized in precast concrete technology is one of the major factors that prevent the extensive use of these systems in the Turkish construction industry. Structural analysis and design of precast concrete components may not be much different from those of reinforced concrete structures, but the foremost issue in these systems is the analysis and design of connections, which is critical for the performance of these structures, especially under seismic loads. A significant number of precast concrete industrial buildings showed enormous deformations and underwent severe failures during the major earthquakes occurred in Turkey due to distress in the connections, which eventually resulted in huge amount of economic and non-economic losses. Thus, the performance of precast concrete structures under seismic loads, which is directly related to the expertise level of workforce in this technology, is one of the most important factors in the Turkish construction market participants' decision-making process regarding using those systems in their projects or not.

A short questionnaire survey was conducted to explore the level of expertise in precast concrete systems currently available in the Turkish precast concrete industry. It was found that 83% of the respondents, who use precast concrete systems in their building projects, recorded that they employed qualified professional within their organizations. On the other hand, the majority of the respondents reported that the academic curricula in universities did not provide adequate education about precast concrete systems from structural, architectural, and managerial standpoints. Moreover, the majority (81%) of the respondents reported that the number of qualified laborers, who can be claimed to be experts in the erection of precast concrete structures, was not satisfactory in the Turkish precast concrete industry. 76% of the respondents reported that they conducted training programs for the employees within their organizations. Obviously, precast concrete industry participants conceive conducting training programs within their companies as a way to overcome the unqualified workforce problem in the market.

Obviously, there is an urgent need for qualified workforce comprising both professionals and labourers in the Turkish precast concrete industry. Professionals', i.e., architects and engineers, awareness of precast concrete systems can be increased by providing them with adequate knowledge about these systems. This can be achieved by establishing not only new elective courses but also mandatory courses in the current undergraduate and graduate curricula in architecture and civil engineering programs, by changing those courses' contents to a new form which provides practical experience as well as theoretical knowledge, and by providing continuous education programs for the benefit of the active professionals. Moreover, initiating extensive training programs such as apprenticeship programs and establishing technical schools would help in increasing the number of qualified labourers. Universities, government, relevant ministries and/or institutions such as TPA, TCA, ATCEA, and the precast concrete industry participants should do their parts in order to improve the qualifications of workforce in the precast concrete industry.

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