Implementing a System for Achieving Innovation Opportunities in a Construction company

Yepes, V.
ICITECH, Universidad Politecnica de Valencia
(email: vyepes@cst.upv.es)
Pellicer, E.
School of Civil Engineering, Universidad Politecnica de Valencia
(email: pellicer@cst.upv.es)
Correa, C. L.
Faculty of Engineering Sciences, Universidad Catolica del Maule
(email; clcorrea@ucm.cl)
Alarcon, L.F.
GEPUC, Pontificia Universidad Catolica de Chile
(email: lalarcon@ing.puc.cl)

Abstract

Small and medium-sized contractors are characterised by organisational structures that are highly focused on control. As a result, employees concentrate on day-to-day activities with little time or motivation to generate creative ideas. Generally, the technological improvements of these companies arise as a result of problem-solving at the construction site. Nevertheless, the actual status quo is changing. In fact, some Spanish public agencies are already considering innovation as an added value in public bids; thus, large contractors are starting to systemise their innovative efforts. This means that small and medium-sized enterprises must modify their attitudes towards innovation in order to sustain their competitiveness. The implementation of a system that enhances systematic innovation and acquisition of knowledge may be the solution to overcome this disadvantage, as discussed in this paper. The authors analysed the implementation of an innovation management system in a Spanish construction company of medium size. The system builds on a set of processes aimed to generate R&D projects that allow the contractor to document the innovation, not only for internal purposes related to knowledge management, but also for external ones associated with obtaining better scores in public biddings. These processes are: (a) technological watch; (b) creativity; (c) planning and executing R&D projects; (d) technology transfer; and (e) protection of results. The last step is the feedback of the entire process through the assessment of the final outcomes. The implementation of the R&D system is ensured within the organisation, through training of personnel, participation of stakeholders and encouragement of the innovation culture.

Keywords: contractor, innovation, management, process, R&D, system

1. Introduction

Innovation is an essential business management tool for organisations that wish to survive. But, can innovation be a strategy to strengthen the competitiveness of construction firms? Some would say that innovation is a trend, as was quality or environmental management some years ago. Even a casual observer, unaware of the reality of the construction industry, might think that this sector is stuck in the past and that it has little capacity to innovate. Currently construction companies have a high capacity to innovate but, unfortunately, are still far from the effort made by other industrial sectors.

The construction industry produces about 10% of the Gross Domestic Product in developed countries; Spain is one of the European countries with higher output in the construction sector, along with Germany, Britain, Italy and France (Seopan, 2008). Nevertheless, the construction industry invests only 0.27% of its turnover in R&D activities (COTEC, 2009). It should be stressed however that although this percentage is very low, some Spanish institutions (large construction companies, universities and research institutions) are actively involved in major international research.

Applying the commitments made in 2000 by the European Union (CICYT, 2003), the Spanish government launched a special program to reduce the gap in R&D investment with other developed economies (BOE, 2005). Spain is one of the countries that offers the greatest tax incentives on R&D spending for enterprises (OECD, 2006); currently, companies that invest in R&D can obtain tax incentives through the Spanish Law 4/2004 on Income Tax (BOE, 2004). Additionally, since late 2006, the Spanish Ministry of Infrastructures rewards companies in the tendering process if they carry out R&D activities; this incentive can increase the final score of the tender by 25% (Pellicer et al., 2008).

In spite of the aforementioned figures, it would not be fair to state that construction companies are not innovative. These companies overcome major technological challenges around the world. Contractors are facing extremely complex challenges everyday that are reflected in singular projects difficult to execute, solving the most diverse technical problems effectively. The key problem is that this contribution to knowledge is often not sufficiently systematised and disseminated throughout the company. Seldom is the economic effort that these challenges pose really valued. It cannot be said, therefore, that construction firms are not innovative enough. The challenge is to standardise and systematise innovation to make it more effective and efficient.

To encourage innovation in the Spanish economy, the experimental set of standards UNE 166000 was published in 2002 by AENOR; in 2006 the final version was published (AENOR, 2006a & 2006b). These standards aim to help companies systematise R&D management. They consider innovation as a process that can be standardised in a similar way to quality or environmental management. Innovation, therefore, is a process that can be normalised using the methodology "Plan-Do-Check-Act". The opportunities for innovation arise from internal and external analyses.

The implementation of a system that enhances systematic innovation and knowledge acquisition is described in this paper. The authors analysed the implementation of an innovation management system in a medium-sized Spanish construction company. The system is built on a set of processes

aimed to generate innovation projects that allow the contractor to document the innovation, not only for internal purposes related to knowledge management, but also for external ones associated with obtaining better scores in public biddings.

This paper is structured as follows. First, a strategic analysis of the company is presented; two surveys were developed: one focused on a group of similar contractors (external analysis), whereas the other focused on directive staff of the company (internal analysis). As an output of the strategic analysis, a system for R&D management in the company is created. Thus, the innovation system is illustrated with descriptive charts, consisting of five processes: (a) technological watch; (b) creativity; (c) planning and executing R&D projects; (d) technology transfer; and (e) protection of results. Once the system is designed, observations from the implementation of the system in the company under study are enumerated.

2. Strategic analysis of the case study

2.1. Case study

The internal analysis of the selected company reveals an enterprise with a workforce of over 1500 employees in eight regional offices. It has long proven its experience in the civil engineering and building sector, being its annual turnover around four hundred million Euros.

This company has not yet taken into consideration innovation as a business strategy. For the internal analysis of this study, a qualitative research methodology was used. Project management, in general, and its application to the construction sector in particular, is currently seen as a social behaviour (Cicmil et al., 2006), so the case study approach is suitable for its analysis (Yin, 2003). Direct observation was used as the general methodology, together with surveys and interviews, analysis of internal reports and technical documents over a twelve-month period. A questionnaire was also distributed to 20 executives of the company, as explained in the next subsection.

The external perspective, by contrast, essentially focuses on determining exogenous factors affecting the competitiveness of the company. This perspective brought to light the opportunities and threats in the construction sector, thus defining the competitive environment with all possible risks and potential benefits. The external perspective of the study took into account the analysis of different sources of information, such as official documents, technical and scientific journals, technical reports and websites, among others. A questionnaire was also distributed to more than a hundred companies in the Spanish construction industry; the results are discussed in Pellicer et al. (2008), although they will be summarised later.

Presently, the strategic analysis of the company from an internal and external perspective is fundamental. The internal analysis identifies the company's strengths and weaknesses, as well as other aspects that determine its resource profile and its abilities with regard to its competitors. On the other hand, the external point of view highlights the opportunities and threats; they are inherent to the construction sector within which the company competes. The results of the research were used to

draw up a strategic analysis of the company under study using the SWOT (strengths, weaknesses, opportunities and threats) model.

2.2. Internal and external analyses

In order to gather first-hand information on the subject of innovation, twenty executives (principal and directors of functional and regional departments) were interviewed to find out more about their business perception. Vallés (1997) pointed out the following advantages of using this type of interview: richness of contextualised information; flexibility and economy; a qualitative counterpoint to quantitative results; accessibility to information that is difficult to observe; and feasibility of exploitation. Table 1 summarises the main conclusions drawn from the direct interviews with executives; this survey is thoroughly described in Correa (2009).

In order to know the current scenario of innovation management in the Spanish construction sector, a survey was developed in 2006 taking into account a representative sample of construction companies; 105 out of 120 companies responded to the questionnaire. Among the results obtained (see Pellicer et al., 2008, for details) one-third of the companies have specific departments for R&D management. However, two-thirds of the respondents revealed that the company's personnel is given little time and few incentives to pursue innovation; almost the same percentage affirms that companies put their efforts in production or operation processes, without time for innovation. Another result is related to the certification of R&D management system: only 5% of the companies hold a certificate from an external certification body. Companies aim to obtain certification in R&D management systems and to truly assimilate these systems within the company.

Table 1: Summarised results of direct interviews with executives

FACETS	***OUTPUTS***
Conceptual framework	*Innovation is associated almost exclusively with research and, moreover, no distinction is drawn between exploitation and innovation activities.*
Strategic framework	*The company does not have an innovation system; furthermore, its competitive strategy does not seem to incorporate policies that foster innovation.*
Organisational factors	*The organisational structure is rigid and controlling. The company culture is not innovative; although it is acknowledged as being important, in relation to the size of the firm, no physical or financial resources are allocated to such purposes.*
Process innovation	*Changes take place only in the basic processes and only when major problems are detected.*
Technological innovation (product/service)	*Innovation is not a priority for the company. All the company's efforts are focused on its day-to-day activities. Nevertheless, the company does keep track of its main competitors (albeit in an unorganised way) and monitoring is carried out by several different individuals.*
Knowledge management	*The company's current situation of urgency does not favour reflection and knowledge generation. Fostering creativity and generating innovative concepts are not priorities.*

2.3. SWOT analysis

The firm under study has significant tangible and intangible resources. The tangible ones are common to other large and medium-sized firms and include elements such as regional offices, vehicles and equipment, coating and concrete mixing plants, mobile plants and financial capital, among others. In comparison to smaller firms, a larger company has a greater financial capacity to cover the expenditure involved in R&D and to assume the risks inherent to such activities (Seaden et al., 2003). The firm under study has three primary intangible resources: (1) its select group of skilled staff who are well-suited for reaching the company's objectives; (2) its know-how or years of experience in the public works and building sector; and (3) its being recognised throughout the country for its capacity to successfully carry out the construction projects awarded. Finally, the company has been awarded quality-assurance, environmental management as well as health and safety standards certificates.

Although the company's chief officers are aware of the competitive advantages of engaging in innovation, they have not undertaken any actions in that direction. Consequently, investment in R&D activities is scarce with respect to other large contractors. More specifically, there is no specific department for the research and development of new products or processes, nor to focus efforts on benchmarking from the technological point of view. The absence of a specific R&D department also limits the success of the R&D activities. Another indicator of the company's deficient innovative culture is reflected in the few actions taken to participate in national or international organisations that promote R&D in the construction sector, such as the Spanish Construction Technology Platform (www.construction2030.org/ptec.php). The company does not seem willing to take risks, and that impedes innovation (Tatum, 1989).

The company's loss of competitiveness is its greatest threat. Such a detrimental effect could render the company unable to bid for contracts with a higher added value. Therefore, it is at a disadvantage in public tenders due to its scarce R&D activities compared to other medium and large contractors. The company's lack of innovation could also make its product portfolio obsolete. The company's reputation and prestige as a versatile, pioneering enterprise may also be affected by its lagging competitive performance from the technological point of view (Kangari and Miyatake, 1997).

Nevertheless, the company can benefit from the tax incentives the government offers to firms that carry out R&D activities (BOE, 2004). Moreover, technological watch can be used to identify the novel technology requirements essential for the future of the business. Similarly, a system focused on management of R&D that helps to acquire and distribute knowledge can also reduce these threats and transform this scenario into an excellent opportunity for success. Taking into consideration the new rules regarding procurement enforced by many Spanish public agencies, innovation is valued in competitive bidding as a key asset (Pellicer et al., 2008). The new Spanish standards on management of R&D projects –UNE 166001 (AENOR, 2006a)– and R&D systems –UNE 166002 (AENOR, 2006b)– are the major tools used to pursue this goal.

3. Description of the R&D management system

3.1. Overall description of the system

The standard UNE 166002 establishes the basis for the systematisation of innovation in companies (AENOR, 2006b). It also aims to integrate R&D management systems with those of quality (ISO 9001), environment (ISO 14001) or health and safety (OHSAS 18001). The UNE 166002 standard is process-based, using the methodology "plan-do-check-act". Regarding our case study, the company under analysis started the procedure of implementing the innovation system to stop the main threat of staying behind its traditional competitors (contractors of medium and large size) and even to exploit the opportunity of taking some advantage over them. However, the company pursues these goals in spite of keeping its hierarchy unchanged; the firm has not set up a R&D department yet, but it is using the current organisational structure to perform the new tasks.

The R&D management system forms part of the overall management system of the business that includes organisational hierarchy, planning, responsibilities, records, procedures, processes and resources. Its purpose is to develop, implement, execute, review and maintain the company's R&D policy (AENOR, 2006b). The two main goals of an innovation system are: (a) to increase the technological competitiveness of the company, favouring an innovative spirit and creativity; and (b) to improve internal knowledge management in the company, obtaining added value for its clients. To achieve these goals, a methodology must be designed and its own organisational structure should be established.

In relation to the methodology, the innovation system designed is divided into five processes: (1) technological watch; (2) creativity; (c) planning and executing R&D projects; (d) technology transfer; and (e) protection of results. This proposal complies with the Spanish standard UNE 166002 (AENOR, 2006b) and it may be certified by an external body (Pellicer et al., 2008). In the rest of this section, we will develop each one of these processes to explain the methodology implemented in the company for establishing a R&D management system.

3.2. Process of technological watch

Technological watch is a systematic and organised effort to observe, collect, analyse, disseminate and retrieve accurate information relevant to the business environment (AENOR, 2006c). Technological watch aims to detect opportunities or threats so as to anticipate changes with minimal risk in making decisions. Therefore, it is bound to the strategy of the company. Furthermore, the technological watch is a mechanism that facilitates brainstorming; as a consequence, the information generated may be made available to all employees.

As illustrated in Figure 1, the surveillance process involves several stages: identifying means and sources, gathering and analysing information, deciding on relevance by an appropriate evaluation, categorising and storing information in the company management system. Although the process of technological watch is included in the UNE 166002 (AENOR, 2006b), this process has a specific standard (UNE 166006) for its development (AENOR, 2006c).

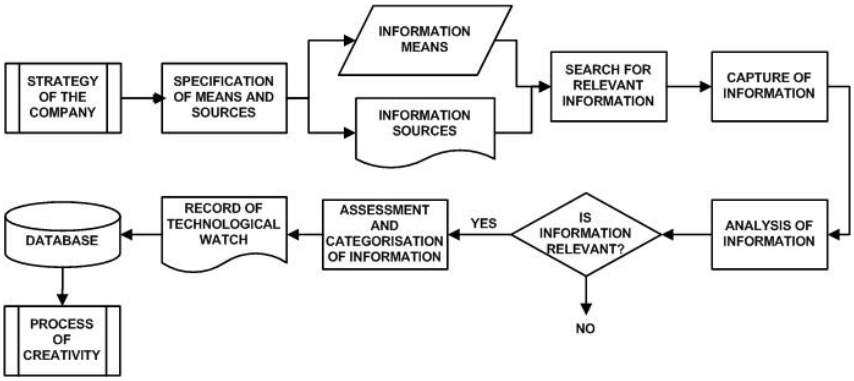

Figure 1: Process of technological watch

The first phase is to collect relevant information existing in regular information sources (magazines, websites, newsletters, software, etc.), as well as specific ones (visits to exhibitions, lectures, etc.), managed by different departments of the company. This requires the identification a priori of the needs, according to the company's strategic analysis. The search strategy and actions to perform must also be fully established. Each of the selected sources has a specialist in charge, in order to examine the information assigned. When an interesting document, article or news report is discovered, it should be included in the document management software available. The evaluation of information must be carried out according to the relevance, reliability, relevance and quality. Thus, the specialist responsible for the source of information summarises the document (record of technological watch), providing search descriptors and classifying it within the system. The categorisation of information is done through filtering and homogenisation, according to the functionality or importance. In addition, the company recognises the prevalence of certain issues as well as the existence of key factors arising from the overall strategy of the company.

The information contained in the database system is available to all employees and partners in order to solve problems at construction sites or simply to generate innovative ideas applicable to the business organisation.

3.3. Process of creativity

Creativity is the generation of ideas, by company employees, and contributes to improving the organisation in accordance with the strategic guidelines established. The information required for the generation of ideas can come from the analysis of weaknesses, threats, strengths and opportunities in innovation, or from particular problems that arise at the construction site. Hence, of all stakeholders, the employees directly involved in the execution of the works (site managers) are a main part of the system.

The recording of ideas takes place in a database. The technical and economic feasibility of an idea and its affinity with the strategic lines previously established by the company are valued by key factors. The idea is assessed by a special committee for R&D activities, taking into account cost, schedule, resources, technical capacity and expected benefits; the contribution to meeting the company's strategy is also included. Depending on the company's ability to undertake projects and the quality of

ideas, some will be chosen for further development. Therefore, the selected ideas are regarded as preliminary R&D projects, also called briefs. The periodicity of the process depends on the timing set by the company: quarterly, annual or biannual.

The R&D committee appoints a technician in charge of generating the preliminary R&D brief. If the idea is not his/hers, it is advisable to work closely with the author of the idea. The brief includes details regarding the person in charge, objectives, scope, design description, design characteristics, needs (resources, time and costs), basic graphic schemes, preliminary state of the art, risks assumed, and probability of success. The latter is considered as the likelihood of achieving the R&D certification (Pellicer et al., 2008).

The R&D projects to eventually be developed by the company are selected by the upper management. Normally, the estimate of the risk assumed in each case and the likelihood of subsequent success in achieving certification under the UNE 166001 are taken into consideration. This process is depicted in Figure 2.

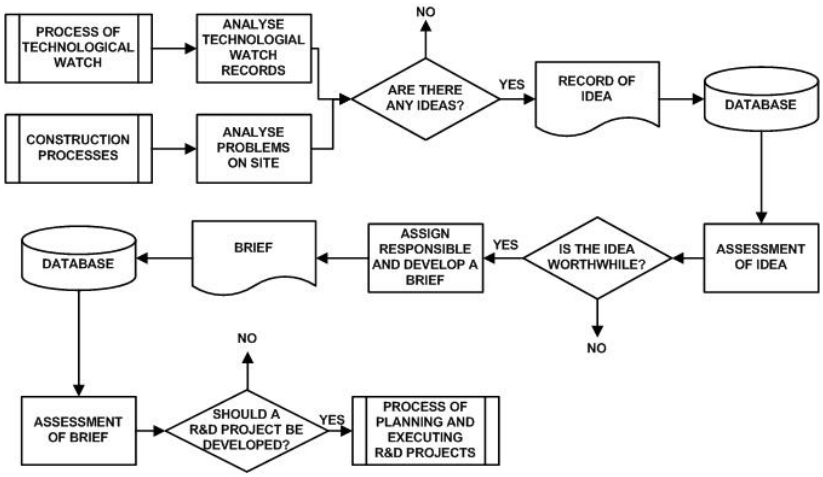

Figure 2: Process of creativity

3.4. Process of planning and executing R&D projects

This process moves from the detailed project design to actual implementation at the construction site or in the company, as summarised in Figure 3. When a problem-solving issue is involved, the project is designed at the same time as works are carried out at the construction site; this case is quite frequent, since the work at the construction site should never stop. This process is the responsibility of the project manager, who is usually the same person accountable for the preliminary brief.

The project manager must prepare a detailed report of the planning of the R&D project prior to its execution. This report includes the methodology, schedule and budget. Also, it is the project manager's responsibility to make progress reports of the projects if necessary. These follow-up reports are reviewed regularly by the company's upper management. Upon completion of the project,

the project manager must prepare a final report, specifying the objectives which were reached. This report contains the following sections: executive summary, state of the art, technical developments proposed, description and justification of R&D activities, scheduling, organisational structure, budget, control, quality assurance, and protection of the results. Every report must include the minimal contents to meet the requirements of the Spanish government (BOE, 2004) or certifying agencies (AENOR, 2006b) to obtain tax benefits, on the one hand, or the certification document, on the other hand.

As discussed earlier, the project implementation at the construction site is the basis of the whole process. During project implementation at the construction site, the R&D project becomes a tool of competitiveness for the company and, therefore, determines whether it is a failure or a success. Responsibility for the implementation of the innovation lies with the construction manager at the site or with the department head that implements the innovation at the firm. Generally, a group is formed under his/her leadership. As stated previously, many times there is the added difficulty of developing the R&D design while executing the works at the construction site.

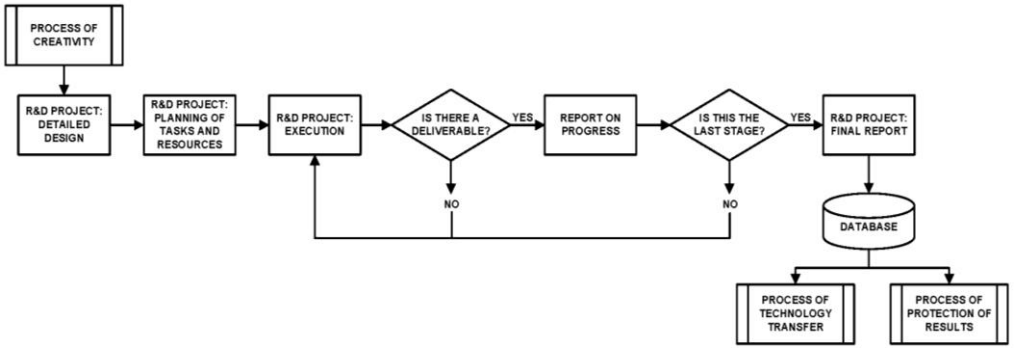

Figure 3: Process of planning and executing of R&D projects

3.5. Processes of technology transfer and protection of results

Technology transfer is the process of acquiring, transferring, sharing, licensing, accessing or positioning innovative knowledge on the market (AENOR, 2006c); the main steps are specified in Figure 4. This set of actions is oriented to take advantage on the open market of the results of R&D activities. It is directly related with the commercial and social exploitation of intellectual property. Whenever the transfer of technology is feasible, risk should be assessed; if they are too high, the idea must be abandoned. Otherwise, the type of technology transfer will be determined as one of cooperation, transmission or delivery of services. A contract is signed, if necessary, to finalise the agreement.

Protection of results aims to secure the knowledge produced. This activity is carried out throughout the innovation process. However, when the R&D project ends, the company has to evaluate all the existing mechanisms to protect the results (either commercial secrets or administrative protection); Figure 5 summarises the process. The tools are diverse. Patents are technical inventions that entail

new features, imply inventive activity and may be applied industrially. Brands or trademarks are symbols (graphic or text) that distinguish products and services on the market. Industrial designs protect the external appearance of a product or part of it, rather than its technical features. Copyrights protect original literary, artistic and scientific works (including computer applications and databases). Industrial secrets are used for information that is both confidential, thanks to efforts of the owner, and valuable (technical know-how, formulas, ideas, etc.).

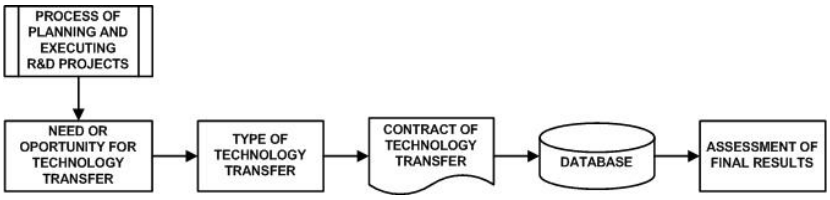

Figure 4: Process of technology transfer

The construction company also seeks to protect sensitive R&D information when contracting with employees, firms or institutions. Specific agreements are developed for cooperation contracts, as well as those for employees, to include confidentiality clauses regarding sensitive information.

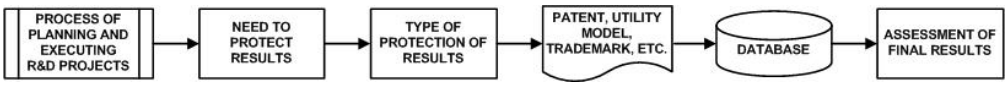

Figure 5: Process of protection of results

3.6. Feedback and assessment of results

The standard UNE 166002 is designed to integrate the R&D management system with other management systems already existing in the company, especially standard ISO 9001 on quality management. This characteristic eases the implementation and enables the continuous improvement of the system.

The case study company is currently working to develop a database that contains the final reports for R&D projects, as well as the recommendations of the site managers. This database can be accessed by all members of the organisation. However, the knowledge management system is not yet fully developed in the company.

In addition, this contractor has set performance indicators for the system and each of its processes. These indicators allow for the understanding the innovative behaviour of the system, meeting the objectives set by upper management. These indicators include: regular sources of information; records of technological watch that lead to ideas; accumulated ideas; projects that obtain certification or administrative protection; other contractors certified by UNE 166002; official tenders that consider

the evaluation of R&D projects; ideas approved as briefs (1st selection); briefs approved as projects (2nd selection); average cycle of innovation; and agencies, institutions or companies that maintain cooperation agreements in R&D with the company.

4. Conclusions and final remarks

This paper analyses the implementation of an innovation management system in a Spanish medium-sized contractor. The system builds on a set of processes aimed to generate R&D projects that allow the company to document the innovation, not only for internal purposes related to knowledge management, but also for external ones associated with obtaining better scores in public biddings. Once the innovation system is designed, its implementation is ensured within the organisation. This involves the active and permanent participation of all stakeholders affected by the system. Thus, once in operation, the system does not become a burden for the company. Its implementation has the advantage of previous experience given by the quality, environmental, and health and safety systems, already implemented by the company. This experience demonstrates that it is difficult to make changes that affect the behaviour of employees, in particular, and stakeholders, in general.

Change involves moving the organisation from the current scenario to a new level, and keeping it there. Consequently, the company develops a procedure to implement the system that involves three stages: (a) diffusion of the R&D system among the organisation's personnel; (b) certification of the R&D management system applying the UNE 166002 standard; and (c) developing and promoting an innovative culture through daily operation and exploitation of the system. These stages correspond to those proposed previously by Lewin (1951): unfreezing; change or transition; and freezing. The construction company is aware that implementing a new process poses specific problems, which must be considered to ensure that the organisation can achieve the expected benefits as far as possible. At every stage it is necessary to train staff in R&D activities and to maintain the constant incentive of the innovative attitude.

Acknowledgments

This research was partially funded by the *Universidad Católica del Maule* (project MECESUP-UCM0205), the Spanish Ministry of Infrastructure (project 2004-36), and the *Universidad Politécnica de Valencia* (contract UPV-20050921). The authors are grateful to Francisco Vea, Ricardo Lacort and Manuel Civera for their help and support throughout the implementation of the system. The authors also want to thank Dr. Debra Westall for revising the text.

References

AENOR (2006a) *UNE 166001:2006 - R&D&i management: requirements for R&D&i projects*. AENOR, Madrid.

AENOR (2006b) UNE 166002:2006 - *R&D&i management: requirements for R&D&i management systems*. AENOR, Madrid.

AENOR (2006c) *UNE 166006/2006 EX - R&D&i management: technological watch system*. AENOR, Madrid.

BOE (2004) *Ley 4/2004 de impuesto sobre sociedades*. Boletín Oficial del Estado, Madrid (in Spanish).

BOE (2005) *Convergence and employment. The Spanish national reform program*. Boletín Oficial del Estado, Madrid.

Cicmil S, Williams T, Thomas J, Hodgson D (2006) "Rethinking project management: researching the quality of projects". *International Journal of Project Management* **24**: 675-686.

CICYT (2003) *The Spanish national plan for scientific research development and technological innovation for the period 2004-2007 - Summary*. Ministerio de Educación y Ciencia, Madrid.

Correa CL (2009) *Análisis, diseño y desarrollo de un modelo de gestión de la I+D+i para empresas constructoras, basado en la norma UNE 166002*. PhD Thesis, Universidad Politécnica de Valencia, Valencia (in Spanish).

COTEC (2009) *Tecnología e innovación en España*. COTEC, Madrid (in Spanish).

Kangari R, Miyatake Y (1997) "Developing and managing innovative construction technologies in Japan". *Journal of Construction Engineering and Management* **123(1)**: 72-78.

Lewin K (1951) *Field theory in social science*. Harper & Row, New York.

OECD (2006) *Science, technology and industry: scoreboard 2005*. OECD Publishing, Paris.

Pellicer E, Yepes V, Correa CL (2008) "Enhancing R&D&i through standardisation and certification: the case of Spanish construction industry". *Revista Ingeniería de Construcción* **23(2)**: 112-119.

Seaden G, Goulla M, Douxtriaux J, Nash J (2003) "Strategic decisions and innovation in construction firms". *Construction Management and Economics* **21(6)**: 603-612.

SEOPAN (2008) *Spanish construction activity report 2007*. Seopan, Madrid.

Tatum CB (1989) "Organizing to increase innovation in construction firms". *Journal of Construction Engineering and Management* **115(4)**: 602-617.

Vallés M (1997) *Técnicas cualitativas de investigación social*. Síntesis, Madrid (in Spanish).

Yin R (2003) *Case study research: design and methods*. Sage Publications, London.