KNOWLEDGE MANAGEMENT IN CONSTRUCTION COMPANIES: DEVELOPMENT OF A WEB-BASED DATABASE SYSTEM

by

Cenap Göktuğ Karataş

B.Sc., Civil Engineering, Istanbul Technical University, 2008

Submitted to the Institute for Graduate Studies in
Science and Engineering in partial fulfillment of
the requirements for the degree of
Master of Science

Graduate Program in Civil Engineering

Boğaziçi University

2011

KNOWLEDGE MANAGEMENT IN CONSTRUCTION COMPANIES:
DEVELOPMENT OF A WEB-BASED DATABASE SYSTEM

APPROVED BY:

Assist. Prof. Beliz Özorhon . . . . . .
(Thesis Advisor)

Assist. Prof. Özer Çinicioğlu . . . . . .

Prof. Ali Rıza Kaylan . . . . . .

DATE OF APPROVAL: 07.06.2011

ACKNOWLEDGEMENTS

I would like to express my gratitude to all people, who in one way or another contributed to the development of this research. I would like to express my sincere appreciation to my advisor Assist. Prof. Beliz Özorhon; thank you for your valuable help in instructing, guiding and supporting me throughout the duration of this thesis.

Also, I would like to thank the members of my Master's thesis examination committee: Assist. Prof. Özer Çinicioğlu, and Prof. Ali Rıza Kaylan for all their valuable comments and advice.

It should also be noted that this thesis is produced based on the research project funded by Boğaziçi University Research Fund (BAP) under the grant number 5501.

Finally, I would like to thank my precious family members and dedicate this thesis to them for their support and encouragement during each phase of my academic career.

ABSTRACT

KNOWLEDGE MANAGEMENT IN CONSTRUCTION COMPANIES: DEVELOPMENT OF A WEB-BASED DATABASE SYSTEM

Companies struggle against complex and dynamic conditions in order to survive in their business settings. Being in the knowledge era, learning has been accepted as one of the main sources of sustainable competitive advantage. Organizational learning (OL) is a set of activities to obtain organizational memory (OM) by acquiring, sharing, interpreting, integrating and institutionalizing knowledge. OM is exploited by the companies in strategic decision-making process, which makes OL a critical concept.

The major objective of this study is to explore how construction companies create OM and how they exploit this asset in project management activities. In this context, a questionnaire survey is conducted with Turkish construction companies. Findings of the survey are discussed in detail. The survey revealed the strengths and weaknesses of construction companies in terms of their OL competence. One of the key findings is that companies are successful at acquiring knowledge but they have difficulties at storing and sharing the acquired knowledge within their organizations.

Although construction companies are aware of web-based database systems, they do not effectively use them. In order to meet the requirements of the industry in terms of effective learning and creation of OM, a web-based database system is developed to assist construction companies in making informed decisions in project and corporate management. This tool is also proposed to increase the OL competence of construction companies through the provision of all knowledge management activities.

ÖZET

İNŞAAT ŞİRKETLERİNDE BİLGİ YÖNETİMİ: WEB-TABANLI BİR VERİTABANI SİSTEMİ GELİŞTİRİLMESİ

Şirketler içinde bulundukları iş piyasasında varlıklarına devam edebilmek için karmaşık ve değişken koşullara karşı direnmektedirler. Bilgi çağının bir getirisi olarak öğrenme, sürdürülebilir rekabet avantajının en önemli kaynaklarından biri sayılmaktadır. Kurumsal öğrenme (KÖ), bilginin edinimi, paylaşımı, yorumlanması, entegrasyonu ve kurumsallaştırılması yoluyla kurumsal belleğe (KB) ulaşmak için yapılan aktivitelerin tümüne denmektedir. KB şirketlerin stratejik kararlarını vermesinde kullanıldığından, KÖ kritik bir kavram haline gelmektedir.

Bu tezin asıl amaçlarından biri inşaat şirketlerinde KB'nin nasıl oluşturulduğunu ve stratejik karar verme aşamasında bu varlıktan nasıl faydalanıldığını ortaya çıkarmaktır. Bu bağlamda, Türk inşaat şirketleriyle bir anket çalışması yürütülmekte ve her bir şirketin KB hakkındaki görüşleri sunulmakta ve irdelenmektedir. Bu çalışma ile KÖ yeteneği açısından güçlü ve zayıf yönleri ortaya koyulmaktadır. En önemli bulgulardan biri de, şirketlerin bilgiyi edinmede başarılı olmakla beraber bu bilgiyi depolamada ve paylaşmada aynı başarıyı gösterememeleridir.

İnşaat firmaları Web-Tabanlı Veritabanı sistemlerini tanımalarına rağmen etkin olarak kullanmamaktadırlar. Sektörün etkin öğrenme ve KB gerekliliklerini sağlamak amacıyla bir web-tabanlı veritabanı sistemi geliştirilerek inşaat firmalarının proje ve kurumsal yönetimde kararlar almasına destek olunması amaçlanmaktadır. Bu araç aynı zamanda bilgi yönetimi aktivitelerini sağlamak vesilesiyle inşaat firmalarının KÖ yeteneğini de geliştirmek üzere önerilmektedir.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS iii
ABSTRACT iv
ÖZET v
LIST OF FIGURES ix
LIST OF TABLES xi
LIST OF SYMBOLS / ABBREVIATIONS xii
1. INTRODUCTION 1
2. KNOWLEDGE MANAGEMENT IN CONSTRUCTION COMPANIES 4
2.1. Definitions of Organizational Learning and Learning Organization 5
2.2. Dimensions of Learning Organization 6
2.2.1. Learning in the Organization 6
2.2.1.1. Levels of Learning. 6
2.2.1.2. Types of Learning. 7
2.2.2. Organizational Transformation 8
2.2.2.1. Vision 8
2.2.2.2. Culture. 9
2.2.2.3. Structure 9
2.2.2.4. Strategy. 9
2.2.3. Knowledge Management in Construction 10
2.2.3.1. Knowledge Acquisition and Storage. 10
2.2.3.2. Information Distribution. 11
2.2.3.3. Information Interpretation. 11
2.2.4. Organizational Memory 12
2.2.5. Role of Information Technologies in Organizational Learning 13
2.2.6. Organizational Memory Information Systems and Databases 13
2.3. Organizational Learning in Construction Industry 14
2.3.1. How Construction Companies Learn 17
2.3.2. Enablers of Organizational Learning 18

2.3.3. Organizational Learning Barriers 19
2.3.4. Strategic Role of Organizational Learning for Construction Companies 20
2.4. Performance Measurement and Management in Construction Companies 21
2.4.1. Performance Management in General 21
2.4.2. Performance Management in Construction 23
2.4.2.1. Performance Management at Project Level. 25
2.4.2.2. Performance Management at Corporate Level. 25
2.4.2.3. Performance Management at Industrial Level. 26
2.4.3. Importance and Benefits of Performance Measurement 26
2.4.4. Development of Conceptual Frameworks and Process Models 27
2.4.4.1. The Balanced Scorecard. 28
2.4.4.2. The Performance Pyramid. 29
2.4.4.3. International Key Quality Awards. 30
3. RESEARCH METHODOLOGY AND FINDINGS 33
3.1. Research Methodology 33
3.1.1. Administration of the Survey 35
3.1.2. Content of the Survey 35
3.1.2.1. General Information About the Respondents and the Companies. 35
3.1.2.2. Learning From Own Experiences of the Company. 35
3.1.2.3. Learning From Corporate, Individual and Group Attempts 40
3.1.2.4. Data Sharing. 42
3.1.2.5. Use of Knowledge. 44
3.2. Research Findings 46
3.2.1. General Information About the Respondents and the Companies 46
3.2.2. Learning From the Own Experiences of the Company 48
3.2.3. Learning Through Corporate, Individual and Group Attempts 50
3.2.4. Data Sharing 52
3.2.5. Use of Knowledge 53
3.3. Discussion of the Findings 54

4. A WEB-BASED DATABASE SYSTEM FOR CONSTRUCTION COMPANIES ..56
4.1. Web-Based Database Systems 57
4.2. The Proposed System 58
4.2.1. System Development 58
4.2.2. System Architecture 59
4.2.2.1. Home Page. 61
4.2.2.2. Company Profile Page. 62
4.2.2.3. Corporate Information Page. 63
4.2.2.4. Regional Information Page. 64
4.2.2.5. Project Information Page. 65
4.2.2.6. Ongoing Projects Database Page. 66
4.2.2.7. Tendering Department Database Page. 75
4.2.2.8. Business Development Page. 82
4.2.2.9. QA/QC and HSE Page. 83
4.2.1.10. Human Resources Page. 84
4.2.1.11. News and Announcements Page. 85
4.2.1.12. Messaging Page. 86
4.2.1.12. Search Tool Page. 88
4.3. Implementation of WEB-CONS 88
4.4. Benefits of WEB-CONS 90
4.5. Shortcomings of the System 91
5. CONCLUSION 93
APPENDIX A 99
REFERENCES 106

LIST OF FIGURES

Figure 2.1. OL Framework 16

Figure 2.2. Balanced Scorecard Framework 29

Figure 2.3. Smart System 30

Figure 2.4. EFQM excellence model 31

Figure 3.1. Knowledge management activities in construction 34

Figure 4.1. User Management Page and Authorization Levels 60

Figure 4.2. Log-in Page 60

Figure 4.3. Home Page 62

Figure 4.4. Company Profile Page 63

Figure 4.5. Corporate Information Page 64

Figure 4.6. Regional Information Page 65

Figure 4.7. Project Information Page 66

Figure 4.8. Ongoing Projects Page 67

Figure 4.9. Project Management Database Page – Part 1... 69

Figure 4.10. Project Management Database Page – Part 2. 69

Figure 4.11. Project Management Database Page – Part 3 70

Figure 4.12. Tendering Information Page 76

Figure 4.13. Tendering Management Database Page – Part 1 78

Figure 4.14. Tendering Management Database Page – Part 2 78

Figure 4.15. Tendering Management Database Page – Part 3 79

Figure 4.16. Business Development Page – Part 1 82

Figure 4.17. Business Development Page – Part 2.. 83

Figure 4.18. QA/QC and HSE Page 84

Figure 4.19. Human Resources Page 85

Figure 4.20. News and Announcements Page 86

Figure 4.21. Messaging Page 87

Figure 4.22. Message Composing Page 87

Figure 4.23. Search Tool Page 88

LIST OF TABLES

Table 3.1. General Information About the Survey Respondents 47

Table 3.2. Average Response Rates for Learning from Own Experiences 48

Table 3.3. Average Response Rates for Learning from External Resources 51

Table 3.4. Average Response Rates for Data Sharing Mechanisms 52

Table 3.5. Average Response Rates for Knowledge Use at Strategic Decisions 53

Table 4.1. Project Management Page Main Headings and Subtitles 68

Table 4.2. Tendering Management Page Main Headings and Subtitles 77

LIST OF SYMBOLS / ABBREVIATIONS

AAR	After Action Review
ASP	Application Service Providers
BSC	Balanced Scorecard
EFQM	European Foundation for Quality Management
HSE	Health, Safety and Environment
IS	Information Systems
IT	Information Technologies
KM	Knowledge Management
KPI	Key Performance Indicators
OL	Organizational Learning
OM	Organizational Memory
OMIS	Organizational Memory Information System
PPA	Post-Project Appraisal
TCA	Turkish Contractor Association
TQM	Total Quality Management
QA	Quality Assurance
QC	Quality Control

1. INTRODUCTION

Learning is considered to be an integral part of a human's life; people have to continuously learn to improve their adaptability to the environment and to augment their living conditions. Similarly, organizations should also learn in continuous manner for survival and to stay competitive in their business settings.

For a long period of time, the value of information and knowledge have been realized, studied and new learning styles were explored by the researches as well as the business members. Following the developments of learning skills in other industries, construction industry has also started to improve its skills in learning and knowledge management. Construction companies carry out their knowledge management activities by acquiring, storing, sharing and utilizing knowledge in purpose of increasing their efficiency and effectiveness at organizational operations. Although construction companies are observed to learn, how and in what extent they make use of knowledge still remains unresolved. As Kululanga *et al*. (2001) state, due to its project-based nature of construction business, there is not a suitable culture for learning in the construction industry, however the companies should be more careful in developing and measuring their OL competence to fully benefit from OL principles.

Organizations learn through their employees and finally obtain a corporate asset called organizational memory (OM) by the integration of knowledge to their organizational activities. Construction companies are more successful at collecting project data compared to conversion of this data into knowledge and use of this knowledge at different stages of performance management. The formation of OM and then its use in strategic decision making in construction was found to be limited (Özorhon, 2004). One of the major objectives of this thesis is to investigate how the construction companies create their OMs and to explore how they make use of OM at their project management processes. In this respect, a questionnaire survey is carried out with multiple of Turkish construction companies, all of which are members of Turkish Contractors Association.

According to the results of the questionnaire survey, a web-based database system namely WEB-CONS is developed to aid the knowledge management activities of the construction companies. The system not only works as a project management tool, but also helps the companies by improving their abilities on corporate management.

Chapter 2 is on knowledge management (KM) in construction companies. In order to discuss the role of OM in construction companies, first of all essential concepts related to organizational learning (OL) should be explained. The following chapter gives the definitions of OL and learning organizations; the dimensions of a learning organization are mentioned and the importance of OL for construction companies is addressed. After defining the principles of OL, the role of OM for the construction companies are also explained. Based on the OL framework developed by construction companies, knowledge management activities are reviewed with OL enablers and barriers are listed. Besides, the role of both OM and OL in performance management is emphasized.

Chapter 3 is on the research methodology and key findings of the research in terms of OL and OM perceptions and applications. A questionnaire form is designed on the main knowledge management activities for a construction company. The questionnaire is administrated to Turkish construction companies. They are asked to respond to the questions related to OL and OM on behalf of their companies. The research findings are presented and discussed in this chapter.

The research findings are presented to demonstrate the outcomes of the questionnaire. Although a lot of companies from Turkish Contractor Association are involved in this study, it would not be proper to generalize the answers of the respondent companies as if they are common to all other companies in the construction industry. Presented research findings identify company specific assumptions and behaviors of OL and also determine a general trend about the topics discussed at the beginning of the third chapter. Based on the findings, companies are observed to be poor at creating and exploiting OM specifically, the use of information systems to aid project management is limited. In order to address this issue, a web-based database system is proposed in this thesis.

Chapter 4 presents the web-based database system for construction companies namely WEB-CONS. The system architecture is discussed in terms of various functional web pages to present various project and corporate level information such as; company profile, corporate information, regional information, project information, ongoing projects database, tendering department database, business development, quality assurance (QA) and quality control (QC), health, safety and environment (HSE), and human resources. There is also a communication aspect within the system such as news and announcements, and messages.

The key point in preferring a web-based system is its provision of world-wide access where the Internet technology is available, since most of the Turkish construction companies are carrying out international projects. The web-based characteristic of the system also helps the companies to create a common platform of knowledge sharing and utilization. Besides, the system facilitates the formation of the OM within the companies and utilizes this asset in strategic decision-making process.

Development of the web-based database system increases the effectiveness and performance of a construction company at all three stages of a construction which are respectively; pre-project decision-making stage, project management stage and post-project evaluation stage. An application of the system at one of the respondent companies of the questionnaire survey is also presented to demonstrate the benefits and shortcomings of the system.

Finally, based on the research findings, concluding remarks are provided in the fifth chapter.

In addition to the main text, this thesis also includes an appendix. In Appendix A, a sample of the survey related to the research study can be found.

2. KNOWLEDGE MANAGEMENT IN CONSTRUCTION COMPANIES

Organizations, just like humans, improve their business success by learning. According to Bhatt and Zaveri (2002), due to the changes such as technological advances, growing and changing customer demands, competitive forces, environmental and political concerns, and changes in the labor force; it has become more important for the organizations to be able to respond and adapt to this dynamic environment. In order to survive and stay competitive in this environment, companies have to come up with new ideas to improve their operation techniques, develop new technologies and accomplish all these tasks to grow and become more effective in their business settings.

Companies should be aware of the importance of knowledge and learning for better cooperation, collaboration, autonomy, being proactive, long term thinking and learning when they make strategic plans. As Senge (1990a) remarks: "The rate at which organizations learn may become the only sustainable source of competitive advantage". Competitive advantage requires an organization to be more adaptable to changes and assess its capability relative to the demanded capacity (Özorhon, 2004). Companies are encouraged to become "learning organizations" in order to develop new strategies for their survival and to stay competitive in their business environment.

The aim of this chapter is mainly to investigate the basic ideas related to the concepts of organizational learning (OL) and learning organizations. Then the steps of learning organizations will be discussed in a system-linked model. In this model, a learning organization has five subsystems namely; learning, organization, people, knowledge and technology. These subsystems will be discussed in detail in the following sections. After introducing basic concepts, creation of organizational memory (OM) will be explained in detail. Finally, as an important driver of OM and OL; performance measurement and management in construction will be explained.

2.1. Definitions of Organizational Learning and Learning Organization

The concept of OL has taken its reputation in construction industry in the past several decades. Construction companies see OL as a way to gain competitive advantage in their business domain. There are several definitions of OL and the learning organization regarding to the components forming the learning process; which may be the human dimension, the environment, the knowledge concept or the organization's identity.

One of the earliest definitions of OL is given by Angryis (1977) as the process of "detection and correction of errors". Learning occurs if a company changes through the processing of information (Huber, 1991). From this point of view, it is insisted that the capacity of change within an organization is associated with its capacity of adopting organizational learning throughout the organization. With a wider perspective, Dodgson (1993) claims that the organizations build, supplement, and organize knowledge and routines around their activities within their cultures, and adapt and develop organizational efficiency by improving the use of the broad skills of their workforces. Also Kululanga *et al*. (2001) defines OL as a trigger that encourages the learning culture of the organization at all levels, individually and collectively, continually increasing their capacity to improve their level of performance.

In the light of the above definitions, OL can be summarized as a set of organizational actions such as acquiring, sharing and interpreting knowledge among the individuals whose main purpose is to increase company performance for the improvement in the quality of project management decisions in the company (Özorhon, 2004).

Garvin (1993) describes a learning organization as a concept in which people at all levels, individually and collectively, continuously expand their capabilities to a desired level by creating, acquiring and transferring knowledge, modifying its behavior to new knowledge era and insights. On the other hand, Senge (1990a) defines the learning organization as a place where people continuously expand their capacity to create productions they truly desire, by nurturing new and expansive ways of thinking, by setting the collective aspiration free and by creating organizations which constantly are "learning how to learn".

2.2. Dimensions of Learning Organization

As Özorhon (2004) states "learning organization is a multidimensional notion that has to be investigated from different approaches". Each factor that builds up the learning organization should be investigated one by one in order to gain an understanding and capabilities of the creation of a learning organization. The foremost point is the existence of knowledge management infrastructure within the organization which aims to identify, analyze, manage, maintain and disseminate knowledge to appropriate individuals within the organization and externally to others (Leibowitz, 1999). This can only be achieved through the proper combination of relevant systems and skills that are influential in the learning process of the organization. Senge (1990a) identified five major learning skills or disciplines that would be helpful for the transformation of the company into a learning organization. The skills or disciplines of systematic thinking, mental model, personal mastery, team learning and shared vision are necessary to maximize OL in a company.

Marquardt (1996) proposed a system-linked learning organization model, which is made up of five closely interrelated subsystems that support one another. The main subsystem of the learning organization is learning and this dimension permeates the other four subsystems. All the other four subsystems namely; organization, people, knowledge and technology are necessary to increase and augment the quality and effect of the learning dimension. Building the learning organization will be discussed by examination of these subsystems.

2.2.1. Learning in the Organization

As the core of the proposed model, the learning dimension will be covered in detail. The learning subsystem refers to the levels and types of learning which are crucial for the OL.

2.2.1.1. Levels of Learning. Strategic management of OL requires the intuiting, interpreting, integrating and institutionalizing of knowledge flow that takes place at individual, group and organizational levels respectively (Crossan and Bontis, 1998). According to Jeffries *et al.* (2003), levels of OL can be defined in three phases beginning

from the individual level by interpreting and reflection, maturing at group level by integration and conceptualization and finally reaching organizational level by institutionalizing and experimentation.

Individual learning is the basis for the existence of an organization's learning and it should be developed to obtain a more effective OL. Individuals learn by detecting and correcting errors (Angryis, 1977) and they learn when they produce effective actions from errors. As Espejo *et al.* (1996) state, individuals learn by developing necessary practices and skills to make effective actions.

Group/team learning is an inseparable member of OL which functions as a bridge between individual and organizational learning steps by providing new approaches to the learning process (Marquardt, 1996). As Özorhon (2004) states "groups learn from their own experiences and past histories, and transform knowledge among themselves and the organization".

Organizational learning requires the crucial step of the transformation of individual learning into OL. As Crossan *et al.* (1999) suggest, this transformation process necessitates a framework made up of four main events including intuiting, the preconscious recognition of the possibilities inherent in a personal experience; interpreting, the explanation of an idea to oneself and to others; integrating, the developing of a shared understanding coordinated action among individuals, and institutionalizing, the process of ensuring that actions are made routine (cited in Robey *et al.*, 2000).

2.2.1.2. Types of Learning. Angryis and Schon (1978) assert that there are reflective methods or processes of learning at the individual level and the connection between individual learning and OL, and describe three types of OL.

Single-loop learning can be defined as the learning type which the organization responds to changes in its own environment by detecting errors and correcting them, but maintaining its organizational standards (1990b). Single loop learning has also been referred as adaptive learning by Senge (1990b).

Double-loop learning, on the other hand, involves the adjustment of organizational culture, assumptions, guidelines, objectives, strategies and structure of an organization (Senge, 1990b). Double-loop learning is also called the generative learning by Senge (1990b) which is a process of creative renewal and rediscovery of an organization to remain competitive.

Deutro-learning is defined as of creativity in the problem-solving process, in other words, learning about learning (Angryis and Schon, 1978). Single-loop learning is more concerned with problem solving without questioning the underlying assumptions via core beliefs, whereas double-loop learning and deutro-learning are more concerned with the questions of why and how to redefine the organization to adapt and survive in the dynamic business environments (Bhatt and Zaveri, 2002).

It can be concluded that many construction companies may have difficulties with double-loop or deutro-learning, since these types of learning might force them to leave their traditional norms and value systems.

2.2.2. Organizational Transformation

Organization is the structure in which the individuals, groups and organization itself learn. As Huber (1991) states, organizations that do not have the suitable structures, processes and technologies to deal with the increasing environmental complexity and knowledge are unlikely to survive. Around the shared vision and culture, organizations should become learning organizations in order to stay competitive in their business settings. Subsystems of vision, culture, structure and strategy components will be discussed to emphasize the importance of organizational transformation for learning at the organizational level.

2.2.2.1. Vision. The vision of an organization can be defined as its commitment for a certain goal, direction or reliance for the future of the organization (Özorhon, 2004). According to Marquardt (1996), to build a solid foundation or shared vision about learning is the first and the most important step of becoming a learning organization. Above all, individuals of the organization should have a common understanding of the organization's

identity which would improve the members of the organization to have more than just a common view of its mission, but also creates a common direction for the development of the organization.

2.2.2.2. Culture. Walsh and Ungson (1991) define culture as the conscious and unconscious patterns of assumptions, values and beliefs shared by a collective (cited in Berthon *et al.*, 2001). According to Weick (1994), culture acts as a knowledge filter; it specifies the value of information, influences the interpretation of information and coordinates the collective action taking (cited in Berthon *et al.*, 2001).

Organizational culture is regarded as a pattern of basic assumptions which is created by means of the past experiences of the company that helps to learn the ways of solving both internal and external problems. The organization should aim to teach the members to perceive, think and feel continuously in relation with those problems.

According to Lehner and Maier (2000), available knowledge will be acknowledged by an organization when it does not conflict with its organizational paradigm. Since the organizational culture involves assumptions, adaptations, perception and learning, it determines the quality and quantity as well as its influence on project management decisions (Jeffries et al., 2000).

2.2.2.3. Structure. According to Özorhon (2004) "structure of an organization links the various elements of the organization through the transformation of information". The structure of the organization is important mainly because of its effect on the interactions of the individuals. Structure also affects the capability of knowledge sharing within the organization as well as its influence on the capacity of learning from the activities conducted by the company.

2.2.2.4. Strategy. Organization's strategic objectives are to be aligned with identification, capture and transfer of knowledge within the individuals. Strategy is influenced by learning for its assistance at every stage of a project, which causes the managers of the company to give healthier decisions at their decision-making processes (Malone, 2002).

2.2.3. Knowledge Management in Construction

Lehner and Maier (2000) defines a knowledge management system as a dynamic system which aims to support OL and organizational effectiveness, comprising of functions to identify, acquire, maintain, search, retrieve and distribute knowledge. Before discussing the necessary knowledge management activities, first the distinctions between data, information and knowledge should be explained.

According to Egbu and Botterill (2002), *data* can be defined as the simple observations of states of the world. *Information* is viewed as the organized facts and data to describe a particular situation, and conditions, whereas *knowledge* consists of truths, beliefs, perspectives, concepts, judgments, expectations, methodologies and know-how and it exists in different forms. As information gains meaning by interpreting, information becomes true knowledge.

Knowledge may be classified in two types namely; *tacit* (informal or soft) and *explicit* (formal and hard). The tacit knowledge is composed of competences, values and norms whereas the explicit knowledge can be found in forms of specifications, instructions and definitions. The informal knowledge is difficult to capture and keep; which includes ideas, facts, assumptions, meanings, questions, decisions, points of view and stories (Conklin, 2002). Knowledge is realized to be hard and transferrable in case of specific, commercial and technical information; which can easily be codified, documented and transferred to other people (Hong, 1999).

Organizations should have enough capacity to process information to acquire, interpret, distribute and store information throughout the organization. The discussion of knowledge management will cover these activities such as knowledge acquisition, information distribution and information interpretation.

2.2.3.1. Knowledge Acquisition and Storage. The OL cycle starts with the collection of information from both internal and external sources. Acquisition of knowledge can be achieved by monitoring the environment and using the information systems to store, manage and retrieve information. According to Ingram and Baum (1997),

organizations can learn from two different sources of experience to improve their performance namely; their own and industry experiences (cited in Hong, 1999). As it can be noticed, organization's own experience is not the only source of gathering information. Additional external sources such as government agencies, advertising agencies, societies, accounting offices, news agencies and the media etc. can be sources of knowledge acquisition other than own experiences of the organization (Walsh and Ungson, 1991 cited in Lehner and Maier, 2000). From the above sources, it can be concluded that there are three main knowledge acquisition sources for companies namely; company's own experience, other companies' experiences and external resources.

After the acquisition of knowledge, organizations should develop an effective storage mechanism to ease their activities of distribution and interpretation of knowledge. These mechanisms used for the storage of knowledge by utilizing information technologies will be discussed in the following chapters.

2.2.3.2. Information Distribution. Information distribution can be referred as the process of sharing information among the units and members of the organization, therefore encouraging learning and producing new knowledge, and understanding (Özorhon, 2004). In addition to traditional ways of information distribution such as sharing stories, to capture and distribute tacit knowledge, computer-aided communication systems such as intranet, web-based systems and networks can be effectively used for sharing information among the members of the organization.

2.2.3.3. Information Interpretation. Interpretation is defined by March (1998) as the process of translating the events, developing models for comprehending, giving meaning and assembling conceptual schemes (cited in Hong, 1999). Individuals and groups have prior belief structure that shape their interpretation of information and thus the formation of meaning (Huber, 1991). A database system can support the storage and retrieval of information going into the project management process and also can be regarded as a tool to promote learning and awareness among individuals and groups.

2.2.4. Organizational Memory

Huber (1991) defines OM as the means by which the organizations store knowledge for future use. A similar definition given by Stein and Zwass (1995) who define OM as the extraction of knowledge from the past to bear on present activities thus resulting in increased levels of effectiveness for the organization (cited in Özorhon, 2004). Although organizations do not have brains like humans, they intentionally or unintentionally develop brains, in other words memories. From the knowledge created by its individuals, organization develops its corporate memory by capturing, organizing, disseminating, and reusing knowledge.

The OM structure developed by Walsh and Ungson (1991) is composed of acquisition, retention and retrieval, and postulated the existence of five storage bins that constitute the structure of memory within organizations and one source outside of the organizations being individuals, culture, transformations, structures, ecology and external archives (cited in Ji and Salvendry, 2001). Another approach to OM by Cross and Baird (2000) lists the components of OM as individual memory, personal relationships, databases, work processes and support systems, products and services.

Many authors like Angryis and Schon (1978) have stressed how OM development can produce habitual decisions and actions, which emphasize short-term operational efficiency over long-term strategic effectiveness (cited in Berthon, 2001). For any organization, OM can be imagined as the bridge connecting the past and the present decision-making situations.

OM is a general term that implies that the knowledge can be stored in several places, human mind and artifact. It is predictable that the managerial decisions are not only made utilizing the codified formal knowledge but also using the knowledge in the form of know-how and experience. It is obvious that asking the company members to share much information is a difficult duty since they may not desire to disclose valuable information for fear of losing their individual competitive advantages. This fact brings out the need for information systems (IS) to store and retrieve such important knowledge collected from the

members of the organization to store the tacit knowledge and further increase the level of OL in the organization. At this point, the necessity of technological means comes out.

2.2.5. Role of Information Technologies in Organizational Learning

Technology should be regarded as an important driver of improvement for the corporate memory developed by the organization. The influence of technology on both OM and OL will be discussed at this section and the next, by mentioning the information technology (IT) tools that support learning in the organizations; importance of IS to construct corporate memories; and role of database systems in enabling OL. It should be remembered that although these two sections have different headings, these concepts are interrelated and they have several common points.

According to Robey *et al*. (2000), IT can provide an infrastructure for storing, accessing and revising some of the elements of OM due to its importance as an ingredient in the design of learning organizations. IT can be referred as the general term that specifies computer-based tools utilized to gather, code, process, store and apply data between machines, individuals and organizations (Özorhon, 2004). IS can influence the OL by affecting the contextual factors such as structure and environment, which, in turn, influence learning. Although Huber (1991) states that IS have the primary role of directly serving OM, IS can also serve knowledge acquisition, information distribution and information interpretation as well. For example, technologies such as databases, data warehousing, expert systems and Internet/intranet systems, which comprise valuable components of OM (Stein and Zwass, 1995) can facilitate the process of knowledge acquisition, information distribution and information interpretation.

2.2.6. Organizational Memory Information Systems and Databases

According to Lehner and Maier (2000), steps of information processing include data processing, data management, information management and OM management. As Ji and Salvendry (2000) suggest, in purpose of supporting and integrating OL systematically, a form of an information infrastructure namely organizational memory information systems (OMIS) should be implemented. An OMIS can be understood by the application of

different types of information technologies such as databases, knowledge bases, social networks and electronic bulletin boards, and intranet that together form the OMIS infrastructure.

Lehner and Maier (2000) state that the development of OM systems are relatively more complicated than development of conventional IS since the existing models and planning methods should be advanced further and a relationship with management applications must also be developed due to the fact that the OM has a strategic role in decision-making process of an organization.

According to Ji and Salvendry (2000), an OMIS aims to help the individual's routine decision-making process because whenever a user makes a decision, he or she refers to his or her personal memory and OM, in which organizational knowledge is stored, including past organizational experience that would assist him or her throughout the process of decision-making.

2.3. Organizational Learning in Construction Industry

All companies have the common goal of increasing their performance and profitability to survive in the competitive business environment. OL aids this goal by improving the companies' capacity of taking effective actions (Kim, 1993). According to Kululanga *et al*. (1999), construction companies have to adopt learning skills as a distinctive feature of their activities to increase their ability to innovate and to ensure permanent improvement.

The construction industry has some features that make it different from other industries. As Barlow (2000) states, construction projects are unique projects comprising of the integration of different subsystems and components by a range of participants such as clients, advisors and subcontractors coming together for a temporary coalition, which disintegrates right after the completion of the project.

Due to its project-based nature, construction industry can be referred to as short-term and task oriented which does not allow a culture for continuous learning. For this reason,

construction companies should be more careful in developing and measuring OL so as to benefit from OL principles (Kululanga *et al*., 2001).

As Garvin (1993) suggests, a learning organization in construction should have skills at five main activities namely; systematic problem solving, experimentation with new approaches, learning from their own experience and past history, learning from the experiences and best practices of others, and transferring knowledge quickly and effectively throughout the organization (Love *et al*., 2000). Each of these activities corresponds to a different level of knowledge acquisition and sharing mechanism, and interpretation and utilization of knowledge activities. Systematic problem solving may be referred to as equivalent to standardization of procedures, which may be achieved through the total quality management (TQM) principles. Construction companies should try to develop new approaches to improve their learning for better management of their projects and decision-making processes, and experiment in their activities to remain competitive in their business settlement. Learning from own experiences and past history of the company could be used as a guide to improve future actions. As well as learning from its own resources, a construction company also learns from the external resources through partnership and benchmarking. Finally, as Kululanga *et al*. (2001) state, construction companies should not just learn from internal and external sources but also have to code the knowledge to make it useful for future applications in order to achieve success.

In general, the concept of OM can be defined as the storage of useful information and retrieval of it at a later point in time. According to Özorhon (2004), OM is created by the interpretation of acquired knowledge within the organization, integration of this knowledge to daily activities and institutionalizing it to obtain a corporate level. When companies or employees are making decisions, they should exploit the OM to have more proper judgement at their decision-making at both project and corporate levels. Since the output of the decision-making and project management processes are new ideas or knowledge, these can be converted back into the learning framework to be transferred into a component of OM. Özorhon (2004), presents this OL process in the following framework (Figure 2.1). In this framework, knowledge is acquired from own experiences, from competitors and partners, and even from external resources. These are converted into the

OM, that is a corporate asset within the company. Then, OM is utilized to aid strategic decision-making.

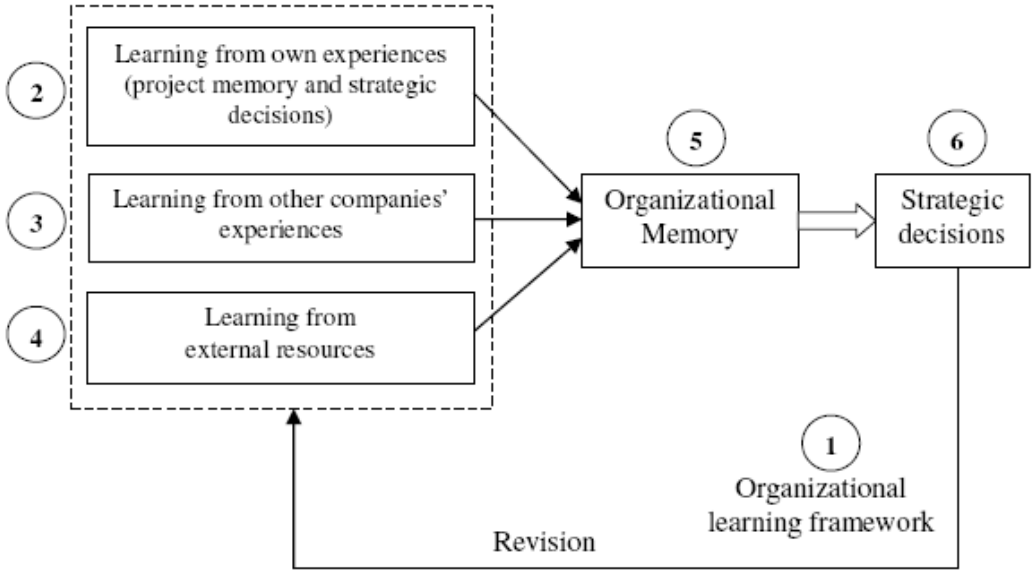

Figure 2.1. OL Framework

Fiol and Lyles (1985) state that learning includes the development of the insights, associations and conclusions about the effectiveness of past experiences and their influence on future actions to be taken (cited in Love, 2000). OM enables organizations to quickly respond to critical situations and make effective and efficient decisions about the conflicting requirements of the environment.

Similar to other companies in other industries, construction companies have a common goal of taking more jobs and making profit. Since the objective of the companies is to earn money from projects, profitability can be referred as the major concern while giving strategic decisions. According to Berthon *et al*. (2001), strategic problems deal with the determination of an organization's purpose, goals and direction, to fit or align between the organization and its environment, and keep the organization as a whole. Due to the unique nature of construction projects, uncertainties and incomplete scope definition, it is almost impossible to make decisions with all needed information available so mostly decision-making problems are solved by expert judgement (Ahmad, 1990).

The following sections explain how those essential activities are carried out by the construction companies and how competitive advantage can be created through these learning practices. Creation of corporate memory through project learning, other companies' experiences and external resources will be discussed, and then some examples for the enablers of OL will be presented, which will be followed by the barriers of learning for construction companies. Finally, the importance of knowledge exploitation for construction companies will be explored.

2.3.1. How Construction Companies Learn

Like most of the activities in a company, learning is also concerned with production and delivery of goods and services. The major idea behind learning for organizations is that they learn as they produce. Due to the nature of construction works, the unit of production and service is actually the project, and this brings out the fact that the project-related activities are the main source of learning that constitute own experiences of the companies. Kasvi *et al*. (2003) state that the project knowledge includes technical knowledge concerning the product, its details, technology and methods used, procedural knowledge concerning producing and using of the product, and organizational knowledge concerning communication and collaboration between work teams (cited in Özorhon, 2004). According to Hansen *et al*. (1999), there are two fundamental strategies for knowledge management, one of which is the codification strategy based on codifying and storing the knowledge in artifacts or databases where it can be accessed. The other is the personalization strategy in which knowledge is tied to people developing it and it is shared by personal interaction.

Since the construction projects differ from one another, discontinuities are encountered in flows of personnel, materials and information, which ends up with the difficulty of developing routines to maximize project knowledge flow and capturing the useful learning from one project to the next. Due to the high turnover in construction industry, companies are responsible for documentation of project knowledge and know-how, making it accessible for new employees and protecting the knowledge when employees leave the company. Unfortunately, as Schindler and Eppler (2003) state, for most construction companies, the systematic integration of knowledge and experiences

gathered from different projects into the organizational knowledge base turns out to be a challenge. Form a long-term perspective; project learning leads the company to a continuous competitive advantage with the contribution of organizational discipline, motivation, debriefing skills and, know how about adequate documentation formats. Related documentation techniques will be explained in detail in the following chapter.

According to Love *et al*. (2000), when the construction companies have learning foundations; lean production, concurrent engineering, benchmarking, partnering and supply-chain management can be effectively implemented. This idea emphasizes the cyclic nature of OL; through some mechanisms companies enhance their learning potential as well as their potential creates opportunities to apply some techniques successfully. Benchmarking is popular throughout the construction companies for its means of learning the best practices used by other companies, including the competitors. On the other hand, partnering, with its emphasis on communication, is a good way of sharing risk and reward with another company promoting cultural relationships within which technical and process innovation could develop in addition to OL among the members of the partners (Barlow, 2000). Cooperative strategic alliances also encourage partner companies to commit resources into the relationship, companies learn from each other that increase the competitiveness of the companies by compensating their lacks. All these mechanisms enhance learning from other companies' experiences other than techniques such as quality management practices and innovation which increase their OL competence through their own experiences.

2.3.2. Enablers of Organizational Learning

According to Özorhon (2004) "TQM philosophy, which has a major goal of continuous improvement, can be regarded as a framework for the organizations to develop a shared and even synergistic understanding of information, experiences and objectives of all individuals within the organization so that change can be consciously and protectively managed". Hill (1996) argues that continuous improvement and learning complete each other, in a way that learning is the most important reason for organizational improvement. If the construction companies want to become learning organizations, ideas of continuous learning together with TQM components such as empowerment and partnership should

also be involved in a change of behavior and culture of the organization (Love *et al*., 2000). Effective quality management implementation with continuous improvement practices may also reduce the project costs by a significant amount. These kinds of experiences may also be useful for increasing the knowledge potential of companies and enhance their business processes.

Innovation is also intangible resource which is difficult to possess and imitate, can have a valuable contribution to the enhancement, development and improvement of professional specialty in construction companies. Companies use OL and innovation to solve their problems and to increase their adaptability to the changing conditions because these make them obtain a competitive edge over their competitors.

2.3.3. Organizational Learning Barriers

In the previous sections, we have discussed the necessity of OL for construction companies is discussed for their survival. However there are some barriers that prevent them from reaching desired levels of OL. These barriers can also be referred to as the factors that prevent individual learning to become a corporate asset.

According to Bresnen *et al*. (2003), organizational structure effects cultural context, the climate for change, skills and capabilities, communications, networks and information flows, technological mechanisms and objectives which of all can be regarded as influential variables of OL. Another implication stated by Hansen *et al*. (1999) is that the establishment of knowledge in a company depends on the interpersonal and social facts rather than the technological or procedural mechanisms.

Some of the OL barriers can be stated as; cultural barriers, structure of the company, high employee turnover, uniqueness of each project, unsupportive nature of the industry, and lack of consciousness (Özorhon, 2004). Among these OL barriers, the most encountered factor is high employee turnover, which is a common problem for most construction companies due to the project-based nature of the construction industry. Structure of an organization also has certain influences on possessing an environment convenient for learning. The ability to acquire, store and share knowledge may be allowed

or interrupted due to the deficiencies in information flow. Uniqueness of each project may also create a negative effect for small-to-medium scale construction companies that do not have vision for long-term OL targets. Lack of consciousness should also be taken into account as a barrier for small-to-medium scale construction companies since OL might not be a familiar concept and creation of OL might not be evaluated as a competitive advantage by these companies.

2.3.4. Strategic Role of Organizational Learning for Construction Companies

According to Kululanga *et al*. (2001), long-term effectiveness and survival of an organization is influenced by a successful OL culture. In order to achieve their OL goals, companies should try to employ new ways for improving and measuring their OL capabilities. OL may be referred to as one of the strategies for improving construction business processes. Different mechanisms should be adapted to companies for continuous improvement of OL which also increase the performance of them. There are several parameters that increase the performance of companies by promoting OL.

Another important point in OL is the utilization of external learning resources other than their own past experiences, and experience and best practices of other companies. Learning from the external sources is an indicator of the absorptive capacity of the organization due to the fact that the company should have the ability of searching, encoding, distributing and interpreting the external knowledge (Cohen and Levinthal, 1990, cited in Hong, 1999).

Companies should pay more attention to sharing, interpretation and utilization of knowledge to integrate this asset in their daily activities to make better decisions. According to the results of a survey referred by Egbu and Botterill (2002), the most frequently used technologies for sharing knowledge amongst the individuals of the organizations are the telephone, Internet/intranet/e-mail, and documents and reports which are followed by face-to-face meetings and interaction with the supply chain. It may also be argued that the creation of a corporate intranet system as a database would be an efficient tool for storing and sharing knowledge by controlling the flow of explicit knowledge,

which would improve company's project management skills and decision-making processes, and lead the organization to a greater innovation.

In order to enhance the control of knowledge flow and to make healthier decisions, web-based database systems may be used. These systems are assumed to increase OL, since they require acquisition of data, storage of useful information in databases and retrieval of knowledge when needed, mostly at strategic decision-making stages. Web-based database systems can assist the construction companies at solving management problems and stimulating their learning activities.

In fact, there are not many examples exploring the role of corporate knowledge namely; the OM, in decision making process. According to Özorhon (2004) "although companies create intentionally or unintentionally a shared asset as a result of learning practices including knowledge acquisition through own experiences, other companies' experiences and external resources; storage of collected information either in databases by codification or in individuals' mind as tacit knowledge and knowledge sharing among employees through intranets and other technology tools, the advantage of possessing such a value should be revealed in the quality of strategic decisions made in the company".

In order to find out how the construction companies create their OMs and how they make use of this corporate asset, a questionnaire survey is carried out with the participation of leading construction companies in Turkey. The context of the survey and concepts related to the study is given in the following chapter with research findings presented as case studies.

2.4. Performance Measurement and Management in Construction Companies

2.4.1. Performance Management in General

Gaining competitive advantage started to become one of the main goals for the companies recently. Therefore, companies started to develop new strategies to gain competitive advantage in their business settlements. This often resulted in the adoption of new philosophies such as concurrent engineering, lean production, TQM, benchmarking,

business process re-engineering in manufacturing and service industries (Smook and Ligny, 2001).

Performance of a company should be managed considering its corporate and functional strategies and objectives. The main objective of performance management process is to provide a "proactive closed-loop control system" where the corporate and functional strategies are deployed to all business activities and tasks (Schalkwyk, 1998). The feedback from the performance management operations are obtained through performance measurement systems. Performance management systems support and coordinate the process of systematic management, decision-making processes and taking action throughout the organization.

Level of performance measurement in a company is an indicator of how successful organizations and individuals have been attaining their objectives and strategies. In this process, the outputs of organizational and operational strategies are measured in quantifiable form to monitor the quality indicators of an organization (Kagioglu *et al*., 2001). According to Bitici *et al*. (1997), performance measurement system of an organization can be referred to be the heart of the performance management process and has a critical importance for efficient and effective functioning of performance management system.

According to Love and Holt (2000), performance management in companies has traditionally relied on efficiency, return in capital and profitability, which might be criticized mostly as financial, narrow and reactive; whereas for a long-term and broader view, corporate strategies, business processes and stakeholder needs should also be taken into consideration. Organizations that rely on financial measures can identify their past performance but have difficulty designating the elements contributed to achieve the performance (Kagioglu *et al*., 2001).

It can be stated that reliance on financial indicators in a company would just promote short-term behavior which would cause the organizations to disregard long-term viability issues (Kaplan and Norton, 2000). The traditional financial measures of performance encourage short-termism; they are retrospective and hence are always to some

extent out of date, do not accurately reflect the interest of the stakeholders, fail to provide information on what customers really want and what they are actually getting, do not identify how competitors are performing, lack strategic focus and provide data on quality, responsiveness and flexibility, give misleading signals for continuous improvement and innovation activities, encourage local optimization, and report on outcomes but do not communicate with the drivers for future performance.

As Love and Holt (2000) suggest, business performance measurement should overcome traditional financial measures and embrace fundamental business drivers that determine and influence a company's future business.

According to Neely (1999), in today's business environment, organizations compete on the basis of many factors other than just the financial ones, and they need information on how they are performing across a broader spectrum of dimensions such as operational extents.

2.4.2. Performance Management in Construction

Progress of construction industry to a more successful level depends on the fact of understanding the inevitable characteristics of performance measures for construction companies. Performance improvement and measurement should become an integral component of construction industry due to its role as a strategic tool in the seeking success and sustainable development.

New concepts related with performance including performance measures, performance drivers, key performance indicators (KPIs), critical success factors, success criteria, project success/failure, project management performance, project performance, company performance are discussed in the literature.

Traditional approach of construction industry is mainly based on project performance and its indicators on the extent to the client's objectives like cost, time and quality achieved at the projects. Although these measures give an opinion about the success or failure of a project; they do not give a balanced view of project's performance

and apparently can only be implemented in project at its end. For this reason, Kagioglu *et al*. (2001) classify these three measures as "lagging" rather than "leading" indicators of performance. Several researches also support this argument that indicates the performance related to cost, quality and schedule is influenced by other factors such as health and safety, productivity, performance relative to the environment, and employee satisfaction (Smallwood and Venter, 2001).

Ward *et al*. (1991) mention that the evaluation of projects, contractors, professionals or procurement methods are conducted solely according to the objectives and parameters of the client is problematic and unreliable. The problems of managing the performance according to the targets of the client are; the prejudice of the client, wrong attitudes in measuring intangibles and invisible aspects, establishing priorities among objectives, effects of procurement processes needed to accomplish these goals, and effects of external factors such as adverse weather conditions and business environment (Ward *et al*., 1991).

In purpose of sustaining competitiveness and to survive in their national and international markets, companies should properly understand how they are currently performing and how they will need to perform in the future. However, as in many other industries, performance measurement in construction industry focuses primarily on traditional performance indicators such as efficiency, return on capital employed, and profitability which are defined as retrospective due to the reason that they fail to assess the true performance of construction projects and organizations (Kagioglu *et al*., 2001). As Love and Holt (2000) state, the results obtained from the financial performance measurement system also provide limited use for the long-term strategic business planning. For this reason, there is the need for an appropriate wider performance measurement/management system concerned not only about satisfying customers but also improving the efficiency and effectiveness of construction companies. The results derived from the wider performance measurement process may be used as inputs for a continuous strategic management process in order to form a competitive foundation in construction business environment.

In the following sections, the methods of performance management employed by construction companies will be discussed in detail for all three levels namely; project level, corporate level and industrial level.

2.4.2.1. Performance Management at Project Level. Construction companies have recently started to develop new methods for the effective management of project knowledge to improve their performances. Even though project knowledge is usually informal and difficult to codify, for the development of an effective knowledge management system at project level, the companies should develop new methods for capturing and reusing project knowledge. Two of these performance measurement methods that are commonly employed by the construction companies for the management of project knowledge can be referred to as; post-project appraisal (PPA) and after action reviews (AAR). These methods can be regarded as process-based methods of collecting the lessons learned from concluded projects.

The most common approach used in the industry for capturing the learning from the project is PPA (Orange *et al*., 2000). This method stands for a special type of project review approach that contains a strong learning element. This review is conducted by all participating organizations in a project, which can be useful for consolidating the learning of people involved in the project but it can be seen that current practice does not provide an effective framework for the capture and reuse of project learning. A common problem is that the PPA might not be conducted efficiently at the right time due to the high turnover rate in the construction industry (Orange *et al*., 2000).

AAR is useful for learning immediately from errors and successes, which can have a range from a 20 minutes of brainstorming to a 2 hours of discussion periods (Schindler and Eppler, 2003). Major purposes of this method are to improve the team learning, building trust and team integrity between the individuals in a project. The learning gathered from AARs are codified and captured for future use to be referred before or during similar occasions in another project.

2.4.2.2. Performance Management at Corporate Level. Although performance management in construction projects is fairly important, construction companies should

also improve their performance at corporate level to reach competitiveness in the industry. In order to achieve the goals set at corporate level, there are several methods that can be adapted to companies' operational level management system as well as its strategic management system. Among these methods, the balanced scorecard (BSC) is the most common method, which will be explained in detail in the following parts of the chapter.

2.4.2.3. Performance Management at Industrial Level. Companies have to develop new strategies for both project and organizational levels which directly reflect their performance targets at industrial level. KPI can be used to measure the performance of construction operations. They are methods of management which typically compare the actual and estimated performance of employees at a particular task in terms of effectiveness, efficiency, and quality in the light of both workmanship and product (Cox *et al*., 2003). Additionally, the KPI are designed as a benchmark for the whole industry where the construction companies benchmark themselves against the national and international performance and identify areas of improvement, but KPI do not give an inner vision into the handling of improving performance and therefore have limited use for internal management and decision making process (Bassioni *et al*., 2004).

2.4.3. Importance and Benefits of Performance Measurement

Current situation of globalization and increasingly competitive environment, measuring performance has become critical for construction companies to gain success in their business settings. From the performance measurement point of view, organizational resources, activities and processes can be referred to as the major objectives of an organization. Performance measurement focuses on the long-term goals by developing a continuous strategic follow-up in the organization and produces meaningful measures. It is useful in benchmarking, which sets the standards for comparison with best practices in other organizations and provides consistent basis for comparison during internal change efforts.

Obviously, performance measurement alerts the companies during unfavorable performance periods. It also increases company-wide understanding of corporate vision and strategy by providing a stronger communication through the members of the

organization. Moreover, information overload is avoided due to the fact that only the most important measures are considered such as the ones related to the long-term targets and strategic objectives. Improved organizational structure consisting of employees that are aware of the identified strategy is a common result of well implemented performance management system.

Performance measurement helps construction companies to have a clear vision of their objectives and to optimize their operations since the objectives of the company and the outcomes of the operations are closely interrelated. It also changes the perspective of companies by forcing them to develop continuous communication among members due to the fact that the performance should turn into a permanent strategy making process rather than a one-time conditional trial and error case.

2.4.4. Development of Conceptual Frameworks and Process Models

Performance measurement can be regarded as a very productive subject of interest for the researches due to the effect of increasingly competitive environment and globalization. During 1990s, researches started to have an interest in techniques and philosophies to measure and manage performance, such as TQM, benchmarking, business process re-engineering and business process management.

McNair *et al*. (1990) described a pyramid of measures which integrates performance through the hierarchy of the organization; and Cross and Lynch (1988) developed SMART model of strategic measurement analysis and reporting technique as a part of measurement process.

Brignall *et al*. (1991) applied the non-financial performance concept to the manufacturing and service industries by suggesting the idea of dividing performance criteria into determinants and results. Ward *et al*. (1991) considered the problems associated with the identification and use of project-related objectives which are kept by the project-owning or client organization.

Kaplan and Norton (1992) introduced the relationship between the four perspectives of their "balanced scorecard". BSC of Kaplan and Norton (1996) was then improved to become a strategic performance management system. Cooper *et al*. (1992) also defined the four perspectives from which the business should be measured. Adams and Roberts (1993) offered another model which they called EP^2M (effective progress and performance measurement) (cited in Olve *et al*., 1999).

All previous frameworks point out the fact that performance measurement should be built upon strategy aspects. However Neely and Adams (2001) assert that, while measuring performance; stakeholders' needs and contributions still have the first priority beyond the strategies, processes and capabilities.

There are many performance management system frameworks, even more than the ones listed at the above paragraphs. Some of the widely used frameworks will be explained in detail in the following sections.

2.4.4.1. The Balanced Scorecard. This approach to strategic management of companies was developed in the early 1990's by Drs. Robert Kaplan and David Norton. The pursuit of new strategies and business models to measure and improve performance was an essential need for the companies in the market-driven competitive business world. They named this system as BSC which includes financial measures that show the outcomes of the past actions, and completes them with operational measures on customer satisfaction, internal processes, and the organization's innovation and improvement activities. BSC approach provides a clear perception as to what the companies should measure in order to balance the financial perspective by revealing some of the weaknesses and vagueness of previous management activities.

Other than being a measurement system, the BSC acts as a management system that enables organizations to determine their vision and strategies, and interpret them into their actions. It also provides a good feedback for both internal business processes and their outcomes, which of both should be taken into account for continuous improvement at strategic and organizational performance. The following figure by Kaplan and Norton (1996) can be referred to as a good demonstration of BSC approach.

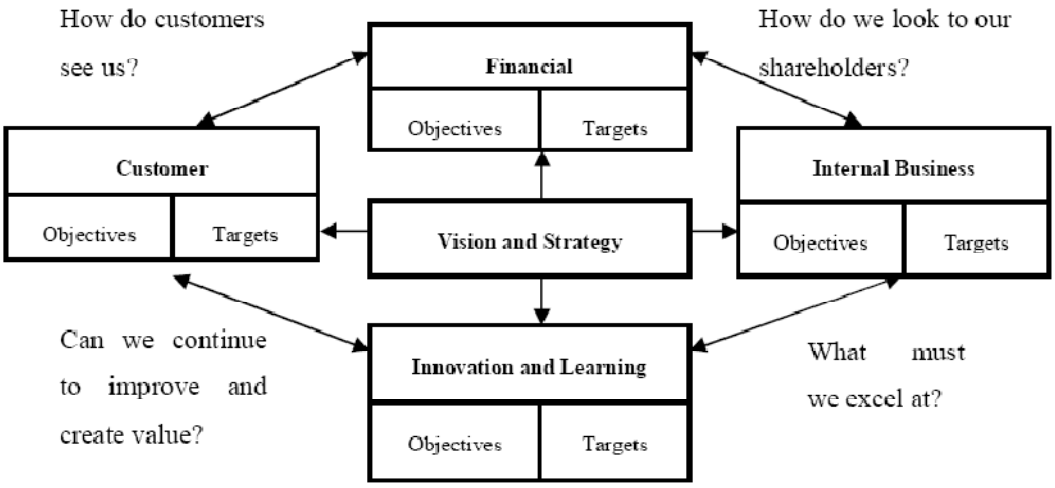

Figure 2.2. Balanced Scorecard Framework

Kaplan and Norton (1992) discovered the balanced scorecard (BSC) as a measurement framework for strategic, operational and financial measures. The concept of BSC aims to align corporate values with operational objectives, customer satisfaction, shareholder value and expectations, and individual employees' objectives, competencies and aspirations (Kaplan and Norton, 1996). The balanced scorecard is an effective oversight of the business activities for the managers due to its allowance to look at them from four important perspectives, which can be seen in Figure 2.1 (Kaplan and Norton, 1996).

According to Olve *et al*. (1999), the leading ideas of the BSC are actually quite straight forward such as; a compact structure for communication strategy, the cause-and-effect relationships among different factors and the strategic hypothesis underlying the course of actions, and a systematic procedure for conducting these course of actions. The BSC aims to change the planning and control system based on almost purely financial nature to a newer, more effective and efficient performance management approach.

2.4.4.2. The Performance Pyramid. The strategic measurement analysis and reporting technique (SMART) system which can also be referred to as the performance pyramid was developed as a result of dissatisfaction with traditional financial performance measures such as utilization, efficiency and productivity (Cross and Lynch, 1988).

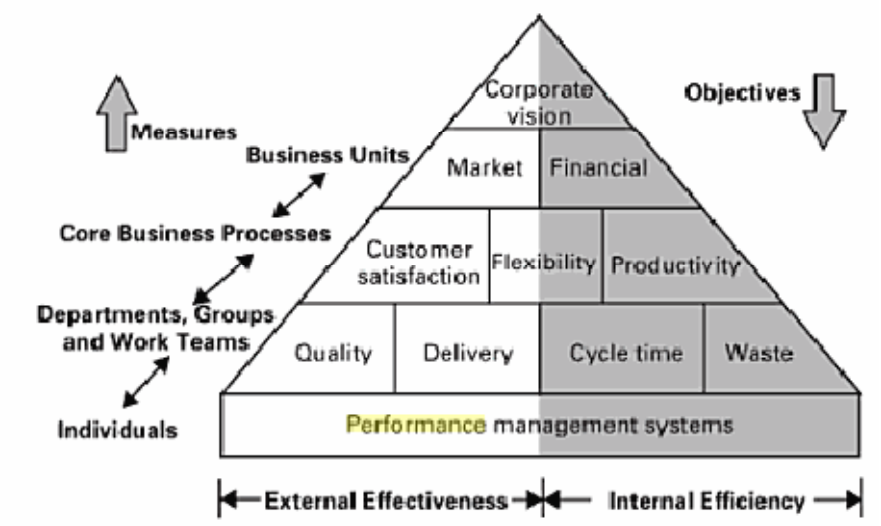

Figure 2.3. Smart System

The basic principle lying behind a customer-oriented model linked to the company's overall strategy is that the financial signs are supplemented by several other key elements of non-financial performance indicators (Olve et al., 1999). A graphical demonstration of SMART system by Cross and Lynch, 1988 is represented in Figure 2.2 on which the steps of the performance management system can easily be identified.

At the corporate vision level, management of the company assigns a portfolio role to each business unit, and allocates resources to support them. At the second level, objectives for each business unit are defined taking into consideration of market and financial terms. At the third level, more tangible operating objectives and priorities can be defined for each business operating system in terms of customer satisfaction, flexibility and productivity. At the forth level, which can be referred to as the department level; customer satisfaction, flexibility and productivity are represented by their specific operational criteria in terms of quality, delivery, process time and cost.

2.4.4.3. International Key Quality Awards. In recognition of substantial improvements in business performance that many of the construction companies achieved, different awards regarding the performance of the companies have been established. The criteria used for qualifying organizations for such prestigious awards lead the companies to

improve their performance in their activities by identifying their KPI and advancing their performance measurement techniques.

The European Foundation for Quality Management (EFQM), as an example of quality awards, was founded in 1988 and is committed to promoting quality in companies as their fundamental process for continuous improvement within their business areas. EFQM is dedicated according to the principles of TQM to the companies that stimulate and assist innovation within their management activities (Watson and Seng, 2001).

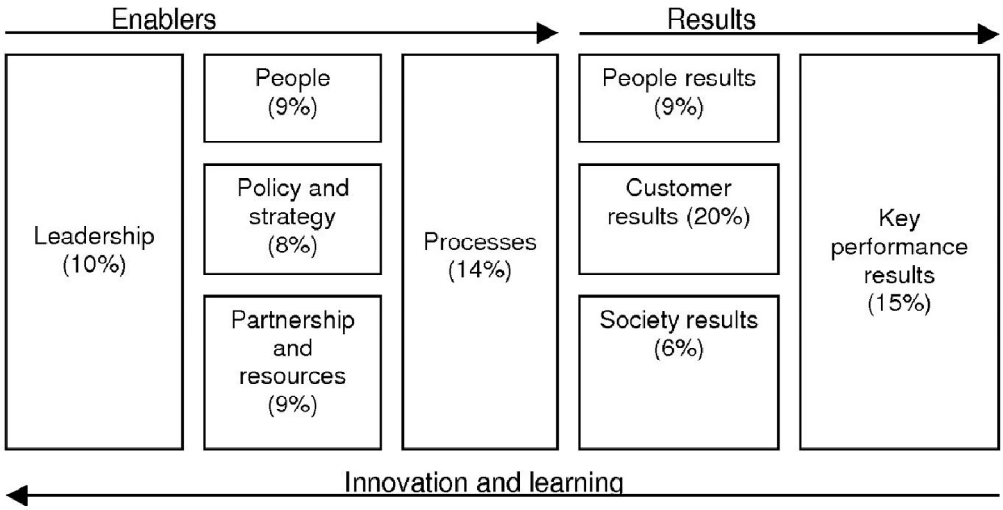

Figure 2.4. EFQM excellence model

As can be seen from the Figure 2.3 by Watson and Seng (2001), the EFQM excellence model, a non-prescriptive framework based on nine criteria, can be used to assess an organization's progress towards excellence. The model indicates that there are many approaches of achieving sustainable excellence in all aspects of performance (Watson and Seng, 2001).

The key characteristic of the model is its "radar" logic, where the elements of "radar" are results, approach, deployment, assessment and review. The elements of approach, deployment, assessment and review are used when assessing "enabler" criteria and the results element is used when assessing "results" criteria (Watson and Seng, 2001).

OL and formation of OM in construction companies is critical for effective performance management at both project and corporate levels, Companies can easily transfer the required knowledge from their OM to carry out performance measurement tasks. The web-based database system developed in this thesis not only enhances OL in a company but also supports performance management by providing key information that could be used to assess project success and organizational effectiveness.

3. RESEARCH METHODOLOGY AND FINDINGS

3.1. Research Methodology

Organizational Learning (OL) has been an important source of sustainable competitive advantage for construction. The concepts of OL contains some questions that should be answered such as; in what ways learning at organizational level takes place, how the data is collected and stored, and knowledge is created and shared, and finally how the knowledge is utilized to improve decision-making in the organization.

OL can be defined as an organizational process intentionally and unintentionally recognized, which enables the acquisition, access and revision of organizational memory (OM) and organizational actions at the end (Robey *et al*., 2000). In the learning process of OM, which can be thought in cyclic manner, creation of OM occurs with the acquisition of knowledge from three main resources such as; learning from own experiences, learning from other companies' experiences and learning from external resources, and learnt knowledge can be utilized at project management activities, and strategic decision-making process. Moreover, by revision, it turns into new knowledge and can be used for future actions and decisions.

In the context of this research study, the main objective is to find out how the construction companies manage knowledge, create their OM and how they exploit this corporate asset in their decision making process. Construction companies transfer some of their employees' individual learning into OL and they obtain a common understanding in perceiving problems in which they begin to act together for a similar manner. The useful knowledge is stored in an organizational asset called OM. The knowledge management activities in construction are represented in the below framework (Figure 3.1). In order to understand how the construction companies in Turkey manage the knowledge and create their OM, a questionnaire survey study is designed based on the framework developed.

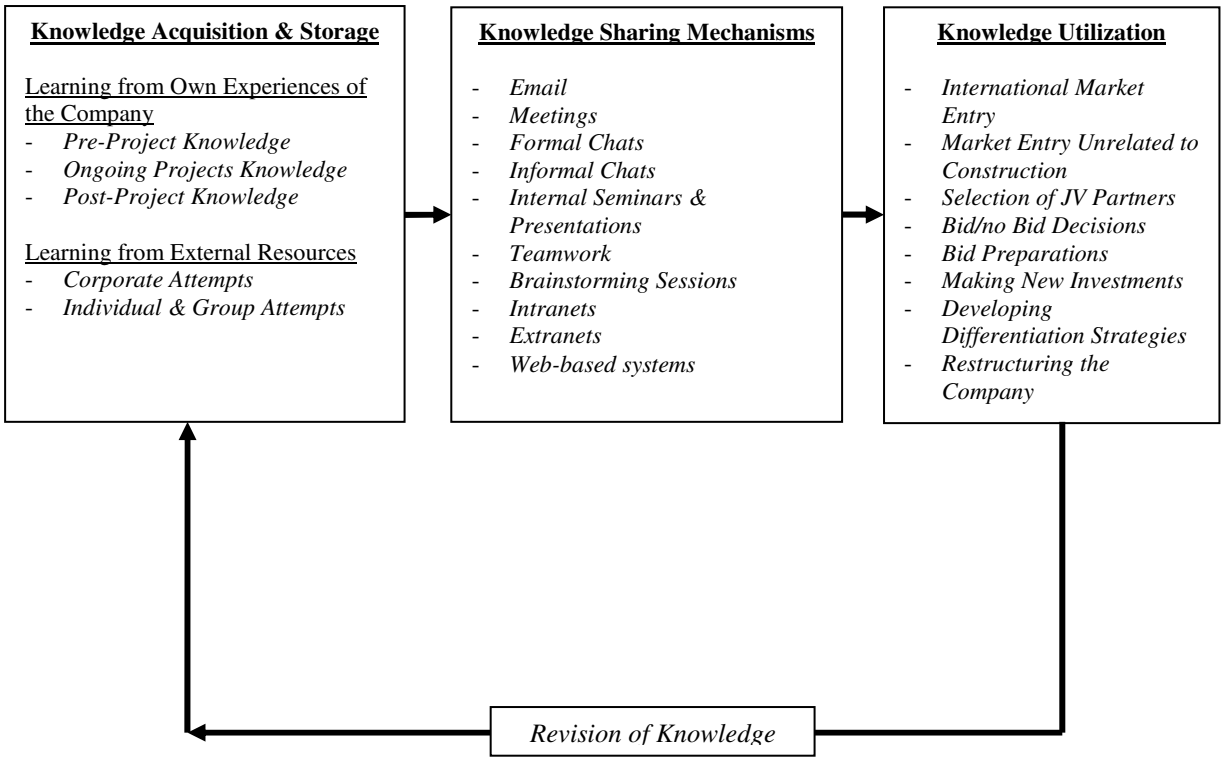

Figure 3.1. Knowledge management activities in construction

The major idea behind Figure 3.1 is that a systematic process is required to institutionalize OM within a company. In order to construct OM, some learning sources are used to acquire the necessary knowledge. OM is formed by learning from company's own experiences through its projects and learning from external sources through corporate, individual and group attempts. Own experiences from the projects can be classified into three main knowledge sources; pre-project knowledge, ongoing projects knowledge and post-project knowledge. In order to ensure that OM is formed, people working in the company should be made aware of the knowledge acquired from different sources by use of various knowledge-sharing mechanisms such as e-mail, meetings, formal chats, informal chats, internal seminars and presentations, teamwork of the personnel, brainstorming sessions, intranets, extranets, and web-based systems. Finally, when OM is formed by institutionalizing the knowledge within the organization, it is used during decision-making to enhance the quality of decisions. However, it is a cycle rather than a sequential process as newly acquired knowledge from the given decisions should be used to revise OM. How this cycle operates in each company depends on company characteristics and the height of OL barriers. Each component of this framework

constitutes a separate section in the questionnaire survey. The following sections will explain the administration and content of the questionnaire survey in detail.

3.1.1. Administration of the Survey

This research consists of a survey carried out with respondents from large Turkish construction companies who are at different levels and positions. The questionnaire is sent to 150 members of Turkish Contractors Association (TCA). Data is collected from 64 companies, with a response rate of approximately 43%. Questionnaires are administrated to respondents from different levels and positions, either via e-mail or as face-to-face interviews. After explaining the aim of the research and basic definitions of the main subjects, the respondents are asked to evaluate the listed items concerning OL and OM effectiveness of their companies.

3.1.2. Content of the Survey

The respondents are given a Table of Contents on which the major headings and their explanations can be obtained. A sample of the survey can be found in Appendix A. This survey contains four main topics and each will be examined in below sections.

3.1.2.1. General Information About the Respondents and the Companies. Respondents are asked to state how many years they have been in the construction sector and their current positions in their companies; number of years that their company have been in the industry, companies' domestic and overseas turnover, and the annual average turnover of the companies for domestic and overseas projects for the last 5 years.

The main purpose of asking questions about the respondents and their companies is to develop a profile of the respondent companies whose ideas about different topics are asked. It may be considered that the creation of OM expands as the age and experience of the companies increase.

3.1.2.2. Learning From Own Experiences of the Company. Since the unit of work performed in the construction industry is projects, companies mainly learn from their own

project experiences that they have undertaken or the projects that are planned to be undertaken, and other parties that are involved in these projects. Learning from their own experiences may be considered as the most frequent source employed by construction companies in the OL since the employees of the company, when they have an active role in a project, have various chances to experience different conditions, correct their mistakes, face different problems and observe the methods of different people and organizations.

Learning from the own experiences can occur at all three stages of a project namely; pre-project stage, project execution or ongoing project stage and post-project stage. All the phases get improved and strengthened as the company undertakes more projects and more people get involved in these projects. Finally, the useful information gained from different projects turn out to become an important component of OM.

About this subject, the respondents are asked if their companies' acquisition and storage of project information is paper-based or online, how would they themselves evaluate the importance of learning from the own resources of the company and how would they evaluate the performance of their companies at acquiring and storing the useful data. The respondents are asked to do their assessment by using a five level Likert scale, containing very low, low, medium, high and very high. The respondents were asked to mark "Not Applicable (N/A)" box for those items that their companies do not acquire and store.

Pre-Project Knowledge part of the survey includes the acquisition and storage of knowledge that can be collected before a project is undertaken. The subheadings for this topic which are explained below in detail can be listed as; risk assessment, host-country information, unit cost estimation calculations and any assumptions and important decisions at the bidding stage.

- *Risk assessment* is an important subject for the construction industry and it is crucial for the companies for its impact on determination of risks, as well as its influence on taking corrective actions that can be useful to reduce future risks. Usually, risk assessment is carried out at management level and documented as reports.

- *Host country information* is a report prepared when the company is intending to enter a new country or region as a prospect market. Usually, for larger companies, there is available template for host country report which has critical questions from a broad perspective about the new country or region. Host country report is filled by a representative of the company and the information gained from the report can easily be preserved and spread among the members of the organization.
- *Unit cost estimation calculations* are quantitative activities carried at the bidding stage of a project where the proposal engineers of the company perform calculations based on the current workmanship, material and machinery prices. Until the award of the contract, the calculations and prices are usually kept secret internally and externally by the engineers and managers of the company, but after the award of the contract, the information, prices and experiences gained from the calculations are spread within the organization for the utilization in future bidding preparations.
- Although the *assumptions and important decisions made at the bidding stage* are usually made up of managerial decisions and should also be documented successfully, taking any future use of these ideas into consideration, to avoid the loss of crucial information in a situation of the turnover of an employee.

Ongoing Projects' Knowledge is also a part of the survey, consisting of the knowledge created during the execution of the projects. The subheadings of ongoing projects' information are thought as; unit costs, methods applied, organizational structure, planning and programming, master plan, periodical reports, machinery and equipments used, and job rotations.

- *Unit costs* of project items can be divided into three main portions namely; material, workmanship and machinery costs which sum up to make the price of the item itself. When all the prices of unique items are added together, the price of the project can be reached. These costs can be regarded as a basis for the costs of similar works that are going to be carried out in the future so they should all be preserved carefully.

- *Method of construction* is an operative indicator for the construction companies' capability of overcoming construction projects. Especially, for challenging parts of a construction, methodology can assist the progression of works which also would aid the project teams when they will be executing similar types of assignments in coming projects.
- *Organizational structure* of a project is a project specific structure depending on the type and size of the project which represents the duties of the project members and their positions on the structure. The structure of the organization for the project can serve as a model for the coming projects with similar nature.
- *Planning and programming* of the project can be regarded as a crucial step due to its importance as a template indicating the relations between different works that are going to be carried out. Different computer programs such as Primavera or MS Project can be used to develop a program for the construction works which would include scheduling and resource management activities that are aimed to be followed throughout the execution period of the project. Planning and programming of the project activities contain details for the execution of the works which can be a reliable prediction for future experiences in similar scope and nature.
- *Master plan* of a project is developed at the beginning of the project as a prediction of monetary and physical progression, usually prepared according to the assumptions and calculations carried out at the bidding studies. Master plan should be preserved until the end of the project for the comparison of the foreseen and realized advancement of the tasks.
- *Periodical reports* which can be classified as *daily, weekly and monthly* reports are developed on the basis of master plan with a similar in-house company format which indicates the improvement of construction works periodically for both physical and monetary issues. Due the fact that a report will be based on the previous one, formerly created reports should be preserved in orderly fashion for the ease of the preparation studies of coming reports for the project team.
- *Machinery and equipment used* in the project stage are carefully chosen to overcome the difficulties of construction in different tasks throughout the project, which is also closely related with the method of construction. The list,

properties and brands of machinery and equipments used for a project constitutes a good example for handling future practices.

- *Job rotations* of the employees are an important factor for the construction companies due to the advantages or disadvantages it forms during the execution of a project. A good record of job rotations should be kept in purpose of determining the performance of an employee at a specific position for the certain time period that can be utilized for his/her future assignments.

Post-Project Knowledge, as a part of the survey contains the knowledge formed at the end of the project. The subtopics of post-project knowledge can be listed as; post-project appraisal, after action review, performance of personnel, assessment of the client, evaluation of subcontractors' performance, evaluation of profit/loss situation, performance of the partner or partners, in case of a joint venture (JV), and success and failure factors.

- *Post-project appraisal (PPA)* can be referred to as a documentation method, performed by a PPA unit after two years from the completion of the project which covers all project information and results of strategic decisions made; to learn from mistakes and transfers knowledge. More detailed explanation of PPA can be found in the previous chapter.
- *After action review (AAR)* is a collection and storage mechanism performed after each decision-making stage that covers the answers to questions like "what was supposed to happen"; "what actually happened"; "why were there differences" and "what can you learn from this experience". Like PPA, detailed information about AAR can also be found in the previous chapter.
- *Performance of the personnel* employed at the project indicates the success or the failure of the personnel for the whole project or just a specific task assigned to them, which would give an idea to the managers about re-employing the same personnel for similar works in the future.
- *Assessment of the client* can be regarded as the evaluation of the relations with the client and client's attitude towards the construction works carried throughout the project. In the light of this assessment, the companies may decide to do a job

with the same client or not, according to the approach of the clients in their past projects.

- *Evaluation of the subcontractors' performance* carried out at the end of the project, is the appraisal of the subcontractors considering their seriousness and participation in their specific part of the project which in fact would be a forecast for the main contractor to give an opinion to work with the same subcontractors again at different projects.
- *Evaluation of the profit/loss situation* is again carried out at the end of the project, which is usually referred as the most important success factor of the project team who are assigned to the project. Due to the importance of this evaluation, a perceptible report of profit/loss breakdown may be prepared to demonstrate the financial situation. This report would indicate the specific construction works that are financially riskier than others.
- If the project is executed as *Joint Venture (JV), the performance of the partner(s)* is evaluated according to the success of the project and relations between the partner(s) and the company with all aspects at project management level. The records of the JV should be kept as an indicator to refer or not to the same partner(s) for the coming projects in similar or different nature.
- *Success and failure factors* should be evaluated at the end of each project both for the financial and technical issues in purpose of taking lessons from all activities, successful and unsuccessful, to improve the capabilities of the company for coming projects.

3.1.2.3. Learning From Corporate, Individual and Group Attempts. As mentioned in the previous chapters of the thesis, knowledge domains exist both internal and external to the organization. External learning resources also contribute the OL of the company in the sense of participating to the construction of its memory. External learning occurs through two types of learning attempts which are namely; corporate attempts and individual/group attempts. The respondents are asked how they would evaluate the importance of learning from these attempts and how they would consider the frequency of learning from these attempts for their companies. This part of the survey is also conducted by using a five-level Likert scale, containing very low, low, medium, high and very high,

and for the respondents, whom believed that their companies do not employ any of the listed attempts are asked to mark “Not Applicable (N/A)”.

At the *corporate level*, attempts to learn from the resources other than company’s own sources can be represented as; internal benchmarking, competitive benchmarking, value-chain analysis and environmental scanning.

- *Internal benchmarking* is performed within an organization as the comparison of the practices and performance of similar business units or business process located at the same or different places. This approach is an accessible one as the comparison is conducted between similar operations in other parts of the same company. For construction companies, comparison of the performance of the project teams executing similar types of construction works can be carried out using this method.
- *External benchmarking* is the process of a company’s business activities and performance to industry bests and/or best practices from other industries. The dimensions of comparison typically measured are cost, quality and time. If the external benchmarking can be documented in a company, improvements from learning through these documents would end up conducting new projects cheaper, better and faster by utilizing the best examples from the industry.
- *Value-chain analysis* is used for better understanding of the activities through which a company develops a competitive advantage and creates a shareholder value. It is useful for a construction company to separate their business systems into a series of value-generating activities. Value-chain is an important approach for the improvement of the productivity within the company.
- *Environmental scanning* is a process of gathering, analyzing, and dispensing information for tactical and strategic purposes in a company. The environmental scanning process entails obtaining information on the business environments in which a company is operating and considering entering. Environmental scanning is an important process since the environment and competitors has a significant impact on business operations of a construction company.

At the *individual/group* level, attempts to learn from external resources can be introduced as; internal seminars and presentations, job rotations of the personnel, seminars, congresses, exhibitions and trade shows, and technical and academic publications.

- *Internal seminars and presentations* are an effective way of improving OL within the company by converting the informal knowledge of the personnel into some kind of a codified knowledge. The aim of these is to ensure the organizational knowledge flow between the individuals of the company.
- *Job rotations of the personnel* under this heading is different from the one in the previous part of the thesis which was only concerning about the job rotations at the project teams, whereas this title is interested more about the job rotations of the personnel at managerial level. These have a positive effect on the personnel for improving their learning skills at different levels and job tasks. Job rotations at managerial level would also develop OL due to its fact of making the employees obtain an organizational awareness of what is going around him/her.
- *Seminars, congresses, exhibitions and trade shows* are also influential ways of individual learning by ensuring a broader perspective on various points of view which of the relevant ones should continuously be followed and presented to the other members of the organization to aid OL.
- *Technical and academic publications* are the products of the academic environment which the construction companies may follow to learn new techniques and advanced methods, and to develop their business applications. The individuals within the company should be encouraged to follow these publications for the purpose of increasing their knowledge on related aspects.

3.1.2.4. Data Sharing. Following the collection and storage of the useful knowledge, companies should find effective ways to spread the information throughout the members of the organization, so that the useful knowledge can become accessible by everyone. In order to share the data in the company, mechanisms can be developed to ease the transfer of both explicit and tacit knowledge. The data sharing mechanisms within a company can be presented as; e-mail, meetings, formal chats, informal chats, internal

seminars and presentations, teamwork of the personnel, brainstorming sessions, intranet, extranet and web-based systems.

- *Electronic mail (e-mail)* allows users to send messages electronically to individuals or groups of people. E-mail can reach any place on the world where the Internet technology expands, which eases the communication problem in the international projects awarded to Turkish companies. E-mail is a popular form of information transfer and one of the core technologies for data exchange and sharing. E-mail can be used as a formal or informal way of communication within the company or with the other parties involved in a construction project.
- *Meetings* can take place daily, weekly and monthly among the members of the project where the current situation and developments are discussed, usually in a formal manner, bur preparation of minutes of meeting reports can be one of the ways of formalizing the information generated at the meetings which later on can be shared and used in the future.
- *Formal chats* can be regarded as the written conversations and correspondences between the members of the organization which are paper-based, and can be referred to one of the traditional ways of communication.
- *Informal chats* are referred to as the verbal communications between the individuals of the organization which are assumed to be one of the most difficult types to be codified among all data sharing mechanism.
- *Internal seminars and presentations* are effective ways of improving OL within the company by the personnel sharing their knowledge with the other members of the organization. The aim of these is to ensure the organizational knowledge flow between the individuals of the company.
- *Teamwork of the personnel* is an effective way of knowledge transfer since there is a face-to-face direct transmission of knowledge between the members of the team. Although it is an efficient method, the problem with knowledge sharing via teamwork is that it is informal and difficult to be codified.
- *Brainstorming sessions* are the discussion of the organization members on a task or a specific subject where new ideas can be introduced and debated. Similar to

the teamwork of the personnel, brainstorming sessions are more or less an informal way of knowledge transfer which makes it harder to be documented.

- *Intranets* are private computer networks that use Internet technology to securely share any part of the organizations' information or network operating system within the organization. Intranets can be referred to as the network within an organization which can be an extensive part of the organization's information technology infrastructure.
- *Extranets* are computer networks that allow controlled access from outside, for specific business or educational purposes. An extranet can be thought as an intranet of a company which can be viewed also by users outside the company, usually partners, vendors or suppliers with a limited access. Extranets accelerate the communication between the parties involved in the execution of a construction project by creating a common space for all of them.
- *Web-based systems* are similar to an Intranet that can be accessed over a network which may also mean a computer software application that is hosted in browser controlled environment or coded in a browser supported language and reliant on a common web browser to render the application. Web based systems provide access from any corner of the world where there is Internet technology facilitating the communication and data sharing among the parties in an international construction project at which there may be continents between the members of the project execution team.

3.1.2.5. Use of Knowledge. At the final part of the survey, the effectiveness of their companies in using the acquired and stored knowledge is asked to the respondents. The respondents are asked to evaluate the importance of knowledge for the listed strategic decisions and the frequency of knowledge use at strategic decision-making process for their companies. Similar to all three parts of the survey, this part was also performed by using a five-level Likert scale, containing choices of very low, low, medium, high and very high. For the respondents who believe that their company does not employ OM at any of the strategic decision items are asked to mark "Not Applicable (N/A)" as their answer.

The strategic decisions made by the exploitation of useful information, which will be investigated in this part of the survey can be indicated as; international market entry,

market entry unrelated to construction, selection of JV partners, bid/no bid decisions, bid preparations (determination of risk premium and bid price), making new investments (to increase organizational effectiveness), developing differentiation strategy (marketing strategy, quality management) and restructuring the company (corporate changes to increase productivity).

- *International market entry* is an important milestone for every construction company, since the companies need new markets to increase their profitability and create new business environments for themselves. Although entering a new market can be advantageous for the companies, there are also risks that must be evaluated well and handled with past experiences and knowledge of members. OM should act as a consultant for the companies to give better decisions while they are in the period of entering a new international market.
- *Market entry unrelated to construction* started to become a breakthrough for most construction companies to secure their business conditions and increase their incomes by arranging them to come from different sectors to keep up with the global business environment.
- *Selection of JV partners* for the future projects is another strategic decision for the construction companies due to the fact that another company will be involved in their business sharing the shared profit and becoming a part of the project structure. A broad experience and knowledge about the partner(s) is needed for the assessment of possible JV formations.
- *Bid/no bid decisions* are strategic decisions that affect the company's future business which is usually a decision taken at the managerial level with great foresight, experience and knowledge about both the execution of the projects and the business environments that the projects are in, which the companies attend to bid for. The past histories and OM of the company are considerably influential at this type of strategic decisions and generally the conclusion report from bid/no bid meetings are documented and kept for any chances of future use.
- *Bid preparations (determination of risk premium and bid price)* are the studies carried after the "bidding" decision is taken at the managerial level. During bid preparations, there are a lot of cost calculations, estimations and assumptions for

the determination of risk premium and bid price of the prospect project. It should be taken into account that the bid price will become the project price if the project gets awarded to the company, so the bid preparation period should be conducted seriously by bringing out company's past experiences for ensuring both the profitability and quality at the same time for the probable project.

- *Making new investments (to increase the organizational effectiveness)* are the activities carried out for widening their properties that they own such as machinery, assets or real estate; but these decisions are made at the managerial level with the help of past experiences and by carrying out a lot of investigation.
- *Developing differentiation strategy (marketing strategy, quality management)* is an effective action taken by a company which would cause minor or major changes in the business arrangements of the company. Although developing differentiation strategy is a kind of a decision taken at the managerial level with experience, the OM and current global business settlements affect the decisions of the managers.
- *Restructuring the company (corporate changes to increase productivity)* is another important managerial decision which should be supported with the past experiences of the company and determined according to the expected orientation of the construction industry. Restructuring of a company usually stands out as changes at the organizational structure of the company.

3.2. Research Findings

In this section, responses from 64 companies are evaluated. Results of the survey are presented as tables and discussed in detail. As indicated earlier in this chapter, 64 out of 150 questionnaires are returned, resulting in 43% response rate.

3.2.1. General Information About the Respondents and the Companies

At this section, quantitative information about the respondents and companies will be given. 62 of them among the respondents are civil engineers, whereas only 2 of the respondents are architects. Years that the respondents spent in the construction industry

varies from 1 to 35 with an average of 14.2 years. Number of respondents that have managerial title are 33 with approximately 52%, whereas the total number engineers and architects are 31 with a 48%. Titles, total numbers and percentage distribution of respondent titles are presented in Table 3.1.

Table 3.1. General Information About the Survey Respondents

Titles of Respondents	**Number**	**Percentage**
General Manager	2	3 %
Deputy General Manager	3	5 %
Regional Manager	4	6 %
Project Manager	5	8 %
Deputy Project Manager	5	8 %
Site Manager	7	11 %
Technical Office Manager	5	8 %
Technical Office Engineer	12	12 %
Bidding Manager	2	2 %
Bidding Engineer	5	5 %
Planning Engineer	4	6 %
Site Engineer	8	13 %
Site Architect	2	3 %

When the quantitative information about the companies is investigated; it may be considered that all of the companies have gained a considerable experience and reputation in construction business. Average of operational years for the companies in construction industry is approximately 29.7 years. Companies' domestic and overseas turnovers realized so far are stated as 140.8 billion USD and 182.4 billion USD respectively. Approximately 76% of the companies have a total domestic turnover more than 2.0 million USD and a total overseas turnover more than 2.3 billion USD. Domestic average annual turnover of the companies is 62.4 million USD and overseas average annual turnover is 48.3 million USD. All the respondent companies are certified by ISO 9001 Quality, ISO 14001 Environmental Protection and OHSAS 18001 Occupational Health and Safety Management System Standards.

3.2.2. Learning From the Own Experiences of the Company

Since construction companies mainly learn from the projects they undertake, learning from the own experiences of the company should be investigated in more detail compared to other learning sources. The following table represents the average response rates of respondents and results will be investigated in detail in the following paragraphs.

Table 3.2. Average Response Rates for Learning from Own Experiences

Title of Learning Source	Importance of Acquiring (Ideal)	Frequency of Acquiring (Actual)	N/A	Paper-Based	Computer-Based
Post-Project Knowledge					
Risk assessment	4.14	2.84	13	13	43
Host country information	4.08	3.12	1	18	53
Unit cost estimation calculations	4.43	3.64	1	16	61
Any assumptions and important decisions	4.12	3.11	0	31	50
Ongoing Projects' Knowledge					
Unit costs (material, labor etc.)	4.39	3.86	0	11	61
Methods applied	3.96	3.27	0	13	61
Organizational structure of the project	4.10	3.55	0	20	58
Planning and Programming of the project	4.22	3.67	0	10	63
Master plan	4.27	3.49	0	11	61
Daily, weekly and monthly reports	4.41	3.98	0	13	63
Machinery and equipments used	4.10	3.50	0	11	54
Job rotations during project	3.67	2.90	0	13	50
Post-Project Knowledge					
Post project appraisal	4.18	3.28	4	27	58
After action review	3.70	2.51	3	21	46
Performance of the personnel	3.74	2.43	0	17	28
Assessment of the client	3.45	2.49	0	27	27
Evaluation of subcontractors' performance	4.14	3.45	0	18	44
Evaluation of profit/loss situation	4.10	3.61	0	20	51
If JV, performance of partner(s)	3.78	2.47	9	18	54
Success and failure factors	4.06	2.35	12	18	34

When the actual pre-project knowledge acquisition for the companies is evaluated, it can be observed that the most significant knowledge source that the companies collect and store data frequently is unit cost estimation calculations whereas the lowest rate of frequency occurs at risk assessment reports. The ideal pre-project knowledge acquisition source in the opinion of the respondents is similar to the most frequent answer for the companies, which is unit cost calculations but the lowest rate in respondents' opinion is host country survey. It should be noted that the acquisition of pre-project knowledge for construction companies are approximately medium, which proves that the construction companies should improve themselves in their performance of pre-project knowledge acquisition.

According to the results of ongoing projects' knowledge acquisition, the highest rate of acquisition frequency occurs at daily, weekly and monthly reports, in other words periodical reports, and unit costs which of both are concerned with physical development and financial issues of the project. The subtopic of Job rotations within a project is rated as the least frequent knowledge acquisition type among the respondent companies. When the opinions of the respondents are taken into account, they believe that the most important knowledge sources to be acquired during the project are daily, weekly and monthly reports, and unit costs; while the job rotations within a project has the lowest knowledge acquisition rate in their opinion. It can be concluded from Table 3.2 that the acquisition of ongoing projects knowledge is rated as medium-to-high, which makes a rating better than the pre-project and post-project knowledge acquisition performance of companies.

Questionnaire findings for the post-project knowledge states that the companies are concentrating on the profit/loss situation more than the other aspects at the end of the project as expected due to the fact that the most popular concern of the construction companies is profitability. With closest ratios to the profit/loss situation of the companies, subcontractors' performance evaluation and post-project appraisal can be referred as the two other sources that the companies carefully try to acquire knowledge. Although PPA turned out to be the third at the ranking for the frequency evaluation of the companies, it is ideally rated by the respondents as the most important source to be collected and stored. It is closely followed by the evaluation of subcontractors' performance, evaluation of profit/loss situation, and success and failure factors respectively in the opinions of the

respondents. It can also be noted that the companies have an approximate average of medium post-project knowledge acquisition performance which should be improved for better project management activities in the future.

If the Table 3.2 is evaluated from the view of performance measurement and management, it can clearly be seen that the companies should improve their performance measurement activities. Although post-project performance measurement methods rated as important by the respondents, the companies' usage of PPA, AAR and other evaluation methods turn out to be lower than the expected rates which show that the companies lack performance measurement.

When the Table 3.2 is investigated from the point of how the companies store knowledge, it may be seen that the companies are widely using IT for project knowledge storage. Even though all of the listed items in the table shall be codified and stored; most popular sources that the companies employ information technologies can be listed as; unit cost estimation calculations for pre-project knowledge; daily, weekly and monthly reports, planning and programming of the project, master plan, methods applied, unit costs for ongoing projects' knowledge; and evaluation of profit/loss situation and subcontractors for post-project knowledge.

3.2.3. Learning Through Corporate, Individual and Group Attempts

Another way of learning for construction companies is learning from external sources which can be through either corporate, individual or group attempts. The following table represents the average response rates of the companies by both indicating their opinions and approaches of their companies. Results of the table will be discussed in the following paragraphs.

Table 3.3. Average Response Rates for Learning from External Resources

Title of External Learning Attempts	Importance of Acquiring (Ideal)	Frequency of Acquiring (Actual)	N/A
Corporate Attempts			
Internal benchmarking	3.45	2.53	3
Competitive benchmarking	3.94	2.74	1
Value-chain analysis	3.80	2.53	4
Environmental scanning	3.78	2.84	0
Individual and Group Attempts			
Internal seminars and presentations	4.02	2.78	3
Job rotations of the personnel	3.69	2.78	3
Seminars	4.00	2.45	3
Congresses, exhibitions, trade shows	4.00	2.63	0
Technical and academic publications	3.84	2.57	0

According to the answers of the respondents, the most popular corporate learning attempt employed by the companies is found out to be environmental scanning. Competitive benchmarking is another learning source employed by the construction companies. When the opinions of the respondents are taken into account, it may be seen that the competitive benchmarking is seen as the most important external source but the rates of value-chain analysis and environmental scanning are closely following competitive benchmarking. It should be noted at neither of the methods are widely utilized. When the responses are analyzed, it is observed that all of the suggested ways or mechanisms are adopted at a low-medium rate.

When respondents are asked about the individual and group learning attempts, it turned out to that, internal seminars and presentations are the ones that are the most frequently employed by the companies together with job rotations of the personnel. Internal seminars and presentations also are the most popular way of learning for the company in the opinion of the participants. Seminars outside the company, and congresses, exhibitions and trade shows are also effective ways of external learning from the view of the respondents. Similar to corporate attempts the individual attempts are not applied in practice widely. It can be stated that companies make use of these mechanisms at a low-to-medium rate.

3.2.4. Data Sharing

After the acquisition of the data from several sources, it should be shared in purpose of creating OM within the company. The following table presents the average response rates from the respondents reflecting both their opinion and their evaluation of their companies' performance. Results given on the table will be discussed in the following paragraph.

Table 3.4. Average Response Rates for Data Sharing Mechanisms

Data Sharing Mechanism	Importance of Mechanism (Ideal)	Frequency of Mechanism (Actual)	N/A
E-mail	4.06	4.18	0
Meetings	4.00	3.84	0
Formal chats	3.98	3.71	0
Informal chats	3.59	3.59	0
Internal seminars, presentations	3.71	2.86	3
Teamwork of the personnel	3.90	3.33	0
Brainstorming sessions	3.98	3.35	0
Intranet	4.14	3.47	2
Extranet	4.02	2.86	3
Web-based communication systems	4.16	2.24	12

According to the responses of the participant company members, it was found that the most effective way of data sharing employed by the companies is e-mail technology, whereas the informal way of data sharing that the companies employ the most frequently is meetings. Although it is much easier to use web-based database systems in purpose of sharing the data and providing the communication between the members of the organization; it can be seen from the above table that these systems are not yet popular among the Turkish construction companies. According to the questionnaire results, almost 20% of the companies do not employ any type of web-based systems. Still, the desire of the respondents for web-based systems can be understood from its "ideal" rating which represented the value given to it by the respondents. Intranet systems, which are similar to web-based systems, are also a point of interest in the opinion of the participants.

3.2.5. Use of Knowledge

After the acquisition and the distribution of knowledge, interpretation of knowledge shall be successfully implemented within the company in purpose of creating a learning organization. The following table indicates the average responses on the subjects of knowledge use and exploitation of OM while giving strategic decisions answered for both the opinion of the participants and their evaluation of their companies' performance. In the following paragraph, results given in the table will be discussed.

Table 3.5. Average Response Rates for Knowledge Use at Strategic Decisions

Strategic Decisions	Importance of Using Knowledge (Ideal)	Frequency of Using Knowledge (Actual)	N/A
International market entry	4.10	3.39	0
Market entry unrelated to construction industry	3.80	2.33	16
Selection of JV partners	4.11	3.32	1
Bid/no bid decisions	4.06	3.57	0
Bid preparations	4.20	3.71	0
Making new investments	4.08	3.36	1
Developing differentiation strategy	4.02	3.34	1
Restructuring the company	4.03	3.41	1

When the responses of the respondents are investigated, it can be seen that the construction companies exploit their OM mostly on bidding preparations. It can also be realized from the table that the companies do not employ their past experiences while giving decisions about market entry unrelated to construction industry. The opinions of the participants are similar to the companies' results as usefulness of knowledge while bid preparation is seen as the most critical issue, whereas the market entry decisions unrelated to construction industry is the least important case of using the created memory of the construction companies.

3.3. Discussion of the Findings

Important conclusions can be drawn from the responses of the companies. It is observed that most of the companies are fairly good at creating project memory. Project information is shared among the employees of the company but strategic information seems to be accessible only by managerial level personnel for most of the companies. There seems to be a common attitude about the knowledge collection and storage mechanisms. Companies try to avoid preparing long-term documents; instead they prefer shorter and explanatory reports such as daily, weekly and monthly reports. This attitude might be associated with the short-term orientation of Turkish contractors.

When the OM is overviewed, utilization frequencies and knowledge types composing the OM have some common points such as all respondent companies learn mainly from their own experiences; learning from external resources have less contribution to OM compared to own experiences. Due to the existence of four different learning environments in the companies, one of the tacit and/or explicit knowledge types may be dominant to the others in some cases. In accordance with the continuous culture of learning, companies should set their mechanisms to collect and store information to create their codified memories.

According to the answers given by the respondents of the companies, role of OM in strategic decision-making is limited and should be developed for better management of their construction projects. Companies do not rely on their memories to make decisions unless the decision concerns some facts that would be consistent with the historical information of the company. Companies do not utilize web-based systems to aid their decision-making processes whereas the respondents believe that it would be beneficial to have such systems to support their business applications.

When examined from the knowledge management view, companies seem to have a good sense of knowledge acquisition systems but they have some constraints in sharing and utilizing knowledge. As the organizations grow, the need for using more efficient knowledge management systems should be increasing as well.

When the results of the questionnaire survey are investigated, it can be concluded that the companies should improve their knowledge acquisition and storage performance from their own resources at all three stages of a project namely; pre-project, ongoing projects and post-project stages. Although knowledge acquisition from ongoing projects stage seems to be better than pre-project and post-project knowledge acquisition activities of the companies, the performance is still not high-to-very high. Utilization of the data sharing tools should also be improved; by utilizing explicit knowledge sharing mechanisms via IT tools efficiently such as, intranets and web-based systems which should be widely used within the companies even though the rates of utilization for these tools are low-to-medium according to responses of the companies. Although companies seem to benefit from their OM in their decision-making activities, the rates of OM exploitation have an average of medium-to-high which proves us that the companies still make decisions based on the experiences of the managerial personnel.

It can be concluded from the findings questionnaire that the companies lack explicit knowledge sharing mechanisms. This thesis aims to fill in the gaps of data sharing problems within the construction companies which would improve the efficient learning in the organization by increasing the ease of knowledge exploitation in decision-making process. Based on the survey findings a necessity for a web-based system is observed. In this respect, a web-based database model called WEB-CONS is developed in order to assist the construction companies for increasing the effective sharing and utilizing of knowledge, both at project and corporate levels. The following chapter explains the basics of the program, its applications in construction management and presents the model as a project management tool.

4. A WEB-BASED DATABASE SYSTEM FOR CONSTRUCTION COMPANIES

The uniqueness of the construction industry comes from its project oriented nature. As far as the construction projects that are undertaken by Turkish construction companies are concerned, they are becoming more and more complicated due to the improvements in technology and sizes of these projects. The development of construction projects includes several stages during which a large number of human resources of different specialties interact and cooperate for performing various project tasks. An important element in this interaction is knowledge management and communication process which constitutes a determination factor for success of the construction project. Enhancing communication along the participants of the project is proved to be a challenging task due to the extended fragmentation of the construction industry and huge amount, and wide dissimilarity of the information that is involved in the construction process.

The distance between the headquarters of the construction companies and the construction sites renders communication even harder. The information amount and type of associated with construction projects are turning knowledge management into a difficult task while the uniqueness of the projects increases the effort for knowledge standardization.

In order to overcome the current knowledge management and communication deficiencies, more emphasis should be given to IT tools. Database and internet technologies together provide strong capabilities in the direction of more effective knowledge management and communication. Database management systems are nowadays powerful and allow sophisticated manipulation of vast volumes of information. The Internet and the World Wide Web (WWW) are attractive for transferring information rapidly and economically all around the world where there is Internet without any regional or temporal borders. These technologies, therefore, provide a suitable platform on which an organization can have attempts for managing and sharing construction information.

Modeling construction information can be thought as the representation of construction process as “data”. In this thesis, these problems are solved through a developed web-based database system that contains a repository database and a web application. The database is populated along the use of the system with project and corporate information while the personnel of the company can interact with each other through the Internet.

4.1. Web-Based Database Systems

According to Zhu (1999) presently at construction industry, there are three types of web-based applications namely; the fee-based project management service, the build it yourself solutions and the web-enabled software (cited in Chassiakos and Sakellaropoulos, 2008). All three types of web-based applications are explained in the following paragraphs.

The fee-based project management services are provided by professional IT companies called Application Service Providers (ASP). Benefits of these web-based applications is its low cost, need for less IT expertise, ease of application upgrade, and simple system requirements. Its limitations are that the information is under the control of a third party, which would cause concerns about the security, data accessibility and service quality.

The build-it-yourself solutions are suitable for large construction companies, so that they can adapt the application that best fits their business environments and maintain their own business style. The limitation is obviously the investment requirements of the application, outsourcing and long development cycle, and more complicated implementation process.

The last type of the three, web-enabled software refers to a complete set of web-based application which is brought, maintained and owned by construction companies. This solution seems to be the combination of the first two types. It reduces the need for outsourcing, shortens the development and implementation cycle and at the same time, protects important organizational information under the supervision of the in-house

technical staff of the companies. Limitations of this type are higher initial cost and necessity of greater know-how of the staff.

4.2. The Proposed System

The study proposes the use of a web-based database system for construction companies. The system, named as WEB-CONS, is a knowledge storage, sharing, and retrieval platform that serves as an aid for project management activities.

WEB-CONS can be referred to as a web-based knowledge management and communication system which includes both the knowledge created at the project level, and strategic knowledge at corporate level. The development of the system is based upon the technology of databases within web applications. The database technology can handle enormous volumes of information, as those generated throughout the construction process, while internet technologies can instantly and with almost no cost gather and disperse information all over the world without any borders.

WEB-CONS constitutes a web-based database approach as a knowledge sharing mechanism in contrast with the existing document based approaches where the information can just be managed as documents, but not as a whole document systems with reference to their particular classification according to their job domains. Besides, other than just being a knowledge storage bin, databases can also manage the knowledge within the company by assigning date, title and revision to the documents and placing them to their specific locations. Details about document management will be explained in detail in the following sections of this chapter.

4.2.1. System Development

Previous chapter of the thesis contained the design and findings of questionnaire survey conducted within the Turkish construction companies based on an OL framework. The survey outlined the current knowledge management practices in construction industry, observed particular deficiencies, and identified needs of the employees at all levels. Based on the findings the need for a web-based system was crucial for the construction

companies. The construction companies that participated in the survey agreed that the efficient information sharing and communication among participants constitute a critical success factor for construction business.

According to the needs of the project personnel, an effective project management system is developed that mainly includes information about project planning, activity execution and project progress, manpower and equipment management, allocation procurement and inventory management, and corporate information of the company. So as a starting point, the study conducted in the thesis has identified information that is considered as the most significant for construction monitoring, which is an important element of efficient construction management. Such information concerns projects, construction sites, activity progress, manpower usage, material arrival and usage, equipment usage, headquarters' orders and comments and problems.

Although the main purpose of WEB-CONS is to improve the performance management at the project level helps the companies at strategic decision-making. It has not only post-project and on-going project information; it also has tendering stage information as well as other corporate information to help with future actions.

The system is developed as a facilitator of knowledge management in construction companies. The system can be used by any construction company which is designed to meet the expectations of medium-to-large companies.

4.2.2. System Architecture

WEB-CONS is designed mainly as a web-based construction project monitoring and management system. Through their accounts, users affiliated with the company and construction projects are allowed to access the system from anywhere around the world using a web-browser, and access relevant parts of the system, based on the user profiles.

The system is designed to have various authorization levels for the users related content of each part can be uploaded according to the fact of authorization leveling. Another authorized person that can access the page can view or download the uploaded

documents. Based on the specified authorization level, a user can either upload or download the available documents. For example, under the “master plan” subheading of the project database, an accessible user can upload a master plan revision or download when necessary. Authorization levels of the system are presented in Figure 4.1 which are mainly; board and executive team members with all access to each page of the system, and project managers, technical staff, business development staff, quality and HSE staff, human resources personnel and finance manager with access to their relevant parts of the system. The parts of the system where these personnel can access will be explained in the following sections of this chapter.

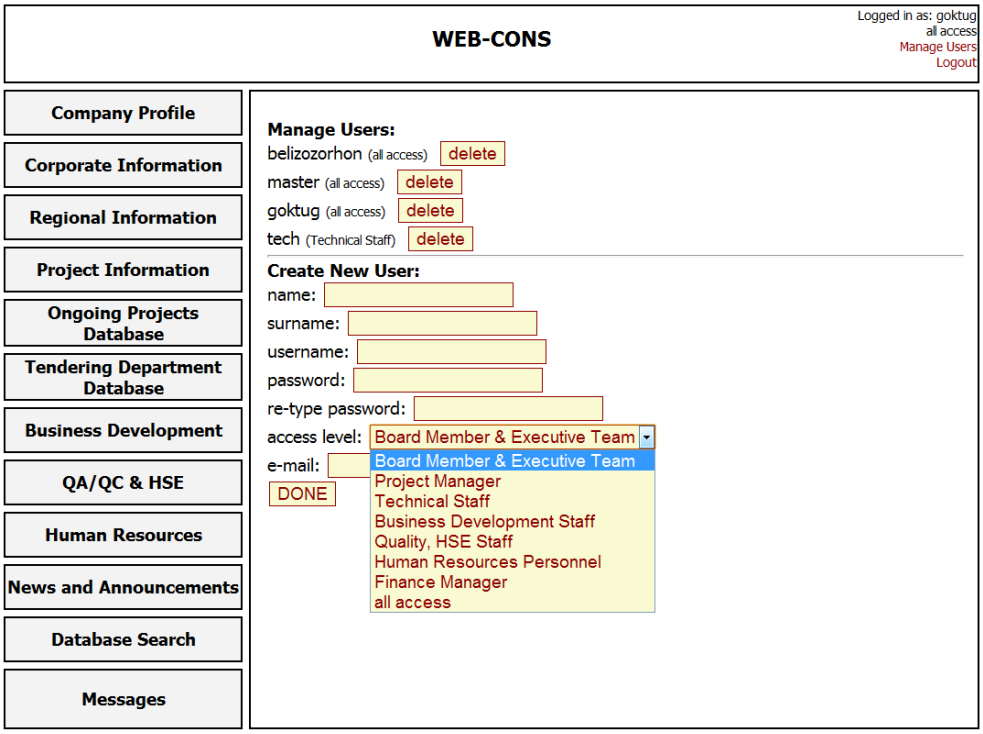

Figure 4.1. User Management Page and Authorization Levels

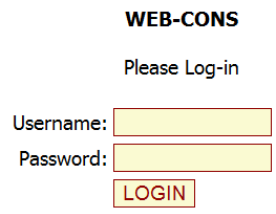

Figure 4.2. Log-in Page

WEB-CONS is developed to run on a server with Microsoft Windows platform, and coded in Active Server Pages (ASP) web-programming language. Four different password-protected MS Access databases are used to store the relevant information namely; project information, user account information and messages, comments and announcements, and titles of uploaded documents. Content is uploaded through a Security Sockets Layer (SSL) connection, and direct web-access to them is prohibited by setting IIS access permissions of the document and database storage folders. Downloading and viewing of possibly confidential documents are managed by a secure web-script, which forwards requested file after checking users' authentication and access permissions. Furthermore, all user inputs are filtered for pieces of SQM, HTML and web-script codes, to protect the system against any potential "injection attacks", which provides the security template for the system.

The activities regarding the web-based database system development are done by a software database developer within the research team. The team gathered to have regular meetings to decide on the system architecture. The team was composed of the advisor of the thesis, author of the thesis and software developer of the system. A total of 40 hours have been allocated for the development of the web-based database system.

Detailed information about the interface design and the contents on each page are given in the following sections. As can be seen from the figures, at the left-hand side of the program, there is a strip on which the main page titles are listed. At the left-hand side of the page, the detailed representation of each main title is occurs. When the links at the left-hand side list is clicked, the system directs the users to the page that they are intended to view. In the following sections, detailed information is going to be given supported by the relevant images.

4.2.2.1. Home Page. When the user accesses the system by typing his/her username and password, he/she is directed to the home page of WEB-CONS where the name and the logo of the company are present which can be regarded as the welcoming page for the users of the system.

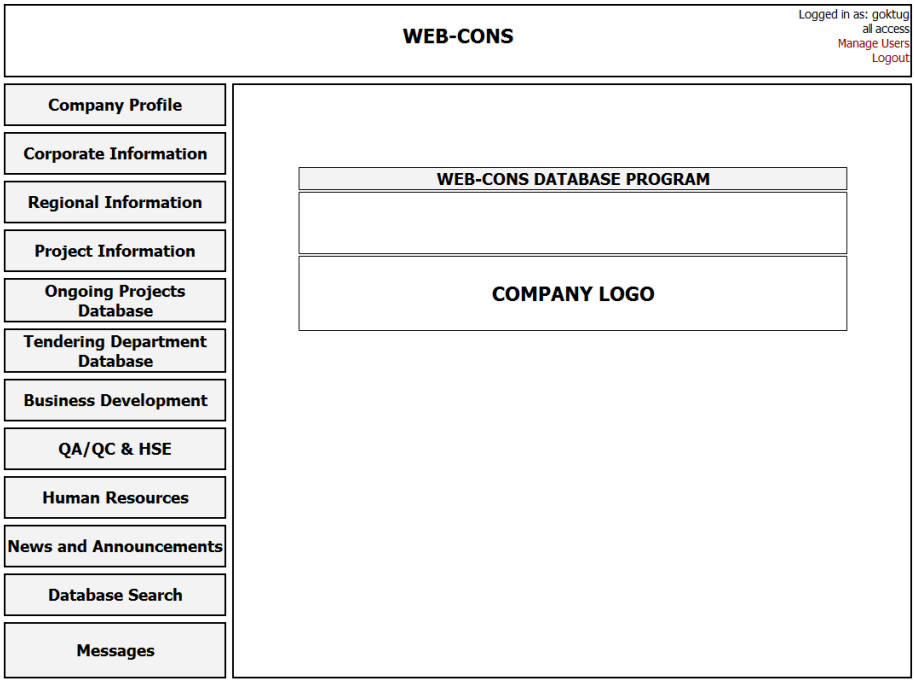

Figure 4.3. Home Page

As seen on Figure 4.1, on the left hand side of the page, there is a menu to access various project and corporate level information classified as company profile, corporate information, regional information, project information, ongoing projects database, tendering department database, business development, QA/QC and HSE, human resources. There is also a communication aspect within the system such as news and announcements, and messages.

4.2.2.2. Company Profile Page. Although all the users that have access to the system are members of the organization, a company profile page is created for the purpose of introducing the general background of the company and fields of activity for the company which would encourage the personnel by making them feel that they are a part of the organization.

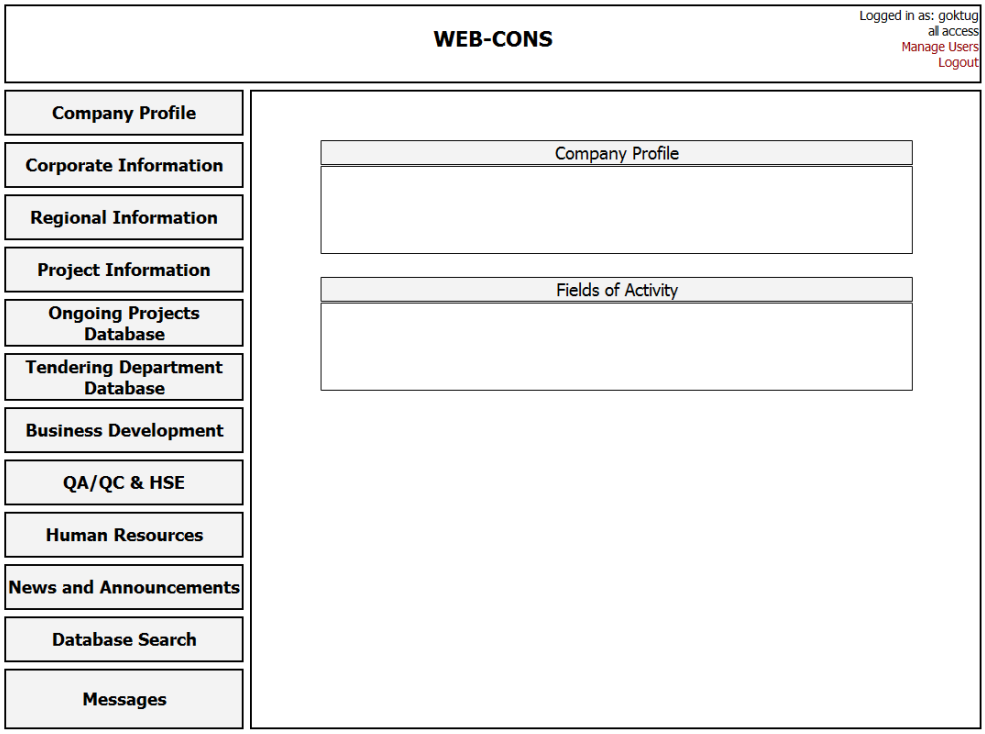

Figure 4.4. Company Profile Page

4.2.2.3. Corporate Information Page. This page of the system is generated for the ease of reaching the corporate documents of the company. Each document has different levels of accessibility; some of the documents can be only be viewed by the managerial level personnel. The subtitles presented on this page can be listed as;

- Shareholders
- Registration Certificate
- Trade Register
- Stock Information
- Annual Reports
- Financial Data
- Corporate Articles
- Frequently Asked Questions
- Meeting Minutes of General Assembly

As an example, the registration certificate of the company can be reached by all the personnel who can access the system, whereas meeting minutes of general assembly can

only be reached by the executive board, high level managers and directors due to its level of confidentiality.

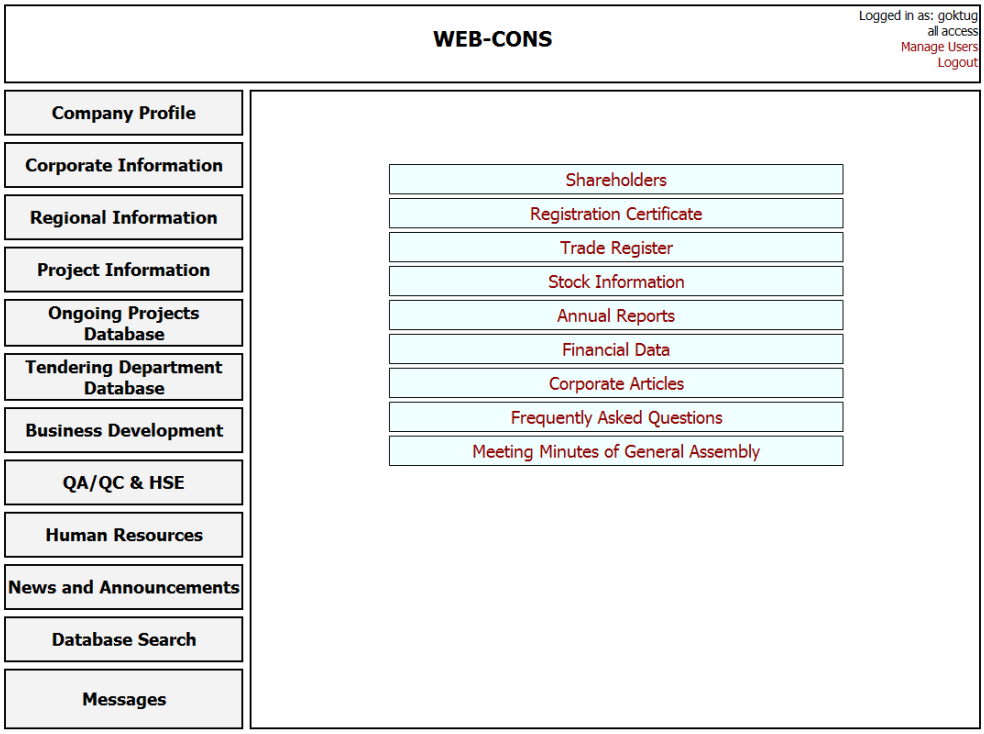

Figure 4.5. Corporate Information Page

4.2.2.4. Regional Information Page. Regional information page of the system is an informatory page that has several information such as; the names, addresses, telephones and fax numbers, and e-mails of the headquarters and regional offices of the company. Since the page is accessible by all users of the company, the main purpose of this page is to ensure that all the members of the organization can easily reach the information on this page.

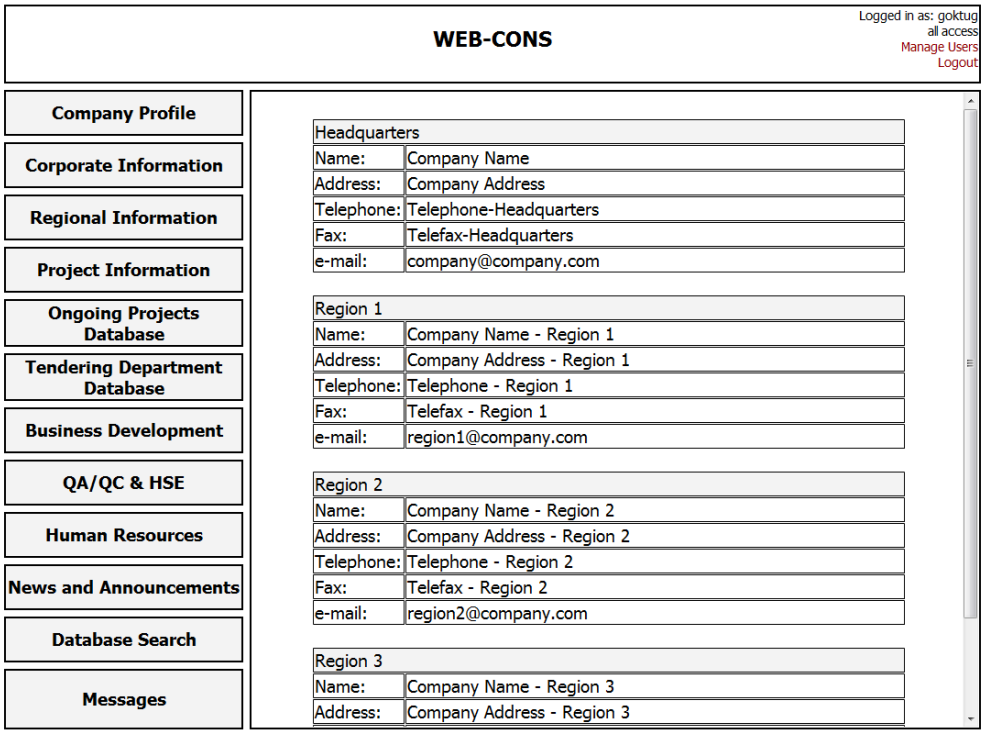

Figure 4.6. Regional Information Page

4.2.2.5. Project Information Page. At this page, a general list of completed and ongoing projects is represented where the projects are classified according to their types such as;

- Industrial & Infrastructure Works
- Buildings Projects
- Marine Works Projects etc.

As the company grows, it starts to perform new projects which might be in different types than the above listed ones and because of that, the users accessible to this page can add new project types besides new projects can be added to the system. When any of the listed projects is chosen, a new detailed project page opens comprising detailed information about the project which will be discussed in the coming parts of the chapter.

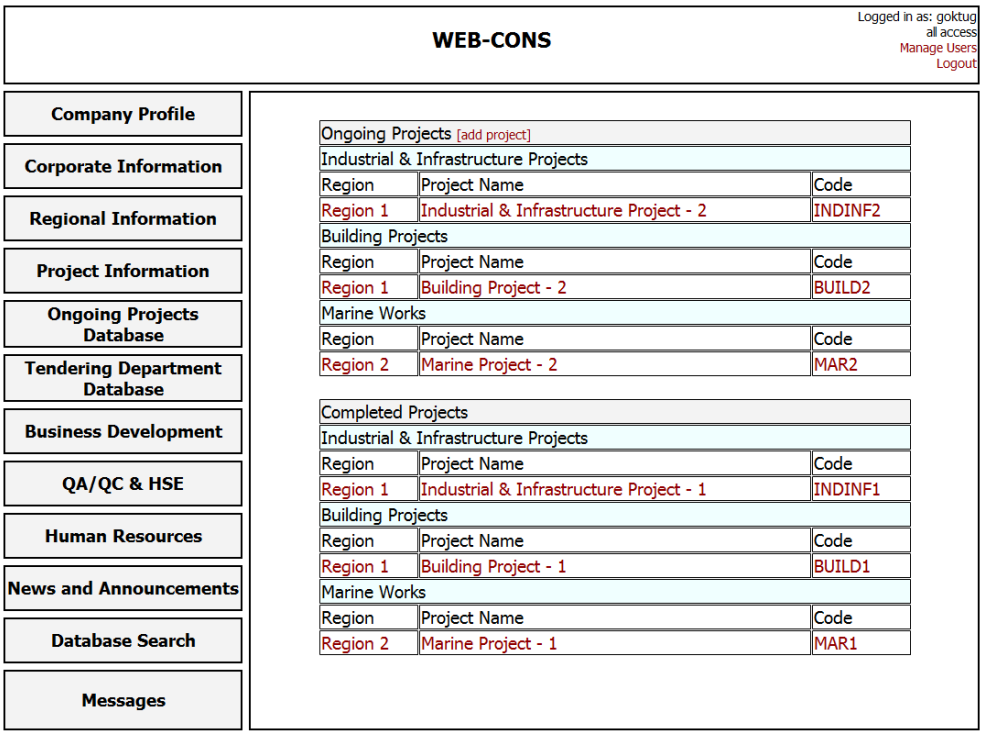

Figure 4.7. Project Information Page

4.2.2.6. Ongoing Projects Database Page. This section of the system represents the list of ongoing projects where the first step of project management for the current projects can be handled.

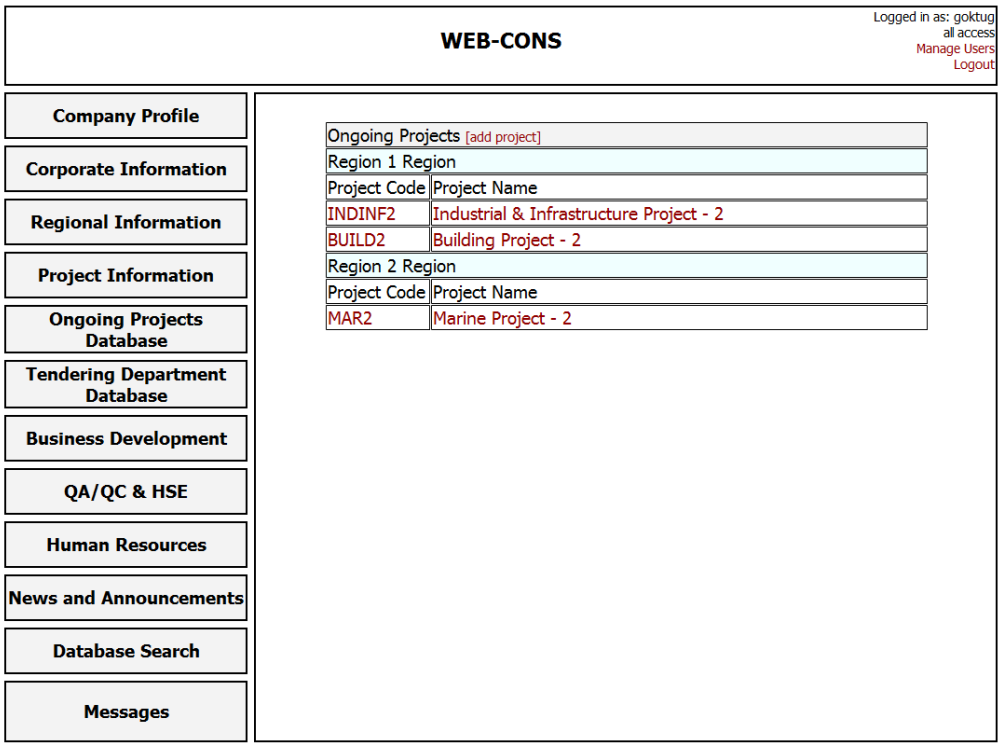

Figure 4.8. Ongoing Projects Page

The first page appears as a list of ongoing projects sorted by their regions which are linked to further specific project management pages for each of the listed projects where the accessible users can share their project information by uploading or downloading them. The main headings and their subtitles of the project management page are represented in Table 4.1 and discussed in the following paragraphs.

Table 4.1. Project Management Page Main Headings and Subtitles

Main Headings	**Subtitles**
(i) *Basic Project Information*	- Region - Type - Code
(ii) *Announcements*	
(iii) *Web-Cam*	
(iv) Correspondences	- Between the Company and the Employer - Between the Company and the Consultant - Between the Company and the Regional Office - Between the Company and Other Participant Parties
(v) *Work Schedule and Master Plan*	- Work Schedule - Master Plan
(vi) *Contractual Issues*	- Contract - Bill of Quantities - Addendums - Insurances - Cost Control - Additional Works and Other Contractual Issues
(vii) *Design Works*	- Schematic Design - Design Development - As-Built Drawings
(viii) *Reports*	- Periodical Reports - Quality Reports - HSE Reports - Financial and Accounting Reports - Photographs - Records and Videos - Material Request Forms - Headquarters Reports - General Reports
(ix) *Progress Payments and Claims*	- Progress Payments - Claims - Invoices
(x) *Materials*	- Quotations from the Suppliers - Information about the Materials - Approval of the Materials
(xi) *Subcontractors*	- Quotations from the Subcontractors - Contracts between the Company and the Subcontractors - Progress Payments of the Subcontractors
(xii) *Corporate Regulations*	- Quality Documents - HSE Documents - Procedures

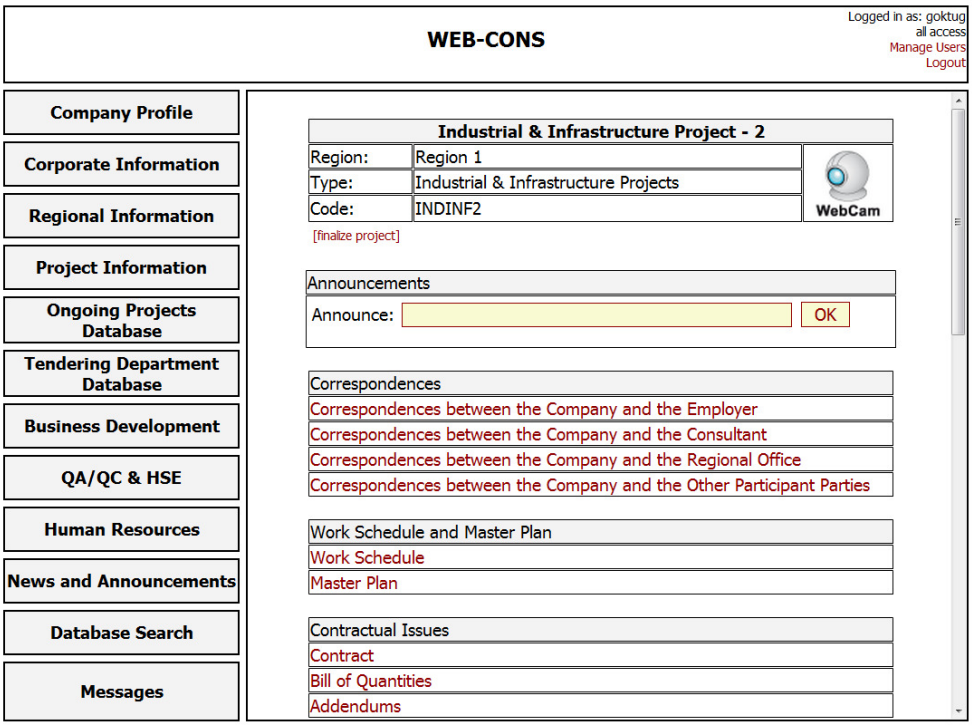

Figure 4.9. Project Management Database Page – Part 1

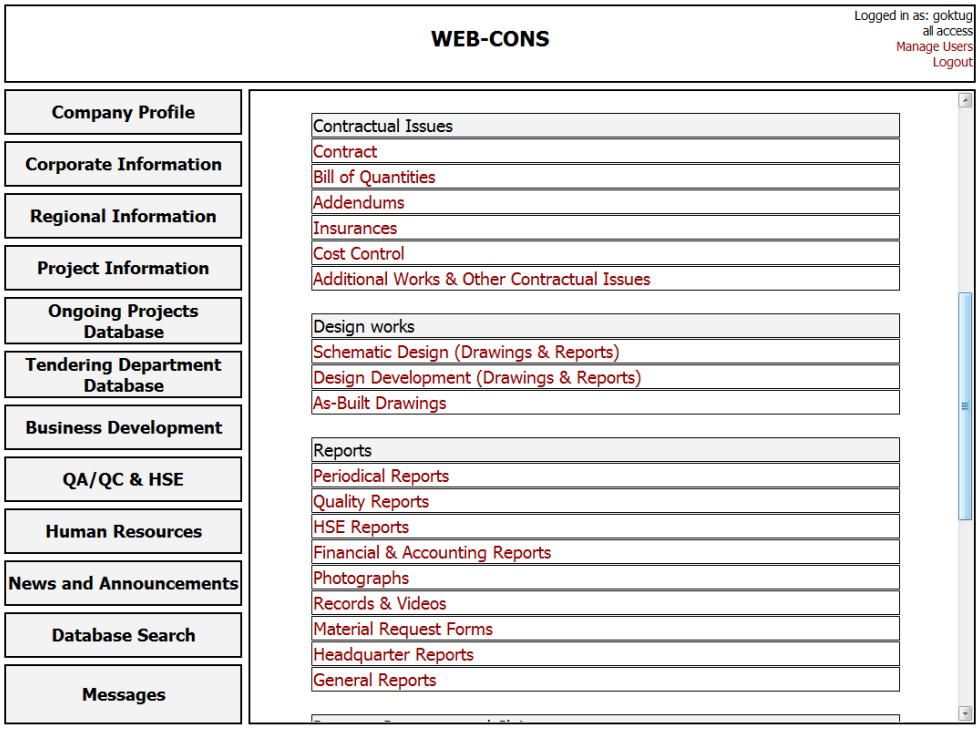

Figure 4.10. Project Management Database Page – Part 2

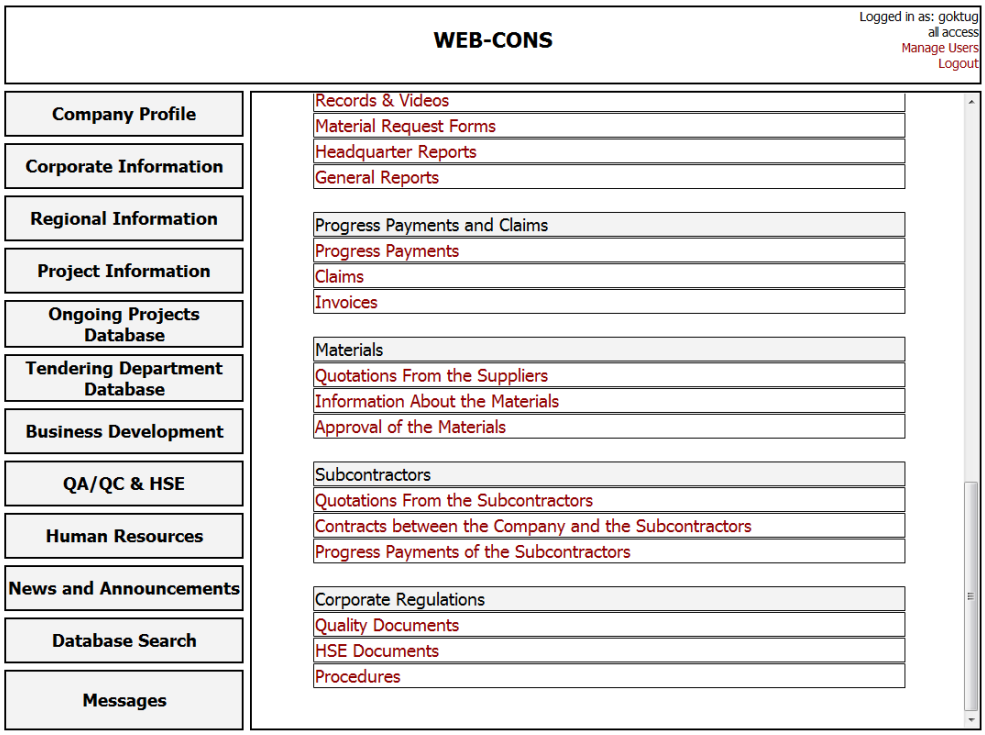

Figure 4.11. Project Management Database Page – Part 3

(i) *Basic Project Information*, at the head of the page presents the general information about the project by representing the region, type and company specific code of the project.

(ii) *Announcements* about the project can be made by the accessible members of the project to attract the attention of other project personnel on a general or specific point about the specific project.

(iii) Due to the fact that the managerial team is mostly at the headquarters, there should be a permanent tool to provide them the progress of the project. *Webcam* tool aims to ensure the participation of personnel in other regions which can establish the advancement of the construction works.

(iv) *Correspondences* heading includes the formal communication matters between the members of the organization or with others parties, and may be documented in e-mail format. The correspondences of the company may be with the client, the

consultant, the regional office of the company or any participant parties such as subcontractors.

(v) *Work schedule and master plan* topic includes the master plan and work schedule prepared at the beginning of the project. Although work schedule and master plan of the project have different types of document formats, both of them can be directly uploaded to the database in their own formats; such as work schedule might be created in MS Project or Primavera whereas the master plan of the project can be in MS Excel format. In time, companies might have to change some parts of these documents and if they do, they may upload the revised document with an appropriate revision naming according to the date and revision number of the document.

(vi) *Contractual Issues* are crucial subjects for managerial view of the project which consists of the subtitles indicated as;

- *Contract* is the legal document that the project is awarded to the company, which is the originally signed document; scanned and uploaded under this link for the view of the accessible personnel for general use when needed.
- *Bill of Quantities* is an important attachment of the contract, which includes all the prices of the items that the company has tendered for. Even though this document is attached to the contract, in many situations it is revised by adding new items or erasing existing items. It is referred many times throughout the execution period of the project by the technical personnel at site and the managers at the headquarters.
- *Addendums* are also attachments of contract which explain the contractual changes containing the work scope.
- *Insurances* are an important form of risk management that are used to hedge risks against the risk of probable or uncertain loss. Both the site personnel and management team have to be aware of the content of the insurances so in purpose of keeping the track of the insurances, all documentation about those insurances should be uploaded to the database.

- *Cost control* is the current situation and future expectations about monetary issues, which comes into prominence for the financial decisions that are going to be taken throughout the execution of the project. Cost control reports and their revisions should all be uploaded to the database for the view of the managerial team for making clearer decisions.
- *Additional works and other contractual issues* are concerned with the documents that do not fit any of the titles listed above; such as contractor issues about personnel or some works awarded to the company during the execution of the works without a contract.

(vii) *Design works* are usually carried out after the award of the contract, determining the execution details of the project according to the method of construction. In many international or even domesti construction projects, the country of the design office and site may be in different countries which makes the web-based database approach more critical for providing easy communication and document sharing between the contractor and design offices, especially just before the crucial parts of the construction works where the speed is critical and the work load is at pressurizing levels. There are three subheadings of this topic such as;

- *Schematic design* is the first-level design that must be approved by the consultants of the client for the continuation of the design works. Schematic design reports in MS Word and MS Excel format and drawings in Autocad format should be uploaded to the database for any discrepancies that can occur after the final design.
- *Design development* can be referred as the stage between the schematic design and the final design in which usually the revisions occur. The documents that are formed in this stage can also be referred to as schematic design documents and should be uploaded to the database considering that manner.
- *As-built drawings,* as the final outcome of the design process contain mostly "For Construction" drawings which should be approved by the consultants of the client to be used for the execution of the works afterwards. According to the technological facilities of the construction site office, these drawings may be

sent to the site as hard-copies if the site office do not have a plotter or can be shared at the database and then be printed at the site office if a plotter is available.

(viii) *Reports* are usually an effective way of realizing the progress of a construction project, which are important aspects of project management and closely followed by the high level managers of the company. Accuracy and order of the reporting should be perfect to provide the knowledge flow in an efficient way. These reports can be listed as;

- *Periodical reports* are mostly prepared by the technical staff of the project team which may be in forms of daily, weekly and monthly reports. All the reports can be stored and shared in the database by assigning appropriate document names with titles and names accordingly to each document. The situation of the project will be evaluated according to these reports by project coordinator and the management team at the headquarters.
- *Quality reports* are arranged by the quality team of the project, viewed by the quality coordinator at the headquarters to see if there are any complications between the quality policy and manual of the company and quality applications carried out at the site.
- *Health, Safety and Environment (HSE) reports* are closely followed by the management team at the headquarters due to the importance of this specific subject in today's construction business entities. Avoiding any accidents at their sites before happening may be one of the most important targets of the construction companies.
- *Financial and Accounting Reports* are prepared by the accounting team at the project site and these reports are closely followed by the finance director at the headquarters. These reports should coincide with the reports from the technical team to prevent any financial discrepancies between the departments.
- *Photographs, records and videos* are not actually written reports but they may be referred as the factual evidence of progress. Since management team in headquarters cannot be at the project site to follow every important achievement,

visual reflection of the execution would be an effective way for them to see if their instruction are carried out in the right manner or not.

- *Material request forms* are prepared by the site technical office personnel to order the material needed for the next phase of the construction. In international contracts of construction companies, it is impossible to find every material from the country that they project is executed so the logistics team at the headquarters deal with the purchasing and logistics activities of requested materials. The use of the database will be efficient for this process since all project participants will be able to see all the required materials in one page lasted accordingly via its type, properties and ordering date.
- *Headquarters and general reports* are prepared by the project coordinator employed at the headquarters for the management team reflecting his/her opinions about the progress of the project.

(ix) *Progress payments and claims* are the most important sources of the project cash flow. Project team members prepare a financial progress at the end of each month, hand it to the representatives of the client and get paid for the progress achieved in that specific month. Invoices of these payments can be referred to as the evidence of these payments. Progress payment reports and invoices should be stored in the database for the management team to keep the track of these. Claims are the financial demands of the contractor from the client for any extra works rather than the ones defined in the Bill of Quantities which can be referred to as a totally new item or extra work done in just one item.

(x) *Materials* are an important component in the execution of the project together with workmanship and machinery used. Keeping an effective track of the material quotations and specifications can save a lot of time for the project team. There are two stages of material purchasing after the material request form is sent from the site project team; receiving quotations from the potential suppliers and evaluation of the quotations according to their prices, specifications and suitability of usage at the construction, and approval of the materials. These steps must be carefully documented in the database in purpose of simplifying the job of the project team

while following the advancement in purchasing, and also using them in tender preparations or future works, as base prices.

(xi) *Subcontractors* are employed when there are tasks that the contractor cannot undertake itself and need more expertise to execute them. Although subcontractors aid the main contractors with their experience in their area of specialty, they should still be under the control of the main contractor, and a good record should be kept by the project and headquarters' teams of the main contractor on subcontractors' progress and payments. Aspects including the performance and selections of the subcontractors that should be followed can be listed as; *quotations from the subcontractors, contracts between the main contractor and subcontractors, and progress payments of the subcontractors* which are the subtitles of the project management database for the main topic of subcontractors.

(xii) *Corporate regulations* are the documentations other than the ones stated above to carry out a project successfully such as; *quality procedures, HSE procedures and general regulations*. These procedures and regulations should be documented in an ordered fashion for the necessity of usage by both the project and headquarters' teams.

4.2.2.7. Tendering Department Database Page. Although most of the companies locate their tendering departments at the headquarters, large-scale international construction companies also have tendering teams at their other regional offices. Due to the fact that there is need for a common platform to share and store the data, WEB-CONS acts as a database for the tendering departments of construction companies.

Tendering projects database part of the system is the section where the coordination of the tendering works between offices can be performed. Firstly, a page showing the lists of current tenders sorted by their locations appears where the tenders are linked to a detailed tendering department page.

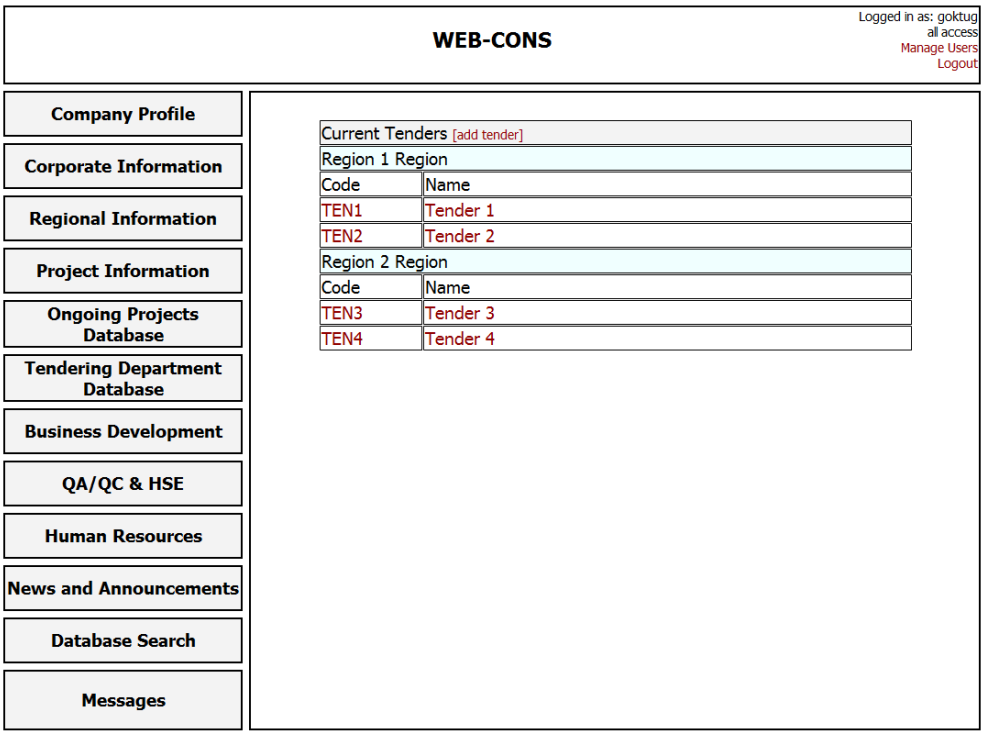

Figure 4.12. Tendering Information Page

When the accessed user clicks on one of the tenders from the list, system directs him/her to a more detailed tender management page where the uploading and downloading of the documents can be actualized. The main headings of the tendering department database are explained in the following paragraphs with the listings of their subtitles which are under each relevant heading. The main headings and their subtitles of the tendering management database page are presented in Table 4.2 and discussed in the following paragraphs.

Table 4.2. Tendering Management Page Main Headings and Subtitles

Heading	**Subtitle**
(i) *Basic Tender Information*	- Region - Type - Code
(ii) *Announcements*	
(iii) *Received Information*	- Tender Documents and Addendums - Site Reports
(iv) *Correspondences*	- Between the Company and the Employer - Between the Company and the Consultant - Between the Company and Other Participant Parties
(v) *Pre-qualification Documents*	- Received Information from the Employer - Analysis Studies
(vi) *Cost Analysis Studies*	- Assumptions and Reports - Analysis Studies
(vii) *Tender Submission Documents*	- Financial Package Documents - Technical Package Documents
(viii) *Design Studies*	- Conceptual Design Studies - Detailed Design Studies - Design Reports
(ix) *Preliminary Work and Procurement Schedules*	- Preliminary Work Schedule - Preliminary Procurement Schedule - Reports and Assumptions on Schedules
(x) *Preliminary Method of Construction*	- Method of Construction - Method Assumptions
(xi) *Received Quotations*	- Materials - Machinery and Equipment - Subcontractors
(xii) *Corporate Regulations*	- Quality Documents - HSE Documents - Procedures

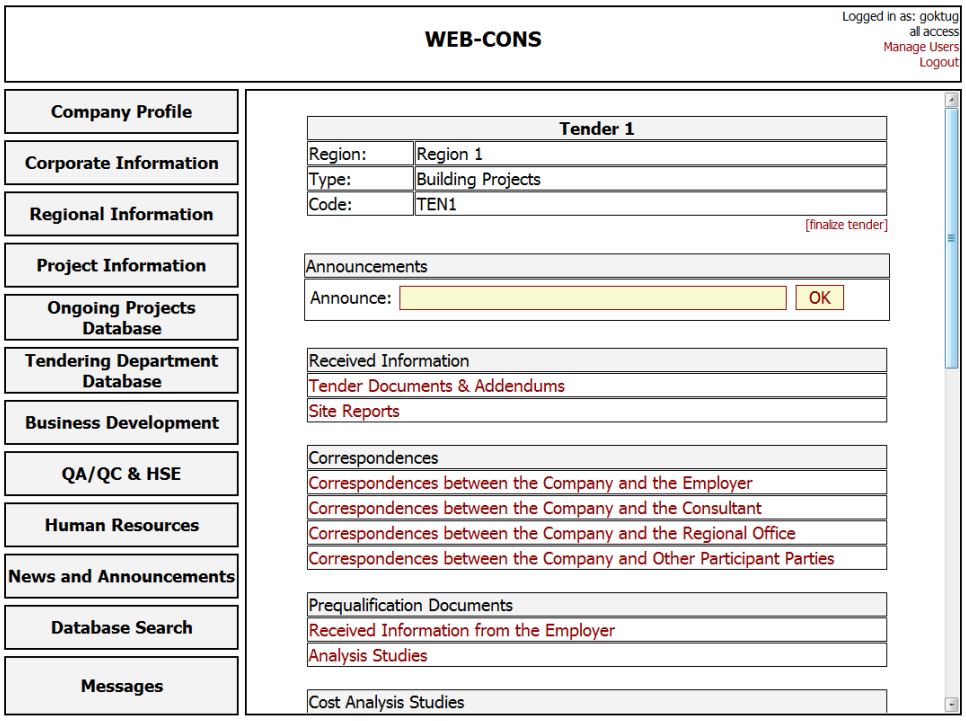

Figure 4.13. Tendering Management Database Page – Part 1

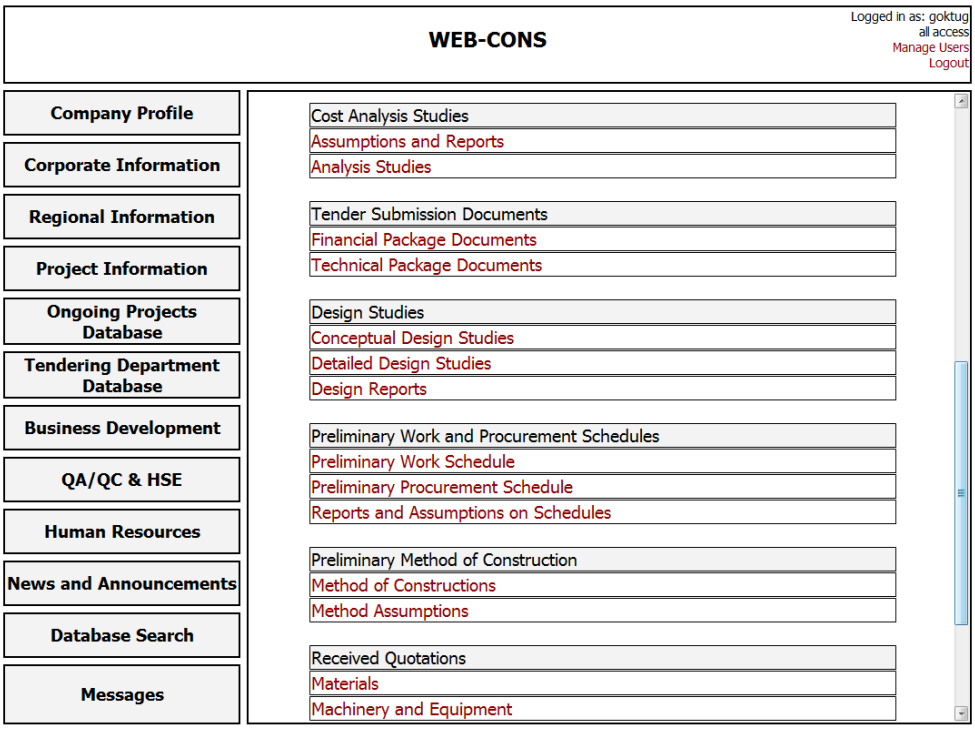

Figure 4.14. Tendering Management Database Page – Part 2

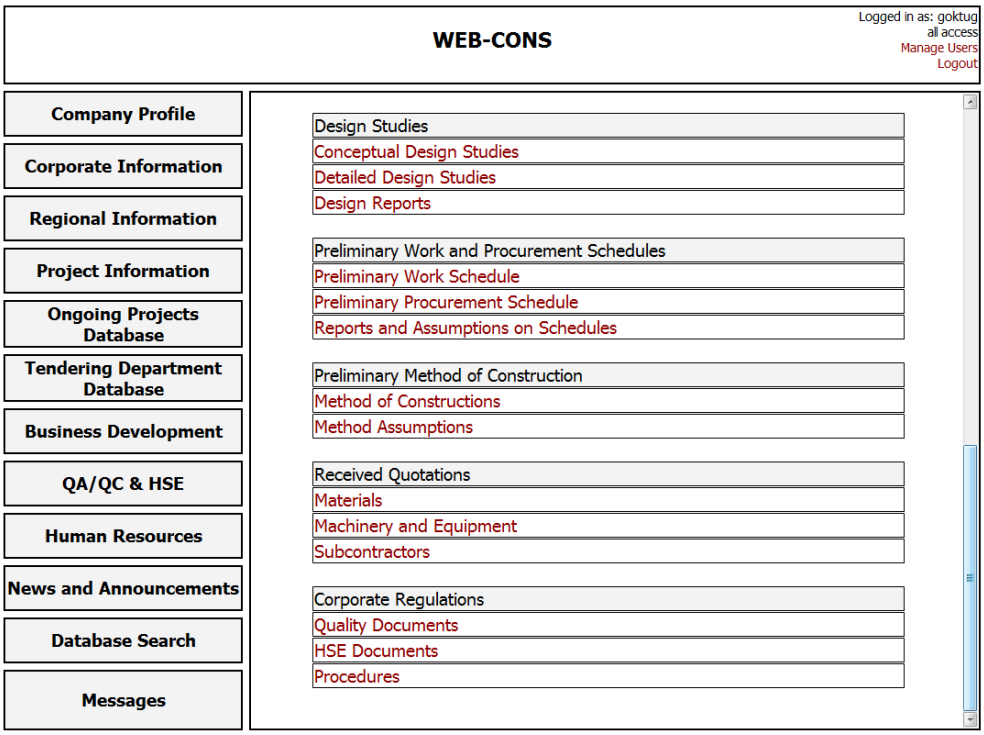

Figure 4.15. Tendering Management Database Page – Part 3

(i) *Basic tender information*, at the head of the page presents the general information about the tender by representing the region, type and company specific code. This part is prepared to inform the accessed users.

(ii) *Announcements* about the tender can be made by the accessible members of the tender to attract the attention of other personnel on a general or specific point about the specific tender.

(iii) *Received information* folder contains documents that come from the client such as; Instructions to Bidders, an empty Bill of Quantities, Specifications and Drawings, which should be kept in a systematic order for the ease of the activities carried out by tendering teams. Also there may be some addendums about the tender that the client has sent to the contractors to inform the contractors about new aspects or clarify some points about the tenders, which also must be stored with the received tender documents. Also, reports from the site visits carried out during the bidding stage to see the conditions of the construction site can be stored and shared at the tendering department database.

(iv) *Correspondences* are also important for the management of the tendering stage, since there may be different offices of the same company or external parties involved in the process of tender preparation. The documentation of this item might be crucial since it involves correspondences of the company with the client, the consultant, the regional office or third parties that are involved in tendering stage, such as subcontractors.

(v) *Pre-qualification documents* are the documents sent to the potential tenderers at the pre-qualification stage of the tender. Most of the professional clients run a prequalification stage before they succeed to the tendering stage, usually to eliminate the insufficient companies in terms of technical capabilities. These documents should be stored due to the fact that they reflect the characteristics and approach of the client to the tenderers and to the project.

(vi) *Cost analysis studies* are one of the most important activities carried out which is carefully throughout the process of tender preparations. Usually, every construction company have their own bid preparation calculation format as an MS Excel document or in-house developed program, which of both can be stored and shared between the accessible members during and after bid preparation calculations. Another important point of storing these documents would be the cost calculations carried for the preparation of a tender may be a good template for the coming tender calculations of projects in similar nature. Also, if the company gets awarded with the contract, the project team would like to know the cost analysis calculations while preparing the master plan of the project. Other than the cost analysis calculations, the assumptions that the engineers do to prepare the prices should also be stored in the database.

(vii) *Tender submission documents* are composed of two documentation types which are handed to the client as the “Bid”; namely; financial proposal documents and technical proposal documents. Both of them are developed according to the tender studies carried, and they should be arranged in a good manner to be stored and used in the future as an example.

(viii) *Design studies* should sometimes be carried at the tender stage of the contract, especially when there are some discrepancies about the design or there are some missing points at the design executed by the consultants of the client. Also, there might be the point that the design prepared by the client's consultants may be schematic design without details which would not be enough for the preparations of the tender and should be improved to detailed design by the tenderer. Under the subheading of *conceptual design studies*, the drawings of the conceptual design given by the client or executed by the contractor's design office can be stored and shared in the database for the view of all accessed participants. *Detailed design development* should be conducted when there is need for more details for the cost calculations of the tender. *Design reports* are the outcomes of all design calculations of the consultant which provides guidance for similar design works in the future.

(ix) *Work and procurement schedules* are prepared for the determination of the method and act as the basis for cost calculation analysis. Usually work and procurement schedules developed at the tender stage are at schedule level without resource management, which still reflects the progress of the construction works.

(x) *Method of construction* arranged at the tendering stage aims to help the cost calculation analysis via the selection of the right technique and machinery to execute the construction works to be carried by the tenderer. Method of construction and the assumptions for the method can be used for similar executions in the future.

(xi) *Received quotations* at the tendering stage be classified in three main headlines namely; quotations for materials, quotations for machinery and equipments, and quotations from the subcontractors. When there are multiple offices of tender preparation in the company, there needs to be quotations taken from different countries, which of all shall be stored and shared at the same folder for the ease of the eligibility of tender preparation teams.

(xii) *Corporate regulations* include other documentation needed for the preparation of the tenders such as; *quality procedures, HSE procedures and regulations.* There are some situations that the clients may seek for evidence of successful quality and

HSE histories as a part of the tender for their evaluations so especially when there are different offices, these documents will have to be shared within these offices.

4.2.2.8. Business Development Page. Business development departments of construction companies try to find and get information about new markets by conducting detailed research on relevant countries, most of the times also by visiting them.

The information gained about existing and new markets shall be stored and shared among the accessible members of the company by utilizing the database. A member of the business development team can be away for visiting a prospect country and may need to share documents with large file sizes that cannot be send via e-mail, and the database would be an effective tool for sharing these types of documents.

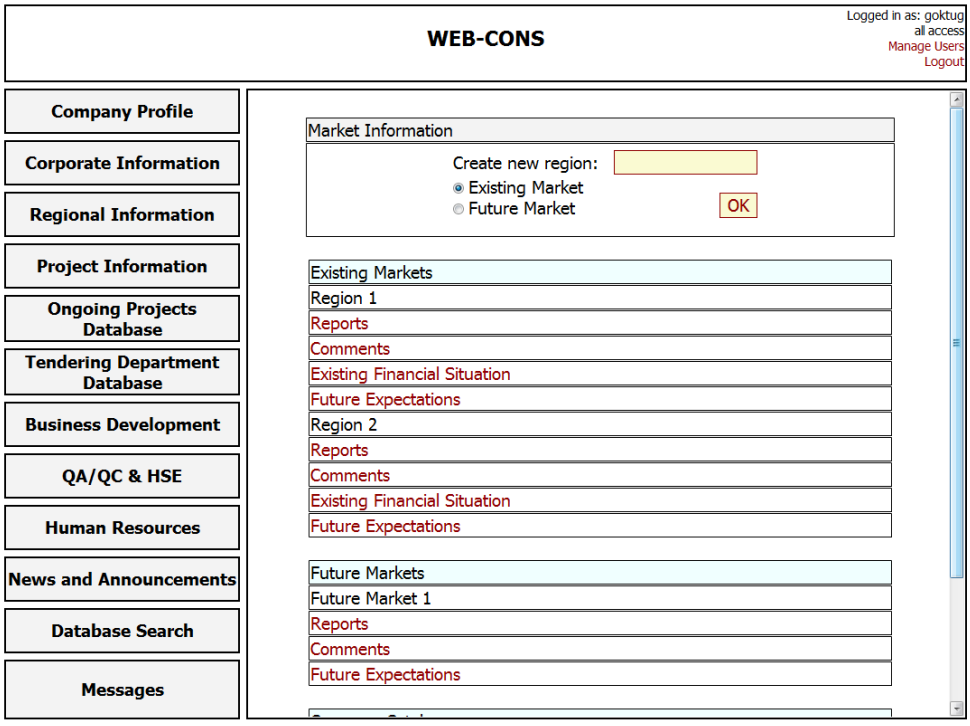

Figure 4.16. Business Development Page – Part 1

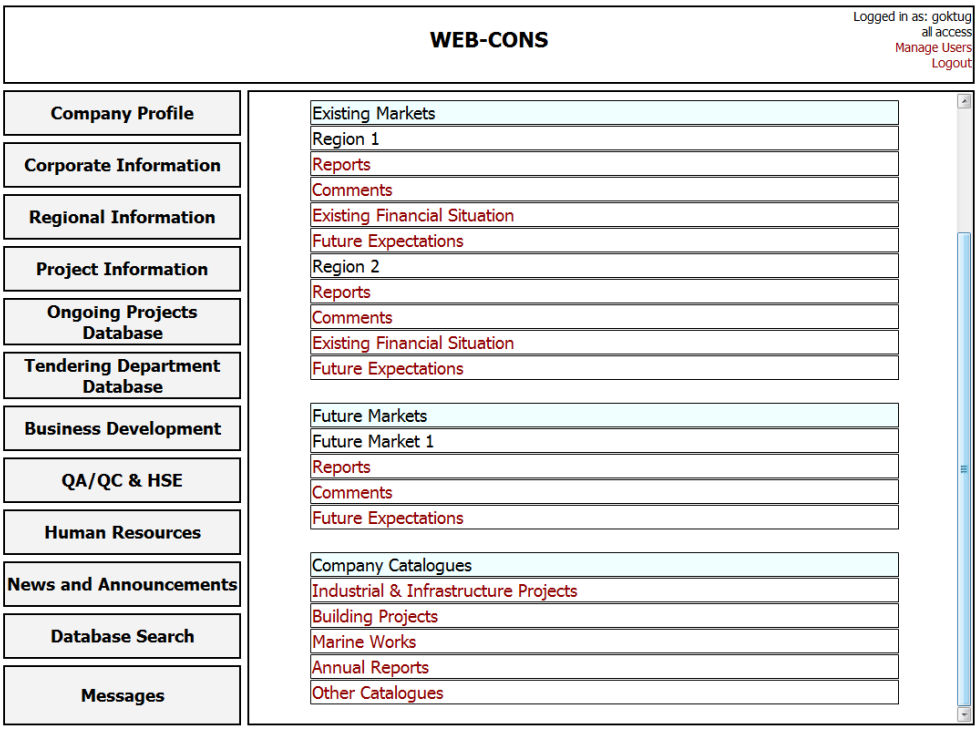

Figure 4.17. Business Development Page – Part 2

The documents that are stored on this page for future markets are; *reports, comments, and future expectations* about the market, whereas for the regions in the existing market; *current and past financial situation* documents can also be stored other than the ones listed for the future markets. Besides the documents about existing and future markets, *company catalogues* and *annual reports* can also be stored in this page of the database.

4.2.2.9. QA/QC and HSE Page. One of the characteristics of medium-to-large construction companies is that they all have effective quality and Health, Safety and Environment (HSE) management systems. Quality assurance (QA) and quality control (QC), and HSE documents prepared by the members of the department should be shared by all project and headquarters personnel for their awareness of developments and innovation in the QA/QC and HSE implementations of the company.

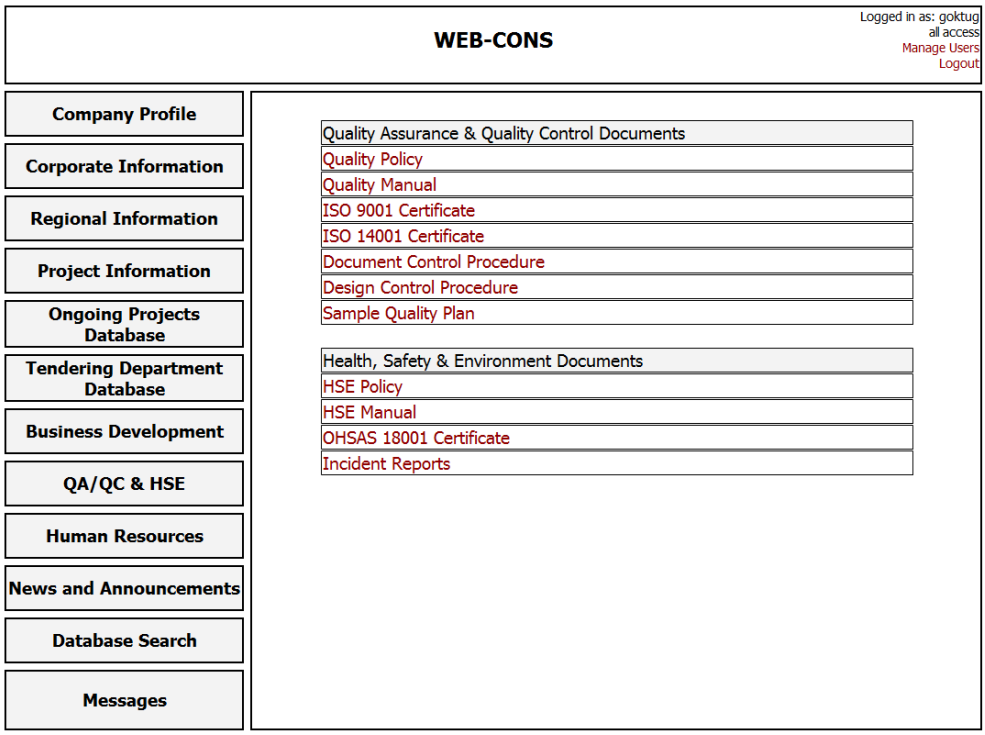

Figure 4.18. QA/QC and HSE Page

Quality control and quality assurance (QA/QC) documents and their revisions that are stored at most of the companies can be represented as; *quality policy*, *quality manual*, *ISO 9001 certificate*, *document control procedure*, *sample quality plan for projects* and any other quality procedures, requirements and plans.

On the other hand; HSE documents that can be shared on this page may be listed as; *HSE Policy*, *HSE Manual*, *OHSAS 18001 certificate*, *incident reports* and any other HSE documents.

4.2.1.10. Human Resources Page. Human resources page of the database can be accessed by only human resources personnel and managers, and CV's of existing personnel and applicants can be uploaded to the relevant position subheadings such as listed in Figure 4.11. With the use of the database, the page can be accessed by any human resources personnel from any region or site, which is a powerful tool for human resources personnel to reach the CV's of both the existing employees and the applicants easily.

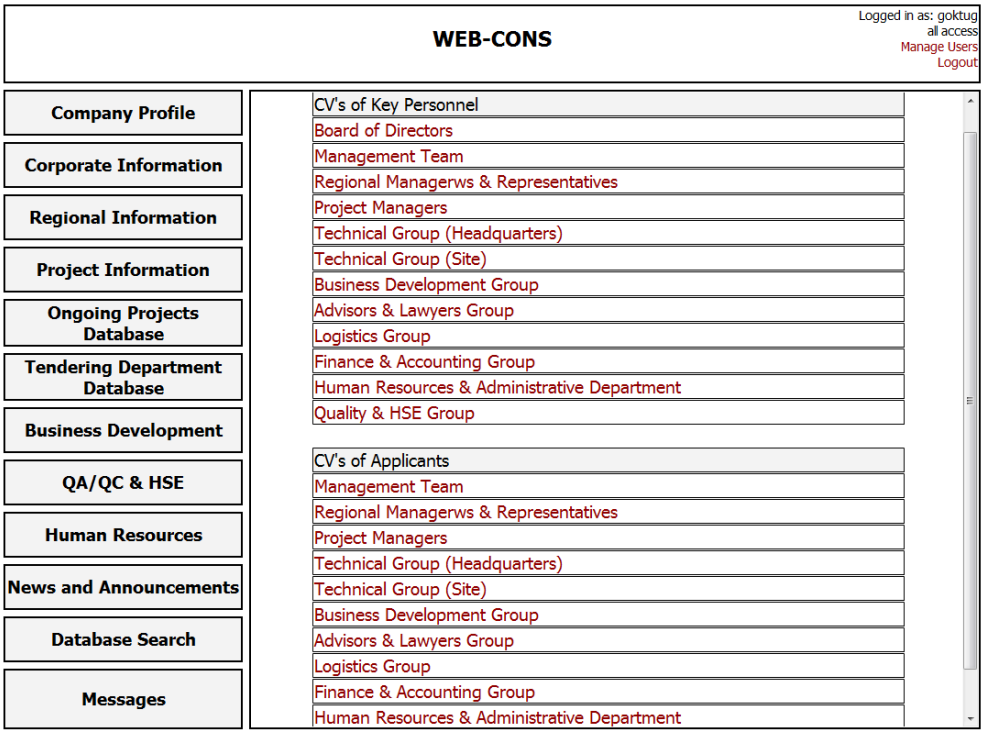

Figure 4.19. Human Resources Page

4.2.1.11. News and Announcements Page. The news and announcement page of the system can be accessed by all the members of the organization. Examples of news and announcements include; the news regarding award of a new project or successful progressions on one of the ongoing projects, and announcements such as job rotations or marriage of one of the employees. This information is posted in the system to attract the attention of members of the company. The aim of this page is to improve corporate synergy and increase the awareness of the personnel about what is going on within the company. It is believed that this will be helpful to enhance the organizational culture, that is the key to success in construction.

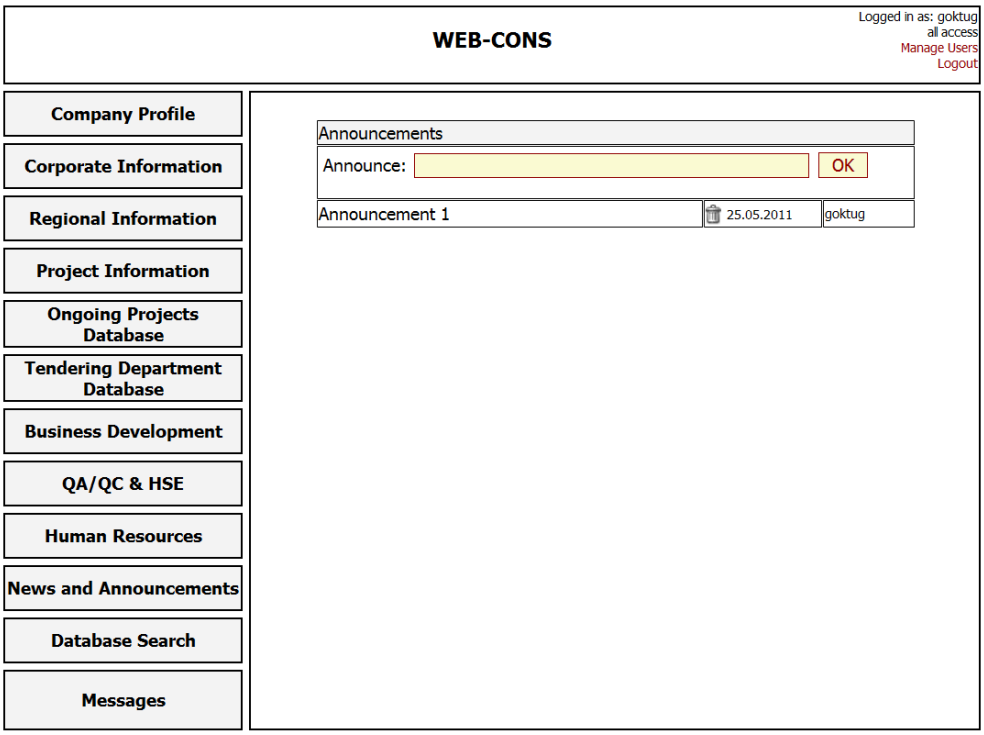

Figure 4.20. News and Announcements Page

4.2.1.12. Messaging Page. Direct messaging between the members would eliminate the communication problem within the organization. There are several communication and instant messaging programs such as Skype, which provides direct interaction between the members of the organization even if they are working in different countries. WEB-CONS provides a similar approach to messaging but there is an advantage that all members of the organization can access to messaging page and simultaneously connect to each other. This system can be assumed to have a faster and more efficient communication than e-mail technologies.

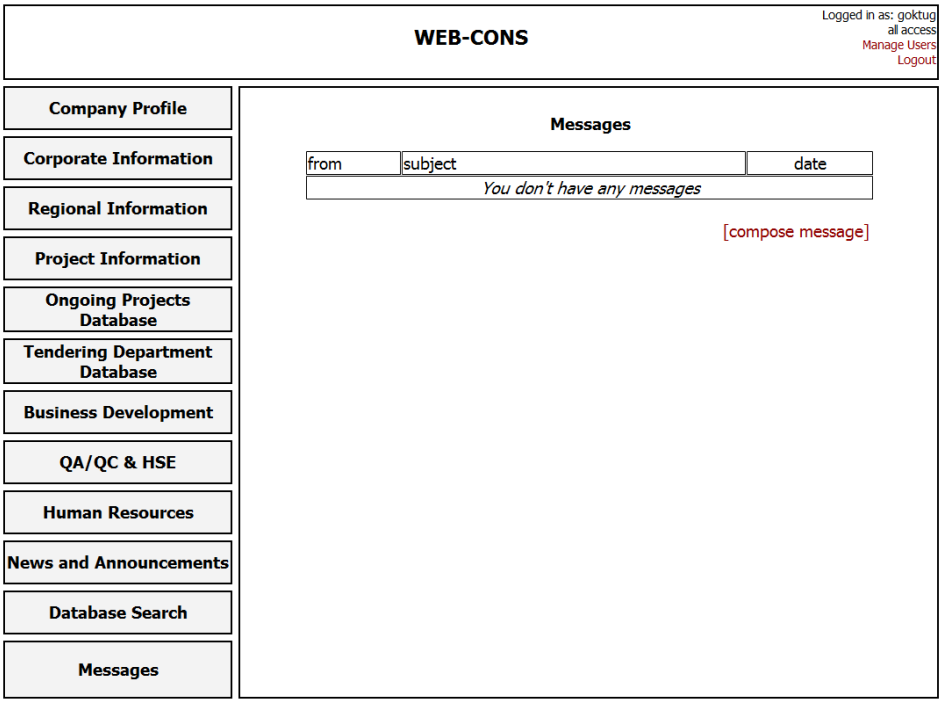

Figure 4.21. Messaging Page

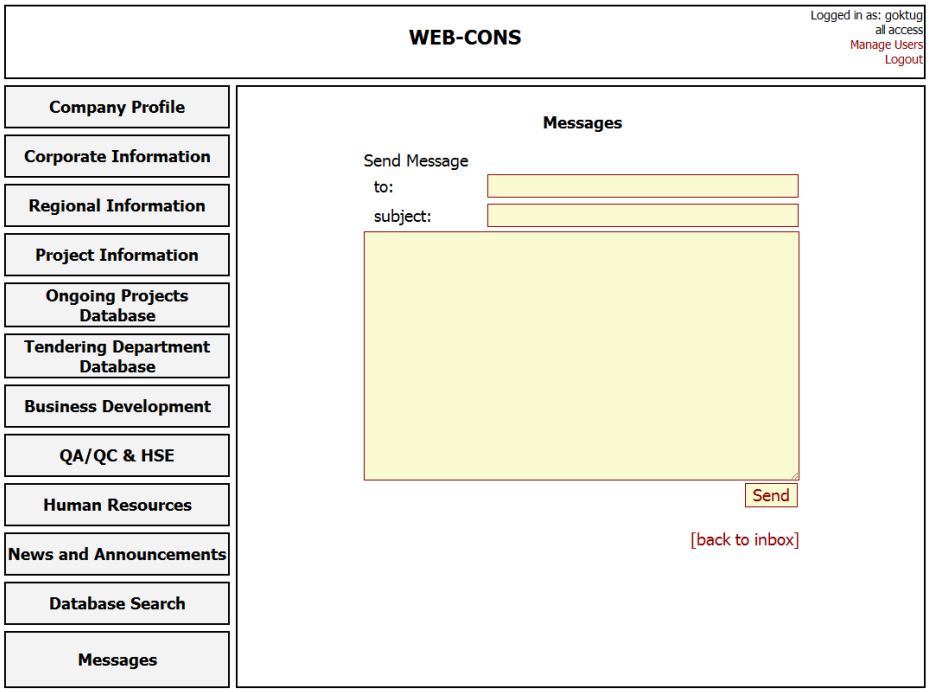

Figure 4.22. Message Composing Page

4.2.1.12. Search Tool Page. Search tool provides the accessed personnel to find the useful information that they are looking for. Search tool provides the opportunity to search users, documents, projects and tenders within the database. The limitation of the search tool which should be improved is; only the words in the names of the documents, projects or tenders can be searched, but the key words within these documents cannot be searched using this tool.

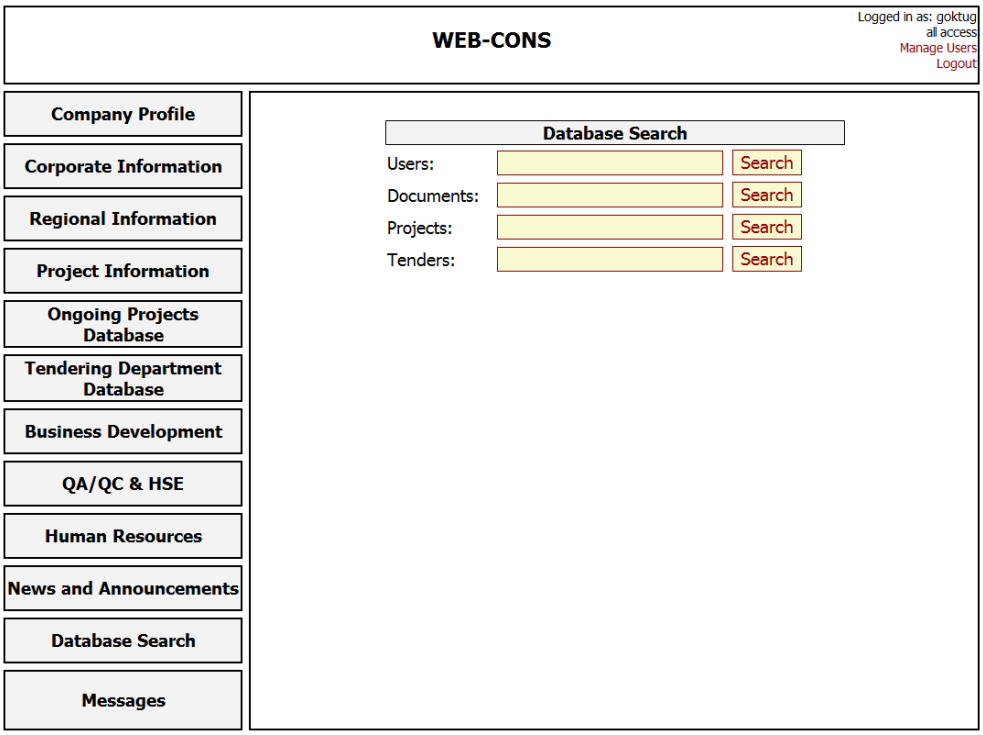

Figure 4.23. Search Tool Page

4.3. Implementation of WEB-CONS

Due to the web-based nature of the system, as soon as the installation and integration of the database to the users' computers in the company is over, the users can start to access the program. The system was installed to several computers at one of the largest companies of Turkey for the gathering evaluation and comments from the users to test the performance of the system and receive feedback from the users. In this respect, 9 senior managers and 3 junior engineers in the company are asked to test the system.

Deputy General Manager of the company stated that the system is easy to manage, the interface is practical and he does not get complicated while using the program. One of the Project Managers who is working abroad, managing an international construction project said that the accessibility of the system from every corner where the internet is available is an important advantage from project and knowledge management views. He also asserted that the program is more useful than e-mail technology due to the document size limits and slow uploading and downloading speed of e-mail technology. Both of them commented that the company information should not be uploaded to internet sites such as Rapidshare for the security issues, so an internal program like this would solve the problem of sharing files with bigger sizes.

Tendering Manager of the company also found the program very useful, since there is no trouble accessing and it can be reached from all of the offices that are involved in bid preparation studies. Similar to the other two users, she also asserted that sharing the documents that have relatively larger sizes can turn into disaster but WEB-CONS might be a good solution as an internal knowledge sharing system. Unlike the other two users, she also commented that the storing characteristic of the system would also assist the users by shortening the period of reaching the documents that they seek for, which is an advantage at bid preparation stage.

Business Development Manager, QA/QC Coordinator, HSE Manager, Human Resources Manager and Logistics Manager of the related company also had a common opinion about the usefulness of the system due to its features of storing the original and revised documents of the similar type at the same page and web-based characteristic that ensures the access of the site team as well.

In addition to senior-level managers, 3 junior engineers of the company also examined the system and they asserted that the system would provide better document sharing among the members of the project and improve the OM of the organization. They also believe that both project and tendering management pages would provide a good database for future projects with the classification of knowledge and a broad information storage capacity.

As a result, the system is found highly attractive and useful but the members of the organization believe that implementing the system in the organization might take some time due to the traditional approach of the employees and managers. According to the opinion of the users, it can also be figured out that the web-based nature of the system is a considerable benefit when compared to other styles of communication and data sharing mechanisms by both minimizing the time spent for data transfer and reducing the communication costs.

4.4. Benefits of WEB-CONS

In the light of above discussions, it can be concluded that WEB-CONS has some benefits and shortcomings in terms of improving the project activities. The proposed system is beneficial for the construction companies that seek a platform for knowledge management; sharing and storage of information from different departments of the company. With its features, it may aid the construction companies by turning them into learning organizations and creating or developing their OMs.

The development of the proposed system has focused on achieving an acceptable level of generality, flexibility, simplicity and integrity. It is aimed to create a system with an easy applicability for the construction companies while managing their project knowledge. As new documents can be uploaded to the database, the system can be regarded as sufficiently flexible and extensible. The system is also simple to use due to its user friendly interface, and departmental divisions that are clearly separated from each other in purpose of preventing any misunderstandings.

There are similar studies carried by several researchers in the last decade. The system proposed by Lam and Chang (2002) introduced the WEBPim System which has a similar characteristic to WEB-CONS by having a web-based approach and a database. Files can be uploaded to and downloaded from the system, but the system lacks classified sections for file management, there are no specific divisions for the users to upload their documents such as departmental classifications. The WEBPim system also has messaging tool and news manager which are also similar to WEB-CONS, and additional to these two features, the system also has the meeting room tool that can be used as an instant

messaging platform for the accessed project participants. Another system developed by Chan and Leung (2004) can be referred to as a prototype web-based construction management system, which allows users to access from different parties to be involved in the data sharing process. Quotations from possible suppliers can be gathered and comments about technical properties and prices can be discussed using the system, but the system cannot be used any other purpose than the technical aspects as a complete project management system.

During the development of the system, it is found out that not only the project management teams need this type of a database; but also other departments of the company also need a web-based database to share and store their information. Especially, it can be understood that the tendering teams need this type of a system to overcome their communication problems with the regional offices of the company during tender preparations.

4.5. Shortcomings of the System

Despite its appealing characteristics, the system lacks some important properties such as not allowing instant messaging throughout the members of the organization. This tool would provide a faster communication between the project participants which may shorten the interference period when the project needs more consultants. Using the telephone or IP phone might help to overcome this problem but in today's condition, there is a greater chance to have trouble with telephone than Internet. The lack of instant messaging function in the system is mainly due to the resource constraint in terms of software development.

The system is good at storing and reusing the past experiences but due to the fact that the past histories are stored as documents, there would still be chance of making mistakes while solving a problem or giving an important decision; the human factor would still be effective at these activities. Moreover, the project success would still be depending on minimizing human errors throughout the period of construction; both for the project team at site and the management team in the headquarters. Also there are some other factors that influence the performance of a project such as the company strategies, intuition

of the decision makers and personal considerations of the company owners. These parameters added to the knowledge gained from WEB-CONS can provide a better project management approach.

Even though the system has understandable user-friendly interface, due to the documentation system of the model, there might be a need for training carried by the experienced members of the company for the new users. There are a lot of headings at the sections and for a user not to confuse where to put the relevant document should be informed before he/she starts to access the system.

Another point that should be mentioned is that the creation of the past project history folders would be a challenge for the companies that are going to use WEB-CONS. The company might have thousands of documents and this might take a long time to create the database. However, once the database is completed, the users will continuously upload the recent documents about current projects and tenders, so there will not be any problems with the past histories anymore.

5. CONCLUSION

Many researchers have studied the concept of OL that can be regarded as an important element of sustainable competitive advantage. Companies need to learn and apply new ideas and methods in order to respond to changing business environment. To gain a competitive superiority, companies should look for ways to exploit the opportunities and avoid the threats of the environment. Despite the fact that OL concepts are more applicable for manufacturing industry, construction companies also have a great potential to learn and make use of the knowledge gained through the learning process. At the final output of learning, what is tried to be obtained is the OM. All activities are carried out to reach an organizational asset because organizations behave within their cultures that are composed of common values, norms and beliefs. Learning organizations and OL are extensively investigated and several views are proposed in the literature. Although how learning takes place in the organizations is clear, how organizations benefit from the output of learning process is vague.

One of the main objectives of this thesis was to find out how construction companies create their OM and how they utilize this corporate asset. In this context, a questionnaire survey is conducted with large Turkish construction companies and as a result of the research findings, a Web-Base Database system is proposed to aid construction companies in their project management activities.

In the context of this study, OL and learning organization concepts are presented and some essential points of OL are explained; levels and types of learning are mentioned. As a different perspective, concept of OM is introduced. Then, dimensions that constitute the learning organization are discussed; learning, organization, people, knowledge and technology components are analyzed in detail. Web-based database systems and IT tools are proposed as means of exploiting OM, which increase OL competence of the companies. Besides, OL in construction industry is also highlighted. How construction companies learn is explained, then enablers and barriers of OL are discussed and finally the strategic role of OL for construction companies is emphasized.

In order to reflect the perceptions and applications of the companies on OM, a knowledge management framework is developed. In this framework, construction companies are assumed to acquire knowledge from their own experiences, other companies' experiences and external resources. Knowledge gained through these main sources is interpreted within the organization and institutionalized in order to achieve the most important intangible asset of a company, namely the OM. OM is then utilized in strategic decision-making processes. New ideas and insights obtained from the decisions made are then revised and these provide feedback to the OL cycle. Revision of knowledge provides a continuous and dynamic aspect of OL. This framework has shaped the content of the survey study. The major premise of this framework is that OM is a useful asset for construction companies and by the help of OM, companies make more accurate decisions.

The survey revealed some facts of the Turkish construction industry in terms of their knowledge management activities. Findings of the survey are based on the experiences and perceptions of Turkish contractors. Since the sample is obtained from the members of TCA, the research reports the facts on medium-to-large contractors' point of view. Research findings based on the data collected from 64 respondents are presented as tables which are then discussed according to the headings of the survey. Most striking points are identified and some common conclusions are drawn as follows:

- Construction companies learn from several sources; it is observed that they are very good at acquiring and storing knowledge but they cannot effectively share the knowledge among their employees. Companies also have some problems with creating project memory. Although project information is shared among other members of the organization, strategic information is only accessible by the managerial level personnel due to some confidential concerns.
- Despite the fact that learning from other companies' experiences does not constitute a high proportion in terms of knowledge acquisition, company representatives express that their companies regard external resources as serious learning sources. Almost all the companies highly utilize the recommended external resources in both corporate and individual/group levels.
- It is a fact that almost all respondent companies learn mainly from their own experiences but learning from other sources still constitute an important part of

the OM constructed in the companies. When the knowledge structure of OM is analyzed, it is observed that the proportion of tacit knowledge, which is composed mainly of personal experiences that cannot be transferred to other members in the company, is playing a remarkable role in learning as well as the explicit knowledge, which can be codified in the databases in an organization.

- One of the most significant points is that the role of OM in decision-making is limited for the construction companies. Managers make strategic decisions generally based on their intuition, expertise and experience. Scientific data is not always required to make decisions at their project management activities, on taking a new job, entering a new market or making new investments. So, even the low frequencies of web-based database usage is not a surprising result since those systems benefit from the OM of an organization.
- When the knowledge management activities are reviewed, it is seen that companies are most successful at acquiring and revising knowledge. However, the respondents believe that knowledge sharing and utilization in decision-making are important two activities, which should be carried out in the construction companies.
- One of the main barriers of OL is the high employee turnover rate that prevents companies from keeping knowledge within the organization. The other important factor is the company structure of the company that determines the effectiveness of the learning environment.
- As a result of this study, major finding is the lack of web-based database systems to aid the companies in both project and corporate management activities. Respondents believe that Web-Based Systems would be beneficial for their companies since these tools provide the storage of useful data to be used for their future projects. Construction companies especially need a systematic knowledge sharing and storage tool for healthier project management decisions as the respondents highlight. In this respect, a Web-Based Database System is developed to meet the requirements of the industry.

The system namely WEB-CONS, developed for this purpose provides outputs to help both site and headquarters teams in their project management processes. This system

is proposed to increase the OL competence of companies since it requires the acquisition of several data, interpretation of data and transferring data into information, storing in a database and utilization of knowledge at decision-making stage. The system is generated as a software utilizing web-based applications and a database at the same time. Within the thesis, web-based database systems are discussed in detail; basic definitions are given, knowledge sharing and storage mechanisms are explained, and applications in the construction industry are mentioned. Then the system is presented as an aid to construction companies and benefits and shortcomings of the system are discussed. The following are some points to be emphasized about the system:

- WEB-CONS is a web-based database system, which helps the organizations to make better project management decisions by utilizing the codified knowledge from their past experiences. With its features, it allows effective sharing and storage of project and corporate knowledge which brings out a suitable approach to help solving construction problems that are generally solved through past experience, expertise and intuition expert people.
- The system architecture constitutes various functional web pages to present various project and corporate level information such as; company profile, corporate information, regional information, project information, ongoing projects database, tendering department database, business development, QA/QC and HSE, human resources. Also, there is a communication aspect within the system such as news and announcements, and messages.
- According to the people that tested the system, it is referred to as a good choice to aid project management problems with its user-friendly interface and documentation system. Also tendering team asserted that the system is beneficial for their tendering management activities with its features that facilitate document sharing. As a result, the system is found highly attractive and useful for its web-based nature, but the users believe that it will take some time to implement this system and create the database from the past projects of companies.
- The performance of the system may be enhanced as the company gets new jobs and continuously store the information gained from each project or tender at the

database. As the database enlarges, the experience that can be gathered from the database increases and project teams can make more accurate decisions. Also, this would help the companies to overcome the view of making decisions by only experience but also knowledge that they have separately collected to create a memory in the organization.

- Communication between the members of the organization both at project level and corporate level can be increased by the use of news and announcements, and messaging tools. Although the system lacks serial messaging activities, the database can be more effective than e-mail technologies about sharing corporate and project information within the organization. Also searching tool is another important specialty of the system which allows the users to find any document within the database whenever needed.
- There are several systems similar to WEB-CONS in some ways but WEB-CONS seems to have a wider document classification range than the ones that are mentioned in the thesis. However, WEB-CONS has an important missing property of instant messaging within the accessible members of the organization.

From the above discussions, it can be concluded that construction companies are successful at the creation of OM but unfortunately they have to improve making use of the knowledge. Storage of knowledge and strategic information leads to the provision of OM but more importantly modeling and solving some project and corporate management decisions in the organizations. Companies should be aware of the fact that OL creates competitive advantage for them in their markets and they should provide their employees with effective environment that would support the learning process.

It is also observed that companies are familiar with web-based systems but they do not utilize these systems which would make them use their OL potential. In order to meet the requirements of the industry in terms of effective learning and creation of OM, a system is developed to assist construction companies in making decisions on project and corporate management. This tool is proposed to increase the OL competence of construction companies through the provision of all knowledge management activities that should be carried out in construction companies. Obviously, this cannot be the only way to increase the OM of a construction company; each organization can increase its learning

potential through the utilization of recommended knowledge sources in the OL framework and application of several IT tools in parallel with its objectives and corporate strategies.

As a future work, a more professional product can be designed for the use of construction companies. An instant messaging tool might be added to improve the online communication between the members of the organization. Also video-conferencing can be added to the system, which would aid the visual communication among the project personnel at different locations. The system can also be combined with a decision-making program or software which would assist not only the knowledge management activities but the strategic decision-making process of the company.

APPENDIX A



BOĞAZİÇİ UNIVERSITY

DEPARTMENT OF CIVIL ENGINEERING

KNOWLEDGE MANAGEMENT QUESTIONNAIRE

Aim of the research:

The major objective of this study is to explore how Turkish construction companies create their organizational memories and how they exploit this memory in strategic decision-making process. In this respect, how the companies acquire, store and share the data obtained from construction projects will be examined.

1. General information about the respondent and the company

2. Data collection and storage

Collecting and storing the data has a positive effect on increasing organizational learning and creation of an organizational memory within a construction company. Please mark the boxes that you find the most appropriate way to store the data gained through the pre-project, ongoing project and post-project stages, along with the importance of obtaining such data in your opinion and how often it is practiced in your company.

3. Learning from external resources

For construction companies, learning through individual and corporate attempts is important for the creation of organizational memory as well as learning from the projects that they execute. Please state the importance of learning from the listed sources in your opinion and your company's learning frequency from these sources.

4. Data Sharing

Following the acquisition of data from projects and external sources, next stage in knowledge management is sharing within the company. Please mark the level of importance for the listed data sharing mechanisms and their frequency of use in your company.

5. Use of Knowledge

Once data is collected, stored and shared within the company, an organizational memory is obtained. One of the main functions of this corporate knowledge is its use in strategic decision making process. Please mark the importance of using the organizational memory in strategic decision making process in your opinion and how often it is practiced in your company.

GENERAL INFORMATION ABOUT THE RESPONDENT AND THE COMPANY

i. Number of years that the respondent has been in the sector:

ii. Position of the respondent at the company:

iii. Number of years that the company has been in the sector:

iv. Company's domestic turnover realized so far in US Dollars:

v. Company's overseas turnover realized so far in US Dollars:

vi. Considering the projects undertaken within the last 5 years, please state the annual average turnover of your company in US Dollars.

Domestic Projects:

Overseas Projects:

	Learning from Own Experiences of the Company														
		N/A	How do you store the below data?		Importance of acquiring (collecting and storing) the below data in your opinion (Ideal)					Frequency of acquiring (collecting and storing) the below data in your company (Actual)				
			Paper Based	Computer -Based	Very Low	Low	Med.	High	Very High	Very Low	Low	Med.	High	Very High
Pre-project information	Risk Assessment													
	Host country information													
	Unit cost estimation calculations													
	Any assumptions and important decisions at the bidding stage													
Ongoing projects' information	Unit costs (material, labour etc.)													
	Methods applied throughout the stages of construction													
	Organizational structure of the project													
	Planning and programming of the project													
	Masterplan prepared at the beginning of the project													
	Daily / weekly / monthly reports of the project													
	Machinery and equipments used for the stages of the project													
	Job rotations during the execution of the project													
Post-project information	Post-project appraisal prepared at the end of the project (Final report)													
	After project actions													
	Performance of personnel employed at the project													
	Assessment of the Client													
	Evaluation of subcontractors' performance at the project													
	Evaluation of profit/loss situation at the end of the project													
	If Joint Venture, information about the partner(s)													
	Success & Failure factors													

	Learning through Corporate, Individual and Group Attempts											
		Importance of learning from the below sources in your opinion (Ideal)					N/A	Frequency of learning from the below resources in your company (Actual)				
		Very Low	Low	Medium	High	Very High		Very Low	Low	Medium	High	Very High
Corporate Attempts	Internal benchmarking											
	Competitive benchmarking											
	Value-chain analysis											
	Environmental scanning											
Individual/Group Attempts	Internal seminars, presentations											
	Job rotations of the personnel											
	Seminars											
	Congresses, exhibitions, trade shows											
	Technical and academic publications (books, journals, reports etc.)											

	Data Sharing											
		Importance of below data sharing mechanism in your opinion (Ideal)					N/A	Frequency of below data sharing mechanism in your company (Actual)				
		Very Low	Low	Medium	High	Very High		Very Low	Low	Medium	High	Very High
Data Sharing Mechanisms	E-mail											
	Meetings											
	Formal chats											
	Informal chats											
	Internal seminars, presentations											
	Teamwork of the personnel											
	Brainstorming sessions											
	Intranet											
	Extranet											
	Web-based communication systems											

	Use of Knowledge											
		Importance of using OM* to make below decisions in your opinion (Ideal)					N/A	Frequency of using OM* to make below decisions in your company (Actual)				
		Very Low	Low	Medium	High	Very High		Very Low	Low	Medium	High	Very High
Strategic Decisions	International market entry											
	Market entry unrelated to construction											
	Selection of Joint Venture partners											
	Bid/no bid											
	Bid preparations (determination of risk premium and bid price)											
	Making new investments (to increase organizational effectiveness)											
	Developing differentiation strategy (marketing strategy, quality management)											
	Restructuring the company (corporate changes to increase productivity)											

*Organizational Memory (OM) is obtaned through the interpretation, integration and institutionalization of knowledge within the organization with the acquisition, sharing, transfer, dissemination and storage mechanisms. Since the companies refer to their memories in strategic decision-making process, organizational learning concept has been accepted as a critical source for sustainable competitive advantage.

REFERENCES

Ahmad, A. and Plaza, E., 1994, "Case-Based Reasoning: Foundation Issues, Methodological Variations and System Approaches", *Al Communications*, 7(1), pp 39-59.

Angryis, C., 1977, "Double Loop Learning in Organizations", *Harvard Business Review*, 55(5), pp 115-125.

Angryis, C. and Schon, D., 1978, *Organizational Learning: A Theory of Action Perspective*, Addison-Wesley Publishers, Reading UK.

Barlow, J., 2000, "Innovation and Learning in Complex Offshore Construction Projects", *Research Policy*, 29, pp 973-989.

Bassioni, H.A., Price, A.D.F. and Hassan, T.M., 2004, *Performance Measurements in Construction, Journal of Management in Engineering*, 20(2), pp 42-50.

Berthon, P., Pitt, L.F. and Ewing, M.T., 2001, "Corollaries of the Collective: The Influence of Organizational Culture and Memory Development on Perceived Decision-Making Context", *Journal of Academy of Marketing Science*, 29(2), pp 135-150.

Bhatt, G.D. and Zaveri, J., 2002, "The enabling role of decision support systems in organizational learning", *Decision Support Systems*, 32, pp 297-309.

Bitici, U.S., Carrie, A.S. and McDevitt, L., 1997, "Integrated Performance Measurement Systems", *International Journal of Operational Product Management*, 17(5), pp 522-534.

Bresnen, M., Edelman, L., Newell, S., Scarbrough, H. and Swan J., 2003, "Social Practices and The Management of Knowledge in Project Environments", *International Journal of Project Management*, 21, pp 157-166.

Brignall, T.J., Fitzgerald, L., Johnston, R. and Silvestro, R., 1991, "Performance Measruement in Service Busineesses", *Management Accounting*, 69(10), pp 34-36.

Chan, S.L. and Leung, N.N., 2004, "Prototype Web-Based Construction Project Management System", *Journal of Construction Engineering and Management*, 130(6), pp 935-943.

Chassiakos, A.P. and Sakellaropoulos, S.P., 2008, "A Web-Based System for Managing Construction Information", *Advances in Engineering Software*, 39(11), pp 865-876.

Conklin, J., 2001, "*Designing Organizational Memory: Preserving Intellectual Assets in a Knowledge Economy*", http://cognexus.org/dom.pdf, 2010.

Cox, R.F., Issa, R.R.A. and Ahrens, D., 2003, "Management's Perception of Key Performance Indicators for Construction", *Journal of Construction Engineering and Management*, 129(2), pp 142-151.

Cross, K.F. and Lynch, R.L., 1988, "The SMART Way to Define and Sustain Success", *National Productivity Review*, 8(1), pp 23-33.

Cross, R. and Baird, L., 2000, "Technology is Not Enough: Improving Performance by Building Organizational Memory", *Sloan Management Review*, Spring, pp 69-78.

Crossan, M.M. and Bontis, N., 1998, "The Strategic Management of Organizational Learning", *paper presented at the organizational conference at George Washington University*, Washington DC.

Dodgson, M., 1993, "Organizational Learning: A Review of Some Literatures", *Organization Studies*, 14(3), pp 375-394.

Egbu, C.O. and Botterill, K., 2002, "Information Technologies for Knowledge Management: Their Usage and Effectiveness", *ITcon*, 7, pp 125-137.

Espejo, R., Schuhmann W., Schwaninger, M., Bilello, U., 1996, *Organizational Transformation and Learning: A Cybernetic Approach to Management*, John Wiley and Sons Ltd., West Sussex, England.

Garvin, D., 1993, "Building A Learning Organization", *Harvard Business Review*, July-August, pp 78-91.

Hansen, M.T., Nohria, N. and Tierney, T., 1999, "What's Your Strategy for Managing Knowledge", *Harvard Business Review*, 77(4), pp 106-116.

Hill, F.M., 1996, "Organizational Learning for Total Quality Management Through Quality Circles", *Total Quality Management Magazine*, 8(6), pp 53-67.

Hong, J., 1999, "Structuring for Organizational Learning", *The Learning Organization*, 6(4), pp 173-185.

Huber, G.P., 1991, "Organizational Learning: The Contributing Processes and The Literatures", *Organization Science*, 2(1), pp 88-115.

Jeffries, M.C., Chen, S.E. and Zenke, R., 2003, "Using Learning Histories To Evaluate Organizational Learning Culture", *Proceedings of the Joint International Symposium of CIB Working Commissions*, Singapore, 22-24 October, Vol.1, pp 150-162.

Ji, Y.G. and Salvendry, G., 2001, "A Framework for Improving Organizational Learning Through a User-Adaptive Intranet Portal Organizational Memory Information System", *International Journal of Aviation Psychology*, 11(2), pp 123-148.

Kagioglu, M., Cooper, R. and Aouad, G., 2001, "Performance Management in Construction: A Conceptual Framework", *Construction Management and Economics*, 19(1), pp 85-95.

Kaplan, R.S. and Norton, D.P., 1992, "The Balanced Scorecard – Measures that Drive Performance", *Harvard Business Review*, 70(1), pp 71-79.

Kaplan, R.S. and Norton, D.P., 1996, "Using the Balanced Scorecard as a Strategic Management System", *Harvard Business Review*, 74(1), pp 75-85.

Kaplan, R.S. and Norton, D.P., 2000, *The Strategy-Focused Organization. How Balance Scorecard Companies Thrive in the New Business Environment?*, Harvard Business School Press, Boston, MA, US.

Kim, D.H., 1993, "The Link Between Individual and Organizational Learning", *Sloan Management Review*, Fall, pp 37-50.

Kululanga, G.K., Edum-Fotwe, F.T. and McCaffer, R., 2001, "Measuring Construction Contractors' Organizational Learning", *Building Research and Information*, 29(1), pp 21-29.

Kululanga, G.K., McCaffer, R., Price, A.D.F., Edum-Fotwe, F., 1999, "Learning Mechanisms Employed by Construction Contractors", *Journal of Construction Engineering and Management*, 124(4), pp 215-223.

Lam, H.F. and Chang, T.Y.P., 2002, "Web-Based Information Management System for Construction Projects", *Computer-Aided Civil and Infrastructure Engineering*, 17, pp 280-293.

Lehner, F. and Maier, R.K., 2000, "How Can Organizational Memory Theories Contribute To Organizational Memory Systems?", *Information Systems Frontiers*, 2(3/4), pp 277-298.

Leibowitz, J., 1999, *Building Organizational Intelligence: A Knowledge Management Primer*, CRC Press LLC, USA.

Love, P.E.D., Li, H., Irani, Z. and Faniran, O., 2000, "Total Quality Management and The Learning Organization: A Dialogue for Change in Construction", *Construction Management and Economics*, 18, pp 321-331.

Love, P.E.D. and Holt, G.D., 2000, "Construction Business Performance Measurement: The Stakeholder Perspective Measurement Alternative", *Process Management Journal*, 6(5), pp 408-416.

Malone, D., 2002, "Knowledge Management: A Model for Organizational Learning", *International Journal of Accounting Information Systems*, 3, pp 111-123.

Marquardt, M.J., 1996, *Building the Learning Organization: A Systems Approach to Quantum Improvement and Global Success*, McGraw Hill, USA.

McNair, C.J., Lynch, R.L. and Cross, K.F., 1990, "Do Financial and Nonfinancial Performance Measures Have to Agree?", *Management Accounting*, November, pp 28-55.

Neely, A., 1999, "The Performance Revolution: Why Now and What Next?", *International Journal of Operations and Production Management*, 19(2), pp 205-228.

Neely, A. and Adams, C., 2001, "The Performance Prism Perspective", *Journal of Cost Management*, 15(1), pp 7-15.

Olve, N., Roy, J. and Wetter, M., 1999, *Performance Drivers: A Practical Guide to Using the Balanced Scorecard*, Wiley, Chichester.

Orange, G., Burke, A. and Boam, J., 2000, "The Facilitation of Cross Organizational Learning and Knowledge Management to Foster Partnering Within the UK Construction Industry", *Proc., 8th European Conference on Information Systems*, Austria, http://is.lse.ac.uk/b-hive

Özorhon, B., 2004, *Organizational Memory in Construction Companies: A Case-Based Reasoning Model as an Organizational Learning Tool*, M.Sc. Thesis, The Middle East Technical University.

Robey, D., Boudreau, M.C. and Rose, G.M., 2000, "Information Technology and Organizational Learning: A Review and Assessment of Research", *Accounting, Management and Information Technologies*, 10, pp 125-155.

Schindler, M. and Eppler, M.J., 2003, "Harvesting Project Knowledge: A Review of Project Learning Methods and Success Factors", *International Journal of Project Management*, 21, pp 219-228.

Schalkwyk, J.C., 1998, "Total Quality Management and The Performance Measurement Barrier", *The TQM-Magazine*, 10(2), pp 124-131.

Senge, P., 1990a, *The Fifth Discipline: The Art and Practice of the Learning Organization*, Doubleday, New York.

Senge, P.M., 1990b, "The Leader's New Work: Building Learning Organizations", *Sloan Management Review*, 32(1), pp 7-23.

Smallwood, J. and Venter, D., "The Performance of Contractors: Client's Perceptions", *CIB World Building Congress: Performance in Product and Practice*, Wellington New Zealand, 2-6 April 2001.

Smook, R.A.F. and Ligny, E.L.C., 2001, "Measuring Construction Productivity, Technological Performance, Capabilities and Competitiveness", *CIB World Building Congress: Performance in Product and Practice*, Wellington New Zealand, 2-6 April 2001.

Stein, E.W. and Zwass V., 1995, "Actualizing Organizational Memory with Information Systems", *Information Systems Research*, 6(2), pp 85-117.

Ward, S.C., Curtis, B. and Chapman, C.B., 1991, "Objectives and Performance in Construction Projects", *Construction Management and Economics*, 9(4), pp 343-353.

Watson, P. and Seng, L.T., 2001, "Implementing the European Foundation for Quality Management Model in Construction", *Construction Information Quarterly*, Construction paper 130, Chartered Institute of Building, Ascot, U.K.