İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

THE COMPARISON OF CONSTRUCTION MANAGEMENT PRACTICES IN THE UNITED STATES AND IN TURKEY

M.Sc. Thesis by
Harun Övünç ORAL

Department : Civil Engineering

Programme : Construction Management

Thesis Supervisor: Dr. Murat KURUOĞLU

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M.Sc. Thesis by
Harun Övünç ORAL
(501031157)

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Supervisor (Chairman) : **Dr. Murat KURUOĞLU (ITU)**
Members of the Examining Committee : **Assoc. Prof. Dr. G. Emre GÜRCANLI (ITU)**
Assist. Prof. Dr. Ümit IŞIKDAĞ (Beykent U.)

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<u>İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ</u>

AMERİKA BİRLEŞİK DEVLETLERİ VE TÜRKİYE'DEKİ YAPI İŞLETMESİ UYGULAMALARININ KARŞILAŞTIRILMASI

YÜKSEK LİSANS TEZİ

Harun Övünç ORAL
(501031157)

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Tez Danışmanı : Öğr. Gör. Dr. Murat KURUOĞLU (İTÜ)
Diğer Jüri Üyeleri : Doç. Dr. G. Emre GÜRCANLI (İTÜ)
Yrd. Doç. Dr. Ümit IŞIKDAĞ
(Beykent Ü.)

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FOREWORD

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Harun Övünç ORAL

Civil Engineer

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ABBREVIATIONS

AACE : The Association for the Advancement of Cost Engineering
ABET : Accreditation Board for Engineering and Technology
ACI : American Concrete Institute
ADM : Arrow Diagram Method
AEC : Architecture, Engineering, and Construction
AGC : Associated General Contractors
AHP : Analytic Hierarchy Processes
AIA : American Institute of Architects
AIPM : The Australian Institute of Project Management
AISI : American Iron and Steel Institute
AOA : Activity-on-Arrow Diagram Method
APP : Appendix
APRAM : Advanced Programmatic Risk Analysis and Management Model
ARIS : Architecture of Integrated Information Systems
ASCE : American Society of Civil Engineers
ASME : American Society of Mechanical Engineers
ASTM : American Society for Testing and Materials
BIM : Building Information Modeling
BOT : Build-Operate-Transfer
CAD : Computer-Aided Design
CAE : Computer-Aided Engineering
CCM : Certified Construction Manager
CCRT : Center for Construction Research and Training
CEM : Construction Engineering and Management
CERF : Civil Engineering Research Foundation
CERP : Construction Enterprise Resource Planning
CII : Construction Industry Institute
CM : Construction Management
CMAA : The Construction Management Association of America
CMP : Construction Management Practice
CPM : Critical Path Method
DB : Design-Build
DBB : Design-Bid-Build
DOB : Department of Buildings
DOT : Department of Transportation
DRB : Dispute Review Board
DRBF : Dispute Review Board Foundation
EHSMS : Environmental Health and Safety Management Specialist
EMS : Environmental Management System
EPC : Engineering, Procurement, Construction
ERP : Enterprise Resource Planning
FAR : Federal Acquisition Regulation
FBO : Federal Building Opportunities

FHWA : Federal Highway Administration
FIDIC : Fédération Internationale des Ingénieurs Conseils (International Federation of Engineering Councils)
FTCNY : Future Tech Consultants of New York
GC : General Contractor
GDP : Gross Domestic Product
GMP : Guaranteed Maximum Price
GPO : Government Printing Office
GPS : Global Positioning Sensors
ICC : International Code Council
ICT : Information and Communication Technology
IPMA : International Project Management Association
IPD : Integrated Project Delivery
IRC : International Residential Code
ISO : International Organization for Standardization
IT : Information Technology
ITAA : Information Technology Association of America
IS : Information Systems
İK : İş Kanunu (Labor Law)
KİK : Kamu İhale Kurumu (Public Procurement Authority)
KİSK : Kamu İhale Sözleşmeleri Kanunu (Public Procurement Contract Code)
LADAR : Laser Detection and Ranging
LAN : Local Area Network
METU : Middle East Technical University
MIS : Management Information Systems
MPIC : Management Practices in Construction
NAHB : National Association of Home Builders
NARA : National Archives and Records Administration
NASP : National Association of Safety Professionals
NCEES : National Council of Examiners for Engineering and Surveying
NORA : National Occupational Research Agenda
NSF : National Science Foundation
NSPE : National Society of Professional Engineers
NYC : New York City
OBM : Office of Management and Budget
OCIP : Owner Controlled Insurance Program
OFPP : Office of Federal Procurement Policy
OFR : Office of Federal Register
OGCM : Owner's Guide to Construction Management
OHSAS : Occupational Health and Safety Management System
OOH : Occupational Outlook Handbook
OSHA : Occupational Safety and Health Administration
OSHRC : Occupational Safety and Health Review Commission
P2M : A Guidebook for Project and Program Management for Enterprise Innovation
PDM : Precedence Diagram Method
PDRI : Project Definition Rating Index
PE : Professional Engineer
PERT : Program Evaluation and Review Technique

PM	: Project Management
PMP	: Project Management Professional
PMI	: Project Management Institute
PMCC	: Project Management Professionals Certification Centre
PPE	: Personal Protective Equipment
QA	: Quality Assurance
QC	: Quality Control
QMC	: Quality Management Committee
QMP	: Quality Management Plan
QMTF	: Quality Management Task Force
QPMTF	: Quality Performance Measurement Task Force
RADAR	: Radio Detection and Ranging
R&D	: Research and Developments
RFID	: Radio Frequency Identification
RIC	: Responsible in Charge
RP	: Recommended Practice
SCA	: School Construction Authority
TCCIT	: Technical Council on Computing and Information Technology
TMB	: Türkiye Müteahhitler Birliği (Turkish Contractors Association)
TMMMB	: Türk Müşavir Mühendisler ve Mimarlar Birliği (Association of Turkish Consulting Engineers and Architects)
TMSK	: Türkiye Muhasebe Standartları Kurulu (Turkish Accounting Standards Board)
TQM	: Total Quality Management
TQMTF	: Total Quality Management Task Force
TRB	: Transportation Research Board
TSE	: Türk Standardlar Enstitüsü (Turkish Standards Institute)
US	: The United States of America
UWB	: Ultra Wideband
WAN	: Wide Area Network
WBS	: Work Breakdown Structure
WTEC	: World Technology Evaluation Center
YİATS	: Yapım İşlerine Ait Tip Sözleşme (Standard Contract for Construction Works)
YİGS	: Yapım İşleri Genel Şartnamesi (General Specifications for Construction Works)
YÖK	: Yüksek Öğretim Kurumu (Council of Higher Education)

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THE COMPARISON OF CONSTRUCTION MANAGEMENT PRACTICES IN THE UNITED STATES AND IN TURKEY

SUMMARY

The history of modern construction project management dates back to 1950s in the United States. However, the importance of this concept is still being understood day by day with the establishment of postgraduate studies on the subject in some of civil engineering schools in Turkey. Therefore, it seems important to thoroughly evaluate the practices of construction project management in all aspects in the United States, where a special emphasis has been given to the subject, and in Turkey in an attempt to identify the status of construction project management in our country in comparison with that in the US. With regard to methodology, in this Master of Science thesis, construction project management in the US and in Turkey have been evaluated in the light of recent literature. Construction management practices based on the CMAA standards as applied in the US, which are adopted by Turkey as well, are thoroughly compared in all knowledge areas including project management planning, cost management, time management, quality management, contract administration, and safety management. Additionally, other topics that would have an impact on construction management practices such as general engineering issues, training in construction management at both undergraduate and graduate levels, certificate programs, accreditation of training, and professional/trade organizations are also dealt with in order to reveal differences and similarities between the US and Turkey. Based on the thorough evaluation of construction management practices in the US and in Turkey, it can be concluded that construction management practices and standards are better understood and well documented in the US. The US practices that step forward include advocacy on construction management by professional/trade organizations in order to promote this discipline which result in higher awareness and acceptability, credentials offered, the use of IT/ICT, IIS including CAD, BIM and IPD, innovative contracting practices, alternative dispute resolution techniques, a variety of project delivery methods including IPD, concepts such as “resilience engineering”, “concurrent engineering” “value engineering” and “cost engineering” come forward as signs of best practices as well as more comprehensive training on CM and accreditation of training programs.

Whereas in Turkey, there seems to be inadequate understanding of construction management by the majority of the parties in the construction industry even by some of the construction engineers themselves, which result in improper construction management practices regarding planning, cost, time, quality and safety management. However, although the concept of construction management is rather new, the achievements of Turkish researches on the use of methodologies on cost, time and safety management as well as IT/ICT use as evidenced by the literature deserve attention. Moreover, practices of construction management are gaining growing interest based on the efforts of a group of construction engineers in universities who successfully advocate this important area of practice in the

construction process. Additionally, the interest and the enthusiasm of young civil engineers on construction management and the efforts of academic persons in the universities for improving the profession show promise for rapid achievement of better practices on the subject in Turkey.

AMERİKA BİRLEŞİK DEVLETLERİ VE TÜRKİYE'DEKİ YAPI İŞLETMESİ UYGULAMALARININ KARŞILAŞTIRILMASI

ÖZET

Amerika Birleşik Devletleri'nde modern yapı işletmesinin tarihi 1950lere uzanmaktadır. Ancak bu kavramın önemi Türkiye'de inşaat mühendisliği bölümlerinin bir kısmında konu hakkında mezuniyet sonrası eğitim programlarının oluşturulmasıyla birlikte hala günden güne anlaşılmaya devam etmektedir. Bu nedenle, ülkemizde yapı işletmesinin yerini bu konuya özel bir önem veren Amerika Birleşik Devletleri'ndeki yeri ile kıyaslamalı olarak belirleyebilmek amacıyla Amerika Birleşik Devletleri'nde yapı işletmesi uygulamalarını tüm yönleriyle derinlemesine değerlendirmek önemli görünmektedir. Metodoloji olarak, bu yüksek lisans tezinde Amerika Birleşik Devletleri'ndeki ve ülkemizde yapı işletmesi uygulamaları en son literatürler ışığı altında incelendi. Ülkemizde de benimsenmiş olan Amerika Yapı İşletmesi Derneği (CMAA) uygulama standardlarındaki tüm bilgi alanlarındaki- proje işletmesi planlaması, maliyet yönetimi, zaman yönetimi, kalite yönetimi, kontrat yönetimi, ve güvenlik yönetimi- uygulamalar karşılaştırıldı. Bunlara ilave olarak, yapı işletmesi uygulamalarına katkıda bulunabilecek genel mühendislik kavramları, hem lisans ve hem de yüksek lisans düzeyinde yapı işletmesi eğitimi, sertifika programları, eğitim akreditasyonu ve konuyla ilgili profesyonel organizasyonlar karşılaştırma için incelendi.

Bu incelemelere dayanarak, sonuç olarak Amerika Birleşik Devletleri'nde yapı işletmesi uygulamalarının ve standardlarının daha iyi anlaşılmış olduğu ve çok iyi dökümante edilmiş olduğu söylenebilir. Öne çıkan Amerika Birleşik Devletleri yapı işletmesi uygulamaları arasında profesyonel organizasyonlarının bu konunun yoğun savunuculuğunu yapması ve dolayısıyla yapı işletmesinin farkındalığının ve kabul görme düzeyinin artması, bu konuda profesyonelleşmeyi sağlayan sertifikasyonlar, enformasyon teknolojileri kullanımı, bilgisayar destekli tasarımı da içine alan bütünleşik bilgi teknolojileri, "Building Information Modeling", yaratıcı kontrat yönetimi uygulamaları, anlaşmazlıkların çözümü için alternatif çözüm teknikleri, "rezilyans mühendisliği", "eşzamanlı mühendislik" "değer mühendisliği" ve "maliyet mühendisliği" gibi kavramlar ve geniş kapsamlı yapı işletmesi eğitimi ve bu programların akreditasyonu sayılabilir. Türkiye'de ise yapı işletmesinin inşaat mühendislerinin bir kısmı da dahil olmak üzere yapı endüstrisindeki tarafların çoğu tarafından yeterince anlaşılamamış olduğu görülmektedir. Bu durum da planlama, maliyet, zaman, kalite ve güvenlik yönetimi açısından uygun olmayan uygulamalara yol açmaktadır. Ancak, yapı işletmesi kavramı ülkemizde çok daha yeni olmasına rağmen, araştırmacıların maliyet, zaman, güvenlik yönetimi gibi konulardaki çeşitli metodolojilerin kullanımını içeren yayınları özellikle dikkate değerdir. Buna ilave olarak, yapı sektöründeki bu önemli uygulama alanının başarıyla savunuculuğunu yapan üniversitelerdeki inşaat mühendisi gruplarının çabalarıyla ülkemizde de yapı işletmesi uygulamaları gittikçe artan bir ilgi kazanmaktadır. Ayrıca genç inşaat

mühendislerinin konuya ilgisi bu alanda çok yakında çok daha iyi uygulamaların olabileceğine işaret etmektedir.

1. INTRODUCTION

Construction Management (CM) is the study of construction in terms of its managerial and technological aspects.

The Construction Management Association of America (CMAA) (CMAA, 2010) defines CM as “a professional management practice consisting of an array of services applied to construction projects and programs through the planning, design, construction, and post-construction phases for the purpose of achieving project objectives including the management of quality, cost, time, and scope”. In a broad description from the point of view of civil engineers, construction management is the act of overall planning, co-ordination, organizing, overseeing and control of the tasks involved in a construction project from inception to completion focused on client’s requirements in order to produce a functional, efficient and financially viable project that will be completed on time within budgeted costs and to the required quality standards (URL-1, 2010). Coordination is the major aspect in construction management. It focuses on arranging the timing and working relationships between owners, subcontractors, designers, suppliers, expediters and whoever involved in execution of a construction project. A construction manager’s responsibilities include organizing bids for specific parts of a project, signing off on subcontractor work, quality control, and monitoring time and costs. Construction project management requires knowledge of modern management as well as an understanding of the design and construction process.

The history of modern construction project management dates back to 1950s in the United States. At that time, as milestones in this specific area, the “Program Evaluation and Review Technique” (PERT), a method to analyze the involved tasks in completing a given Project, was developed by Bill Pocock of Booz-Allen & Hamilton and Gordon Perhson and the “Critical Path Method” (CPM) was developed in a joint venture by both DuPont Corporation and Remington Rand Corporation for managing plant maintenance projects, which, thereafter, spread into many private enterprises for managing projects (Barrie and Paulson, 1992). At the same time, technology for project cost estimating, cost management, and engineering economics was evolving, with pioneering work by Hans Lang and others.

In 1969, the Project Management Institute (PMI) was formed to serve the interests of the project management industry (PMI, 2010). In 1981, the PMI Board of Directors authorized the development of “A Guide to the Project Management Body of Knowledge (PMBOK® Guide”), containing the standards and guidelines of practice that are widely used throughout the profession (PMBOK® Guide, 2008) (PMI, 2010).

In 1982, the Construction Management Association of America (CMAA) has attempted to take a leadership role in regard to critical issues impacting the construction and program management industry, including the setting of standards of practice for construction management (CMAA, 2010b).

Therefore, CMAA and PMI are well known for their long-standing commitments to career development and professionalism in the construction industry in the US and throughout the world as well.

Both organizations offer practice standards for construction management based on knowledge areas for successfully managing projects.

As mentioned previously, Project Management Institute (PMI) publishes and updates “A Guide to the Project Management Body of Knowledge (PMBOK® Guide)”. Now, PMBOK® Guide - Fourth Edition is available as released on December 31, 2008.

The Guide recognizes 42 processes that fall into five basic process groups and nine knowledge areas that are typical of almost all projects. The five process groups are: 1) Initiating, 2) planning, 3) executing, 4) controlling and monitoring, and 5) closing. The nine knowledge areas are : 1) Project integration management, 2) project scope management, 3) project time management, 4) project cost management, 5) project quality management, 6) project human resource management, 7) project communications management, 8) project risk management, and 9) project procurement management. Each of the nine knowledge areas contains the processes that need to be accomplished within its discipline in order to achieve an effective project management program. Each of these processes also falls into one of the five basic process groups, creating a matrix structure such that every process can be related to one knowledge area and one process group (PMI, 2010).

CMAA also publishes books with the title "Construction Management Standards of Practice", serving as a guide for owners and service providers alike which define the range of services that constitute professional construction management. Now, 2010 edition is available (CMAA, 2010b). In this resource, six construction management knowledge areas -1)Project management, 2) cost management, 3) time management, 4) quality management, 5) contract administration, and 6) safety management- are incorporated to five phases - 1) Pre-design phase, 2) design phase, 3) procurement phase, 4) construction phase, and 5) post-construction phase- of the construction process. In addition to six knowledge areas, CMAA also includes a section on "Construction Management Professional Practice", which includes specific activities like defining the responsibilities and management structure of the project management team, organizing and leading by implementing project controls, defining roles and responsibilities and developing communication protocols.

Although PMI practice standards (PMBOK® Guide) and CMAA CMP standards cover similarly structured bodies of knowledge, they have some differences. The differences between the practice standards of these two institutions are summarized in Table 1.1 (URL-2, 2010).

Table 1.1: Comparison of the Features of PMI Practice Standards (PMBOK® Guide) and CMAA Construction Management Standards of Practice (CMP)

Features	PMI (PMBOK® Guide)	CMAA CMP
Perspective	Looks from the point of view of the "project manager"	Looks from the point of view of the "owner"
Nature	Generic; applicable to a vast array of industries and management applications	More specific to construction industry
Coverage	More fundamental level of knowledge	More specific knowledge
Knowledge areas	Nine	Six
Emphasis, differences	Integration management; human resources management; communications management	Risk management; sustainability and BIM (not previously available, but added sections in the 2010 edition)
Categories	Processes	Phases
Marketing	Education in targeted organizations; word of mouth, grass roots	Promote with owner organizations; publications, ads in trade magazines

Based on the "Report from the CMAA & PMI Collaboration Discussions" (November 2008, Santa Fe, NM, USA) (URL-2, 2010)

Both organizations also offer similar credentialing programs. The Project Management Professional (PMP) and Certified Construction Manager (CCM) credentials of the PMI and the CMAA, respectively, address nearly identical competencies based on similar bodies of knowledge. However, there are also some differences between the two credentials which are shown in Table 1.2 (URL-2, 2010).

Table 1.2: Comparison of PMP and CCM Credentials

		PMP	**CCM**
Purpose		Demonstrate minimum level of knowledge and experience to practice project management; Enhance the credibility of the PM Professional; Reflect and implement the PM Body of Knowledge (BOK)	Similar knowledge and experience, but construction management focused; Reflect and implement CMAA practice standards
Lexicon		Engages terms defined in the PM Body of Knowledge Guide	Engages terms specific to construction management
Perspective		The “project management professional”	The “owners’ representative”
Emphasis		Knowledge acquisition, some application; generic project delivery	Field experience and knowledge application; construction process delivery
Education		College degree H.S. degree, more experience 35 hrs in PM courses	4 yr Degree: A, E, C. 2 yr Degree: A, E, C. No degree, more experience
Experience		4,500 hrs directing projects H.S. plus 5 yrs experience	4 yr degree: 2 yrs experience 2 yr degree: 4 yrs experience, with 2 yrs design/construct No degree: 8 yrs experience, with 2 yrs design/construct
Exam		4 hrs, 200 questions; 9 knowledge areas; 5 process areas	5 hrs; 200 + multiple choice questions
Recertification		Every 3 yrs; • 60 hrs CEUs	Every 3 yrs; 45 points for P.D activities and professional practice
Which to choose	**Employer motive**	Large facility owners	Construction management firms
	Industry transfers	People entering the field from fields that are not project management-oriented	Experienced professionals who transfer into construction management from other fields that require project management ability
	Career Starting Point	Recent graduates from degree programs in A/E that do not emphasize management	Experienced professionals

Based on the “Report from the CMAA & PMI Collaboration Discussions” (November 2008, Santa Fe, NM, USA) (URL-2, 2010)

In the US, there are many applicants for either of these credentials or for both. As to the choice of these credentials, the following situational factors may affect the choice in addition to those shown in Table 1.2: It can be the applicant’s own will to acquire either of these credentials or their employer/customer may specify which credential the applicant should choose. As another affecting factor, the party paying for the credential may make the choice. It should also be noted that construction management firms are more apt to mandate the CCM because they believe it has greater marketing impact when submitting proposals and the tested competencies address their specific requirements. On the other hand, large facility owners employ a diversified workforce, including many non-construction professionals who do not need the specific knowledge of a CM, but who do need to understand the project management environment of the construction industry, making the PMP the more appropriate credential (URL-2, 2010).

Having defined two widely known construction/project management standards in the US, the question, "Which one is mostly used in the US?", may arise. Although a specific answer may not be given due to commonalities of the two and the complementing nature of one-another, the factors mentioned previously as to the choice of credentials, PMP and CCM, may explain that either PMI or CMAA or both practice standards may be used based on the situational factors in the US.

With the features described, construction management practices have become a vital aspect of the construction process over the years to meet the needs of the construction industry in the 21st century, the scope and size of which has drastically expanded. In the United States, construction is a multibillion dollar annual enterprise (Russell et al. 2007) as well as in most of the countries including Turkey.

However, the idea of incorporating construction management practices in civil and architectural engineering in Turkey is rather new. It is known that multidisciplinary courses that would improve competency of civil engineers as managers and entrepreneurs are not sufficiently implemented in the curricula in civil engineering schools in Turkey up to 1990s (Müngen, 1999). To cope with the changing practices in the world and to meet the needs in our country, the extraordinary efforts of Prof. Dr. Doğan Sorguç led to the "Construction Management Master of Science Program" in the frame of Department of Civil Engineering in Istanbul Technical University in 1990 (Sorguç, 1996, Sorguç, 1997). In 2003, CMAA practice standards are translated to Turkish to serve as the practice standards in construction management in Turkey as well (Turkish CMP Standards, 2003).

However, the actual construction management practices differ between countries as influenced by various factors including socioeconomic status and cultural values.

Comparing construction management practices in different countries in an attempt to identify similarities and disparities may be helpful to reorganize practices especially in developing countries toward worldwide common applications.

Therefore, attempts to thoroughly evaluate the practices of construction project management in all aspects in the United States, where a special emphasis has been given to the subject, and in Turkey may be helpful to identify the status of construction project management practices in our country in comparison with that in the US. Analyzing data and determining opportunities for improvement may lead to better practices.

With regard to the choice of construction management standards and practices to serve as the basis for this thesis to compare practices, CMAA construction management practice standards are preferred, the reason for which is the adoption of these standards in Turkey as well.

1.1 Aim of the Thesis

The aim of this thesis is to compare construction management practices in the United States and in Turkey, to highlight and give information about some construction management procedures which are mostly practiced in the US and to give ideas to compare and improve the practice in Turkish construction society.

The author of this thesis has been working in the construction sector in the US for 5 years. He worked for a while in KiSKA Group LTD that specializes in Luxury Condominium projects in New York City, USA, world's most demanding market and most competitive arena. Depending on the clients' needs, KiSKA Group provides clients with construction management services by handling the bidding and awarding of contracts, scheduling the construction, providing aggressive procurement, cost and quality control. KiSKA Group services include construction consultation, general contracting, value engineering, constructability review, cost estimating & scheduling, and joint-venture development (URL - 3, 2010).

Now, he is working for Future Tech Consultants (FTC) of New York, Inc. (URL- 4, 2010). FTC is a comprehensive engineering, inspection and testing organization that currently services the five boroughs of New York City (Bronx, Brooklyn, Manhattan, Queens, and Staten Island), Long Island, Southern Westchester, Western Connecticut and eastern parts of New Jersey.

1.2 Methodology

Since the methodology for evaluating construction management practices in the US and Turkey and that of comparisons differ to some extent, the methods used for relevant sections will be described separately in the following subsections.

1.2.1 Methodology for evaluating the practices of construction management in the US

Firstly, the practices of construction management in the US are mentioned step by step based on the seven major categories (six knowledge areas plus CM professional practice) proposed by the CMAA.

With regard to methodology, construction management practices and standards in the US have been evaluated in the light of recent literature and some case studies.

For reviewing relevant literature on various aspects of construction project management, the websites of scientific journals on construction/ civil engineering have been gone through. The websites of relevant professional/trade organizations and official websites responsible for disseminating latest information on "how-to-do"/"must-do" in construction issues have also been checked to collect information on current practices, recommendations, laws and regulations on construction management.

Several reference books on the subject have also been consulted.

1.2.2 Methodology for evaluating the practices of construction management in Turkey

Construction management practice standards in Turkey have been evaluated only in the light of available articles. Available literature on the subject and available theses on the subject which were the only resources the author of this thesis is able to have access because of living outside of Turkey. A large number of articles on the subject published in national journals or bulletins enabled the author of this thesis to gain information on construction management practices and standards.

Turkish Chamber of Civil Engineers' (TCCE, 2010) website, which aims disseminate the developments in the domain of the civil engineering profession, is gone through carefully to obtain information.

Therefore, when comparing the US and Turkey practices and applications, data given for Turkey are based on the scientific work of the experts in this area.

As another intention in this work to mention in the methodology section, safety management practices are prioritized because of the importance of the issue as well as the abundance of literature (scientific work) in this area.

1.2.3 Methodology for the comparisons of the practices of construction management in the US and in Turkey

While the general information regarding construction management practices in the US and in Turkey are given separately in the relevant sections, practices will be compared to give insight to similarities and disparities between the US and Turkey.

With regard to the methodology of comparisons of construction management practices in two countries, comparisons are made based on the published literature on the subject, official publications by authorities [i.e. Code of Federal Regulations (CFR) (CFR, 2010), Occupational Safety and Health Administration (OSHA) (OSHA, 2010) documents and nationally/universally accepted guidelines and recommendations of professional/trade organizations.

The reason for giving special importance to the literature in this thesis is the fact that published literature is the basis of a scientific work and published literature is a reflection of real, not assumed, practice. Some case studies included intend to highlight common practices relevant to construction management in a "how-to-do" manner.

In Table 1.3, a summary of the objectives, rationale and findings in general in each section of this thesis work is presented.

Table 1.3: The Objectives and the Context of the Thesis

Section 2. CONSTRUCTION MANAGEMENT PRACTICE STANDARDS		
Objectives	**Rationale**	**Findings**
To define CM, to describe CM standards and practices in 7 domains of CM	CM is very important to promote excellence in managing the development and construction of projects and programs	CM basic principles, practices and standards are defined and described
To describe "how-to-do" in 6 domains of practice in CM based on phases of construction process	In addition to "know-how", "do-how" is important for practitioners	Specific CM practice standards are given in detail in a "how-to-do" manner to be of use to practitioners
Section 3. COMPARISONS AND DISCUSSION		
Objectives	**Rationale**	**Findings**
To identify similarities and disparities or discrepancies in CM practices in the US and Turkey	Highlighting best practices and addressing defective or lacking or inadequate practices may contribute to improvement in CM	Many aspects of CM practices compared in the US and Turkey mostly based on the literature revealed some differences
Section 4. CONCLUSIONS AND RECOMMENDATIONS		
Objectives	**Rationale**	**Findings**
To present extracted differences in CM practices in the US and Turkey and to provide appropriate recommendations	Presentation of key points identified may help better understanding of the work	Key points may contribute to better practices in construction management issues

2. CONSTRUCTION MANAGEMENT PRACTICE STANDARDS

As mentioned previously, the standards put forward by the Construction Management Association of America (CMAA) will form the basis of the practices in construction management as the one with most recognition.CMAA indicates that the most common responsibilities of a Construction Manager fall into the following seven categories (CMAA, 2010b):

1) Project Management Planning
2) Cost Management
3) Time Management
4) Quality Management
5) Contract Administration
6) Safety Management
7) Construction Management Professional Practice, which includes specific activities like defining the responsibilities and management structure of the project management team, organizing and leading by implementing project controls, defining roles and responsibilities and developing communication protocols, and identifying elements of project design and construction likely to give rise to disputes and claims (CMAA, 2010b).

2.1 Construction Management Knowledge Areas

2.1.1 Project management planning

Construction projects are expected to be performed and delivered under certain constraints such as scope, time, cost, and quality. The time constraint refers to the amount of time available to complete a project. The cost constraint refers to the budgeted amount available for the project. The scope constraint refers to what must be done to produce the project's end result. These three constraints are often competing constraints: increased scope typically means increased time and increased cost; a tight time constraint could mean increased costs and reduced scope; and a tight budget could mean increased time and reduced scope. A further refinement of the constraints separates product "quality" or "performance" from scope, and turns quality into a fourth constraint (Chatfield and Johnson, 2007). As illustrated in Figure 2.1 (URL-5, 2010), the idea in the “project management triangle”, is that one side of the triangle cannot be changed without affecting the others. The discipline of Project Management is about providing the tools and techniques that enable the project team (not just the project manager) to organize their work to meet these constraints. However, this traditional view has switched somewhat recently. It should be noted that a project has many more constraints to be observed other than the scope, the time, and the cost (PMBOK® Guide).

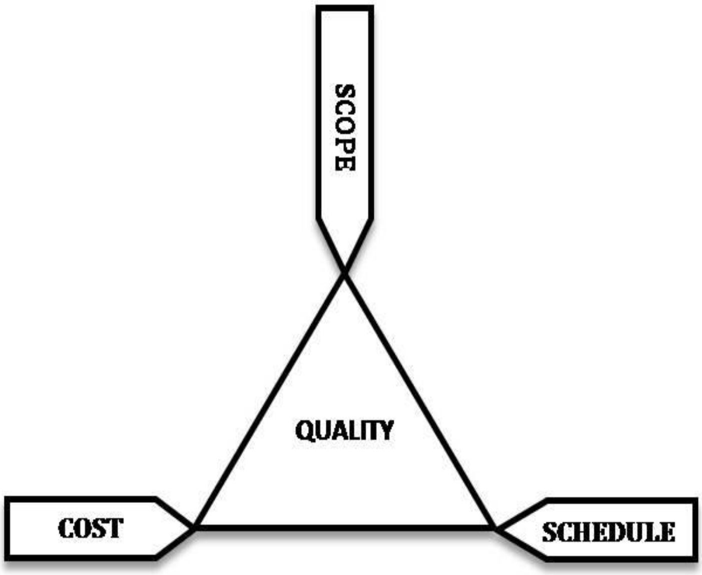

Figure 2.1: The project management triangle (Adopted from the figure available at URL- 5, 2010)

Project management is defined as “the use of integrated systems and procedures by the project team to accomplish design and construction as qualified to a construction project” (CMAA, 2010b). Project management (PM) is an integral part of construction management.

Project management tools and their coverage and objectives are clearly identified in the US and include the following (CMAA, 2010b):

PM Tool n.1. “Construction Management Plan” articulates the project vision, defines / documents project requirements, establishes scope, budget, schedule and quality management approach, identifies team members and their roles /

responsibilities, identifies organizational structure, addresses significant site and environmental issues, establishes communications protocol, identifies contracting strategy, and defines basis for evaluating team's performance.

PM Tool n.2. "Project Procedures Manual" consists of cost control procedures, schedule control procedures, communications procedures, management information systems (MIS) procedures, QA program procedures, team organization, contractor coordination procedures, safety program procedures, meeting protocol, documentation procedures, and procedures for all contract administration documents.

PM Tool n.3. "Quality Management Plan" consists of project organization, quality goals and objectives (services and construction), general methodology for QA, QA responsibility, decision flow charts, quality control plan, and quality assurance plan.

PM Tool n.4. "Procurement Plan" identifies alternative contracting strategies, evaluates strategies and identifies, pros/cons with respect to owner's requirements and constraints, recommends a strategy or strategies with supporting rationale, and establishes actions necessary prior to procurement.

PM Tool n.5. "Contracts or Agreements" deals with standard forms of agreements, modified standard forms, owner-prescribed forms, and reviewing of contracts (by legal counsel, insurance provider).

PM Tool n.6. "Laws" consist of Statutes, both Federal and State and case laws

PM Tool n.7. "Standards of Care" deals with terms of the CM agreement, current statutes and case law and evaluation of what other CMs would do in similar circumstances at the location and time the services were provided.

In relation to project planning, bidding and contracting practices in the US also deserve special attention. The processes include the following steps or issues (CMAA, 2010b): 1) Solicitation and prequalification, 2) Evaluation of guidelines, 3) Notices/advertisements, 4) Bidders/interest campaign, 5) Delivery of bid documents, 6) Information to bidders, 7) Issuance of addenda, 8) Bid opening and evaluation, 9) Monitoring compliance with and execution of contracts, 10) Provisions for permits, insurance and labor affidavits, and 11) Arranging owner-purchased equipment.

Specific Construction Management Practice (CMP) standards defined by CMAA (methods, techniques, processes, acquirements, and requirements) in Project Management Planning Phase are given in Appendix1.

As a complementary discipline to project management, a concept called “concurrent engineering (CE)” is attracting attention in the AEC industry.

The Concurrent Engineering Research Center (CERC) defines “concurrent enginnering (CE)” as a methodology for developing new products efficiently by designing a product while simultaneously considering the aspects of manufacturing, maintenance, and operation ("Red Book" 1989). CE is also known as "simultaneous engineering" or "parallel engineering".

For an engineering and construction project, Concurrent Engineering (CE) can be viewed as a systematic means in which all stakeholders participate in the planning, engineering, design, and execution phases of the project., a means by which input from key participants- the design disciplines, suppliers, constructors, operations personnel, maintenance personnel, and other endusers- is obtained early in the conceptual phase, then clearly interpreted and specified in the detailed design phase. Throughout the design phase reviews are concurrently done by all participants and hence approvals and consensus are achieved at the earliest possible time. It is an additional project management tool with which a project can achieve minimum overall delivery time and ensure the elimination of late design changes that are often costly and detrimental to the project schedule (Eldin, 1997).

Concurrent Engineering strives to do the right job right the first time and is based on two fundamental observations: 1) Changes become more and more costly, the later they are done in a project, and 2) doing in parallel the different steps of a project make the project done more quickly then doing the steps sequentially. The consequences are that new requirements of production, maintenance, operations, etc. must be addressed during the earlier stages of design and the dependencies among them must be analyzed in order to execute the activities in paralel (Zangwill, 1992).

2.1.2 Cost management

Cost management includes the establishment of systems for the management, control, and monitoring of project costs during all phases of the project to maintain project costs within the predefined limits.

The capital cost for a construction project includes the expenses related to the establishment of the facility as follows (Hendrickson, 1998): 1) Land acquisition, including assembly, holding, and improvement, 2) Planning and feasibility studies, 3) Architectural and engineering design, 4) Construction, including materials, equipment and labor, 5) Field supervision of construction, 6) Construction financing, 7) Insurance and taxes during construction, 8) Owner's general office overhead, 9) Equipment and furnishings not included in construction, and 10) Inspection and testing.

It is crucial to determine the budget of a construction project before the execution of the project since influencing the construction costs of a project at the beginning stage of a project period has a lot more influence than those made at later stages (Figure 2.2).

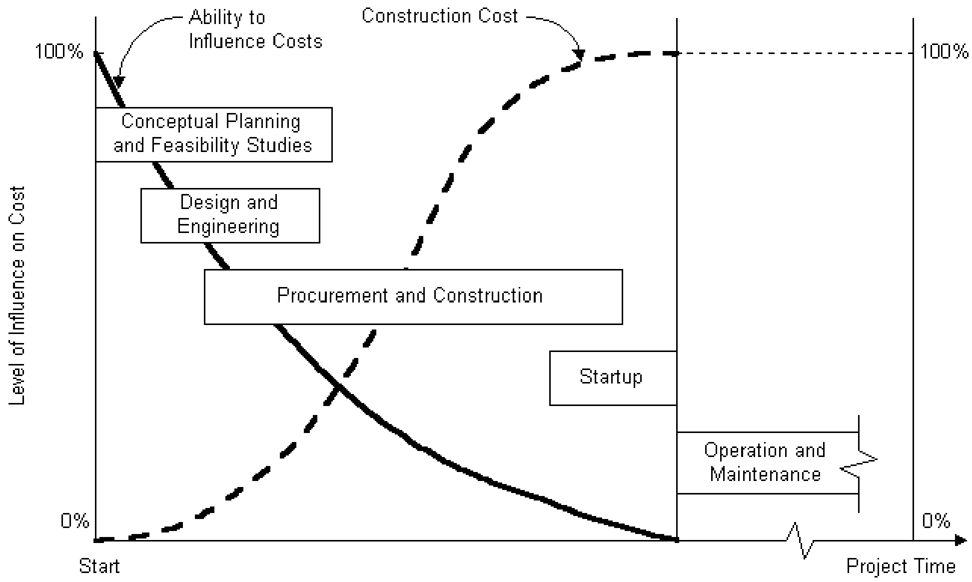

Figure 2.2: Ability to influence construction cost over time (Adopted from URL- 6, 2010)

A concurrent engineering approach, described in section 2.1.1, has been shown to reduce the costs of a project (Eldin, 1997).

The objectives of the cost management system is to ensure project completion within the budget with careful consideration of cost of project resources as well as effects of project decisions on project cost and life cycle cost with the fact in mind that there is a cost to construct / cost to maintain (CMAA, 2010b).

Therefore, the cost management system includes the development and implementation of several processes (CMAA, 2010b):

- Resource planning (The nature and the quantity of resources)
- Cost Estimating (Approximate cost of the resources needed)
- Cost Budgeting (Allocation of the estimated costs to project components)
- Cost Control (Controlling the changes that impact an accepted budget)

The Cost Management Plan is based on a reliable cost estimate. The important factors for a reliable cost estimate include selection of estimating techniques, identifying factors for conceptual estimating, parameters for cost estimating, concepts of range estimating, and quantity survey based cost estimates and procurement strategies (CMAA, 2010b).

CMAA describes seven steps for effective cost estimating (CMAA, 2010b):

- Knowledge (experience, education)
- Study (documents, the site, the schedule)
- Visualize (how to build, site operations)
- Organize (by operation / division)
- Analyze (measure the price)
- Check (for accuracy; perform a comparison)
- Finalize the package (best information, mark-ups)

There are numerous available techniques for cost estimating. These include 1) In-house estimating data files, 2) Outside estimating software data files, 3) Outside estimating services, 4) Standardized cost indices, 5) End-product "unit method", 6) "Scale of Operations" method, 7) "Ratio" or "Factor" methods, 8) "Physical Dimensions" method, and 9) "Quantity Take off" method (CMAA, 2010b).

Factors for conceptual estimating vary based on project type, project size or capacity, project location and project schedule (CMAA, 2010b).

When performing a conceptual estimate, parameters such as design phase costs, construction phase costs, plans and specifications, construction and procurement strategies, site information, engineering, quantity take-offs, labor, materials, equipment, general conditions, home office overhead, schedule, inspection and permits, bid alternates and allowances, and mark-ups should be taken into account (CMAA, 2010b)

Another important concept in cost management is “range estimating”, which is a combination of analysis, simulation, and speculation to determine the probability of cost overruns, and maximum possible deviation from the target estimate.

Regarding quantity-based survey estimating, construction manager does complete take-off of all components of the project.

Especially after 2008 economical crisis in the US, construction managers started to pay excessive attention for the cost management operations in construction projects.

2.1.3 Time management

The objectives of time management include managing project time, resources and cost with good scheduling and accurate forecasts with the integration of multiple parties (owner, contractor, user, and community) and evaluation of options such as changes, delays, and acceleration. Schedule issues are one of the main reasons for conflict on projects. Therefore, time management is very important in resolving disputes (CMAA, 2010).

There are many techniques for scheduling a project such as CPM, PERT, or Gantt Chart. Depending on the complexity of the project, the schedule requirements vary greatly.

The Critical Path Method (CPM) is commonly used with all forms of projects, including construction for the purposes of time management as well. CPM is a project planning technique that defines all the necessary activities and their individual durations, sets the relationships connecting the activities, and calculates the total time required to complete the project based on those definitions (Halpin and Woodhead, 1998). The CPM formally identifies tasks which must be completed on time for the whole project to be completed on time, identifies which tasks can be delayed for a while if resource needs to be reallocated to catch up on missed tasks. It also helps the identification of the minimum length of time needed to complete a project. The CPM determines both the early start and the late start date for each activity in the schedule (Prensa, 2002).

A PERT chart is also a project management tool used to schedule, organize, and coordinate tasks within a project. PERT stands for "Program Evaluation Review Technique", a methodology developed by the US Navy in the 1950s to manage the Polaris submarine missile program. PERT acknowledges that there will be a time variance (due to uncertainty) in the completion of each activity, therefore the PERT network uses a probabilistic approach to estimating for each activity. By doing this, the completion time variance is accounted for. To estimate for an activity, the following formula is used: Expected time = (Optimistic + 4 x Most likely + Pessimistic) / 6, where "optimistic" probability is the lowest probability (approximately 1%) that the activity will be completed within the optimistic time, "most likely" probability is the highest probability of completing the activity in this time, and "pessimistic" probability is the longest possible time that an activity might require to get completed (Sharma, R., 2010; URL- 7, 2010; URL- 8, 2010).

A comparison of CPM and PERT scheduling techniques is given in Table 2.1.

Table 2.1: Comparison of CPM and PERT

Features	CPM	PERT
History	1950s	1950s
Development	Private sector (DuPont & Remington Rand Corporation)	Public sector (US Navy)
Intial purpose	To manage plant maintenance projects	To manage the Polaris submarine missile program
Purpose in AEC	To control both the time and the cost of the project	To control time (cannot be used for the time/cost tradeoff analysis)
Estimation principles	A deterministic approach to estimation is used. There is no range or probability that comes into play	A probabilistic approach to estimating for each activity is used. PERT acknowledges that there will be a time variance (due to uncertainty) in the completion of each activity
When to use	Best used in projects where the activity time estimate can be predicted fairly accurately	For projects that have a higher degree of uncertainty

As a principle for scheduling techniques-CPM and PERT, at the beginning of a project, scope is defined and the means and methods for completing the project are determined. After that the durations for the tasks necessary to execute the project are listed and grouped to create a work breakdown structure. The dependencies between tasks are defined using an activity diagram that enables identification of the critical path. Float or slack time in the schedule can be calculated using project management software (Fleming, 2005).

Essentially, there are six steps which are common to both the techniques (URL- 7, 2010):

1. Create an activity list: These are the list of activities within the project that need to completed so that the project can be closed.
2. Create a Precedence Diagram: This is a project network diagram that illustrates the activity flow in the project. The dependencies between each activity are clearly identified.
3. Assign time and/or cost estimates for each activity: The estimated time to complete each activity.
4. Identify the critical path: The longest activity execution path within the network diagram.
5. Calculate the float of each activity: The slack of each activity in the project network diagram.
6. Use the network to help plan, schedule, monitor and control the project.

A simplified version of the program evaluation and review technique (PERT) for project planning is developed and tested. The simplification is to reduce the number of estimates required for activity durations from three, as in conventional PERT, to two. The two required duration estimates are the “most likely” and the “pessimistic.” This simplification reduce the level of effort needed to apply PERT (Cottrell, 1999).

As another scheduling technique, a Gantt chart may be used. It is a horizontal bar chart developed as a production control tool in 1917 by Henry L. Gantt, an American engineer and social scientist. Frequently used in project management, a Gantt chart provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project (URL- 7, 2010).

Project Management software such as Microsoft Project and Primavera schedule give critical information about progress and sequence of the tasks. MS Project can create a PERT chart from a Gantt chart.

2.1.4 Quality management

"Quality" is shortly defined by the CMAA as the degree to which the project and its components meet the owner's expectations, objectives, standards, and intended purpose. Quality is determined by measuring conformity of the project to the plans, specifications, and applicable standards. The CMAA definition of "Quality Management" is the process of planning, organizing, implementing, monitoring, and documenting a system of management practices that coordinate and direct relevant project resources and activities to achieve quality in an efficient, reliable, and consistent manner (CMAA, 2010b).

The issue of quality management can be considered as one of the most difficult issue in construction management. The main objective of quality assurance is focused on client satisfaction. Quality management offers even a more structural approach to creating organization-wide participation in planning and implementing a continuous improvement process that exceeds the expectations of the clients (Shutb, 1994).

"Quality Management Guidelines, prepared by the Quality Management Committee (QMC) of the CMAA (QMC, 2010), are intended to assist construction managers in implementing acceptable Quality Management (QM) procedures in their practice. Quality management covers various issues related to the topic of quality such as quality system for design, procurement and construction, quality audits, quality documentation, Quality Assurance/ Quality Control (QA/QC), and Total Quality Management (TQM) aspects, statistical quality control, and the role of contracts, standards and specifications in quality management.

In the QMC Guidelines (QMC, 2010), some above-mentioned aspects are defined as follows:

"Quality Control (QC)" is the continuous review, certification, inspection, and testing of project components, including persons, systems, services, materials, documents, techniques, and workmanship to determine whether or not such components conform to the plans, specifications, applicable standards, and project requirements.

"Quality Assurance (QA)" is the application of planned and systematic reviews which demonstrate that quality control practices are being effectively implemented.

“Total Quality Management (TQM)” is a structured process for continuous improvement whereby long-range quality goals are established at the highest levels of an organization and the means to reach those goals are defined. The TQM process must be consistently applied through all facets of the organization. It includes process documentation, staff empowerment, and training. Benchmark measurements and periodic audits must be performed to steer the continuous improvement efforts. A primary focus is directed to internal and external client satisfaction.

The QMC guidelines stress the importance of “Quality Management Plan (QMP)” in quality management practices. QMP is a project-specific, written plan prepared for certain projects which reflects the general methodology to be implemented by the construction manager during the course of the project to enhance the owner’s control of quality through a process-oriented approach to the various management tasks for the program. The Quality Management Plan complements the construction management practices and forms a basis of understanding as to how the project team will interrelate in a manner that promotes quality in all aspects of the program, from the pre-design phase through completion of construction. Its purpose is to emphasize the quality goals of the project team in all issues associated with the work. This pertains not only to the traditional QA/QC of constructing elements of the work, but also addresses the quality needs of management tasks such as performing constructability reviews during design, checking estimates, making appropriate decisions, updating schedules, guiding the selection of subcontractors and vendors from a quality-oriented basis, to dealing with the public when applicable (QMC, 2010).

Quality management practices in each phase of construction process are given in detail in Appendix 1.

2.1.5 Contract administration

Contract administration is associated with handling of contracts in some aspects such as invitation to bid, bid evaluation, award of contract, contract implementation, measurement of work completed, computation of requisitions and payments. monitoring contract relationship, addressing contract-related problems, incorporating necessary changes or modifications in the contract, ensuring both parties meet each other's expectations, and interacting with the contractor to achieve the contract's objectives (Hinze, 2000).

Contract administration concentrates on the relationship between the client and contractors from the contract award to the contract close out insuring the contractor delivers the services in conformance with the project requirements. The contract administrator must completely understand all aspects throughout the entire period of the project.

A contract administrator’s responsibilities are shown in Table 2.2 as defined officially (URL- 9, 2010).

Table 2.2: A Contract Administrator’s Responsibilities

1)	Having sufficient knowledge of contracting principles as it relates to their responsibilities in administering the contract
2)	Communicating both with the owners/client and contractors on contractual issues
3)	Maintaining records or logs to turn over to the procurement office after the completion of the project
4)	Monitoring contract activities for compliance with the work progress to ensure services are performed according to the quality, quantity, objectives, timeframes and manner specified within the contract
5)	Reviewing progress reports, status reports, and timesheets as required
6)	Approving the final product/services by submitting a written document accepting the deliverables
7)	Providing any documentation to the department's procurement office when contract administrator activities are not assigned to the buyer
8)	Monitoring expenditures, ensuring funding availability when contract extends over multiple years
9)	Verifying accuracy of invoices and approving invoices for payment
10)	Requesting amendments and/or contract renewals in a timely fashion as determined by departmental policies and complexity of the request (often three - six months in advance)
11)	Verifying all work is completed and accepted by the department prior to the contract expiration date
12)	Performing contract close out activities completing Contractor Evaluation Report for consulting services or in accordance with department policies and procedures as well as notifying responsible parties when funds can be disencumbered
13)	Reporting any contract disputes immediately to the department procurement office.
14)	Keeping an accurate auditable paper trail of contract administration

According to CMAA (CMAA, 2010b) Construction Contract Administration aims to to manage critical construction parameters in terms of time, cost, quality and information and to satisfy the owner's goals and objectives for the project.

There are essentially five different types of contracting procedures used in the US construction industry (Hinze, 2000):

1) General contracting method
2) Separate contracts method
3) Force account method
4) Design-construct method
5) Professional construction management method

"General contracting method" consists of a contract drawn up between the owner and a general contractor.

"Separate contracts method" is an arrangement by which the owner lets contracts directly to specialty contractors for the various portions of the work.

"Force account method" is the one in which no contracts are written for a construction project where the owners' own workers or employees are solely responsible for the construction.

In the "Design-Construct method", the owner lets a single contract for both the design and the construction of a project (Hinze, 2000).

"Professional construction management method" is one in which the owner hires a construction firm to perform professional services.

Standard contract documents developed by professional organizations are commonly used in the US. The most common ones are developed by the organizations listed below:

- The American Institute of Architects (AIA) (AIA, 2010)
- The National Society of Professional Engineers (NSPE) (NSPE, 2010)
- The Associated General Contractors (AGC) of America (AGC, 2010)

Types of contracts can be classified either with respect to parties and subject of the contract or with respect to payment procedures.

Classification with respect to parties and subject of the contract are listed as the following: 1) Owner-Contractor Agreements, 2) Owner-Architect/Engineer Agreements, 3) Owner –Project Manager Agreements 4) Architect/Engineer-Other Specialists Agreements, and 5) Contractor-Subcontractor Agreements.

Those with respect to payment procedures are stipulated sum contracts, cost plus contracts and unit price contracts.

Main types of contract delivery methods are (CMAA, 2010b):

- Traditional: Design–Bid–Build
- Multiple Prime
- CM at Risk
- Design-Build

Contract formats include bid, negotiated, fixed price, and reimbursable. Different combinations are also possible.

In order to be valid, all contracts must meet certain criteria such as meeting of the minds, offer and acceptance, consideration, lawful subject matter and competent parties (Hinze, 2000).

At this point, a concept called "Value Engineering (VE)" is very important. The term "Value Engineering (VE)" relates to reviewing the contract documents with the owner's best interest in mind. It is described by the Office of Management and Budget of the White House as "an organized effort directed at analyzing the functions of systems, equipment, facilities, services, and supplies for the purpose of achieving the essential functions at the lowest life cycle cost consistent with the required performance, reliability, quality, and safety" (OMB, 2010).

In other words, VE is a process whereby team efforts are made to understand the functions of a system in order to realize the essential functions of that system at the lowest possible life-cycle cost (Younker, 2003). This concept expanded to design and construction in 1960's in the US for eliminating unnecessary costs which include lack of time, lack of information, lack of key ideas, lack of budget, temporary circumstances, habits and attitudes, honest wrong beliefs, politics, and inadequate definition of value (Doran et al., 2010).

Value engineering studies may provide solutions for eliminating unnecessary costs.

A value engineering study begins with a creativity phase which is critical to the success in which the brainstorming technique is deployed to generate ideas. A value engineering workshop includes intensive and focused team during a 3-5 day dedicated effort. The third phase, post-workshop, consists of follow-up, assessment, report, meetings if needed, and implementation on issues such as cost models, energy / maintenance models, function analysis, issues analysis, brainstorming and group dynamics, economic analysis/life cycle costing/sustainability, examples, value enhanced design/integrated value enginnering, standards, value engineering reporting procedures, summary of results / implementation matrix, executive summaries, proposals, cost estimates, appendix materials, cost models, function analysis, idea listings, and agenda (Doran et al., 2010).

2.1.6 Safety management

Construction is one of the most dangerous industries in which to work. As a result, safety is a priority in construction industry. According to the National Institute for Occupational Safety and Health, about 8% of workers in the United States are in construction, but account for 22% of the fatalities reported for industry sectors (NIOSH, 2010).

Project safety is a common responsibility of all the parties involved in construction process as shown in Figure 2.3.

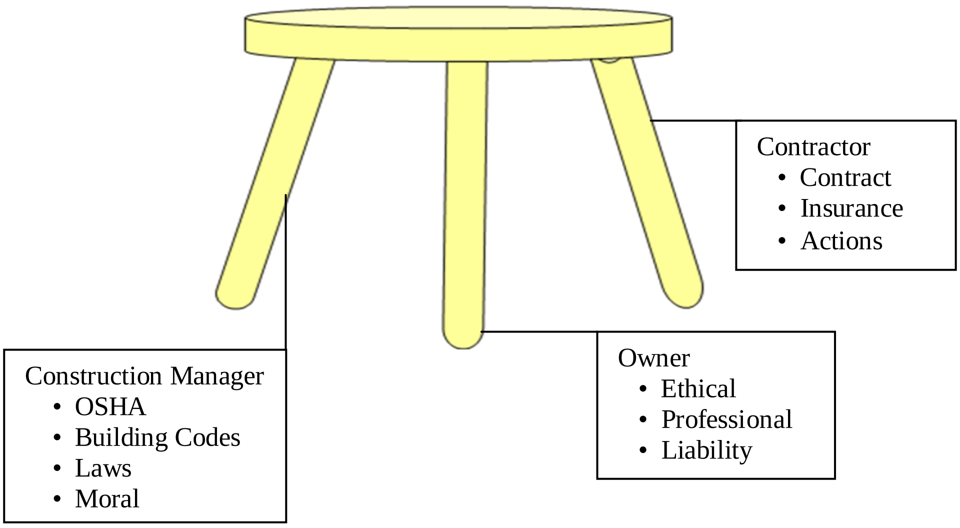

Figure 2.3 Project Safety (Adopted from Doran et al., 2010)

In the US, special attention is paid to “Safety Management” in construction industry. The Occupational Safety and Health Administration (OSHA) of the United States

Department of Labor sets clear regulations and standards associated with safety measures in construction sites and related issues (OHSA, 2010). Everybody is expected to obey these regulations strictly. OSHA is the official agency which regulates the safety operations the US construction industry as well as other sectors.

Basic principles of OSHA Guidelines for construction industry include the following (OSHA, 2010):

- Management commitment and employee involvement
- Labor and management accountability
- Worksite analysis (JSA/JHA)
- Incident / accident investigation
- Hazard prevention and control
- Safety and health training
- Employee involvement
- Periodic plan evaluation

As mentioned above, there are different roles, tasks, and responsibilities for each party in the construction process and specific issues related to the safety of the project itself as outlined below (CMAA, 2010b):

"Construction Manager Safety Program" includes concepts such as management commitment, accountability, employee buy-in, hazard communication and establishment of a safety committee to help develop the plan.

"Contractor Safety Program" include the following issues: Management accountability, emergency contacts for the project, orientation and training, hazard communication and awareness, accident / incident reporting, JSA / JHA, hazard correction, Protective Personal Equipments (PPE), first aid and medical attention, housekeeping and fire protection, fall protection and other site-specific requirements.

"Project Safety" depends on Owner / Construction Manager / Contractor Relationship. Two important issues are 1) Owner Controlled Insurance Program (OCIP) with the following features: a) Owner, insurance carrier, or CM may run the safety program, b) CM has better liability protection under an OCIP, c) Site-specific safety program is used by all, d) More stringent safety requirements so that savings can be maximized, e) Experience follows the individual contractor's, and f) Incentives can be built into the contracts. The other issue is 2) Safety is the responsibility of the contractor with the following features: a) Owner, CM only monitor the contractor's activities, b) GC is responsible for project safety, including the subs, c) Hazard protection is up to the individual contractor, d) Imminent danger stop work authority possibly with the CM (by contract), and e) Contractor is to provide safe access to the work for inspection process.

The responsibilities of the employers of different origins are also well defined by CMAA (CMAA, 2010). As the worksite policy of multi-employers, citations are normally issued to the employer of the exposed employees (exposing employer), citation possibly to the employer who has contractual responsibility / authority for safety (controlling employer), citation possibly to the employer who created the hazard (creating employer), citation possibly to the employer who has responsibility for correcting the hazard (correcting employer).

Construction safety is very important in the US, so an additional body, the National Institute for Occupational Safety and Health (NIOSH) aiming to provide National and World Leadership to Prevent Workplace Illnesses and Injuries, also publishes guidelines to prevent injuries (NIOSH, 2010).

In the US, there are also posts called "Occupational Safety and Health Specialist" also known as "Safety and Health Professionals or "Occupational Health and Safety Inspectors" (OOH, 2010-2011) and "Environmental Health and Safety Management Specialist" (NASP, 2010). These degrees are offered as an Associate of Science degree and technician certificates in some universities/colleges. These specialists inspect worksites for unsafe equipment and working conditions and assist employers in complying with Occupational Safety and Health Act (OSHA) regulations and standards by conducting inspections, observing and repairing monitoring equipment, conducting safety and health training, investigating accidents, and improving safety preparedness. National Association of Safety Professionals (NASP) also provides certificates for "Environmental Health and Safety Management Specialist" (NASP, 2010).

It is apparent that every effort is put forward by governmental or professional organizations to ensure construction safety based on the development and proper dissemination of laws, rules and regulations in the US. Inspection is also provided by qualified personnel. A penalty for violation of any rule is also a common practice.

2.1.7 Construction management professional practice

Professional practice related competencies in construction management, emphasized by CM experts in the US as a rule of thumb include creating and executing project work plans and revising as appropriate to meet changing needs and requirements, identifying resources needed and assigning individual responsibilities, managing day-to-day operational aspects of a project and scope, reviewing deliverables prepared by team before passing to client, effectively applying the CM methodology and enforcing project standards, preparing for engagement reviews and quality assurance procedures, minimizing risk on project, ensuring project documents are complete, current, and stored appropriately, tracking and reporting team hours and expenses on a weekly basis, managing project budget, determining appropriate revenue recognition, ensuring timely and accurate invoicing, and monitoring receivables for project, following up with clients, when necessary, regarding unpaid invoices, and analyzing project profitability, revenue, margins, bill rates and utilization (URL-2, 2010).

2.1.7.1 Certified Construction Manager (CCM)

In the US, a Certified Construction Manager (CCM) is a recognized industry professional who is certified by both experience and examination.

According to CMAA, a CCM must meet strict certification program criteria (CMAA, 2010):

1) Formal Education
2) Actual documented and verified CM Experience
3) Demonstrated understanding of the CM body of knowledge

CMAA indicates that a CCM must have 48 months responsible in charge (RIC) experience as a CM/PM plus one of the following (CMAA, 2010):

- 4-year Degree (Construction Management, Architecture, Engineering, or Construction Science)
- 2-year degree and 4 years of experience in general design/construction
- 8 years of experience in general design/construction

CCM Qualifications Matrix is shown in Table 2.3.

Table 2.3: Certified Construction Manager (CCM) Qualifications Matrix (Doran et al. 2010-adopted from the instructors' power points at the standards of Practice course of CMAA)

PHASE	Pre-design	Design	Procurement	Construction	Post-construction
FUNCTION/ ROLE					
Project Management	RIC	RIC		RIC	
Cost Management		RIC	RIC	RIC	
Time Management		RIC		RIC	
Quality Management		RIC		RIC	RIC
Contract Administration			RIC	RIC	RIC
Safety Management				RIC	
	RIC Experience	Minimum Total of 48 months required in these Phases & Function/Roles			

RIC: "Responsible in Charge"

Construction Management Association of America requires 48 month cumulative experience in noted areas in order to apply for a certification. This proves the great attention that CMAA pays to the practice experience that an individual must have in order to get certified. Educational degrees are required and important but not enough unless complemented by enough amount of experience. Initial granted certification lasts for five years. Following renewals are due every three years. Such dynamic nature of the certification emphasizes CM professionals to update their knowledge as well as review new methods, laws, rules and standards that are being used in the construction industry.

2.1.7.2 Code of ethics

"Code of ethics" helps to define the primary responsibilities of a construction manager to the clients and community.

Regarding CM Professional practice, ethical considerations are also well documented by the CMAA as outlined below (Doran et al. 2010 - adopted from the instructors' power points at the standards of Practice course of CMAA):

Code of Ethics #1: Client Services: A construction manager is expected to serve his/her clients with honesty, integrity, candor, and objectivity and to provide my services with competence, using reasonable care, skill and diligence consistent with the interests of his/her client and the applicable standard of care.

Code of Ethics #2: Representation of Qualifications: A construction manager will only accept assignments for which he/she is qualified by his/her education, training, and professional experience and technical competence, and he/she will assign staff to projects in accordance with their qualifications and commensurate with the services to be provided, and he/she will only make representations concerning his/her qualifications and availability which are truthful and accurate.

Code of Ethics #3: Standards of Practice: A construction manager will furnish his/her services in a manner consistent with the established and accepted standards of the profession and with the laws and regulations which govern its practice.

Code of Ethics #4: Fair Competition: A construction manager will represent his/her project experience accurately to his/her prospective clients and offer services and staff that he/she is capable of delivering. He/she will develop his/her professional reputation on the basis of his/her direct experience and service provided, and he/she will only engage in fair competition for assignments.

Code of Ethics #5: Conflicts of Interest: He/she will endeavor to avoid conflicts of interest, and will disclose conflicts which, in his/her opinion, may impair his/her objectivity or integrity.

Code of Ethics #6: Fair Compensation: A construction manager will negotiate fairly and openly with his/her clients in establishing a basis for compensation, and he/she will charge fees and expenses that are reasonable and commensurate with the services to be provided and the responsibilities and risks to be assumed.

Code of Ethics #7: Release of Information: A construction manager will only make statements that are truthful, and he/she will keep information and records confidential when appropriate and protect the proprietary interests of his/her clients and professional colleagues.

Code of Ethics #8: Public Welfare: A construction manager will not discriminate in the performance of his/her services on the basis of race, religion, national origin, age, disability, or sexual orientation. He/she will not knowingly violate any law, statute, or regulation in the performance of his/her professional services.

Code of Ethics #9: Professional Development: A construction manager will continue to develop his/her professional knowledge and competency as a construction manager, and he/she will contribute to the advancement of the construction and program management practice as a profession by fostering research and education and through the encouragement of fellow practitioners.

Code of Ethics #10: Integrity of the Profession: A construction manager will avoid actions which promote his/her own self-interest at the expense of the profession, and he/she will uphold the standards of the construction management profession with honor and dignity.

2.2 Specific Construction Management Practice Standards

It is clear that construction management involves the control of the scope of the work, the optimum use of available funds, effective project scheduling, enhancing project design and construction quality, the avoidance of delays, changes and disputes, and optimum flexibility in contracting and procurement, based on the knowledge areas described in section 2.1.

Efforts have been made to standardize the practices associated with those issues in order to execute common practices.

Among the several professional organizations involved in putting standards in construction management such as PMI, CMAA etc., CMAA is widely recognized in the US as well as worldwide. As mentioned in the introduction section, CMAA's standards of practice are the subject of discussion in this work.

2.2.1 CMAA Construction Management Practice Standard (CMP)

Construction Management and Practice (CMP) Standard is a resource developed by CMAA in which construction management approach is defined based on the previously discussed following domains:

- Project Management
- Cost Management

- Time Management
- Quality Management
- Contract Administration
- Safety Management

CMP standards also define practices under the above headings in terms of the phases of construction management processes.

These phases include the following:

- Pre-design phase
- Design phase
- Procurement phase
- Construction phase
- Post-construction phase

In CMAA CMP standards, methods, techniques, processes, acquirements, and requirements in all phases in the previously mentioned six domains are explained in detail in a table (Appendix 1). It should be noted that practice standards are given in a"how-to-do" manner to facilitate the understanding of actual practices, as described in the standards of practice course of the CMAA (CMAA, 2010b).

The above mentioned practice standards are listed under the headings of six construction management knowledge areas as defined by CMAA (CMAA, 2010b) in CMP standards. On the other hand, CMAA, ASCE, AIA, and AGC attempted to formalize the duties of a CM in their respective contract forms. A total of 124 duties and responsibilities were identified covering CM disciplines using the input of the Committee on Management Practices in Construction (MPIC) of the ASCE Construction Institute based on particularly from the CMAA Standard Form of Agreement between Owner and Construction Manager (CMAA, 1999), the AIA General Conditions of the Contract for Construction-Construction Manager-Adviser Edition (AIA, 1992), and the AGC Standard Form of CM Agreement between Owner and Construction Manager (AGC, 1997). These 124 duties are incorporated to a table (Table 2.4) under the headings of phases in a project life cycle (Arditi, Ongkasuwan and MPIC Committee of ASCE, 2009).

Table 2.4: Duties of the Construction Manager

Project life cycle				
Predesign phase	**Design phase**	**Bidding phase**	**Construction phase**	**Postconstruction phase**
1. Develop scope of project and areas of use	1. Assist designer in preparing detailed design schedule	1. Review and evaluate owner’s proposed procurement methods	1. Arrange and chair project team meetings	1. Advise owner of expected transfer date
2. Conduct market research	2. Recommend method of selecting contractors	2. Interview and select special consultants	2. Ensure all approvals, permits, and licenses are obtained	2. Liaise with operating staff manager to arrange training
3. Collect typical operating costs, tax information, etc.	3. Develop security loss prevention program	3. Establish bidding schedules	3. Organize access to temporary facilities and services	3. Obtain and verify guaranteesa
4. Establish models for optimizing return on investment	4. Arrange survey monitoring of adjacent properties	4. Recommend breakdown of bid packages to be let	4. Establish system of cost control	4. Obtain and verify “as-built drawings”
5. Develop broad outline schedule	5. Liaise with owner’s legal counsel	5. Prepare forms of contracts and proposals	5. Administer monthly accounting review	5. Coordinate commissioning, testing, balancing of all systems
6. Develop conceptual budget.	6. Develop bid package formats	6. Issue invitation to bidders	6. Update cash flow	6. Arrange acceptance and approval of completed facilities
7. Evaluate financing sources and alternatives	7. Identify and purchase long-lead items	7. Conduct campaign to increase bidder interest	7. Establish shop drawing submittal procedures	7. Transfer facility to owner’s “care, custody, and control”
8. Develop target design fees	8. Develop phased construction schedule	8. Prepare sets of bid documents (general and special conditions, contract forms)	8. Expedite deliveries	8. Arrange final photographs and publicity releases
9. Develop feasibility study report	9. Initiate preliminary insurance review	9. Establish prequalification criteria for bidders and prequalify bidders	9. Obtain schedule updates from trades and suppliers	9. Arrange opening ceremonies
10. Establish cash flow projections	10. Arrange and chair design coordination meetings	10. Prepare documents for alternative bids	10. Evaluate progress and update schedule	10. Perform final accountinga
11. Determine organization and staffing to administer project	11. Oversee the production of schematic drawings	11. Evaluate requests for substitutions during bid phase	11. Establish payment procedures to contractors and suppliers	11. Prompt contractors to rectify deficiencies
12. Outline responsibilities of the project team	12. Prepare outline specifications	12. Prepare, review, and distribute addend	12. Approve monthly progress billings	12. Liaise with jurisdictional authorities for certificates and permits
13. Establish basic communication procedures	13. Identify, review, and recommend special areas of study	13. Maintain a log of bidders	13. Report to owner monthly progress, payments, costs, and trends	13. Verify all guarantees, manuals, and documentation are received
14. Prepare contractual agreements	14. Prepare and analyze alternate design schemes	14. Organize and conduct prebid meetings	14. Review submissions for design requirements compliance	14. Recommend holdback releases
15. Establish reporting and accounting procedures	15. Conduct constructability reviews	15. Organize and conduct bid openingsa	15. Receive, record, and schedule turnaround of submissions	15. Assist in expediting guarantee items
16. Interview and select architects, engineers, estimators, land surveyor, and other consultants	16. Conduct value engineering analysisa	16. Receive, evaluate, and analyze bids for responsiveness and price	16. Review and approve change orders	16. Conduct postoccupancy evaluation
17. Conduct site evaluation	17. Coordinate engineering designs	17. Conduct postbid conferences	17. Coordinate distribution of change order information	

Table 2.4 Duties of the Construction Manager (Contd.)

Project life cycle				
Predesign phase	**Design phase**	**Bidding phase**	**Construction phase**	**Postconstruction phase**
18. Select project delivery system (traditional, D/B, multiple primes, etc.) 19. Explore partnering possibilities between parties	18. Arrange for models, mock-ups, renderings, etc. of key design elements 19. Conduct public consultations 20. Review operating and maintenance costs 21. Establish general conditions of contract 22. Evaluate labor and trade contractor markets 23. Prepare general or trade contractor bid lists 24. Monitor cost estimates as details develop 25. Update cash flow requirements 26. Establish insurance program 27. Assemble tender documentation for owner's confirmation 28. Finalize selection of architectural components and systems 29. Liaise with jurisdictional authorities over design details 30. Review working drawings and specifications	18. Notify bidders of bid results 19. Negotiate with bidders 20. Assist owner in contractor selection 21. Organize and conduct preaward meetings 22. Assemble, deliver, and execute contract documents 23. Assist owner in the award of contracts 24. Approve subcontractors and suppliers 25. Issue notice to award	18. Facilitate settlement of contract disputes 19. Administer safety and security programs 20. Deal promptly with labor relations problems 21. Arrange inspections by jurisdictional authorities 22. Establish reasonable dates for substantial completion 23. See that no liens exist for the worka 24. Verify all deficiencies and outstanding documents are completed 25. Establish reasonable dates for final completion 26. Approve final payments to contractors 27. Inspect and monitor conformance to design 28. Select independent testing companies 29. Administer quality assurance and control programs 30. Verify monthly progress billings against actual work to date 31. Issue certificate of substantial completion 32. Issue punch list at substantial completion 33. Issue certificate of final completion 34. Review and evaluate documentation of claim by trade contractors	

When mentioning construction management standards in the US, it would be useful to give some statistical information on construction managers, who are trained to apply these standards.

The number of construction managers are more than half a million in the US.

The US Department of Labor, Bureau of Labor Statistics (BLS) records information on the construction industry construction managers (BLS, 2009). It is reported that construction managers held 551,000 jobs in 2008. About 61 percent were self-employed, many as owners of general or specialty trade construction firms. Most salaried construction managers were employed in the construction industry—11 percent by specialty trade contractor businesses (for example, plumbing, heating, air-conditioning, and electrical contractors), 10 percent in nonresidential building construction, and 7 percent in residential building construction. Others were employed by architectural, engineering, and related services firms. Projections data from the National Employment Matrix indicate that projected employment in 2018 is 645,800, with a change in number and percent will be 94,800 and 17%, respectively, from 2008 to 2018 (CM-Occupational Outlook Handbook, 2010-11).

As of May 2009, industries with the highest levels of employment in construction managership are given in Table 2.5 [Adopted from the Department of Labor, Bureau of Labor Statistics (BLS) records-11-9021Construction Managers (BLS, 2009)]

Table 2.5: Employment and Hourly and Annual Wages of Construction Managers in the US

Industry	Employment	Hourly mean wage	Annual mean wage
Nonresidential Building Construction	50,560	$44.36	$92,260
Residential Building Construction	33,100	$42.81	$89,040
Building Equipment Contractors	26,420	$47.85	$99,520
Foundation, Structure, and Building Exterior Contractors	12,260	$43.35	$90,160
Other Specialty Trade Contractors	10,360	$44.16	$91,840
Other Professional, Scientific, and Technical Services	30	$68.53	$142,550
Nondepository Credit Intermediation	30	$60.03	$124,870
Oil and Gas Extraction	290	$57.25	$119,070
Insurance Carriers	40	$56.20	$116,900
Office Administrative Services	870	$53.61	$111,500

2.2.2 Construction management practice standards in Turkey

There is no official organization and/or institution that are engaged in establishing standards and/or regulations for the successful management of construction processes in Turkey. In other words, no professional body has put forward standards of practice in construction management similar to that of CMAA. However, academic staff in Istanbul Technical University has well defined CPM in Turkey based on the CPM standards of CMAA. The principles of construction (project) management have been the subject of a series of articles by Dr. Murat Kuruoğlu posted in the Bulletins of the Chamber of Construction Engineers in Istanbul (Kuruoğlu, 2003a, Kuruoğlu, 2003b, Kuruoğlu, 2003c, Kuruoğlu, 2003d, Kuruoğlu, 2003e) based on the standards of construction (project) management proposed by Professor Doğan Sorguç, a pioneer in CM in Turkey (Sorguç, 2004). Therefore, similar standards to those in the US have been adopted in Turkey as well, not by official bodies but by practitioners in this field.

There is a translation of CMAA practice standards published as a book by IMO (Sorguç and Kuruoğlu, 2002; Turkish CMP Standards, 2003).

The question whether construction project management in Turkey is in the right place or not has been raised and discussed in an article by Kuruoğlu (Kuruoğlu and Ezcan, 2005).

The authors indicate that the development of construction management in Turkey has been slow when compared to that in the world. In this area, the most important improvements are reported to have taken place after 1980s, and especially around 1990s with the implementation of courses related to construction management in the curricula of civil engineering schools, followed by graduate training on construction management. However, further improvements have not been noted due to the lack of undergraduate training solely on construction management. Consequently, the discipline (culture) of project management has not been established in Turkish construction sector, but stayed at the level of project management planning. The authors conclude that the latest situation regarding construction management is the gain of “Construction (Project) Management Service and Practice Standards” (Sorguç and Kuruoğlu, 2002; Turkish CMP Standards, 2003) prepared as a result of the collaboration with CMAA.

Kuruoğlu and Polat (2002) aimed to compare the project management applications in Turkish construction sector with CMAA standards by investigating the permeation of the main principles using a conceptual framework, drawn from the CMAA standards and fundamental requirements for the implementation of the construction management principles in a survey.

Their survey revealed the following:

- The application of construction management techniques is limited
- Site managers or the professionals working on the site often consider construction management as a redundant procedure
- There have been many hindrances for the adoption of the construction management techniques in Turkish construction sector and there is not a consensus on the basic definitions and concepts
- There was a great variation in perceptions: all of the respondents defined the project management in different ways, some of them were erroneous some of them were imperfect

As a result of this evaluation, it is estimated that the level of current construction management applications in Turkish construction sector compared with CMAA standards is approximately 36 % (40 % in pre-design, 20 % in design, 30 % in procurement, 80 % in construction phases). In the prevalent structure of the sector, the contractor firms do not get involved in the design phase. As a result of this situation, firms do not perform the requirements of this phase.

The authors observed that there are not many project management consulting firms which result in the limited application field. Site managers or the professionals working on the site often neglect the usage of the project management principles and do not believe that the application of project management principles will add any value for the production of construction on site. Furthermore, they are not involved in the planning and making decision periods. They also think that the applications of project management principles do not satisfy their expectations and requirements

They concluded that, in spite of these negative impressions, there are some positive developments. It is evident that construction management principles can be adopted by the construction sector with the help of the increase in the governmental sanctions, qualified and educated professionals.

Given the CMP of the CMAA is adopted as a practice standard in Turkey, because these standards of practice have already been discussed in section 2.2.1 of this work, they will not be repeated in this section.

3. COMPARISONS AND DISCUSSION

3.1 Project Management Planning Practices in the US and in Turkey

The project management planning is considered as one of the most critical steps toward success. In a recent article by Hanna (2010), it was noted that projects on sheet metal that used a specific planning process achieved an average profit margin of 23% while projects that were poorly planned experienced an average profit margin of -3%.

Project management practices in Turkey have been well documented in a Master thesis by Ata (2009). In the context of this thesis, a survey on the awareness and usage of project management professional standards in construction industry has been performed. Among the 30 construction firms planned and tried to reach, 18 firms were reported to have agreed to participate in the survey.

The results of the survey by Ata (2009) were as follows:

- Approximately 16% of the participants were not aware of the professional standards of practice in construction project management provided by professional organizations in the field
- Only 31% was aware of PMBOK
- 74% of the participants did not have any certificate provided by worldwide known professional bodies in construction management
- 59% of the participants conceived “project management” as a specialty area under some other profession, while 41% thought of it as an independent profession
- 29% of the firms used PMBOK in their project management practices
- 24% of the firms used none of the standards in their project management practices
- Approximately 15% of the participants thought that project management standards were useful for being recognized well by the clients with positive influences in marketing

- Only 14% was interested in quality of the construction processes supported by using project management standards
- Only 6% thought that using project management standards would be useful in cost management
- 24% of the participants indicated that the obstacle for not using the standards was that firms had difficulty in accepting those standards
- 5% even thought that these standards resulted in inefficient processes and applications
- 24% of the participants thought that there is no need for project managers to be trained in project management
- While 41% of the participants thought that there is a need for standards supported by laws and regulations, 10% did not
- While 44% of the participants thought that there is a need for an organization which would regulate project management services and firms, 10% did not

Kuruoğlu and Polat (2002a) also evaluated the level of construction management applications in Turkey compared with CMAA standards by investigating the permeation of the main principles. Their survey revealed the following:

- Only a limited application of construction management techniques and project management principles in Turkish construction sector
- No consensus on the basic definitions and concepts
- A great variation in perceptions of the respondents who defined the project management in different ways, some defining erroneously and not perfectly

Kuruoğlu and Ergen (2000) depicted also a picture of project management planning in Turkey in an article titled “the Effects of Economic Development on Project Management in Developing Countries”. The interviews conducted with the authorized persons in planning departments revealed the following:

- The majority of the firms have recently established a planning department
- Planning has become more important for the technical personnel and managers
- In planning departments, civil engineers and architects usually work with people who have no education in construction (like industry engineers).

However, the contractor firms who are serious in planning prefer the engineers having a Master of Science degree in Construction Management

- Planning process is usually carried out in site offices and training and supervision is performed by the headquarters
- Planning departments are established upon the demand of middle managers with the permission of decision makers
- Middle managers demand to have a planning department to be able to organize and co-ordinate the work properly and the decision makers want it to monitor the cash flow and work progress (percentage of completion)
- The contractors who work abroad require a planning department in order to compete with foreign construction firms and to provide the demanded quality
- The main goal in planning is to complete the construction in due time with minimum cost
- Time planning is performed properly in all the firms that are included in the research but cost and resource planning are not
- Planning department obtains data through speech, writing or network from the personnel who are responsible for the site work
- These data that are mostly related to the percentage of completion are used in time planning
- For planning, usually a computer program called “Primavera Project Planner” is used
- The site experience is necessary for determination of the duration and relations of the items and this information is provided by either planning engineers or technical staff
- The persons who are working in planning department have either one or two years site experience or none
- The firms do not trust in the analysis of the Ministry of Public Works and they try having their own
- In labor planning, approach of manpower is used
- Some firms use a program called MS-Excel if only work schedule is necessary for them

- Work schedule is updated monthly, weekly and daily and usually monthly activity report is delivered to the related technical department at site. The results are also delivered to decision makers
- The diversions from projected values are mostly caused by incorrect values of manpower, trouble in resource and cash flow and weather conditions.

Kuruoğlu and Ergen (2000) identified the problems in planning departments as the following:

- Data transferred to the planning departments is insufficient
- The engineers responsible for site have negative approach to planning
- Planning department deals with the work other than its own
- There is none or insufficient database based on past experiences
- In Turkey the number of issues about planning are insufficient
- There are insufficient number of people who have their education about planning system and tools
- The planning staff doesn't have enough knowledge in human behavior and organization
- Since the reports prepared by the planning departments aren't taken into consideration seriously, the planning staff lacks motivation
- In Turkish construction sector, planning only means time planning

Işık et al. (2009) recently attempted to explore the factors that can enhance project management competencies in Turkey, hypothesizing that ‘‘project management competencies” are influenced by ‘‘corporate strengths/weaknesses”. The data obtained from a questionnaire survey administered to 73 contractors were analyzed using structural equation modeling (SEM) and the analyses revealed that the determinants of ‘‘corporate strengths/weaknesses” such as ‘‘company resources and capabilities”, ‘‘strategic decisions”, and ‘‘strength of relationships with other parties” play an important role on the success of projects since they have a direct and significant influence on ‘‘project management” competencies. This finding, adding a different perspective to success criteria in project management, is particularly important since construction is largely project-based. Based on the findings of the study, the authors recommend the following:

- Companies should adjust their resources and capabilities, their long-term strategies and their relationships with other parties to better serve the needs of the individual projects
- Companies have to behave farsighted in order to survive in the dynamic environment of the construction industry
- Ample leadership qualities should be acquired in addition to being open to innovation and fostering research and development
- Tactical considerations which are short-term have to be complemented by long-term and strategic decisions
- Strong relationships should be developed with prospective clients, unions, and government

The findings in the above-mentioned studies point to the need to evaluate and benchmark best practices for project planning management.

Many literatures emphasize that the capital projects industry will be transformed through the use of Information Technology (IT). IT is considered as one very important instrument for the current status of the construction industry, not only for project management but also for many aspects. It is suggested that IT will significantly alter the work practices of construction projects, and that corresponding changes to the construction project management practices are required (Froese, 2005).

In a paper by Kang et al. (2008), the use of information technology and its impact on project and company performance in the construction industry is evaluated using project level data from 139 projects and company level data from 74 companies. The findings suggest that more IT use correlates with improved performance; schedule performance has a strong positive association with increased IT use, whereas cost performance, although positively correlated, has a weaker relationship. Specific findings are that for Construction Industry Institute (CII) member company projects, cost savings are on the order of 2%, and for southeastern US contractors, cost savings are about 3% with increased use of IT. Predictability, measured by the CII delta cost growth metric, showed a 3% benefit to owners, but none were observed by contractors. Schedule compression for CII owners was observed at 17%, whereas southeastern US contractors benefited by a 16% improvement in schedule performance. Predictability for owners, as measured by the CII delta schedule growth metric, improved by 15%.

El-Mashaleh et al. (2006) indicate that for every 1unit increase in IT utilization, there is an increase of about 2, 5, and 3% in firm performance, schedule performance, and cost performance, respectively. No relationship is found between IT use and customer satisfaction, safety performance, and profitability.

In the US, Technical Council on Computing and Information Technology (TCCIT), with a mission "to advance professional knowledge and improve the practice of civil engineering by encouraging the effective use of current and emerging computing and information technologies" is responsible for producing conference proceedings, special publications, and monographs on computing-related topics (Melhem and Issa, 2008).

The use of information and communication Technologies (ICT) within the construction industry in Turkey, not only for project management but in general, has been the subject of several presentations and publications (Işıkdağ, 2002; Sarshar and Işıkdağ, 2004; Işıkdağ et al., 2008a; Işıkdağ et al., 2008b; Işıkdağ et al., 2009). Ümit Işıkdağ, a faculty member in the Department of Management Information Systems in Beykent University, extensively dealt with ICT issues in the construction sector in Turkey.

In one of his previous works, Işıkdağ (2002) surveyed IT use in the Turkish Construction Industry, followed by another one in which (Sarshar and Işıkdağ, 2004) the ICT capabilities of the Turkish construction industry have been examined. Some key findings are shown in Table 3.1.

Table 3.1: The ICT capabilities of the Turkish construction industry

1)	The Turkish construction industry faces similar challenges as other countries, in terms of difficulties in communication and loss of information
2)	IT is viewed as strategic by senior industry figures who are prepared to spend time and effort in order to increase awareness and improve training
3)	In general, the software packages used by larger organisations are similar to the ones used in Europe. However, the SMEs have less ICT awareness and capabilities. It is, therefore, more complex to use ICT across the supply chain
4)	Owing to the absence of trained staff, many of the technologies are underutilised. ICT education is critical for future advancement and uptake of technology by the industry
5)	The workforce in Turkey is cheaper than in Europe. Therefore, the business needs for automation of some of the processes are less urgent

Işıkdağ et al. (2008) also investigated the strategic role of ICT within the Turkish AEC Industry. Some of the reported findings are outlined in Table 3.2.

Table 3.2: The Strategic Role of ICT within the Turkish AEC Industry

ICT	Current status (as of 2008)
Perceptions	The majority of the organisations mentioned the role of ICT as value adding (58%) and critical (38%) in order to gain advantage against their competitors Only a few organisations (10%) viewed ICT as simply a tool for supporting their business processes
Strategy	The majority of the organisations (65%) do not have a documented ICT strategy while 30% mentioned that they do have a documented ICT strategy (in the form of a written strategy report). 5% of the interviewees mentioned that their organisation does not have any form of an ICT strategy
Strategy formulation	More than half of the respondents (60%) mentioned that the organisations' ICT strategy is formulated by their central/core ICT department to align with the operational needs, which is dependent on the feedback from various departments. On the other hand, 33% pointed out that their central/core ICT department alone formulates the organisational ICT strategy (without input from other departments), and 7% stated that individual departments are responsible for formulating their own ICT strategy
Focus	5% of the interviewees indicated that their focus is on developing in-house software and IS, and in contrast 35% mentioned that they only outsource software development. More than half of the interviewees (55%) stated that their organisation implement a mix-and-match approach where some parts of their IS is developed in-house, while the development of some components is outsourced
Investment	80% of the organisations stated that they invest on ICT training, while 20% make no investment at all
Barriers	The greatest barriers related to successfully implementing and managing ICT were identified as infrastructure problems and inefficient use of software

These findings led to the conclusion that the development of a well-formulated and documented ICT strategy is not common practice in the construction industry in Turkey. Overall ICT is having a supporting role throughout the lifecycle of a facility/project. However, ICT is perceived vital particularly during the design phases along with the management of time/cost and the supply chain. The role of ICT is the most valued factor in the management of AEC projects in Turkey.

In one of the latest publications of his and colleagues', the strategic role of ICT implementations from an industrial perspective has been investigated and if organizations within the AEC industry view ICT as a strategic resource for their business practice has been explored. The investigation revealed that ICT is seen as a value-adding resource, but a shift towards the recognition of the importance of ICT in terms of value adding in winning work and achieving strategic competitive advantage is observed (Işıkdağ et al., 2009). On the other hand, ICT Training is found to be the theme of highest priority from the academia point of view.

As stressed in the articles discussed above, there is a need for ICT training in construction industry that might add to project management practices in Turkey.

An Information System (IS) called enterprise resource planning (ERP) is being widely used in the US to ensure the success of project management planning. Enterprise resource planning (ERP) is an integrated computer-based system used to manage internal and external resources including tangible assets, financial resources, materials, and human resources, the purpose of which is to facilitate the flow of information between all business functions inside the boundaries of the organization and manage the connections to outside stakeholders (Sheilds, 2001).

The construction ERP (C-ERP) includes three modules on the application framework: project system, material management, and project maintenance. The modular functions contain cost management, schedule management, subcontractor management, construction planning, field equipment management; field materials warehouse management, procurement management, and facility operations and management (Shi and Halpin, 2003).

The benefits expected from C-ERP implementation are as follows: real-time visibility of the finances of projects and enterprise, managing projects on time and within budget, enhanced decision-making capabilities, strengthened client, supplier, and subcontractor relationships, eliminating data reentry, and increasing management efficiency (Ahmed et al., 2003).

The scope of the C-ERP system is depicted in Table 3.3 below.

Tatari et al. (2008), considering that the construction business is based on projects, attempted to quantify the effect of C-ERP by rating the level of performance of each project function with respect to the information attributes. They assessed the performance of the project in terms of its total cost and duration with the following hypotheses: As C-ERP affects the project functions, it will affect the project outcome: total cost and duration. In normal circumstances, if C-ERP offers better information quality and integration, then the use of C-ERP should decrease the cost and duration of the project. With better information capabilities, project management functions will be more efficient and less time consuming (e.g., equipment management, materials management, workforce management, supplier management, subcontractor management, and financial management). This will lead to an increase in the progress rate, which will successfully affect the project performance.

Table 3.3: Scope of C-ERP System in Construction Project Life Cycle (Adopted from Tatari et al., 2008)

Construction Project Life Cycle					
Project Bidding & Marketing	**Project Planning**	**Engineering & Design**	**Procurement**	**Construction Project Control**	**Closing & Operations**
•Marketing planning •Bid database •Proposal preparation	•Cost estimation •Project budgeting •Activity and resource planning •Risk management •Detail scheduling •Quantity take-off	•Document & drawings management •Specifications, manuals, and documents development •CAD integration •Constructability review •Collaboration	•Resource management •Request for quotation & awarding •Subcontracting & purchase orders •Equipment management •Equipment maintenance •Materials management	•Site management •Claim/change management •Quality management •Milestone and execution plan •Project billing and costing	•Commissioning •Handover •Maintenance & operations •Service operations
Human Resources Management					
Knowledge Management					
Finance/Accounting					
Enterprise Management					

After evaluating two firms in the US before and after C-ERP implementation, they found that in terms of information quality, there have been major performance improvements in materials management, quality management, and financial/accounting management. On the information integration side, there have been major performance improvements in scheduling/planning, materials management, subcontractor management, and financial/accounting management. Overall improvement has been found to be approximately 20–25%.

Skibniewski and Ghosh (2009) evaluated ERP from a different point of view and searched an answer for the question, “What are the areas of business processes within the engineering construction industry where ERP cannot be used to collect key performance indicators (KPI) related to business processes?” They reviewed empirical and specialized processes within the construction industry to identify business processes not covered by existing ERP systems in the US with the following hypotheses: 1) Hard time-sensitive KPI data are not captured in traditional ERP implementations, 2) Soft time-sensitive KPI data are often captured in traditional ERP implementations, but not always, 3) Knowledge-sensitive KPI data are most likely to be captured in traditional ERP implementations. In this research, they formulated a theoretical framework for identifying and classifying such KPIs to form the basis of understanding the spectrum of ERP implementations.

Ahmed et al. (2003), apart from the engineering and design firms, investigated the suitability and the implementation status of ERP systems in contractor firms. They found that the majority of contractor firms have awareness about ERP but very few organizations have so far (as of 2003) implemented an internal system. The major reason is that the implementation of an ERP system requires a large investment in time, money and resources. The authors conclude that when implemented to solve the right problems, these ERP systems can be a powerful tool for business improvement with the previously mentioned benefits. Some of the findings in this study obtained from questionnaires administered to 12 construction firms are outlined below in order to depict a picture of the understanding and implementation of ERP in construction industry in the US before 2003.

Knowledge about ERP systems and their implementation

- 58% of the respondents were aware of the ERP systems in general
- 33% of the respondents indicated that they were earlier contacted by an ERP vendor about the possible implementation of ERP systems in their organizations
- 8% of respondents think that ERP system will work “very well” in their organization and 51% think that it will work to “some extent”. The rest of the respondents are either “not sure” or have the opinion that ERP will “not work” in their setup
- 58% of respondents indicate that the ERP systems, if implemented, will be beneficial for their organization

From the above findings, the authors (Ahmed et al., 2003) concluded that a slightly more than half of the respondents are aware of the ERP systems and they think that ERP systems could work in their organizations and will benefit the organization. However, a good number of contractors showed fear that such systems will not work well in their organization due to the small size of the organization, limited resources and not adequate technical skills.

The same authors (Ahmed et al., 2003) also explored the benefits expected from the implementation of ERP systems which revealed the following:

1) Improve decision-making capabilities
2) Improve responsiveness to customers
3) Enhance organizational flexibility
4) Strengthen supply chain partnerships
5) Reduce project completion time and cost

With regard to implementation of ERP systems, the status was as follows:

- The contractor firms who are already using an ERP system indicate that their ERP vendors are Oracle, MS Project, AutoDesk and Primavera
- The respondents point out to the following functions which their ERP systems are performing: Accounting, project management, construction management, scheduling, contact management, estimating, budgeting, historical cost tracking and projections, project documentation, CADD, photography management, office administration tools, messaging, project collaboration, payroll, corporate finance, fixed asset management, equipment fleet management, subcontract management, work order management, billing generation, material purchasing, mailing list, and documentation storage, word processing, calculations, finance, project control, human resources, engineering, procurement
- 42% of respondents indicate that their current ERP systems are not fully integrated and they need further customization
- 83% of respondents recommended the need of extensive training programs to fully understand the functionality of ERP software to enjoy their benefits Majority of these respondents pointed out that the training must be started with the top management and then on the middle and lower management respectively
- The respondents indicate that the implantation cost of ERP system in their organization varies from $500,000 to several million dollars
- The minimum implementation time taken was 1.5 years and the maximum was up to 10 years
- Satisfaction level about the performance of ERP systems was found high by 8%, moderate by 33%, and low by 42%, while 17% did not give an answer

To compare ERP understanding and usage in Turkey, in a similar survey by Açıkalın et al. (2008), the use of Enterprise Resource Planning (ERP) systems in Turkish construction industry was explored by means of questionnaries responded by data processing managers in 21 construction firms. In this survey, 52% of the respondents indicate that they have an Integrated Information Management System (IIMS); 26% indicate that IIMS is being established; and 21% indicated that they do not have any IIMS. However, majority of those firms who already have an IIMS are reported that their project management, client relations management, and document management data do not have an integration with the IIMS. Furthermore, no integration is reported with computer-aided design (CAD) data in Turkish construction sector. In general, in systems with an avearage of 10 modules, finance and accounting modules are the first considered ones followed by buy-in, logistics and budget planning modules. Project management module, if any, is reported to have been the lastly considered one. It is also noted that the emerging concept BIM is an unfamiliar one in Turkey. The findings of this survey point to the need for an IIMS. It is indicated that ERP systems are gaining an important role in the Turkish construction sector paving the road to IIMS for all the project and management processes.

The comparison of the two surveys (Ahmed et al.,2003-US vs. Açıkalın et al., 2008-Turkey) reveals some similarities in terms of the implementation of IIMS/ERP in construction firms in the US and in Turkey when the periods before 2003 in the US and before 2008 in Turkey are concerned. However, the very wide array of modules implemented in the US contracting firms, ranging from project management (lastly considered module in Turkey) to CAD and a large number of others point to advanced practices of ERP even before 2003 in the US. Considering that minimum and maximum implementation time taken is 1.5 to 10 years, it may be argued that Turkish construction firms are in need of more efforts to implement IIMS/ERP to fully benefit from this IS for the success of project management.

Yıldız and Dikmen (2009) report that only in the last couple of years a large number of construction firms has invested in ERP due to the high level of construction projects in recent years.

As revealed from the above status of ERP knowledge and use in construction firms, although many construction firms recognize the benefits of ERP system implementation, they still hesitate to adopt these systems due to high cost, uncertainties, and risks.

Chung et al. (2008) analyzed critical factors that need to be considered to ensure successful ERP system implementation in the construction industry. They proposed a conceptual ERP success model based on the available literature. This conceptual ERP success model is shown in Figure 3.1.

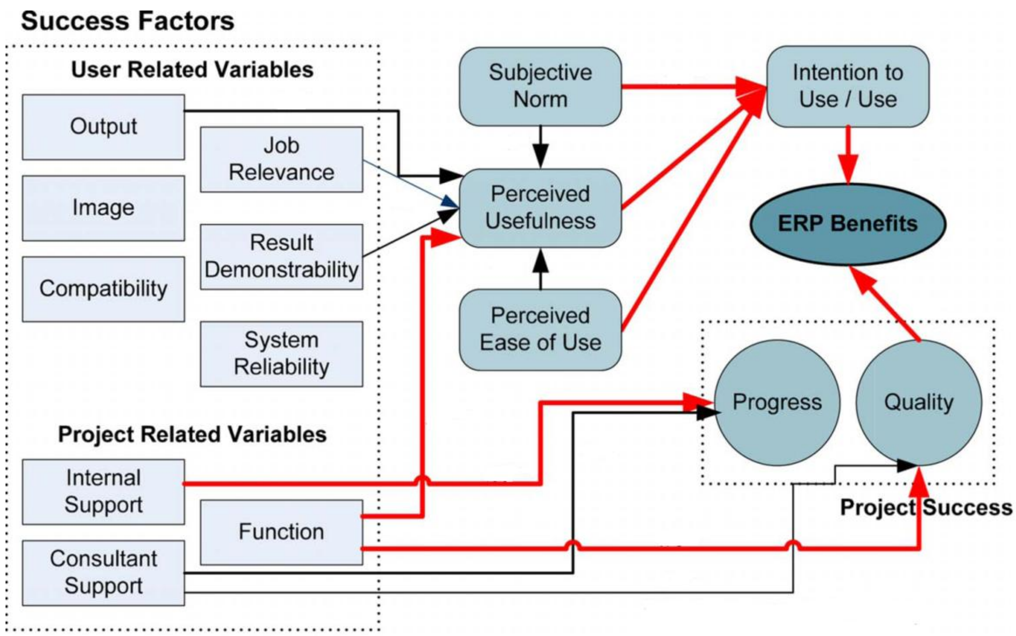

Figure 3.1: Conceptual ERP success model (Adopted from Chung et al., 2008)

The authors identified five different dependent variables associated with ERP success: perceived usefulness, intention to use/use, project success/progress, project success/quality, and ERP benefits. They found that function, subjective norm, output, perceived ease of use, and result demonstrability were highly associated with perceived usefulness. Based on this result, they provided the following recommendations to increase usefulness of the ERP system (Chung et al., 2008):

1) Function: The functions of the ERP system should be well defined to cover the company's necessary business functions. It is also important to choose the right software considering whether or not it can support the defined functions as well as its functionality.

2) Subjective norm: All the members in the company should be encouraged to use the ERP system because their use can increase the company's business value and productivity.

3) Output: To make the ERP system more useful, the company should focus more on enhancing the quality of output during its implementation, especially in management and measurement reports.

4) Perceived ease of use: The ERP system should be easy to use. A complex system decreases usefulness, which also make users reluctant to work with. The system should be carefully designed to be user friendly, considering screen design, user interface, page layout, help facilities, menus, etc.

5) Result demonstrability: The company should clearly define what positive results can be expected from the use of the ERP system before or during ERP implementation.

These recommendations are expected to be valuable for decision makers of companies before or during their ERP implementations.

As to the use of ERP in various business sectors in the US, ML Payton Consultants (2000), a management-consulting firm, examined how the US and European firms currently use Enterprise Resource Planning (ERP) systems and how its use will change over the next few years. Study results showed that the market is showing steady growth and could reach $52 billion by 2002. Top vendors include SAP, Oracle, J.D.Edwards, Baan and PeopleSoft. SAP has traditionally been the market leader, although its share has been declining in the past few years. Most of the Fortune 1000 companies have ERP systems in place, so vendors are targeting smaller mid-level markets such as construction.

To support ERP implementation, a novel function mapping approach named the Architecture of Integrated Information Systems (ARIS)-house-based (AHB) method has been proposed in a study by Tserng et al. (2010). AHB method uses the structure of ARIS-house diagram to guide the function mapping process, streamline existing information systems, meet future requirements, and successfully implement ERP. General contractor and ERP consultant have been shown to successfully transfer the process of function mapping from many time-consuming meetings to a logical analysis method, to reduce labor-consuming meetings, and to increase the efficiency and precision of an ERP project.

To reflect more project management practices in the US, Peter J. Zipf, an Engineering Program Manager at the Engineering Department of Port Authority of New York and New Jersey indicates that new technologies, especially local area networks and wide area networks, are enabling project managers to change direction rapidly by speeding communication with staff members and other technologies, such as the right project management software, geographic information systems and document management systems also are proving crucial. The engineering department of the Port Authority of New York and New Jersey having awarded 229 construction contracts—with a total value of $456 million—and placed $935 million worth of construction in the ground in 1999 states that although the amount of work has increased over the past few years, the actual number of staff members performing the work has decreased through organizational restructuring with a multitude of technology initiatives that focused on how a project manager gets the architect, the design engineer, the construction engineer, and the contractor to work together as a project team to successfully plan and implement the construction project. The "project control process" was reported to be one method used by project managers to address this issue. The technologies including local area networks (LANs), wide area Networks (WANs), electronic communication, integrated project management systems, geographic information systems, electronic document management systems, and enterprisewide database systems were reported to provide the project managers with timely information to be able to manage effectively (Zipf, 2000).

Regarding research studies to improve practice in this area, aiming to develop a generic, user-friendly preproject planning tool, Cho and Gibson (2004) developed a Project Definition Rating Index (PDRI) to address need for a publicly available tool for determining the adequacy of scope definition during the critical stage of the preproject planning phase of the construction life cycle. The PDRI provides a means for an individual or team to evaluate the status of a building project during preproject planning with a score corresponding to its level of definition.

In relation to IT, two emerging and fast growing concepts, building information modeling (BIM) and integrated project delivery (IPD) are sweeping through in AEC industry as new modes of interdisciplinary information sharing (Becerik-Gerber and Kensek, 2010).

These two concepts brought a new paradigm of project management into the industry by promoting functional and organizational integration for project management.

By definition, BIM is a modeling technology and associated set of processes to produce, communicate, and analyze building models and interfaces, methods, and applications that are pertinent to BIM technology, including but not limited to the following: sustainable practices, management and organizational issues around technology, and assisting technologies and methods (Eastman et al., 2008).

IPD is a predesign to construction method that creates a collaborative environment required for the most comprehensive use of BIM by aligning the incentives and goals of all team members; it addresses the problems associated with traditional delivery methods and provides another alternative (Becerik-Gerber and Kensek, 2010).

In a very recent article, Becerik-Gerber and Kensek (2010), BIM research topics that are considered to be important to a wide range of practitioners and future practitioners, both architecture and engineering students were identified as being critical to the development and implementation of BIM in the AEC profession as the following: the concept of one virtual database versus linked information, coordination with sustainable sustainable design, rethinking of IPD as a method to promote BIM, educational ramifications, return on investment, and management issues throughout the life cycle of the project. The authors conclude that BIM, vertical enterprise integration (or IPD), and sustainability are three symbiotic forces that are sweeping through the AEC industry.

The issue of quantifying the business impact of information management strategies and the associated investment in information technology has also been the subject of research in the US. Back and Moreau (2000) indicated that the prevailing assumption that corporate investment in information technology will immediately result in more efficient business operations and inevitably improve the standard measures of business performance is now highly suspect in many US industries. The authors investigated the answer to two important questions: (1) how can companies objectively measure the potential benefit of information management, and (2) what information management strategies can be successful in construction engineering? The research concluded that substantial cost and schedule reductions result from improving internal information exchange and integrating project-based information across organizational boundaries.

It is indicated that an integrated intelligent construction management application that enables process modeling and algorithmic analysis of construction process planning, interacts with a mainframe-based automated relational database system, and drives the project sequencing, scheduling, decision making and change management processes can introduce dramatic speed, simplicity, accuracy, and collaboration into existing project planning practices (Salem and Mohanty, 2008).

It is suggested that engineering and construction companies will have to make radical changes to their project management techniques if they are to be successful in the global marketplace in the 21st century. Project management is not a business as usual. Global companies will have to be very good in the basic project management processes of planning, designing, scheduling, controlling costs, and managing materials and construction. Some of the key areas, in which engineering and construction companies will have to excel to be successful in satisfying the global customer, include an organization that can match their expertise in a cost-effective manner to the needs of their global customers and information technology (IT) systems that will permit fast, reliable transfer of data to any point on the globe (Kini, 2000).

The comparisons of project management practices are presented in the Table 3.4.

3.2 Cost Management Practices in the US and in Turkey

It is indicated in the US that because the owner often lacks expertise in cost control; the designer is typically more concerned with technical aspects and aesthetics; the contractor is typically concerned with completing work within its budget, and maximizing profit, it is the construction manager who is in sole possession of the cost control role (CMAA, 2010b).

According to CMAA (CMAA, 2010b), cost management system helps establish and manage the project budget, provide the tools necessary to manage and monitor budget such as feasibility studies, cash flow schedules and cost models, helps ensure the project is delivered within budget, and helps to manage the budget from inception to completion.

The development and implementation of cost management system include several processes: a) Resource planning where the issues of “what resources and in what quantity of these resources are needed" are considered, b) Cost estimating where the cost of the resources needed are approximated, c) Cost budgeting where the estimated costs to project elements or activities are allocated, and d) Cost control which include controlling the changes that impact an accepted budget (CMAA, 2010b).

Table 3.4: Comparison of Project Management Practices in the US and in Turkey

	Practices in the US	**Practices in Turkey**
PROJECT MANAGEMENT		
• Perception	Percieved as it should be[a,b]	Percieved as time planning[c]
• Awareness	High[a,b]	Low[d]
• Acceptability	High[a,b]	Lower[d]
• Existence of internal departments	In most of the firms[e]	Recently established[c]
• Knowledge of CMP standards	CMP of CMAA[a], PMBOK[b]	Mostly PMBOK[d]
• IT/ICT		
• Usage	High[f, g]	Underutilised [h]
• ERP		
• Functions	In a wide range from project management to CAD[e]	Mainly finance and accounting; Project management lastly considered[ı]
• Integration	More than half fully integrated[e]	Almost none fully integrated; no integration with CAD[ı]
• Systems	Primavera > MS Project[e]	Primavera[d]
• Effect	20-25% improvement in terms cost, time etc.[j]	No data
• BIM	Sweeping through in construction projects[k]	Unfamiliar concept[ı]
• IPD	An important emerging concept[k,l]	No data

[a]CMAA, 2010; [b] PMI, 2010; [c]Kuruoğlu and Ergen, 2000; [d]Ata , 2009; [e]Ahmed et al, 2003; [f]Kang et al., 2008; [g]El-Mashaleh et al.,2006; [h]Sharshar and Işıkdağ, 2004; [ı] Açıkalın et al., 2008; [j]Tatari et al, 2008; [k]Becerik-Gerber and Kensek, 2010; [l]Lancaster and Tobin, 2010

Resource planning

Resource is a broad term that can include materials, labor, and equipment that are directly involved in the productive activities on a construction project, as well as a wide range of less tangible items, e.g. permits, access, information, and money that function as conditions or enabling factors for actual execution (Lucko, 2010).

Basic inputs to resource planning include scope of work, work breakdown structure (WBS), historical information, resource pool description (market survey), and organizational policies (CMAA, 2010).

As recommended by AACE (AACE RP No. 23R-02), scope documents and supporting information may include the following:

- Statement of work
- Functional requirements
- Project concept documentation (including all appropriate contract drawings and technical specifications)
- Work breakdown structure (WBS)
- Significant project milestones and constraints
- Project estimate (including preliminary schedule of values)
- Risk analysis information including appropriate regulatory considerations that may affect the schedule
- Project procurement/contracting plan (long lead items)
- Lessons learned from previously completed similar projects

The work breakdown structure (WBS) is a work categorization tool used for planning, managing, executing and reporting for the project. Therefore, the WBS should be a major reference source during the planning process, especially for identifying activities (AACE RP No. 23R-02).

Cost estimating

The cost estimate is considered one of the most important and critical phases of a construction project. During each of the first four phases of a project lifecycle-conception phase, development phase, construction phase, and completion phase, a new cost estimate must be prepared, depending on the availability of design drawings and specifications. It is during the initial phase that feasibility studies and parametric cost estimates are most likely to be carried out (Jrade and Alkass, 2007).

Feasibility studies and parametric cost estimates play an important role in determining whether a project could be realized based on the available budget. Such estimates are first developed at the order-of-magnitude level with an accuracy of +50% to −30%, later refined to the budget/conceptual level with an accuracy of +30% to −15%, and the definitive level with an accuracy of +15% to −5% (Rast and Peterson, 1999).

The parametric approach to cost estimating is a procedure involving the use of a constant parameter (with variable values) as a reference for other variables. The parameters from which parametric cost estimates are derived include physical properties that describe project definition characteristics such as size, building type, foundation type, exterior closure materials, roof type and material, number of floors, and functional space and utility system requirements (Meyer and Burns, 1999).

The most basic method for modeling the parametric cost estimate is to identify the intended scope of the project; this would be measured in gross square feet and referred as the “square foot” method for buildings (Larson, 2002). In this method, historical building cost data or cost books are used to get an estimate of the cost per square foot of the type of building under consideration. The estimated unit cost is then multiplied by the gross floor area of the proposed building after being adjusted for factors as location, size, and the expected quality of the proposed building. Therefore, besides the methods, parameters, parameters, and the historical data used, modeling the process of parametric estimates is a prime requirement for the preparation of a liable and accurate estimate (Karshenas, 1984).

Jrade and Alkass (2007) presented a methodology that can be used for an integrated conceptual cost estimating and life-cycle cost analysis for construction projects during their initial phase, which automates the preparation of parametric cost estimates and forecasts future running costs of building projects. The system, integrating relational databases, a parametric cost estimate module, an AutoCAD module, a global module, a cost estimate forecasting and decision support system module, and a life cycle costing and sensitivity analysis module, automatically generates a new parametric estimate upon any modification in building design. Once the capital costs are identified, the system forecasts the cost of running and maintaining the new building throughout its expected service life. After assigning the range of deviation, a sensitivity analysis is conducted, which identifies the most sensitive parameters for further consideration and analysis.

Karshenas (2005) indicates that despite the importance of estimating, it has remained a very time consuming process. The most inefficient part of construction cost estimating is determination of the amount of resources needed for the construction of a project, also known as quantity takeoff. The quantity takeoff process is still very slow, is not very accurate, and does not eliminate the possibility of an estimator missing or duplicating estimating items. New parametric CAD software is revolutionizing the way architects design buildings and will significantly increase construction cost estimator productivity by substantially reducing the manual work necessary for performing quantity takeoff.

According to an assessment made by Bozkurt and Kuruoğlu (2007) on the difficulties in cost estimating at the feasibility phase in the construction sector in Turkey, it was found that only 3.5% of construction firms has achieved 5% of a deviation in cost estimation, while 19.3% of the construction firms reached a deviation of 15–10%, 33.3% had a deviation of 10–15%, 19.3% experienced 15–20% of a deviation and 24.6% of the firms exceeded a deviation of 20% in cost estimation, with the result that 77.2% of the construction firms are able to preestimate costs with a deviation exceeding 10%. It was observed in this assessment that database systems have not yet been established at the construction firms and similar projects comparison approach has mostly been used in Turkey.

However, the success of cost management practices seem to have many constraints.

Regarding the most important constraints in cost estimating practices in Turkey, the reported findings by Bozkurt and Kuruoğlu (2007) are as follows:

- Lack of time
- The specificity of project, not being a serially performed project
- Insufficient information on the project subject to cost estimation
- Project ambiguity, concept changes
- Unpredictable procedures that may arise during the realization of the project
- Insufficiencies in project documents

The new procurement law in Turkey (PPL, 2002) is based on turnkey delivery by the contractor, and total price estimates are required from the tendering firms. The price of projects should therefore be estimated more realistically and uncertainty should be decreased. Given the fact that the public sector in Turkey is still the biggest employer in the country with public investments averaging 3.86% of Turkey's gross domestic product (GDP) and constituting 39.36% of construction sector investments in Turkey between 1999 and 2003 (PPA, 2004), there is a need for better cost estimating with less deviations (Öcal et al., 2006).

Gencer (2007) points to the same issue indicating that in turnkey delivery, cost estimation is very important.

Alroomi et al. (2010) identified 23 core cost estimating competencies. These are shown in Table 3.5.

Table 3.5: Cost Estimating Competencies

1.	Analyzing what's missing in the scope definition
2.	Develop clear and organized estimates with sound basis
3.	Ability to see the big picture, realize what is important
4.	Know what questions to ask and who to ask
5.	Able to apply judgment, do reality checks, then explain why
6.	Know how to read and interpret drawings
7.	Ability to work under pressure with tight deadlines
8.	Be inquisitive, ask questions, find resources, and make decisions
9.	Have good communication skills, self confident, work with others
10.	Be dependable, straight forward, objective, fair, and consistent
11.	Quantity take-off
12.	Be task oriented with the drive to achieve the end results
13.	Construction/ Site condition knowledge
14.	Have interest in details and numbers with ability to organize work
15.	Productivity and labor rates
16.	Risk assessment/ Analysis & contingency
17.	Able to stand ground and resist pressure to change numbers
18.	Obtaining quotations accurately from vendors
19.	Escalation impact
20.	Open to working in new areas where you may not feel comfortable
21.	Design/Engineering Skill
22.	Planning and scheduling
23.	Development of reports for management

Cost budgeting

In a study attempting to find ways to reduce an owner's construction contingency budget such that just enough contingency is allocated that will allow the owner to deal with uncertainties but at the same time not tie up valuable funds that can be used for other activities, it is suggested that the common practice of allocating a fixed owner contingency (e.g., 10% of the contract value) to all projects contracted out by an owner is not appropriate. Instead, Günhan and Arditi (2007) propose a methodology whereby the owner analyzes historical project data, identifies the line items that are problematic, takes the necessary measures at the preconstruction stage to streamline these line items with respect to site conditions, time constraints, constructability issues, and project scope, and (budgets contingency funds based on this information.

Cost control

The amount and uncertainty of the project cost undergoes significant changes during project lifecycle. Cost discrepancies may occur as the deviation of a cost amount at a given phase compared with that at a previous phase These can translate into an increase or decrease in project cost defined as a cost overrun or underrun, respectively.

Bordat et al. (2004) reported that the Indiana Department of Transportation incurred approximately $17 million in cost overruns in 2001 which represented 9% of the total amount for all contracts in that year, and that over a 5-year span, over one-half (55%) of all state highway contracts incurred cost overruns. In order to predict cost overruns, researchers have been trying to develop approaches to predict cost descrepancies.

Cost overruns can be traced back to “root causes”. However, these root causes are often associated with the preliminary phases of project planning or design. These may include poor estimation of quantities, design variations or errors, project schedule changes, scope changes, unexpected site conditions, rising costs of materials and labor that are largely due to inflation, and/or unforeseen events. Most of the problems associated with these root causes are often unknown at the contract award phase. They may appear only during or after the project construction phase. Thus, in general, between the contract award and final construction phases, it is not possible to predict cost overrun on the basis of the root causes (Gkritza and Labi, 2008).

Gkritza and Labi (2008) developed a multistep econometric approach that can be used to estimate the effects of factors associated with the contract bidding process, project type, and the project physical environment on cost discrepancies in highway contracts. The authors indicate that determinants of cost overruns may include contract size in terms of the dollar value of a construction project and implementation phase length-contract period- and project type. Their estimation findings revealed that for a given project type and project year, contracts of larger size or longer duration are generally more likely to incur cost overruns. In addition, for contracts that incur cost overruns, the cost overrun rate decreases nonlinearly with increasing contract size up to a certain point after which the cost overrun rate increases with increasing contract size. They point to the possibility that cost overrun amounts are not linearly related to contract award amounts (contract size) and greater analytical flexibility needs to be incorporated into any investigation of contract cost overruns.

As another example for cost management practice in the US, Imbeah and Guikema (2009), demonstrated the usefulness of the Advanced Programmatic Risk Analysis and Management Model (APRAM) for managing schedule, cost, and quality risks in the construction industry. The results of their study showed that APRAM simultaneously addresses cost, schedule, and quality risk together in a coherent, probabilistic framework. When properly implemented, cost management will translate into reduced costs of execution of a construction project, as well as increased value being delivered to the customer.

Kuprenas (2003) analyzed over 270 engineering design projects to assess the impact of the use of project management processes on design phase cost performance. Factors which would reduce design costs included frequency of design team meetings, frequency of reporting of design phase progress, project manager training and the use of a project management based organizational structure. Calculation of regression lines for the meeting and reporting frequency variables against design costs was shown to be a method to quantify the potential savings to be obtained by application of each process.

Implementation of concurrent engineering principles has also been shown to reduce costs in the design phase (Karlsson et al., 2008).

It should be noted that CPM scheduling can also be used for tracking costs, as reported to be practiced by 18% of the contractors in the US construction industry as indicated by Galloway (2006b).

When dealing with cost estimating practices in the US, an occupation called “cost estimatorship” is defined. In construction sector, “Cost estimators” may be employed by the project's architect, engineering firm, or owner to help establish a budget, manage and control project costs, and to track actual costs relative to bid specifications as the project develops, and during construction to manage the cost of change orders and negotiate and settle and extra costs or mitigate potential claims. Estimators may also be called upon as expert witness on cost in a construction dispute case. On large construction projects, there may be several estimators, each specializing in one area, such as electrical work or excavation, concrete, and forms (CE -Occupational Outlook Handbook, 2010-11).

There are also "cost engineers" in the US, who have this degree on graduate training (AACE, 2010).

According to Uğur (2007a), costs are considered of utmost significance by 62% of the firms and of least significance by only 8% in construction projects. 77% of construction firms use the unit price and comparison with similar projects. 62% is reported to use data of past projects. While 23% prefers computer software for cost estimation, 38% uses escalation based cost estimation procedures.

As another practice in Turkey, based on the latest literature assessed, database models used for "cost management" in Turkey include R.S. Means Company, Inc's "Unit Price Cost Multiplier Method", proposed for complete use and the "Square Foot Estimate Method" proposed for partial use by Polat et al. (2005).

Dikmen et al. (2007) proposed a fuzzy risk assessment methodology for international construction projects in Turkey, which uses the influence diagramming method for construction of a risk model and a fuzzy risk assessment approach for estimating a cost overrun risk rating. The proposed procedure has been implemented in an international construction company carrying out a project in Turkey. Findings of the case study demonstrated that the proposed methodology can be easily applied by the professionals to quantify risk ratings, with the advantage of the providing guidance for a company about the amount of risk premium that should be included in the mark-up.

Günaydın and Doğan (2004) also worked on cost management issues in Turkey. They investigated the utility of neural network methodology to overcome cost estimation and showed that using this methodology an average cost estimation accuracy of 93% was achieved.

Sönmez (2008) presented implementation of bootstrap method for conceptual cost estimating. According to the author, bootstrap method offers several advantages over the classical statistical techniques. The nonparametric bootstrap avoids restrictive and sometimes dangerous assumptions about the form of the underlying populations.

Sönmez et al., (2007) presented a model that used regression analysis for determination of the contingency amount in international projects.This model explained the majority of the variations in the contingency levels and had a reasonable predictive accuracy.

With regard to differences in cost management practices in the US and in Turkey, we can comment that special importance is not given to this issue (Uğur, 2007a) that might be due to cheap workpower in Turkey. However, in the US, every effort is dedicated to cost reduction.

Because there is not sufficient literature regarding cost management practices in Turkey, a broader comparison has not been possible. The issued related to cost management practices in the US and in Turkey are given in Table 3.6.

Table 3.6: Comparison of Cost Management Practices in the US and in Turkey

COST MANAGEMENT	Practices in the US	Practices in Turkey
Responsible team/person	Usually construction management team[a] Cost estimator[b] Cost engineer[c]	Usually an engineer[d]
Cost estimating	Mostly based on computer software[e]	~1/4 prefers[d]
•Methods/Models	Parametric and probablistic[f,g] Highly comprehensive ones like APRAM[h]	Mostly parametric[d,ı] *Fuzzy sets[j];neural networks[k];[l]bootstrap
• Cost overruns	To some extent[g]	Deviations in cost estimating in a large extent[m]
• Consideration	Very important[a]	~1/3 may not consider of utmost significance[d]
Concurrent engineering use	Found to reduce costs[n]	No data on cost management
Success in cost management	Satisfactory reduction in costs[o]	Not satisfactory[d]

[a]CMAA, 2010; [b]CE-Occupational Outlook Handbook, 2010-11; [c] AACE, 2010; [d]Uğur, 2007a; [e]CMAA, 2010; [f]Larson, 2002; [g]Bordat et al., 2004; [h]Imbeah and Guikema, 2009; [ı]Polat et al, 2005;[j]Dikmen et al.,2007; [k] Günaydın and Doğan, 2004; [l]Sönmez, 2008;[m] Bozkurt and Kuruoğlu, 2007; [n]Karlsson et al., 2008; [o]Hanna, 2010; *No data on regular usage of these models.

3.3 Time Management Practices in the US and in Turkey

Wasting time is one of the biggest problems in construction industry even in the US. An analysis for quantifying levels of wasted time reveals that an average of 49.6% of time in construction is devoted to wasteful activity (Horman, 2005).

Galloway, the ASCE's first woman president assuming office in 2003 (ASCE, 2003), indicates that there is a growing need for project controls on today's construction projects. Not only is on-time delivery important, it translates directly into whether the parties will earn a profit and/or provide a return on investment. Delivering a project on time does not just mean signing a contract and hoping that the required completion date will be met. More often than not, the majority of today's construction projects encounter events and/or changes that affect the original plan of executing a project. Further, resources such as labor, material, and equipment may be scarce, in high demand and as a result may hamper project execution. Attempting to solve these unforeseen issues during a project without a plan in place to determine the immediate impact is a major risk which can often lead to delayed projects and disputes between the parties (Galloway, 2006a).

To achieve best practices in time management, CPM scheduling is known to be used for time management purposes as discussed in section 2.1.3 of this work.

According to Galloway, (2006b) while critical-path method (CPM) scheduling has been around since the 1950s, its application in the construction industry has still not received 100% acceptance or consistency in how it is used. The author carried out a survey for the stakeholders in the construction industry in order to determine how the industry views its applicability and usage. This survey depicts a clear picture of the use of CPM scheduling for construction projects based on the survey questions responded by both the owners and the contractors, which reflect the US practices relevant to this area. In Table 3.7, the findings of this survey are summarized.

To reflect practices on the use of CPM scheduling more comprehensively, it should also be added that reasons for use of CPM by the contractors included the following (Galloway, 2006b):

- Periodic control of work after start of construction (85%)
- Developing look-ahead schedules (85%)
- Coordination of subcontractors (82.1%)

Table 3.7: Construction Industry Views on the Applicability and Usage of CPM

		Owners	Contractors
Requirement for CPM scheduling		Always required on their projects (47.6%)	67% prepare
Contract specifications for CPM scheduling		72.5% do specify	Specified (> 50%)
Software		Primavera (>64%); MS Project (>20%); Others (OPLAN, MS Excel, Government Proprietary software, CBCM, and CA Super Project)	Contract specification valid
Methods		Precedence diagramming methods (46%); Arrow diagramming CPM scheduling (14%)	Contract specification valid
Other scheduling techniques		Bar charts or some other form (50%); PERT (27%); 4D Planning (4%); Line of Balance or Linear Balance Charts (20%)	Contract specification valid
Views on CPM scheduling	**Advantages**	"What if" scenarios could be performed to determine impacts on changes and delays to the project Allows summarization into a bar chart format	• Improved planning before work starts (92%) • Improved scheduling (84%) • Improved understanding of the project (83%) • Improved project control after work starts (80%) • Improved communications among the workforce (54%) • Increased control over risk and uncertainty (53%) • Reduced delays (50%) • Minimization of disputes between the contractor and owner (46%) • Time savings (39%) • Faster response to problems (34%) • Cost savings (30%) • Improved estimating/bidding (28%) • Helps train future project managers (26%) • Positive psychological effect on employees (22%) • Imparts a sense of control for the management team enabling them to accurately plan ahead • Useful tool to discuss issues that could be clearer • Gets owners to react more quickly
	Disadvantages	The construction managers and project managers do not use the software enough to be knowledgeable in its use and what it is portraying The contractor is more informed about CPM and can more easily manipulate the schedule and use it for claims.	• Requires excessive work to be implemented (32%) • Requires too much dependency on specialists (26%) • Not responsive to the needs of field personnel (21%)

- Detailed planning of work prior to construction (78.1%)
- Schedule impact, claims analysis and tracking of changes (75%)
- Coordination of own trades (59%)
- Estimating and bidding (44%)
- Tracking shop drawings and submittals (39%)
- Calculating payment requests for work performed (31%)
- Design development (28%)
- Operation and maintenance of projects (22%)
- Tracking costs (18%)
- Materials planning (less than 3%)

Based on the results of this important survey, Galloway (2006b) reaches the following conclusions to reflect practices on this issue in summary:

1) CPM scheduling has become a standard project control tool and both owners and contractors use the tool whether it is or is not required by contract
2) While all parties generally felt that CPM scheduling was a good project control tool for monitoring, planning, and executing a project, commonality existed relative to: a. CPM scheduling has become so sophisticated that specialists in CPM scheduling are now required to develop and understand CPM schedules, b. While Primavera software is the number one choice among the stakeholders, it is believed to be complex and difficult to understand, thus increasing the cost to the project, and c. CPM schedules are easily manipulated, especially with respect to logic abuse
3) Of the two organizations which primarily have CPM scheduling as a key focus: PMICOS and AACE, more than 70% of the respondents had not heard of one of the organizations
4) The majority of those responding indicated that they believed certification of schedulers would improve the industry
5) The majority of those responding indicated that there was an immediate need for standards for CPM scheduling although half of those responding did not know who should develop such standards and the remainder

indicated multiple organizations; noting that the organizations should come together to develop common standards

6) Over 92% indicated that they desired to have some sort of best practices guidelines that could be issued to both owners and contractors relative to CPM scheduling
7) The majority of the respondents felt that CPM scheduling was beneficial in risk management applications
8) Most participants agreed that there should be consistency in the university curriculums

Time management, especially time contingency, is crucial in construction (project) management. Various prediction models are being used in the US for estimating the expected time contingency of a construction project.

According to Mohamed et al. (2009), construction projects often suffer from high level of uncertainty in some aspects such as time, cost, quality, safety. Most of the conducted research focuses on estimating cost contingency. Even though construction project scheduling has received extensive attention of researchers, time contingency was not treated well in the literature. In order to meet the deadline of a project, an accurate scheduling should be sought. Due to the nature of construction projects, scheduling should be flexible enough to accommodate changes without negatively affecting the overall duration of the project. Mohamed et al. (2009) assessed the factors that affect scheduling contingency and developed a simple model that can be used in estimating the expected time contingency of a construction project. A survey was conducted on sixteen construction companies in Montréal, Québec, Canada. The data obtained from the survey was then processed using Analytic Hierarchy Processes (AHP) to develop a time contingency model. Results showed that the predicted time contingency matches with 87% the estimated contingency for real projects (Mohamed et al, 2009).

Ongoing research as presented above puts forward efforts in the US to manage time in construction. However, it is still a problem in the US as the work of Horman (2005) demonstrates the time wasted.

As to time management practices in the US, principles, aims, processes, projedures and tasks are clearly defined in CMP standards of the CMAA as shown in the time management columns in every stage of construction processes in a table (Appendix 1).

It is also useful to give graphic formats for scheduling that are widely used in the US as proposed by CMAA to reflect time management practices in the US (CMAA, 2010b):

- AOA: Activity-on-Arrow Diagram Method
- ADM: Arrow Diagram Method
- PERT: originally "Program Evaluation Research Task, now "Performance Evaluation and Review Technique"
- PDM: Precedence Diagram Method, or Activity-on-Node

The Association for the Advancement of Cost Engineering (AACE) released a recommended practice on time impact analysis as applied in construction from the point of view of cost engineering, which would be helpful as a "how-to-do" approach. This document provides guidelines for the project scheduler to assess and quantify the effects of an unplanned event or events on current project completion. In this document, time impact analysis is accomplished by following the steps shown in Table 3.8 (AACE Recommended Practice No. 12R-89).

Table 3.8: Steps of Time Impact Analysis

Step 1	Model the impact with a schedule fragnet
Step 2	Select the appropriate accepted schedule update to impact
Step 3	Insert the fragnet into a copy of the current schedule update prepared
Step 4	Insert the durations used in the fragnet into the added delay activities and recompute the CPM
Step 5	Identify the activity indicating project completion and note any change in the project completion date
Step 6	Determine the correct time impact for the project delay
Step 7	Determine the actual dates of the delay
Step 8	Eliminate delay dates from the time impact analysis request that have previously been awarded

The Association for the Advancement of Cost Engineering (AACE) also describes schedule levels of detail— as applied in engineering, procurement and construction. This recommended practice (RP) is intended to serve as a guideline for owners and contractors to establish a common frame of reference and understanding when describing the level of detail for any construction project schedule. In this recommended practice, Engineering, Procurement, Construction (EPC) schedule levels are described as shown in Table 3.9 (AACE, Recommended Practice No. 37R-06).

Table 3.9: Engineering, Procurement, Construction (EPC) Schedule Levels

EPC Level 1 Schedule	Summarizes the overall project for client and management
	Shows start and finish dates for the major project phases and key milestones (such as design, procurement, construction, and commissioning and start-up)
EPC Level 2 Schedule	Contains more detailed activities for each of the summary phases previously identified in the Level 1 schedule
	Often includes a breakout of the various trades or disciplines responsible for the activities in each phase, the critical procurement activities, the major elements of construction, and general commissioning and start-up requirements It is the first level of scheduled detail where logical links or task relationships may be shown
EPC Level 3 Schedule	It is the first level where the full use of critical path method (CPM) techniques could be shown effectively
	In addition to start and finish dates for each grouping of deliverables or activities within each phase of the project, it also includes major review and approval dates
EPC Level 4 Schedules	They are detailed work schedules and generally would be prepared outside of the CPM software, with correlation to the CPM schedule activities and scope of work

As an indepth research matter, Kim and Ellis (2010), in an effort to address the issue of time management, analyzed the schedule generation schemes- the serial scheme and the parallel scheme- to identify their performance, using a permutation-based Elitist genetic algorithm. The algorithm using the serial scheme is shown to provide better solutions than the one using the parallel scheme.

US researchers report that one way to achieve sustainable reductions in design delivery time is to develop a framework based on concurrent engineering principles. In order to achieve desired time-saving goals, concurrent engineering advocates concurrent, overlapped processes instead of sequential product and process design

Considering that the concept of concurrent enginnering evolved in the manufacturing industry as a necessity to meet the requirements of today's competitive market that demands shorter time-to-market for new products, similarities between product development in manufacturing and the design construction process in the AEC industry have led several researchers to address concurrent engineering in the AEC industry (Bogus et al., 2005).

Karlsson et. al. (from the US) (2008), in a research aiming to identify best practices for integrating the concurrent engineering environment into multipartner project management, report 40% time saving related to request for information (RFI) process (2 days per RFI) (traditionally disseminated by fax between parties), about 326 fewer days in information distribution delays, and overall time savings of about 365 hours (aproximately 46 work days).

Eldin (2005) also points to concurrent engineering as a schedule reduction tool, implementation of CE showing a promising potential for reducing project delivery time with a reduction of up to 25% of the project schedule.

With regard to concurrent engineering practices in Turkey, it is reported that 33% of the Turkish contracting firms had no knowledge on “concurrent engineering (Öcal and Şekerci, 2009).

Regarding best practices in time management, Hastak et al. (2008) analysed the techniques leading to radical reduction in project cycle time. Top ten schedule reduction techniques are identified as follows:

1) Use of electronic media
2) Startup-driven scheduling
3) Participative management
4) Construction-driven schedule
5) Pareto's Law management
6) Realistic scheduling
7) Well-defined organizational structure
8) Avoidance of interruption
9) Non-traditional drawing release
10) Vendor/Engineer early information exchange

Bohn and Teizer (2010) indicate that high-resolution automated cameras can reduce the time needed for project control, which is one of the most time-consuming tasks for construction managers.

Other than research, practical "how-to-do" applications on time management are given in detail in a table (Appendix 1).

Regarding Turkey, it seems that "time management" has the least importance in construction management domain because of insufficient literature on the subject. However, a limited number of articles point to the efforts for achieving proper time management practices in Turkey as well.

Applications of Analytic Hierarchy Process, although not exactly for time management, but for the selection of construction area in Turkish construction industry (Tezcan et al., 2009) show promise for its use to develop a time contingency model.

As also commented above, Uğur (2007) indicates that time is considered of utmost significance only by 23% of the firms, of intermediate significance by 31%, and of the least significance by 23% in construction industry. Regarding time estimation practices, 77% of the firms compare similar projects, 62% uses already available data on past experiences, 54% make a separate analysis of each item, and 38% seeks assistance from experts, with 38% not attempting any time estimation.

Factors influencing time planning in the construction projects has been the subject of investigation as well as a Master's thesis (Şaşmaz, 2005).

Kuruoğlu et al. (2009) listed the groups of influencing factors for time planning as the following:

- Project related factors
- Factors related to the use of resources
- Administrative factors
- Uncontrollable factors

Among these group of factors, the most influencing parameters were found to be "the use of an efficient work program", " timely delivery of the materials", "workforce efficiency", "adequate number of experienced administrative personnel" and "firm-based financial problems".

On the other hand, Turkish engineers have also worked with sophisticated models to improve time management practices. Ökmen and Öztaş (2008) presented a new simulation-based model — the correlated schedule risk analysis model (CSRAM) — to evaluate construction activity networks under uncertainty when activity durations and risk factors are correlated. The authors applied this model to a single-story house project. The findings of this application showed that CSRAM operates well and produces realistic results in capturing correlation indirectly between activity durations and risk factors regarding the extent of uncertainty inherent in the schedule.

Ökmen and Öztaş (2006) also report their experience with CPM and PERT.

Time management practices in the US and in Turkey are compared in Table 3.10.

Table 3.10: Comparison of Time Management Practices in the US and in Turkey

TIME MANAGEMENT	Practices in the US	Practices in Turkey
Amount of waste time in construction projects	Approximately 50%[a]	No data
Use of CPM scheduling	Encouraged greatly[b]	Some experience[c]
• Requirement	~50%[b]	No data
• Contract specification	72.5%[b]	No data
• Software	Primavera>MS project[b]	Primavera[d]
Use of other scheduling techniques	Bar charts or some other form (50%); PERT (27%); 4D Planning (4%); Line of Balance or Linear Balance Charts (20%)[b]	Comparison; available past data[d]
Concurrent engineering	Shown as a schedule reduction tool[e]	1/3 has no knowledge[f]
Consideration	Very important[b]	Sometimes of least significance[d]

[a]Horman, 2005; [b]Galloway, 2006b;[c]Ökmen and Öztaş,2006;[d]Uğur, 2007a;[e]Eldin, 2005; [f]Öcal and Şekerci, 2009

3.4 Quality Management Practices in the US and in Turkey

In the US, quality management is considered to be very important in the construction industry.

Total Quality Management (TQM) philosophy concentrates on process improvement, customer and supplier involvement, teamwork, and training to achieve customer satisfaction, cost-effectiveness, and defect-free quality work. It focuses on continuously improving the process that makes the product rather than attempting to inspect or test the product to achieve quality (Crosby, 1990).

Total Quality Management (TQM) gained popularity in the United States in the 1970s as the success of the Japanese quality control programs became evident. In the 1980s, TQM began to be used by the construction and engineering communities within the US (Kuprenas et al. 1998).

Professional organization pay special attention to qualtiy management issues.

As an example, the National Society of Professional Engineers (NSPE) (NSPE, 2010) suggests the adoption of TQM by all parties (architects, engineers, owners, vendors, and subcontractors) throughout the construction process.

Also, the Construction Industry Institute (CII) created a quality management task force (QMTF), commissioned in the summer of 1985 (CII,2010b), to conduct research in the construction industry to identify attributes of quality management organizations and techniques that have been considered to be effective in the construction industry. The objectives of the task force were to identify the reasons for the effectiveness of the attributes, how they were developed and implemented, and to recommend generic guidelines for achieving improved quality management in the construction industry. The CII QMTF emphasized that an integrated approach of TQM and quality assurance/quality control is required to improve the quality of the products and services provided by the construction industry (Arditi and Günaydın, 1998).

In the spring of 1990, CII formed two additional task forces focused on quality, the Total Quality Management Task Force (TQMTF) and the Quality Performance Measurement Task Force (QPMTF). The purpose of the TQMTF was to further investigate the implementation of TQM in the construction industry. One of the main products of this task force was a roadmap for implementing TQM from a broad, company-wide perspective. The QPMTF focused its attention on measurement at the project level (CII, 2010b; Ries et al., 2010).

The success of these construction and engineering firm implementations, however, has been inconsistent for a variety of reasons (Kuprenas et al., 1998).

In 1990 Iowa State University researchers held a national workshop for owners, designers, contractors, and subcontractors to address Total Quality Management (TQM) in the design and building process. The participants identified many problems that faced the industry in the United States, with the first three problems being (Chase and Manning, 1990):

- Lack of teamwork,
- Poor or insufficient communication and co-operation,
- Inadequate planning and scheduling

The Construction Institute of ASCE sponsored a survey of construction owners to ascertain the owners' satisfaction level with the performance of the individuals in relation with quality in which design quality was found to be the biggest problem facing the construction effort (Minchin, 2010).

Regarding quality management practices in the US, the work of Deffenbaugh (1993) serves as a good example. The problems identified at this research formed the basis for development of a model for TQM implementation on the jobsite called “Jobsite Quality Planning” in which TQM tools and techniques are used to arrive at a common project mission supported by specific objectives. Following the quality principles of customer satisfaction, respect for people, management by fact, and continuous improvement, a quality lead team puts its unique plan into action. It focuses on recognition, quality teams, quality indicators, and training and development.

Ries et al. (2010) attempted to identify best practices regarding quality management systems in the US. The research found that organizations with highly effective quality management systems had demonstrable management commitment with adequate resources for effective quality management which included capable and consistent quality procedures across the organization, integrated and aligned quality management and project execution processes, effective training, strong partnerships with suppliers and contractors across the project life cycle, metrics that met organizational and project needs, and quality metrics used during all stages of engineering, procurement, construction, and start-up and commissioning.

Gransberg and Molenaar (2004) analyzed of owner’s design and construction quality management approaches in design-build projects. The six approaches identified are quality by qualifications, evaluated program, specified program, performance criteria, specification, and warranty. These are important for design-build contractors to understand so that they can craft their proposal in a manner that is both responsive to the owners' requirements and consistent with the owner's system to make the best value contract award decision.

Arditi and Günaydın (1998) identified the factors that affect process quality in the three phases (design, construction, and operation) of the life cycle of a building project and ranked by degree of importance.

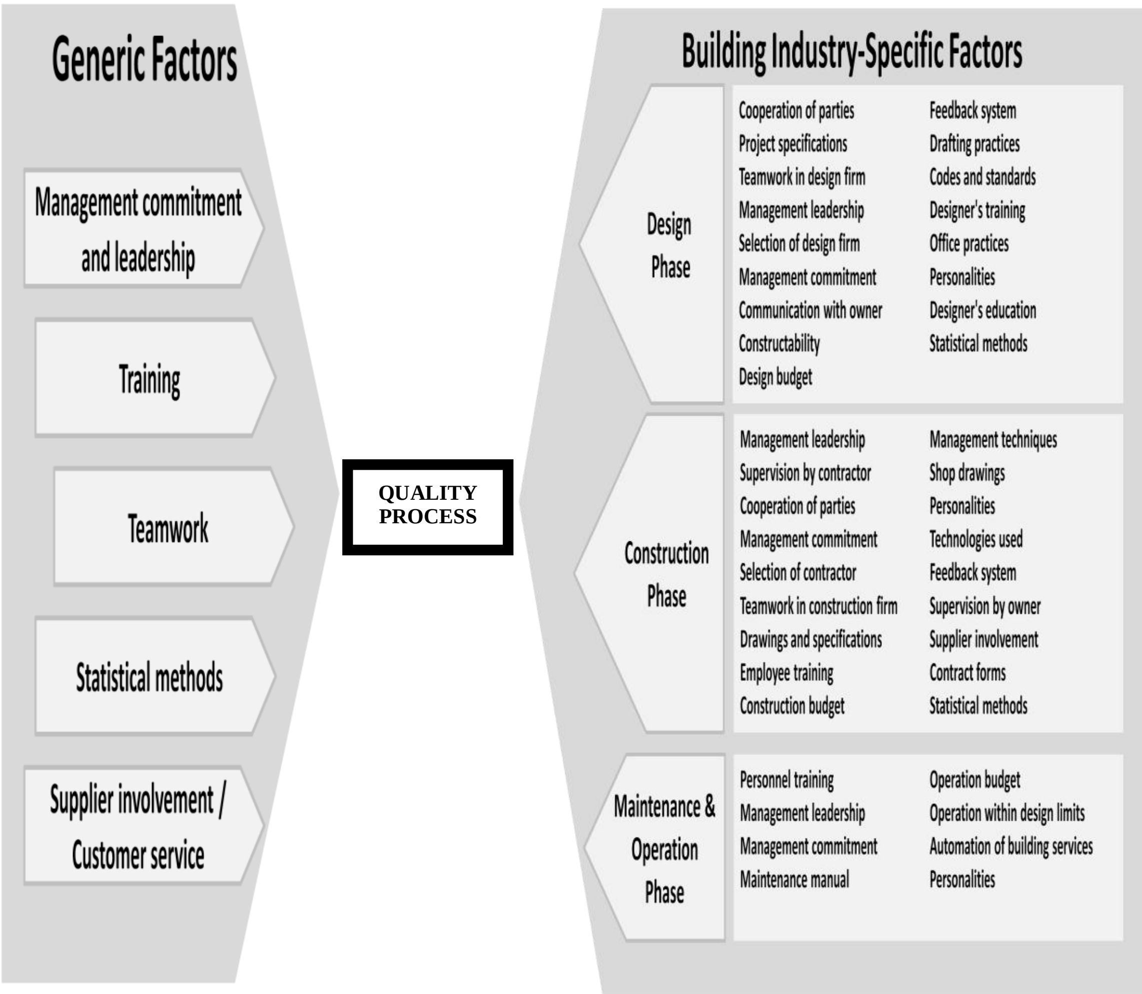

Figure 3.2: Factors that affect quality (Adopted from Arditi and Günaydın, 1998)

Kuprenas, and Kenney (1998), having analysed the status of the TQM implementations in some construction companies in 1993 and afterwards in 1997, found three strong links that carried through the four years:

1) Certain reasons and methods for using TQM are traditionally linked, and organizations follow a logical progression of linked reasons and methods

2) Firms that undertake TQM implementations for quality reasons are more successful than firms that implement TQM programs for profit reasons
3) An organizational structure change is necessary for an effective TQM implementation

Some international quality standards that are being used in the US, certainly internationally as well) are the following:

ISO 9000 in construction

ISO 9000 is an umbrella name given to a group of standards developed to build a management system that will support continuous improvement in quality. The ISO 9000 family of standards embraces the use of Plan-Do-Check-Act principles and various project management procedures to enhance quality (ISO, 2010).

Due to the generic nature of ISO 9000, it has also been implemented in the construction industry. Specifically, ISO 9001 and 9002 can be applied to construction-related firms.

Benefits associated with the adoption of ISO 9000 quality standards have been found to include increased profitability, expanded market share, increased customer satisfaction, reduced operating costs, heightened demand for products and services, and better employee working conditions (Koehn and Datta, 2003).

ISO 14000

The ISO 14000 family addresses various aspects of environmental management. ISO 14001, an integral part of the ISO 14000 series of global environmental management standards, integrates business practices and environmental goals that enable an organization to manage its potential impact on the environment. From an operational perspective, utilizing the ISO 14000 criteria can lead to reduced cost of waste management, savings in consumption of energy and materials, lower distribution costs, improved corporate image among regulators, customers and the public, and continuous improvement of environmental performance. The Environmental Protection Agency in the US is encouraging the use of recognized environmental management frameworks, such as the ISO 14001 standard, as a basis for designing procedures and implementing outcomes aligned with the US environmental policy goals (Koehn and Datta, 2003).

ISO 18000 in Construction

The ISO 18000 criteria has been proposed for the development of an occupational health and safety management system. The requirements are similar to the ISO 14001 environmental management systems (EMS) standards. The primary difference is the ‘‘risk assessment’’ section, which replaces the environmental aspects section of ISO 14001, and the substitution of the words ‘‘health and safety’’ for ‘‘environmental.’’ It also requires a management system that identifies, controls, and seeks continuous improvement in occupational health and safety (Koehn and Datta, 2003).

It is interesting to note that the construction industry in the United States has generally lagged behind other industries and other countries in the acceptance and implementation of ISO 9000 standards. Differing opinions surround the issue of ISO 9000 in the U.S. construction industry; it has received either the support or the criticism of experts, who weigh the effects of ISO 9000 as a matter of real improvements in quality against competitiveness and specific requirements at a domestic and international level (Chini and Valdez, 2003). In a questionnaire survey, Chini and Valdez (2003) reported that a majority of companies (94%) have quality systems in place. Some have an internal quality assurance department or system. Other firms have specific quality systems such as standards for marine transport and codes from the American Society of Mechanical Engineers (ASME). Some companies are implementing quality systems based on ISO 9000. These firms may be motivated to implement but are unwilling to go through the burden of the certification process of ISO 9000. A large percentage (83%) of these firms are not pursuing ISO 9000 certification at present (as of before 2003).

Rosenbaum (1997) advocates the use of ISO 14001 in the US. He indicates that there is a quiet revolution occurring that is about the ascendancy of environmental management systems such as ISO 14001 as an alternative to “command-and-control” environmental regulation. He points to the concerns of the press on the legal disadvantages an organization may meet by adopting ISO 14001. Many of articles express concerns over audit confidentiality, creation of “litigation road maps,” reporting consideration under various environmental statutes, and the potential liability of outside auditors. He also points to the advantages of ISO 14001 that may provide significant legal protections in the following five general areas: (1)

insurance, lender, and investor liabilities; (2) contractor and supplier liabilities; (3) regulatory and criminal liabilities; (4) civil liabilities; and (5) trade embargoes.

These international quality standards are more welcome in Turkey in construction industry.

Çerçi and Ergönül (2007) report that the majority of ISO 9001 certified construction firms clearly benefit from this certification. Client satisfaction, competing with other companies, quality and efficiency are reported to be the positive consequences of such a certification.

With regard to auditing quality management performance, Samuel (1994) describes the technical practice of the construction facilities audit executed in 1994 when the procedures for conducting audits of construction systems were relatively new. The construction facilities audit analyzes the effectiveness of complex quality-management systems by focusing on the end results of the system, that is the actual construction. Information about construction nonconformities or defects can be used to trace back through the system to the appropriate planning, design, or construction processes and correct the process for future projects.

The objective of construction facilities audits can be summarized as follows: Optimize the performance of the quality system, follow up on appropriateness of organizational planning, monitor effectiveness of policy and procedure applications, recommend and implement system improvements, provide consistency among inspectors and projects, analyze effectiveness of standard designs and specifications, analyze and improve constructability of project documents, provide information for life-cycle facility management, and determine training needs.

The typical steps to a field review of facilities audit include the following:

1) Review of project requirements
2) Arrange for facilities audit
3) Perform facilities audit
4) Hold close-out conference
5) Classify findings
6) Commend those who have most contributed to the success when there are no findings
7) Correct processes

8) Issue report to operations
9) Correct construction process
10) Correct design process

Samuels (1994) concludes that construction facilities audits should be performed when real-time, objective information is needed for positive quality management system control. Audits are particularly important when system changes are being made.

In this section of quality management, it may be useful to include inspection issue, which is a sine qua non of quality control.

In New York City, in order for a building to obtain a Certificate of Occupancy, the structure must pass a series of inspections, as well as a walk-through from the Department of Buildings (DOB). In most cases, the inspections include, but are not limited to, plumbing inspections, sprinkler inspections, fire alarm inspections, electrical inspections, fire pump pressure tests, architectural inspections (where inspector checks if building was built in accordance with an Architect's stamped and approved drawings), elevator inspections, completion of lobby, and an inspection to see if the building complies with the proper amount of egresses required for its size. After all inspections are passed, the last step is generally to have a walk-through by a member of the Department of Buildings (DOB), who sees that there is no major construction remaining on the job site, that there are no obstructions to the egresses, that there are no safety hazards in the building, and that everything in the building was built according to plan. If the inspector approves his walk-through, a Certificate of Occupancy is usually granted. A Temporary Certificate of occupancy can be issued if DOB determines that the building is safe enough to occupy towards the end of the project. TCO usually expires after 90 days after its issue date. A new building cannot be legally occupied until a final or a temporary Certificate of Occupancy is granted.

Therefore, in order to get Certificate of Occupancy, material test results and controlled inspections must pass. All material tests are performed according to American Society for Testing and Materials Standards.

American Society for Testing and Materials (ASTM) (ASTM, 2010), is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services.

Here are the major steps of an inspection procedure for testing materials and applications:

- Site visit
- Meeting with the client representative, other project officials and the contractor
- Review of approved plans, drawings and specifications
- Inspection of the location and the materials of the work
- Sampling the materials used
- Reporting (A report form is given as Appendix 2)

Regarding testing procedures, below photographs examplify how these testing procedures are performed in the US.

A Case Study: An NYCSCA Project at a glance from QA/QC aspect (FTCNY, 2010)

The School Construction Authority (SCA) was established by the New York State Legislature in December 1988 to build new public schools and manage the design, construction and renovation of capital projects in New York City's more than 1,200 public school buildings, half of which were constructed prior to 1949.

SCA completely accountable for the Capital Program had several goals:

1) To improve management of the construction process,
2) To reduce school construction costs by simplifying design standards, and to
3) Increase competition among contractors.

NYC SCA manages numerous renovation projects as well as new construction projects one of which is Public School 273 in Queens, NY.

Futuretech Consultants of NY Inc. is responsible from QA/QC of the Project.

Project: PS 273 Queens (New School)

Address: 88-01 102nd Street, Queens, NY 11418 USA

Owner: The City of New York

General Contractor: Turner Construction Company

Construction Manager: New York City School Construction Authority

Inspection Sub-contractor: Futuretech Consultants of NY Inc. (FTC)

FTC is directly hired by NYCSCA to make controlled on-site inspections, test materials used and sign off the project.

Inspection & Testing Services given by FTC at this Project:

- SOIL INSPECTIONS AND TESTING: Including subgrade Inspection, Controlled Fill Inspection, Percolation Testing, Sieve Analysis, Proctors, Borings.

Figure 3.3: Field test for water leakage test: Water tests are performed components and facades, like window assemblies, metal panel systems, storefronts, curtain walls, roofs, and skylights. Testing may be performed at various stages of construction, but the best timing is to test prior to the installation of finished interior wall materials.

Figure 3.4: Concrete inspections: Concrete is tested and sampled at least once at every 50 cubic yard of each pour. Temperature, slump, unit weight & air content should be tested for every batch sampled. In the City of New York only ACI certified field technicians can perform such non-destructive tests.

- CONCRETE STRUCTURE INSPECTION AND TESTING: Including Field placement Inspection, Concrete Sampling, Steel Reinforcement Inspection.
- STRUCTURAL STEEL INSPECTION: Including Shop Bolting & Welding Inspections, Field Bolting & Welding Inspections, Metal Deck Inspections
- FIRE PROOFING INSPECTION: Including Field Inspection, Cohesion/Adhesion Testing, Density Testing.
- FIRE STOPPING FIELD INSPECTION
- MASONRY INSPECTION: Including Placement Inspection Mortar & Grout Sampling and Testing Block and Brick Testing Prism Testing
- MECHANICAL INSPECTIONS: Including HVAC Inspection, Fuel Burning/Storage Inspection Refrigeration System Sprinkler Testing High Pressure Steam Standpipe Testing

QA/QC activities consist of inspections of applications and testing of materials. Since FTC is responsible for overseeing several number of trades listed above, a crew of certified engineers and technicians are assigned for this particular project. Work is performed based on a dispatch cycle which is scheduled upon NYC SCA’s (CM) request. Depending on the magnitude of the work, inspectors/engineers can assigned either half day or full day of inspection. All field personel of FTC has to sign-in with the CM at the beginning of the job and has to sign-out when inpection is done and they are ready to leave the jobsite.

An 8 Hrs weekday's cycle starts at 7:00 am in the morning and finished 3:30 pm in the afternoon including a 15 minute coffee break and excluding a 30 minute lunch time. Early start is prefered in the construction industry in order to avoid delays of delivery of materials due to rush hours' traffic both in the morning and in the afternoon.

Controlled inspections are scheduled upon CM's request. Obviously there is no need or sometimes possiblity to make all related personel present at the jobsite at all times.

There is an FTC project engineer who is a P.E. present at the jobsite throughout the entire project but other inspection personel is at the job whenever CM calls for.

A typical concrete inspection takes place as follows;

Inspection personel including PEs, other engineers and technicians are present at the jobsite at least 30 minutes prior to the pour. As the contractor prepares for the pour, inspectiom crew prepares for the inspection. This is a routine wet concrete non-distructive inspection. The first thing an inspection personel should do is to see an approved concrete mix design at the jobsite of the concrete to be delivered. Otherwise neither the inspection nor the wet tests would not make any sense unless there is an approved mix design to compare the results with.

The inspection for this specific project covers the following procedures:

Concrete inspector arrives at the jobsite at least 30 minutes prior to the concrete pour. Inspector has to be provided with an aproved mix design in order to perform non-distructive concrete tests. As the pre-mixed concrete mixers start arriving at the jobsite, concrete inspector checks all the mixer receipts and batch ticket to insure that wet concrete delivered to the project is the right, approved concrete which has not been overtime. According to ASTM standards, the inspector has to make temperature test, slump test, unit weight test and air test for every 50yrds of wet concrete delivered to the site. After these tests, concrete inspector should prepare sample specimen for strength tests. According to the client need 1day, 3days, 7days or 14days results can be requested. The actual strength of the concrete poured will be 28 days result. Licensed comcrete inspector is responsible from the wet test results and the waiting time of the mixers onsite. Any difficient result or situation should be immidiately reported to an authorized person onsite. Inspector is also responsible of reporting the healty result and any problem observed on the written report which is to be submitted to FTC Inc.

According to Kazaz (2005), achievement of acceptable levels of quality in the construction sector is problematic in Turkey with great expenditures of time, money, and resources being wasted each year due to inefficient or nonexistent quality levels prevailing in the industry. In the case of mass housing projects, the deviation types were assessed and it is concluded that households are not completely satisfied from the quality of products and/or services delivered within their housing units. The authors recommend that the causes and costs of the rework should be researched for better understanding the results together with the remedial measures being implemented.

Güner (2003) evaluated total quality management issues in Turkey and reached the following findings:

- 53.7% of the firms in construction sector in Turkey has not at all attempted to deal with quality management issues or has just started to deal with this issue; while 46.3% has already dealt with quality management and some had ISO 9001 documents
- 46.7% of the firms in the construction industry has no quality standards, while 53.3% does
- Half of the firms has implemented training on quality for their employees and half did not
- 26.7% of the firms in the construction industry did something regarding motivation, 73.3% did not
- While 86.7% of the firms has never evaluated employees' satisfaction, 13.3% did

Güner and Giritli (2004) indicate that corporate culture has been identified as the primary factor that affects whether or not total quality management implementation efforts was successful. They observed that there is lack of top management commitment, leadership, understanding of necessity of culturel change to establish corporate culture, acceptance of internal customer concept, common education, motivation, coordination, team work, partnering, and participation of employees, sub-contractors and suppliers to quality. Therefore most of the implementations of total quality management in construction industry is unsuccessful. Total quality management values will only be established if managers are able to understand and accept total quality management's concepts and values, identify the desired culture and manage the organisation in a manner consistent with these values. The success of quality depends on the genuine commitment to quality of every member of the organization.

These findings imply that there is a need for the construction sector in Turkey for more effort to improve its quality management practices.

On the other hand, some Turkish investigators point to promising activites regarding quality management related issues in construction industry in Turkey.

Oztas et al., (2004), having investigated the status of total quality management (TQM) implementation in Turkish cement industry, indicate that the importance of TQM has increased in Turkish cement industry because of customers' demands and the realization that the effective quality system is a foundation of better performance. They indicate that the employees have the necessary experience and qualifications and will not have any difficulties in reaching their goals of applying TQM philosophy. The firms are collecting data to evaluate their work performance and are trying to measure the level of service provided, and are evaluating the collected data in order to solve any problems through teamwork In almost all of the firms,the top management supports the quality improvementprogrammes that will lead the firms to success in a short period of time.

Turk (2009) examined the application of ISO 14000 environmental management system (EMS) in construction in Turkey. It is known that the ISO 14000 EMS series acts as a guide for firms to minimise the use of materials harmful to the environment, to plan the production process in a manner that minimises the amount of waste and to develop waste management in a way that directs the respective management strategies to take into account environmental concerns (ISO, 2010). It is obvious that EMS can provide a reduction of potential impacts from construction investments to the environment as an important activity area in Turkey and find solutions for construction wastes, facilitate compliance with legal regulations regarding the environment, provide a competitive edge for Turkish firms operating internationally and serve as a guarantee for the protection of the environment. Turk (2009) indicates that the utilisation of the ISO 14000 EMS by construction firms in Turkey is rather new, the number of ISO 14001 certificates held by construction firms in Turkey being low when compared to other countries, particularly European and Asian countries. However, he reports that there is a positive approach to the ISO 14000

EMS within the construction sector in Turkey. Among the firms surveyed, 71.8% (28) of those that do not have ISO 14001 certificates, are considering obtaining them in the near future.

Comparison of quality management practices between the US and Turkey is given in Table 3.11.

Table 3.11: Comparison of Quality Management Practices in the US and in Turkey

QUALITY MANAGEMENT	Practices in the US	Practices in Turkey
Advocacy	Professional organizations, task forces, committees (CII, NSPE,ASCE..)[a,b,c]	Mainly IMO[d]
Interest	Considered very important[e]	>50% not dealing with QM[f]
Problems	Lack of teamwork ;Design quality [g,h]	Mainly corporate culture[ı]
Quality standards use	Mainly their own standards[j]	Half of the firms with no quality standards[f]
• Use of ISO standards	Some ISO 9001;~80% are not using[j] ; problems with ISO 14001[k]	Some ISO 9001[f]; some 14001[l]
Codes	A great variety -e.g. ASTM codes for materials[m]	Mainly TSE[n]
Quality audit	Common practice[o]	
Best practices identified	Management committment[e]	Motivation improving[p]

[a]CII, 2010b; [b]NSPE, 2010; [c]ASCE, 2010; [d] IMO, 2010;[e]Ries et al, 2010; [f]Güner, 2003;[g]Chase and Manning, 1990; [h]Minchin, 2010; [ı]Güner and Giritli, 2004; [j]Chini and Valdez, 2003;[k]Rosenbaum, 1997;[l]Turk, 2009; [m]ASTM, 2010; [n]TSE, 2010; [o]Samuels , 1994; [p]Öztaş et al.,

3.5 Contract Administration Practices in the US and in Turkey

Contract administration practice plays an important role in construction projects from invitation to bid through close-out of the project.

To ensure best practices in contract management, Office of Federal Procurement Policy (OFPP) releases guides, on which contract administration are based commonly (OFFP, 2010).

According to Office of Federal Procurement Policy (OFFP, 1994) the goal and benefits of contract administration include the following:

- In contract administration, the focus is on obtaining supplies and services, of requisite quality, on time, and within budget
- Good contract administration assures that the end users are satisfied with the product or service being obtained under the contract

Basic set of players in the US include the owner, the construction manager, the designer(s), other consultants (providers of specialized services), and the contractor (OGCM, 2002). Therefore, there is a need for agreement between all the parties, the first of which is between the owner and the construction manager.

In the US, it is a common practice to include the construction managership, which can be a firm, a team of firms, or an individual, in construction projects.

In the US practice, administration of construction manager agreements follow specific steps as outlined below (URL- 10, 2010):

- Scheduling negotiation between the owner and construction manager
- Negotiation for pre-construction services
    - Preparation of agreement
    - Distribution of executed agreement
    - Pre-construction agreement file
- Negotiation of guaranteed maximum price (GMP)
- Preparation of the GMP amendment
- Transmittal of amendment to construction manager
- Review of insurance issues
- Distribution of executed GMP amendment
- GMP File
- 100% Construction documents
- Bidding schedule
- Pre-qualification of subcontractors
- Bid openings and award recommendations
- Construction manager invoices and pay requests
- Requests for self-performance
- Construction manager's contingency authorizations
- Change orders

However, because agreements are not always between the owner and the construction manager as a party in Turkey, which is usually the case in the US, practices of contract administration differ to some extent.

Project delivery methods are also discussed in this section and practices are compared in the two countries based on the available literature.

To start with, some definitions are given below.

Delivery method of a construction project is the system prefered by the owner or the owner's representative, to execute the project by means of making contracts or agreements with one or more entities or parties.

Construction industry has been searching for effective project delivery methods to maximize project performance. There is the traditional project delivery strategy, design/bid/build and alternative project delivery methods such as design/build and build/operate/transfer. No single project delivery system can be considered most appropriate for any kind of project. Instead, combinations of different strategies are used for different circumstances (Gordon, 1994).

The most common methods of construction project delivery are design-bid-build (DBB), design-build (DB), construction management at risk or construction management as general contractor (CM/GC), and construction management as program management (CM/PM).

The DBB method is also referred to as the "traditional" delivery method. There are three parties in this method: owner, designer (architect), and general contractor (build). The owner enters into two separate contracts. A contract with an architect/engineer for the design of the project, and then a contract with a general contractor after the bids are received and analyzed. Normally, the DBB method is priced by lump sum. The owner monitors and controls the quality of the contractor's activities to assure adherence to contract requirements (Mahdi and Alreshaid, 2005).

In DB the owner makes a contract with a single party of which is responsible for both design and construction of the project. This is a preferred option when a single source of responsibility and accountability is desired by the owner. As a single entity is responsible for both design and construction, the adversarial relationship in DBB can be eliminated. The overall time for project complementation can be reduced and design and construction expertise can be combined. The DB approach is more appropriate when the scope is clearly defined, the design is standard and repetitive, and the schedule is tight (Warne and Beard 2005). Design/build is the oldest approach that is regarded as a new and alternative delivery method. During ancient times in Mesopotamia and Egypt, the master builder was responsible for the design and construction of the entire project. This continued to be the most commonly used project delivery method until the late 19th century, when advances in science and technology allowed the fields of architecture and engineering to become two different professions (Songer and Molenaar, 1996).

DB projects outperformed DBB with respect to time, but the results related to cost were not as convincing. It’s concluded that the skill of the project management team and the experience of the contractor had greater impacts on project performance than the project delivery method (Ibbs et al., 2003).

In CM/GC, the construction manager is a general contractor (GC) hired by the owner to provide consultation in both operational and financial aspects, on his/her behalf, for the entities involved in process of project development. There are still two separate design and construction contracts to be managed. Thus, the construction manager is responsible to provide consultation for architect in evaluation of costs, schedule, materials, etc., to select an optimal design alternative. A construction manager at risk is also responsible to monitor and control construction process in terms of costs, time, and other requirements to ensure a guaranteed maximum price for the project (Mahdi and Alreshaid 2005).

In CM/PM, the owner outsources all or parts of the project management process to a program manager (or program management agency). The program manager could be the project manager for the entire process or be the owner’s agent to support and supplement the owner’s facility management expertise. It should be mentioned that program management tasks could be delegated to any or both of design and build entities (Dorsey, 1997; Mulvey, 1998).

The characteristics of the above-mentioned project delivery systems are summarized in Table 3.12 based on the data in AIA/AGC primer released on 2004. It should be noted that this document does not cover CM/PM method.

Another project delivery method not mentioned in AIA/AGC Primer is the Build Operate Transfer (BOT) model.

Public procurement policies since the 1940s have greatly embraced design-bid-build, making it the most widely used project delivery method in the United States for the majority of the 20th century (Miller et al., 2000).

After 1990s, design-build method has gained substantial popularity including public projects (ASCE, 1996).

Table 3.12: Characteristics of Project Delivery Systems (Data from AIA/AGC, 2004)

Project delivery system	Defining characteristics	Typical characteristics
DBB	• Three prime players: owner, designer, builder • Two separate contracts: owner-designer and owner-builder • Contract selection based on lowest responsible bid or total contract price	• Three linear phases: design, bid, build • Well-established and broadly documented roles • Carefully crafted legal and procedural guidelines • A lowest responsible bid that provides a reliable market price for the project • Contract documents that are typically completed in a single package before construction begins • Complete specifications that produce objective quality standards • Configuration and details of finished product agreed to by all parties prior to construction start
DB	• One contract between owner-design/builder	•Project-by-project basis for establishing and documenting roles • Continuous execution of design and construction • Overlapping phases: design and build •Two prime players: owner and design/build entity • Carefully crafted legal and procedural guidelines for public owners • Overall project planning and scheduling by the design/build entity prior to mobilization • Cost or solution is the basis for selection of the design/build entity
CMR (CM/GC)	• Three prime players: owner, designer, builder • Two separate contracts: owner-designer and owner-builder • Contract selection based on aspects other than total cost	• Overlapping project phases are possible •Construction Manager (CM) is hired during design • Preconstruction services are provided by the CM • Specific contractual arrangement determines the role of players •Clear quality standards produced by the contract's prescriptive specifications

(Adopted from AIA/AGC Primer, 2004).

Construction Manager-at-Risk (CMR) is well accepted in the building industry and is beginning to emerge as a viable delivery method for transportation projects in the US (Shane and Gransberg, 2010).

Kent and Becerik-Gerber (2010) point to a a new project delivery method that has recently emerged in the United States, commonly referred to as integrated project delivery (IPD). Among other applications, IPD has materialized as a delivery method that could most effectively facilitate the use of building information modeling (BIM) for construction projects.

The AIA definition of IPD is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction (AIA, 2007). The integrated delivery model indicates that with full collaboration and participation of contractors, estimators, designers, and the owner in an ongoing informationsharing process, not only can time be saved, but the ultimate value of the project can be greater than that possible under the traditional process (Lancaster and Tobin, 2010).

Lancaster and Tobin indicates that the new true IPD requires early input from all parties, and an acceptance of a different mindset regarding relationships and workflow processes requiring to embrace the following ideas:

- Get used to 3D model shop drawings
- Get used to working with different 3D formats
- Anticipate not looking at paper in the future, but modeling accurately
- Get used to asking what the correct level of detail for modeling will be, and who expects to receive the model
- Expect a better way to deliver projects with better results

However, projects using IPD are reported to be relatively smaller and construction industy in the US, the US adopting this method slowly (Kent and Becerik-Gerber, 2010). There are several reasons for slow adoption: high degree of concern regarding risk in relation to IPD, the close partnerships it necessitates, and need for new legal frameworks to match new IPD approaches. Additionally, there is a need for those within the industry to assimilate new competencies and skills relating to collaboration and information management to support IPD.

Kent and Becerik-Gerber (2010) conducted an online survey that was designed to target a wide range of professionals in the construction industry to determine the level of awareness, experience, and interest of the respondents regarding IPD. The authors concluded that the use of IPD by the US construction industry is still in its infancy. Although some professionals have worked on IPD or IPD-like projects, the majority either does not have direct IPD experience or is not familiar with its concepts, which suggests that a focus on education in IPD is necessary. The authors also point to cultural, procedural, and organizational barriers to widespread use of IPD within the industry.

Back to another project delivery method that emerged earier, in the early 1980's a growing trend emerged among governments in many countries to solicit investments for public projects from the private sector. The main reasons for this trend are a shortage of public funds and a handsoff approach of government agencies. The Build Operate Transfer approach (BOT) is an option for the government to outsource public projects to the private sector. With BOT, the private sector designs, finances, constructs and operates the facility and eventually, after a specified concession period, the ownership is transferred to the government. Therefore, BOT can be seen as a developing technique for infrastructure projects by using private initiative and funding. Such infrastructure projects include a wide array of public facilities with the primary function to serve public needs, to provide social services and promote economic activity in the private sector. The most common examples are roads, bridges, water and sewer systems, airports, ports and public buildings (Vaughan and Pollard, 1984).

The “Build, operate, and transfer model” (BOT) is a financing model, which is used in many developing countries to finance new infrastructure projects with private sector participation. The BOT method foresees the financing, designing, building, operating, and managing of the facility by the private sector and then its transfer free of charge, to the owner after a predetermined concession period (Şentürk et al, 2004).

BOT method does not seem to have been used frequently in the US.

Algarni et al. (2007) conducted a survey to determine the extent to which large municipalities and state departments of transportation are using BOT in their large projects. The findings indicated that very few agencies use BOT. The reasons why most do not use BOT were reported by the respondents to be the availability of proven alternatives and enough funds, the existence of political barriers, and resistance to change both on the part of government agencies and private sponsors.

Izmit Domestic and Industrial Water Supply Project is the first privately financed water supply project procured under the BOT model in Turkey (Şentürk et al, 2004).

Koçer et al. (2009) compared Delivery methods’ properties which are financed by public resources (as specified in “KiK”) and those financed by private resources (Build-operate-transfer delivery method). While the first category depends on public (governmental) resources, takes longer time to be approved by the related authorities, has the risk of staying behind schedule with speed not being an important factor in executing the project; whereas BOT depends on private sector resources, allows the appropriate projects to be approved rapidly. Projects are usually completed before expected timelines and speed of the project has a primary role.

Regarding the use of other project delivery methods in Turkey, design-bid-build and design-build methods are both used in Turkey (Boyacılar, 2002).

Stager (1996), the CEO of Dillingham Construction Holdings, CA, US, points to the political challenges encountered on a Finance-Design-Build Project (Izmir-Aydın highway project) in Turkey. He indicates that other aspects not involving construction have proved much more difficult to deal with. He reports that inflation is an important influencing factor for resulting in change-orders, with the initial contract for $296,000,000 increasing to $790,000,000 as the design progressed.

Boyacılar (2002) indicates that CMR is not used in Turkey (as of 2002) and emphsises the definite need for CMR and recommends that it should be included in the contract awarding law.

The use of project delivery methods between the US and Turkey are compared in Table 3.13.

In a research paper regarding improvement of the selection method of project delivery systems, Mafakheri et al. (2007) proposes a decision aid model using the analytical hierarchy process (AHP) coupled with rough approximation concepts to assist the owners. It is known that selecting an optimal project delivery system is a critical task that owners should do to ensure project success. The complexity of the selection arises from the uncertain or not well-defined parameters and/or the multiple criteria structure of such decisions. The model proposed by the researchers is able to effectively facilitate the decision making process. The pairwise comparison procedure in this model provides the availability of capturing relative judgments of two elements at one time in a trustworthy manner and ensures the consistency of those values.

When the three principal project delivery systems used in the US Construction management at risk (CMR or CM/GC), design/ build (DB) and design/bid/build (DBB) are compared in terms of unit cost, construction speed, delivery speed, cost and schedule growth, a study using project-specific data collected from 351 U.S. building projects revealed the following data (Konchar and Sanvido, 1998):

- Unit cost: DB projects at least 6.1% less than DBB projects and 4.5% less than CMR (CM/GC) projects on average in terms of unit cost: The unit cost of projects using CMR (CM/GC) 1.6% less than those using DBB.
- Construction speed: DB projects at least 12% faster than DBB projects and 7% faster than CMR (CM/GC) projects on average. CMR (CM/GC) projects at least 5.8% faster than DBB projects.
- Delivery speed: DB projects at least 33.5% faster than DBB projects and 23.5% faster than CMR (CM/GC), on average. CMR (CM/GC) projects at least 13.3% faster than DBB projects.
- Cost Growth: DB projects at least 5.2% less than DBB projects and 12.6% less than CMR (CM/GC) projects on average in terms of cost growth. DBB projects with at least 7.8% less cost growth than CMR (CM/GC).
- Schedule Growth: DB projects at least 11.37% less than DBB projects and 2.18% less than CMR (CM/GC) on average. CMR (CM/GC) with at least 9.19% less schedule growth than DDB projects.

Table 3.13: Comparison of the Use of Project Delivery Methods in the US and in Turkey

Project delivery systems	**US**	**Turkey**
DB	Used in the private and public sector; gained popularity after 1990s[a]	Mostly private sector[b]
DBB	Used extensively by the public sector before 1990s[c]	Public sector[b]
CMR (CM/GC)	Gaining popularity in both sectors[d]	Not used; should be encouraged[b]
BOT	Rarely used by public sector[e]	Used more by public[f] sector
IPD	Emerging method; Projects using IPD relatively small[g]	No data

[a]ASCE, 1996; [b]Boyacılar, 2002; [c]Miller et al., 2000; [d]Shane and Gransberg, 2010; [e]Algarni et al., 2007; [f] Şentürk et al., 2004; [g]Kent and Becerik-Gerber, 2010

In another recent study evaluating cost performance for project delivery methods, data collected from state records and previous studies on 297 completed schools in two states in the US showed no significant difference between CMR and DBB in construction change order costs, school project costs exceeding the GMP in 75% of the cases, and a significant difference in cost growth between CMR and DBB projects during buy out, making CMR projects less efficient at controlling cost growth at buy out (Rojas and Kell, 2008).

In the mid-1980s in the US, the Federal Highway Administration (FHWA), the Transportation Research Board (TRB), and state Departments of transportation (DOTs) began to actively research innovative ways of improving highway construction contracts. In 1994, the research team, having studied literature on innovative contracting concepts, identified 16 innovative contracting practices (McCrary et al., 2010). These practices and their definitions are given in Table 3.14.

McCrary et al. (2010), using the 16 practices given in Table 3.14, generated a mail-in survey and sent to all state DOTs in 1996, asking for a response to the use of these innovative contracting practices. Then in 2007, even though the scope of innovative contracting techniques changed slightly, the same survey was sent to all the state DOTs again. The results of the survey are given in Table 3.15.

The authors report changes in four broad categories with respect to innovative contracting concepts in state DOTs: 1) increased experience with innovative contracting methods, 2) increased use of quality management practices, 3) increased concern over value engineering benefits, and 4) decreased support for project partnering (McCrary et al., 2010).

Warranty contracting practices in the US have also been surveyed (Bayraktar et al., 2004) for State Departments of Transportation. The study revealed that warranty contracting is being utilized by 32 State Departments of Transportation in the United States as assessed in 2004. However, for the majority of the 13 State Departments of Transportation included in the analysis (76%), the number of warranty projects was less than 5% of the total annual number of projects awarded by the agency. According to the results of the survey, the initial bid price increases due to warranty provisions are estimated to be somewhere between 0 and 15%, while the changes in maintenance and project life-cycle costs are expected to be minimal. Warranty provisions is reported to have increased the quality of the projects and reduced the need for site inspection and record keeping. The study also revealed the unwillingness of surety companies to underwrite small contractors when the project calls for long term warranty durations.

Table 3.14: Innovative Contracting Practices in Highway Construction Contracts

Practices	Definition
Partnering	Refers to a relationship between the owner and the contractor that includes the elements of long-term commitment to mutual goals and trust among participants
Guarantee/warranty	An assurance by the construction contractor that the final product will meet the specifications for a specified period of time after final acceptance
End-Result Specifications	Focus on measurable attributes or properties of the end products rather than on the construction techniques and materials used, giving the contractor more responsibility for quality by allowing the contractor more freedom and therefore more control in the development and use of appropriate construction methods
Performance-Related Specifications	Focus on statistical characteristics, properties, or attributes of materials and methods that both correlate with final performance and can be tested during construction; incorporates statistical parameters that measure the variability of construction techniques, materials, and sampled final products
Quality Incentives/ Disincentives	A concept wherein the owner provides the contractor with stipulations for either increased compensation (incentive) or decreased compensation (disincentive) to the base contract amount. It can be established for cost, schedule, quality, and/or safety aspects of a project
Contractor prequalification	A process for screening prospective contractors according to a predetermined set of criteria designed to measure a contractor's ability to meet the project's objectives
Subcontractor/ supplier approval	A concept where the owner preapproves or prequalifies subcontractors and suppliers on a project. The owner rates all subcontractors and suppliers on the basis of past experience, past performance, and/or financial stability
Quality assurance-quality control	Another method for increasing the contractor's control over the methods used to obtain quality in the final product, integrates a number of the previously defined systems including endresult specifications, performance-related specifications, and quality incentives/ disincentives
Cost Plus Time	Contractors submit proposals that consist of both a construction bid price and a construction bid time to complete the project bid days
Lane rental	A procedure where the contractor is assessed a rental charge, based on a predetermined users' cost, for each lane and/or shoulder closure, or other obstruction from the time of "notice to proceed" until the project is complete or the lane is opened
Build-own-operate-transfer (BOOT)	Innovates by passing responsibility for ownership of a facility, traditionally held by the granting authority to the contractor for a long period of time
Design/build (D/B) (turnkey)	Allows for both innovative/ alternative design options and the shifting of design risk to the design/builder
Value engineering	A concept that allows alternate designs, construction procedures, or materials to be considered prior to the notice of bidding, in order to consider other more economical, more constructible, or more maintainable options
Dispute resolution	Dispute resolution, using dispute review boards (DRBs), is a mixture of both expert opinions and neutral evaluations
Cash allowance	Refers to a process that allows the owner to set a fixed cost for equipment or materials within the bid proposal
Construction management	Intended to provide a better interface between the contractor and designer. A third party who is experienced in both construction and design is added who contract with the owner to act as the owner's agent or representative

Table 3.15: The Usage of Management Concepts by DOT in the US

Management concept	1996 usage (%)	2007 usage (%)
Construction management	15	52
Cost+time	50	89
Design/build	13	62
Dispute resolution	26	61
Guarantee/warranty	30	79
Lane rental	23	74
Performance rated specification	61	85
Quality control/quality assurance	70	100
Quality I/D	62	85
Value engineering	90	100

DOT: Department of Transportation (Adopted from McCrary et al., 2010).

Traditionally, the use of warranties in highway construction in the US has been limited to electrical and mechanical equipment and maintenance. The use of guarantees and warranties are common for a period of 1 year after completion of a project. However, long-term warranties, which cover 2–5 years, may result in increased quality in the final project because the contractor is responsible for any latent defects (Hancher, 1994).

Wyse and Malik (2005) suggests to incorporate an express audit provision in the owner/contractor contract. The authors emphasize that an owner should consider requiring, implementing, and monitoring real-time accounting systems that would alleviate the need for an audit at the end of the project. If the owner does not clearly identify the duties and obligations of the contractor in regard to an audit and real-time reporting systems, an owner may be left relying on hybrid legal theories and the subjective opinion of an unrelated third party to decide the information that the contractor is required to provide to the owner.

The construction industry is increasingly burdened with disputes.There are various reasons for conflicts in a construction project: Size and duration of the project, unclear project objectives, loose contractual arrangements, the complexity of the contract documents, inadequate design, sloppy or ambiguous documentation and non-confirmation in writing of statements or instructions, changed conditions, weak management, poor communication and understanding, personal attitudes, political aspirations, cultural background or customs, arguments over methods and procedures, limited resources, financial issues, labor issues and force majeure (Harmon, 2003).

With respect to dispute resolution in the US, the practices are given below.

The stair-step chart (Figure 3.5) illustrates dispute resolution methods commonly used in the construction industry (Cheung, 1999).

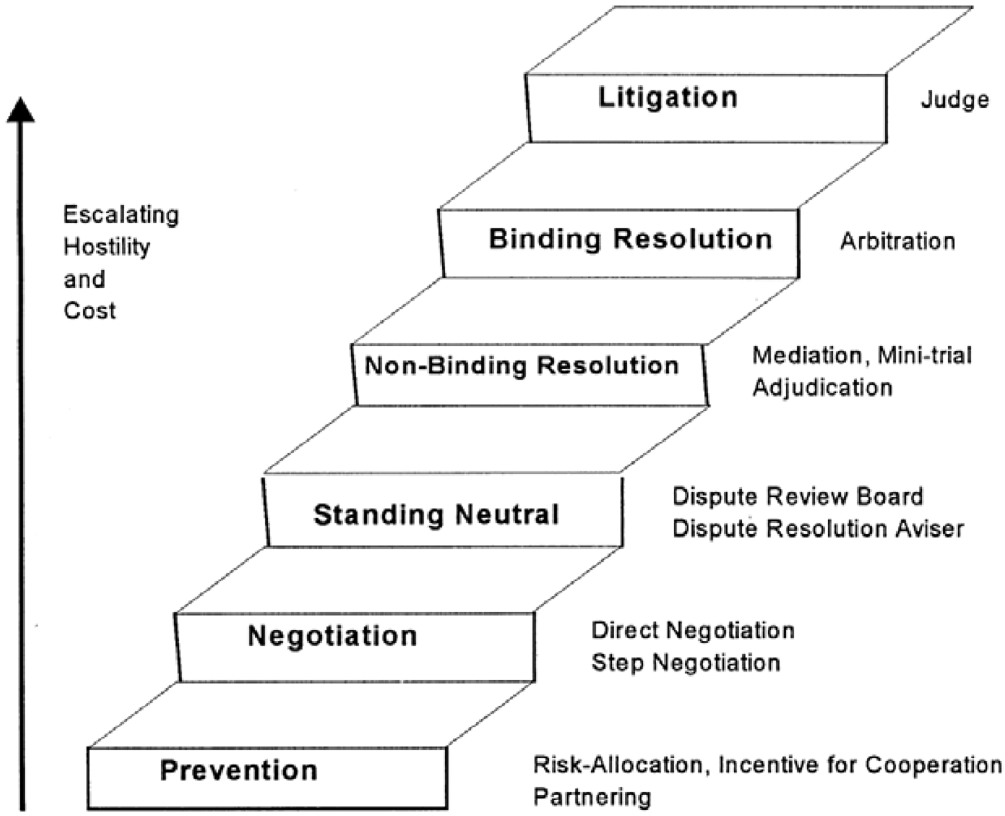

Figure 3.5: Construction dispute resolution steps

In the global arena, there are many forms of dispute resolution methods. Techniques other than litigation are referred to as alternative dispute resolution techniques. In construction contracts, most contracts in the US will not go for litigation unless other alternative dispute resolution techniques have been attempted first (Yates et al., 2007)

The definition of dispute resolution methods in international projects are given in Table 3.16 (Prepared using the information provided by Gad et al., 2010)

As an alternative dispute resolution technique, dispute review boards (DRBs) have been extensively used in construction projects across the United States since 1975. The main concept of a DRB is to engage three neutral experts during the construction phase of the project. These three experts become familiar with the progress of construction on site and are ready to lend a neutral third party recommendation in case a conflict escalates to a dispute between the construction parties (DRBF, 2007).

Table 3.16: Dispute Resolution Methods in International Contracts

Methods	Definition
Litigation	A dispute resolution government run system, involving judges and courts
Mediation/ Conciliation	A voluntary non-binding process where a mediator assists the parties in achieving a negotiated settlement
Adjudication	A neutral adjudicator decides on a resolution of a contractual dispute between the parties within a predetermined time limit
DAB	Developed by the construction industry as result of the inadequacy of institutional arbitration to provide an efficient and cost-effective means of dispute resolution. It constitutes a panel of technical experts that works with a particular construction project who are familiar with the project's contract and progress, and adjudicate quasi-binding disputes that arise out of the contract. In international projects, it is desirable to have DAB members of nationalities as those of the parties involved.
Arbitration	An alternative to litigation with prior agreement of the parties
Expert Determination	The parties refer the dispute to an expert who has full authority to make a decision solely without any of the parties' consultation based on the expert's own knowledge

The critical difference between a DRB and other forms of alternative dispute resolution is that the DRB meets both before and during construction operations so that DRB members can familiarize themselves with the people, process, and project specifics. The DRB's main responsibility is to make nonbinding recommendations to the parties when a resolution cannot be reached at the project level. Acceptance by the parties is facilitated by their confidence in the DRB—in its members' technical expertise, firsthand understanding of the project conditions, and practical judgment—as well as by the parties' opportunities to be heard (Matyas et al., 1996).

Since their first successful implementation in 1975, dispute review boards (DRBs) gained popularity as a standing neutral alternative dispute resolution technique in the US.

Menassa and Pena Mora (2010) analysed dispute review boards application in US construction projects from 1975 to 2007. In the analysis of a total of 1,042 US construction projects that had DRB as part of their contract provisions, the effectiveness of DRB as a prevention technique was observed on approximately 50% of the 810 projects where no disputes were ever heard through a DRB panel formal hearing. For the remaining 50% of the projects, the effectiveness of DRB as an alternative dispute resolution technique was found to exceed 90% when comparing the number of disputes that were settled due to DRB recommendation to those that were actually heard during a DRB hearing session.

More on dispute resolution, Borg (2004) points to ASCE's role in the work of the National Construction Dispute Resolution Committee of the American Arbitration Association (AAA) which may examplify an important practice in the construction sector as to the efficient involvement of a professional organization in dispute resolution. ASCE has been reported to be in the forefront of changes and improvements in the method of settling, resolving, and preventing disputes in the construction industry and it has been able to help shape and direct the alternative dispute resolution process in ways that benefit the members of engineering society in the US.

With regard to the situation concerning claims and dispute resolution for Turkish construction industry, the most severe claim issues for the Turkish international construction projects is reported to be the change requests of the owners, the payment failures of the owners, and the failure of owners in fulfilling their contractual obligations including late approval of the project documentation, deficiencies in arrangement of domestic materials, inefficiency and lateness in visa permissions for project personnel to enter the country, inefficiency and lateness in conducting customs regulations to import materials, and late construction site handovers. Others include administrative failure of owners, design related problems and contractual problems, deficiencies in recovering the additional costs, the owner procurement failures, the accidents and force majeure. They reported the following practices of Turkish contractors regarding dispute resolution: They solve their problems commonly by means of negotiation; very few employ arbitration or litigation, alternative dispute resolution methods are seldomly used (Yiğit et al., 2009).

Other than international projects, in national projects Turkish constructors use mediation (conciliation), arbitration and litigation for resolving disputes. It is suggested that "Yüksek Fen Kurulu" should be converted to a body like a dispute resolution board (Uyanık, 2006).

Construction contracts in the US frequently contain a clause on "Value Engineering" allowing contractor-initiated design changes. Papazian Bedian (2004) indicates that that such a clause would simply be ignored because it involves changes in design, often major changes in very short time, and change is feared, and moreover, vehemently resisted by all parties, owner, designer, and contractor. The author reports that, despite some resistance to “value engineering” practices, major design changes are reported to have successfully implemented in record speed on even very large projects.

Regarding standard forms of agreements in the US, there are many developed by professional organizations, the most commonly used being AIA contract forms (AIA, 2010).

More than 100 forms and contracts comprise AIA Contract Documents. These forms and contracts define the relationships and terms involved in design and construction projects. The AIA organizes contract documents by two methods:

- By families based on types of projects or particular project delivery methods
- By series based on the use of the document

The series document types include Owner/Contractor, Owner/Architect, Architect/Consultant, Architect/Industry, and Architect's Office & Project Forms. AIA also groups these documents into families for application to various project delivery methods. Within each family, the documents provide a consistent structure and text base to support the major relationships on a design and construction project. The AIA standard contract forms with suitability and “when- to- use” information are given in Table 3.17 (AIA, 2010):

It is clear that standard contract agreements are created in the US to meet particular needs in construction sector, with a bewildering variety of forms.

AIA Document A 101 is given in the Appendix as an example (A 1997 Document which is retired).

Another point to emphasize as a different practice regarding contract forms is that, for example, AIA periodically revises AIA Contract Documents, generally on a ten-year cycle. The AIA’s goal in revising documents every ten years is to maintain state-of-the-art legal documents that reflect industry trends and practices, and balance the interests of the parties on the construction project (AIA, 2010).

However, in Turkey, there is a tendency to keep existing documents once they are prepared.

Table 3.17: AIA Standard Contract Forms

Document families	Type of project	Description
Conventional (A201) Family: A101, A107, A111, A201, A201/SC, A401, A511, A701, B141, B144 ARCH-CM, B151, B163, B181, B352, B511, B727, C141, C142, C727, C801	When the owner's project is divided into separate contracts for design (with the architect) and for construction (with one or more builders)	For the conventional delivery approach of linearly sequential design-award-build; used for small to large projects
Small Projects Family: A105/A205, B155	When the owner's project is small, straightforward in design, of short duration and without delivery complications such as competitive bidding	For small projects such as residential renovations, additions and other projects of relatively low cost and brief duration (less than one year from start of design to completion of construction)
Construction Manager-Advisor Family (CMa): A101/CMa, A201/CMa, A511/CMa, B141/CMa, B801/CMa	When the owner's project incorporates a fourth prime player-the CM- on the construction team (owner, architect and contractor) to act as an independent adviser on construction management matters through the course of both design and construction; used in small to large public and private sector projects	Enhances the level of expertise applied to managing the project from start to finish; Preserves the construction manager's independent judgment, keeping that individual from being influenced by any monetary interest in the actual labor and materials incorporated into the construction work
Construction Manager as Constructor (CMc) Family: A133, A134	When the owner's project employs a CM who will complete the construction and also provide construction management services; used in small to large projects	Functions of contractor and CM are merged and assigned to one entity that may or may not give a guaranteed maximum price, but which typically assumes control over the construction work by direct contracts with the subcontractors
Design/Build Family: A141, A142, A441, B142, B143, C441, G704DB	Where the project delivery method is design-build	Owner enters into a contract with a design-builder who is obligated to design and construct the project. The design-builder then enters into contracts with architects and construction contractors, as needed.
Integrated Project Delivery (IPD) Family Transitional Forms(TF): A195, A295, B195 Multi-Party Agreement (MPA): C191 Single Purpose Entity (SPE) Agreements: C195, C196, C197, C198, C199	A collaborative project delivery approach that utilizes the talents and insights of all project participants through all phases of design and construction; used in large private sector commercial projects	TFs are modeled after existing CM agreements and offer a comfortable first step into integrated project delivery. MPA is a single agreement that the parties can use to design and construct a project utilizing integrated project delivery. SPE creates a limited liability company for the purpose of planning, designing and constructing the project and allows for complete sharing of risk and reward in a fully integrated collaborative process
Interiors Family: A151, A251, A751, B152, B153	For furniture, furnishings and equipment procurement services and combined with architectural interior design and construction services: used in small to large tenant projects	The Interiors documents procure FF&E under a contract separate from design services, preserving the architect's independence from any monetary interest in the sale of those goods. B152 may be used as the owner/architect agreement for the design of both FF&E and architectural interiors. B153 is not suitable for construction work, such as major tenant improvements, and is used for design services related solely to FF&E
International Family: B161, B162	For US architects working on projects located in foreign countries; Small to large projects	Because US architects usually are not licensed in the foreign country where a project is located, these agreements identify the US architect as a consultant, rather than an architect
Digital Practice Documents: C106, E201, E202	for any projects involving digital data or Building Information Modeling; used in	C106 provides a licensing agreement for transmission of digital data when not included in the prime agreement. E201 and E202 are exhibits that establish protocols for managing digital data and BIM
Contract Administration & Project Management Forms: A305, A310, A312, B305, D101, D200, G601, G602, G612, G701, G702, G703, G704, G705, G706, G706A, G707, G707A, G709, G710, G711, G712, G714, G715, G716, G801, G802, G803, G804, G806, G807, G808, G809, G810	These forms are generally useful for all project delivery methods in small to large projects	The variety of forms in this group includes qualification statements, bonds, requests for information, change orders, construction change directives, and payment applications and certificates.

Furthermore, standard contract documents are rather new in Turkey.

In Turkey, in Article 53-b of the Turkish Public Procurement Law gives the duties of preparing, developing and guiding the implementation of all the legislation concerning this law and Public Procurement Contracts Law and the standard tender documents and contracts to the Public Procurement Authority (KİK, 2010). Based on this law, standard forms, agreements, general conditions and standard administrative conditions developed and prepared by the Public Procurement Authority are available since 2002 (accepted as valid on January 1, 2003). The standard documents of "KİK" are very important for the construction industry in Turkey. There used to be a lot of problems before the publication of the new documents.

In Turkish public sector, Yapım İslerine Ait Tip Sözleşme (YIATS) (Standard Contract for Construction Works) prepared by KİK are used in the tenders. On the other hand, Turkish construction companies working abroad mostly encounter with Fédération Internationale des Ingénieurs Conseils (FIDIC) (International Federation of Engineering Councils) (FIDIC, 2010) application both in public and private sector works. Being the basic standard, FIDIC contract on construction, FIDIC Red Book (FIDIC, 1999) was commonly used in these works (Sertyeşilışık, 2007).

It should also be noted that Turkish Accounting Standards Board [Türkiye Muhasebe Standartları Kurulu (TMSK)] released "TMS 11 İnşaat Sözleşmeleri Standardı (TMS 11 Construction Standards)", published in the Official Gazette at the end of 2005 (TMSK, 2005).

In a thesis work by Yalçın (2004), standard agreements and general conditions are compared in the US and in Turkey. This comparison revealed some important shortages in Standard Lump Sum Contract between the Owner and Contractor and General Conditions of the Construction Contracts of the "KİK" (YİGŞ, 2010). These are summarized with recommendations in this thesis work as the following:

- Instead of repeating provisions that are in the agreement form in the conditions of the contracts, with regard to procedures and time limits, more detailed provisions should be prepared in the conditions of contracts
- Contract administration provisions should be considered in the documents
- Because of the nature of the construction project, agreements and the conditions of contracts should allow the changes in the project; both of the

documents do not allow changes; therefore, there is a need to revise these documents

- The document of “KİK” should be revised in terms of the procedures and time limits which are not adequate
- Both documents should propose a mechanism about “dispute resolution” procedure, because in the US document if any disputes arise between building inspection officer and contractor, parties apply to an owner, which is not a suitable approach. If the owner cannot solve the problem, this dispute goes to court for resolution. In this case, all parties and construction project are affected.

In a thesis work, Sertyeşilışık (2007) identified the main problem areas in the execution of the FIDIC and “KİK” (YIATS) contracts as the following:

- Financial issues: insufficient resource allocation for the work; issues related with the acceptance of the work and production drawings,
- Temporal issues: delay in submission of site; production drawings including delay in submission of the production drawings to the contractor; design errors causing rework; delay in approval of the production drawings) and unforeseeable physical conditions,
- Non-compliance of the work with specifications or owner’s requirements: poor workmanship; defective material and erroneous production drawings information

Recommendations of Sertyeşilışık (2007) regarding FIDIC and YIATS contracts are given in Table 3.18.

It is interesting to note that a recent article from Purdue University School of Civil Engineering, US, deals with the issue of knowledge management in contract administration. Since the contract administration process involves the management and organization of daily project tasks, including monitoring of project progress, project payment quantification, project change management, project time control and delay analysis, and project closeout processes, innovative techniques for managing the knowledge contained in construction contract documents are being developed to facilitate quick access and efficient use of such knowledge for project management and contract administration tasks. Based on the hypothesis that natural language processing can be effectively used to perform document text analysis, A system called, “technique for concept relation identification using shallow parsing (CRISP)” which utilizes a shallow parser to extract semantic knowledge from construction contract documents is proposed for use to improve electronic document management functions such as document categorization and retrieval (Al Qady and Kandil, 2010).

Regarding contracting practices in Turkey, in a survey conducted by Kuruoğlu and Polat (2002a), it was observed that, the 50% of the firms use all types of the contracts, 25% were using unit price method (if the work is short-termed), the 8% were using lump sum fee (if there are no uncertainties in the project) and the 17% arranged characteristic type of contracts originated from their special needs.

Table 3.18: Recommendations for the Contractors for FIDIC and YIATS Contracts

1.	The contractors should pay attention to “determination” and “site data” clauses in the contract. “Determination” and “site data” clauses in standard forms generally contain statements causing unbalanced risk distribution against contractor’s benefit.
2.	The contractors should avoid fuzzy issues in contracts. It is important to clarify fuzzy issues before drawing up of the contract. When there is a problem in taking over of the works and fuzziness in clause or absence of relevant clause in YIATS, the risk of the contractor to experience adverse consequences of this situation increases 10.111 times.
3.	The contractors should pay attention that the parties of contract are not in default. Especially, time for completion issue in YIATS and valuation at date of termination in FIDIC are affected by default by both parties.
4.	In order to reduce the risk of problem in receiving payment, it is important for the contractors to pay special attention to the following clauses: consequences of suspension; payment for plant and materials in event of suspension; design error and owner’s financial arrangements. In FIDIC contract, in case there is problem of failure to pass tests on completion, the risk of emergence of problem in receiving payments increases 11.25 times.
5.	The contractors should pay attention in selecting the cost determination method as it affects the risk of emergence of problem. In order to reduce the risk of emergence of problems about the clauses of: design, technical standards and regulations; nominated subcontractors; evidence of payments and value engineering, the maximum cost-plus fee/cost plus guaranteed maximum ceiling should not be preferred. When the lump sum method is used, the contractor should pay special attention to prevent delay in drawings..
6.	The contractor should establish proper management and control organization on site to reduce the risk of emergence of non compliance problems such as failure in purchasing the proper material, defective workmanship, high progress rate of work, defects in material, error caused by the contractor; misunderstanding or misinterpretation of construction drawings by the staff in execution of the work, problems in communication, lack of care in application of the work, etc., to notice and prevent any nonconformities in time.

Table 3.18: Recommendations for the Contractors for FIDIC and YIATS Contracts (Contd.)

7.	The contractor should also pay special attention to reduce the risk of emergence of problems about financial issues. The issues related to delay of payments and suspension of the payments can be caused due to default by both parties. The contractor should be careful with non compliance problem area that causes emergence of the financial problems. On the other hand, contractor should spend his efforts to arrange contract clauses properly in contract drafting phase for the problems such as changes in costs, insufficient budget of the administration, improper allocation of the credit, change in the budget due to the shortages or due to the changes in government, change in cash flow, etc. Which are not under the his control during execution of work. Especially, in public works, contractors should pay attention to issues about sanctions in case the public entity fails to make the payment on time, adjustment for changes in cost, advance payment and allocation of funds in the contract.
8.	The contractors are also recommended to pay attention to the risk of emergence of temporal problems such as delay in submission of site; delay in submission of the production drawings to the contractor; design errors causing rework; delay in approval of drawings. Especially, the issues such as date of submission of site and drawings, duration for approvals should be clearly determined in the contract.

Yigit et al. (2009) investigating contract management behavior of Turkish construction companies in international projects in a survey involving 51 construction firms. The findings of their survey are given in Table 3.19.

Table 3.19: Contract Management Behavior of Turkish Construction Companies in International Projects

- Turkish contractors consider contract management to be significant for success at international markets
- Turkish contractors are also well aware of the need for a continuous contract management application even though this rate cannot be achieved in current application
- The relationship management function of the contract management is the function that most weight is given by firms in current application
- The least weight is given to the administration of the contract function
- The contract management behavior of Turkish contractors is most impacted by risk and complexity of the project, and three owner related factors: country of the project or country of the owner, relations with the owner, and type of the owner
- Contractors give more emphasis on contract management while they are working for owners from EU countries, USA and other countries with tight laws and regulations, contrary to the sitiation that they give little emphasis to contract management. while the contractors are working for owners from Turkey
- Contractors mostly value the actions taken during the regular contract process, followed by pre-tender and pre-contract processes. Claim and dispute processes considered to be significant only when potential losses are of issue.
- Four activities of contract administration function rated as the most important key factors for success: instant recording of changes, appropriate and on time data gathering together with an efficient documentation and record system, recording any kind of communication, and continuous contract administration based on knowledge to the contract

Table 3.19: Contract Management Behavior of Turkish Construction Companies in International Projects (Contd.)

- Among pre-tender process strategies, complete and comprehensive examination of tender documents and determination of potential risks rated to be more important strategies
- For pre-contract process, ensuring the clarity of the contract is rated as the most important strategy for success
- As for the claims, the notification of the claim is rated as the most important activity of the claim process
- As for the disputes, contractors mostly concerned with the speed of the resolution, followed by the manageability of the resolution. The bindingness of the resolution being the third key factor.Rather than non-binding alternative dispute resolution methods contractors prefer arbitration and litigation. Arbitration is the most consulted resolution method following the negotiation
- Turkish contractors, with a great majority assign contract management task to either individuals or groups at both corporate and project management levels. Several companies assign this task to personnel already employed with other tasks. The biggest responsibility regarding the contract management, especially for critical decisions, rather than contract managers is still at project managers and top management of the company.
- The international experience of company and existence of contract administration department both have an influence on participation of different company or project groups to different contract management processes and decisions.
- The most severe claim issues are change requests, payment failures, and contractual failures of the owners
- The weight given to the contract administration function of contract management and employing contract managers at site has an influence in reduction of claim issues regarding contractors' procurement failures
- Turkish contractors with a great majority believe that contract management is effective in reducing the numbers of conflicts and disputes
- Contractors very often employ negotiation to solve their disputes and mostly consider themselves as successful in negotiation for time extensions. In resolutions with negotiations for cost claims, they also consider themselves as successful with a decreasing rate. They rarely apply to arbitration and litigation, and almost never apply alternative dispute resolution methods

Issues related to contract administration are compared in Table 3.20.

3.6 Safety Management Practices in the US and in Turkey

3.6.1 Construction hazards

The magnitude of injuries, illnesses, and fatalities in the construction industry remains a significant social and economic problem.

According to the Bureau of Labor Statistics (BLS, 2009), the construction industry employs approximately 8% of the American workforce. However, data assembled by the Center for Construction Research and Training (CCRT, 2009) indicates that construction accounts for approximately 21% of the all occupational deaths from injuries in the United States (1,243) and has the fourth highest fatality rate of all US industries.

Table 3.20: Comparison of Contract Administration Practices in the US and in Turkey

	Practices in the US	**Practices in Turkey**
CONTRACT ADMINISTRATION		
• Policy makers	OFFP[a]	"KİK"[b]
• Agreements	Between many parties, including the construction manager[c]	Not commonly including the construction manager[d]
• Project delivery methods	DBB, DB, CM/GC[e]	Usualy DB and DBB[d]
• IPD	Emerging[f]	No data
• BOT	Rarely used[g]	Many examples[h]
• Selection of methods	Various decision models used[ı]	No data
• Standard documents	Many (AIA, NSPE, AGC, CMAA etc.)[j]	YİGŞ[k], YİATS[l], FIDIC[m]
• Professional organizations developing the documents	The above ones[j]	TMSK put standards[n]
• Nature of documents	With a bewildering variety to meet the needs[c]	A few
• Contracting practices		
• Dispute resolution	DRB involved extensively[o]	Rarely used in international projects[p]
•Warranty contracting	Used extensively[q,r]	No data
•Value engineering	Reaching to 100% by public sector[r]	No data

[a]OFPP, 2010; [b] "KİK", 2010; [c]AIA, 2010; [d]Boyacılar, 2002; [e]AIA/AGC Primer, 2004: [f]Kent and Becerik-Gerber,2010;[g]Algarni et al, 2007; [h]Şentürk et al, 2004; [ı] Mafakheri et al., 2007: [j]CMAA, 2010; [k]YİGŞ, 2010; [l]YIATS, 2010; [m]FIDIC, 1999;[n]TMSK, 2010;[o]Menassa and Pena Mora, 2010; [p]Yiğit et al., 2009;[q]Bayraktar et al., 2004; [r]McCrary et al., 2010;

It is reported that over the recent decades, the accident rates in construction have declined as a result of substantial effort by many parties. Great strides towards a safe workplace environment have been made in the construction industry. For 2007, the Bureau of Labor Statistics estimated 380,500 recordable cases of injuries and illnesses (BLS, 2009), an incident rate of 5.4, which is lower than the 5.9 rate of 2006. The number of fatalities seem to have decreased as well, with 1,192 fatalities in 2005, 1,239 in 2006, and 1,178 in 2007.

However, the number of injuries and fatalities can still be considered high unmatching great strides for improving construction safety.

These data point to the enormeous danger in the construction industry, with implications to the need for more emphasis for safety management practices.

Some typical construction hazards in the US include fall hazards, vehicles, equipment, excavations, maintenance of traffic, access and egress, reliance on others, confined spaces, electrical, cutting, welding, PPE requirements and contaminants such as lead, silica, and asbestos, similar to those encountered in most of the countries (Doran et al, 2010).

In the construction industry, falls are the most frequently occurring types of accidents resulting in fatalities. Falls have been the cause of the highest number of injuries and fatalities in the US construction industry, accounting for 33% of all construction worker fatalities within the years of 1985 to 1989 (OSHA, 1990).

Analysis of data from January 1990 through October 2001 revealed a total of 7,543 OSHA-investigated accidents. Falls (both from an elevation and from the same level) accounted for 34.6% of the injuries. It is apparent that the proportion of falls has increased with time in the past 12 years: the average proportion of falls was 34.1% during the years before 1996 and increased to 38.4% in the following years. This analysis shows that most fall accidents take place at elevations of less than 9.15 m (30 ft) occurring primarily on new construction projects of commercial buildings and residential projects of relatively low construction cost. Furthermore, experience does not seem to diminish accident occurrence and hazards are often misjudged by workers. Most alarming, the analysis shows that fall accidents account for a growing proportion of the total number of construction worker fatalities (Huang and Hinze, 2003).

It is noteworthy that human errors contributing to falls are also analysed in this work. They are listed as the following in descending order (the percentage for all fall accidents, being 33.42% for the first item and 0.04% for the last item) (Huang and Hinze, 2003):

1) Misjudgment of hazardous situation
2) Safety devices removed or inoperative
3) Equipment in use not appropriate for operation or process
4) Insufficient or lack of protective work clothing and equipment
5) Malfunction of procedure for securing operation or warning of hazardous situation
6) Operational position not appropriate for task
7) Procedure for handling materials not appropriate for task
8) Insufficient or lack of engineering controls
9) Insufficient or lack of written work practices program 36 2.96 83 3.03
10) Malfunction of perception system with respect to task environment
11) Malfunction of neuro-muscular system
12) Defective equipment: knowingly used
13) Distracting actions by others
14) Malfunction of procedure for lock out or tag out
15) Insufficient or lack of housekeeping program
16) Insufficient or lack of respiratory protection

Distribution of immediate sources of falls for the dates between January 1990 and October 2001 include working surface (with the highest percentage of 33.24), buildings/structures, bodily motion, ladder, hoisting apparatus, materials handling equipment, dirt/sand/stone, motor vehicle (highway) and motor vehicle (industrial) (Huang and Hinze, 2003).

Crane injuries and fatalities are also a big problem in the construction sector in the US. The collapse of a tower crane on East 51st street in Manhattan on March 15, 2008 that claimed seven lives, six of whom being construction workers and the other being a bystander inside a nearby building that was impacted, drew more attention to crane safety.

In an analysis of crane safety, as reported by the Center for Construction Research and Training (CCRT), from 1992 to 2006, data from the Bureau of Labor Statistics indicates that there were 632 construction worker deaths resulting from crane accidents, or an average of 42 worker deaths per year. The leading cause of death from these accidents, roughly 25%, was electrocution from contact with power lines. Crane collapses accounted for about 14% of the reported deaths. Surprisingly, for over half of the crane collapses, the cause is listed as unknown. The other crane collapses were attributed mostly to ground conditions, overloading, or shifting of the load. Of the reported crane collapses, approximately 40% involved mobile cranes. In 2008, a review of trade and news media by CCRT indicated that there were 54 construction worker fatalities associated with crane accidents, an approximately 30 % increase over the annual average from 1992 to 2006 (Peraza and Travis, 2009).

Prenza and Travis (2009) indicate that following the 2008 crane accident in Manhattan, the Department of Buildings and the City of New York (NYC) swiftly enacted new regulations and measures as given in Table 3.21.

Table 3.21: NYC Department of Buildings New Regulations and Measures for Crane Safety

New regulations and Measures
• The requirement that written plans and specifications be prepared by an engineer for the erection, jumping, and dismantling of a tower crane
• The use of nylon slings was generally prohibited. Nylon slings shall only be used if the manufacturer's manual specifically recommends that nylon slings be used. Nylon slings should never be used unless softening mechanisms have been applied to all sharp edges
• Minimum training requirements for the crew performing the erection, jumping or dismantling
• Requiring that safety coordination meetings be held prior to erection or jumping a crane
• A building inspector must be present whenever a tower crane is raised or lowered
Other changes being considered by the NYC Department of Buildings
• Mandatory Labeling Requirements for Critical Crane Components. This would be a universal system of labeling each key structural component of the crane in order to track it throughout its lifetime. The labeling will include the climbing frame, machine deck, engine, cab, A-frame, turntable, all mast and boom sections and other critical parts.
• Impose Additional Requirements for Testing. This would require suitable testing of critical crane components including, but not limited to, the climbing frame, machine deck, engine, cab, A-frame, and turntable as well as connections, joints, pins, bolts, tiebacks, and collars.

Beavers et al. (2006) also investigated crane-related fatalities in the construction industry in the US. Their research results showed the use of mobile cranes with lattice and telescopic booms, truck or crawler mounted, represented over 84% of the fatalities in the use of cranes/derricks.

They classified the reasons of crane-related fatalities as follows:

1) Failure of boom/cable
2) Crane tip over

3) Electrocution
4) Struck by load (other than failure of boom/cable)
5) Falls
6) Crushed during assembly/disassembly
7) Struck by cab/counterweight

The recommendations they provided based on their study results for preventing crane-related injuries and fatalities are given in Table 3.22.

Table 3.22: Recommendations for Preventing Crane-Related Injuries and Fatalities

• Employers should have a system in place to assess the "hazardousness" of each of their construction worksites in relation to the potential for a crane-related event
• As a minimum, employers should have a crane safety plan that describes the procedures for each lift, which can be part of the site safety plan
• A "diligent" competent person should by assigned by the manager of construction operations to be in charge of overall crane operations with complete authority to stop unsafe operations
• Several types of crane-related construction fatalities will not be reduced until crane operators and riggers are required to be qualified with requalification perhaps every 3 years
• Crane operators must have the authority to stop crane lifting operations if an unsafe lifting operation is observed
• The rigger must have the authority to stop rigging operations if an unsafe rigging operation is observed.
• Ironworkers, laborers, carpenters, etc. who are going to be required to work around or near cranes must have some crane safety training before they are allowed to do the work.
• Although there is no OSHA requirement, the data from the case files suggest a "diligent" competent person [as defined in 29CFR 1926.32(f)] should be in charge of all aspects of lifting operations;
• OSHA should consider modifying its list of major crane related fatality causes to match those observed in the studies
• OSHA should continue to improve its system of collecting information during fatality investigations, including emphasis on intervention strategies, from top management down to field staff. During the collection of data OSHA needs to ensure that the data are accurate and capture all relevant features of the situation in which the fatality occurred in order to improve usefulness to researchers and policymakers inside and outside the Agency

Construction fatalities also continue to occur during steel erection. Beavers et al. (2009), using 166 case files resulting from Occupational Safety and Heath Administration (OSHA) investigations of steel erection fatalities during the years 2000–2005, examined the data revealing that of the 166 fatal events, proximal cause “falls” represented 125 of the fatal events, “crushed/struck/hit by object” represented 40, and one was caused by electrocution. The rate of fatalities tended to reduce from 2000 to 2005. The authors concluded that OSHA may be reaching one of its goals established following the introduction of the new steel standards in 2002, an annual reduction of 30 fatalities. The results of their study also indicate that employer compliance with OSHA’s fall protection standards and instructing employees in recognition and avoidance of unsafe conditions could save lives.

Similar statistical comparisons can be made between the US and Turkey as to the construction hazards.

In Turkey, compared with the western countries, the number of fatal injuries and incidence rates are high. Approximately 72,000 occupational accidents occur each year, and approximately 1,000 of these cases end with deaths (MLSS, 2003). This might be due to the fact that many construction projects are realized by small or middle scaled companies and, these companies do not give adequate importance to occupational safety in their practice.

Manisalı et al., (2007) evaluated construction accidents in Turkey based on SII (2005) . Construction idustry ranks the second as far as work-related accidents are concerned, preceded only by metal industry. When the means of the data of 4 years before 2005 are examined, of the 76,691.3 work-related accidents, 7,691.5 (10.03%) occurred in the construction sector. In 2005, of the 73, 923 work-related accidents , 10,283 (13.91%) occurred in the metal industry, followed by 6,480 (8.77%) in the construction sector.

As to the number of construction fatalities, they rank the first among the others in other sectors with a percentage of 30 according to 2005 statistics, that doubles or almost triples those of logistics sector. The frequency of construction accidents is reported to rank the fourth with a mean of 0.37.

It is also reported that (Gürcanlı and Müngen, 2007) the statistics of the past twenty years reveals that while the mean of work-related fatalities is 33 out of 100 thousand workes, this value is 66.4 in the construction sector in Turkey.

Kuşan et al. (2007) reported that the percentage of construction showed a decrease from 12.06% in 1996 to 8.77% in 2005 among work-related accidents. They comment that while 14 workers out of a thousand were exposed to construction accidents, it was 7 out of a thousand in 2005.

Ural et al. (2007) reported that the most frequent cause of construction accidents is falling from a high level, the finding being based on their study in construction sites in the Çukurova region between the years 2003 and 2005.

Aydın (2007) comments that falling from a higher level ranks the sixth among the causes of accidents reported in 2005 (SII, 2005) which may not have revealed the actual status that is expected to be higher.

With regard to other causes of construction injuries and/or accidents, Gürcanlı et al. (2008), focusing upon 5,289 fatal and non-fatal injuries that occurred on construction sites reported that for this industry, and not only for fatalities but also for non-fatal cases, traffic accidents and construction equipment related injuries are the leading causes after falls, electrocutions and injuries by falling objects. The authors conclude that fatalities are resulting from the negligence of basic safety measures. Their suggestions for equipment operators as well as site workers to prevent fatalities in construction sites are given in Table 3.23.

Child fatalities on or near the construction sites unfortunately seem to be common in Turkish construction sites. Gürcanlı (2009a) investigated nine hundred and fifty six expert witness reports, which were submitted to criminal and labour courts and analyzed third party and child fatalities according to causation and type of construction . One hundred and twenty two (98 fatalities) of 971 victims were third parties and 69 (58 fatalities) of 122 victims were children (under age 12). All non-employee (50.0%) fatalities and 48.3% of child fatalities were caused by falls from height. The vast majority of child deaths (79.3%) were reported to occur in five most hazardous work areas: residential/commercial (39 cases, 39.8%), institutional (15 cases, 15.3%), small buildings (12 cases, 12.2%), wells (9 cases, 9.2%) and channels (6 cases, 6.1%) (Gürcanlı, 2009a).

Müngen (1997b) noted that analyses of Social Insurance Institution of Turkey Statistical Yearbook (SII, 2003) revealed that fatal accidents in the construction industry are caused by the negligence of basic and ordinary safety measures, carelessness and absentmindedness of the workers, level of training and consciousness of the workers as well as site engineers and poor traffic organization levels on construction sites. The authors concluded that a culture of safety and awareness among the workers and engineers did not seem to exist adequately with insufficient importance given to safety management; furthermore, safety management practices were indicated to be perceived as an extra cost for construction projects. Employers were also noted to perceive safety measures as extra work due to the of the lack of safety culture. The authors also observed training and knowledge on legislation of occupational safety and health was very unsatisfactory both among unskilled workers but also among civil engineers (Gurcanli, 2006). This situation was also revealed in a previous report of this group in the way that more than half of the interviewed civil engineers were uninformed regarding the current legislation and their legal responsibilities (Müngen and Kuruoğlu, 1997).

Table 3.23: Recommendations for Preventing Fatalities in Construction Sites in Turkey

- Training of operators for proper use of the equipment
- Training of the group of personnel who are responsible for the traffic plan to observe
- Inspecting and warning the construction workers during operations such as lifting, loading, or excavation or when the traffic density inside the site at a high level
- Continuous evaluation of safety programs to address changing conditions at the worksite
- Recognition and avoidance of the site workers of unsafe conditions
- Following required safe work practices revised according to the changing working environment
- Identification and labelling all machine controls by the operators, co-operators, drivers or mechanics at the garage of the site to ensure that the manufacturers' safety features are working, and installing and maintaining equipment attachments and their operating systems according to manufacturers' specifications
- Awareness of all the workers on the of the machines' established swing areas and blind spots before the operator turns on the machine
- Keeping the workers and third parties outside the construction areas by marking them with rope, tape or other barriers
- Connecting locking attachments securely before the work begins and instructing operators for lowering the boom to a safe position with the bucket on the ground and turning off the machine before stepping off for any reason, as a routine work
- Not allowing the workers approaching the hydraulic excavator or backhoe loader on foot until they signal the operator to shut down the machine and receive acknowledgments from the operator
- Performance of risk analysis in detail according to the changing working environment
- Obligatory certification of employers in risk analysis programs before the work commences at construction sites

Gurcanlı et al. (2006) also point to the lack of sufficient government inspections regarding safety in construction sites with very few number of officials (294 government inspectors for all industrial branches-in 2006) who are able to check safety measures in only 10% of the companies in 90,130 construction sites (SII , 2003).

Müngen and Kuruoğlu (1997b) also pointed to the importance of construction safety in civil engineering education in a book chapter.

It is obvious that efforts of the academic persons in universities in Turkey for identifying hazardous situations in construction industry, developing methods for risk assessment regarding safety, and making suggestions based on the data they gathered through careful investigations contribute substantially for the improvement of safety management practices in Turkey.

3.6.2 Laws and regulations

Considering laws and legislations, it may not be wrong to say that the US is a society based on the concept of laws. The laws, bylaws, rules, regulations, or legislations are very comprehensive and detailed that they even define the "steps" of construction engineers.

Regarding laws for safety management practices in the US, Occupational Safety and Health Act (OSH Act) was introduced in 1970 (OSH Act, 1970; With the Occupational Safety and Health Act of 1970, Congress created the Occupational Safety and Health Administration (OSHA) to ensure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance. OSHA is part of the United States Department of Labor. The administrator for OSHA is the Assistant Secretary of Labor for Occupational Safety and Health. OSHA's administrator answers to the Secretary of Labor, who is a member of the cabinet of the President of the United States (OSHA, 2010).

The U.S. Government Printing Office (GPO) (GPO, 2010) and the Office of the Federal Register (OFR) (OFR, 2010), an agency of the National Archives and Records Administration (NARA) (NARA, 2010), disseminate the official text of Federal laws; Presidential documents; administrative regulations and notices; and descriptions of Federal organizations, programs and activities. Among the publications, The Code of Federal Regulations (CFR) (CFR, 2010), the codification of the general and permanent rules and regulations (sometimes called administrative law), is of special importance to construction engineers regarding safety management.

The most important safety and health regulations for construction are the following:

- Subpart P—Excavations
- Subpart E, Personal Protective Equipment (PPE)
- Subpart H, Rigging
- Subpart Q, Concrete & Masonry
- Subpart D, Hazard Communication
- Subpart R, Steel Erection

Regulations regarding "excavations" are given as an Appendix (Please see Appendix). This more than thirty page document covers scope, application, and definitions applicable to this section, all the requirements for excavation, and requirements for protective systems including the appendices for specific topics. One may be surprised to see how detailed they are. Even configurations of sloping and benching systems are given in tables and are illustrated in figures (Table B-1, Figure B-1 in Appendix 1). Another prominent feature is that they are updated regularly, with a notice on top highlighted in red. It is open to public access. It emphasizes the fact that the US is a society based on the concept of rules and regulations. Therefore, safety management relies on extensive laws and regulations for the prevention of construction-related injuries. Everybody involved in construction sector is expected to go through these rules and regulations using the internet and obey these.

It should also be noted that every civil engineer, even anybody working at the jobsite, is required to take an OSHA Construction Health and Safety training course in order to be allowed to enter a jobsite.

Because each part is so elaborated, other subparts of Title 29 (Labor), PART 1926—SAFETY AND HEALTH REGULATIONS FOR CONSTRUCTION or PART 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS in the CFR are not given in this work. One may refer to the electronic version at http://ecfr.gpoaccess.gov in case of interest.

Below are some photographs showing safety issues in construction sites:

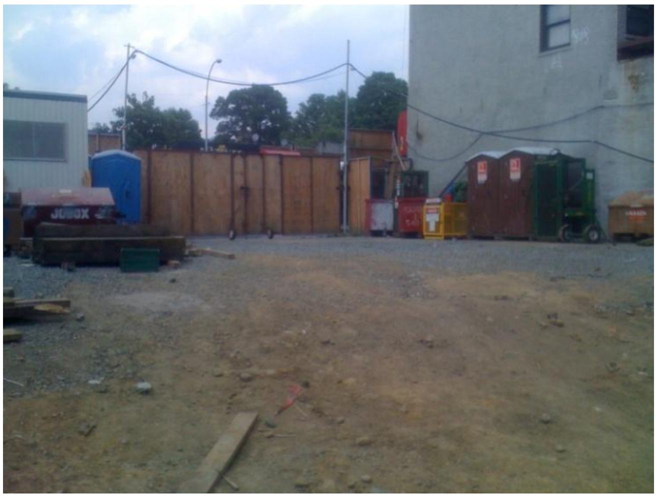

Figure 3.6: Inner view NYCSCA school construction jobsite: Jobsite is surrounded with a wooden fence which blocks all unauthorized trasspassings. Gate is kept closed at all times.

Figure 3.7: Street entrance at an NYCSCA school construction: Precautions are taken both for pedestrians and vehicles on the sidewalkand at the left lane (bike lane) of the street.

Figure 3.8: Precaution signs: Coution signs are placed in or around the construction site o inform and warn authorized personnel who has right to be or at the jobsite (Oral, 2010- photographed personally).

Figure 3.9: Sidewalk fence: Street vehicle traffic is seperated from the jobsite by surrounding wood fence. Pedestrian traffic is banned at the construction side curb and diverted to opposite side. Also at the upper floor of the back building security fencing at slab edges are clearly visible (Oral, 2010- photographed personally).

Figure 3.10: Temporary netting around the slab opening: Slab opening is secured with temporary netting in order to create a safe environment for work and to avoid falls, dropping of tools and equipments to prevent hazardous accidents.

Figure 3.11: Fire extinguishers: Mandatory fire extinguishers are provided near all welding, soldering, or other sources of ignition at the jobsite to be used in case of a fire.

Figure 3.12: Pipe scaffolding: Pre-manifactured scafolding is erected at the working area of a renovation project and surrounded with netting around it.

Regarding construction safety issues, an important paradigm in the US is the owner's liability in construction safety. In the US, the owner's role in construction safety has also been investigated, which might set a good example for safety management practices in the US. Although the contractor is undoubtedly the pivotal party to control job-site safety, the involvement of owners has been regarded as an essential requirement for the zero injuries objective. Owners can favorably impact construction safety by selecting safe contractors, encouraging designers to address safety issues in the designs, and participating in safety management during construction (Huang and Hinze, 2006a).

Huang and Hinze (2006b) present a model that evaluates the impact of owner practices on project safety performance. In this model, the owner's involvement with the following project practices are assumed to be implemented by the owner:

- The owner requires the primary contractor to report OSHA recordable injuries
- The owner assigns at least one safety representative to the project with high authority, with responsibilities clearly defined
- The owner's site safety representative regularly monitors the contractor's safety performance
- The owner places a priority on safety when selecting contractors, and maintains an approved contractor list for awarding the contract
- The owner specifies basic safety requirements in the contract document;
- Basic components are required in the contractor's safety program
- The owner addresses safety in the design phase
- Key responsibilities assumed by the owner's safety representative include:
- Enforcing safety rules
- Reviewing site safety performance and submitting reports to the home office
- Monitoring pretask analysis programs
- Participating in safety recognition programs
- Participating in safety and/or toolbox meetings.

Having evaluated these assumed practices in different projects, the authors conclude that the owner's participation in project safety can significantly influence project safety performance.

With regard to violations of OHSA standards, the most cited violations of OSHA standards and consequences are given in Table 3.24.

As seen in Table 3.24, specific excavation requirements have been the subject of the highest number of citations regarding OHSA standards. The highest penalty charged, with 1,900,529 USD, was for requirements for protective systems. However, obedience to accident prevention signs and tags, general safety and health provisions and general duty clause seem good, with the least number citations despite moderately higher penalties. The National Safety Council (NSC, 2010) also reports that the average cost of each of fatalities was approximately $1,150,000.

Table 3.24: Top 10 OSHA Standards Cited for 2005 in the US (Doran et al. 2010 adopted from the instructors' power points at the standards of practice course of CMAA)

Standard	# Cited	# Insp	$ Penalty	Description
Total	2900	1033	4505716	Total Assessed Penalties
19260651	729	419	920550	Specific Excavation Requirements
19260652	578	487	1900529	Requirements for protective systems
19260021	173	163	202466	Safety training and education
19260100	116	115	71936	Head protection.
19260501	82	72	159879	Duty to have fall protection
19261053	68	55	43298	Ladders
19260200	67	60	63502	Accident prevention signs and tags
19260550	60	38	100950	Cranes and derricks
19260020	56	49	58388	General safety and health provisions
5A0001	54	49	224876	General Duty Clause

Mohan and Niles (2002) also investigated OSHA citations pertaining to earlier years. Two hundred fifty-five OSHA citations were decided by the Occupational Safety and Health Review Commission (OSHRC) during the years 1991–1993. These 255 cases included 884 violations of OSHA Standards 29 CRF 1926. Out of these 884 violations, 56% were affirmed, 18% were modified, and 26% were vacated by the OSHRC. The most frequently contested violations belonged to Subpart D—Occupational Health and Environmental Controls (118 violations), Subpart P—Excavations (103 violations), and Subpart K—Electrical (90 violations). The authors point to the effectiveness of OSHA citations that an increase in monetary penalties places a greater impact on construction companies that violates the standard. They indicate that with a greater risk of penalties, an increase in safety spending for each company becomes economically justifiable. However, the most important point they make is a need for a reversal of employer motivation. Currently, citations are written and fines are assessed for negative behavior, that is the absence of safety. On the contrary, the goal of employers should be to see their employees work safely, and then go home to their families at day’s end. The authors conclude that the primary goal of the 1970 OSH Act is to protect employees from dangerous situations and provide measures for the employer to follow to safely construct projects. It is clear that employee safety is the number one priority. OSHA and the individual employers should work together to make sure every worksite is as safe as possible. Ideally, a compliance officer would come to the site and leave without writing a citation. No standards would be overlooked, but all activities on the site would be done as set forth in the standard.

In a study in the US, workers compensation claims frequency has been found as an indicator of contractors' safety performance (de la Garza et al., 1998). Workers’ compensation "best practices" of the contractors are identified as sharing accident investigation with their employees, educating their workers about workers’ compensation issues, reviewing claims to look for fraud, having a modified work program to encourage the return to work as early as medically possible, preselecting a panel of physicians and/or medical, facilities, having a formal workers’ compensation management program, having their workers’ compensation costs affected by the relationship, or lack thereof, with insurers, using incentive programs to help control workers’ compensation, and having a workers’ compensation cost allocation system in place to assign responsibility and allocating costs among the various levels of management for workers’compensation claims.

Regarding laws and regulations related to construction in Turkey, 4857 Labor Law of the Turkish Republic deals with Occupational Health and Safety in CHAPTER 5 (İK, 2010). However, although they are supported by some other bylaws and regulations or other laws, it can easily be seen that subparts are not as detailed as those in the US (As an example, further information on “Hafriyat toprağı, inşaat ve yıkıntı atıklarının kontrolü yönetmeliği” is available from URL-11, 2010.

The construction engineers report that Occupational Health and Safety Law in Turkey is not systematically arranged with existing laws, regulations and by-laws being disorganised. It is also reported that while Occupational Health and Safety Regulation in Construction Works arranges the code of practices in construction, there is only one article regulating traffic organisation on construction sites. Article 17 of the regulation states that “If trucks or similar motor vehicles operating in the construction work zones, for entrance and exit of the vehicles, places are arranged properly with the traffic signs, where vehicles have to reverse (manoeuvre) they must be controlled by properly trained banksmen. Vehicle access and parking points and routes around the site must be provided and unless the necessary safety measures satisfied, drivers must not leave their vehicles even momentarily" (Gürcanlı, 2006a).

Ercan (2007) well documented the organizational structure pertinent to occupational safety and health in Turkey in comparison to that in the US. The issue of "occupational safety and health" is dealt with several organizations in terms of legal, technical and training aspects (Occupational Health and Safety Center, and Social Security Instutition, and Auditing Committee) in Turkey. However, in the US, OSHA is in charge of occupational safety and health issues in the three aspects above, which prevent the probable lack of communication between more than one organization in charge.

With regard to the use of safety standards in Turkey, while OSHA standards are indispensable in the US, OHSAS 18000, an international occupational health and safety management system with two parts 18001 and 18002 (OHSAS, 2010), and International Labor Organization's instruments on occupational safety and health (ILO-OSH) (ILO, 2010) are used in Turkey (Gürcanlı and Müngen, 2005a;Gürcanlı and Müngen, 2007).

Öktem et al.(2008) indicate that there has been a substantial increase in the number of firms who apply OHSAS 18001 in the construction sector in Turkey, with the number being only one in 1999 and 67 in 2007. Their survey involving 23 Turkish firms with ISO 9001 accreditation revealed that 14 of them (61%) were applying OHSAS 18001 as well.

Enforcements for safety violations in Turkey include penalties, suspensions, closing of the jobsite, and prevention of the workers from continuing to work (stop-orders) (Baycık, 2007).

Summons for a fatality in a construction jobsite may reach to 1-1,5 million TL in Turkey (Müngen and Gürcanlı, 2009).

Regarding laws and regulations, Işık (2007) points to the situation that while there is a parallelism with international practices, applications are not at the same level in Turkey.

Aslan (2001) indicates in his Master's thesis that the success of safety management practices is at a very low level of 8% compared to ideal CMAA practices as assessed in 2001 in an industrial facility construction.

In conclusion, based on the data evaluated in the articles published by Turkish authors, "Safety Management" is an inadequately performed part of construction management, contrary to the safety management practices in the US, where it is properly regulated by laws and legislations; furthermore, the US practices on "safety management" are highly different than those in Turkey in terms of penalties due to the violations of the relevant laws and legislations.

3.6.3 Improving health and safety

The poor safety records of the construction industry have forced researchers to find solutions for improving the occupational health and safety.

Researchers are trying hard to improve safety management practices, particularly for the prevention of construction injuries.

In 1996, the National Institute for Occupational Safety and Health (NIOSH) initiated the National Occupational Research Agenda (NORA), a research framework that identified critical occupational safety and health issues. To become more effective in preventing fatalities, injuries, and illnesses in construction, the NORA Construction Sector Council developed fifteen strategic goals for the "National Construction Agenda." One of the strategic goals was aimed at improving the effectiveness of safety and health management programs in construction and increasing their use in the industry (NORA, 2008).

In an effort to address that goal, Calhoun and Hallowell (2010) highlighted the most important elements that constitute an effective safety program which were consistently emphasised in relevant literature they reviewed. The fifteen critical elements to an effective construction safety program, the authors identified, are given in Table 3.25.

In another study, Hallowell and Gambatese (2009b) reported the quantification of the construction safety risk mitigation associated with essential safety program elements identified in the above study (Calhoun and Hallowell, 2010). The results of their research indicate that the most effective safety program elements are upper management support and commitment and strategic subcontractor selection and management and the least effective elements are recordkeeping and accident analyses and emergency response planning. The data they present can be used to strategically select elements for a safety program, target specific safety and health risks, and influence resource allocation when funds are limited.

Table 3.25: Critical Elements to an Effective Construction Safety Program

Safety Program Element	Definition
Emergency response planning	Plans that include emergency response personnel, equipment, and procedures that cover emergency situations.
Frequent safety inspections	Regularly conducted safety inspections by safety manager or safety committee across the project site to identify hazardous exposures to workers.
Job hazard analyses	Identification of specific safety hazards prior to a routine job, task, or process.
On-site first aid	Basic emergency treatment given to someone injured before medical services can arrive.
Project safety incentives	A tangible incentive given out on the project level for meeting a pre-specified outcome or level of performance.
Record keeping and accident analyses	The investigation, documentation, and reporting of accidents, nearmisses, first-aid cases, and other incidents.
Safety and health committees	A divers group of individuals on a specific project with the sole purpose of addressing safety and health on the worksite.
Safety and health orientation	Orientation and training sessions that focus on safe work practices and company safety policies for all new hires.
Site-safety manager	Full-time employment of a safety professional with formal safety experience and/or education that is charged with site safety.
Site-specific safety plan	A safety plan developed prior to construction commencing that is specific to a project that documents safety objectives, goals and methods for achieving success.
Subcontractor selections and compliance	The selection and oversight of subcontractors to ensure effective safety protection for all workers at the site.
Substance abuse programs	The identification and prevention of substance abuse in the workforce. Drug testing programs intended to reduce safety incidents and improve productivity.
Training and regular safety meetings	Formal in informal safety and health training provided for managers, supervisors, and employees. Regular safety meetings are conducted to emphasize training and commitment to safety culture.
Upper Management Support	Upper management of an organization that acknowledges worker safety is a primary goal through motivation and resources to worker safety and health.
Worker participation and involvement	Worker involvement in the planning and operation of the safety and health program

(Prepared based on the work of Calhoun and Hallowell, 2010).

As another effort for improving health and safety in construction industry, Koehn and Data (2003) have analysed the causes of incidents in construction and provided possible solutions to prevent these incidents. These recommended solutions are given in Table 3.26.

Table 3.26: Recommended Solutions for Incidents in Construction

Causes of incidents	Possible/Recommended solutions
Poor site supervision and practice	Implement work procedures, prepare inspection checklist, and use it effectively
Lack of motivation and care	Staff motivation and support
Lack of knowledge and training	Provide both job training as well as institutional training
Lack of quality, environmental, health, and safety budget	Provide adequate funds to improve poor quality, environmental, health, and safety conditions
Design too complicated to build	Take quality, environmental, and health and safety conditions under consideration during design stage
Overemphasis on speed of construction rather than quality, environmental and health, and safety conditions	Maintain uniform speed rather than rushing. Use critical path method, Microsoft Project, etc. for project duration calculations.
Defective materials	Reject defective materials on-site. Conduct material testing when required
Defective documentation procedures	Proper documentation and document control
Overlooked site conditions	Visit site by qualified personnel before bidding a project
Lack of communication between contractor and design team including regulatory authorities such as Building Construction Authority, Occupational Safety and Health Administration, etc.	Establish proper communication channels. Check on any new rules and regulations, periodically
Inadequate supply of personal protective equipment i.e., safety boots, helmets, ear plugs	Supply proper and adequate number of personal protective equipment and enforce workers to use them
Poor subcontractor with new unskilled workers	Select only those subcontractors who have a good record, and provide on-the-job training

(Adopted from Koehn, and Datta, 2003)

Han et al. (2010) very recently addressed a rather new concept, what is called "resilience engineering", in safety management. The authors describe "resilience engineering" as a proactive management approach that allows future risk to be anticipated and the safety level in an organization to be maintained, based on perceptions of current and changing safety levels and recognition of acceptable limits. This concept is rather new in the way that it advocates the necessity to control safety by predicting hazards and planning for the organization to recover safety to an acceptable state, just as the load in a stress-strain curve should be in the elastic zone to prevent the deformation of materials, which is beyond the conventional perspective that human errors and unsafe physical conditions cause accidents. This approach provides a new direction in safety management, and the concept of resilience is reported to have recently been adopted in the construction industry in the US.

In relation with this new concept, Ghosh et al. (2010) also stress the importance of predictive indicators such as measures of safety climate to reduce the need to wait for incident to occur. Safety climate, referred to as the people's perception of the value of safety in the work environment, has been measured in various industries including construction. The authors examined the survey instruments to identify key terms that reflect the main safety climate themes. They identified two core themes (safety rules and procedures, role of management) which have been repeatedly used in safety climate measures, along with a number of other dimensions (impact of work environment, workers' involvement, communication) emerging less frequently. Safety rules and procedures included safety attitude, risk taking behavior, safety training, and competency of supervisor; management roles included encouragement, systems and procedures, work pressure, and management commitment. Thus it is evident that perception of the state of safety procedures in any organization is an important component of the safety climate. The second theme, the labeled role of management, encompasses many different managerial aspects of an organization such as commitment of the management to the safety and well being of the employees, their encouragement and incentive programs, and the work pressure.

In a paper by Hallowell and Gambatese (2009a), a method to quantify the comprehensive safety risk at the activity level for a common construction process is presented in an attempt to allow managers to focus safety program elements such as job hazard analyses and inspections on high-risk activities rather than large-scale processes e.g., roofing and steel erection. Their analysis, using the Delphi method, indicated that the highest risk activities include the application of form oil, lifting and lowering form components, and accepting materials from a crane. Considering all formwork activities, the highest safety risks were exposure to harmful substances, struck-by, and overexertion.

As a new way of looking, task analysis for safety concerns have also been addressed by Mitropoulos and Guillama (2010) in a recent article. Their analysis resulted in a framework of five task factors that increase the task demands: 1) working platform constraints, 2) ergonomic postures constraints, 3) material/load handling requirements, 4) tool use/accuracy requirements, and 5) difficulties due to external forces.

Another attempt of researchers was to develop and validate a sustainable construction safety and health rating system (SCSH) aimed specifically at designers (Rajendran and Gambatese, 2009). It is reported by the researchers that addressing construction worker safety in the design of a project is a relatively new concept in the construction industry.The authors advocate that in order to have sustainable safety and health, the SCSH rating system should include elements that deal with safety and health of the facility maintenance personnel as well.

As an important practice, in order to reduce the costs and hazards of field training on heavy construction equipment, computer-based simulators are being used in the US. Computer-based simulators are reported to eliminate such risks involved in construction-equipment operator training Systems endorsed and utilized by equipment manufacturers are also being adopted by independent equipment operator training schools (Dunston et al., 2010).

Integrating sensing technologies within existing safety management strategies have also been the subject of research. In recent years, researchers have made considerable efforts to develop proximity sensing technologies that provide workers and equipment operators with an audible warning when predefined proximity thresholds have been breached (Hallowell et al., 2010). Multiple potential technologies are technically available to the construction industry for hazard sensing. Candidate sensors are: (a) Radio Detection and Ranging (RADAR), (b) Ultrasound, (c) Ultra Wideband (UWB), (d) Radio Frequency Identification (RFID), (e) Laser Detection and Ranging (LADAR), (f) Global Positioning Sensors (GPS), (g) Visual video (stereo or mono, wide field-of-view, pan-tilt-zoom), (h) Thermal video, (i) Digital imaging (visual and still, thermal, 3D range), (j) Range video, and (k) possibly others. Of these technologies, vision and wireless sensing technologies (video cameras, passive and active RFID proximity and alerts, and UWB positioning) offer particularly promising approaches to enhance safety. However, these technologies have many current limitations including positioning error (Teizer et al., 2007).

Hallowell et al. (2010) report that RFID/UWB technologies can be employed to prevent injuries on construction worksites. These Technologies have particular application to real-time warnings of proximity to unsafe work zones, equipment, and materials. The technologies may also have potential for enhancing recordkeeping and accident analyses, job hazard analyses, orientation and planning, and enhancing management activities conducted by the safety manager. Despite these potential benefits, there are some significant barriers that may preclude the immediate use of these technologies including reliability, appropriate design for unique and dynamic work environments, and lack of expertise of typical safety and project managers. The authors suggest that safety professionals and construction managers are encouraged to adopt the technologies and implement on a small sample population. It is expected that initial integration with a sample crew would involve a relatively low cost and have high short-term and long-term payback that could result in a safer worksite and a competitive business advantage.

Ergen et al. (2007) also investigated sensing technologies. They aimed to identify how RFID technology can improve current facility management processes and to determine technological feasibility of using RFID within a facility repetitively on a daily basis. The authors tagged fire valves in a facility with RFID tags and conducted a longevity test for sixty consecutive days by simulating tag identification, data access, and entry in real-life conditions. The results demonstrated that current commercially available active RFID technology performs well in a building environment where metallic objects and different obstructions are present. The observed reading distances were approximately half of the reading range expected in open air provided that there are not any massive obstructions between the reader and the tag.

The subject of "safety management" in the construction industry have been addressed in a number of studies by a group of researchers in the Department of Construction Management in the Construction Engineering Division of Istanbul Technical University in Turkey (Müngen, 1984; Müngen 1990; Müngen 1991; Müngen, 1993; Müngen, 1996a; Müngen 1996b; Müngen 1997a; Müngen 1997b; Kuruoğlu, 2005; Gürcanlı, 2006). One of the first attempts on "safety management" issues in Turkish construction industry was the work of Müngen (1993) who classified the construction injuries (Müngen, 1993).

Regarding risk analysis, an occupational safety risk analysis method at construction sites using fuzzy sets has also been suggested by Turkish experts (Gürcanlı et al., 2005b; Gürcanlı and Müngen, 2006b and 2009b). This method uses a fuzzy rule-based safety analysis to deal with uncertain and insufficient data. Using this approach, historical accident data, subjective judgements of experts and the current safety level of a construction site can be combined. Combining these data and the subjective judgement of safety experts, parameters are derived such as the accident likelihood, current safety level and accident severity and they are utilized as input parameters for the fuzzy rule-based system. The relevance of this study to industry is linked to the possibility of providing, through the use of proposed methodology, safety level scores for the construction sites that could result in work improvement and productivity. The application of the proposed method can reveal which safety items and factors are most important in improving workers safety, and therefore decide where to concentrate resources in order to improve the safety of the work environment. Although there is legislation in Turkey demanding risk analysis at job sites, the legislation does not suggest any risk assessment method. The method proposed by the authors will obviously be helpful for safety practitioners in the construction industry in Turkey as well as at the international level.

In a study similar to that of Hallowel and Gambatese (2009b), Gürcanlı and Müngen (2007) investigated the knowledge and practice of 76 persons in 68 construction sites and in a center of a construction firm regarding basic safety elements comparable to those used in the US study. The questionnaire survey revealed that the responses with the highest score were related to record keeping and accident analyses and the one with the lowest score was related to inspections. The authors pointed to the low level of inspection by governmental authorities.

On the other hand, it should be noted that considerable endevours have been made in Turkey after 2000 in order to improve occupational health and safety which may partly due to the efforts of Turkey to be a member of the European Union (Baradan, 2006).

One example might be the İSAG project, "İş Sağlığı ve Güvenliğini Geliştirme Projesi (Occupational Health and Safety Improvement Project) (İSAG, 2005). The Ministry of Labor and Social Security has given a start to this project in November 2004 with the aim of raising awareness on work-related safety issues. Another aim of this project is to imrove occupational health and safety standards to the level at the European Union.

Issues related to safety management practices in the US and in Turkey are compared in Table 3.27.

Table 3.27: Comparison of Safety Management Practices in the US and in Turkey

	Practices in the US	**Practices in Turkey**
SAFETY MANAGEMENT		
• **Construction hazards**		
• **Construction industry rank**	Fourth[a]	Second[b]
• **Incidents**	380,500* in 2005[c]	6480 in 2005[d]
• **Fatalities**	1243[c]	~1000[e]
• **Increase/decrease**	Decrease by 4.9% (2006-2007)[c]	Decrease to 8.77% in 2005from 12.06% in 1996[f]
• **Causes**		
• **Falls**	Ranks first [c]	Ranks first[g]
• **Construction equipment**	42 workers death per year (crane-related) [c]	Follows falls[g]; No precise data
• **Rules and regulations**		
• **Responsible authority**	US Department of Labor, OSHA[h]	Ministry of Labor of TR[ı]
• **Main law**	OSH Act[j]	4857 Labor Law of TR[k]
• **Regulations**	29 CFR Part 1926[l]	Various[m]
• **Contents**	Very detailed and clear [l]	Less detailed; disorganized[m]
• **Dissemination**	GPO, OFR, NARA in collaboration[n]	Ministry of Labor of TR[ı]
• **Inspection**	Safety Health Professionals, Safety Management Specialists[o], Inspectors	Inspectors, but very few Safety specialist and Safety Engineer (new)[p]
• **Enforcement**	OSHA[h]	Ministry of Labor of TR[ı]
• **Tasks**	OSHA[h] (all in one hand)	3 different organizations involved[q]
• **Updating/Enacting new ones**	Swiftly enacting new regulations and measures when needed[r]	Slow[ı]
• **Penalties for violations**	High[h]	Relatively low[s]
• **Other systems applied**	OSHA[h]	OHSAS; ILO-OSH[t]
• **Improving health and safety**		
• **Research agenda setting**	NORA[u]	No data
• **High technology use**	Sensing technologies (rare)[v]	No data
• **New concepts**	Safety climate[w];Resilience engineering[x]	
• **Success in safety management**	Great strides to improve safety at construction sites[c]	At a lower level[y]; Considerable improvement in the last years[z]

[a]CCRT, 2009; [b]SII, 2005;*Including illnesses;[c]BLS, 2009;[d]Manisalı et al., 2007; [e]MLLS, 2003;[f]Kuşan et al., 2007; [g]Gürcanlı et al., 2008;[h]OSHA, 2010; [ı]ML, 2010;[j]OSH Act, 1970; [k]İK, 2010; [l]CFR, 2010;[m]Gürcanlı et al, 2006a; [n] GPO, 2010, OFR, 2010, and NARA, 2010; [o]OOH, 2010-11, NASP, 2010; [p]Işık, 2007;[q]Ercan, 2007;[r]Preza and Travis, 2009; [s]Müngen and Gürcanlı, 2009; [t]Gürcanlı et al, 2007; [u]NORA, 2008; [v]Hallowell et al., 2010; [w]Ghosh et al., 2010;[x]Han et al., 2010; [y]Aslan, 2001; [z]Baradan, 2006.

3.7 CM Professional Practice Rules in the US and in Turkey

The concept of “construction management professional practice includes specific activities like defining the responsibilities and management structure of the project management team, organizing and leading by implementing project controls, defining roles and responsibilities and developing communication protocols, and identifying elements of project design and construction likely to give rise to disputes and claims as defined by CMAA (CMAA, 2010).

CM professional practice rules, the concept of “certified construction manager (CCM)”, and “Code of ethics” that helps to define the primary responsibilities of a construction manager to the clients and community are already discussed in subsections 2.1.7, 2.1.7.1, and 2.1.7.2, respectively.

Although the concept of CM professional practice is very well defined and there is accumulated experience in the past 30 years in the US, the Committee on Management Practices in Construction of the ASCE Construction Institute points to some confusion as to what exactly CM is and how it should be practiced (Arditi, 2009). One major reason for this confusion is noted to be the different expectations of the different parties in the construction process. It is advised by the relevant committee that it would be advantageous for all parties concerned to reconcile their differences and have a common understanding of CM duties over all phases of the construction project with a uniform understanding of CM duties across the industry in the US. It is also emphasised that CM duties are well established and well recognized by most parties at least in the construction phase of a project.

Regarding circumstances related to CM Professional practice rules in Turkey, task descriptions, responsibilities, ethical considerations and certification procedures are not defined clearly in Turkey.

Issues related to CM professional practice in the US and in Turkey are given in Table 3.28.

3.8 Training in Construction Management

Having compared construction management practices in the US and in Turkey, it would be incomplete if training in engineering or construction management is not mentioned because training forms the basis of CM paractices.

3.8.1 Professional engineering

"Professional Engineering" as a differing practice in the US from that in Turkey, is worth mentioning to stress the importance of education and experience for technical staff who would take public responsibilities.

Table 3.28: Comparison of CM Professional Practice Rules in the US and in Turkey

	Practices in the US	**Practices in Turkey**
CM PROFESSIONAL PRACTICE RULES	Defined well[a] Known well by CMs[b] Not known well by all parties[b]	Not well defined Not well known by CMs Not well known by any party[c]
• **Code of ethics**	Well defined[a]	No data
• **Existence of Specific Professional Organizations**	Many[a]	None (IMO is involved; not a specific CM association)[d]
• **Certification of construction managers**	CCMs[a], PMPs[e] CCMs certified based on extensive experience	Only certifcates after a 9 month certification program[f];not equivalance of CCM

[a]CMAA, 2010; [b]Arditiet al; 2009; [c]Kuruoğlu and Polat, 2002; [d]IMO, 2010;[e]PMI, 2010;[f]Kuruoğlu, 2002b

National Society of Professional Engineers (NSPE) provides its members with the information and resources they need to earn and maintain the respected PE seal as described below (NSPE, 2010):

A Professional Engineer (PE) is an engineer who is registered or licensed to offer professional services directly to the public. This title is a proof of competency for the individual to offer engineering services. This service can be offered both individually and as a business. A business must employ at least one Professional Engineer in order to offer engineering services to the public.

In order to protect the public health, safety, and welfare, the first engineering licensure law was enacted in 1907 in Wyoming. Now every state in the US regulates the practice of engineering to ensure public safety by granting only PEs the authority to sign and seal engineering plans and offer engineering services to the public.

Only a licensed engineer may prepare, sign and seal, and submit engineering plans and drawings to a public authority for approval, or seal engineering work for public and private clients. PEs shoulder the responsibility for not only their work, but also for the lives affected by that work and must hold themselves to high ethical standards of practice. Licensure for a consulting engineer or a private practitioner is not something that is merely desirable; it is a legal requirement for those who are in responsible charge of work, be either their principals or employees. Licensure for engineers in government has become increasingly significant as well. In many federal, state, and municipal agencies, certain higher level and responsible governmental engineering positions, must be filled by PEs. Many states require that individuals teaching engineering must also be licensed.

To become a licensed professional engineer, engineers must complete these steps to ensure their competency:

1) Complete a standard Fundamentals of Engineering (FE) written examination, which tests engineers on understanding of the basic engineering principles and some elements of an engineering specialty. Completion of FE qualifies for certification in the U.S. as an Engineer-In-Training (EIT)
2) Accumulate a certain amount of engineering experience. In most states the requirement is four years, but in others the requirement is lower
3) Complete a written Principles and Practice in Engineering (PE) examination which tests the applicant's knowledge and skills in a chosen engineering discipline (mechanical, electrical, civil etc.), as well as engineering ethics

It is the National Council of Examiners for Engineering and Surveying (NCEES), a national nonprofit organization dedicated to advancing professional licensure for engineers and surveyors, which develops, administers, and scores the examinations used for engineering and surveying licensure in the United States.

The fundamental difference between the US and Turkey regarding the authorisation of engineers to sign and seal engineering work public and private clients appears to be PE licensure. While Turkish engineers are authorized to sign and seal engineering work as soon as they are graduated after a 4-year of education, those in the US are not allowed to do so.

Some criticisms arise that 4-years of engineering training is not sufficient for providing competencies that would enable technical staff to provide efficient solutions to problems in construction industry in Turkey. Some advocate that the concept of “Professional Engineering”, which is a common practice in the US, is required for Turkey as well (Kuruoğlu, 2002b).

With the leadership of Turkish Chamber of Civil Engineers (IMO), these kinds of arguments has recently led to a legislation with the title “Yetkin İnşaat Mühendisliği Uygulama Yönetmeliği (Professional Civil Engineering Practice Rules)” (published in the Official Gazette n. 26285 on September 10, 2006) ((URL- 12, 2010), which is expected to form the basis for a relevant law.

The first “written exam” for professional engineering has been performed on April, 2007 in Turkey, confined to the specialty area of construction. Although a question bank has not been prepared so far, due to the similarities of the exams to those of the US, the applicants may benefit from some books with preparatory questions developed for the US applicants (Baradan and Çalış, 2007). IMO also electronically publishes the questions and answers of the previous exams (URL-13, 2010).

Table 3.29 shows the similarities and differences between professional engineering practice in the US and in Turkey.

Table 3.29: Comparison of Professional Engineering Practices in the US and in Turkey

Professional Engineering	In the US	In Turkey
Original name of the title	Professional Engineer (P.E.)	“Yetkin Mühendis”
History	1950s	September 2006
Training	To be a graduate of a civil engineering school	To be a graduate of an accredited program of engineering
Postgraduate exam	Required	No
Work experience (minimum)	4 years (differs between the states)	5 years of job experience with a professional engineer
Report	No need	Required
Oral presentation	No	No
Written exam	Required	Required
Advantages	Authorised to sign and seal public projects, authorized to give expert opinion, increments in salary, job opportunities, prestige	Prestige
Authorized institution	National Council of Examiners for Engineering and Surveying	Professional Engineering Council

(Prepared based on Baradan and Çalış, 2007; NSPE, 2010; NCEES, 2010)

Regarding professional engineering practices in Turkey, some problems were expected to appear for the time being in terms of the 5-year job experience with a professional engineer. Considering that the first exam was in 2007, it is obvious that that no licencure was given to any engineer at that time. This confusion has been corrected with the delay of the requirement for 5 years of experience with a professional engineer for the following 5 years. It is still not mandatory to be a professional engineer to sign and seal engineering plans/projects in Turkey. It can be argued that for now it is just a prestigeous title. There is a need to mandate this title to give authorisation to sign and seal public projects, to give expert opinion, to apply for bidding, and to create advantages such as increments in salary and better job opportunities to encourage engineers to obtain this title, Otherwise, it is unavoidable that engineers will not take PE seriously (Baradan and Çalış, 2007).

3.8.2 Required skills for an engineer

With regard to required skills for engineers in the construction education and training in the US, Dorsey (1991) reports that numerical skills (mathematics), written communication, verbal communication, graphical communication, financial management, planning and control, ethical decision making, leadership, and communication with the personnel are those that can be listed in the order of importance as viewed by the industry.

Farooqui and Ahmed (2009) attempted to determine the extent of agreement between industry and academia as to the required key skills from graduating construction management students, both undergraduate and graduate level, in order to identify any differences in perspectives. The authors point to the notion that skills ranked high by the industry including interpreting contract documents (for both undergraduates and graduates), listening ability/ giving attention to details (for undergraduates), time management (for undergraduates), construction accounting (for graduates), value engineering/ constructability analysis/ design review (for graduates) and contract negotiations/conflict resolution (for graduates) are given lesser significance by the educators.Their findings are summarized in Table 3.30 below.

While in Turkey, Kuruoğlu and Arslan (2002c) listed the top ten skills required for an engineer as the following: Decision making, planning, solution making, organizing, team establishment, administrative work, leadership, controlling, initiative, and work distribution.

When required skills for an engineer in the US and in Turkey are compared, it appears that communication skills are very important in the US, while in Turkey issues such as decision making, teamwork and work distribution emerge as priorities.

Table 3.30: Required Skills for Construction Management Students for Undergraduate and Graduate Level Employment: Industry vs. Educator Perspective

Industry perspective	Educator Perspective
Undergraduate level	
1. Knowledge of health and safety regulations	1. Knowledge of health and safety regulations
2. Interpreting contract documents	2. Knowledge of construction operations
3. Listening ability/ Giving attention to details	3. Scheduling
4. Knowledge of building codes & regulations	4. Communication/ Plans interpretation/ Blueprint reading/
5. Time Management	5. Understanding shop drawings
6. Scheduling/ Plans interpretation/ Blueprint reading	6. Interpreting contract documents
7. Understanding shop drawings	7. Knowledge of building codes & regulations
8. Knowledge of construction law and legal environment	8. Teamwork/ Collaboration/ Managing relationships/ Networking
9. Hands-on project experience prior to graduation/ Internship	9. Proficiency in construction information technology/ software
10. Knowledge of construction operations	10. Hands-on project experience prior to graduation/ Internship
11. Trade Coordination	11. Knowledge of construction law and legal environment
12. Communication – Verbal and Written	12. Problem solving/ Analytical skills
Graduate level	
1. Knowledge of health and safety regulations	1. Knowledge of health and safety regulations
2. Interpreting contract documents	2. Knowledge of construction law and legal environment
3. Knowledge of construction law and legal environment	3. Personnel/ Resource management
4. Knowledge of building codes & regulations	4. Interpreting contract documents
5. Construction accounting	5. Knowledge of building codes & regulations
6. Personnel/ Resource management	6. Communication – Verbal and Written
7. Contract Negotiations/ Conflict Resolution	7. Teamwork/ Collaboration/ Managing relationships/ Networking
8. Communication – Verbal and Written	8. Leadership/ Decision making
9. Leadership/ Decision Making	9. Risk Planning, Assessment and Control
10. Value engineering / Constructability analysis/ Design Review	10. Financial Management
11. Risk Planning, Assessment and Control	11. Marketing with clients/ Developing client relations
12. Marketing with clients/ Developing client relations	12. Proficiency in construction software/ IT

These comparisons are important in the way that they indicate requirements in engineering education to meet the needs of the industry in order to reach the levels in western countries.

3.8.3 Undergraduate training

The need to include a focus on the management of projects in both undergraduate and graduate education was recognized and began to develop in civil engineering programs at a number of universities in the US in the late 1950s and early 1960s (Arditi and Polat, 2010). It is well known that construction engineers are engaged not only in tasks that require pure technical expertise such as production and maintenance of constructed facilities, but also in specialized tasks that require extensive management and administrative expertise including marketing, finance, accounting, human resource management, contract law, and economic and environmental analyses (Atalah and Muchemedzi, 2006).

Despite the diversity of views on the extent and content of construction management training in undergraduate education ranging from the acquisition of CM education at the workplace without any formal training to the implementation of training on managerial, entrepreneurial, professional, and interpersonal skills at the undergraduate level, and to the necessity of CM education only at graduate level after one has received a degree in engineering or architecture (Arditi and Polat, 2010), as can be seen in Table 3.31, undergraduate education in civil engineering introduces and emphasizes construction management related topics both in the US and in Turkey.

The course listings of civil engineering programs in Engineering Schools in the US and in Turkey given in Table 3.31 may provide insight to available topics. It should be noted that the engineering divisions of universities in the US offer programs usually on Civil and Environmental Engineering and a common course listing where a students selects topics relevant to civil engineering if he/she wants to have only that degree. Therefore, the course topics listed for civil engineering undergraduate training in the US include those related to and contribute to construction management. The huge number of topics the universities offer is another reason for not including the whole. The University of Berkeley Civil and Environmental Engineering (CEE) progam (URL- 14, 2010) - CEE undergraduate programs ranked n.1 in Environmental and n.2 in Civil Engineering as released by the US News and World Report (URL-15, 2010) for 2011-, the Istanbul Technical University Civil Engineering undergraduate program (URL-16, 2010) -the oldest technical university in Turkey as a state university -, and Beykent University Civil Engineering undergraduate program (URL-17, 2010) - a relatively recently established private university with course listings electronically available- are chosen for comparison of the undergraduate course listings as given in Table 3.31.

As also can be seen in Table 3.31, CM education is highly stressed in a private university in Turkey, including courses on even CAD in addition to topics specific to construction management.

However, it is also seen that the curricula of universities that offer training in engineering do not cover interdisciplinary courses to provide competencies such as managership, practitionership, and entrepreneurship in undergraduate training in engineering either in the US or in Turkey (except for "entrepreneurship" in BU), as also reported by Arditi and Polat (2010) and Kuruoğlu (2002b). It seems that both the US and Turkey suffer the problem of inadequate training on interdisciplinary courses in an engineering undergraduate training.

Although in a survey covering almost all the contracting firms undertaking 90% of the construction investments in Turkey, the notion as to the insufficiency of undergraduate traing in engineering has been reached unanimously from an industrial point of view in 1994 (Adiloğlu, 1994), it is obvious that the situation has changed with the inclusion of satisfactory number of courses even on construction management.

However, in a relatively recent survey, Uğur (2007) points to the following problems in civil engineering undergraduate training in Turkey based on the responses of 52 civil engineers:

- 6% of the respondents believe that their civil engineering training is very good for performing their profession efficiently, 33% rate the training as good, 55% as intermediate, and 6% as bad
- The areas for which the respondents felt lack of competency was the specialty area of seafront-harbor structures as responded by 52%, followed by computer programs (50%), steel construction (44%), law (44%) and "construction management" as responded by 21%
- The area that ranked the first for a graduate study was the specialty area of construction as responded by 46%, followed by "construction management" as responded by 21%

Table 3.31: Course Listings of Civil Engineering Undergraduate Programs in the US and in Turkey

US	Turkey	
	ITU	**Beykent University**
Engineering Data Analysis	Physics I	Introduction to Civil Engineering
Engineering Analysis Using the Finite Element Method	Physics I Lab.	Technical Drawing
Engineering Project Management	General Chemistry I	Mathematics I
Database Systems for Engineering and Management	General Chemistry I Lab.	Physics I
Visualization and Simulation for Engineering and Management	Intr. to Comp. and Info. Sys.	Phsics I Lab.
Design, Construction, Maintenance of Civil and Environmental Engineered Systems	Mathematics I	General Chemistry
The Art and Science of Civil and Environmental Engineering Practice	Technical Drawing	Statics
Engineering Risk Analysis	Physics II	Engineering Geology
	Physics II Lab.	Programming Techniques and Languages I
	Statics	Mathematics II
	Mathematics II	Physics II
	Intr. to Sci & Eng Comp.	Physics II Lab.
	Differential Equations	Resistance I
	Dynamics	Dynamics
	Materials Science	Materials Science
	Resistance I	Engineering Economics I
	Construction geology	Measurements Science
	Fluid Mechanics	Linear Algebra
	Resistance II	Resistance II
	Topography	Fluid Mechanics
	Construction materials	Construction Materials
	Hydrolics	Differential Equations
	Soi land Railway Engineering	Probability and Statistics
	Construction statics I	Construction Statics I
	Construction Management	Railway Engineering
	Ground Mechanics I	Ground Mechanics
	Probability and Statistics	Hydrolics
	Reinforced Concrete I	Computer Applications in Civil Engineering
	Foundation Engineering I	Introduction to Law
	Hydrology	Construction to Statics II
	Transportation Engineering	Reenforced Concrete I
	Construction Statics II	Steel Structures I
	Reinforced Concrete II	Foundation Construction I
	Economics	Road Construction
	Water Resources	Hydrology
	Water Supply and Environmental Health I	Reenforced Concrete II
	Steel Structures I	Construction Management and Jobsite Techniques
	Design Project in Engineering	Water Supply and Drainage
	Labor law	Construction cost analysis
	Ethics in engineering	Hydroelectrical Plants
	Electives*	Introduction to Administration
	The Art of Communication	Entrepreneurship
	Human Resources and Management	Special topics in Construction Statics
	Jobsite techniques	Labor Law
	Constructional fire safety	Water Resources
	Building design management	Ethics in Profession
	Corporate Management	**Electives***
	Work safety	CAD
	Construction Management Law	Corporate Economics
		Project management

*Only those related to and/or contribute to construction management are included

The reason for pointing to lack of competency on construction management by 21% of the respondents may be due to the relatively recent introduction of courses on CM, unavailability of interdisciplinary courses, or lack of training on practical issues related to construction management, which remain to be eluciated by future studies.

Because a university- METU- offers a specific program on Construction Engineering and Management with the same common title in the US, it may be useful to compare course offerings specific to CEM training. A course catalog in CEM at the University of Washington, Seattle, WA, USA (UW, 2010) is given on the below table (Table 3.32) in comparison with a similar program with the same title “CEM” in Middle East Technical University (METU) in Turkey (URL-18, 2010). It is only the METU that offers an engineering program with the title “CEM” in Turkey. It should be noted that a single course catalog is accessible at the official web site of the CEM program at the University of Washington both for undergraduate and graduate training. In METU’s official web site, the graduate courses are available under a separate heading.

Table 3.32 points to the a resemblence between the two CEM programs; however, CEM program at the University of Washington seems much more comprehensive. It may not mean all universities in the US offer the same courses at undergraduate level.

Arditi and Polat (2010) report, as a general conclusion, that some very important categories in CEM education- Contract administration, Project management, Scheduling, construction equipment, and technologies- are commonly neglected in undergraduate curricula in civil engineering in the US.

3.8.4 Graduate training

It has been reported that for many years, construction managers were either craft persons without college education or graduates of an engineering program who were trained on the job in the US (Atalah and Muchemedzi, 2006). With the drastical expansion of construction projects that resulted in the emergence of the construction industry as an economic force in the United States, there happened to be a substantially increased demand for well-educated and well-trained construction managers with knowledge of business and building management (Atalah and Muchemedzi, 2006; Arditi and Polat, 2010).

Table 3.32: Course Listings for CEM Training in the US and in Turkey

	US*	Turkey**
Course listing	Construction and Culture Construction Communications Introduction to the Construction Industry Construction Documents Construction Accounting Construction Methods and Materials I Construction Contract Documents Mechanical Systems in Buildings Electrical Systems in Buildings Construction Methods and Materials II Construction Estimating I Construction Equipment Management Construction Safety Construction Surveying Sustainable Building Design and Construction Practices Design/Build Studio Construction Estimating II Project Planning and Control Construction Practice Competitive Business Presentations Virtual Construction Heavy Construction Practices Temporary Structures Project Management I Computer Applications in Construction Construction Law Concrete Technology Building Code and Environmental Regulations Project Management II Soils and Foundations Construction Labor Relations Construction Project Management Real Estate Development Facility Life Cycle 1: Planning Facility Life Cycle 2: Design and Construction Facility Life Cycle 3: Relocation and Operational Issues Facility Management Studio Undergraduate Research Design and Construction Law Advanced Integrated Computer Applications Advanced Construction Techniques Innovative Project Management Concepts Construction Procurement Systems Cost Analysis and Management Project Economics and Risk Analysis Research Methods in Construction Sustainable Construction Real Estate Development Residential Project Development Construction Firm Management Design-Build Project Management Managing International Projects Facilities Management Leadership in Construction Temporary Structures Heavy Construction Estimating Marine Construction Utility Systems Construction Construction Operations and Productivity Research Methods in Construction Engineering Systematic study and offering of specialized subject matter Independent Study or Research Master's Thesis	**Undergraduate courses (Starting from the 2nd year)** Engineering Economy Civil Engineering Drawing Construction Engineering And Management Construction Cost Estimating And Control Practical Aspects Of Construction Management Construction Planning Construction Site Techniques Legal Aspects In Construction Works Railway And Metro Tunnels Building Information Modeling And Its Applications In Construction **Graduate Courses** Special Topics In Construction Risk Management Special Topics in Strategic Management of Construction Companies Special Topics in Information Technology in Construction Special Topics in Construction Project Manangement Special Topics in Construction Productivity Measurement and Improvement Special Topics in Data Collection, Analysis and Modeling in Construction Industry

* University of Washington, Seattle, WA, USA (UW , 2010)
** Middle East Technical University (METU), Ankara, Turkey (URL-18, 2010)

The need to include construction project management programs in both undergraduate and graduate education was first recognized at a number of universities in the United States in the late 1950s and early 1960s (Chinowsky and Diekmann, 2004). Now, as demonstrated in an article by Arditi and Polat (2010), according to the Accreditation Board for Engineering and Technology, Inc. (ABET), there were 221 accredited civil engineering programs in 2008 in the United States (ABET, 2010). Out of these 221 civil engineering programs, only 174 offered graduate programs in civil engineering. It was found that only 44 of these educational institutions offered Master's programs in CEM through their Department of Civil Engineering. In other words, only 20% of the American educational institutions that offer accredited undergraduate programs in civil engineering offer Master's programs in construction engineering and management (CEM).

In order to find out the number of Master's programs on construction management in Turkish universities, the official web sites of all the universities were accessed through the web site of the Council of Higher Education (YÖK, 2010; URL-19, 2010). The universities with schools of Engineering or Engineering and Architecture are included for analysis as to the availability Civil Engineering (CE) programs, departments of "construction management (CM)" at the divisions of civil engineering, and Master's programs on "construction management" or related topics.

These universities are listed in Tables 3.33 and table 3.34 and the availabilities of CE, Dept. of CM, and Ms Sci on CM are designated as + (available) or as – (not available). Because there are two types of institutions of higher education in Turkey, state universities and those established by foundations (private universities), they are listed in separate tables, Table 3.33 for state universities and Table 3.34 for private universities.

As can be seen in Table 3.33, among the 70 state universities with Engineering or Engineering and Architecture Schools, 57 have Civil Engineering Divisions, only 11 of which (19%) have departments of "construction management". Graduate training is offered through these departments. However, not all of these departments offer Master of Science degree. There are only 4 Master's programs offered by Civil Engineering programs of state universities and 1 offered by Architecture School of a state uiversity under the name of "Construction-Project Management". Therefore, the percentage of CM Master's program for state universities is approximately 9% (Table 3.33).

Table 3.33: Availability of Civil Engineering Programs, Departments of Construction Management and Master's Programs on Construction Management in Turkish State Universities

Universities (State)	CE	Dept.of CM	MsSci on CM
1. Abant İzzet Baysal University	-	-	-
2. Akdeniz University	+	+	-
3. Aksaray University	+	-	-
4. Anadolu University	+	+	-
5. Ankara University	-	-	-
6. Ardahan University	+	-	-
7. Ataturk University	+	-	-
8. Balikesir University	+	-	-
9. Bartin University	+	-	-
10. Batman University	-	-	-
11. Bayburt University	+	-	-
12. Bilecik University	+	-	-
13. Bitlis Eren University	+	-	-
14. Boğaziçi University	+	-	-
15. Bozok University	+	-	-
16. Celal Bayar University	+	-	-
17. Cumhuriyet University	+	-	-
18. Çanakkale 18 Mart University	+	-	-
19. Çukurova University	+	-	-
20. Dicle University	+	-	-
21. Dokuz Eylül University	+	-	-
22. Dumlupınar University	+	-	-
23. Düzce University	-	-	-
24. Ege University	+	+	-
25. Erciyes University	+	-	-
26. Erzincan University	+	-	-
27. Eskişehir Osmangazi University	+	-	-
28. Fırat University	+	-	-
29. Galatasaray University	-	-	-
30. Gazi University	+	-	-
31. Gaziantep University	+	-	-
32. Gaziosmanpaşa University	-	-	-
33. Gebze High Technology Inst.	-	-	-
34. Gümüşhane University	+	-	-
35. Hacettepe University	-	-	-
36. Hakkari University	+	-	-
37. Harran University	+	-	-
38. Iğdır University	+	-	-
39. İnönü University	+	-	-
40. İstanbul Technical University	+	+	+
41. İstanbul University	+	+	
42. İzmir High Technology Inst.	+	-	-
43. Kahramanmaraş Sütçü İmam University	+	-	-
44. Karabük University	+	-	-
45. Karadeniz Technical University	+	-	-
46. Kırıkkale University	+	-	-
47. Kilis 7 Aralık University	+	-	-
48. Kocaeli University	+	-	-

Table 3.33: Availability of Civil Engineering Programs, Departments of Construction Management, and Master's Programs on Construction Management in Turkish State Universities (contd.)

Universities (State)	CE	Dept.of CM	MsSci on CM
49. Marmara University	-	-	-
50. Mersin University	+	-	-
51. Middle East Technical Univ.	+	+	+
52. Mimar Sinan University	-	-	+*
53. Muğla University	+	-	-
54. Mustafa Kemal University	+	+	-
55. Niğde University	+	-	-
56. Ondokuz Mayıs University	+	-	-
57. Osmaniye Korkut Ata University	+	-	-
58. Pamukkale University	+	-	-
59. Sakarya University	+	+	+ +**
60. Selçuk University	+	-	-
61. Siirt University	-	-	-
62. Süleyman Demirel University	+	-	-
63. Şırnak University	+	-	-
64. Trakya University	-	-	-
65. Tunceli University	+	-	-
66. Uludağ University	+	-	-
67. Yalova University	-	-	-
68. Yıldız Technical University	+	+	+
69. Yüzüncü Yıl University	+	+	-
70. Zonguldak Karaelmas University	+	+	-

* Construction-Project Management in the School of Architecture; **Quality management (In addition to CM graduate program, there is also a "quality management" Master's degree program)

As for the private universities (Table 3.34), among the 38 universities with Engineering or Engineering and Architecture Schools, 7 have Civil Engineering Divisions, only 1 of which (14%) has a department of "construction management". There is only 1 Master's program offered by the Civil Engineering program of a private university under the name of "Project Management" (Table 3.34).

It can be calculated that the overall percentage of Master's programs (6) including all the state and private universities (57+7= 64 Civil Engineering programs) is still approximately 9%, which is less than half of those in the US reported as 20% by Arditi and Polat (2010). However, it should be noted that graduate programs in the US refer to "accredited" programs.

It should be noted that while there used to be 46 universities offering Civil Engineering education in 2007 in Turkey (Birinci and Koc, 2007), now the number of universities has reached to 64, as of August 2010.

Table 3.34: Availability of Civil Engineering Programs, Departments of Construction Management and Master's Programs on Construction Management in Turkish Private Universities

Universities (private)	CE	Dept. of CM	MsSci on CM
1. Acıbadem University	-	-	-
2. Atılım University	+	-	-
3. Bahçeşehir University	-	-	-
4. Beykent University	+	-	-
5. Çankaya University	-	-	-
6. Doğuş University	-	-	-
7. Fatih Sultan Mehmet University	-	-	-
8. Fatih University	-	-	-
9. Gazikent University	+	-	-
10. Gediz University	-	-	-
11. Haliç University	-	-	-
12. Işık University	-	-	-
13. İhsan Doğramacı Bilkent University	-	-	-
14. İstanbul Arel University	-	-	-
15. İstanbul Aydın University	-	-	-
16. İstanbul Bilgi University	-	-	-
17. İstanbul Kültür University	+	-	+ *
18. İstanbul Medipol University	-	-	-
19. İstanbul City University	-	-	-
20. İstanbul Commerce University	-	-	-
21. İzmir Economy University	-	-	-
22. İzmir University	-	-	-
23. Kadir Has University	-	-	-
24. Koç University	-	-	-
25. KTO Karatay University	-	-	-
26. Maltepe University	+	-	-
27. Melikşah University	-	-	-
28. Mevlana University	-	-	-
29. Okan University	+	-	-
30. Özyeğin University	-	-	-
31. Piri Reis University	-	-	-
32. Sabancı University	-	-	-
33. TOB Economics and Technology University	-	-	-
34. Toros University	-	-	-
35. Yaşar University	-	-	-
36. Yeditepe University	+	+	-
37. Yeni Yüzyıl University	-	-	-
38. Zirve University	-	-	-

* Project Management

Regarding the courses offered at these Master's programs in CEM in the US, a total of 513 graduate courses was reported to be offered by the 41 departments of civil engineering in their Master's programs in CEM. The average number of courses per school is found to be 12.51, ranging between a minimum of six courses in one school to a maximum of 30 courses in another (Arditi and Polat, 2010).

Arditi and Polat drew attention to the following points for the courses offered in CEM:

- Most of the Master's programs in CEM constitute an effort to convey information to students on mainly six categories, namely, contract administration, project management, scheduling, equipment management, construction technology, and CEM research
- Fewer CEM programs (<60%) offer courses in systems optimization, cost estimating, computer applications, economic analysis, and real estate management
- Contrary to expectations, cost-related courses are offered by so few CEM programs (only 59%), despite the fact that in the US, civil engineers have to make quantity takeoffs from given plans, compute unit costs, and calculate bid prices
- Only 56% of the CEM programs offer one or more courses in computer applications
- Only few CEM programs (29%) offer courses in economic decision analysis

Arditi and Polat (2010) suggest that a dynamic Master's degree program in CEM needs periodic adjustments in the course offerings on the basis of information obtained by 1) periodically surveying the graduates of CEM programs and their potential employers, 2) consulting an advisory board composed of captains of industry; and 3) being engaged with regulatory agencies such as ABET, professional societies such as ASCE, CMAA, PMI, etc., and trade associations such as the Associated General Contractors (AGC) of America, National Association of Home Builders (NAHB), etc.

Regarding CM training in Turkey, the first department of "Construction Management" in Turkey was established in 1976 following the change of the name of the Department of "Construction Tools-Machinery and their Management" which was founded in 1947. In 1981, after the establishment of the Department of Construction, Construction Management Department has continued to exist as a working group. In 1990, Construction Management working group was seperated from the Department of Construction and became a seperate Department and offered the first Master's program in 1991 (ITU, 2010a).

Course listing for a Master’s program on “construction management” at the Istanbul Technical University in Istanbul, Turkey (ITU, 2010b), and for a Master’s program on “project management” at Istanbul “Kültür” University, offered by the School of Architecture (URL- 20, 2010) are given in Table 3.35.

Table 3.35: Course Listing for Master’s Programs on “Construction Management (CM)” and “Project Management (PM)” in Two Turkish Universities

ITU	KU
Management Mathematics	Global Project Management
Financial Issues in Construction Processes	Project Management Applications I
Project (Time) Management	Project Financing
System Planning in Construction Management	Project Management Applications II
Public Infrastructure Management	Computer-Aided Project Planning Techniques
Human Relations	Management in Multinational Firms
Contract Administration	Human Recourses Management
Financial Management and Corporate Finance	Personal Development
Human Factor in Construction	Special Practices in Project Management
Computer-based Planning Systems	Project Management and Communication
Project Housing and Construction Coops	Case Studies in Project Management I
Project Appaisal and Inv. Criteria in Developing Country	Case Studies in Project Management II
Professional Construction Management	Management System Standards in Project Management
Construction Machine Management	Marketing Projedures
Cost Management	Advanced Cost Analysis
	Construction Site Management
	International Financial Management
	Investment Management
	Management Mathematics
	Introduction to Seafront Areas Management
	Insurance and Risk Management
	Case Studies in Project Management III
	Labor Laws in Project Management
	Management of Specific Projects
	Research Methodology in Project Management
	Construction Agreements Management
	Fire and Prevention of Fire
	Storage, Carying, and Usage of Dangerous Materials in Industrial Plants
	Efficiency and Performance Management in Construction Projects

As seen in this table, there are 15 courses available for ITU’s Master’s program and 29 for “Kültür” University’s Master’s program. The METU’s program is given in Table 3.32. There are 6 courses offered, each one covering a wide range of topics. As accessed at the official web sites of Yıldız Technical University (URL-21, 2010) and Mimar Sinan University (URL- 22, 2010), the number of courses offered are 28 and 8, respectively (course listings not included). At the official web site of Sakarya University (URL-23, 2010), the course listing of the construction management graduate program is not available, despite the inclusion in the program listing.

Therefore, courses for the graduate program for CM rages between 6-29, with an average of 17.2, higher than that in the US (average 12.51, not including electives).

Regarding the content of graduate courses in Turkey, the following can be stated:

- Graduate program contents vary between the universities
- The number of courses may be higher than that in the US in some programs
- Courses on information systems, data collection and analysis, efficiency, corporate behavior, and corporate culture are neglected in the majority of graduate programs
- Research methodology course is not emphasized and available only in very few programs
- Real estate management is not covered in graduate programs

Periodically surveying the potential employers of the graduates of CM has been a suggestion to improve CM graduate programs (Arditi and Polat, 2010). Birgönül et al. (2007) identified the expectations of the construction industry in a questionnaire surver administered to the executives of the leading construction firms in Turkey. Based on the survey, the most important five areas of knowledge on consruction management are identified as planning, efficiency, construction site organization and management, dispute resolution, and cost estimating. The most lacking five areas of knowledge on consruction management are identified as risk management, project financing, enterprise resource planning, dispute resolution, and the management of international projects.

3.8.5 Certificate programs

There are many certificate programs on construction management in the US (e.g. URL-24, 2010) to meet the incersing needs of the construction sector for those who are not able to attend graduate programs.

Because graduate training can be offered to a limited number of students in 5 master programs for the time being in Turkey, it is far from satisfying the need in this area. To offer training in construction management to a large number of students, Istanbul Technical University, Department of Construction Management offers certificate programs of 9 months (36 weeks) on construction management (Müngen, 1999, Kuruoğlu, 2002b).

However, as described in section 2.1.7.1 of this work, a Certified Construction Manager (CCM) is not the same as a civil engineer who has a certification on CM in Turkey. A minimum total of 48 months is required in various phases of construction process to become a CCM in the US as shown in Table 2.1.

Therefore, certification concept is also different in the US than that in Turkey.

The contents of two certification programs, one in the US and one in Turkey, are given as examples in Table 3.36.

3.8.6 Specific training programs

Given the fact that construction management practices require a great variety of competencies, some specific master programs are offered in the US. Although there are many of these, two of them seem to be of special importance

Master's Degree in "Cost Engineering"

Because human workforce is very expensive in the US, special attention is given to cost management issues. It is believed that well educated professionals in this area would contribute substantially to cost management.

The Association for the Advancement of Cost Engineering (AACE) identifies five primary subject areas that are recognized as required for the cost engineering knowledge base (AACE, 2010):

- Motivational management
- Statutory aspects of personnel management
- Fundamentals for business project management
- Advanced economic analysis
- Advanced cost estimating
- Detailed course catalog is also included in AACE International Recommended Practice No. 12R-89 (AACE, 2010).
- Based on the listed areas above, it is interesting to note the US prioritizes human factor even in cost issues.
- There is no Master's degree programs in "Cost Engineering", in Turkey.

"Information and Communication Technologies (ICT)" Training

Along with many universities offering graduate degrees on the subject, Information Technology Association of America (ITAA) (ITAA, 2010) offers free information Technology (IT) training open to companies with employees working in California through a funding.

Table 3.36: Comparison of Certificate Programs in the US and Turkey

	In the US*	In Turkey**
Certificate Program Curriculum	**OSHA 30 Hour Construction Health and Safety Outreach Program**** Introduction Safety Pays Subpart P, Excavations Subpart E, PPE Job Hazard Analysis Subpart H, Rigging Subpart Q, Concrete & Masonry Subpart D, Hazard Communication Subpart R, Steel Erection **Core Course Offerings** Construction Procedures, Materials & Costs Computer Enhanced Planning, Scheduling & Control Principles of Construction Project Management **Elective Course Offerings** Understanding Contracting Methods & Documents Fundamentals of Construction Estimating Construction Accounting Basics Field Supervision for Construction Projects	Jobsite techniques and Construction Machinery Basic laws and labor law Human relations Construction legislation and Construction Coops Project management Computer supported planning practices (Primavera) Accounting Construction Management legislations Cost management and Bidding Financing Bidding and Contract Administration Safety management

*Rutgers University. Construction Management Certificate program (Available from URL-24, 2010)
** Istanbul Technical University Construction Management Certificate program (Kuruoğlu, 2002b; ITU, 2010c)
*** This 10-week course is a required course to complete the certificate program. It covers the basics about safety on all construction projects. Students learn how to effectively use the Code of Federal Regulations as it pertains to construction. Students also learn the role of Occupational Safety & Health Administration and how safety and health affect the bottom line. Topics which covered include OSHA policies, procedures and standards.

Turkey is very well aware of the importance of this area due to the efforts of academic persons in the universities in this field. Some universities offer Master's degree programs on ICT/IT (e.g. URL-25, 2010).

As a summary of this section, Table 3.37 describes similarities and discrepancies in construction engineering or construction management issues related to education.

3.8.7 Program accreditation

In the US, Accreditation Board for Engineering and Technology (ABET) (ABET, 2010) sets the criteria for accrediting engineering and technology programs both at the undergraduate and graduate level and performs accreditations to assure quality and to foster the systematic pursuit of improvement in the quality of engineering education that satisfies the needs of consftituencies in a dynamic and competitive environment.

Table 3.37: Comparison of Training in Engineering and Construction Management in the US and in Turkey

	In the US	**In Turkey**
TRAINING IN ENGINEERING AND CM		
Professional Engineering	A common practice since 1950s[a]	Since 2006[b]
Required skills	Communication skills prioritized[c]	Others like "decision making" and "team work"[d]
Engineering Training	Not accessed to all the universities	108 universities[e]
• **Civil Engineering programs**	221 accredited programs[f]	64 universities[e]
• **CM in undergraduate education**	Some very important categories not covered[f,g]	Some very important categories not covered [h,ı,j,k]
• **CM** G**raduate education**	20% of accredited civil engineering programs offer[f]	9% of civil engineering programs offer[e]
• **Number of courses**	Total 513; Average per school:12.51; reaching to 30 (not including electives)[f]	Total 71; Average per school 17.2 (reaching to 29 (including electives)[j,l,m,n,o]
• **Comprehensiveness of the courses offered**	Some very comprehensive[p]	Some comprehensive [j,l,m,n,o]
• **Specific subject emphasis**	Stress on research; leadership[p]	Mostly basic principles of CM; Research not prioritized[j,l, m,n,o]
• **Certificate programs**	Safety course required[q]	Not required[r]
• **Complementing education on CM**	Programs like Cost Engineering[s], IT[t]	Programs like Quality Management [u], IT[v]
• **Program accreditation**	Common practice; Accrediting Institution: ABET; N. of accredited civil engineering programs: 221[f]	Not common; No official accrediting institution;N. of accredited civil engineering programs: 2[w]

[a] NSPE, 2010; [b] URL-12, 2010; [c]Dorsey, 1991;[d]Kuruoğlu and Arslan, 2002c; [e]URL-19, 2010, [f]Arditi and Polat, 2010; [g] URL-14, 2010; [h] URL-16; [ı]URL-17, 2010; [j] URL-18, 2010; [k]Kuruoğlu, 2002b;[l] ITU, 2010b; [m]URL-20,2010, [n]URL-21,2010; [o]URL-22, 2010; [p]UW, 2010; [q]URL-24, 2010; [r]ITU, 2010c; [s]AACE, 2010;[t]ITAA, 2010; [u]URL-23, 2010;[v] URL-25, 2010; [w] Birinci and Koç, 2007.

General criteria for accrediting baccalaureate level engineering programs include student aspects (Criterion 1), educational aspects of the program (Criterion 2), aspects related to program outcomes and assessment (Criterion 3), professional component (Criterion 4), faculty aspects (Criterion 5), aspects related to facilities (Criterion 6), issues related to institutional support and financial resources (Criterion 7), and issues related to the program (Criterion 8) (ABET, 2010).

In criterion 3, as a program outcome, expected competencies of an engineering student are well defined by ABET (ABET, 2010)

Engineering programs must demonstrate that their students attain:

a) An ability to apply knowledge of mathematics, science, and engineering
b) An ability to design and conduct experiments, as well as to analyze and interpret data
c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) An ability to function on multi-disciplinary teams
e) An ability to identify, formulate, and solve engineering problems
f) An understanding of professional and ethical responsibility
g) An ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) A recognition of the need for, and an ability to engage in life-long learning
j) A knowledge of contemporary issues
k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

As for program criteria for “civil” and similarly named engineering programs, ABET in conjuction with the leading society “American Society of Civil Engineers”, defines the following (ABET, 2010):

1. Curriculum

The program must demonstrate that graduates have: proficiency in mathematics through differential equations, probability and statistics, calculus-based physics, and general chemistry; proficiency in a minimum of four (4) recognized major civil engineering areas; the ability to conduct laboratory experiments and to critically analyze and interpret data in more than one of the recognized major civil engineering areas; the ability to perform civil engineering design by means of design experiences integrated throughout the professional component of the curriculum; and an understanding of professional practice issues such as: procurement of work, bidding versus quality-based selection processes, how the design professionals and the construction professions interact to construct a project, the importance of professional licensure and continuing education, and/or other professional practice issues.

2. Faculty

The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate that it is not critically dependent on one individual.

As for program criteria for "construction" and similarly named engineering programs, ABET in conjuction with the leading society "American Society of Civil Engineers", defines the following (ABET, 2010):

1. Curriculum

The program must demonstrate the graduates have: proficiency in mathematics through differential and integral calculus, probability and statistics, general chemistry, and calculus-based physics; proficiency in engineering design in a construction engineering specialty field; an understanding of legal and professional practice issues related to the construction industry; an understanding of construction processes, communications, methods, materials, systems, equipment, planning, scheduling, safety, cost analysis, and cost control; and an understanding of management topics such as economics, business, accounting, law, statistics, ethics, leadership, decision and optimization methods, process analysis and design, engineering economics, engineering management, safety, and cost engineering.

2. Faculty

The program must demonstrate that the majority of faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The faculty must include at least one member who has had full-time experience and decision-making responsibilities in the construction industry.

In Turkey, there is no official institution or organization that provides accreditation for engineering programs of the universities. However, an independent committee, “Engineering Evaluation Committee”, composed of academic persons, professional engineers, and representatives of nongovernmental organizations/chambers, has been working since 2002 with the aim of accrediting engineering programs (Birinci and Koç, 2007).

Two universities with civil engineering programs (METU and ITU) are known to have ABET program accreditation (Birinci and Koç, 2007). It should be noted that there 221 ABET accredited civil engineering programs in the US.

3.9 Professional Organizations Associated with Civil Engineering and Construction Management

Throughout the text of this work, a considerable number of professional/trade organizations in the US have been addressed in relevant sections as influencing or indeed enforcing bodies in dealing with engineering issues.

In this section, mentioned bodies in the US and in Turkey are summarized in a table (Table 3.38) in an attempt to depict a more easily seen picture on this issue.

Table 3.38: Comparison of Professional Organizations Associated with Civil Engineering and Construction Management in the US and in Turkey

	In the US	**In Turkey**
Engineering / Civil Engineering	ABET, ACI, AGC, AIA, AICI, ASCE, ASTM, CII, NAHB, NCEES, NSPE	IMO, TMB*, TMMMB*, TMSK*
Construction Management	AACE, CMAA, ITAA, NASP, PMI, PMCC	None (IMO extensively deals with CM issues).

*These organizations also work on improving engineering practices in terms of setting standards, education and training.Note: The names of all these organizations are given in the “Abbreviations” section in this work; Web addresses are given in the “references section”.It should be noted that not all professional organizations associated with engineering are included in this table.

As can be seen in Table 3.38, many powerful organizations in the US give information, training, licensure in civil engineering or construction management and related topics, get effectively involved in dispute resolution, accredit programs, and give certificates to engineers as mentioned in relevant sections with related references. On the other hand, in Turkey, there is only one very important body dealing with all civil engineering issues including construction management.

In Turkey, Adiloğlu (1994) pointed to the problem of not getting organized well in construction sector as far as chambers, unions, and associations are concerned.

Koç and Birinci (2007) also report that Chambers of Civil Engineering are neither sufficient nor effective. They add that the organizational structure of IMO is not adequate anymore. They make the following suggestions:

- There is a need for new legislations for defining task and authority of IMO
- There is a need for adequate personnel and equipment for neww chambers for performing their tasks accordingly
- There is a need for evaluation of proper execution of the profession and of ethics in civil engineering, instead of only examining projects
- There is a definite need for the chambers to work for improving the status of their members

4. CONCLUSION AND RECOMMENDATIONS

4.1 Summary of the Comparisons

Construction management practices based on the CMAA standards as applied in the US, which are adopted by Turkey as well, are thoroughly compared in all knowledge areas including project management planning, cost management, time management, quality management, contract sdministration, and safety management. Construction management profesional practice rules are also discussed for comparison. Furthermore, general engineering issues, training in construction management at both undergraduate and graduate levels, certificate programs, accreditation of training, and professional/trade organizations that would contribute to construction management practices are also dealt with in order to reveal differences and similarities between the US and Turkey practices.

The differences and similarities of engineering and construction management practices in the US and in Turkey are summarized in Table 4.1.

Table 4.1: Summary of the Comparisons of Engineering/CM Practices in the US and in Turkey

CM Practice Comparisons	US	Turkey
General	CM well defined and well trained in all categories defined by CMAA	Growing interest in CM
Understanding	Increasing advocacy for the understanding of CM; Understood well by many parties; ways of practice may not be uniformly accepted or understood by all parties in the construction process	Inadequate understanding of CM by the majority of the parties in the construction industry even by some of the construction engineers themselves
Standards	CMAA CMP; PMBOK guide	CMAA CMP adopted
Construction managers	Usualy involved in construction processes	Limited number of civil engineers with a graduate education on CM; some believe not useful
Credentials	CCM, PMP	Not offered
Project management planning	Considered as core of CM;	Perceived as time planning
Planning departments	In many bg firms	Recently established
IT/ICT	Prioritized	Underutilized
ERP	Strong interest	Not widely used
BIM	An emerging important concept	Not a familiar concept

Table 4.1: Summary of the Comparisons of Engineering/CM Practices in the US and in Turkey (contd.)

CM Practice Comparisons	US	Turkey
IPD	An emerging important concept	Not a familiar concept
Cost management	Research reveals success; wide use of computer based applications	Cost estimation is weak; computer based applications not widely used
Time management	Considered very important	Less significant
Quality management		Some firms accredited
Quality standards	Mainly own standards	Some ISO 9001; ISO 14001
Contract administration	Innovative contracting practices	Limited
Dispute resolution	Alternative techniques used widely	
Project delivery methods	DBB, DB, CM/GC, CM/PM; BOT rarely used	Various; BOT used more
Safety management	Very important; new concepts; incidents decreasing; penalties high	Traditional concepts; incidents with a tendency to decrease; penalties low
Construction hazards	Ranks the fourth	Ranks the second
Laws and regulations	A whole bunch of laws, rules, and regulations for practicing and applying CM activities	Comprehensive but not as detailed as they are in the US
Occuptional safety and health issues	Mainly OSHA is in charge	Diverse governmental organizations
Standards	OSHA	OHSAH, ILO-OSH
Improving safety and health	Extensive reseaech and effort	Improving
New applied concepts	"Resilience engineering; "Concurrent engineering"; "Value engineering"	Not known well
Training	Comprehensive graduate programs; specific training programs like cost engineering	Less comprehensive; certificate programs
Professional engineering	Obligatory for signing and sealing projects	Only prestigeous
Accreditation	Civil engineering programs of 221 universities	Civil engineering programs of 2 universities
Professional organizations	Effectively involved in establising standards, providing guidelines, and best practice recommendations for CM	No specific organization; IMO is doing its best
Research	Many research to base practices: "Action research"	Some

4.2 Conclusions and Recommendations

Based on the thorough evaluation of construction management practices in the US and in Turkey, it can be concluded that construction management practices and standards are better understood and well documented in the US. The US step forward with advocacy on construction management by professional/trade organizations in order to promote this discipline which result in higher awareness and acceptability.

Credentials offered aid in recognition of the profession of CM. Other outperforming US practices may include the use of IT/ICT more efficiently. Integrated information systems including CAD, BIM and IPD may be examples of such practices. Innovative contracting practices, alternative dispute resolution techniques, a variety of project delivery methods including IPD, concepts such as "resilience engineering", "concurrent engineering" and "value engineering" come forward as signs of best management practices. The utmost importance given to safety management issues and rapid actions for new legislations and measures deserve attention. More comprehensive training on CM, accreditation of training programs may serve as examples of better practices. Furthermore, the concept of "action research" should not be overlooked.

In Turkey, although the concept of construction management is rather new, the achievements of Turkish researches on the use of methodologies on cost, time and safety management as well as IT/ICT use as evidenced by the literature deserve attention.

Additionally, the interest and the enthusiasm of young civil engineers on construction management and the efforts of academic persons in the universities for improving the profession show promise for rapid achievement of better practices on the subject in Turkey.

It is well known that Turkish construction companies are competing in the international arena. Their best practices may not have revealed because of lack of published literature.

With regard to recommendations, some of them are made based on the assumption that US is very advanced or ahead in some areas regarding construction issues. This assumption is based on the work of Civil Engineering Research Foundation (CERF) (CERF, 2010), the National Science Foundation (NSF) (NSF, 2010), the Federal Highway Administration (FHWA) (FHWA, 2010) and the World Technology Evaluation Center (WTEC) (WTEC, 2010) that attempted to take "snapshots" of construction research and developments internationally, focusing on specific areas where the United States is competitive with the construction industry of some other country. The evaluations of these organizations are based on on-site inspections of construction sites, meetings with experts at essential research institutes, academic institutions, construction firms, and government agencies, and reviews of additional secondary materials. This investigation focused on research and developments (R&D) in six countries in Western Europe to compare with the R&D in the US. The R&D standings of selected constructed civil infrastructure systems are shown in Table 4.2 (Belle, 2000).

Table 4.2: Status of Constructed Civil Infrastructure Systems

Major Area	Subarea	Status
High-performance materials	Portland cement concrete	U.S. slightly ahead
	Asphalt	Europe slightly ahead
	Steel	U.S., Europe about equal
	Composites	U.S., Europe about equal
Automation and robotics		U.S., Europe about equal
Computer-aided construction	Field computer use	U.S. very advanced
	Integrated databases	U.S. ahead
	CAD/CAE	U.S. very advanced
	Global positioning systems	U.S. ahead
	Geographic information systems	U.S. ahead
	Project management information systems	U.S. very advanced
Construction methods	Underground construction	Europe ahead
	Tunneling	Europe very advanced
	Marine construction	Europe very advanced
	Construction site safety	U.S. ahead
Construction methods	Steel systems	U.S. slightly ahead
	Concrete systems	U.S. ahead
	Mixed systems	U.S. slightly ahead
	Vibration damping	U.S. slightly ahead
	Retrofit (concrete)	Europe ahead
	Retrofit (steel)	U.S. ahead
	Building systems	U.S. ahead
Environment	Solid/hazardous waste disposal	U.S. ahead
	Recyclability	U.S., Europe about equal
	Water/wastewater treatment	U.S. ahead
	Energy conservation	Europe ahead
	Site remediation	U.S., Europe about equal
Instrumentation and measurement	Fiber-optic sensing	Europe ahead
	High-speed pavement measurement	Europe slightly ahead
	Real-time site positioning	Europe slightly ahead
	Intelligent buildings	U.S. ahead

(Adopted from Belle, 2000).

The assessments including “field computer use (U.S. very advanced)”, “integrated databases (U.S. ahead)”, “CAD/CAE (U.S. very advanced)”, “project management information systems (U.S. very advanced)”, “construction site safety (U.S. ahead)”, “building systems (U.S. ahead)”, “solid/hazardous waste disposal (U.S. ahead)”, and “intelligent buildings (U.S. ahead)”, which are all important issues for better construction management practices, may justify the recommendations made to improve practices assuming they are better in the US.

Identifying the best practices in the design and construction industry is not easy, but benchmarking may be of use to improve the construction industry's performance.

When recommending construction management practices based on the practices in the US, the question, " To what extent are those actually used in the US?" may also arise. The relevant literature on surveys of actual practices in the US as to the use of some of the practices as well as statistical information provide evidence.

The evaluation of CM practices in the US point to the following needs on the subject in Turkey:

- There is a need for a better understanding of construction management
- There is a need for more engineers with a graduate training on construction management
- There is a need for more research based/ evidence based guidelines to improve construction management practices
- More emphasis should be given to IT/ICT
- ERP use should be encouraged
- There is a need for better integrated information systems
- Turkish engineers shoud be more familiar with BIM
- There is a need for better cost estimating
- More attention should be given to time management
- Construction firms should be encouraged to deal with quality management issues more
- Environmental management systems particularly in Turkey may reduce environmental problems in construction activities.
- There is a need for the construction firms to be sensitive about training and education for implementing the TQM philosophy properly
- There is a need for development of practices for the performance of construction quality-management system audits
- There is a need for innovative contracting practices
- Bodies like dispute resolution boards should be established

- New detailed laws, legislations and/or by-laws should support proper construction management practices
- More emphasis should be given to safety management practices
- There is a need for prompt action for enacting new regulations and measures when a specific incident occurs
- Inspection of construction management practices by authorities to ensure proper applications is important
- There is a need for strong associations or societies solely committed to the development of this area which also do their best to increase awareness on the importance of construction management and lead construction management issues in Turkey according to the needs of our country
- Courses on construction management principles and practice standards should be implemented in the curricula in the undergraduate level at the civil engineering faculties of the universities
- Accreditation of training programs will lead to better construction management practices
- Professional engineering concept may better be applied as it is in the US
- More research is needed to adequately identify the situation in Turkey and to put forward relevant solutions for weak areas in construction management.

At this point, the idea of "action research" is well worth mentioning as a strong recommendation. As also stressed in the US, academic research in applied disciplines such as construction engineering and management should have the dual mission of simultaneously contributing to the solution of practical problems and creating theoretical and conceptual knowledge. A clear need in CEM is a research approach that combines the objectives of both applied and basic research by contributing toward solution of practical problems and creation of new theoretical knowledge at the same time. "Action research" can be a very valuable approach to fulfill these criteria where the researcher reviews the existing situation problem domain, identifies the problems, gets involved in introducing some changes to improve the situation, evaluates the effect of those changes, and reflects on the process and the outcome to generate new knowledge (Azhar et al., 2010).

Based on the literature reviewed in this work, it can be argued that in Turkey research activity is mainly based on identifying the problems. Much less research is directed to improve CM practices. However, Turkish reseachers in the universities have recently attempted to develop and/or revise models such as Analytic Hierarchy Process to be potentialy used in project management planning and “fuzzy sets” to be used in safety management in construction processes

A thorough review of construction management practices in the US compared to those in Turkey may serve as a quick reference for engineering students interested in construction management practices. The literature and comprehensive analyses presented in this work regarding construction management practices in the US can be applied as construction management strategies in Turkey as well. Conclusions reached and the recommendations made regarding construction management may contribute to better practices in construction management issues in Turkey.

4.3 Limitations and Strengths of the Thesis

With regard to the limitations of this thesis, practices in construction management are mainly based on thorough review of literature and careful evaluation of basic standards proposed by professional/trade/official organizations on construction management issues. Some practical issues in daily practice may not have been reflected extensively, because the author of this thesis is not a construction manager in the US. Nevertheless, some of his experiences are covered in relevant sections.

A survey might have been useful to allow head-to-head comparisons of some actual practices in construction management domains both in the US and in Turkey. It may be appreciated that performing a survey in the US is not as easy as it is in Turkey. Funding emerges as the first constraint. While an online survey may have been more appropriate, then reluctance of people in answering time consuming questions may appear as a problem in their daily routine.

The author of this thesis believes that evaluation of approximately a hundred and eighty articles published in international peer-reviewed journals and in national journals or bulletins and the review of thesis work of peers enhance the strength of this thesis and overcome the lack of practical activities in some aspects of construction management.

Additionally, the huge breadth of the subject may not have allowed to discuss all aspects in detail. However, every effort is made to include details that would improve the understanding of construction management in some aspects of construction management issues.

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APPENDICES

APPENDIX 1 : CMAA Standards of Practice (CMP)
APPENDIX 2 : A quality control report in the US
APPENDIX 3 : AIA Contract Document
APPENDIX 4 : Code of Federal Regulations (Subpart P—Excavations)

Appendix 1: CMAA Standards of Practice (CMP)

	Project management	Cost management	Time management	Quality management	Contract administration	Safety management
Objectives	To develop management plans to ensure the success of the project To coordinate components in different disciplines	To establish systems for the management, control, and monitoring of project costs during all phases of the project To maintain project costs within the predefined limits	To manage project time/resources/cost with good scheduling and accurate forecasts To integrate multiple parties (Owner, contractor, user, community) To evaluate options such as changes, delays, and acceleration To resolve disputes	To plan, organize, implement, monitor, and document a system of management practices that coordinate and direct relevant project resources and activities to achieve quality in an efficient, reliable, and consistent manner	To manage critical construction parameters in terms of time, cost, quality and information To satisfy the owner's goals and objectives for the project	To take precautions and to ensure the application of these precautions for the safe completion of the project for all the parties involved in a project

Appendix 1:CMAA Standards of Practice (CMP) (Contd.)

	Project management	Cost management	Time management	Quality management	Contract administration	Safety management
Pre-design Phase	Establish project organization Identify construction management plan Design “Project Procedures Manual” Identify management information systems Select the designer Special studies/reports Constructability Reviews Pre-design project conference	See the project site Investigate factors that would influence construction costs Develop construction budgets Cost analysis	Estimate time required: concept/ schedule - Outline Owner’s objectives / wants / needs - Identify funding sources - Consider / decide contract type; source selection - Determine site location; procure if necessary - Allow time to meet government regulatory requirements: EIS, local zoning, building permits, etc. - Establish milestone targets for remaining phases	Clarifying owner’s objectives and concerns Scope of CM services – CM Agreement Selection of design team Project implementation tools Construction Management Plan Quality Management Plan Project Procedures Manual Management Information System (MIS) Pre-Design Conference	Develop the following: - Construction Management Plan - Project Procedures - Management Information System - Quality Management Plan - Communications Procedures - A master schedule, a milestone schedule Identify possible project delivery methods Manage designer selection / contract form Feasibility studies Conceptual studies Pre-design cost studies Environmental analyses	Evaluate the owners contract, project organization and personnel factors in terms of safety Establish safety as a project goal above other issues Try to keep safety separate from other project issues Talk about safety before the work starts and agree to any changes Identify who is at risk while there is an argument

Appendix 1: CMAA Standards of Practice (CMP) (Contd.)

	Project management	Cost management	Time management	Quality management	Contract administration	Safety management
Design Phase	Document review Document distribution Scope verification and sign-offs Front-end documents: contract, general conditions & supplementary general conditions Public relations Project funding Meetings Cost control: independent phased cost estimates Time control: milestone development Consultant coordination Permit approval oversight	Estimate cost and budget impacts - Proactive, not reactive - Uniform framework throughout the design phases • Schematic design • Design development • Construction documents • Bid set and addenda Ideally, the CM should participate in the design process and provide timely cost advice - The cost estimate should be on a unit price basis - Dig into the "boiler plate" - Determine cost impacts - Escalation Evaluating the level of design detail Value / Analysis Program	Refine milestone schedule Define structure for program schedule - Key players - Key activities - Identify long lead items; track in schedule Establish Design Milestone - Example: 35%, 65%, 95%, and 100% design docs - If Design-Build, establish review periods Refine durations of remaining phases	Initial design meeting Partnering Design procedures Document control Owner / User reviews Review of design submittals Changes in scope or criteria during design Owner authorizations and approvals Quality management system and specifications Quality audits Project estimates and value engineering studies Constructability / design reviews Project plan, schedule, and milestones Construction inspection and testing requirements Public relations Public funding Project review meetings and reports Commissioning requirements Warranties and project close out Non-conforming and corrective work	Team building / leadership development Administration of design contract(s) Fulfill CM contract requirements Assist in developing contract specs Develop contracting strategy / bid package / contract formats Develop the procurement plan Prepare bid/award documents and schedule	Attend the contractor's tool box meetings Ask about safety when reviewing the working schedules Try to dissuade using the OSHA codes as the basis for recognizing the hazardous conditions Know who the contractor's designated safety person is

Appendix 1: CMAA Standards of Practice (CMP) (Contd.)

	Project management	Cost management	Time management	Quality management	Contract administration	Safety management
Procurement Phase	Public relations: means of reaching potential bidders Assessing bidding climates Requirements for selection of pre-qualified bidders Assessing and evaluating bidder qualifications Understanding basic content required of contract general conditions Addressing risk management issues in contractor's pre-award meetings	Bid evaluation, review, and contract award - Follow established Owner procedures - Evaluate and analyze the bid: • Completeness • Responsiveness • Technical / references • Math error • Alternates - Compare to budget - Recommend action If over budget, possible options include: - Reject all bids; redesign and re-bid - Negotiate with the apparent low-bidder - Use bid alternates - Increase the project budget to allow award	Construction Manager (previously awarded) Designer Constructor Design-Build firm Notices; complete bidding docs (FBO); Request for quotation Request for proposal; bid due dates; award dates NTA; NTP; contact duration Substantial completion; beneficial occ Punch-out & Close-Out milestones Develop pre-bid construction schedule Develop language for specs related to schedule requirements - Software requirement - Acceptance of contractor's Schedule - Requirement for Time / Impact analysis - Early completion - Who owns the float? - Weather delays - Liquidated damages	Permits Bidder interest campaign Procurement planning Advertisement and solicitation of bids Select bidders list Instruction to bidders Pre-bid conference Proposal document protocol and bid opening Pre-award conference Contract award	Develop bidders list Bidders interest campaign Bidder pre-qualification Bid advertisement Distribution of bid documents Addenda Pre-bid conference Information to bidders Bid opening and evaluation - Procedures - Review - Exceptions / Conditions / Alternatives Notice of award Pre-award meeting Notice to Proceed (NTP) Schedule and budget adjustments	Develop a written safety program Conferences and meetings for safety issues Coordination with relevant organizations for emergency situations

FBO: Federal Business Opportunities (FBO, 2010)

Appendix 1: CMAA Standards of Practice (CMP) (Contd.)

	Project management	Cost management	Time management	Quality management	Contract administration	Safety management
Construction Phase	Public relations / Public Outreach Safety On-site facilities Coordination/ Meetings between all parties Time management Budget and cost reporting Payment request processing Change orders Dispute resolution Utility, SWPP and off-site improvement oversight Quality management Record keeping Management reporting Owner-purchase materials and equipment Record drawings Claims management	Check if contract documents specify: - Schedule of values - Earned value information - Payment application procedures: form and frequency - Use of resource-loaded CPM schedule and updates - Requirements for certified payrolls - Submittal of unit costs for equipment, general conditions, or daily delay Contingency Management Schedule of Values Cost Loaded CPM Schedule Controlling the Change Order System Productivity and efficiency, using man-hour analysis Cost Evaluation System for Potential Claims	Check to see if the work program is in accordance with the master program Check if the new situation is in consistency even after the updating process Document progress Check project status Anticipate problems and minimize delays Review for: - Sufficient level of detail - Inflated durations to hide float - Logic ties to hide true critical path - Missing or incorrect logic - Arbitrary milestones: non-logic driven - Open-ended activities - Primary and secondary critical paths - Phasing - Regulatory requirements - Code compliance / inspections - Long lead procurement items	Contractor QA/QC control Preconstruction conference Pre-installation conferences Partnering Construction planning and scheduling Inspection and testing Control of testing and measuring equipment Reports and record keeping Changes in the work Document control and distribution Non-conforming and corrective work Quality audits Job meetings Progress payments Project documentation Final reviews Punch lists Public relations Special process control Dispute resolution Release of retainage Liquidated damages Occupancy permits Substantial completion Beneficial occupancy Final acceptance Record drawings O & M manuals and operational training	Pre-construction conference - Attendees - Coordination with utilities / Owners / others - Schedule - Submittals Partnering Existing conditions Owner-furnished items Deliverables checklist Permits, insurance, labor agreements, bonds Communications Meetings Verify GCs procurement process Claims mitigation / evaluation Review / process contract modifications Oversee on-site safety program compliance Administer progress payment process Ensure as-built record drawings maintained Fulfill reporting requirements Ensure retention requirements are fulfilled Quality Management Plan Monitor compliance with the contract	Identify sanctions for obedience to safety regulations and rules Apply whenever necessary Meetings for safety issues Establish committees for safety Establish auditing committees for safety Define tasks and responsibilities of these committees Point out safety concerns to the contractor Provide information to the contractor and owner and advise employees to keep away from the hazard until corrected Not take “control” away from the contractor

QA: Quality Assurance; QC: Quality Control; O&M: Operations and Management

Appendix 1: CMAA Standards of Practice (CMP) (Contd.)

	Project management	Cost management	Time management	Quality management	Contract administration	Safety management
Post-Construction Phase	Preparing and transmitting documents connected with the final payment Organization of O&M manuals, warranties, training Assembling record drawings Contractor follow-up Owner move-in or start-up Contractor call-back Contractor closeout	Project closeout Release of liens Release of retainage Final cost Accounting Final closeout Report	Items to consider: - As-built schedule; actual versus baseline target comparison - Review time impacts of change orders - Close-out schedules - Transfer of title / ownership schedules (turnover of completed facilities) - Occupancy / relocation schedules - Follow on contract schedules - Revenue forecasting schedules - Facilities O&M schedules	Disposition of project record and documents Recommendations on any outstanding items QM assessment with owner Final report and recommendations Warranty follow-up and management	Claims resolution Contract closeout Final payment (including retention) Call-backs	Write a report for the whole precautions Prepare a report for follow-up of safety measures

O&M: Operations and management; QM: Quality management

Appendix 2. A quality control report in the US

FTC

INSPECTION AND TESTING OF CONCRETE REPORT

☐ FOUNDATION ☐ SUPERSTRUCTURE ☐ SITE WORK

CLIENT: ______ DATE: ______

PROJECT: ______ FTC NO.: ______

PROJECT LOCATION: ______ PAGE NO.: ______ OF ______

CONTRACTOR: ______ WEATHER: ______ °F

PRODUCER: ______

MIXTURE PROPORTIONS (FTC ID. NO.)		
Concrete Class:	PSI:	No. Cu Yds.: No. Loads:
	Dry Wts. (lbs.) per CY.	Brand/Source
Cement		
Fine Agg.		
Coarse Agg.		
Water, Gals.		
Admix 1		
Admix 2		
Admix 3		

INSPECTOR(S) TIME			
Inspector (P) = Plant (F) = Field Plant Method II	Time Arrive	Time Left	Total Hrs.

FIELD REPORT

Cylinder No.		Time	Truck I.D. #	Slump Inches	% Air	Concrete Temp	Unit Wt. Cu. Ft.	Remarks

☐Specimen (6"x12" cyl) Area 28.27 Sq. In. COMPRESSION TEST RESULTS ☐Specimen (4"x8" cyl) Area 12.56 Sq. In.

Cylinder No.		Date Tested	Age at Test	Max. Load (lbs.)	PSI	Fracture Type	Cylinder No.		Date Tested	Age at Test	Max. Load (lbs.)	PSI	Fracture Type

Placement Location(s): ______

REMARKS: ______

(Rev 10/25/05) Future Tech Consultants of New York, Inc.
52 East 2nd Street, Mineola, New York, 11501 Tel: (516) 355-0168 Fax: (516) 355-0271

Appendix 3. AIA Contract Document

1997 EDITION

AIA DOCUMENT A101-1997

Standard Form of Agreement Between Owner and Contractor
where the basis of payment is a STIPULATED SUM

AGREEMENT made as of the day of
in the year
(In words, indicate day, month and year)

BETWEEN the Owner:
(Name, address and other information)

and the Contractor:
(Name, address and other information)

The Project is:
(Name and location)

The Architect is:
(Name, address and other information)

The Owner and Contractor agree as follows.

This document has important legal consequences. Consultation with an attorney is encouraged with respect to its completion or modification.

AIA Document A201-1997, General Conditions of the Contract for Construction, is adopted in this document by reference. Do not use with other general conditions unless this document is modified.

This document has been approved and endorsed by The Associated General Contractors of America.

SAMPLE: This standard document is NOT a model form. Its inclusion in the *Architect's Handbook of Professional Practice* does not constitute a grant of any implied or explicit license to copy it in whole or in part. See the Instruction Sheet information on licensed reproduction.

AIA DOCUMENT A101-1997
OWNER-CONTRACTOR AGREEMENT

The American Institute of Architects
1735 New York Avenue, N.W.
Washington, D.C. 20006-5292

1

Appendix 4. Code of Federal Regulations (Subpart P—Excavations)

ELECTRONIC CODE OF FEDERAL REGULATIONS
e-CFR Data is current as of July 27, 2010
http://ecfr.gpoaccess.gov

Title 29: Labor

PART 1926—SAFETY AND HEALTH REGULATIONS FOR CONSTRUCTION

Subpart P—Excavations

Authority: Sec. 107, Contract Worker Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4, 6, 8, Occupational Safety and Hea1th Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12–71 (36 FR 8754), 8–76 (41 FR 25059), or 9–83 (48 FR 35736), as applicable, and 29 CFR part 1911.

Source: 54 FR 45959, Oct. 31, 1989, unless otherwise noted.

§ 1926.650 Scope, application, and definitions applicable to this subpart.

(a) *Scope and application.* This subpart applies to all open excavations made in the earth's surface. Excavations are defined to include trenches.

(b) *Definitions applicable to this subpart.*

Accepted engineering practices means those requirements which are compatible with standards of practice required by a registered professional engineer.

Aluminum Hydraulic Shoring means a pre-engineered shoring system comprised of aluminum hydraulic cylinders (crossbraces) used in conjunction with vertical rails (uprights) or horizontal rails (walers). Such system is designed, specifically to support the sidewalls of an excavation and prevent cave-ins.

Bell-bottom pier hole means a type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

Benching (Benching system) means a method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in means the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

Competent person means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Cross braces mean the horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

Excavation means any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Faces or *sides* means the vertical or inclined earth surfaces formed as a result of excavation work.

Failure means the breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere means an atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kickout means the accidental release or failure of a cross brace.

Protective system means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp means an inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer means a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting means the members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system) means a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with §1926.652 (c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring system) means a structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

Sides. See "Faces."

Sloping (Sloping system) means a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Stable rock means natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp means a ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system means a structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

Tabulated data means tables and charts approved by a registered professional engineer and used to design and construct a protective system.

Trench (Trench excavation) means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box. See "Shield."

Trench shield. See "Shield."

Uprights means the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales means horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

§ 1926.651 Specific excavation requirements.

(a) *Surface encumbrances.* All surface encumbrances that are located so as to create a hazard to employees shall be removed or supported, as necessary, to safeguard employees.

(b) *Underground installations.* (1) The estimated location of utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall be determined prior to opening an excavation.

(2) Utility companies or owners shall be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation. When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by state or local law), or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used.

(3) When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means.

(4) While the excavation is open, underground installations shall be protected, supported or removed as necessary to safeguard employees.

(c) *Access and egress* —(1) *Structural ramps.* (i) Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

(ii) Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.

(iii) Structural members used for ramps and runways shall be of uniform thickness.

(iv) Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.

(v) Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.

(2) *Means of egress from trench excavations.* A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.

(d) *Exposure to vehicular traffic.* Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

(e) *Exposure to falling loads.* No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with §1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.

(f) *Warning system for mobile equipment.* When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

(g) *Hazardous atmospheres* —(1) *Testing and controls.* In addition to the requirements set forth in subparts D and E of this part (29 CFR 1926.50–1926.107) to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements shall apply:

(i) Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.

(ii) Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation in accordance with subparts D and E of this part respectively.

(iii) Adequate precaution shall be taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20 percent of the lower flammable limit of the gas.

(iv) When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.

(2) *Emergency rescue equipment.* (i) Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

(ii) Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a life-line securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.

(h) *Protection from hazards associated with water accumulation.* (1) Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

(2) If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.

(3) If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person and compliance with paragraphs (h)(1) and (h)(2) of this section.

(i) *Stability of adjacent structures.* (1) Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.

(2) Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:

(i) A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or

(ii) The excavation is in stable rock; or

(iii) A registered professional engineer has approved the determination that the structure is sufficently removed from the excavation so as to be unaffected by the excavation activity; or

(iv) A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

(3) Sidewalks, pavements, and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.

(j) *Protection of employees from loose rock or soil.* (1) Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of scaling to remove loose material; installation of protective barricades at intervals as necessary on the face to stop and contain falling material; or other means that provide equivalent protection.

(2) Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet (.61 m) from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.

(k) *Inspections.* (1) Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.

(2) Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

(l) Walkways shall be provided where employees or equipment are required or permitted to cross over excavations. Guardrails which comply with §1926.502(b) shall be provided where walkways are 6 feet (1.8 m) or more above lower levels.

[54 FR 45959, Oct. 31, 1989, as amended by 59 FR 40730, Aug. 9, 1994]

§ 1926.652 Requirements for protective systems.

(a) *Protection of employees in excavations.* (1) Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section except when:

(i) Excavations are made entirely in stable rock; or

(ii) Excavations are less than 5 feet (1.52m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

(2) Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

(b) *Design of sloping and benching systems.* The slopes and configurations of sloping and benching systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (b)(1); or, in the alternative, paragraph (b)(2); or, in the alternative, paragraph (b)(3), or, in the alternative, paragraph (b)(4), as follows:

(1) *Option (1)—Allowable configurations and slopes.* (i) Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.

(ii) Slopes specified in paragraph (b)(1)(i) of this section, shall be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this subpart.

(2) *Option (2)—Determination of slopes and configurations using Appendices A and B.* Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall be determined in accordance with the conditions and requirements set forth in appendices A and B to this subpart.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of sloping or benching systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and shall include all of the following:

(A) Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;

(B) Identification of the limits of use of the data, to include the magnitude and configuration of slopes determined to be safe;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under paragraph (b) of this section shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include at least the following:

(A) The magnitude of the slopes that were determined to be safe for the particular project;

(B) The configurations that were determined to be safe for the particular project; and

(C) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy shall be made available to the Secretary upon request.

(c) *Design of support systems, shield systems, and other protective systems.* Designs of support systems shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)(3); or, in the alternative, paragraph (c)(4) as follows:

(1) *Option (1)—Designs using appendices A, C and D.* Designs for timber shoring in trenches shall be determined in accordance with the conditions and requirements set forth in appendices A and C to this subpart. Designs for aluminum hydraulic shoring shall be in accordance with paragraph (c)(2) of this section, but if manufacturer's tabulated data cannot be utilized, designs shall be in accordance with appendix D.

(2) *Option (2)—Designs Using Manufacturer's Tabulated Data.* (i) Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

(ii) Deviation from the specifications, recommendations, and limitations issued or made by the manufacturer shall only be allowed after the manufacturer issues specific written approval.

(iii) Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations shall be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy shall be made available to the Secretary upon request.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of support systems, shield systems, or other protective systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and include all of the following:

(A) Identification of the parameters that affect the selection of a protective system drawn from such data;

(B) Identification of the limits of use of the data;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2 or Option 3, above, shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include the following:

(A) A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and

(B) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design shall be made available to the Secretary upon request.

(d) *Materials and equipment.* (1) Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.

(2) Manufactured materials and equipment used for protective systems shall be used and maintained in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.

(3) When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.

(e) *Installation and removal of support* —(1) *General.* (i) Members of support systems shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.

(ii) Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.

(iii) Individual members of support systems shall not be subjected to loads exceeding those which those members were designed to withstand.

(iv) Before temporary removal of individual members begins, additional precautions shall be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.

(v) Removal shall begin at, and progress from, the bottom of the excavation. Members shall be released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.

(vi) Backfilling shall progress together with the removal of support systems from excavations.

(2) *Additional requirements for support systems for trench excavations.* (i) Excavation of material to a level no greater than 2 feet (.61 m) below the bottom of the members of a support system shall be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.

(ii) Installation of a support system shall be closely coordinated with the excavation of trenches.

(f) *Sloping and benching systems.* Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.

(g) *Shield systems* —(1) *General.* (i) Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand.

(ii) Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

(iii) Employees shall be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.

(iv) Employees shall not be allowed in shields when shields are being installed, removed, or moved vertically.

(2) *Additional requirement for shield systems used in trench excavations.* Excavations of earth material to a level not greater than 2 feet (.61 m) below the bottom of a shield shall be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

Appendix A to Subpart P of Part 1926—Soil Classification

(a) *Scope and application* —(1) *Scope.* This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. The appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

(2) *Application.* This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in §1926.652(b)(2) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with appendix C to subpart P of part 1926, and when aluminum hydraulic shoring is designed in accordance with appendix D. This Appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in §1926.652(c), and the use of the data is predicated on the use of the soil classification system set forth in this appendix.

(b) *Definitions.* The definitions and examples given below are based on, in whole or in part, the following: American Society for Testing Materials (ASTM) Standards D653–85 and D2488; The Unified Soils Classification System, The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and The National Bureau of Standards Report BSS–121.

Cemented soil means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.

Cohesive soil means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical sideslopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

Dry soil means soil that does not exhibit visible signs of moisture content.

Fissured means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

Granular soil means gravel, sand, or silt, (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

Layered system means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

Moist soil means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

Plastic means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Saturated soil means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.

Soil classification system means, for the purpose of this subpart, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of exposure.

Stable rock means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Submerged soil means soil which is underwater or is free seeping.

Type A means cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:

(i) The soil is fissured; or

(ii) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or

(iii) The soil has been previously disturbed; or

(iv) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or

(v) The material is subject to other factors that would require it to be classified as a less stable material.

Type B means:

(i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or

(ii) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.

(iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.

(iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or

(v) Dry rock that is not stable; or

(vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C means:

(i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or

(ii) Granular soils including gravel, sand, and loamy sand; or

(iii) Submerged soil or soil from which water is freely seeping; or

(iv) Submerged rock that is not stable, or

(v) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.

Unconfined compressive strength means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

Wet soil means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

(c) *Requirements* —(1) *Classification of soil and rock deposits.* Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

(2) *Basis of classification.* The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses shall be conducted by a competent person using tests described in paragraph (d) below, or in other recognized methods of soil classification and testing such as those adopted by the America Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

(3) *Visual and manual analyses.* The visual and manual analyses, such as those noted as being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

(4) *Layered systems.* In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(5) *Reclassification.* If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

(d) *Acceptable visual and manual tests* —(1) *Visual tests.* Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

(i) Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

(ii) Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

(iii) Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

(iv) Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

(v) Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

(vi) Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

(vii) Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

(2) *Manual tests.* Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

(i) *Plasticity.* Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as1/8-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of1/8-inch thread can be held on one end without tearing, the soil is cohesive.

(ii) *Dry strength.* If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

(iii) *Thumb penetration.* The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488—"Standard Recommended Practice for Description of Soils (Visual—Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a miminum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

(iv) *Other strength tests.* Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shearvane.

(v) *Drying test.* The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

(A) If the sample develops cracks as it dries, significant fissures are indicated.

(B) Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as a unfissured cohesive material and the unconfined compressive strength should be determined.

(C) If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

Appendix B to Subpart P of Part 1926—Sloping and Benching

(a) *Scope and application.* This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in §1926.652(b)(2).

(b) *Definitions.*

Actual slope means the slope to which an excavation face is excavated.

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and ravelling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short term exposure means a period of time less than or equal to 24 hours that an excavation is open.

(c) *Requirements* —(1) *Soil classification.* Soil and rock deposits shall be classified in accordance with appendix A to subpart P of part 1926.

(2) *Maximum allowable slope.* The maximum allowable slope for a soil or rock deposit shall be determined from Table B–1 of this appendix.

(3) *Actual slope.* (i) The actual slope shall not be steeper than the maximum allowable slope.

(ii) The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least1/2horizontal to one vertical (1/2H:1V) less steep than the maximum allowable slope.

(iii) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with §1926.651(i).

(4) *Configurations.* Configurations of sloping and benching systems shall be in accordance with Figure B–1.

TABLE B-1

MAXIMUM ALLOWABLE SLOPES

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V) [1] FOR EXCAVATIONS LESS THAN 20 FEET DEEP [3]
STABLE ROCK	VERTICAL (90°)
TYPE A [2]	3/4 : 1 (53°)
TYPE B	1:1 (45°)
TYPE C	1½ : 1 (34°)

NOTES:

1. Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
2. A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53°).
3. Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

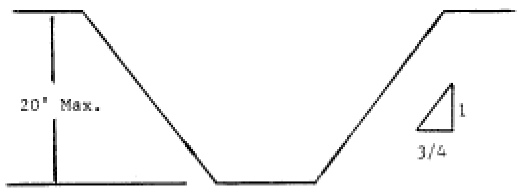
Figure B–1

Slope Configurations

(All slopes stated below are in the horizontal to vertical ratio)

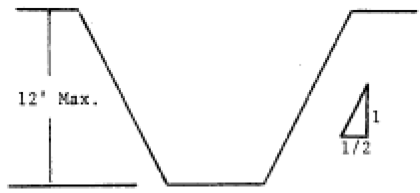
B–1.1 Excavations made in Type A soil.

1. All simple slope excavation 20 feet or less in depth shall have a maximum allowable slope of3/4:1.



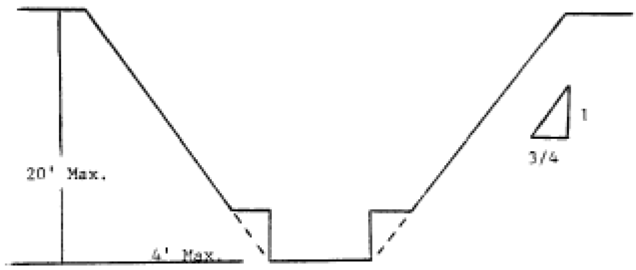
Simple Slope—General

Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of1/2:1.

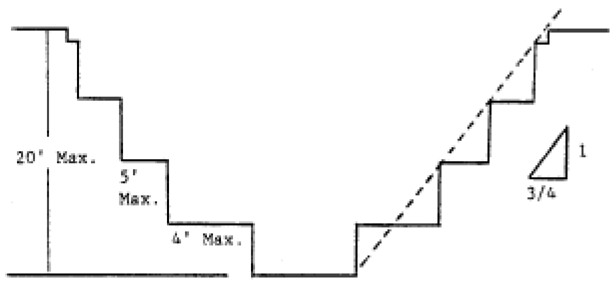


Simple Slope—Short Term

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of3/4to 1 and maximum bench dimensions as follows:

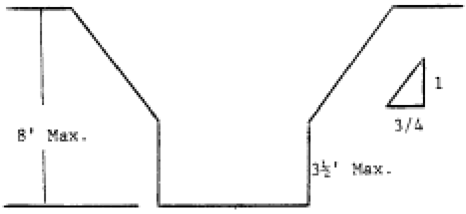


Simple Bench



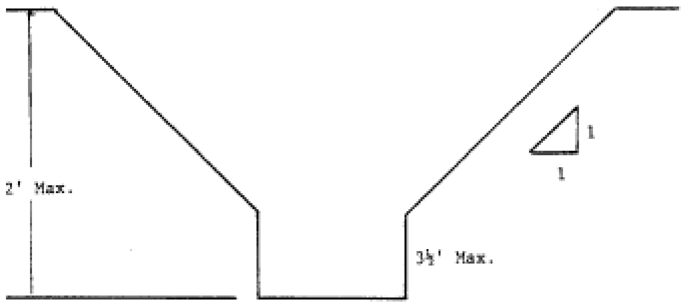
Multiple Bench

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of 31/2feet.



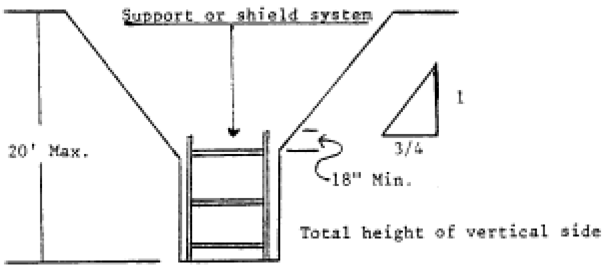
Unsupported Vertically Sided Lower Portion—Maximum 8 Feet in Depth

All excavations more than 8 feet but not more than 12 feet in depth which unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 31/2feet.



Unsupported Vertically Sided Lower Portion—Maximum 12 Feet in Depth

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of3/4:1. The support or shield system must extend at least 18 inches above the top of the vertical side.

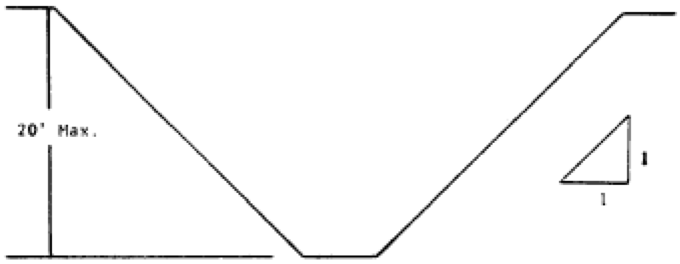


Supported or Shielded Vertically Sided Lower Portion

4. All other simple slope, compound slope, and vertically sided lower portion excavations shall be in accordance with the other options permitted under §1926.652(b).

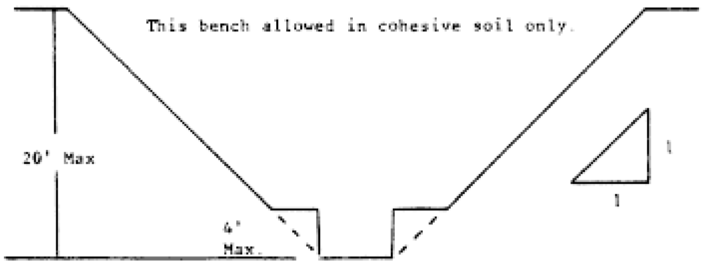
B–1.2 Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.

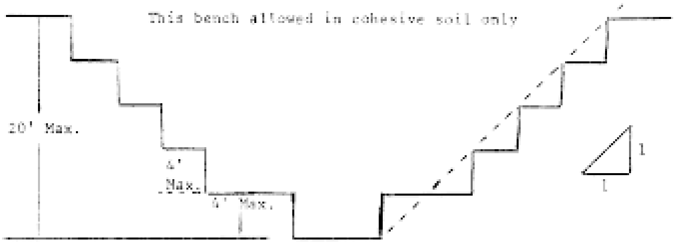


Simple Slope

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

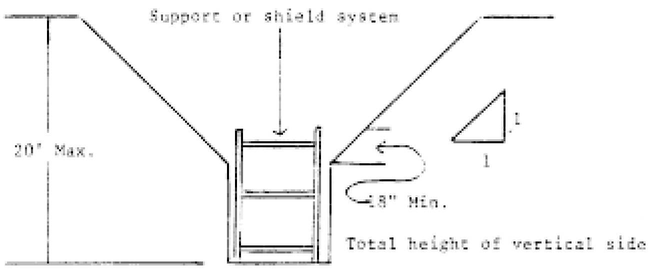


Single Bench



Multiple Bench

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

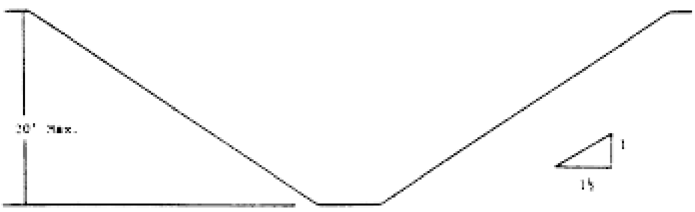


Vertically Sided Lower Portion

4. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

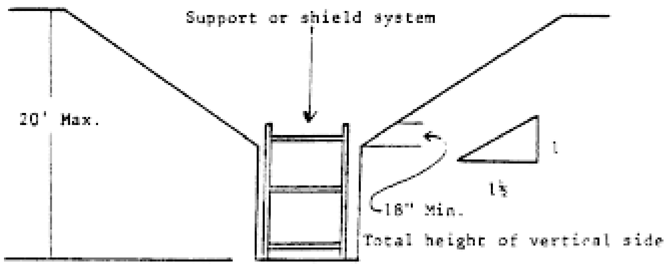
B–1.3 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 11/2:1.



Simple Slope

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 11/2:1.

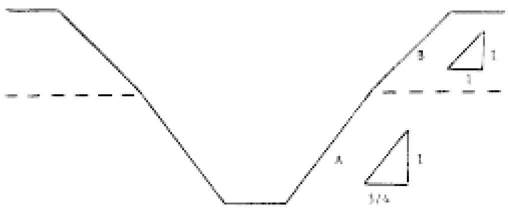


Vertical Sided Lower Portion

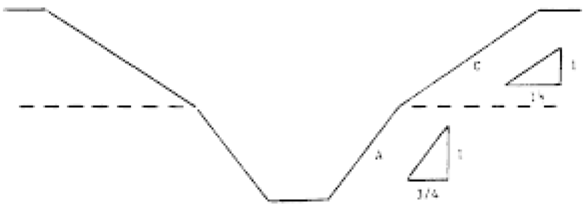
3. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

B–1.4 Excavations Made in Layered Soils

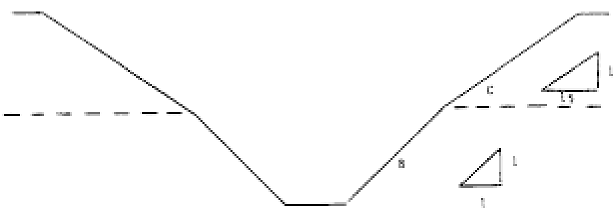
1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



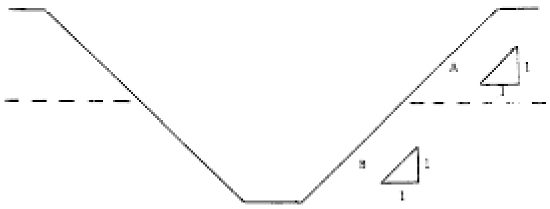
B OVER A



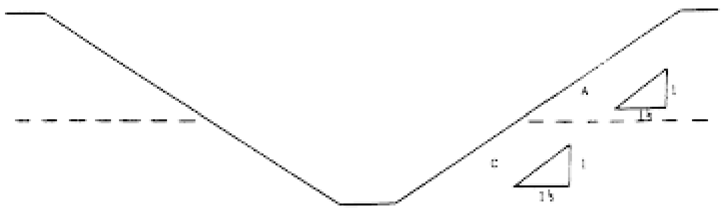
C OVER A



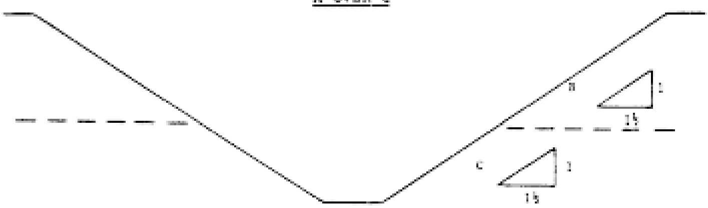
C OVER B



A OVER B



A OVER C



B OVER C

2. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

Appendix C to Subpart P of Part 1926—Timber Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with §1926.652(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in §1926.652(b) and §1926.652(c).

(b) *Soil Classification.* In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables C–1.1, C–1.2, and C–1.3, and Tables C–2.1, C–2.2 and C–2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations regarding Tables C–1.1 through C–1.3 and Tables C–2.1 through C–2.3 are presented in paragraph (g) of this Appendix.

(d) *Basis and limitations of the data* —(1) *Dimensions of timber members.* (i) The sizes of the timber members listed in Tables C–1.1 through C–1.3 are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.

(ii) The required dimensions of the members listed in Tables C–1.1 through C–1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C–2.1 through C–2.3, or have this choice under §1926.652(c)(3), and are referred to The Corps of Engineers, The Bureau of Reclamation or data from other acceptable sources.

(2) *Limitation of application.* (i) It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in §1926.652(c).

(ii) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with §1926.652.

(A) When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.

(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

(C) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(D) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables.* The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.

(f) *Examples to Illustrate the Use of Tables C–1.1 through C–1.3.*

(1) *Example 1.*

A trench dug in Type A soil is 13 feet deep and five feet wide.

From *Table C–1.1,* for acceptable arrangements of timber can be used.

Arrangement #B1

Space 4×4 crossbraces at six feet horizontally and four feet vertically.

Wales are not required.

Space 3×8 uprights at six feet horizontally. This arrangement is commonly called "skip shoring."

Arrangement #B2

Space 4×6 crossbraces at eight feet horizontally and four feet vertically.

Space 8×8 wales at four feet vertically.

Space 2×6 uprights at four feet horizontally.

Arrangement #B3

Space 6×6 crossbraces at 10 feet horizontally and four feet vertically.

Space 8×10 wales at four feet vertically.

Space 2×6 uprights at five feet horizontally.

Arrangement #B4

Space 6×6 crossbraces at 12 feet horizontally and four feet vertically.

Space 10×10 wales at four feet vertically.

Spaces 3×8 uprights at six feet horizontally.

(2) *Example 2.*

A trench dug in Type B soil in 13 feet deep and five feet wide. From Table C–1.2 three acceptable arrangements of members are listed.

Arrangement #B1

Space 6×6 crossbraces at six feet horizontally and five feet vertically.

Space 8×8 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #B2

Space 6×8 crossbraces at eight feet horizontally and five feet vertically.

Space 10×10 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #B3

Space 8×8 crossbraces at 10 feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Space 2×6 uprights at two feet vertically.

(3) *Example 3.*

A trench dug in Type C soil is 13 feet deep and five feet wide.

From Table C–1.3 two acceptable arrangements of members can be used.

Arrangement #B1

Space 8×8 crossbraces at six feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Position 2×6 uprights as closely together as possible.

If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #B2

Space 8×10 crossbraces at eight feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Position 2×6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) *Example 4.*

A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C–1.3. Only one arrangement of members is provided.

Space 8×10 crossbraces at six feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Use 3×6 tight sheeting.

Use of Tables C–2.1 through C–2.3 would follow the same procedures.

(g) *Notes for all Tables.*

1. Member sizes at spacings other than indicated are to be determined as specified in §1926.652(c), "Design of Protective Systems."

2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.

3. All spacing indicated is measured center to center.

4. Wales to be installed with greater dimension horizontal.

5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.

6. Trench jacks may be used in lieu of or in combination with timber crossbraces.

7. Placement cf crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

TABLE C-1.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A $P_a = 25 \times H + 72$ psf (2 ft Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---				2X6	
	UP TO 8	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---					2X8
	UP TO 10	4X6	4X6	4X6	6X6	6X6	4	8X8	4			2X6		
	UP TO 12	4X6	4X6	6X6	6X6	6X6	4	8X8	4				2X6	
10 TO 15	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---				3X8	
	UP TO 8	4X6	4X6	6X6	6X6	6X6	4	8X8	4		2X6			
	UP TO 10	6X6	6X5	6X6	6X8	6X8	4	8X10	4			2X6		
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4	10X10	4				3X8	
15 TO 20	UP TO 6	6X6	6X6	6X6	6X8	6X8	4	6X8	4	3X6				
	UP TO 8	6X6	6X6	6X6	6X8	6X8	4	8X8	4	3X6				
	UP TO 10	8X8	8X8	8X8	8X8	8X10	4	8X10	4	3X6				
	UP TO 12	8X8	8X8	8X8	8X8	8X10	4	10X10	4	3X6				
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may by substituted for wood.

TABLE C-1.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C P_a = 80 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**														
	CROSS BRACES									UPRIGHTS					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET) (See Note 2)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE				
5 TO 10	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	2X6				
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6				
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6				
	See Note 1													
10 TO 15	UP TO 6	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6				
	UP TO 8	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6				
	See Note 1													
	See Note 1													
15 TO 20	UP TO 6	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6				
	See Note 1													
	See Note 1													
	See Note 1													
OVER 20	SEE NOTE 1														

* Mixed Oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-1.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B P_a = 45 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**														
	CROSS BRACES							WALES		UPRIGHTS					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3		
5 TO 10	UP TO 6	4X6	4X6	6X6	6X6	6X6	5	6X8	5			2X6		
	UP TO 8	6X6	6X6	6X6	6X8	6X8	5	8X10	5			2X6		
	UP TO 10	6X6	6X6	6X6	6X8	6X8	5	10X10	5			2X6		
	See Note 1													
10 TO 15	UP TO 6	6X6	6X6	6X6	6X8	6X8	5	8X8	5		2X6			
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X10	5		2X6			
	UP TO 10	8X8	8X8	8X8	8X8	8X10	5	10X12	5		2X6			
	See Note 1													
15 TO 20	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	3X6				
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	3X6				
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6				
	See Note 1													
OVER 20	SEE NOTE 1														

* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may by substituted for wood.

TABLE C-2.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A P_a = 25 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4X4	4X4	4X4	4X4	4X6	4	Not Req'd	Not Req'd				4X6	
	UP TO 8	4X4	4X4	4X4	4X6	4X6	4	Not Req'd	Not Req'd					4X8
	UP TO 10	4X6	4X6	4X6	6X6	6X6	4	8X8	4			4X6		
	UP TO 12	4X6	4X6	4X6	6X6	6X6	4	8X8	4				4X6	
10 TO 15	UP TO 6	4X4	4X4	4X4	6X6	6X6	4	Not Req'd	Not Req'd				4X10	
	UP TO 8	4X6	4X6	4X6	6X6	6X6	4	6X8	4		4X6			
	UP TO 10	6X6	6X6	6X6	6X6	6X6	4	8X8	4			4X8		
	UP TO 12	6X6	6X6	6X6	6X6	6X6	4	8X10	4		4X6		4X10	
15 TO 20	UP TO 6	6X6	6X6	6X6	6X6	6X6	4	6X8	4	3X6				
	UP TO 8	6X6	6X6	6X6	6X6	6X6	4	8X8	4	3X6	4X12			
	UP TO 10	6X6	6X6	6X6	6X6	6X8	4	8X10	4	3X6				
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4	8X12	4	3X6	4X12			
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B P_a = 45 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3	4	6
5 TO 10	UP TO 6	4X6	4X6	4X6	6X6	6X6	5	6X8	5			3X12 4X8		4X12
	UP TO 8	4X6	4X6	6X6	6X6	6X6	5	8X8	5		3X8		4X8	
	UP TO 10	4X6	4X6	6X6	6X6	6X8	5	8X10	5			4X8		
	See Note 1													
10 TO 15	UP TO 6	6X6	6X6	6X6	6X8	6X8	5	8X8	5	3X6	4X10			
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X10	5	3X6	4X10			
	UP TO 10	6X8	6X8	8X8	8X8	8X8	5	10X12	5	3X6	4X10			
	See Note 1													
15 TO 20	UP TO 6	6X8	6X8	6X8	6X8	8X8	5	8X10	5	4X6				
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X12	5	4X6				
	UP TO 10	8X8	8X8	8X8	8X8	8X8	5	12X12	5	4X6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P_a = 80 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **														
	CROSS BRACES							WALES		UPRIGHTS					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)					
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE					
5 TO 10	UP TO 6	6X6	6X6	6X6	6X6	8X8	5	8X8	5	3X6					
	UP TO 8	6X6	6X6	6X6	8X8	8X8	5	10X10	5	3X6					
	UP TO 10	6X6	6X6	8X8	8X8	8X8	5	10X12	5	3X6					
	See Note 1														
10 TO 15	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	10X10	5	4X6					
	UP TO 8	8X8	8X8	8X8	8X8	8X8	5	12X12	5	4X6					
	See Note 1														
	See Note 1														
15 TO 20	UP TO 6	8X8	8X8	8X8	8X10	8X10	5	10X12	5	4X6					
	See Note 1														
	See Note 1														
	See Note 1														
OVER 20	SEE NOTE 1														

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Appendix D to Subpart P of Part 1926—Aluminum Hydraulic Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet (6.1m) in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with §1926.652(c)(2).

(b) *Soil Classification.* In order to use data presented in this appendix, the soi1 type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of part 1926.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables D–1.1, D–1.2, D–1.3 and E–1.4. Each table presents the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D–1.1 and D–1.2 are for vertical shores in Types A and B soil. Tables D–1.3 and D1.4 are for horizontal waler systems in Types B and C soil.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations (footnotes) regarding Table D–1.1 through D–1.4 are presented in paragraph (g) of this appendix.

(6) Figures, illustrating typical installations of hydraulic shoring, are included just prior to the Tables. The illustrations page is entitled “Aluminum Hydraulic Shoring; Typical Installations.”

(d) *Basis and limitations of the data.* (1) Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in the D–1 Tables. Aluminum material is 6061–T6 or material of equivalent strength and properties.

(2) Hydraulic cylinders specifications. (i) 2-inch cylinders shall be a minimum 2-inch inside diameter with a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufaturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe working capacity of not less than 30,000 pounds axial compressive load at extensions as recommended by product manufacturer.

(3) Limitation of application.

(i) It is not intended that the aluminum hydraulic specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be otherwise designed as specified in §1926.652(c).

(ii) When any of the following conditions are present, the members specified in the Tables are not considered adequate. In this case, an alternative aluminum hydraulic shoring system or other type of protective system must be designed in accordance with §1926.652.

(A) When vertical loads imposed on cross braces exceed a 100 Pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.

(B) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(C) When only the lower portion or a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables D–1.1, D–1.2, D–1.3 and D–1.4.* The members of the shoring system that are to be selected using this information are the hydraulic cylinders, and either the vertical shores or the horizontal wales. When a waler system is used the vertical timber sheeting to be used is also selected from these tables. The Tables D–1.1 and D–1.2 for vertical shores are used in Type A and B soils that do not require sheeting. Type B soils that may require sheeting, and Type C soils that always require sheeting are found in the horizontal wale Tables D–1.3 and D–1.4. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is made. The selection is based on the depth and width of the trench where the members are to be installed. In these tables the vertical spacing is held constant at four feet on center. The tables show the maximum horizontal spacing of cylinders allowed for each size of wale in the waler system tables, and in the vertical shore tables, the hydraulic cylinder horizontal spacing is the same as the vertical shore spacing.

(f) *Example to Illustrate the Use of the Tables:*

(1) Example 1:

A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table D–1.1: Find vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)

(2) Example 2:

A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table D–1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)

(3) A trench is dug in Type B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D–1.2: Find vertical shores and 2 inch diameter cylinder (with special oversleeves as designated by footnote #B2) spaced 5.5 feet o.c. horizontally and 4

feet o.c. vertically, plywood (per footnote (g)(7) to the D–1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)

(4) Example 4: A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep and 12 feet wide. 8 foot horizontal spacing between cylinders is desired for working space. From Table D–1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(5) Example 5: A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D–1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(g) *Footnotes, and general notes, for Tables D–1.1, D–1.2, D–1.3, and D–1.4.*

(1) For applications other than those listed in the tables, refer to §1926.652(c)(2) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to §1926.652(c)(2) and §1926.652(c)(3).

(2) 2 inch diameter cylinders, at this width, shall have structural steel tube (3.5×3.5×0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.

(3) Hydraulic cylinders capacities. (i) 2 inch cylinders shall be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(4) All spacing indicated is measured center to center.

(5) Vertical shoring rails shall have a minimum section modulus of 0.40 inch.

(6) When vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

(7) Plywood shall be 1.125 in. thick softwood or 0.75 inch. thick, 14 ply, arctic white birch (Finland form). Please note that plywood is not intended as a structural member, but only for prevention of local raveling (sloughing of the trench face) between shores.

(8) See appendix C for timber specifications.

(9) Wales are calculated for simple span conditions.

(10) See appendix D, item (d), for basis and limitations of the data.

ALUMINUM HYDRAULIC SHORING

TYPICAL INSTALLATIONS

FIGURE NO. 1

VERTICAL ALUMINUM HYDRAULIC SHORING

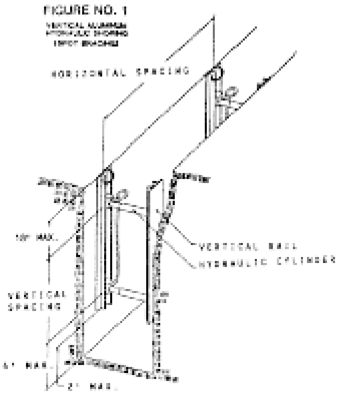


FIGURE NO. 2

VERTICAL ALUMINUM HYDRAULIC SHORING

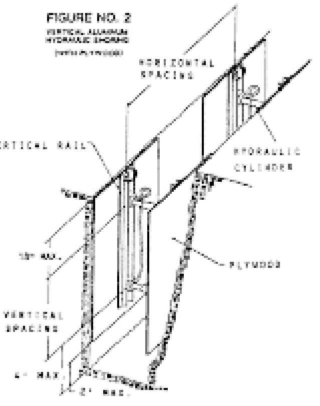


FIGURE NO. 3

VERTICAL ALUMINUM HYDRAULIC SHORING (STACKED)

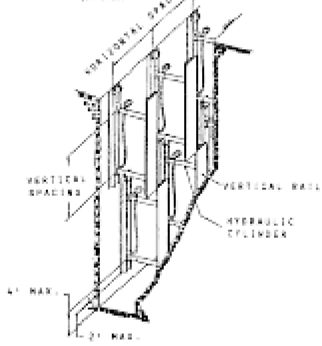


FIGURE NO. 4

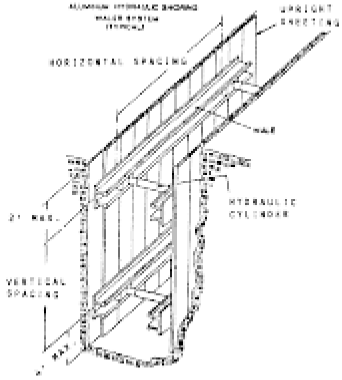


TABLE D - 1.2
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE B

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8				
OVER 10 UP TO 15	6.5	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 15 UP TO 20	5.5				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g) (1)
Note (2): See Appendix D, Item (g) (2)

TABLE D - 1.1
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE A

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8				
OVER 10 UP TO 15	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 15 UP TO 20	7				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g) (1)
Note (2): See Appendix D, Item (g) (2)

TABLE D - 1.4
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE C

DEPTH OF TRENCH	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
			WIDTH OF TRENCH (FEET)						MAX HORIZ SPACING (ON CENTER)		
	VERTICAL SPACING	SECTION MODULUS *	UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT.	3 FT.
(FEET)	(FEET)	(IN^3)	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	6.0	2 IN	6.0	2 IN NOTE(2)	6.0	3 IN	3x12	—	—
		7.0	6.5	2 IN	6.5	2 IN NOTE(2)	6.5	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 10 UP TO 15	4	3.5	4.0	2 IN	4.0	2 IN NOTE(2)	4.0	3 IN	3x12	—	—
		7.0	5.5	3 IN	5.5	3 IN	5.5	3 IN			
		14.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
OVER 15 UP TO 20	4	3.5	3.5	2 IN	3.5	2 IN NOTE(2)	3.5	3 IN	3x12	—	—
		7.0	5.0	3 IN	5.0	3 IN	5.0	3 IN			
		14.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, item (g) (1)
Notes (2): See Appendix D, Item (g) (2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

TABLE D - 1.3
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE B

DEPTH OF TRENCH	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
			WIDTH OF TRENCH (FEET)						MAX HORIZ SPACING (ON CENTER)		
	VERTICAL SPACING	SECTION MODULUS *	UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO15		SOLID SHEET	2 FT.	3 FT.
(FEET)	(FEET)	(IN^3)	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	8.0	2 IN	8.0	2 IN NOTE(2)	8.0	3 IN	—	—	3x12
		7.0	9.0	2 IN	9.0	2 IN NOTE(2)	9.0	3 IN			
		14.0	12.0	3 IN	12.0	3 IN	12.0	3 IN			
OVER 10 UP TO 15	4	3.5	6.0	2 IN	6.0	2 IN NOTE(2)	6.0	3 IN	—	3x12	—
		7.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 15 UP TO 20	4	3.5	5.5	2 IN	5.5	2 IN NOTE(2)	5.5	3 IN	3x12	—	—
		7.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
		14.0	9.0	3 IN	9.0	3 IN	9.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, item (g) (1)
Notes (2): See Appendix D, Item (g) (2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

Appendix E to Subpart P of Part 1926—Alternatives to Timber Shoring

Figure 1. Aluminum Hydraulic Shoring

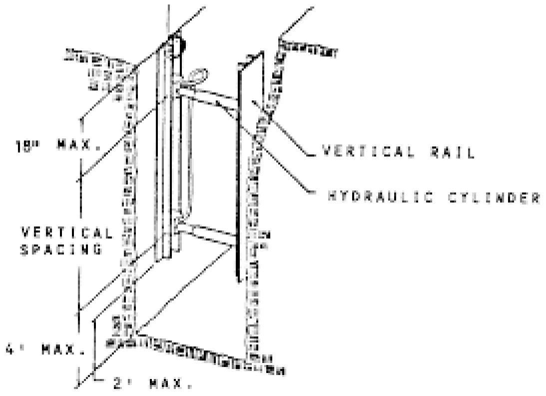


Figure 2. Pneumatic/hydraulic Shoring

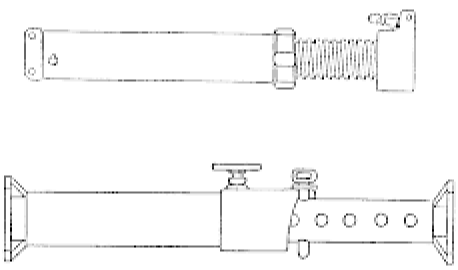


Figure 3. Trench Jacks (Screw Jacks)

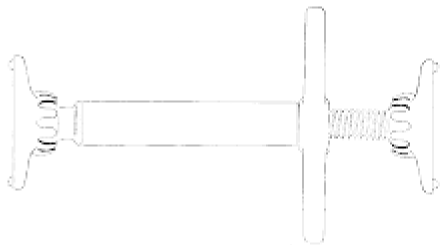
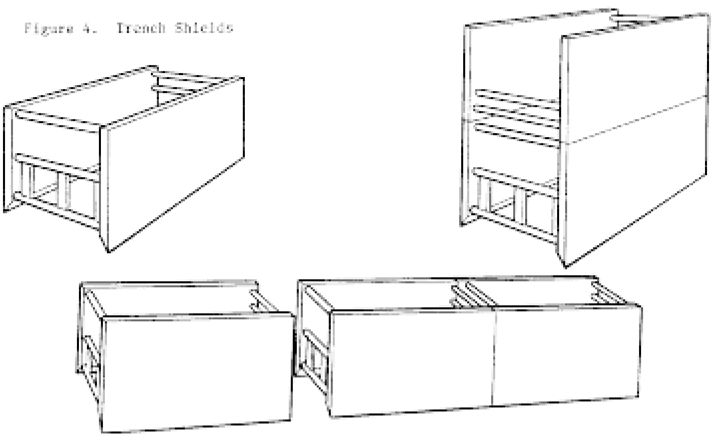


Figure 4. Trench Shields



Appendix F to Subpart P of Part 1926—Selection of Protective Systems

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with §1926.652 (b) and (c).

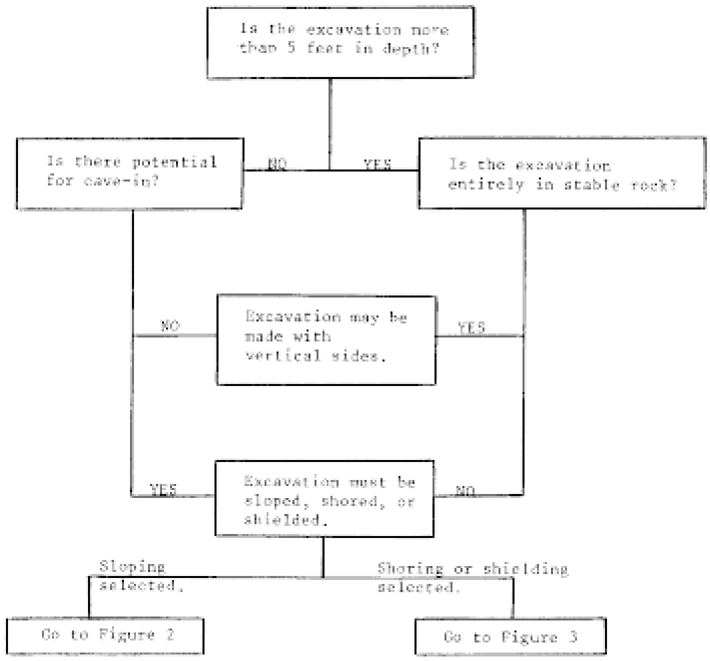


FIGURE 1 - PRELIMINARY DECISIONS

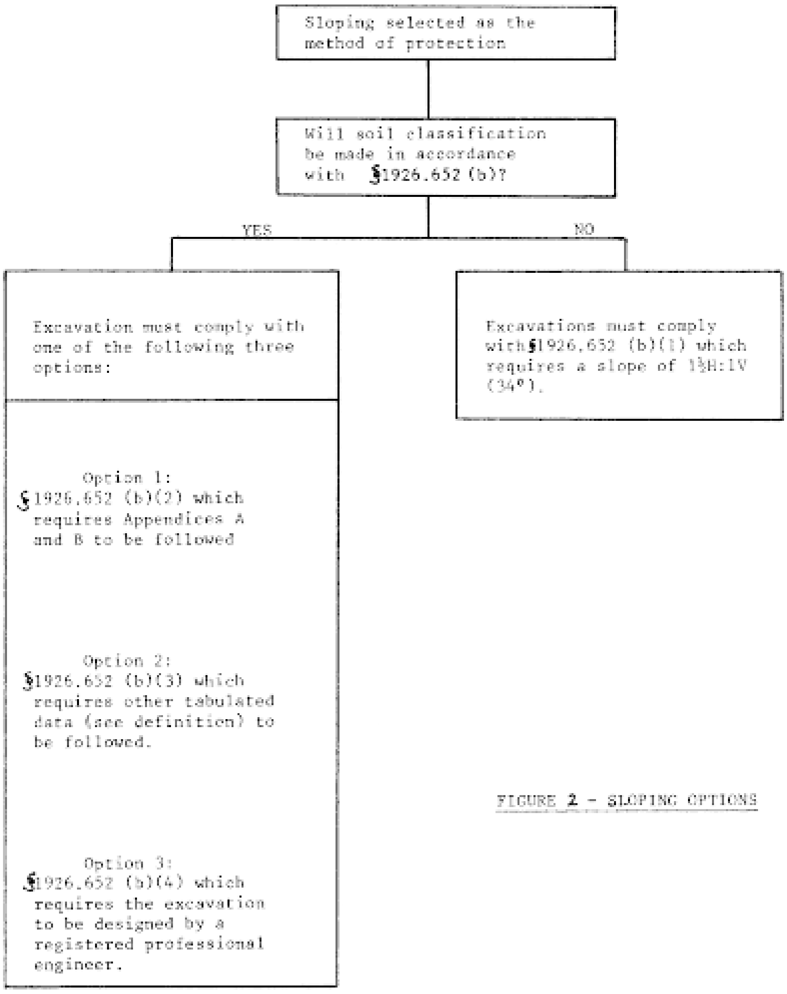


FIGURE 2 - SLOPING OPTIONS

Shoring or shielding selected as the method of protection.

Soil classification is required when shoring or shielding is used. The excavation must comply with one of the following four options:

Option 1
§1926.652 (c)(1) which requires Appendices A and C to be followed (e.g. timber shoring).

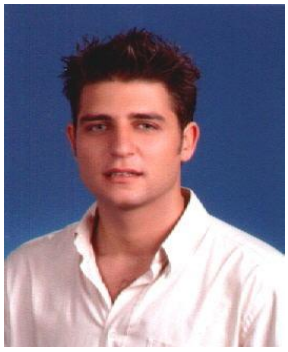
Option 2
§1926.652 (c)(2) which requires manufacturers data to be followed (e.g. hydraulic shoring, trench jacks, air shores, shields).

Option 3
§1926.652 (c)(3) which requires tabulated data (see definition) to be followed (e.g. any system as per the tabulated data).

Option 4
§1926.652 (c)(4) which requires the excavation to be designed by a registered professional engineer (e.g. any designed system).

FIGURE 3 - SHORING AND SHIELDING OPTIONS

CURRICULUM VITA



Candidate's full name: Harun Övünç ORAL

Place and date of birth: Istanbul, 3 December 1979

Permanent Address: 2360 36^{th} Street, 2^{nd} Floor, Astoria, NY 11105, USA

Universities and Colleges attended: Istanbul Technical University, Faculty of Civil Engineering, Department of Civil Engineering (2003 Graduate)

Publications: N/A