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Contracting

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**Assessment of constructability practices
among General contractors in the eastern
province of Saudi Arabia**

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ABSTRACT

It is common for a construction project to encounter difficulties, especially if the project is complex kind of project. This thesis will cover the industry in Saudi Arabia eastern province where the focus of the industry development is. The studies shows by applying proper planning and coordination systems in every project, we could witness an increase in overall cost efficiency and project quality. The researcher believes that constructability or buildability is the solution, as it is based on integration of construction knowledge and experience during planning, design, procurement and construction phases of a project. Understanding the key role played by the general contractors in the construction project, the researcher developed a questionnaire as a measuring tool to asses constructability implementation among general contractors in the eastern province of Saudi Arabia. Upon obtaining valuable data, it was found the general contractors in the eastern province of Saudi Arabia have a good awareness of constructability implementation, and this is due to the existence of Saudi Aramco, which insists on the constructability program as a part of its contractor qualification process. It was understood that general contractors are practicing constructability commonly during the pre-construction phase.

INTRODUCTION

Constructability, or buildability, as term is not well known, in fact these two terms are not found in most dictionaries but in practice the concept has been known since the beginning of the construction industry. “In ancient times the design was dedicated, about how the project should be built, and the construction was done by the master builder.” (Uhlik and lores 1998)

The construction industry in the kingdom of Saudi Arabia experienced tremendous growth during the early 1970s and continued to grow until the late 1980s. Today, it is still growing, but far less in comparison. This construction boom period helped in gaining an ocean of knowledge and mastering many valuable lessons. But of course, this was in return for many human lives and huge financial losses. Still, how much of this knowledge and experience is passed on form one project to another? The answer to such huge irreparable loss is in constructability.

Involving people with constructions knowledge and experience at the very beginning of the project results maximizing benefits.” It has been shown that the integration of \construction knowledge during the planning, design and procurement phases of a project bring extraordinary benefits into the delivery of the project. This is due to the fact that these are the phases in which one is able to influence the overall project the most.” (Lores 1997)

To receive the design after completion is not a constructability program. It has to start from the beginning, because it is very difficult to make substantial changes in the design once you are through with it. Constructability considerations have to be started at the same time as the initial project planning and should continue during the entire life of the project.

Previous Studies

Highlights of constructability effectiveness

The construction industry institute (CII) made many case studies to highlight the importance and the effectiveness of constructability. In one case study (Residence community in San Antonio, Texas) the resulting savings reduced project costs by approximately 10 percent (\$3.5 Million) and enabled the project to be completed on schedule. In another case study (Refinery Expansion), the project was completed 14 months ahead of schedule with a 23 percent (\$253 million) saving from the original estimate. A third one (Arctic oil production facility in Alaska) had a project cost reduction from \$3.8 billion to \$ 1.4 billion.

The benefits attained on these projects clearly demonstrate that an effective constructability program was a major factor in achieving completion ahead of schedule and reducing costs. However, studies indicate that, overall, constructability is not begin implemented to its full potential (Construction, 1986),

Definition of constructability

Constructability, as defined by the construction industry institute (C11), is the “optimum integration of construction knowledge and experience in planning, engineering, procurement and field operations to achieve project objectives” (construction, 1986). Along the same lines, O’Connor and tucker in their study ‘Industrial project constructability improvement’ give a slightly different definition: “constructability is seen as the ability of project conditions enable the optimal utilization of construction resources.”

The construction management committee of the ASCE construction division has defined constructability as “the capability of being constructed.” It has also defined a constructability program as “the application of a disciplined, systematic optimization of the construction-related aspects of a project during the planning, design, procurement, construction, test and start up phases by knowledgeable, experienced construction personnel who are part of a project team, to enhance the project’s overall objectives.” (ASCE,1991).

Why constructability is needed

“We can have all the computers in the world to help us, and we can draw like angels; but if we don’t really know what the materials are like and how they are made and the way they are handled by people actually building the thing, then we really can not be very creative. We cannot innovate unless we know so much about building that we can suggest how to change things.” LeMessurier,1989:99-100).

In the past, the so-called “master builder professional” used to manage all the knowledge required to plan, design and construct a project. Nowadays, it is no longer possible to do the same, due to the complexity of project and the variety of materials that can be used in design and construction. Materials have particular characteristics and behave differently under the same loads. Another reason is that “science and technology are moving so fast that it is difficult, even for professionals in particular areas of specialization, to stay up to date.” (Lores, 1997). In addition to all of the above, there are the regulations, standards, and codes, which are so diverse that it needs a professional to be specialized in this area.

Research Objectives

The purpose of the present piece of research is to:

1. Determine current implementation practices for constructability in the eastern province of Saudi Arabia.
2. Assess the existence of common barriers to constructability implementation.

Methodology and limitations:

The major steps in this research study can be summarized as follows:

1. A review of previous research on constructability was conducted, in order to become familiar with the topic and to facilitate the analysis of the data obtained from the survey.
2. A survey was used for the purpose of collecting data as well as identifying the participant.
3. A Questionnaire was developed and sent by either mail, e-mail or carried to the participants.
4. Finally, the collected data and the findings were analyzed.

Scope and limitation:

The objective of this study was to determine whether or not the general contractors in the eastern province of Saudi Arabia were applying the constructability concept, and if they were, to what extent. If they were not, what were the common barriers?

Significance of this study:

Construction projects usually involve heavy total cost. Therefore, time and resources play a vital and critical role in deciding the cost factor of every project. Hence, by doing the job right the very first time, total project cost can be reduced substantially by identifying mistakes, analyzing the situation and solving any problem.

One study conducted earlier on industrial project showed the direct cost for construction rework at greater than 12% of the total project cost (Ledbetter, Davis & Burati, 1989).

The construction industry in Saudi Arabia is one of the biggest industries and any extra cost means huge losses to the contractors and higher expenses to the clients. To avoid such loss on construction rework, extensive research needs to be conducted to improve the construction process.

The Questionnaire

Initially, it had been decided to have face-to-face interviews with the participants. But, considering various contingencies like fixing appointments, traveling long distances, participants' minimum acceptance level for personal interviews, keeping of appointments etc., many of the participants suggested receiving questionnaires by fax for effective participation. As a result, the plan was changed to e-mail and fax the questionnaire and closely follow up by telephone.

The questionnaire was designed in three parts. A copy of the questionnaire is presented in Appendix A.

The first part includes questions one through seven, to obtain information about the characteristics of the organization, such as (See figure 1.2):

1. Name and position of the person, company name, address, phone and fax. All are optional.
2. Organization's nationality.
3. In what sector the organization is performing work.
4. What type of work the organization is involved with.
5. What range of annual volume of work.
6. What type of contract.

The second part of the questionnaire contains the definition of the term "constructability" in order to assess the participants' awareness of the term. Even if the respondent is not fully aware of the term "constructability", the definition helps him to understand constructability enough to completed the questionnaire, as many organizations may be unknowingly practicing the concept of constructability.

Constructability Questionnaire

This questionnaire will be sent to a representative sample of General Contractors in Saudi Arabia. Certain questions may have more than one answer and are indicated by the words check all that apply. Otherwise, please check only one answer. Individual responses to questions and Company and Project identifications will remain anonymous.

- Information about the person filling the questionnaire:

Name: (Optional) _____

 Position: _____

Company: _____

 Address: _____

Phone: _____ Fax: _____

 Email: _____
- Organization Nationality.

Saudi.

 Joint Venture.
 Other (Specify: _____).
- What best describes your organization type:

General Contractor. Design Build Contractor.

 Subcontractor. Other (Please list: _____).
- In what sector does your organization perform work? Check all that apply.

Private (____% of total volume). Public (____% of total volume).
- What type of work is your organization typically involved with? Check all that apply.

General Building. Industrial.

 Civil (Heavy and Highway). Other (List: _____).
- Please indicate the range of annual volume of work.

Less than SR50,000,000

 Between SR50,000,000 and SR100,000,000
 Between SR100,000,000 and SR500,000,000
 More than SR500,000,000
- Under what type of contract do you perform work? Check all that apply?

Traditional (design without construction input) (____% of total volume).

 Design-build (____% of total volume).
 Construction Management (____% of total volume).

Figure 1.1: Questionnaire part 1 “Introductory part “

The third part of the questionnaire was designed to determine the opinions of the general contractors on the following issues:

1. Their participation during the pre-construction phase by inserting construction knowledge.
2. Rating a list of barriers to constructability by choosing – “Always / sometimes/ Never”.
3. Indicating the type of projects that constructability should be implemented with.
4. The difficulties that they encountered by using a traditional method (design without construction input).
5. Whether the participation of construction contractors during the design phase can improve the drawing and specifications.
6. If constructability should be included during the design phase as another specialty.

Discussion of the Results

Response Rate

The response rate against the total number of questionnaires sent to various participants is summarized below.

The list obtained from the chamber of commerce and industry containing 49 contractors in the grade 2 and above category was expected to respond to the questionnaire faxed by the researcher. Of the above 49 contractors only 12 (25%) responded. Out of these 12, 2 of them were not under the general contractor's type and therefore excluded from the list.

A second list containing 43 contractors. Obtained from Aramco contracting Dept., was sent to those concerned. Of this list, 25 contractors responded to the questionnaire, making the rate of response 58%. Out of these 25 respondents, 4 were not under the general contractors type and therefore excluded from the list.

Therefore, of the total 92 questionnaires sent to different contractors, 37 (40%) responded. From this 37, 6 did not fit under the general contractors category and therefore remained excluded, which means that only 31 questionnaires were used and included in the database.

In this exercise of data collection through the questionnaire survey method, sixty percent (60%) of the contractors did not care to reciprocate or show any form of interest in the constructability issue despite of continuous follow-up efforts.

Description of the Results

The presentation of the results will be in four major parts.

The **first part** will discuss the characteristics of the organization, such as: nationality, type of work, and the sector where work is performed, type of contract and volume of work. The results of this part were acquired from questions 2 to 7 in the survey questionnaire.

The **second part**, that is questions 8, 13, 15, 16, 17, and 18, indicates the respondents' opinions with respect to the constructability issues.

The **third part** covered under question 14 presents the results regarding the barriers to constructability.

The **fourth part** contributes the answer on how the participants are using the concept of constructability in their different project stages. These results were obtained from questions 9, 10, 11 and 12, in the survey questionnaire.

Part 1: Characteristics of Organization

The majorities of the participating organization were of Saudi Nationality (i.e. about 75 %) and had an annual project volume of up to SR. 100 million.

Of the participating organization, the majority of the general contractor worked in general building construction project (77 %) and industrial projects (55 %) under the construction management and design-build method of contract. Many of them performed work in both private and public sectors.

Figure 4.2 summarize the general characteristic in terms of nationality, sector of work performed, type of work, volume of work, and type of contract for all the organization that participated in the survey.

Table 4.2: Respondent's Opinions about Constructability Issues

Q	Opinion of Respondents	% Frequency n=31
8	Have you heard of the term constructability before?	
8a	Yes	84%
8b	No	16%
13	How often do you participate by inserting construction knowledge during the preconstruction phase of projects?	
13a	Commonly	77%
13b	Seldom	20%
13c	Never	3%
15	Where do you think constructability should be implemented? *	
15d	All Projects	71%
15c	Large Projects	26%
15a	Complex Projects	16%
15e	Certain type of Projects	10%
15b	Small Projects	3%
16	Using the traditional process (design without construction input), have you encountered any of the following difficulties? *	
16a	Specification problems	90%
16e	Unrealistic schedule	77%
16c	Problems with physical interference	70%
16b	Tolerance problems	53%
16d	Weather related problems that could be avoided during design phase	30%
17	Do you agree that the participation of construction contractors during the design of a project can help to produce better drawings, specification, and buildable projects?	
17a	Yes	90%
17c	Sometimes	10%
17b	No	0%
18	Do you think constructability should be included as another specialty during the design phase of the project such as: architectural, mechanical, electrical, etc.?	
18a	Yes	74%
18b	No	13%
18c	Sometimes	13%

Note: * Not an exclusive question

Figure 4.2: Contractors opinion

Part 2: Contractors' opinion on Constructability

A detailed summary of the participants' opinions about the constructability issue is showing in figure 4.2 and 4.9. Question 8 defines constructability and judges the participants' awareness of the definition.

Eighty-four percent (84 %) of the participants' were aware of the term constructability. This indicates that constructability is very common in this part of Saudi Arabia among the general contractors.

One main reason for the high percentage (84%) of constructability awareness could possible by the result of Saudi Aramco's existence in the province that stipulates the need for constructability for all general contractors as a key requirement for qualification.

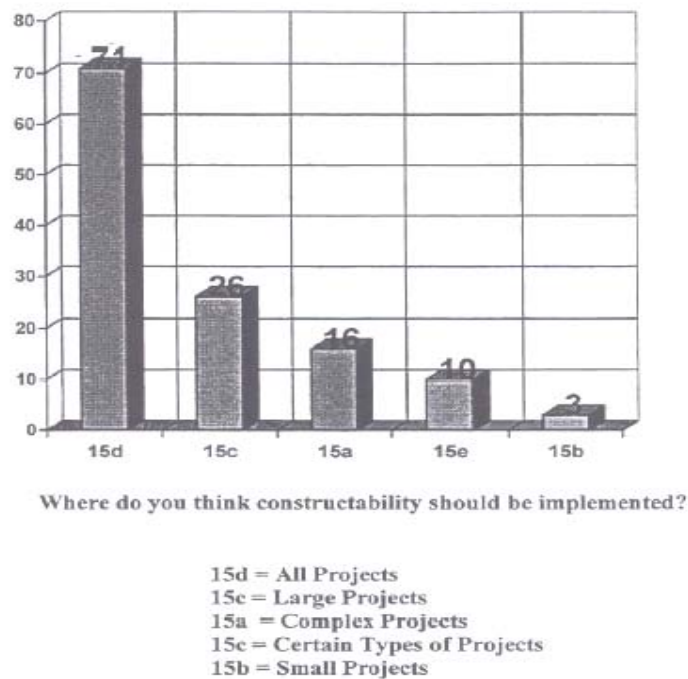


Figure 4.9: Where Constructability Should be Implemented.

Two remarks from 2 respondents who answered to not having heard of the constructability term before were:

“No, but I an practicing it”
“We know the concept”

Question 13 asked “how often do you participate by inserting constructability knowledge the pre-construction phase of project?”

Seventy seven percent (77%) of the general contractors were commonly participating during this stage of the project and only three percent (3%) expressed that they never participated during this stage of the project. This result shows that general contractors are participating in the earlier phase of the projects.

Question 15: “where do you think constructability should be implemented?”

Seventy one percent (71%) thought that constructability should be implemented in all projects. Twenty six percent (26%) thought that constructability should be implemented in large project, and sixteen percent (16%) in complex projects. One respondent thought that it should be implemented in small project and this seen to be odd.

One remark from a participant about where constructability should be implemented was: “certain type of projects: schedule driven, technically challenging”.

Question 16: “Using the traditional process, have you encountered any of the following difficulties?”

Most of the respondents (90%) face a specification problem when using the traditional process. Also, unrealistic schedules, physical interference and tolerance were common difficulties encountered by general contractors.

Question 17: “do you agree that the participation of construction contractors during the design of a project can help to produce better drawings, specifications and buildable projects?”

The majority of the participants (90%) agreed that the participation of general contractors during the design could help to produce better specifications and drawings. Some remarks made by the participants are as follows:

“Sometimes: Only input”.

“Sometimes: when they understand what they are talking about”.

“Yes: He will advise some practical experience”.

Question 18: “Do you think constructability should be included as another specialty during the design phase of the project.”

Seventy four percent (74%) of the general contractors agreed that constructability should be included as another specialty. Among the participants that answered “sometimes”, some stated the following:

“ Sometimes : Input by the Construction Manager after 60% detail design is very helpful”.

“Sometimes : In projects that are special or where cost and time of completion are critical”

“Sometimes : Not specialty but requirements, it applies to all”

Part3: Barriers to constructability

As explained earlier, the rating of the barrier is derived from the selection of “Always/ sometimes / Never” against every respective barrier mentioned.

“Always” equals “Yes”

“Never” equals “No” ,and

“sometimes” means to show that the barriers exist, but not in all cases”

The most significant barriers encountered were:

1. Design without construction inputs in the traditional form of contracting.
2. Owners do not care about constructability in the contracting strategy, and
3. Owners do not choose constructability in their projects.

The last selected barrier was:

- There are one proven benefits of constructability.

This means that General Contractors are very well aware of the benefits of constructability.

Upon analyzing the response, it appears that the “sometimes” rating frequency is too high, and it may be that General Contractors are uncertain of their answers or may be these barriers exist, but not regularly.

A participant stated one barrier as “ The lack of general awareness for quality services by contractors in the community in general”

Part 4b: statistical Analysis

In this part of the study, relationships, between the characteristics of the organization and the implementation of the constructability concept are to be found. In order to test for a relationship, a Chi-square test was used to determine the independence between these characteristics, such as: the organization’s nationality, type of work etc. and the application of the constructability concept in different stages of a project.

One of the most frequent of Chi-square is for testing a null hypothesis that two criteria of classification are independent. “Two criteria of classification are said to be independent if the distribution of one criterion in no way depends on the distribution of the other” “(Daniel &Terrell, 1995).

In order to carry out the Chi-square test for independence, a statistics package called SPSS 9.05 was used.

The level of significance was selected before collecting the data to equal 0.05 . This choice of α , which is the most common value, was based on tradition. If the value obtained for P (observed significance) was less than $\alpha = 0.05$, the null hypothesis H_0 which stated independence between variables was rejected and the variables were said to be dependent. Appendix C shows examples of the computer output for the Chi-square tests.

1. The relationship between the organization's nationality and the application of the constructability concept.
It was found that none of the constructability activities were influenced by the nationality of the organization except for the preparation of the schedule, estimates and budget in the conceptual phase. Results indicate that Saudi General Contractors participate in preparation of the schedule, estimates and budget more than joint venture or others.
2. Application of the constructability concept related to sector where work is performed. It was found that there is a relationship between the private sector and the following activities: selection of major construction methods and materials; insertion into design the concern of accessibility of personnel, materials and equipment; analysis of specifications to allow easy construction and careful analysis of layout; access and temporary facilities to improve productivity.
3. Application of the constructability concept related to type of work performed. There was no relationship found between the constructability concept and the building general contractors.

In the case of Industrial General Contractors a relationship was found with the following activities: advising owner of the project's goals and objectives; execution of feasibility studies and selection of site; advice in contracting strategy; selection of major construction method and materials; planning the sequence of field takes to improve production; use of pre-assembly or pre-fabrication for the execution of work; and capture and transfer of lessons-learned to future projects. These results show that Industrial General Contractors participate more during the conceptual phase and are also concerned with the use of pre-assembly and transfer of lessons-learned to future projects. This may be due to the fact that Industrial General Contractors were dealing with bigger project that require more preparation, especially in the conceptual phase.

Conclusions and recommendations

Conclusions

Upon carefully studying the facts of historical evidences, understanding current construction methodology and implementation practices in construction project in this region, and that affect the optimization of project objectives, the researcher puts forward hereunder his conclusions and suggestions.

General Issues of constructability

- a) The term “constructability” is very well known to the General Contractors in this part of Saudi Arabia this high level of awareness among General contractors in this region may be due to Saudi Aramco, which insists on a constructability program as part of its contractor qualification process.
- b) General Contractors are commonly participating during the pre-construction phase of the project by inserting their construction knowledge.
- c) Most of the General Contractors think that constructability should be implemented in all projects regardless of the project size, type or complexity.
- d) Specification problem and unrealistic schedules are the most significant difficulties encountered by the General contractors under the traditional method of contracting.
- e) General Contractors feel that constructability should be included as another specialty requirement during the design phase of a project. This practice can help them to produce better drawings and specifications by participating during the design phase.

Barriers

- a) General Contractors in common were having the same opinion about the barriers to constructability, irrespective of the volume of work, type of work or type of contract. As an exception, only organizations with an annual volume of more than SR 500 Million were found to have fewer barriers.
- b) The most significant barriers to constructability highlighted by General Contractors were as follows:
 - Design without construction input is the traditional from of contracting.
 - Owners do not care about constructability in the contracting strategy.
 - Owners do not choose constructability in their projects.
- c) The least mentioned barriers to constructability by General Contractors were: “There are no proven benefits of constructability” By this, it is obvious that General Contractors are very well aware of the benefits of constructability.
- d) General Contractors believe that the following barriers to constructability exist sometimes, but not always:

- Designers' lack of construction experience and knowledge of construction technology.
 - The concept is unknown to the owners.
- e) A new barrier to constructability witnessed during the research process was the lack of general awareness of quality services by contractors in the community in general.

The constructability concept

- a) The application of the constructability concept by General Contractors was found most in the construction phase.
- b) Constructability programs are commonly implemented by General Contractors.
- c) It was found that, in the implementation of constructability concepts by General Contractors in the industrial type of work and the design-build contract, there is a dependent relationship between them.

General Findings

- a) The majority of General Contractors agreed that the management of their organization supported constructability.
- b) Organizations with a large volume of work tend to have a formal constructability program.

Recommendations

- a) General contractors should practice constructability and educate their clients in its implementation, thereby developing in them an awareness of the various benefits that could result from constructability implementation.
- b) General Contractors, owners and designers should form an association for Constructability. This will enable them to be fully aware of constructability and its related benefits. This association will give them a chance to share banks of related information and best practices, thereby benefiting construction projects as a whole. Also, it will help them create special clauses in contracts in order to improve teamwork and integration among participants.
- c) As part of promoting constructability programs, owners should insist on involving the General Contractors in the conceptual phase and design-procurement phase. Design –build is one way to deliver a project that can bring many benefits based on the successful integration of design and construction.
- d) Designers and General contractors should practice insertion of concern for accessibility of personnel, materials and equipment in the design phase of any project. This could result in huge saving for the contractors.
- e) Constructability should be implemented in all projects, regardless of their size or complexity.
- f) Constructability should be included as another specialty during the pre-construction phase of a project
- g) General Building and Heavy construction contractors should practice successful implementation of constructability concepts in their projects. The same benefit obtained by implementing constructability in Industrial projects can be obtained in General Building and Heavy constructors too.

- h) General Contractors should put more effort into making use of the lesson learned. This can be made possible by creating a database of the various facts and figures witnessed during all construction projects and should be used for the benefit of future projects.
- i) Construction engineering and construction management colleges need to add constructability to their curriculum. It will have a great effect in applying constructability in the future.

Areas for further studies

The researcher feels that there should be more studies to identify various barriers to constructability, and to plan tactics techniques to overcome or mitigate each individual barrier.

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