

# Factors Affecting Design Documentation Quality in Construction Industry

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## Abstract

This thesis discusses the main factors affecting Design and Documentation Quality in Construction Industry in Saudi Arabia. A survey of 21 contractors, 19 consultants and 14 owners from the Eastern Province was performed. The survey included 39 different factors affecting Design and Documentation Quality and their level of importance. The severity of those factors were measured by the level of importance and were ranked according to the importance index for consultants, contractors, owners and a combination of all respondents. It was concluded that, last minute changes by client, Insufficient overall design time, Unstable client's requirements, Waiting for client decision and that Consultants tend to copy and modify from their previous work to minimize time and cost, were the most important factors. Finally, some recommendations were made in order to improve the design and documentation quality in the construction industry.

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## Introduction

To allow construction contractors to transform the design concepts and ideas into physical product, the designers provide drawings the specifications. The quality of these design documents greatly affects the efficiency of the construction phase. Over the past few years, a decline in the project documentation quality has caused delays, disruption and increased costs to all parties in the construction process.

The design and documentation is considered deficient if it is incomplete, conflicting, or has erroneous information. To determine the level of documentation quality achieved, a number of attributes should be considered such as time, accuracy, completeness, coordination and conformance. Any improvement in design and documentation quality would definitely lead to corresponding improvements in the construction process. The quality of the

design and documentation process can be defined as the ability to provide the contractor with all the information needed to enable construction to be carried out as required efficiently and without hindrance.

The aim of this study is to assist all construction parties to plan effectively before starting a project during the design phase in order to minimize problems and eliminate extra costs needed to complete the defective design and documentation. The results of this study benefit owners, designers, contractors, consultants and public agencies. The awareness of the value of quality design and documentation would ensure that sufficient time and fees are available to allow designers to provide the needed level of services. In addition, more projects will be completed on time, within budget, and with less rework and disputes.

This study is starts with a literature review of the topic. The questionnaire design is then presented including sample size and the selection of experts. After that, findings and

results are discussed, followed by conclusion remarks and recommendations. This study is based on questionnaire to experts with more than 10 years experience and projects greater than SR 10 million. All building projects are located in the Eastern Province of Saudi Arabia. The focus is on traditional procurement projects in the Public sector.

### Objective of the study

- To identify main factors affecting design and documentation quality in the Saudi Arabia construction industry
- To investigate the nature and extent of the impacts of design and documentation deficiencies on project cost and time
- To calculate the percentage agreement between different project participants on the ranking of the factors

### Literature review

Many articles and studies have been conducted on design quality and documentation quality in construction process. These articles deal with three aspects: time, cost, and management. Quality is defined as meeting the requirements of the owner, design professional, and constructor as specified by contract, while complying with laws, codes, standards, regulatory rules, and other matters of public policy". Therefore, "quality design" is the design that is effective and compatible with the best possible economy and safety. A related term to "design quality" is "deviation". Deviation is a departure from established requirements and may be classified as an imperfection, nonconformance, or defect based on its severity. In a previous study, conducted by

Tilley and McFallan (2000), a number of design and documentation attributes are identified as having a direct impact on the quality of design and documentation achieved. It was found that designers believed the most important attributes of design quality were:

- Functionality: effectively serves the purpose for which it was intended
- Relevancy: ensuring project documents requirements are met
- Competence and Experience: of the person managing design process

The attributes of documentation quality were:

- Accuracy: drawings and other documents are free of errors, conflicts and inconsistencies
- Clarity: drawings and other documents are legible, easily read and interpreted
- Final checking: drawings and other documents are properly checked prior to release to the contractor

Of major concern to the construction industry, is the extent to which poor coordination and design is contributing to the problem of rework and rectification. In a previous study, done by Love (1997), it was noticed that a large proportion of rework and nonconformance costs are due to deficiencies in design and documentation and in the transfer of information during the design process. The reduction in the level of design fees together with the limited time made available to carry out the work have caused problems in the quality of design documents. In addition, these problems have negatively affected the efficiency of the construction process.

Most design deficiencies can be identified as one of the following three types:

- Contract document conflict
- Interdisciplinary coordination errors
- Technical compliance discrepancies

In a study into the causes of quality deviations in design and construction, conducted by Burati (1992), it was found that an average of 78% of the total number of deviations were design related and these deviations made up 79% of the total deviation costs. Another study, conducted by Morgan (1986), identified the three major causes of the contract modifications as being: (1) Design deficiencies; (2) User requested changes; and (3) Unknown site conditions. It was found that 56% of all contract modifications are needed to correct design deficiencies. A study, done by Aldubiasi (2000), stated that the owner is the main source of changes in large building projects. Change of plans by the owner is the main cause of changes. There three possible explanations to this. First, the owner was not involved in the design development. Second, the owner did not understand or visualize the design. Third, it is merely a change of mind while not appreciating the negative impacts of change. Most design deficiencies affect the owner or end-user by impacting one or more of the following items during the construction phase and/or the operational life of the facility:

- Owner satisfaction
- Schedule and completion
- Construction and operational costs
- User safety and health
- User morale
- Litigation and liability

Many approaches have been followed to measure the design quality. One approach is to calculate the project cost after construction. Another approach is to measure issues directly related to quality as meeting the requirements of the owner, the design professional, the constructor, and the regulatory agencies. A third approach, introduced by Davis (1989), is to develop a system to evaluate the quality management

activities in both the design and construction phases, and then try to determine the cost of poor quality in design and construction. Any improvements in design and documentation quality can lead to corresponding improvements in the efficiency of the overall construction process. Paying attention to the following issues, suggested by McGeorge (1989), will improve the overall design and documentation quality:

- The procedure for selecting a consultant or designer, and the basis for payment of fees
- The method of selection of a contractor has shortcomings
- There need to be communication with the contractor at an early stage of the design
- The lack of formal techniques and procedures for managing the design process

The factors affecting design and documentation quality have been identified by various researches in the construction industry. One study, performed by Tilley and McFallan (2000) in Australia, lists 23 factors used in a questionnaire survey. They concluded that the factors that designers consider most frequently occurring were: unrealistic expectations by clients in terms of fees, service and timing; low fee structures; and insufficient profits to enable the training of staff. Another study, conducted by Andy and Minato (2003) in Japan, lists 26 factors used in a questionnaire survey. They concluded that the designers believe that the most important factors affecting design and documentation quality are insufficient design time; client's tendency to shop around for design fee; and a low design fee.

First of all, an extensive literature review was done in order to identify the important factors causing problems in the design and documentation quality from the point of view of researchers and project participants from Australian, Japan, Hon Kong, USA, and Kuwait. Then, a questionnaire is designed based on the literature review with thirty-nine (39) factors. This questionnaire is designed in order to evaluate the frequency of occurrence, severity, and importance of the identified causes. However, this research is targeted only to those projects participants (experts) belonging to three major construction group (Consultant/design, Contractor, and Owner) who had more than (10) years experience in the Saudi Arabia construction industry in the Eastern Province.

**Questionnaire Design**

After reviewing the literature, the most influential factors affecting design and documentation quality were determined and presented in an initial questionnaire with a (43) factors. However, a pilot study was then done and a six construction experts were interviewed in order to enhance the questionnaire. As a result of this pilot study, the initial (43) factors were reduced to Thirty-nine (39) factors. Final questionnaire was developed for interviewed of selected Grade-1 and Grade-2 Contractor, eminent Consultant/designer, and Owner/Owner representative in the Eastern Province.

**Data Analysis Approach**

*A. Sample Size*

Four (4) restrictions were imposed on the selection process of respondents which are:

- 1- Restricted to large project (10 millions SR or more)

- 2- Restricted to Contractor with Grade-2 or better as classified by the chamber of commerce.
- 3- Restricted to building projects.
- 4- Restricted to Eastern Province of Saudi Arabia.

According to the chamber of commerce list, (72) consultants and (131) contractors are compatible with the above restrictions.

In order to get the required sample size of both consultants and contractors, the statistical principles of exploratory research is employed. This principles state that the sample size is calculated by the following (2) equations:

$$n_0 = (p*q) / V^2 \dots\dots\dots (Eq 3.1)$$

$$n = n_0 / [ 1+ (n_0/N)] \dots\dots (Eq 3.2)$$

Where:

$n_0$ : First estimate of sample size.

$p$ : The proportion of the characteristics being measured in the target population.

$q$ : Complement of  $p$  or  $1-p$ .

$V$ : The maximum standard error allowed.

$N$ : The population size.

$n$ : the sample size

In this case  $N$  are 72 and 131 for consultants and contractors respectively. To maximize  $n$ ,  $p$  is set to 0.5 and to account for more error in qualitative answers, maximum standard error  $V$  is set to 10% or 0.1. Substitutes these values in the above equations gives the minimum sample size for consultants is 19 and for contractor is 21. For the Owner, there are 88 owners dealing with large projects. Using the same formula, the minimum sample size of owner is found to be 13.

*B. Important Index*

The questionnaire is designed to have a (39) factors and for each factors the respondents

have five options. These options are: "always", "often", "occasionally", "rarely", and "not at all". The scale (interval) value assigned for each response appearing in the questionnaire as follows:

Always= 100%; often= 75%; occasionally= 50%; rarely= 25% and Not at all=0%.

The Important Index (II), in this case, will be calculated as follows:

$$II = 100 X_1 + 75 X_2 + 50 X_3 + 25 X_4 + 0 X_5 / (x_1+x_2+x_3+x_4+x_5) \dots\dots (Eq3.3)$$

### ***Findings and Results***

#### ***A. General Information and Industry Characteristics***

In this research, the participated in the questionnaire are (21) contractors, (19) consultants engineers, and (14) owner representatives. This gives the research a total of 54 respondents.

Almost 80% of the total is over 15 years of experience which clearly shows that the respondents are very experienced in KSA. Also, 57% of the (21) contractors are classified as Grade-1 and 43% are Geade-2. Finally, most of the consultants companies (94%) have less than 400 employees (medium size) whereas 48% of the contractors have grater than 400 employees (Large size). The owner range from small size (43%) to large size (36%)

#### ***B. Statistical Techniques***

The results of the statistical analysis of the data given by the respondents which include: the weighted mean, standard deviation, standard error of mean, and coefficient of variation are all presented in Table 1.

#### ***C. Ranking by the Important Index***

By applying the important index formula, the ranking of the main factors affecting design and documentation quality is found to be as in Table 2.

#### ***D. The Spearmen Correlation***

The spearmen correlation used to find and compare how well any two parties agree while ignoring the third party completely. Spearmen correlation can be found as follows:

$$r_s = 1 - 6 \sum d^2 / (n^3 - n)$$

Where:

$r_s$  = the spearmen correlation

$d$  = the difference between ranking for each group

$n$  = number of factors (39).

From this equation, the following calculations are obtained:

$$R_s (\text{cont. - consl.}) = 1 - [ 6 * 5508 / (39^3 - 39) ] = 0.443 = 44.3\%$$

$$R_s (\text{owner - cont.}) = 1 - [ 6 * 5736 / (39^3 - 39) ] = 0.419 = 41.9\%$$

$$R_s (\text{owner - consl.}) = 1 - [ 6 * 9534 / (39^3 - 39) ] = 0.035 = 3.50\%$$

These results showed that contractors and consultants have moderate agreement on ranking of the factors and the effects of these factors. This is contrary to the common perception that consultants and contractors would not agree. On the other hand, the results showed that consultants and owner have a little agreement on the ranking of the factors. It is also noticed that the normally adversarial relation between consultants and owner has affected their evaluation of the problem. Each part is blaming the other.

**Table 1**  
**Statistical Results for Combined Responses**

Factors	Min.	Max.	Mean	Standard dev.	Coef. of variation
1. Insufficient overall design time.	1	5	3.49	1.06	0.3
2. Client tends to "shop around" more for design service.	1	5	3.20	1.09	0.34
3. Low fee structure for designer.	1	5	3.34	1.31	0.39
4. Inadequate or insufficient project estimates or budgets.	1	5	3.36	1.21	0.36
5. Unstable clients requirements.	1	5	3.49	1.18	0.34
6. Inadequate experience of foreigner Engineers about the culture, nature of the people and environment of the kingdom.	1	5	2.66	1.09	0.41
7. Inadequate or moving client brief.	1	5	2.93	0.93	0.32
8. Waiting for client decision.	1	5	3.53	1.20	0.34
9. Saudization, using Saudi staff as required by the country regulation.	1	5	2.85	1.33	0.47
10. Difficulty in finding good staff (e.g. Spec. writers and construction detailers).	1	5	2.83	1.12	0.40
11. Unrealistic expectations by client-In relation to the fees, services and timings, etc.	1	5	3.12	1.10	0.34
12. Last minute changes by client.	1	5	3.53	1.20	0.34
13. Client requesting design changes, without being prepared to pay for them.	1	5	3.28	1.39	0.42
14. No Saudi building code is available or used.	1	5	3.00	1.43	0.48
15. Uncertainly of design brief at bid stage.	1	5	2.79	1.21	0.44
16. Request for unpaid design submission.	1	5	3.06	1.21	0.39
17. Additional work necessary to meet "Quality Assurance" (QA) requirements.	1	5	3.19	1.30	0.41
18. Insufficient profits being generated to enable the training of the staff.	1	5	3.34	1.22	0.37
19. Use of junior staff to decrees the overhead.	1	5	3.13	1.23	0.39
20. Lack of understanding of clients requirements.	1	5	2.79	1.12	0.40
21. Proliferation of ' backyard' operations prepared to work for minimal fees.	1	5	2.93	1.23	0.40
22. No one person or office being responsible for design coordination.	1	5	3.17	1.12	0.47
23. Builder-employed managers instigating design changes.	1	5	2.87	1.33	0.46
24. Fellow consultants not clearly defining what is required.	1	5	2.89	1.04	0.36

25. Difficulty in convincing clients of the value of comprehensive & clear documentation.	1	5	3.26	1.24	0.38
26. Improper implementation of CAD.	1	5	2.27	1.12	0.49
27. Fellow consultants having reduced service for overall project team requirements.	1	5	2.87	1.12	0.42
28. Architectural consultants being engaged on a ' design only' basis.	1	5	3.40	1.12	0.36
29. Obtain approval or permission from government agencies.	1	5	3.28	1.33	0.40
30. Lack of understanding by the client of the value of bill of quantities.	1	5	3.26	1.28	0.39
31. Difficulty in interfacing between varying contractual relationship.	1	5	3.17	1.16	0.37
32. Using unrealistic work time-schedule ( Unachievable ).	1	5	3.13	1.23	0.39
33. Availability of the liquidity and budgeting needed for the projects.	1	5	2.73	1.42	0.52
34. Consultants tends to copy & modify from their previous work to minimize time and cost.	1	5	3.47	1.33	0.38
35. Professional relationships and trust have come under threat.	1	5	3.23	1.15	0.35
36. Repetitive design reviews by the owner.	1	5	3.13	1.39	0.44
37. Using of part-time (unqualified) staff from outside the organization to reduce cost.	1	5	2.66	1.23	0.50
38. Increasing in the level of competition inside & outside the kingdom.	1	5	3.30	1.23	0.37
39. Increasing difficulty in getting paid on time by the clients.	1	5	3.40	1.26	0.37

**Table 2**  
**Combined Ranking of the Factors**

Factors	Importance Index	Ranking
12. Last minute changes by client.	63.30	1
1. Insufficient overall design time.	62.23	2
5. Unstable client's requirements.	62.20	3
8. Waiting for client decision.	61.76	4
34. Consultants tends to copy & modify from their previous work to minimize time and cost.	61.70	5
28. Architectural consultants being engaged on a ' design only' basis.	60.18	6
39. Increasing difficulty in getting paid on time by the clients.	60.10	7
4. Inadequate or insufficient project estimates or budgets.	59.04	8

3. Low fee structure for designer.	58.51	9
18. Insufficient profits being generated to enable the training of the staff.	58.40	10
36. Repetitive design reviews by the owner.	58.15	11
38. Increasing in the level of competition inside & outside the kingdom.	57.45	12
13. Client requesting design changes, without being prepared to pay for them.	57.07	13
29. Obtain approval or permission from government agencies.	57.03	14
25. Difficulty in convincing clients of the value of comprehensive & clear documentation.	56.38	15
30. Lack of understanding by the client of the value of bill of quantities.	56.35	16
35. Professional relationships and trust have come under threat.	55.85	17
11. Unrealistic expectations by client-In relation to the fees, services and timings, etc.	55.32	18
2. Client tends to "shop around" more for design service.	54.89	19
17. Additional work necessary to meet "Quality Assurance" (QA) requirements.	54.79	20
31. Difficulty in interfacing between varying contractual relationships.	54.35	21
22. No one person or office being responsible for design coordination.	54.26	22
19. Use of junior staff to decrease the overhead.	53.19	23
32. Using unrealistic work time-schedule ( Unachievable ).	53.11	24
16. Request for unpaid design submission.	51.60	25
14. No Saudi building code is available or used	50.00	26
7. Inadequate or moving client brief.	48.37	27
21. Proliferation of ' backyard' operations prepared to work for minimal fees.	48.30	28
24. Fellow consultants not clearly defining what is required	47.28	29
23. Builder-employed managers instigating design changes	46.81	30
27. Fellow consultants having reduced service for overall project team requirements.	46.70	31
9. Saudization, using Saudi staff as required by the country regulation	46.20	32
10. Difficulty in finding good staff (e.g. Spec. writers and construction detailers).	45.65	33
15. Uncertainty of design brief at bid stage.	44.68	34
20. Lack of understanding of clients requirements.	44.60	35
33. Availability of the liquidity and budgeting needed for the projects.	43.33	36
6. Inadequate experience of foreigner Engineers about the culture, nature of the people and environment of the kingdom.	41.49	37
37. Using of part-time (unqualified) staff from outside the organization to reduce cost.	41.45	38
26. Improper implementation of CAD.	31.67	39

## Summary and Recommendations

The results of the survey clearly show a need for owners and developers to allocate adequate funds and time to the planning and design phases of a project, in order to maximize construction process efficiency and minimize overall project costs and duration. By reducing design fees to minimize costs, owners and developers were by their own actions, contributing to the problems, which lead to inefficiencies in the construction process and increase in overall project costs, time and causing disputes.

Improvements in construction process efficiency will result from creating an awareness of the value of quality design and documentation and the implementation of selection criteria that includes consideration of the designer's skill and experience. Once developers fully understand the important value of the design and documentation process quality, they would then ensure that sufficient time and fees are available to allow designers to provide the level of service needed to carry out the design function completely and precisely. The benefits would be more projects being completed on time, within budget and with a reduced legal action due to contractual disputes. In addition, it will reduce project duration and efforts.

More reasonable fee levels would also enable designers to restore staff training programs – to develop a higher standard of designer – and encourage innovation and creativity within design and documentation quality. A predetermined set of minimum standards for any design consultancy would ensure that design and documentation coordination with other design disciplines is a mandatory component of the design

service. Also required to overcome a major cause of design deficiency as determined by all professional in construction industry, is the lack of coordination in the design and documentation phases.

Owners need to make the consultant selection process more transparent – clearly setting out selection requirements, minimum service requirements and possibly minimum fee levels. Also, design consultants need to be selected by non-price criteria based on prequalification selection. This would ensure that the most appropriate consultants, those with the appropriate skills, experience, and offering the required levels of service are selected for the project, not those with the lowest price.

Owners need to ensure that project briefs are clearly stated before bidding – and without uncertainty and ambiguity – what their project requirements are, thereby removing the risk from the designers and contractors that occur when there is inadequate clarity from the client as to their requirements. Where the owner is unsure of his requirements and objectives, then this should be stated to let all those tendering on the project know what the situation is.

Consultants (designers) need to consider properly the role and proper contribution of the owners and contractors when preparing project documentation, to ensure that it meets their requirements and objective in relation to their contract obligations. In addition, owner and contractor proper involvement in the early stage of the design proves will be effective in improving overall design documentation quality. This will give consultant the chance and enough time to correct and complete any errors, omissions or ambiguities during the design time, before construction phase starts.

Design consultants have to be financially accountable for the overall design quality and the consequences caused by any lack of quality in design and documentation process. However, they should also share in the losses that their negligence or limitation might have caused during construction phase.

According to overall construction experts' responses, there is a strong association between the quality of design documentation, and construction process efficiency. The results of the survey clearly show a need for owners and developers to allocate adequate funds and time to the planning and design phases of a project in addition to stable decisions and specific requirements, in order to maximize construction process efficiency and minimize overall project costs and time (duration).