Impact of the Shop Drawings on Accuracy of Estimated Cost of Construction Projects

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ABSTRACT

Meeting the project's estimated cost is a main target in construction project especially in mega projects. The objective of this paper is assessing the impact of shop drawings in meeting project cost target. A comprehensive literature reviews as well as survey for industry expert's opinions to identify that impact were carried out. About 30 factors that may effects on accuracy of the cost estimation were identified through a comprehensive literature review and were validated via structured interviews. The main finding in this research was that the shop drawings have a real impact on the cost estimation process. The results analysis based on the Pareto role showed that 8 factors out of 30 factors had the most impact factors. These factors include the following: improper planning and unavailability of cost indices average; poor design/delay in providing design; size and location of the project with inaccurate evaluation of the project time/duration. In addition to incomplete drawings/detailed design at time of tender; finishing in clear of detailed shop drawings in an early stage if it possible; design change, inadequate studying for tender documents before going out to tender.The main finding is that it is important to consider the shop drawings as a new significant factor during the cost estimation process in the early stage of the project.

Index Terms- Cost Estimation; Shop Drawings; Construction Projects; Accuracy; Importance Index.

I. INTRODUCTION

For any construction project, it is important to know that there are specific requirements that are necessary to be available, so that it can be said this project was successfully finished. One of the most important of the aforementioned requirements is the success of the cost estimation process, especially in the projects of big budget. This research is an attempt to assess the impact of the shop drawings in project cost variance during or by its completion. Therefore, it is important to know if there is an impact of the shop drawings on cost estimate or not, to be considered as factor or value in project cost estimate. In which the gap in the value that the shop drawings can cause between the initial cost and the final cost of the project may be decreased, in case it was found that it has a real effect on the estimated cost. The next step is to define several expressions, then mention the factors that may causes effects on accuracy of the cost estimation and may cause cost overrun according to the previous researches in this point.

Asal (2014), defined the cost estimation process as "the means of forecasting and foreseeing the future costs of a construction project before it actually exists". However, the final project's cost will not be known until the construction is finished and the facility is operated. Another definition Samphaongoen (2010), contended that cost estimating is an essential task for budgeting and bid preparation for any construction project.

Shop Drawings according to Taylor (1996), states the most famous definition for the shop drawing according to the American Institute of Architects' (AIA), Document M101 State that: "Shop Drawings are drawings, diagrams, schedules and other data specially prepared for the work by the Contractor, Subcontractor, Sub-subcontractor manufacturer, supplier, or distributor, which illustrate how specific portions of the work shall be fabricated and/or installed."
Varma (2008), defined and put sheds light on the importance of the Shop Drawings technically in the construction field, also he mentioned that Shop drawings can illustrate design concepts shown on the architect/engineer's contract drawings, and convert the design concepts into actual in the construction, and any mistakes in this drawings may cause failure later for the building.

II. LITERATURE REVIEW

Many factors may effect on the project life cycle cost and especially on the cost estimation process. During several journal researches, it will mention factors that may effect on the accuracy of the cost estimation and cause cost overrun during the project. Asal (2014) stressed that cost estimating is an assessment of expected cost of any construction projects. Hence, some factors should be added to base estimate to increase the level of confidence. Twelve factors may cause effects on the accuracy of the cost estimation process namely: economic instability, quality of firms project planning and management, relevant experience of estimating team, availability of management and finance plans, ability of estimating team, labor and equipment required, estimating method, project location, periodical payments accuracy of bidding documents provided by client, competent and leadership of project, and manager and impact of project schedule (expected delay).

Alumbugu and et al. (2014), stated that 66 questionnaires were administered with 35 to consultants, 15 to contractors and 16 to clients. From this study, it was found that statistically significant relationship existed between clients, consultants, and contractors on the essential factors affecting accuracy of pre-tender cost estimate. It was concluded that the most important factors that affected accuracy of pre-tender cost estimate in Kaduna, Nigeria were experience and skill level of the consultants, project teams experience on the construction type, clear and detail drawings and specification, completeness of cost information accuracy and reliability of cost information.

Enshassi and et al. (2013) concluded that:

1) materials (prices/availability/supply/quality/imports)
2) closure and blockade of borders
3) project team's experience in the construction type
4) the experience and skill level of consultants
5) clear and detailed drawings and specifications

are the top five factors from analyzing 64 factors considered in the questionnaire, that affected the accuracy of pre-tender cost estimates from the perspective of clint and consultants in the Gaza strip. Mahamid and et al. (2014), concluded that there is a number of difficulties arising when conducting cost estimation during the early phase. Leading to identifying the main factors affecting accuracy of pretender cost estimate in building construction projects in Saudi Arabia from owner's perspective. The factors are level of competitors in the tendering, material price changes, communications with suppliers, communications with client, and estimating method used. Trost and Oberlender (2003), identified and grouped 45 factors that contribute to the accuracy of early stage estimates into 11 orthogonal factors. Of these 11 factors, the five most important are process design, team experience and cost information, time allowed to prepare estimates, site requirements and bidding and labor climate.

According to Subramani et al. (2014), the factors that may cause cost overrun in construction projects in India are: slow decision making, poor schedule management, increase in materials / machines prices, poor design / delaying in providing design, rework due to wrong work, problem in land acquisition, wrong estimation / estimation method and long period between design and time of bidding / tendering. In addition, this paper Bekr (2015), aimed to identify the most important factors causes cost overrun in Jordan. These factors were schedule delay, design change, change, and additional work at owner's request, in complete drawings / detailed design at time of tender and other factors.

III. RESEARCH METHODOLOGY

This research is quantitative relying on a survey questionnaire to collect primary data. The objective of this questionnaire is to collect, then analysis and evaluate views, and opinions on the impact of shop drawings on the cost estimate of construction projects. whether positive or negative or no effect. This will be during several analysis programs. Taking into consideration during the study the factors that may effect on the accuracy of calculating the cost in general for construction projects and cause cost overrun.

Questionnaire design:

The questionnaire is written in Arabic and English languages. It consists general questions related to the response, then questions related to the point of research, and finally table contain 30 factors that may cause effects on cost estimation process, and it has divided into four sub-main factors as follows:

1- Factors that relate to the project.
2- Factors that relate to estimating process.
3- General factors and the other related to design.
4- Factors related to bidding/tender situation.

Almost of these factors used in this questionnaire were identified through literature review. Some of them were taken as it is and the others were modified. While other factors were suggested during interviews with experts, who were related to the subject of the research. The following Table 1 and show the sources of each factor of them.

Table 1: The sources of the factors that may affect the accuracy of the cost estimation and cause cost over run

No	Factors	Sources
1	Size and location of the project	Asal (2014)
2	Type of the project (residential, commercial…)	Mahamid, et al.(2014)
3	General site condition (topography, access...)	Mahamid, et al.(2014)
4	In-accurate evaluation of the project time/duration	Olawale and Sun (2010)
5	The technique and method of implementation of the project	Suggested by Experts
6	Poor communications & management between parties of project	Enshassi, et al.(2013)
7	Efficient and leadership of project manager	Asal (2014)
8	Estimated time for completion of the cost estimation process	Trost and Oberlender(2003)
9	Estimating method used	Mahamid, et al.(2014)
10	Relevant experience of estimating team	Asal (2014)
11	Improper planning & Un-Availability of cost indexes average	Alumbugu, et al.(2014)
12	Ability of estimating team &its experience in management	Asal (2014)
13	Finishing & accuracy of detailed drawings(Shop drawings) in early stage if it possible	Suggested by Experts
14	in complete drawings / detailed design at time of tender	Bekr GA (2015)
15	Accuracy of bidding documents & specification providing by client	Asal (2014)
16	Experiences of engineers that responsible for work/revision of shop drawings & sample material	Suggested by Experts
17	Weather effect	Chimwaso (2001)
18	Unsupportive government policies	Nida (2008)
19	Shortage in trained labors & materials	Asal (2014)
20	Increase or change in equipment & materials prices	Enshassi, et al.(2013)
21	Economic instability	Asal (2014)
22	Manager & Poor schedule management	Asal (2014)
23	Poor design / delay in providing design	Subramani, et al. (2014)
24	Design change	Bekr GA (2015)
25	Type of contract	Asal (2014)
26	Size of contract	Asal (2014)
27	Quality and accuracy of contract's items/specifications	Suggested by Experts
28	Level of competitors in the tendering	Mahamid, et al.(2014)
29	long period between design and time of bidding / tendering	Subramani, et al. (2014)
30	Inadequate studying for tender documents before going out to tender	Ramabodu and Verster (2010)

Size and type of study sample:

The sample size of the study was 50 respondents, as the number of projects and engineers in Egypt and the Gulf States is very big, in this case infinite population formula is used for determining of the sample size**,** as follow

$$n = \left[\frac{Z^{\propto}/_{2} * \sigma}{E}\right]^2$$ Asal, (2014).

Where;

$Z^{\propto}/_{2}$ is known as the critical value

δ is the population standard deviation.

n is the sample size.
E is the margin of error.
At a 95% degree confidence and δ = 6.95, $Z\propto_{/2}$= 1.96 and margin of error =2

$$n = \left(\frac{1.96*6.95}{2}\right)^2 = 46.39$$

The statistical analysis of the data collected was analyzed using the Statistical Product and Service Solutions – SPSS, an IBM software Hejase, and Hejase, (2013), as well as Microsoft Excel program. Each respondent had the choice from (1to5) five-level Likart scale, in which: [1- very minor effect, and 5 very major effect].
The questionnaire was sent to experts who work for either governmental or private contractors and occupy one of the following jobs: 50% from this study worked as technical office engineer (Shop drawing, or site engineer), cost estimator 12%, planner, and cost control about 22%, and finally project manager 16%.
As for the respondents' years of experience, 34% of them have more than 11 years of experience (divides as follows: 20% from 11 to 15and 14% with more than 15 years of experiences), 34% have 5 to 10 years of experience and about 32% have less/equal 5 years of experience, 80% from these questionnaires were collected from Egypt and 20% from the Gulf countries.

IV. RESULTS ANALYSIS AND DISCUSSIONS

Analysis of the first part of the questionnaire:
Analysis of the questions of the surveyed engineers was as follows: the first question was "If Shop Drawings or related factors taken into consideration during the estimation process or not"**.** Results show that, 60% of the respondents said always, 28% said sometimes, and 12% never taken into consideration.
Then the second question analyzed was "the degree of importance to finish the shop drawings in early stage during the project" and the result was as follows, 42% agreed that it is very important to finish the shop drawings in early stage, 38% said it is important only, and finally 20% said not important.

Analysis of the second part of the questionnaire:
The Alpha Cronbach test should be carried out at first for any questionnaire, and before any analysis, as this test used to measure the internal consistency to determine whether all items within the instrument measure the same thing Enshassi, et al. (2013). In this research, the reliability statistics for the table of the questionnaire is more than 0.8, this mean that the alpha value is more than the acceptable range of (0.7-0.8) Loulwa Kharboutli, (2014). This indicates a high degree of internal consistency and consistency in respondents' responses, so it can rely on these results in the analysis.

The analysis for the coming table of the questionnaire depends on the calculation of the importance index for each factor, then a second analysis of the results follows using Pareto analysis chart.

Pareto analysis states that in very simple way "that in almost every case, 80% of the total problems incurred are caused by 20% of the problem causes". So it assumes that 20% of factors can have the most important effect Asal, (2014), about 80% from the problem.
So know it calculate the important index for each factor from this formula Enshassi, et al. (2013).

The importance index for each factor (Imp.I) = $\frac{\Sigma W}{AN} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N}$

Where:
W: is the summation of the response of the participants for each variable (factor) ranges from (1to5); n_1= the number of respondents for not important; n_2= the number of respondents for of little importance; n_3= the number of respondents for somewhat important; n_4= the number of respondents for important; and n_5= the number of respondents for very important.
N: is the total number of the participants (in this questionnaire=50)
A: is constant the Interval of 5 points of Likert scale

By calculation, the importance indices for each set of sub factors are depicted in Table 2, that represent the factors that may effect on accuracy of cost estimation process and cause cost overrun during the project, it can be decided that some factors are heavily considered to have high impact. According to Pareto analysis, there are about six factors that represented the percentage 20% from the all sub factors (30 factors collected in the questionnaire); on other hand, there are factors that have low impact on accuracy of cost estimation process like Weather effect, Unsupportive government policies, Level of competitors in the tendering and other factors as seen Figure 1.

Table 2: Distribution of importance indices for each factor

Factors that may effect on the accuracy of the cost estimation process			
No	**Factors Related to the Project**	**Mean**	**Imp. Index**
1	Size and location of the project	**4.431**	**0.8862**
2	Type of the project (residential, commercial…)	**4.137**	**0.8274**
3	General site condition (topography, access...)	**3.759**	**0.7518**
4	In-accurate evaluation of the project time/duration	**4.368**	**0.8736**
5	The technique and method of implementation of the project	**4.242**	**0.8484**
6	Poor communications & management between parties of project	**3.864**	**0.7728**
7	Efficient and leadership of project manager	**4.158**	**0.8316**
	Factors Related to the Cost Estimation Process		
8	Estimated time for completion of the cost estimation process	**3.927**	**0.7854**
9	Estimating method used	**3.864**	**0.7728**
10	Relevant experience of estimating team	**4.242**	**0.8484**
11	Improper planning & Un-Availability of cost indexes average	**4.473**	**0.8946**
12	Ability of estimating team &its experience in management	**3.906**	**0.7812**
13	Finishing & accuracy of detailed drawings(Shop drawings) in early stage if it possible	**4.347**	**0.8694**
14	in complete drawings / detailed design at time of tender	**4.368**	**0.8736**
15	Accuracy of bidding documents & specification providing by client	**4.053**	**0.8106**
16	Experiences of engineers that responsible for work/revision of shop drawings & sample material	**4.179**	**0.8358**
	General Factors & Other Related to Design		
17	Weather effect	**2.583**	**0.5166**
18	Unsupportive government policies	**3.003**	**0.6006**
19	Shortage in trained labors & materials	**3.780**	**0.756**
20	Increase or change in equipment & materials prices	**3.780**	**0.756**
21	Economic instability	**3.948**	**0.7896**
22	Manager & Poor schedule management	**4.242**	**0.8484**
23	Poor design / delay in providing design	**4.452**	**0.8904**
24	Design change	**4.284**	**0.8568**
	Factors Related to Contracts and Tender situation		
25	Type of contract	**3.759**	**0.7518**
26	Size of contract	**3.549**	**0.7098**
27	Quality and accuracy of contract's items/specifications	**3.759**	**0.7518**
28	Level of competitors in the tendering	**3.318**	**0.6636**
29	long period between design and time of bidding / tendering	**3.675**	**0.735**
30	Inadequate studying for tender documents before going out to tender	**4.263**	**0.8526**

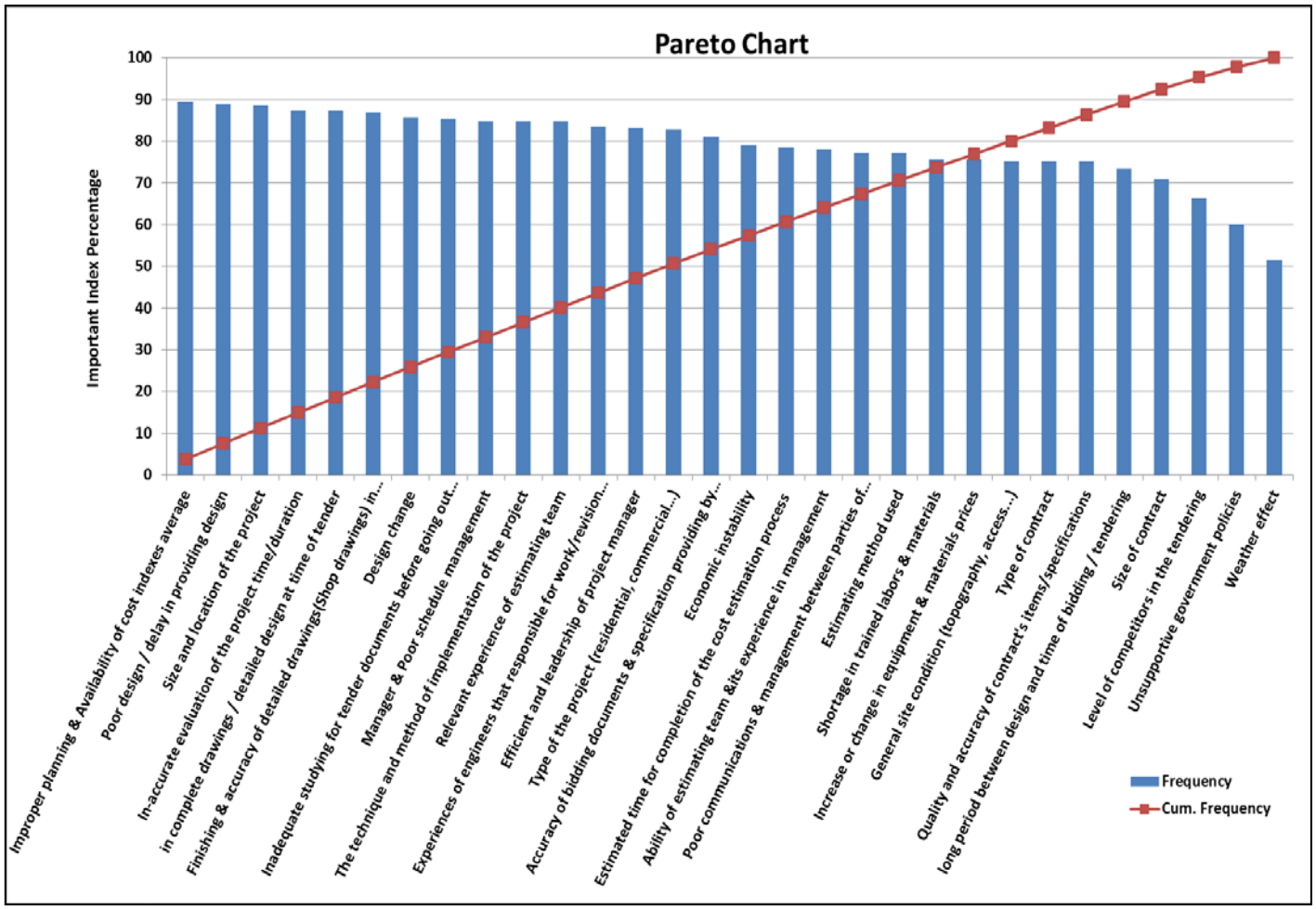

Figure 1: Pareto analysis chart to determine the most important factors affecting on accuracy of the cost estimation

Figure 1 shows the ranking according to the importance, and the relationship between the factors that may effect on the accuracy of the cost estimation and their important index percentage. Eight factors are selected for more accurate "factors with importance index higher than or equal 85%" Asal (2014), as will see in Table 3, the most important factors that may effect on the accuracy of the cost estimation value.

Table 3: Factors that have severity greater than or equal to (0.85)

No	The Most Important Factors	Importance Index
1	Improper planning & Un-Availability of cost indexes average	**0.8946**
2	Poor design / delay in providing design	**0.8904**
3	Size and location of the project	**0.8862**
4	In-accurate evaluation of the project time/duration	**0.8736**
5	in complete drawings / detailed design at time of tender	**0.8694**
6	Finishing in clear of detailed drawings(Shop drawings) in early stage if it possible	**0.8694**
7	Design change	**0.8568**
8	Inadequate studying for tender documents before going out to tender	**0.8526**

Discussion:

According to the previous Table 3 and the first analysis, it was clear that the shop drawing is an essential factor during or before the cost estimation process, at least as a significant coefficient factor. As there are at least 4 factors from the 8 most important factors that related to the drawings in general and one of them is related to the shop drawings directly. This factors are included the

following [1- Poor design / delay in providing design, 2- in complete drawings / detailed design at time of tender, 3- Finishing in clear of detailed drawings(Shop drawings) in early stage if it possible, 4- Design change].
The other 4 factors are also so important to taken into consideration during any estimation process. According to the point of view of consultant even or/and contractor that determined these 8 factors as the most important factors from 30 factors may cause effect on the cost estimation and cause cost overrun during the project. The other 4 factors are related to the following: [1- Improper planning & Un-Availability of cost indexes average, 2- Size and location of the project, 3- In-accurate evaluation of the project time/duration, 4- Inadequate studying for tender documents before going out to tender].

V. CONCLUSION AND RECOMMENDATIONS

Finally, it is concluded from this study that, the majority of respondents who were willing to answer the questionnaire and from the interviews with experienced engineers in this field**, the following important points are stressed:**

- That the shop drawings have really an important impact on cost estimating value, especially for the construction projects of big budget, regardless if these are taken as they are or as a factor during estimating process.
- It is more preferable to finish the shop drawings in early stage during the project, especially if performed during the estimating process if it possible. Since the value of the drawing details in general, and shop drawings in particular has an effect on the general cost of the project and which increases in the final cost value, as compared by the initial estimated cost value of the project.
- The eight most significant factors affecting accuracy on cost estimation process are as follow: improper planning & unavailability of cost indexes average, poor design / delay in providing design, size and location of the project, inaccurate evaluation of the project time/duration, incomplete drawings / detailed design at time of tender, finishing in clear of detailed drawings (Shop drawings) in early stage if it possible, design change, inadequate studying for tender documents before going out to tender.
- Findings include that most of the aforementioned factors have a relation to the drawings, whatever these drawings are (design drawings, detail drawings or shop drawings). This assures the importance as well as the impact of such drawings on the cost in general and the cost estimation process for any construction project, in particular. This refers to the importance of the quality, accuracy, and clearness of the all design and drawings in general during the project.

Recommendations for Future Studies

According to the above findings, the following recommendations are necessary during any cost estimation process, to reach to accurate value that is too close to the actual final cost of the project. These recommendations are:

1. It is necessary for any estimator to take the actual shop drawings value or related factors into consideration during the cost estimation process for any construction project, to avoid or decrease any gap in the value between the initial estimating cost and the final cost of the project.
2. It is more preferable to finish the shop drawings in the early stage during the project if it possible, to control any increase in the final cost of the project.

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