

## Factors Affecting Change Orders In Public Construction Projects

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### Abstract

*This paper discusses change orders in public construction projects in Jordan. A host of factors affecting change orders in public projects were identified and classified according to Drewin's open conversion system. The most common factors were evaluated by using both the data collected through a survey conducted on construction projects' consultant engineers, contractors, and owners and interviews with senior professionals and managers in the field. Most correspondents agreed that factors related to the owner's internal environment, "Owner instructs modification to design," and "Owner instructs additional works" are the leading factors directly affecting change orders in public construction projects. Exogenous factors, "Safety rules and regulations are not followed within the contractor's organization", "Severe weather conditions on the job site" and "Changes in government regulations and laws" ranked lowest by all three parties.*

**Keywords:** Change orders; Public construction projects; Jordanian construction industry; Construction management.

### 1. Introduction

The Jordanian construction sector, which plays a major role in the economy, is facing change orders. Zawawi et al (2010) defined a change order as work that is added to or deleted from the original scope of work of a contract, which alters the original contract amount or completion date. Regardless of its causes, change order often resulted in disputes and dissatisfactions among the parties involved, project delay and difficult to manage due to additional costs. The impacts affect all players in construction projects. Many projects experience extensive delays due mainly to change orders and thereby, exceed initial time and cost estimates (Odeh and Battaineh, 2002), (Assaf S., & Al-Hejji S. 2006). The successful execution of construction projects as well as keeping them within estimated cost and prescribed schedules depend on a methodology that requires sound engineering judgment. The aim of this paper is to identify major factors leading to change orders in the Jordanian public construction projects.

Although there have been many studies about change orders in construction projects, no studies were found that directly tackle the issue of change orders in construction projects in Jordan. Therefore the study objectives are (a) to identify variables that may lead to issue change orders in the Jordanian construction industry; (b) to investigate the relative significance of these factors from consultant, contractor point of view; and (c) to formulate recommendations and solutions to minimize change orders leading to time and cost overruns and improve construction performance.

### 2. Literature Review

Hanna, et. al. (2002) defines change as any event that results in a modification of the original scope, execution time, or cost of work, and is inevitable on most construction projects due to the uniqueness of each project and the limited resources of time and money available for planning.

Change may occur on a project for a number of reasons, such as design errors, design changes, additions to the scope, or unknown conditions. Change order will lead to strong feelings of pessimism for all involved in construction projects (Abdel Rashid., et al. 2012). As the legal means for changing contracts, change orders are standard in the construction industry (Hinze 2001). Table 1 shows types and sources of change orders.

**Table 1: Types and sources of change orders\***

Type	Source
Change in scope	Owner has requested to design change
Unforeseen conditions	Site conditions differ from the expected, requested by contractor or professional
Professional errors and omissions	Requested by contractor or professional
Errors	Professional has incorrectly drawn the construction design plans and specifications.
Omissions	Professional has inadvertently omitted an item or element from the plans.

\*Source: (Hinze, 2001)

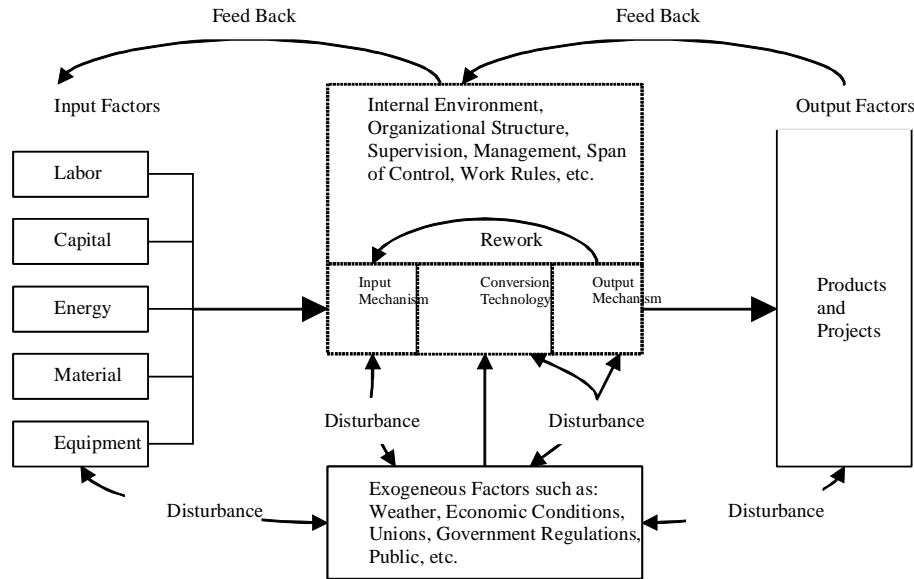
Changes can be classified by the procedure used to introduce them (CII publication 6-10(1990), Cox 1997). This classification is important in discussing the legal aspect of changes. Changes were classified into: (1) Formal or directed change; which is introduced by the owner or his agent under the mechanism of the change clause. (2) Constructive Change; where a change is resulting from a failure to do or not do on part of the owner or owner's agent. (3) Scope change; which is outside the scope of the contract and executed only after complete redefinition of the scope and re-negotiation of the contract. Several reasons can lead to change orders issuance: owner changes, consultant changes, contractor changes, and other changes. Acharya et al. (2006) developed a survey and identified six construction conflict – causing factors pertinent in Korean context. Change order was the third factor causing conflict in construction projects. Assaf and Al-Hejji (2006) carried out a field survey on time performance of different construction projects in Saudi Arabia. They identified 73 causes of delay in the 76 projects surveyed, but the most common cause of delay identified by the three parties completed the survey (clients, consultants, and contractors) was the “change order.” Alnuaimi et al, (2010) studied causes, effects, benefits, and remedies of change orders on public construction projects in Oman and found that the main causes of change orders are those which are related to the client followed by lack of national information and databases.

Their study also indicated that the contractor is benefiting the most from change orders followed by the consultant and then the client. Pourrostan et. al. (2011), found that contractor's financial difficulties and previous construction delays by other contractors working on different contracts were important factors responsible for change orders in construction projects. Moreover, Ijaola and Iyagba (2012) conduct a research that compared change order in construction project in Nigeria and Oman, vis-à-vis the causes, effect, benefits and remedies. “Client’s additional works and modification to design” were the most important causes of change order in both Nigeria and Oman. The most important effects of change order are “variations result in claims and disputes” in Nigeria while “delay in completion date of project and cost overruns” were the most important effects in Oman. In Jordan, no published research so far focused on the factors causing the change orders that are expected to lead to additional time delay or increase in material cost of the project, or both. Thus, this research is conducted to identify these factors and investigate the relative significance of these factors from consultant, contractor point of view.

### 3. Methodology

A questionnaire has been designed based on the Open Conversion System proposed by Drewin (1982). According to Drew in, the conversion process associated with construction is complex, influenced by technology and by many externalities such as government regulations, weather, unions, economic conditions, etc., and by various internal environment components. This research, hence synthesizes potential change orders causes identified in previously mentioned researches and the factors presented in the Drewin’s Open Conversion System (Figure 1). The factors that may affect change orders and those presented in Drewin’s open conversion system have been enumerated to arrive at a clearly structured questionnaire covering most of the major potential factors. A total of 30 potential performance factors were grouped into three major categories:

- Input Factors (IF): Labor (L), Materials (M) and Equipment (E)
- Internal Environment (IE): Contractor, Owner and Consultant
- Exogenous Factors (EF): Weather and Government Regulations.



**Fig.1:** Drewin's Open Conversion System [10]

Due to the dearth of real data relating to change orders in public construction, the researchers developed a survey questionnaire to assess the perceptions and opinions of the contractors, consultants, and owners about the relative importance of the change orders factors and to measure differences in the collective perspectives and any possible popular misconception or prejudice that clearly indicates agreement or disagreement between these parties. The questionnaire was distributed to a random sample of owners, consultants and contractors (hired by the owner) working in public construction projects in Jordan. Responses to the questionnaire were then collected and ranked according to their frequency.

The SPSS software have been used in analyses, employing a one-way ANOVA (used to compare two or more group means to check for significant differences between them), one sample test (T-test), and a post hoc test (or a Tukey test, a single-step multiple comparison statistical test used in conjunction with an ANOVA to find means that are significantly different from each other). These were performed on the means of the three groups' responses for each change orders factors to identify any significant differences among the respondents' perceptions. Discussion of the results occurred through personal interviews conducted to clarify the responses. The interviewees were experts from the Ministry of Housing and Public Works, the Ministry of Transportation, the Association of Construction Contractors, and many other private construction company employees with long experience. The scope of this research includes all construction industry sectors in Jordan, especially the building and government road widening sectors. Sampling was necessary because it would have been practically impossible to rank change orders factors according to all the elements of the population through a census due to the huge volume of this sector.

The population consists of all the consultants, contractors, and owners in the Municipality of Amman and in the other Jordanian municipalities that were actively involved in the public construction sector at the time of the study. The researchers chose to follow a simple random sampling to assure that each element in the population had an equal chance of being included. This technique was deemed most appropriate given the relatively large size of the population of consultants, contractors, and owners. The sample was selected based on the knowledge of the researchers and specialized experts, taking into consideration the low variance or homogeneity of the population elements. Finally a sample of 61 consultants, 53 contractors, and 52 owners was drawn, a size proportional to the population. The returned questionnaires were 52 consultants', 42 contractors' and 45 owners'. The respondents were asked to express their perceptions of the frequencies of the change orders factors mentioned in the questionnaire, which was constructed based on the compiled list of factors.

The respondents used a five-point Likert scale (a psychometric scale commonly used in research employing questionnaires) to measure the severity of the factors affecting contractor performance. The scale and the weights given to each response are shown in Table 2.

**Table 2: Frequency weighting scale in the research survey**

Frequency Scale				
Continual	Frequent	Occasional	Rare	Never
5	4	3	2	1

The analysis of the questionnaire included ranking of the different responses according to their frequency for consultants, contractors, and owners. Furthermore, a one-way ANOVA was carried out among the means of responses of the three groups for each individual change orders cause to measure for any significant differences among the respondents' perceptions. Discussion of the results was based on personal interviews that were conducted to clarify responses. Interviewees were experts from the Association of Construction Contractors and the Ministry of Housing and Public Works.

#### **4. Data Analysis and Results**

The ranking of the change orders factors was determined by taking the average scores of the reported data for all respondents. The resulting averages and corresponding ranks are presented in Table 3.

**Table 3: The resulting averages and corresponding ranks**

	Average Consultant	Average Contractor	Average Owner	Overall Average	F-Values	P-Values
<b>Labor (L)</b>						
1 Shortage of manpower (skilled, semi-skilled, unskilled labor)	2.01	1.78	2.20	2.00	3.21	0.028
2 Presence of unskilled labor	2.78	2.58	2.99	2.78	0.83	0.495
<b>Material (M)</b>						
3 Shortage of materials	1.75	2.98	2.01	2.25	2.64	0.071
4 Delay in materials delivery	2.31	2.78	2.96	2.68	0.54	0.613
5 Materials price fluctuations	2.82	2.65	2.16	2.54	2.93	0.051
6 Modifications in materials specifications	3.78	4.23	2.59	3.53	8.99	0.000
<b>Equipment (E)</b>						
7 Shortage of equipments	2.04	1.89	2.32	2.08	3.75	0.028
8 Failure of equipments	2.03	1.98	2.36	2.12	4.36	0.015
9 Insufficient equipments	2.50	2.46	3.12	2.69	9.24	0.000
<b>Internal Environment (IE)</b>						
<b>Contractor</b>						
10 Shortage of technical professionals in the contractor's organization	2.98	1.98	3.30	2.75	25.89	0.000
11 Insufficient coordination among the parties by the contractor	3.07	1.59	2.80	2.49	49.64	0.000
12 Safety rules and regulations are not followed within the contractor's organization	1.68	1.26	1.60	1.51	0.11	0.849
13 Incompetent technical staff assigned to the project	2.34	1.98	2.54	2.29	3.03	0.049
14 Improper technical study by the contractor during the bidding stage	3.24	1.56	3.03	2.61	13.34	0.000
15 Poor planning and scheduling of the project by the contractor	2.98	1.70	3.80	2.83	10.20	0.000
16 Improper handling of the project progress by the contractor	2.97	1.86	3.43	2.75	3.45	0.029
17 Ineffective quality control by the contractor	2.92	2.12	2.46	2.50	0.89	0.413
18 Use of unacceptable construction techniques by the contractor	1.92	1.68	2.29	1.96	4.29	0.016
19 Financial difficulties faced by the contractor	2.32	2.35	2.54	2.40	8.29	0.001
<b>Owner</b>						
20 Owner instructs additional works	4.22	4.25	4.14	4.20	0.18	0.850
21 Owner instructs modification to design	4.33	4.36	4.25	4.31	0.89	0.413
22 Financial constraints faced by the owner	2.94	2.59	2.72	2.75	2.79	0.069
23 Insufficient coordination among the parties by the owner	3.07	4.20	2.34	3.20	11.89	0.000
<b>Consultant</b>						
24 Ambiguities and mistakes in specifications and drawings	2.88	4.31	3.96	3.72	3.51	0.041
25 Poor qualification of consultant engineer's staff assigned to the project	2.69	3.11	2.78	2.86	1.82	0.164
26 Poor coordination by the consultant engineer with the parties involved	2.56	3.02	2.82	2.80	3.31	0.042
27 Inaccurate quantities take off	2.60	3.20	3.17	2.99	3.72	0.029
<b>Exogeneous Factors (EF)</b>						
<b>Weather</b>						
28 Severe weather conditions on the job site	1.66	1.87	1.87	1.80	0.09	0.892
<b>Government Regulations</b>						
39 Difficulties in obtaining work permits	1.95	2.06	2.39	2.13	1.83	0.167
30 Changes in Government regulations and laws	1.94	1.87	1.93	1.91	0.09	0.949

All average values above 3 are considered “accepted results” and are approved as indicators of change orders factors. Table 4 extracts the five most important causes of change orders based on the opinions of the three parties ranked according to their averages in descending order, from the highest average among the groups’ response.

**Table 4: Ranking the most important causes of change orders**

Factor	Overall Average	Rank
Owner instructs modification to design	4.31	1
Owner instructs additional works	4.20	2
Ambiguities and mistakes in specifications and drawings	3.72	3
Modifications in materials specifications	3.53	4
Insufficient coordination among the parties by the owner	3.20	5

### 5. Discussion of the Results

The following discussion will highlight the most important most important causes of change orders as decided by the three parties and by the experts during the post-results interviews. It is interesting to note “Owner instructs modification to design” is the number 1 cause of change orders with an overall average of 4.31.

The “Owner instructs additional works” received the second cause with an average of 4.20. As all owners’ respondents were from the public sector, they criticized themselves by agreeing with the consultants and contractors in giving high importance to the first and second cause. The modification to design is possibly a result of frequent changes in administrations and merging and splitting of governmental agencies as well as short of experience. (All agreed). Furthermore, the “Ambiguities and mistakes in specifications and drawings” and “Modifications in materials specifications “for the extensive change orders were ranked 3<sup>rd</sup> and 4<sup>th</sup> respectively. (Did not totally agree) This is also a possible result of the owner’s needs during the design stage are unclear or not well-defined. The owner is the major source of changes in public construction projects. Change of plans by owner is one of the main causes of change orders. There are three possible explanations to this. First, the owner was not involved in the design development. This is highly likely due to the high upper management turnover in governmental agencies. Second, the owner did not understand or visualize the design. The designer may not have made the design clear or the owner just lack the ability to read the drawings.

Third, it is merely a change of mind while not appreciating the negative impacts of changes. Ranked 5<sup>th</sup> among the most important factors for change orders “Insufficient coordination among the parties by the owner” (did not totally agree). The fact that shortage of high professional consultancy personnel in the public construction sector and lack of knowledge on how to plan projects. This is due to the low wages in the public sector where the high professionals seek the private sector for higher wages. The following factors: “Safety rules and regulations are not followed within the contractor's organization”, “Severe weather conditions on the job site” and “Changes in government regulations and laws” ranked lowest by all three parties (all agreed). There are no significant differences among respondent perceptions regarding these performance factors. Neither government nor safety rules has a major effect on change orders during public construction projects in Jordan. Most changes in government regulations do not directly affect the construction sector, and Jordan’s weather is rarely severe. As there is no contact between the parties and the government, except to obtain permits and approvals for construction at the early and late stages of projects, and given the stable weather, those factors have little effect on contractors’ performance.

### ***6. Difference in Perception among the Three Groups***

A one-way variance analysis was performed among the means of the three groups’ responses to check for significant differences among the groups’ perceptions of the importance of the contractor performance factors. The mean values for the three groups, the F statistics, and the P values at which a hypothesis of equality of mean values across different groups could be rejected were calculated (see Appendix B). The analysis revealed statistically non-significant differences among the respondent groups for the following factors:

1. Owner instructs modification to design
2. Owner instructs additional works

The results of our ANOVA analysis show that the means of the different groups are not significantly different from one another, indicating a strong agreement among the three groups. Further analysis through the Duncan Multiple Range Test, Scheffe’s test, or Tukey test is necessary to detect where the mean differences lie, since the differences are negligible. Merging the above result with the highest-ranking factors according to the mean of the averages of the three groups “Owner instructs modification to design,” and “Owner instructs additional works” reveals that “Owner instructs modification to design” is, by consensus, the leading change orders factor in the Jordanian public construction sector. In addition, we note a strong agreement among the respondents regarding the three lowest-scoring factors—“Safety rules and regulations are not followed within the contractor's organization”, “Severe weather conditions on the job site” and “Changes in government regulations and laws”.

### ***7. Conclusions and Recommendations***

From this study, it was determined that the main causes of change orders are those which are related to the owner’s internal environment, “Owner instructs modification to design,” and “Owner instructs additional works” are the most important change orders factors. All three groups of respondents agree on the severity of these factors, making them the most critical change order factors in Jordan’s public construction sector. Both consultant and contractor ranked “Insufficient coordination among the parties by the owner “the sixth and fifth most important change orders factors respectively; it was ranked fifth according to the mean of the overall averages of the three respondent groups, indicating that the “Insufficient coordination among the parties by the owner “factor has a huge effect on all parties in the construction industry.

Within the consultant's internal environment, "Ambiguities and mistakes in specifications and drawings" is viewed as the second most important change orders factor by contractors and as the third most important by owners. This change orders factor ranked as the third most important according to the mean of the average ranking of all three respondent groups. However, none of the change orders factors concerning the consultant's internal environment are significant according to the overall average means of the three respondent groups. Among input factors, material appears to be the most significant. The "Modifications in materials specifications" was ranked third by consultants and fourth highest by contractors, while owners ranked it sixteenth. Equipment and labor were ranked low by all parties. The exogenous factors ranked lowest by all three parties were "Safety rules and regulations are not followed within the contractor's organization", "Severe weather conditions on the job site" and "Changes in government regulations and laws" ranked lowest by all three parties. There are no significant differences among respondent perceptions regarding these factors. Most changes in government regulations do not directly affect the construction sector, and Jordan's weather is rarely severe.

As there is no contact with the government, except to obtain permits and approvals for construction at the early and late stages of projects, and given the stable weather, those factors have little effect on change orders factors. In sum, most major factors affecting the change orders in Jordan were within the owner's internal environment. Using the main concepts and terminology of Drewin's open conversion system, we note that the main effects on change orders are related to the internal environment of the system, especially for owners, and to the input factors relating to material. Meanwhile, the effects of equipment and labor, especially the exogenous factors, have a low or even negligible effect on change orders during construction projects. Comparing the outcomes of this investigation with some previous research outcomes we found that in this investigation, contractors, consultants, and owners agreed on the most important factors affecting change orders as illustrated by the statistical results of the questionnaire. First among these important change orders factors are owner's' internal environment factors. These outcomes agree with the results of research conducted in Oman by Alnuaimi et al. (2010) where it is clearly concluded that the first two reasons in Oman are owner related.

A study conducted in Malaysia by Sambasivan and Soon (2007) found that the first three reasons in Malaysia are contractor related (improper planning by contractor, site management by contractor and in adequate contractor experience). The factors affecting change orders in the Middle East (Jordan and Oman) seem different from those affecting contractors in other in Malaysia due to experience differences in construction industry. The outcomes have clear implications for both the public construction sector and the construction industry at large. Ranking these factors from the consultants', contractors', and owners' perspectives provides a fresh insight into an old but critical issue in the construction sector, with its large contractor component. This research has provided solid evidence concerning the most, and the least, significant factors affecting the change orders in the Jordanian construction industry. Finally, as this study was conducted in Jordan, its results could be applicable to other developing countries whose construction sectors include similar factors. This study could also be improved, as follows:

- The methodology used in this research could be applied to other developing countries, thereby increasing the data bank available for future studies or for comparisons among several change order factors.
- This research could be merged with studies conducted in other countries to find the common and uncommon factors affecting change orders so as to enable global research designed to provide guidelines to the construction industry.
- This research could be merged with other types of public research conducted by foreign governmental agencies.

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