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# Investigation of Cost Control Measures for Main Contractors in Construction Projects

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## Abstract

Based on previous research by the authors, (59) cost control factors in construction projects were identified in which (13) were considered as the most influential factors. In this research, control measures that are potentially within the hands of main contractors were investigated according to the opinions of some Iraqi professional engineers of high experience. A questionnaire survey consisting of (55) control measures for the (13) most influential factors were suggested. When ranking those measures, based on the highest (RII), it was found that contractors should focus on; using modern techniques and tools to improve labor productivity, using modern design programs to give clear visualization to the owner so changes is reduced, setting solid rules to attain good performance for contractors, S/C and suppliers, paying liabilities on time to avoid shortage of funding, insure periodical maintenance to enhance equipment performance and lower downtime, integrity and anti-corruption, using work study techniques to insure proper site planning, proper selection of project managers, using modern planning and scheduling techniques, prepare suitable safe off-site locations for backup material storage, insure previous planning for equipment specification and labor skills, insure selecting reliable suppliers.

**Key words:** Field Study, Statistical Tests of the Questionnaire Results, Ranking of Measures.

## 1. Introduction

Cost overrun becomes very frequent in most construction projects in Iraq. Aswad in (2014) stated that "cost overrun had approximate (28%) higher than the estimated budget" [1]. Frimpong et al. in (2003) emphasized that (75%) of projects suffered cost excess over planned budget [2].

Taking into account that construction projects consume plenty of various types resources, cost overrun might happens due to many factors that could occurr during design and/or construction phases. Thus, contractors need to continuously improve their efficiency in cost control by using preventive and corrective measures.

A previous research of the authors revealed (59) cost control factors in construction projects in which (13) were considered as the most influential factors. Ranking of those factors revealed the following order; labor productivity, design and specifications changes, sub-contractors and suppliers performance, project financing and disbursement method, equipment productivity, corruption and fraud, site organization and distribution of equipment, experience and training of project managers, poor scheduling and control techniques, absence of planning for materials supply, absence of planning for equipment supply, delay of materials delivery on time and absence of planning to provide the required skills. It can be noticed that (3) factors are out of the control of contractors namely; design and specifications changes, project financing and disbursement method, and corruption and fraud.

This study is mainly devoted to identify suitable measures to be taken by main contractors to mitigate the influence of the most influential factors on construction cost.

### 1.1 Study Objectives

The aim of this study is to identify mitigating measures to the most influential factors that affect the construction projects cost in order to improve the performance of cost control of main contractors. Three objectives have been set to achieve this aim:

i. To review relevant literature on cost overrun and cost control in construction projects to determine prevailing causes and measures.
ii. To investigate constituencies' opinions about those measures through a well-structured questionnaire survey.
iii. To conduct statistical analysis to test the relevance of results in order to find out the suitable measures.

### 1.2 Research Justification

In order to upgrade the cost control practice in construction projects, suitable preventive and corrective measures, applicable by main contractors, should be identified in order to avoid cost overrun.

### 1.3 Research Methodology

The research was conducted according to the deduction approach. It is an exploratory research based on a questionnaire survey to elicit information about measures to mitigate the causes of cost overrun in construction projects. A wide range of literature on construction cost issues in different countries were investigated in order to provide a common base to start with. A questionnaire was designed to cover prevailing practices to find out measures for the most influential factors. The respondents were asked to rate the factors on a scale of (1 to 5) according to Likert's scale (Likert, 1932) [3]. Likert's scale had been used for such purposes in similar studies such as (Ramachandra and Rotimi, in 2015) and (Gunduz and Abu Hassan, in 2017) [4] [5]. Statistical analysis of the respondents' replies, including all necessary tests was conducted. The Relative Importance Index (RII) was employed to rank the factors highlighted by professional engineers of high experience. It is one of the most popular methods used in such studies according to (Olawale and Sun, in 2010) and (Morsy, in 2014) [6] [7].

## 2. Literature Review

Alin Veronika et al., in 2006 conducted a study to identify the main causes of cost variance in material purchase and to recommend corrective measures. The investigation was conducted through a questionnaire survey and interviews covered high rise building projects. The results were analyzed by Delphi method and showed many causes vs. corrective measures for material cost such as; poor estimation and budgeting of material cost vs. preparing accurate and detailed budget based on direct

market, poor market prediction vs. conducting a pre-survey to enable making the right price estimation and (55) other causes vs. measures classified in (10) categories [8].

Olawale and Sun, in 2010 developed a questionnaire survey that consisted (20) factors related to construction cost. The study revealed (10) factors to be considered as the most influential namely; design changes, risk and uncertainty, inaccurate estimation of project duration, poor performance of subcontractors and suppliers, complexity of works, conflicts between the parties, contradictions in contract documentation, disagreement on contract documents interpretation, inflation and payment for completed works [6].

Lubna W. S., in 2015 carried out a study to identify factors causing cost increase, and to develop a system to aid in controlling cost and time in the construction phase of highway projects. The study concluded that the most important factor is the need of qualified staff for estimating, pricing and scheduling. The earned value method was recommended to be very useful in cost and time control for highway projects [9].

Pirabahar S. et al. in 2017 conducted a study in India to identify factors responsible for project cost and time increase. The study also suggested some suitable remedial measures. After reviewing relevant literature, interviews with practitioners were carried out to identify factors related to construction cost and time overrun. A questionnaire survey on the interviews results was conducted to identify the most influential factors and suggest suitable preventive measures. It was found that; mistakes during construction, transportation cost, rework due to defects, escalation of material prices and complexity of the project were the most influential factors [10].

## 3. Field Study

A questionnaire form was designed in which a list of preventive and corrective measures was included against suitable legislations and organizational measures that need to be considered to aid contractors in cost control. The questionnaire survey was directed to (30) professional engineers of high experience working at four of state companies in the Ministry of Transportation and they were completely collected. The respondents were asked to rate the effectiveness of the measures on a scale of (1-5) according to Likert's scale as shown in Table (1). The measures were categorized based on each of the (13) influential cause of cost overrun. The option of adding more measures was also included in each category. The questionnaire form is shown in Appendix (A).

**Table 1: Ranking scale of measures effectiveness**

| 1.1.1. | **1.1.2. Ranks** | | | | |
|---|---|---|---|---|---|
| 1.1.3. **Scale** | **1.1.4. 1** | **1.1.5. 2** | **1.1.6. 3** | **1.1.7. 4** | **1.1.8. 5** |
| **1.1.9. Effectiveness** | 1.1.10. No Effect | 1.1.11. Low Effect | 1.1.12. Medium Effect | 1.1.13. High Effect | 1.1.14. Extreme Effect |

### 1.2. 4. Results of the Questionnaire

The results of the survey showed that (27) of the respondents hold BSc and (3) of them hold MSc degrees. They were (23) civil, (2) architectural, (2) mechanical and (3) electrical engineers. Concerning the respondents experience, (11) of them have more than (25) years, (12) have (21-25) years and (7) have (16-20) years of experience. Concerning their type of job, they were (5) head-office engineers, (10) site engineers, (12) site managers, (2) planning and control engineers and finally (1) was design review engineer.

### 1.3. 5. Statistical Tests of the Questionnaire Results

## I) Tests of reliability and validity

Reliability and validity of the questionnaire results hae been tested based on Cronbach's Alpha test. SPSS (V.22) was employed to calculate Cronbach's alpha using Equations (3) and (4).

$$\alpha = \frac{N}{N-1} \times [1 - \frac{\sum_{i=1}^{K} S_i^2}{S_t^2}] \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$V = \sqrt[2]{\alpha} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

**Where:**

N: is the number of factors in the group.

$S_i^2$: is the variance associated with item (i).

$S_t^2$: is the variance associated with the sum of all (N) items.

($\alpha$) values range between (0-1), when the value is closer to one, it indicates higher degree of reliability (Gunduz and Abu-Hassan in 2017), (Abdulkadhim in 2018) [5] [11]. The reliability and validity tests results are shown in Table (2).

**Table 2: Reliability and validity of the effectiveness of cost measures**

| 1.1.15. No. | 1.1.16. Group of Cost Measures | 1.1.17. Number of measures | 1.1.18. Reliability 1.1.19. (Cronbach's alpha) | 1.1.20. Validity |
|---|---|---|---|---|
| 1.1.21. 1 | 1.1.22. Labor productivity measures | 1.1.23. 9 | 1.1.24. 0.82 | 1.1.25. 0.908 |
| 1.1.26. 2 | 1.1.27. Designs and specifications changes measures | 1.1.28. 4 | 1.1.29. 0.92 | 1.1.30. 0.957 |
| 1.1.31. 3 | 1.1.32. Contractors, S/C and suppliers performance measures | 1.1.33. 5 | 1.1.34. 0.95 | 1.1.35. 0.973 |
| 1.1.36. 4 | 1.1.37. Project financing and disbursement method | 1.1.38. 2 | 1.1.39. 0.95 | 1.1.40. 0.973 |
| 1.1.41. 5 | 1.1.42. Equipment productivity | 1.1.43. 8 | 1.1.44. 0.93 | 1.1.45. 0.964 |
| 1.1.46. 6 | 1.1.47. Corruption and fraud | 1.1.48. 4 | 1.1.49. 0.99 | 1.1.50. 0.994 |
| 1.1.51. 7 | 1.1.52. Site organization &distribution of equipment | 1.1.53. 3 | 1.1.54. 0.84 | 1.1.55. 0.915 |
| 1.1.56. 8 | 1.1.57. Experience and training of project managers | 1.1.58. 3 | 1.1.59. 0.80 | 1.1.60. 0.897 |
| 1.1.61. 9 | 1.1.62. Poor scheduling and control techniques | 1.1.63. 3 | 1.1.64. 0.94 | 1.1.65. 0.968 |
| 1.1.66. 10 | 1.1.67. No planning for materials supply | 1.1.68. 3 | 1.1.69. 0.96 | 1.1.70. 0.979 |
| 1.1.71. 11 | 1.1.72. No planning for equipment supply | 1.1.73. 4 | 1.1.74. 0.94 | 1.1.75. 0.969 |
| 1.1.76. 12 | 1.1.77. Delay of materials delivery when needed | 1.1.78. 4 | 1.1.79. 0.98 | 1.1.80. 0.990 |
| 1.1.81. 13 | 1.1.82. No planning to provide the required skills | 1.1.83. 3 | 1.1.84. 0.81 | 1.1.85. 0.899 |

### II) Test of normality

In order to check whether the results of the questionnaire were normally distributed, Shapiro-Wilk test and Kolmogorov-Smirnov tests were employed using SPSS (V.22). When the P-value (Significance) is less than (0.05) and values of skewness and Kurtosis are within (± 1.96), it indicates that variables are normally distributed (Abdulkadhim in 2018) [11]. Results of normality test for RII are shown in table (3).

**Table 3: Questionnaire Results tests of normality**

| Test of Normality | | | | | | |
|---|---|---|---|---|---|---|
| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
| | Statistic | df | Sig. | Statistic | df | Sig. |
| **RII** | .091 | 55 | .200* | .951 | 55 | .026* |
| a: is Lilliefors Significance Correction. | | | | | | |
| *: is a lower bound of the true significance. | | | | | | |
| *: Represent the P-value. | | | | | | |

It can be noticed that the questionnaire's results were normally distributed with significance (P-Value) equal to (0.026) for RII. The results have been also approved by a (Q-Q plot) shown in Figure (4).

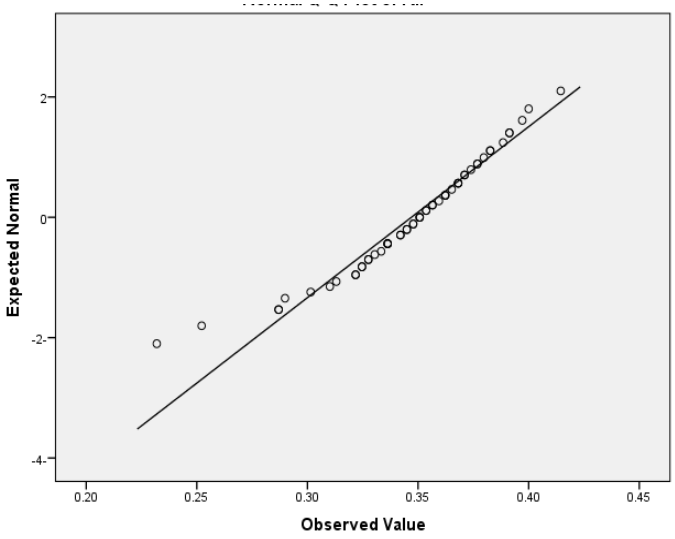


**Figure (4): Q-Q Plot for measures RII**

### 1.4. 6. Ranking of Measures

The Relative Importance Index (RII) was found for each measure in order to rank them using equation (1). Table (4) shows the ranking of the measures recommended by this study.

$$RII = \Sigma W \div (S \times N) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

**Where:**

W: is the total weight given by the respondent to each factor (ranges from 1 to 5)

S: is the highest rank (i.e. = 5).

N: is the total number of respondents.

**Table (4): Recommended cost control measures**

| 1.1.86. No. | 1.1.87. Factor | 1.1.88. Measures | 1.1.89. RII | 1.1.90. Rank |
|---|---|---|---|---|
| 1.1.91. 1 | 1.1.92. Labor productivity | 1.1.93. Using modern techniques and tools | 1.1.94. 0.357 | 1.1.95. 1 |
| | | 1.1.96. Selecting gangs according to skills | 1.1.97. 0.354 | 1.1.98. 2 |
| | | 1.1.99. Replacement of low productive labor | 1.1.100. 0.351 | 1.1.101. 3 |
| | | 1.1.102. Work automation | 1.1.103. 0.348 | 1.1.104. 4 |
| | | 1.1.105. Continuous labor training and development | 1.1.106. 0.336 | 1.1.107. 5 |
| | | 1.1.108. Ensuring employment continuity | 1.1.109. 0.301 | 1.1.110. 6 |
| | | 1.1.111. Increasing labor size | 1.1.112. 0.290 | 1.1.113. 7 |
| | | 1.1.114. Working overtime | 1.1.115. 0.287 | 1.1.116. 8 |
| | | 1.1.117. Proper work break | 1.1.118. 0.232 | 1.1.119. 9 |
| 1.1.120. 2 | 1.1.121. Design and 1.1.122. specifications changes | 1.1.123. Using modern design programs | 1.1.124. 0.368 | 1.1.125. 1 |
| | | 1.1.126. Setting criteria for designers selection | 1.1.127. 0.336 | 1.1.128. 2 |
| | | 1.1.129. Auditing design by third party | 1.1.130. 0.325 | 1.1.131. 3 |
| | | 1.1.132. Setting rules to guide design changes after works commencement | 1.1.133. 0.322 | 1.1.134. 4 |
| 1.1.135. 3 | 1.1.136. Contractors, S/C and suppliers performance | 1.1.137. Setting solid rules to attain good performance | 1.1.138. 0.377 | 1.1.139. 1 |
| | | 1.1.140. Setting criteria for contractors, s/c and suppliers selection | 1.1.141. 0.359 | 1.1.142. 2 |
| | | 1.1.143. Preparing proper substitution for each case | 1.1.144. 0.336 | 1.1.145. 3 |
| | | 1.1.146. Using effective modern communication means between parties | 1.1.147. 0.328 | 1.1.148. 4 |
| | | 1.1.149. Employing a well-documented periodical assessment of their performance | 1.1.150. 0.322 | 1.1.151. 5 |
| 1.1.152. 4 | 1.1.153. Project financing and payment method | 1.1.154. Paying liabilities on time | 1.1.155. 0.362 | 1.1.156. 1 |
| | | 1.1.157. Issuing legislation to grant banking facilitation | 1.1.158. 0.345 | 1.1.159. 2 |
| 1.1.160. 5 | 1.1.161. Equipment productivity | 1.1.162. Periodical maintenance continuity | 1.1.163. 0.377 | 1.1.164. 1 |
| | | 1.1.165. Replace low productive operators | 1.1.166. 0.365 | 1.1.167. 2 |
| | | 1.1.168. Selecting most proper equipment | 1.1.169. 0.362 | 1.1.170. 3 |

| | | | | |
|---|---|---|---|---|
| | | 1.1.171. Locating the tower crane at the right place | 1.1.172. 0.348 | 1.1.173. 4 |
| | | 1.1.174. Add supportive equipment where needed | 1.1.175. 0.328 | 1.1.176. 5 |
| | | 1.1.177. Equipment renewal according to depreciation | 1.1.178. 0.325 | 1.1.179. 6 |
| | | 1.1.180. Replace the equipment | 1.1.181. 0.313 | 1.1.182. 7 |
| | | 1.1.183. Working overtime | 1.1.184. 0.287 | 1.1.185. 8 |
| 1.1.186. 6 | 1.1.187. Corruption and fraud | 1.1.188. Integrity and anti-corruption | 1.1.189. 0.400 | 1.1.190. 1 |
| | | 1.1.191. Doing works professionally | 1.1.192. 0.391 | 1.1.193. 2 |
| | | 1.1.194. Selecting reputable contractors | 1.1.195. 0.388 | 1.1.196. 3 |
| | | 1.1.197. Avoiding complimentary at work | 1.1.198. 0.383 | 1.1.199. 4 |
| 1.1.200. 7 | 1.1.201. Site organization and distribution of equipment | 1.1.202. Proper site planning using work study techniques | 1.1.203. 0.383 | 1.1.204. 1 |
| | | 1.1.205. Providing suitable safe on-site locations for storage and garages | 1.1.206. 0.351 | 1.1.207. 2 |
| | | 1.1.208. Maintaining enough paths for safe movement | 1.1.209. 0.342 | 1.1.210. 3 |
| 1.1.211. 8 | 1.1.212. Experience and training of project managers | 1.1.213. Proper selection of project managers | 1.1.214. 0.414 | 1.1.215. 1 |
| | | 1.1.216. Proper training of project managers | 1.1.217. 0.380 | 1.1.218. 2 |
| | | 1.1.219. Apply the principle of reward and punishment | 1.1.220. 0.345 | 1.1.221. 3 |
| 1.1.222. 9 | 1.1.223. Poor scheduling and control techniques | 1.1.224. Using modern planning and scheduling techniques | 1.1.225. 0.371 | 1.1.226. 1 |
| | | 1.1.227. Maintaining an adequate database for planning | 1.1.228. 0.351 | 1.1.229. 2 |
| | | 1.1.230. Take good care of risk management requirements | 1.1.231. 0.342 | 1.1.232. 3 |
| 1.1.233. 10 | 1.1.234. No planning for materials supply | 1.1.235. Providing suitable safe off-site locations for emergency storage | 1.1.236. 0.362 | 1.1.237. 1 |
| | | 1.1.238. Employing principles of supply chain method and lean construction | 1.1.239. 0.333 | 1.1.240. 2 |
| | | 1.1.241. Set rules for materials loading, transporting, unloading and handling | 1.1.242. 0.330 | 1.1.243. 3 |
| 1.1.244. 11 | 1.1.245. No planning for equipment supply | 1.1.246. Previous planning for equipment types, sizes, numbers and dates. | 1.1.247. 0.374 | 1.1.248. 1 |
| | | 1.1.249. Changing the construction method | 1.1.250. 0.357 | 1.1.251. 2 |
| | | 1.1.252. Taking locally available equipment into account when planning for | 1.1.253. 0.354 | 1.1.254. 3 |

| | | | | |
|---|---|---|---|---|
| | | works | | |
| | | 1.1.255. Enforcing penalties on equipment delivery delay | 1.1.256. 0.310 | 1.1.257. 4 |
| 1.1.258. 12 | 1.1.259. Delay of materials delivery when needed | 1.1.260. Selecting reliable suppliers | 1.1.261. 0.397 | 1.1.262. 1 |
| | | 1.1.263. Accelerating material testing processes | 1.1.264. 0.391 | 1.1.265. 2 |
| | | 1.1.266. Enforcing penalties on materials delivery delay | 1.1.267. 0.371 | 1.1.268. 3 |
| | | 1.1.269. Enforcing penalties on bad quality | 1.1.270. 0.368 | 1.1.271. 4 |
| 1.1.272. 13 | 1.1.273. No planning to provide the required skills | 1.1.274. Previous planning for labor skills, numbers and dates. | 1.1.275. 0.368 | 1.1.276. 1 |
| | | 1.1.277. Take into account the use of locally known techniques and skills | 1.1.278. 0.336 | 1.1.279. 2 |
| | | 1.1.280. Employing foreign labor when using advanced technologies | 1.1.281. 0.252 | 1.1.282. 3 |

## 7. Conclusions

It has been emphasized that modern techniques and tools to improve labor productivity should be adopted. Selecting sub-contractors and suppliers according to their experience and reputation is another preventive action against time and cost overrun. Periodical maintenance to enhance equipment performance and avoid downtime is also emphasized. Moreover, maintaining proper site planning using work study techniques is essential. Selecting project managers according to their competence is vital to maintain project success. Adopting modern planning and scheduling techniques can facilitate cost and time control for it make it easier to follow-up, monitor and update work progress. Furthermore, preparing suitable and safe off-site locations for material backup storage is essential to compensate material shortage.

## 8. Recommendations

It is recommended that contractors and owners should take care of the following:

1. Using modern computerized means in order to ensure an effective cost control.
2. Using modern tools for planning, scheduling and following up.
3. Pay more attention to labour and equipment productivity, S/C and suppliers' performance, site conditions, competence of project managers and resources planning and control.
4. A comprehensive review for schemes, specifications and prepare plan to cover required skills, materials and equipment before starting work.
5. Selecting project managers according to their experience.

**CONFLICT OF INTERESTS.**

- There are no conflicts of interest.

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# تحري تدابير السيطرة للمقاولين الرئيسيين على كلف مشاريع التشييد

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**الخلاصة**

استنادًا إلى بحث سابق للمؤلفين، تم تحديد (59) عاملاً من العوامل المؤثرة في كلف مشاريع التشييد، تتضمن (13) عاملا هي أكثر العوامل تأثيرًا منها (10) عوامل من المرجح أن يسيطر عليها المقاولون الرئيسيون. تم في هذا البحث تحري تدابير السيطرة التي يرجح أن تكون في أيدي المقاولين الرئيسيين وفقا لآراء (30) من المهندسين العراقيين من ذوي الخبرة العالية. تم اجراء مسح استباني يتضمن (55) اجراءً للسيطرة على العوامل الأكثر تأثيراً على الكلفة. وتم ترتيب هذه الاجراءات باستخدام مؤشر الأهمية النسبية. فتبين لأجل السيطرة على الكلفة بشكل أفضل، أن على المقاولين ضمان: استخدام تقنيات ووسائل حديثة لرفع إنتاجية العمال، ووضع قواعد ملزمة للأداء الحسن للمقاولين الثانويين، والالتزام بالصيانة الدورية لتحسين أداء المعدات، وإدامة التخطيط السليم للموقع باستخدام تقنيات دراسة العمل، واختيار مدراء مشاريع مؤهلين، واستخدام تقنيات تخطيط وجدولة حديثة، وتأمين مواقع مناسبة للخزين الاحتياطي للمواد خارج موقع العمل، والتخطيط المسبق لمواصفات المعدات ومهارات العمال، واختيار موردين موثوقين

**الكلمات الدالة:** الدراسة الميدانية، النتائج الاحصائية للاختبار الاستبيان، قياس الاهمية(المرتبة)