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The Effect of Design Phase Meetings on Change Orders in Building Construction Projects

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Abstract

Management of the design phase of construction projects affects the success of the projects. Generally, architects are the main actors who dominate the whole process of the building constructions. In this study, the architects' design experiences in terms of the effect of design phase meetings on change orders in building construction projects are investigated. As a result of the study, it is concluded that there is no relationship between the frequency of meetings and requested and realized project changes in the design phase. It is also observed that, except for the architects, if the formation of the stakeholders participating in the design meetings can be varied, this can minimize the project changes and possible problems due to conflicting interests, and the participation of different groups to the design phase meetings could be a way of keeping the requests of changes in design and construction stage to a minimum.

Keywords: Change orders, Construction cost, Concurrent engineering, Construction management, Stakeholders, Project success

Bina Projelerinde Tasarım Aşaması Toplantılarının Değişiklik Emirlerine Etkisi

Öz

İnşaat projelerinde tasarım aşamasının yönetimi projelerin başarısını etkilemektedir. Genellikle bina inşaatlarının tasarım aşamasında mimarlar tüm sürece hâkim baş rol oyuncularıdır. Bu çalışmada, mimarların tasarım aşamasında gerçekleştirdikleri toplantıların, bina inşaat projelerinin değişiklik talimatları üzerindeki etkisi incelenmiştir. Çalışma sonucunda, toplantıların sıklığı ile tasarım aşamasında talep edilen ve gerçekleştirilen proje değişiklikleri arasında bir ilişki olmadığı sonucuna varılmıştır. Ayrıca projede yer alan mimarlar haricinde diğer paydaşların da tasarım toplantılarına katılmaları, proje değişikliklerini ve çatışan çıkarlarından kaynaklanan olası sorunları en aza indirebileceği, tasarım ve inşaat aşamasındaki değişiklik taleplerinin asgari düzeyde tutulmasına yardımcı olacağı tespit edilmiştir.

Anahtar Kelimeler: Değişiklik emiri, Eş zamanlı mühendislik, İnşaat maliyeti, Paydaşlar, Proje başarısı, Yapım yönetimi

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1. INTRODUCTION

Decisions taken at the beginning of the life cycle of the building projects have an important impact on the construction costs of those project. In fact, the effect of the decisions taken at this stage also affects the operating costs of the structure in the following periods. The final authority in making such decisions is the owner-client but the client must make use of the expertise of the professionals [1]. Professionals such as architects and civil engineers in the project management team carry out project planning, design and manufacturing in an integrated way. In particular, owners-clients and professionals work closely on issues such as design corrections and improvements. It can be said that the design process consists of the following actions: definition of the project, critique and analysis, testing of possibilities, synthesis of results, discussion and communication, report on findings or solutions [2]. In the early design stages of a new project, these actions can be said to be very interactive. In advanced design stages, this interaction is reduced but still exists [3]. Design is a process that requires a combination of expertise in different fields and making a large number of decisions. In design coordination, it is important to relate the pertinent work to ensure compliance across the project. This can be best achieved through effective communication at regular team meetings [4]. The proposed situation can be achieved through weekly meetings. A typical project involves many conflicts. Timely and most positive resolution of these conflicts can be ensured through open discussions. The frequency of meetings will also be affected, depending on the type and magnitude of the problems that may be encountered during the design phase. In the early stages of a building's design process, architects are the main contributors. This process can be mentioned as the first stage of a construction project. Good completion of this stage effects the success of the subsequent stages such as detailed design, construction (manufacturing) and so on, and ultimately to a large extent the customer's satisfaction. Design and construction (manufacturing) should be considered as an integrated system. Conceptual design is made up primarily by architects and then developed more by engineers through interactions with architects. However, due to technological conditions, market conditions and many other factors, changes in design plans during the manufacturing stage are very much common. The contract prepared at the end of the design process specifies in detail the contractor's work. Often, however, changes or extra work may be required after signing the contract. In general, if the change reduces costs, the owner receives it, and if the costs increase, the owner pays the cost. The contract should state how to act in this case. The change order may arise for a number of reasons: changes to the scope of the works specified in the contract and specification; change in material, change to correct project' deficiencies; change in expected conditions; abnormal climatic conditions [5]. In a study with contractors, "having many change orders at different stages of the project" are counted as one of several factors in the failure of the project [6]. In a study about project delays in the Norwegian construction industry, change orders are listed among the ten important factors. In addition, inadequate/poor communication and coordination among the parties concerned are also found to be among the main causes of delays [7]. In this study, the effect of design phase meetings on change orders in building construction projects are investigated.

The remainder of this paper is organized as follows. Section 2 presents the materials and methods used in the study. Section 3 provides the results of the analysis and also discusses the findings. Finally, Section 4 provides the conclusions.

3. MATERIAL AND METHODS

Architects take great part in the design process of buildings although other stakeholders are also involved in this process in varying degrees [8]. Therefore, in this study, the architects' design experiences are investigated. This investigation is based on an analysis of the data obtained from a larger study carried by Coşkun et al. [9]. In the study, a questionnaire survey is carried out among the architects in Turkey. The number of architects surveyed is 94 and the questions asked are about the design process based on the participants' experiences. The questions used in this study presented in Table 1. The data is analyzed using hypothesis -dependency test. Data are analyzed using MS Excel.

Table 1. Analyzed survey questions

No	Questions
1	Do the meetings' time (held before and/or during the design phase) affect the output or performance of a project?
2	How important these meetings are?
3	Who should attend the meetings?
4	How do project changes affect project output?
5	Would, ultimately, project changes be attributable to the number and purpose of meetings?
6	Is there a connection between the meetings and the requests for project change orders?
7	Do the meetings affect the project change order frequency?

The reasons for change orders treated as r×c contingency table and H_o:$p_{ij}=p_{i.}\cdot p_{.j}$; H_1:$p_{ij}\neq p_{i.}\cdot p_{.j}$ hypothesis test is applied. When testing a hypothesis about dependent samples, the process presented below is followed.

- ⇒ State the null and alternative hypotheses
- ⇒ Choose the level of significance
- ⇒ Set the criterion (critical values) for rejecting the null hypothesis
- ⇒ Compute the test statistic
- ⇒ Make a decision, reject or fail to reject the null hypothesis
- ⇒ Interpret the results

3. RESULTS AND DISCUSSIONS

The first observation is, according to the Fisher confidence intervals, it is concluded that the samples come from the population. If the expected value of any of the cells is less than 5 when the sample consistency is small, the Fisher test is used to calculate the exact significance level of a table with a r * c (r row, c column). According to the architects, owners/clients are the representatives that attend the design phase meetings mostly. They are followed by civil engineers and users, mechanical and electrical engineers, subcontractors and material suppliers, respectively (Table 2). These proportions of representatives in meetings can be expected as not illogical. One thing; subcontractor and supplier joins the team later on; their presence is increased in weekly and biweekly meetings. Based on responses, meetings are held weekly (44/94=47%). The value of the meetings can be considered in connection with the requested or realized project changes in the project. Realized or requested project changes can be for different reasons. The frequency and participants' variety of meetings depend on the type and size of the project. Perhaps it can be good for the participants to be from different groups and to talk about possible problems during the design phase. Despite all these meetings, there are still requests for changes in the project. Is the reason not brainstorming enough, not enough research for the subjects (project details, etc.) or the frequency of the meetings (although still meeting every week)? It can be good that there are less surprises in terms of project changes if the meetings are held as brainstorming weekly. It should be stated in this study that there is no choice related to this question, that is how long the design process take or that the customer does not know what he wants. But how do change orders or change requests affect the project? In some cases, the project may be delayed, sometimes costs increase, and sometimes the client/owner becomes dissatisfied (and very rarely vice versa). Therefore, thinking as well as possible at the design stage, estimating and analyzing possible mishaps may also reduce subsequent disruptions in the implementation phase. So, does the frequency of the meetings at the design stage and the identity of the participants and the extent to which they participate provide an answer? Table 3 gives the relation between design phase meeting frequency and reason for change orders. If the p-value is smaller than 0.05, this indicates that there is insufficient evidence to deny H_o. If the null hypothesis is rejected, then it can be concluded that row and column probabilities are independent and that there is no interaction. Only for factor "c" we can say that there is an interaction. For other factors it can be said that there are no interactions between meeting frequencies and the existence of a reason for change order.

Table 2. The participants and frequency of design phase meetings.

Representative present at the design meetings	Frequency of meeting during design phase					
	weekly		biweekly		once or at beginning	
	absent	present*	absent	present*	absent	present*
Owner/client	8	36 0.38 0.28≤p≤0.49	4	19 0.20 0.13≤p≤0.30	2	25 0.27 0.18≤p≤0.37
Civil engineers	14	30 0.32 0.23≤p≤0.42	7	16 0.17 0.10≤p≤0.26	8	19 0.20 0.13≤p≤0.30
Users	10	34 0.36 0.27≤p≤0.47	10	13 0.14 0.08≤p≤0.22	9	18 0.19 0.12≤p≤0.29
Mechanical engineer	26	18 0.19 0.12≤p≤0.29	16	7 0.07 0.03≤p≤0.15	15	12 0.13 0.07≤p≤0.21
Electrical engineer	26	18 0.19 0.12≤p≤0.29	16	7 0.07 0.03≤p≤0.15	15	12 0.13 0.07≤p≤0.21
Subcontractor	24	20 0.21 0.14≤p≤0.31	15	8 0.09 0.04≤p≤0.16	18	9 0.10 0.04≤p≤0.17
Material suppliers	32	12 0.13 0.07≤p≤0.21	14	9 0.10 0.04≤p≤0.17	21	6 0.06 0.02≤p≤0.13
Workplace safety expert **	39	5	21	2	26	1
Apartment/site manager **	42	2	22	1	25	2
Other **	42	2	23	0	26	1

*
first row: observed number of responses;
second row: $\hat{p}$;
third row: **%95 confidence interval for proportion-p**
** the confidence intervals are not computed because of the relatively low percentages.

A 100(1−α) % confidence interval for p for any sample size according to the Fisher test are as follows:

$$\frac{Y}{Y+(n-Y+1)F_{\frac{\alpha}{2},2(n-Y+1),2Y}} \leq p \leq \frac{(Y+1)F_{\frac{\alpha}{2},2(Y+1),2(n-Y)}}{(n-Y)+(Y+1)F_{\frac{\alpha}{2},2(Y+1),2(n-Y)}}$$

where
p: proportion of successes for population; n: sample size; Y: number of observed successes, (0,1,2, ..., n)
$\hat{p}=\frac{Y}{n}$ proportion of successes in sample; an estimate of p for population.

Table 3. The relation between design phase meeting frequency and reason for change orders

Reason for change order	Frequency of meeting during design phase						p-value (between meeting frequency and reason for change order)
	weekly		biweekly		once or at beginning		
	no	yes	no	yes	no	yes	
c: incompatibility between the mechanical and architectural plans	41	3	17	6	25	2	0.05
e: details in architectural plans are vague	38	6	16	7	25	2	0.07
g: inapplicability of architectural details by the subcontractor	27	17	10	13	20	7	0.09
a: incompatibility between the static and architectural plans	36	8	14	9	21	6	0.16
d: architectural plans do not have enough detail	36	8	18	5	25	2	0.33
b: incompatibility between the electrical and architectural plans	41	3	19	4	24	3	0.41
f: request of the owner for a change	10	34	3	20	5	22	0.63
h: unavailability of the material given in architectural plans	35	9	18	5	21	6	0.98

F-test for confidence intervals can be applied as shown in Table 4. 95% confidence intervals indicate that the proportions are alright. We can conclude that the samples are from the population. Therefore for H_0:p=p̂; and H_1:p≠p̂ hypothesis, H_0 was accepted as true. According to results presented in Table 4, the biggest challenge is about the factor “f” that is “request of the owner for a change”.

Table 4. The reasons for change orders are ranked according to the total number of yes

Reason for change order	**observed**	$\hat{p}$	**%95 Confidence Interval**
f: request of the owner for a change	76	0.81	0.88 ≤ p ≤ 0.71
g: inapplicability of architectural details by the subcontractor	37	0.39	0.50 ≤ p ≤ 0.29
a: incompatibility between the static and architectural plans	23	0.24	0.34 ≤ p ≤ 0.16
h: unavailability of the material given in architectural plans	20	0.21	0.31 ≤ p ≤ 0.14
d: architectural plans do not have enough detail	15	0.16	0.25 ≤ p ≤ 0.09
e: details in architectural plans are vague	15	0.16	0.25 ≤ p ≤ 0.09
c: incompatibility between the mechanical and architectural plans	11	0.12	0.20 ≤ p ≤ 0.06
b: incompatibility between the electrical and architectural plans	10	0.11	0.19 ≤ p ≤ 0.05

In Figure 1. only the “yes” responses about “change orders” and “frequency of design phase meetings” is shown. The shown numbers are out of total 94 responses. For example, 34 out of 94 respondents choose the “f” choice and “weekly”, and 17 out of 94 respondents choose the “g” choice and “weekly” and so on. It seems that no matter how frequent the meetings are done, owner requests (choice f) happen anyways. It is observed that to decline the owner’ change order requests on the projects, the meetings have to be held less frequently but it surely would not make any sense. The questions could be that do the meetings help to reduce change requests and is there a causality?

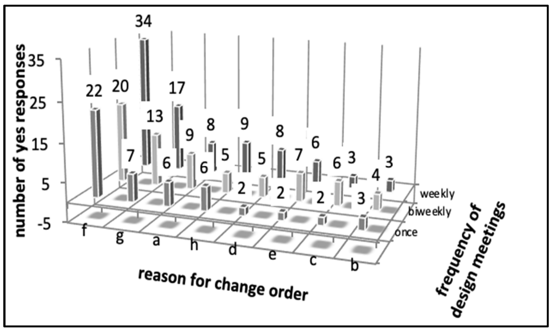

Figure 1. Two-way bar-chart for “yes” responses about change orders design meetings

In another aspect, the effectiveness of the meetings can be examined as follows. The purpose of the meetings at the design stage is to ensure that the building to be constructed in a manner that satisfies the owner. Subsequently, having less problems during the construction phase can be achieved by evaluating the opinions of different groups during the design phase. The meetings during the construction phase can be viewed as to rather to work being done related and ensuring the efficiency/efficiency in performing construction jobs. It would be appropriate to get the opinions of many different groups in the meetings at this stage. In this sense, approaches such as concurrent engineering may be proposed [9,10]. Thanks to these meetings, perhaps the requests for changes during construction phase can be kept to a minimum. This question was also asked to the architects and the answers were cross analyzed as shown in Figure 2. Chi-square analysis of the r×c contingency table presented in Figure 2 resulted with p-value of 0.29. That means there is no interaction between meeting frequency and demand for changes.

“Change order” demands frequency falls into the category “sometimes”. The “change order” requests always happen although in some projects there has been no demand for it as seen that “none” category is more than zero. As can be expected “rarely” and “often” categories are less than “sometimes” category, this may indicate an interesting thing that the more meeting at the design phase the more change order requests. The reasons for that could be:

- That particular project could be difficult
- It may be a good idea to limit the number of meetings,
- The design phase is so successful and well thought so no change order is necessary,
- The selected sample was not representing the characteristics of the universe.

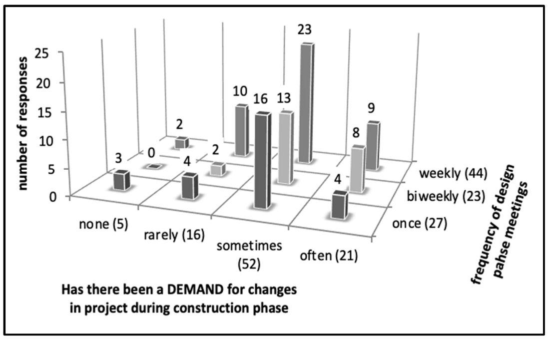

Figure 2. Two-way bar-chart for "yes" responses about change orders during construction phase and design phase meetings (numbers in parentheses are the totals for corresponding variable)

It is just looked at the effect of the meetings held during the design phase on the requests for changes in the project. So, what can be said about project changes that have happened and architects have not been notified? The responses about this survey question are shown in Figure 3. For the values in Figure 3, r×c contingency table analysis was performed, and p-value was found as 0.48. That means there is no interaction between meetings and changes without notifications.

Changes without notification almost always happen although in some projects no changes happen as seen that none category is more than zero. The numbers here tell us that having more meetings in the design phase does not lessen the occurrence of changes. Are the critical points missed despite that many meetings are held? Maybe the focus of these meetings is not project related but some other issues (such as contractual or financial). In any case, the existence of changes during construction is still related to design deficiencies such as:

- Maybe the project is so complicated that having many meetings are not enough to cover up all design issues,
- Maybe the design period is very short but not reflected in this survey. Therefore, problems are tried to be solved during construction which architects may not be aware of them.

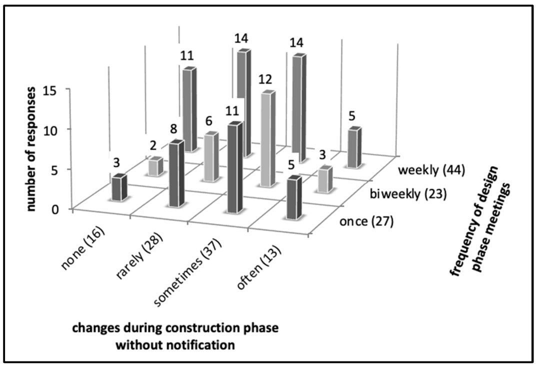

Figure 3. Two-way bar-chart for "yes" responses about design phase meeting frequency and changes during construction without notification (numbers in parentheses are the totals for corresponding variable)

4. CONCLUSIONS

Architects usually play the leading role in the design phase of buildings. In this study, the architects' design phase meeting experiences in terms of the effect of design phase meetings on change orders in building construction projects are investigated. The main contribution of this study to the literature is to find out the main reasons for change orders. Many choices are offered in survey questions and "request of the owner for a change" was found out to be the most influential reason for change orders. Since the main purpose of the meetings are to provide an efficient communication medium, the meetings are thought to help to reduce the reasons for change orders. In other words, there are less surprises in terms of project changes if the meetings are held weekly. However, from the survey results this assumption could not be confirmed. If the survey can be conducted using a larger group, e.g., interviewing other stakeholders, then the results can show any relations not found in this study. For example, the relation between the participants in these meetings and change orders may be determined, if any. Future study will focus on this.

5. REFERENCES

1. Hendricksen, C., Au, T., 1989. Project Management for Construction: Fundamental Concepts for Owners, Engineers, Architects, and Builders, Prenctice Hall, Englewood Cliffs, NJ.
2. Crowther, P., 2010. Assessing Architectural Design Processes of Diverse Learners, Proceedings of Assessment: Sustainability, Diversity and Innovation, ATN Assessment Conference, 24-33.
3. Gaylord, E.H., Gaylord, C.N., 1979. Structural Engineering Handbook, 2nd Ed., McGraw-Hill Book Company, New York.
4. Raymond, E.L., 2000. Project Management for Engineering and Construction, McGraw-Hill, 2000.
5. Ricketts, J.T., Loftin, M.K., Merritt, F.S., 2004. Standard Handbook for Civil Engineers, McGraw-Hill Education, 5 Editions.
6. Diekmann, J.E., Thrush, K.B., 1986. Project Control in Design Engineering, A Report to the Construction Industry Institute, The University of Texas at Austin, Texas.
7. Youcef, J.T., Zidane, B.A., 2018. The Top 10 Universal Delay Factors in Construction Projects, International Journal of Managing Projects in Business.
8. Kanters, J., Horvat, M., Dubois, M.C., 2014. Tools and Methods Used by Architects for Solar Design, Energy Build., 68, 721–731.
9. Coskun, H., Erdis, E., Genc, O., 2016. Improving the Performance of Construction Projects by Employing Concurrent Engineering, Çukurova Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi, 31(2), 47-58.
10. Genc, O., Erdis, E., Coskun, H., 2017. İnşaat Mühendisleri Özelinde Eş Zamanlı Mühendislik Yaklaşımının İrdelenmesi, Çukurova Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi, 32(1), 31-37.