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Design Changes in A Short Duration Construction Project with Cost and Time Boundaries: A Project Review

Rachmad Irwanto[1]
[1]Civil Engineering Study Program, Muhammadiyah Jakarta University,
Jl. Cempaka Putih Tengah 27, Jakarta. Indonesia
Correspondence email: rachmad.irwanto@umj.ac.id
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ABSTRACT

Design changes are inevitable in most projects. In many construction projects they may look not too complicated to be executed in front of computer models. The actual situation turned out to be the other way around. Apart from detailed changes in shop drawings, bill of quantity and specifications, administrative works related to the project are quite considerations. These mounted consequences would be more for short duration projects with government funding executed in the near end book period. The allocated execution period for short duration projects is not usually allowing rapid changes for the unexpected consequences. This paper presents what actually happens inside the project management during the contract change order process.

Keywords: *Design changes, short duration project, overruns, technical consequences, administrative consequences, time period allocation, contract change order.*

1. PRELIMINARY

Once, Heraclitus of Ephesus said "Change is the only constant in life". That opening sentence explains what is being discussed in this paper. Design changes during the execution phase are not considered ideal. However, contract change orders have been treated as close to normal in most construction projects. The variation orders, in many cases, however small in overall scale they are, could generate inevitable repercussions. It is then about how do we anticipate and to deal with them with minimized side effects. Accommodated modifications would include technical and administrative works that in the end affect costing due to variation work volume, additional time to allow the implementation of changes and administrative requirements for reports purposes. Whenever the cost and time boundaries exist, complexity would also increase.

This paper presents a review from an actual completed steel work project. The project was executed successfully on-schedule within two months. The initial design of the structure, for some reasons, was decided to be modified to address discrepancies between site situations and shop drawings. The project was government funded. It has strict budget and schedule limitations. Budget limitations here mean any changes must not exceed the initial budget, while schedule limitation here due to the book and payment systems means any extended schedule would lead to more than one-year

late payment to both the contractor and the consultant. The execution schedule was started in early October while the completion was expected to be at the end of November. The only allowed contract change order is using the existing budget with the same date of expected completion and without any new additional components other than specified in the existing bill of quantity. The building is a part of facilities belonging to a government agency.

This paper is commonly structured with an opening on presentation of contemporary operation management related to design changes during execution phase. Following the opening, this paper presents an elaborated review of implemented works addressing the contemporary issues. A closing discussion will then conclude this paper.

2. LITERATURE REVIEW

A paper by Hindmarch *et al.* [1], extensively proposes idealization of what should be within operation management of a project before deciding to implement changes using a construction design change management model. The proposed model has advantages in measuring potential risk generated by design changes in construction projects. Through the use of design structure matrix (figure 1), the model can provide records of the reason for deviation. Stored outcome databases from this structure matrix can be an accurate source of references whenever a similar project is considering similar changes.

The paper [1], in some ways, may not be practical to some construction projects. Typical projects such as this paper discuss are those with proposed changes that do not tolerate changes in cost and in many cases, do not take any time extension either. Everything is usually rushed and everyone is under pressure for extra work with no extra time. In that situation, administrative works tend to have more attention than actual technical works which may as well cost safety. Again, for more organized project management, the proposed model is ideal for ensuring outcome, optimizing cost and execution time. Yet, when situations get rushed, it is the communication among people in the project that would open the way out.

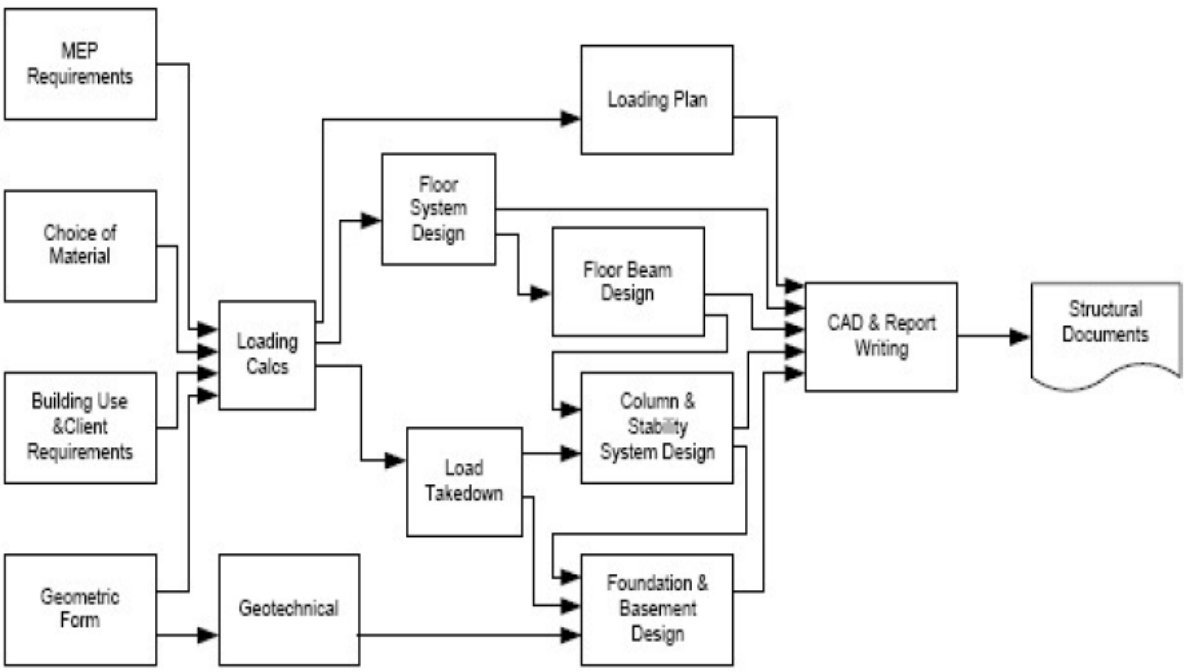

Figure 1. Example Process Map and Design Structure Matrix. [1]

A paper by Irwanto [2], suggested in a broader domain of what could be affecting construction project performance. It classifies constituting factors within broad economic environments during design and execution phase from the operations management perspective for risk recognition purposes. Another paper by Yana *et al*. [3] presents more specific analysis of design changes affecting factors in construction projects. The paper [3] re-emphasizes what has been the common suspect of who or what initially generates more performance disruption of typical construction projects through enforcing design changes. It concludes that among internal and external factors within construction projects, owners are typically the cause of design changes in construction projects.

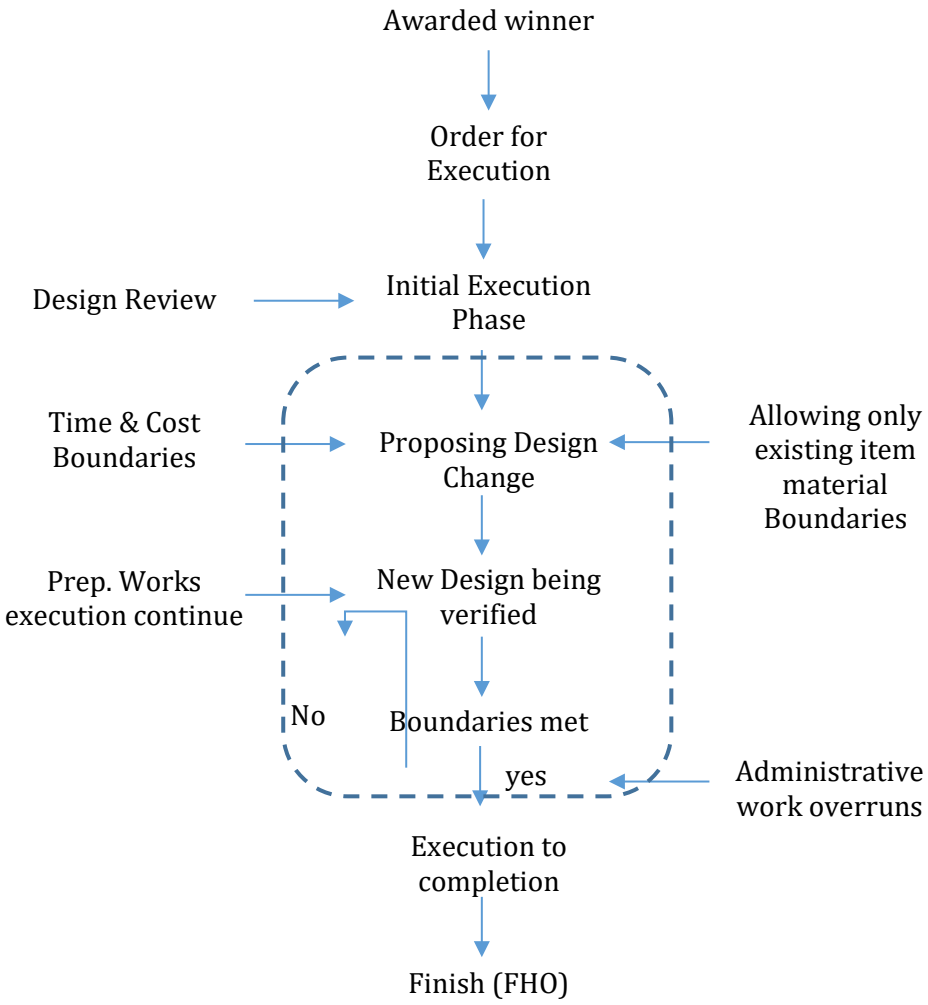

Figure 2. Flow chart of the project discussed in this paper

Papers such as [4], [5]and [6], agree to the idea that design changes contribute to reduced project performance in terms of either cost or time or both. Aslam *et al*. [4] specifically argues that the unfavorable effect of design changes on project performances has actually no established relationship for general construction. Sequential studies starting from cost overrun generated by design changes

could initially start establishing the relationship. Abou Chakra [5], in his paper presents estimations of cost overruns in several project categories due to design changes. The paper by Muhamad *et al*. [6] seems to agree with Yana [3], arguing that overruns in construction projects are significantly instigated by the project owners. Shoar *et al*. [7] presents a deeper analysis using an Interpretive Structural Modeling Approach on the design changes causes. The paper indicates that in many cases, design changes could be initiated by either the owner, by the consultant, by the contractor or even by a mutual agreement among the three. Shoar *et al*. [7] however still agrees that the client -or this paper calls it as the owner- is the root cause of design changes. Theoretically, the findings could help project managers to prepare their operation management strategies to better mitigate risks. More extensive discussion on design changes is presented by Moayeri [8] in his PhD thesis. Moayeri [8] embraces the idea that the owners are where most design changes cases come from and started his presentation on this idea. The paper weighs on the design change management by identifying and quantifying the change's ripple effect (overruns) on cost and time to absorb performance disturbance effect of design changes using Building Information Modeling (BIM). Some notes are presented by [9] related to BIM but overall does not seem to diminish conclusions from [8].

Design changes, for many non-technical people, may look as simple as editing a character while typing on Microsoft Word. What many people are not aware of is the series of effects behind the design changes. This could be the reason why papers [3], [6]and [7] conclude that project owners in many cases are those who initiated the design changes assuming less or no complex consequences. Also in those cases, not all of the project owners are willing to cover the overruns caused by their proposed design changes. In larger projects, the owners are usually consortiums. The people who sit in that consortium are fairly assumed to come from heterogeneous backgrounds in which not all of them understand technical matters. Nevertheless, it is the owner's satisfaction that has the most point in measuring success of a project [10]. This could be related to why the bigger the project the more the chance of over budget [2].

3. THE DESIGN CHANGES

As introduced earlier about the discussed project, the design changes were initiated during its early execution phase. It is a steel structure building for internal warehouse use. A quick review during that phase concluded significant modifications were required mostly in structural design. To add the design change reasons was a request from the user for a position shift of the building from its origin position per the shop drawings. A short pause of site execution was then immediately ordered following a mutual agreement among the consultant, the contractor and the owner to allow time to decide whether the proposed changes were necessary. Boundaries then were the key fronts of negotiations.

The first visible boundary was potential cost overrun. Cost overruns were after the proposed design changes. The owner maintained that there will not be any additional cash to accommodate the design changes on the two-months-scheduled project, yet agreed that the changes were necessary. During the quantity analysis, it turned out that the existing bill of quantity did not cover everything specified in the shop drawing. We had already had a setback even before changing anything. In that case, there were two cost limitations before us.

It was then realized that near-end of year execution has an unfavorable implication to everyone. The accounting and budgeting systems by the government implicitly

indicates that any unexpected delays crossing a certain date in December would lead to a very late payment processing. It may take a period of more than one year through owner's budgeting department procedures. Preparation works at site were then ordered to carry on to catch the work progress targets.

The following situation did not really go as expected. The quantity analyst staff reported that steel fabrication works could not be further progressed and deliveries from suppliers were halted until the new design was approved. Not progressing here means the steel work was temporarily halted and the new bill of quantity needed to wait. A loop work (as figured in Figure 2) of steel structure design and bill of quantity analysis took several days to complete. That was necessary to keep the new final cost and the existing one had the least discrepancy. While the loop work was going on, both the design engineer and the quantity analyst had to work their best to use items already specified in the existing bill of quantity. The latter was required to maintain the administrative reporting work from unnecessary audits. On the other side, the pressure did not stop mounting for the structure engineer while carrying on the new design. Ordering the site work to continue brought a little more pressure to the loop work. As the site preparation works continued according to existing design, the new design must also accommodate limitations from the running preparation works which some were actually those to change. Further discussions with the contractor would not help it either. Stopping works though it was temporarily meaning the contractor paying idle labors without counted progress used for payment term invoices which were already late.

4. MEASURED CHAOS AND PREPARED CONSEQUENCES

The loop works emphasized within the blue discontinued line on Figure 2, and with considering description above may be comprehended as a chaos. The author however, argues it as a measured chaos. It was properly under control. All parties contributed necessarily and coordination among them was just as it should be.

The contractor was actually the one with "nearly victimized" status by the proposed design changes. The contractor had no power to refuse but surely went out limb without tolerance and understanding by the consultant and the owner. The contractor had it through their third party supports facilitating the design changes process by the consultant while keeping the possible works at site progressing. Back-to-back coordination between the consultant and the quantity analyst staffer from the contractor along with confirmations from the owner were in rush but still maintained the work flow well. Staff from the owner were helpful in advising what administrative paper works should be prepared during the loop works. Another good thing happened was that the head staff unit from the owner who oversaw the project is a highly qualified technical person. It would have been another issue to explain that design changes do not get simply fixed only by replacing one or two elements in a computer model. Not everyone understands the implications of design changes. Late progress by the contractor was understood and tolerated by all parties through conversion of non-technical site activities (such as counted partial material deliveries) into work progress to avoid administrative penalties. At the site, the rainy period in the city poured almost every day during the execution phase, slashing the normal working hour half day almost every day. Tolerance from the laborers willing to work after hours were very appreciated to keep up the progress.

After a little more than two weeks after design changes were proposed, the new design was finally approved and mutually agreed. The new design accommodated the deficit in the previous bill of quantity and maintained the total value still within budget with negligible difference. The new design incorporated removal of several unnecessary work items, volume conversion without using new material items other than the ones already specified in the previous bill of quantity and additional detailed modifications of structural drawings on steel works. Overall, the new design does not change the building size, neither does the function and has met the most requirements of all parties.

5. PERSPECTIVE FROM RISK MANAGEMENT

It can be fairly concluded that the discussed project is well completed. Though final handover administration of the project was shifted from initial schedule, the overall site works managed to catch the specified completion date. The shifted final hand over schedule was to allow excess administrative overruns due to the design changes. Everyone has finally expressed satisfaction on the execution.

Design changes with all the entailed consequences could be a source of risk to achieving on time project completion. Looking again at Shoar *et al*. [7], sources of design changes can be from *"Value engineering", "Scope uncertainty", "Change orders"*, and *"Constructability ignored in the design phase"* and *"Clients' attitudes and experience"*. The author has 15 years of site work professional experience in civil engineering construction. Using the author's experience as an example of typical weighing judgment from an experienced civil engineer would likely take the last as the major cause of design changes. Though several papers [3], [4], [6] and [7] agree with the experience of the author, this paper intends to look at those causes without weighing any experience judgments by assuming all the sources above have the same risk potential.

Sivunen *et al*. [11] present in their paper an interesting discussion. This one views the changes from the point of view of the building owner. It concludes the analysis through their specific Design Alliance method that major changes did not negatively affect the project they observed. Furthermore, the paper also noted statements from the user that the co-working and user orientations in the design process exceeded their expectations. The satisfactions came from involving users in their design process. It does not say who initiates the changes but, the final conclusion from the owner's perspective, provides hints that a good cooperation solves the issues and therefore could minimize the potential risk due to changes.

It is rather substandard to know that design changes in a construction project as a source of risk can actually solve itself not by a scientific method but rather a social collaborative attitude among people within the project. Scientific procedures, in this case, for example, are described as methods by Hindmarch *et al*. [1]. The methods in [1], are arguably among the best methods in formal and systematic ways. Meanwhile, the collaborative method is an alternative one to look at construction projects as a socially inclusive community bordered by their perimeter fences and contract agreements. Risk management would need to consider these facts in order to be efficient in measuring and planning.

6. CONCLUSION AND FUTURE RESEARCH

Ideal timeline of general construction projects does not normally incorporate design changes. All designs, specifications and time schedule would be better

prepared for the execution phase. Ideal, as we all know in most cases however, is far from real. That is where risk and insurance are introduced. Design changes could happen anytime during the timeline of projects. Design changes could be instigated by any signing party in a project. There are always reasons to point out a scapegoat. Embracing this kind of risk should at least ease the pressures due to overruns. Yet, pressures always after those situations whenever unexpected things happen within a strict time and cost boundaries. Many discussed cases from our references [3], [6], [7] and [8] analyzed who initiated the design changes and methods of how to mitigate the chain effect of design changes to the completion progress performance. Should the focus of those projects be the project completion, from our project case we learn that understanding, cooperative attitude and tolerance among the signed parties working on the project can overcome the overruns.

Design changes may sound simple for those assuming that way and we all know that does not represent the reality. Future research related to issues in this paper could be interestingly rewriting the situation in a game theory algorithm. We can expect the algorithm would constitute multiple players with win-win solutions within time and cost boundaries.

For projects with a public funding source, administrative work overruns due to proposed design changes that lead to contract change order could have more implications. Such an example from our case, after the design changes decision was approved, though both overall project value and time completion were fairly kept the same with the one before proposed design changes, contract change order was still implemented. That was due to detailed changes in shop drawing and volume in bill of quantity. Financial auditing from the auditors usually puts more focus on neat administrative paperwork. The auditing staff generally work on their own terms and do not always comprehend technical matters and issues during design and execution.

Looking at design changes from a risk management perspective, design changes could be one significant factor to consider. With their overrun's potential, they would bring too many consequences to skip during risk planning. Yet, there are options to look at design changes as part of regular issues within a social community with an attitude to understand each other. Design changes should not be a significant matter.

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