EARLY CONTRACTOR INVOLVEMENT: ADVANTAGES AND DISADVANTAGES FOR THE DESIGN TEAM

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ABSTRACT

The purpose of this paper is to assess the advantages and disadvantages for the design team when the contractor is involved in the early phases of design. The research was carried out by studying relevant literature and conducting nine semi-structured in-depth interviews with key design and construction personnel on two case studies selected from the Norwegian construction industry.

Previous research demonstrates that projects benefits from multi-disciplinary collaboration through all project phases. However, little research has been found concerning how early contractor involvement affects the work of the design team. The analysis documented in this paper show that there are several distinct advantages for the design team when contractors are involved early. The positive implications include not only improved cost estimation, planning, constructability and risk management, but also a reduced amount of errors and changes in latter phases. Unquestionably, the premises governing the design process will change with early contractor involvement. Contractors intervene into a process which used to belong to designers and architects. Designers can thereby experience a challenge of their interests, as contractors are typically perceived to have a distinct focus on constructability, cost and schedule. It is vital with an acceptance and dedication among the team members to adhere to new forms of collaboration. The contract must give incentives for both parties, and the early contractor involvement has to gain all parties in order to succeed.

KEYWORDS

Lean Design, Lean Project Delivery, Collaboration, Contractor Involvement, Constructability

INTRODUCTION

The traditional construction project is organized into three “camps” whose diverse interests sometimes converge and at other times are opposed; the client, the designer and the contractor (Thomsen et al., 2009). Despite positive initiatives from several companies, the industry is still fragmented and traditional contract strategies are

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prevailing. This seems to be the case both within the international and the Norwegian context (Latham, 1994; Lædre 2006). Especially large public projects are often executed as design-bid-build contracts because of their complexity and the importance of client influence. This has enabled design companies to establish complete design teams with collaborating companies in order perform and lead the entire design process for the client.

Lean project delivery principles encourage relational contracting and early involvement of all key players from the project development stage (Ballard, 2000; Forbes and Ahmed, 2011). Effective collaboration, increased efficiency, minimized waste and a unified objective are all key traits of a lean delivery. The literature argues that the separation of designers and contractors prevents constructive use of contractor expertise in the development of the design. The typical result is waste, increased cost and time, and adverse relationships (Song et al., 2009; Thomsen et al., 2009). Hence, clients can choose to involve contractors early in the design to benefit from their expertise and experience from production (Gould and Joyce, 2011). We have found little research, however, that assess the manners by which early contractor involvement affect the work of architects and engineers. Consequentially, this paper set out to reveal the actual advantages and disadvantages early contractor involvement has for the design team, both from a practical and a theoretical perspective. The question we intend to answer is:

- How will the early involvement of a contractor affect the work of the architects and engineers?

RESEARCH METHODOLOGY

The research was carried out by a literature review and by investigation of two cases, thereby aiming at strengthening the analysis according to the methodological approach described by Yin (2009). The literature review focused on how the design process traditionally has been organized and how new methods is changing the way projects are executed. In addition, literature on collaboration, contractors' impact on design and contractor expertise was investigated. The approach was to search for keywords in research databases and library databases. Literature has also been found in references of articles. Books have been found by visiting the university library.

Semi-structured interviews with key design and construction personnel on the selected projects were conducted. The same structure of questions was used in all the interviews, giving possibility for a free conversation. The nature of questions was open-ended, and intended to bring out the respondent's own reflection on the subject matter. In the selected case studies the general contractor is involved in the early phases of design. The respondents were project or design managers for the architect, the contractor or the designer. A total of nine interviews were conducted. In retrospect, more interviews with sub-contractor and non-management participants would validate the information better or even reveal new aspects of interest. Equally, with further research, more case studies could also be located and investigated.

THEORY

Song et al. (2009) state that separation of design and construction is still the prevailing contracting strategy in the construction industry. Traditionally, design is

defined as the work performed by consulting engineers and architects. The design team develops drawings and specifications for production before the contractor is involved (Westgaard et al., 2010). A main argument in this latter paper is that this organization prevents contractors from contributing with their knowledge in the crucial design phases. Historically, developing concepts, designing and performing technical calculations have "belonged" to architects and engineers. Construction expertise on the other hand has been in the hands of the project managers and foremen from general contractors.

Designers perform constructability reviews in an attempt to reduce the knowledge gap between designers and constructors, but in practice the reviews tend to occur far too late to make optimal improvements to the design and construction processes (Forbes and Ahmed, 2011). Design development is still the expertise of architects and engineers, but in order to maximize the value of the project as a whole, a more holistic approach seems necessary. Nonetheless, architects and engineers are known to prefer a separated strategy (Thomas, 2006). Thomas explains his claims with the diverging interests of designers and contractors. He argues that without contractor involvement, the design team is allowed to develop a high-quality concept where schedule and costs are not fully perceived as limiting variables to the design. The design team conceives and develops a concept in collaboration with the client, but the lack of production experience is not compensated for. The consequences of this divorce are long project durations, decreased innovation, and the lack of a holistic perspective on design and construction (Erikson and Westerberg, 2011).

The positive attributes of a design-bid-build contract is that the client has a powerful influence on the design and can specify solutions, in which the design team can implement. In for example a design-build contract, the drawback is diminished client influence in the design work. Research also suggests that quality is better maintained in a design-bid-build, due to the fact that it constrains the contractor from strong-arming the designers into choosing the minimum level of quality (Erikson and Westerberg, 2011).

FROM SEPARATION TO INTEGRATION

Gould and Joyce (2011) emphasize that a good design is the result of multi-disciplinary collaboration. The literature indicates a relatively widespread opposition to separation, which has generated numerous new delivery models. These models share one characteristic, notably the integration of design and construction knowledge. By integration we understand the removal of the traditional barriers between design and construction, and bringing together participants with various knowledge and skills. The objective is to utilize every participant's knowledge through all projects phases. Bringing all the key participants together in the early stages of design allow them to develop a better understanding of the project. Research performed by Sanvido and Konchar (1999) suggest that one of the primary success factors of construction project is the assembly of a multi-disciplinary team with experience and chemistry, preferably before 25% of project design is completed. For the contractor, a holistic understanding of the project is crucial to be able to deliver input concerning cost, constructability and value. Such estimates permit the designers to carry out informed decisions about the design. At the same time, the contractor develops an ownership to the design (Thomsen et al., 2009).

A formalized approach to integration is the Integrated Design Process (IDP). This approach is based on the principle that a multi-disciplinary, collaborative team is working together with a mutual trust and understanding (Busby Perkins+Will and Stantec Consulting Ltd., 2007). Figure 1 suggests the differences between an integrated and a conventional design process. As one can see from the figure, the traits of the IDP are similar to the once presented by Gould and Joyce.

Integrated Design Process		Conventional Design Process
Inclusive from the outset	vs	Involves team members only when essential
Front-loaded — time and energy invested early	vs	Less time, energy, and collaboration exhibited in early stages
Decisions influenced by broad team	vs	More decisions made by fewer people
Iterative process	vs	Linear process
Whole-systems thinking	vs	Systems often considered in isolation
Allows for full optimization	vs	Limited to constrained optimization
Seeks synergies	vs	Diminished opportunity for synergies
Life-cycle costing	vs	Emphasis on up-front costs
Process continues through post-occupancy	vs	Typically finished when construction is complete

Figure 1: Integrated Design Process versus Conventional Design Process (Busby Perkins+Will and Stantec Consulting Ltd., 2007)

Westgaard, Arge and Moe (2010) support figure 1 as they argue that the involvement of contractor knowledge in the design phase typically entail an increase in resources and time spent in the early phases. As figure 2 suggests, this allows the contractor to impact the cost and functional capabilities of the project greatly. Research states that changes made in the early design phases cause less costly rework than changes made later (Samset, 2010). Later in the project changes will cost significantly more and the level of influence is smaller. The figure suggests how an optimal design process should be executed. Pressman suggests that increased effort in a front-end loaded design will reduce the cost of changes.

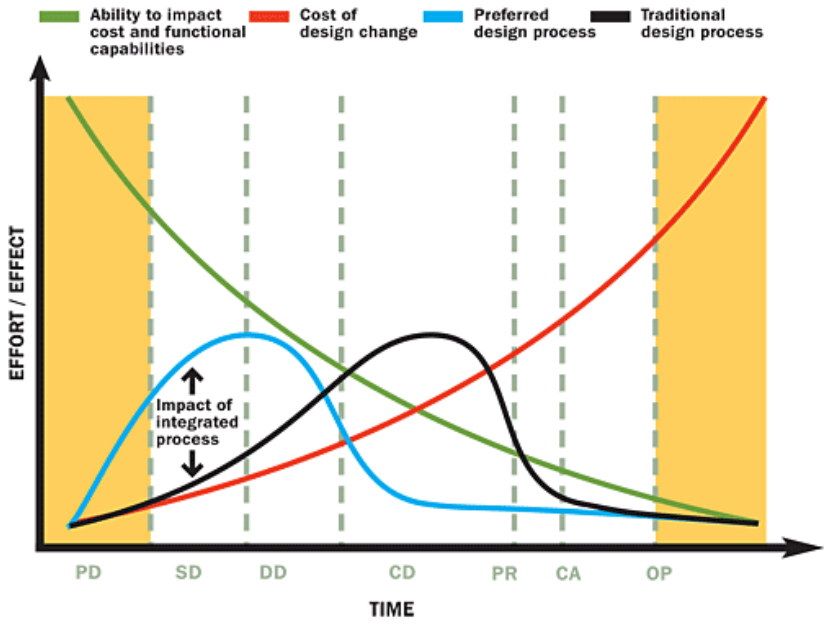

Figure 2: Preferred design process versus traditional design process (Pressman, 2007).

Lean Construction with Lean Project Delivery System also highlights the importance of collaboration in the early phases of design (Ballard, 2000, 2008; Forbes et al., 2011). Freire and Alarcon (2000) suggest that in order to achieve a lean design process it is necessary to emphasize early participation of construction personnel in engineering. The Lean Project Delivery is based on an integrated project organization, which is defined as an effective and efficient collaborative team responsible for the design and construction of a project (Jørgensen and Emmitt, 2009). This includes the client, the architect, design consultants, the general contractor and further trade partners (Heidemann and Gehbauer, 2010). The overall goal is the optimization of the project as a whole rather than pieces of it (Forbes and Ahmed, 2011).

A systematic approach to integration is the Integrated Project Delivery (IPD). The core of an IPD contract is the collaborative, integrated and productive team composed of key project participants (The AIA, 2007). The literature describes IPD as a contractual agreement between a minimum of the owner, design professional, and builder (Cohen, 2010). The catalysts for IPD are typically understood to be multi-party agreements, building information modeling, lean design and construction, and co-location of team (Allison et al., 2010). The team is guided by principles of trust, transparency in every process, shared risk and reward, and perhaps the most important one; stakeholder success is tied to project success. The AIA argues that these are basic principles to have the opportunity to design, build and operate as efficiently as possible.

For the designers, the IPD system allows them to benefit from the early involvement of the contractor during the design phase. The general contractor's expertise in budget estimating is thought to influence the design in a positive manner and improve the overall financial performance (The AIA, 2007). In addition, the opportunity to identify and resolve design issues related to constructability will increase the value of the design. This provides the design team with incentives for

collaboration with the contractor. Figure 3 illustrates the difference in contractor involvement in a traditional design process versus an integrated design process.

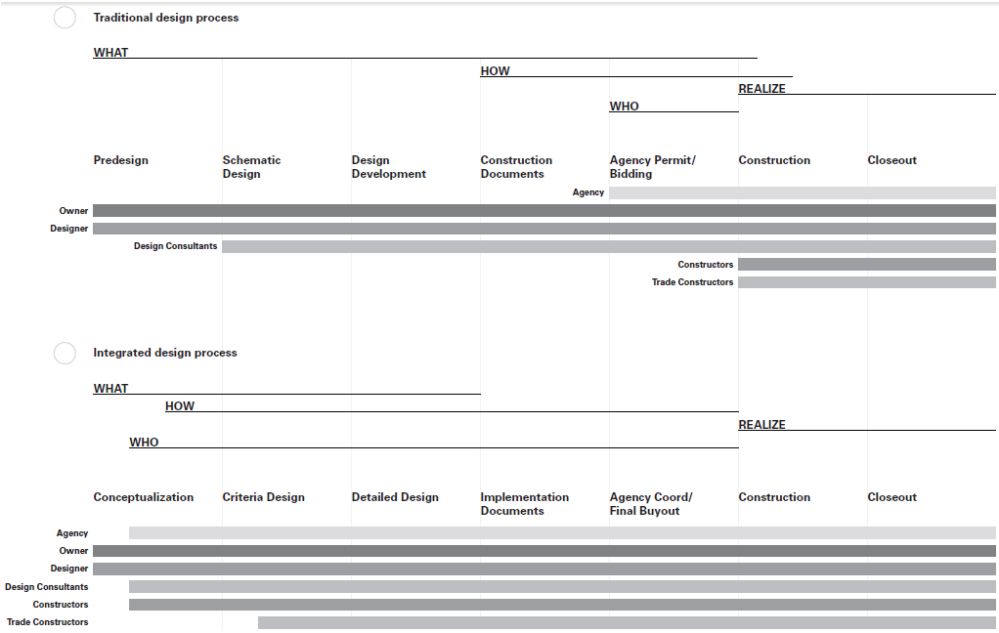

Figure 3 Traditional Design Process versus Integrated Design Process (The AIA, 2007)

The IPD process emphasizes the necessity of a front-end loaded process with more resources then usual allocated to early design phases. The main idea is that the design can be fully developed and construction can be planned accordingly, to minimize delays and errors in both design and construction. It focuses on shifting design decisions forward (What, How, Who) and illustrates when the project participants become involved. As the figure illustrates, the early project phases involve more effort from all parties than their counterparts in the traditional design process.

The most common delivery model, both globally and in Norway, is design-build. Based on extensive research, Erikson and Westerberg (2011) concluded that design-build contracts provide better value for money and improved schedule than design-bid-build contracts. Baiden, Price and Dainty (2006) conclude that project teams work together most effectively in design-build contracts. However, Erikson and Westerberg (2011) claim that using contractors as professional advisors in design-bid-build contracts also contribute to improved team relationships and collaboration in the design. According to their research, quality also appears to be handled better in traditional procurement strategies with contractors and professional advisors. Perhaps just as important, the designers and constructors develop a closer, more productive relationship as they work side-by-side, solving problems together and gaining insight into the other's workings. Erikson and Westerberg (2011) state that higher level of collaboration between design team and contractors in the design stage, and stronger incentives connected to joint objectives, result in better performance with regards to budget, schedule, quality, environment, work environment and innovation.

The theory and literature referred to above clearly state that contractor involvement in the early design has several advantages for projects. The following

chapters investigate what knowledge the contractors possess of value to the consulting engineers.

CONTRACTOR EXPERTISE

Gould and Joyce (2011) state that the most important input from contractors in design are feedback, recommendations and analysis of different materials and details. In addition the contractor can assist in developing work packages for production, pre-qualify bidders and plan the logistics of the production (Gould and Joyce, 2011). An empirical case study from Song et al. (2009) concluded that the contribution from general contractors and subcontractors resulted in improved quality of drawings, improved flow of information and hence better progress relative to the schedule. The contractors are specialists in production. Their expertise regarding material traits, availability and suppliers are valuable to the design. The contractors also have a clear incentive to be involved, as eventually they are the executing part.

Constructability

A common definition of constructability is provided by CII (2009):

> *"Constructability is the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives."*

The definition points to the fact that constructability needs to be implemented through all project phases. The basic principle is that involvement of experienced construction personnel in all project stages ensures that construction factors are considered in the decision making. Literature on constructability indicates that a significant improvement in cost, schedule and safety performance is achieved through constructability programs (Song et al., 2009).

Fischer and Tatum (1997) identify constructability as an important element of design. It differs how it is applied and it is often applied periodically during the design. This will typically sub-optimize the design compared to a continuous implementation (Fischer and Tatum, 1997). A partial understanding of construction requirements, the fragmented project delivery process, contract strategies and the diverging goals between design and construction professionals are all causes that hinder constructability input (Fischer and Tatum, 1997).

Arditi, Elhassan and Toklu (2002) found that 95.7% of design professionals in the top design firms in the US are familiar with constructability, but only about 50% indicate that they have a formalized corporate philosophy on constructability. Only 25% of the respondents from their survey performed constructability analysis continuously throughout the design as a project improvement process. Pulaski and Horman (2005) corroborate this as they found that project teams struggle with how to perform and implement constructability improvements to design in an effective manner. They argue that current methods for utilizing this expertise are unfortunately unstructured, inefficient and are heavily based on design reviews of already performed work. This often results in costly rework and frustration within the design team. Song et al. (2009) suggest that implementation of constructability in design can be formalized by engaging contractors in the early design phase to provide generic construction

knowledge, as well as contractor-specific information. Pulaski and Horman (2005) underline that to utilize construction knowledge effectively the right information must be made available to the design team at the proper phase of design and at the appropriate level of detail. A study Pulaski and Horman performed concluded that only 40% of the constructability issues were addressed at the proper time. 36% were addressed to late and 23% too early. In a more extensive, thorough case study they found that 70% (31 of 44) of the issues were addressed too late. Hence, they concluded that constructability has material impact on cost, schedule, quality efficiency or intensity. Contractor involvement from the early phases of design can therefore provide proper constructability information at the proper time.

CHALLENGES

The majority of literature identifies advantages by integrating the contractor early in the design. Despite no clear disadvantages, there are a number of challenges associated with it. First of all, many public projects are prohibited from involving contractors in design by existing governmental contracting rules (Engelmann, Gehbauer and Steffek, 2008). In Norway there are ways around it, but it requires measures initiated by the client in the tendering process.

Jørgensen and Emmitt (2009) showed that an integrated project team demands a great deal of effort and willingness from the participants to change their routines and behaviour. The team members need to change their usual ways of working in order to enable effective interaction with other. Such changes can be perceived as threatening and hence difficult to handle. The authors also advocate that a strong commitment from every project participant is instrumental to project efficiency and success.

The involvement of new collaborators also increases the number of interfaces in the design. In order to create an effective and efficient working environment there need to be efforts to form relations, identify the participants' abilities and nurture mutual respect among the participants. This will help reduce the number of misunderstandings and unnecessary conflicts, according to the authors (Emmitt and Ruikar, 2013). Senescu et al. (2014) suggest that designers have difficulties in understanding design processes as part of the entire building process. They found a lack of understanding of productivity and the economic benefits associated with design process innovation. Contractors are used to managing building processes and their expertise can be valuable in the design phase.

Even though the collaboration between designers and construction personnel can be productive the inherent conflict of interest can threaten a positive outcome. Westgaard et al. (2010) argue that contractor managed design will tend to have a strong cost focus. This may yield simple, familiar solutions rather than creative and innovative solutions. Architects in special tend to prefer a separated design. They typically believe quality is better maintained that way (Thomas, 2006). In sum, a main challenge is therefore to ensure that every participating party agrees on a united goal and pursue this in a collaborative manner.

FINDINGS AND DISCUSSION

IMPROVED CONSTRUCTABILITY

When asked about the most important contribution from the contractors to the design, the majority of the respondents answered constructability analysis. The consensus is that if the contractor is participating in the design from the early phases, the design's constructability will improve. Findings from the case studies prove that this knowledge is vital in the early phases. Later in the design, a lot of the variables are frozen and are not subject to changes. The contractors interviewed stated that adjustments to the structural system and details early on are most often critical to the constructability. Contractors also have valuable product information from previous projects. Information about technical products and materials are valuable to the design.

The findings confirm that construction knowledge and experience ought to be made available to the design team at the right time. If the general contractor is dividing the work and allocating it to various subcontractors, these need to be involved in the early design as well. It is more beneficial for the electrical engineer to talk to the foremen about construction details than with a top level construction manager. If pre-fabrication is applicable, it is even more important to communicate early with the manufacturers in order to avoid delays in production. On one of the cases, the general contractor mainly used subcontractors and performed little work with in-house resources. The design team felt this compromised the constructability analyses. The general contractor had little input to the constructability of the work carried out by sub-contractors.

Another finding is that even though there is traceable reluctance to standardization amongst designers, component standardization is welcomed. Standardization of dimensions to reduce the suppliers' need for tailoring is an easy way to improve constructability.

According to the findings, the integration of design expertise with construction knowledge is likely to yield a more valuable design to the client. Design teams able to offer this mixture are capable of developing a major competitive advantage. The technical solutions can be assessed with regard to cost, schedule, production safety and quality, thus resulting in savings and improvements in all aspects.

IMPROVED COST ESTIMATION

Both design engineers and contractors agree that the contractors are best suited to do the cost estimation since they are responsible for the construction. Both case studies also reported improved cost management as a result of contractor involvement in design. Certain design variables impact the cost more dramatically than other, and these should be identified at the right time. To illustrate, both the reviewed literature and the respondents suggested that for example changes in column dimensions and unsystematic positioning of columns eliminate the contractors' opportunity for a standardized construction. A combination of constructability knowledge and empirical cost information enable the contractor to improve the cost estimates of the design and foresee production cost. The contractor can estimate the cost more thoroughly and with less uncertainty. The case studies reinforced this finding as several of the respondents pointed out the importance of the contractor's cost

information in estimating. One case study proved this when the estimated project cost exceeded the client's available sum. The design team had to reduce the cost to fit the client's available sum. All parties, independent of each other, mentioned the early involvement of the contractor as one of the reasons why the design team managed to rework and redesign the project to fit the client's available sum.

Better profitability analyses are mentioned as another benefit from early contractor involvement. With every party involved from the early phases of design, the feasibility of the project can be assessed in a better way. This is a result of the improved cost estimates, but also the contractor's input on the constructability of the project after reviewing the initial documents.

IMPROVED RISK MANAGEMENT

Findings from the case studies suggest that early contractor involvement improve the risk assessments in the early phases. The collaboration of all the major stakeholders early in the design phase enables a more thorough identification and a more precise quantification of the risk. Thereby the parties can improve their risk management. For one of the projects, the respondents stated that they had identified and quantified every risk but one: differing site conditions. It could not be quantified until excavation had started. The reduced risk will be of great advantage for the client, too. Risk contingencies can be reduced to a bare minimum, and both schedule risk and cost risk are minimized through better risk management.

CHALLENGES

There are a number of ways to engage the contractor in the early phases of design. In addition to versions of the integrated project delivery, a letter of intent is most commonly used. In the latter case, the contractor is participating in the project development and if the collaboration is successful a design-build contract is formalized. The challenge is who should lead the process in the early phases and who has the decision power? When or if a design-build contract is reached the contractor will most likely assume the position as design manager. The results indicate that this change should not happen too early in the design, due to the contractors' strong focus on cost and schedule in the detailed design. It is important to the architects and designers to fully be able to cooperate with the contractor in the early phases without constantly imposed restraints.

Findings from the case studies indicate that the parties have different interests. Contractors have a stronger cost and schedule focus. Designers can experience a suppression of their interests and the respondents indicated that this could limit the innovative processes. It emerge from the case studies that all parties believe it is vital to the project that contracts contain incentives for the owner, the contractor and the designer. It has to gain all parties to put efforts into a shared goal.

A unanimous finding from both literature and the case studies is that collaboration between designers and contractors will not work without a solid foundation of mutual trust and respect. The case studies indicate that personal relationships between key personnel can influence the project and determine whether it is a success or not. It is also evident need for respect across the disciplines. The architectural expression is just as important to the architect as the cost is to the contractor.

CONCLUSION

In the following matrix a summary of identified advantages and challenges are presented.

Table 3 Advantages and Challenges of Early Contractor Involvement

Advantages	Challenges
Improved constructability	Standardization can reduce value
Design expertise and construction knowledge	Contractor's focus on schedule and cost can reduce innovation
Better product information	
Improved cost estimation	Conflicting interests
Better profitability and feasibility analyses	Suppression of designer interests
Improved risk management	Involving subcontractors at the right time
Better Communication	Establish trust and mutual respect
Improved collaboration in the early phases	
Better plan for construction	

Our main conclusion is that there are more advantages than disadvantages for the designers when collaborating with the contractor in the early phases of design. No distinct disadvantages with early contractor involvement were found. However, a number of challenges were identified. The contractor can contribute with really beneficial construction knowledge and experience from either in-house resources or sub-contractors, but the client must balance the contractor's focus on schedule and cost against the designer focus on value. Our findings indicate that designers and contractors capable of carrying out this balance successfully for their clients will have a major competitive advantage.

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