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Optimal time for contractors to enter infrastructure projects

Freddy Antonsson^a, David Lindvall^a, Johan Lagerkvist^a, Rasmus Rempling^{a*}

^a*Chalmers University of Technology, Department of Architecture and Civil Engineering, Göteborg, Sweden*

Abstract

The design- and construction stage of large construction projects are often two separate fragmented processes. Early contractor involvement (ECI) is a project delivery method where the goal is to include construction knowledge into the design phase. This is done by procuring the contractor during the design phase of a project. There are different approaches to which time the contractor is introduced. This research paper aims to investigate the optimal time for contractors to enter infrastructure projects. In order to do this, an empirical study was conducted, where interviews were held with nine representatives from an ongoing ECI project in Sweden. The studied project was procured by the Swedish Transport Administration, and the contractor entered the project at the beginning of the design phase, before a land acquisition plan had been developed. This is the first time in Sweden that a contractor has been procured this early in a road project. The findings from the interviews show that responsibility, understanding, innovation, risk management, relationship-building and implementation are the aspects that have been affected due to ECI. By analyzing and discussing the results, it was concluded that involving the contractor as early as in the studied case has been beneficial, and that involving the contractor as early as possible in infrastructure project is favorable.

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* Corresponding author. Tel.: +46 317 722 012.

E-mail address: rasmus.rempling@chalmers.se.

1. Introduction

Collaborative management models such as Early Contractor Involvement (ECI) have been established in the Swedish construction sector since the beginning of the 21st century but has mainly been applied to building projects [1]. In 2009, The Swedish Agency for Public Management in Sweden published the report *Sega gubbar* which demonstrates a lower productivity development in the construction industry compared to other industries [2]. The Swedish Transport Administration (STA) has since its founding in 2010 had the mission to increase innovation and productivity in the infrastructure sector [3]. In 2012, the STA initiated an organization-wide rework to become *Renodlad Beställare*, which roughly translates to “a pure client”, where the STA released their focus on construction to take on a more strategic role as a client. This put a lot of focus on strategically working with procurement methods and incentives for contractors to promote innovation and efficiency. Since then, several new policies, guidelines and project delivery models have been developed [3].

One of these models is *Tidig Entreprenörs Medverkan* (TEM), which is the Swedish translation of ECI. The Swedish TEM model follows the model used in the UK, which is a two-phase procurement model with separate contracts for each phase, the design phase and the construction phase [1]. In the first phase, the contractor supports the design team with the development of the design. The development of the design is done in a collaborative manner between the contractor and the client; and during this phase, the contractor is usually paid by the hour. The client and contractor later negotiate a target price and pain/gain- share incentives for the construction phase [4].

An infrastructure project’s life cycle can be divided into the four sub-phases: internal preparation, project definition and design, execution, and use and disposal [5]. These phases will in this paper be labeled: Phase 0 to Phase 3, as shown in Fig. 1. In Phase 1 the client, design team and contractor collaborate to develop the design. Various expected benefits of including the contractor in Phase 1 can be found, such as improved constructability, risk management and innovation [6]. Phase 1 in infrastructure ECI projects can span over several years and involving the contractor too early can cause increased bureaucracy and expenses, while including them too late in Phase 1 can result in losing the expected benefits [7,8]. Wondimu et al. [9] identify three core questions which the client should ask themselves before involving the contractor early:

- When do they want them to become involved?
- Why do they want them to become involved?
- How to achieve this involvement?

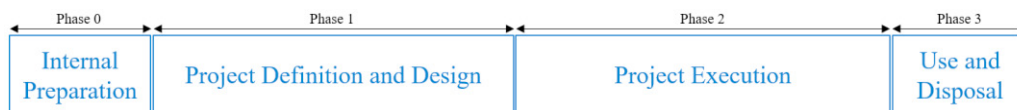


Fig. 1. Illustration of a project’s life cycle, adapted from [5].

This research paper focuses on the first question, regarding when the client should involve the contractor in the project. Further, the second question is studied in order to pinpoint different possible benefits of involving the contractor at specific steps of Phase 1.

The following research question is studied:

- How early should the contractor be involved in an infrastructure project and what is the reason?

This paper is organised as follows: In section 2 the research method of the paper is explained. In section 3 a theoretical background of ECI and the adaptation of ECI in a Swedish setting is presented. Section 4 gives an overview of the studied case, the results of the interview study and a discussion regarding the results. In section 5 the paper is concluded.

2. Research method

A qualitative research approach was adopted to collect primary data which was based on a case study and semi structured interviews. In total, nine interviews were conducted, with three representatives from each actor: contractor, client, and design team. The interviews were conducted online due to the Covid-19 pandemic, using the video communication platforms Zoom, Skype and Microsoft Teams, depending on which software the interviewees were allowed to use according to their company's policies. The interview questions mainly focused on the work progression of the project, differences compared to more traditional road projects and perceived advantages as well as challenges with ECI. All interviews were recorded with the interviewee's approval and were thereafter transcribed by the authors. Before the transcriptions were analysed, a workshop was held together with a collaborative project group from Norwegian University of Science and Technology (NTNU) who were simultaneously conducting a similar study on ECI in Norway. The aim of the workshop was to discuss the interview progression and in which way the transcriptions were to be analysed.

Thematic analysis was used to analyse the interview data. Thematic analysis implies that the data gathered from the interviews is analysed to identify themes [10]. These themes can be more or less prevalent, however, they should all contribute to answering the research questions or provide different aspects [10]. To find themes and analyse the interview results, the transcriptions were imported to the software NVivo 12.

The transcriptions were analysed in accordance with the steps mentioned by Braun and Clarke [10], where the first step is to get familiarized with the data. This was done by reading the transcriptions several times. Secondly, initial codes were created by making nodes in NVivo 12. This means that information related to the same topic is gathered into the same category, where each node represents a code. These codes are referred to by Braun and Clarke [10] as the most basic form of the data, which are the parts that will form the themes. The third step is to start analysing the codes on a broader level, looking for similarities between the codes, to find the themes of the gathered data. Not all codes have to be used to create themes, some can be discarded because they do not fit in any theme, while others might be merged. Some codes were not considered to fit into a theme, which were often more formal aspects and information of the project. These were codes that were not considered relevant to answer our research questions. The codes that define a theme are called subthemes. The fourth step was to review the themes that were found. When this was done, we realised that some of the subthemes fit better under other themes, while others did not seem to fit under any theme, after being reviewed. The fifth step regarded naming the themes and analysing them. The analysis process was iterative, and several of the steps were redone during the analysis as we got more familiar with our codes and themes. The sixth and final step followed the intention of Braun and Clarke [10] and dealt with writing the results of the analysis in the report, which was done after we were satisfied with our thematic analysis. Braun and Clarke [10] mention that it is important to not only present the data in the results, but also to make arguments regarding it, connected to the research questions.

After the interviews had been analysed, another workshop was held together with the collaborative project group from NTNU to discuss and compare preliminary results.

3. Theoretical background

3.1. Early contractor involvement (ECI)

Early contractor involvement (ECI) is a project delivery method that regards involving the contractor in the preliminary detailed design stages in infrastructure projects. Usually, the design -and construction/delivery phase of construction projects are separate, fragmented processes, where the design team and contractor work separately [11]. However, by implementing ECI, the contractor is involved at an earlier stage, and is therefore able to contribute to the development of the design. Traditionally, the design team lacks the production experience that the contractor possesses, potentially leading to designs that are challenging to realize [12]. Due to this, the design team and contractor risk working towards unsimilar goals. By involving the contractor in the design phase, these aspects can be mitigated, thereby reducing possible problems during construction [13].

Even though the main idea of ECI is the same, to involve the contractor earlier than usual, the realization and terms used for the concept alters in different countries [7]. Some countries focus on the relationship aspects throughout the

whole lifecycle of a project, while others focus more on specific parts of the project, to later transition into more traditional working methods and contracts. According to Walker and Lloyd-Walker [5], there are several variations of ECI, which differs in how early and for how long the contractor is involved. Hence, what is specifically referred to by using the term ECI may therefore differ depending on the case. According to a study by Eadie and Graham [14], projects with a traditional DB contract were completed at a lower cost compared to ECI projects. However, the ECI projects were all ranked higher in terms of quality. ECI can still contribute to cost savings, with better potential the more extensive and complex the project is [14]. Other literature mention improved constructability/buildability, risk management, relationship between workers, and innovation as possible benefits with ECI [14–16]. However, Rahmani [16] mention that, to enable the enhancement of innovation in ECI projects, the client must be willing to apply innovative solutions in the project. Although, the client must be “very clear about their expectations” [16 p. 74]. Malvik et al. [17] also emphasise the importance of the client being clear with their expectations, especially in the early stages of the contractor’s involvement. Otherwise, it will be challenging to form a shared vision which will result in unnecessary arguments [17].

Even though ECI has the potential to improve several aspects of a construction project, there are potential barriers that need to be overcome. For instance, if there is a prevalent resistance to cultural change, a project with early involvement of the contractor may not achieve its potential benefits because the involved people in the project do not realise the purpose of ECI and its gains [11]. Trust between the contractor and designer [18] and trust between project owner and contractor [4,6,7] is essential for a better contribution from the contractor. Trust is also needed for the contractor to openly share their proposed solutions.

3.2. ECI in infrastructure projects in Sweden

ECI is a concept that has been used only a few times by the STA and where the method of application and reasoning of usage has differed between cases. In 2016, the first two projects were procured with this approach, and until 2020, eight other projects have been procured by the STA using this collaborative method [1]. The contracting model that has been applied by the STA is a two-phase model, where Phase 1 regards the development of the design, and Phase 2 detailed design and construction [19]. The contractor is procured during the design phase partly based on soft criteria and is often paid hourly for their involvement during the phase based on standardized consultancy contracts [19]. Before Phase 2 begins, the STA and the contractor develop a target price for Phase 2 together. However, if the parties cannot reach an agreement, or the STA feel unsatisfied with the contractor, the STA has the possibility to not proceed with the contractor into the next phase of the project. If the STA however is satisfied, an option within the contract can be triggered which will extend the contract with the contractor through the next phase of the project [19]. During Phase 2, detailed design and construction, a DB contract is often used together with pain/gain- share incentives [19,20]. According to the STA’s guidelines, these incentives should be 80/20 for the client, which means that if the final cost is below target price, the STA earns 80% of the bonus and the contractor 20% [21]. If the target price is overrun, the same ratio is applied, meaning that the STA pays 80% of the extra cost and the contractor 20%.

3.3. Timing of contractor involvement

Integration of construction knowledge and experience is of most benefit in the early phases of a project [22]. The earlier phases are characterized by a high potential to influence the design with a low impact on cost [23], which is illustrated in Fig. 2.

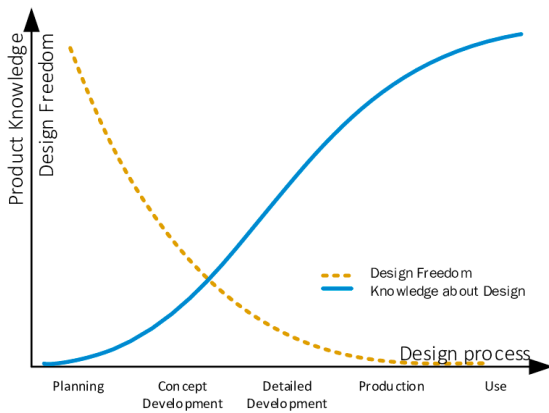


Fig. 2. Illustration of how the design freedom correlates to the design process [24].

Wondimu et al. [25] argue that if the contractor is involved too early, their influence on major decisions can be too high, making the client lose some control over the project leading to increased bureaucracy. If the client is an active client and involved in the processes it can lead to less bureaucracy in the planning and decision phase [8]. On the contrary, if the contractor enters too late, it makes it difficult to accept and implement their proposed solutions due to a lack of time to control and approve the solutions, in addition to client resistance. Eriksson et al. [26] found that the duration of collaboration is what sets the limit for innovation and increased efficiency in the project, where early involvement strengthens the potential for more innovation and potentially higher efficiency. Hence, projects with a high level of complexity, where innovative solutions are essential, would benefit from involving the contractor as early as possible [7,26]. Af Hällström and Bosch-Sijtsema [8] argue that an active client is essential for successful collaboration in the early stages, implying that involving the contractor early does not necessarily result in a successful collaboration. There are various approaches to involving the contractor and it is imperative to find which approach that suits the specific project. For example, DB contracts in large complex project might lead to a higher cost since the contractor might inflate the price to buffer against uncertainties [25].

As mentioned, involving the contractor too early can meet some challenges. Apart from the project-specific challenges there are also legislative ones which a public client face. The contractor selection method involved in projects procured with ECI defy established standards and involving a contractor before the project is described in detail faces several challenges. The STA needs to follow *LOU* which is a law that, amongst other things, specifies that public owners need to use a transparent team selection with several selection criteria, where each contractor use the same basis for proposals [27]. Using price as a criteria before the project has been described in detail is challenging due to various uncertainties in the project [22].

3.4. Phase 1 – The land acquisition plan

Phase 1 in infrastructure projects in Sweden has the goal to produce a land acquisition plan and get it approved by the county administrative board. The process usually spans between three to four years and serves as a foundation for the procurement of a contractor and the detailed planning in traditional DB contracts. The land acquisition plan consists of four sub-phases. During the consultation basis, which is the first sub-phase, the client needs to produce information such as project goal, purpose and extent, affected geographic area, a preparatory project study, conditions, needs and risks and effects on concerned interests [28]. This is followed by the consultation documents where the location of the road, its design, technical solutions and environmental measures are presented.

Parallel to these phases there is continuous consultation with concerned parties such as governmental instances, organizations and individuals who will be affected. The last two sub-phases, the review and confirmation documents, is where the plan proposal will be reviewed and adjusted according to voiced concerns by affected

parties and by the county administrative board. When approved the project is final and will enter Phase 2, to begin detailed design and construction [28].

4. Case findings and discussion

The studied project is a road project in Sweden with the purpose of increasing safety and availability by building a new road and broadening parts of the already existing road. The project is an ECI project procured by the STA, where the contractor submitted a tender together with a design team, with project start in 2016. The contractor is the one who is responsible for the design of the land acquisition plan which means that the design team has a contract with the contractor, and not with the STA, which they usually have. This is the first project in Sweden where the contractor has been involved this early, before the process of developing the land acquisition plan has begun. The case is mainly using ECI approach number 5 as explained by Wondimu et al. [25], which is a DB contract where the contractor enters the project earlier than in traditional DB contracts. In this case the contractor enters the project earlier than recommended in Wondimu et al. [25], who recommend involving the contractor during the pre-engineering stage. The stage where the contractor was introduced in the studied case is shown in Fig. 3.

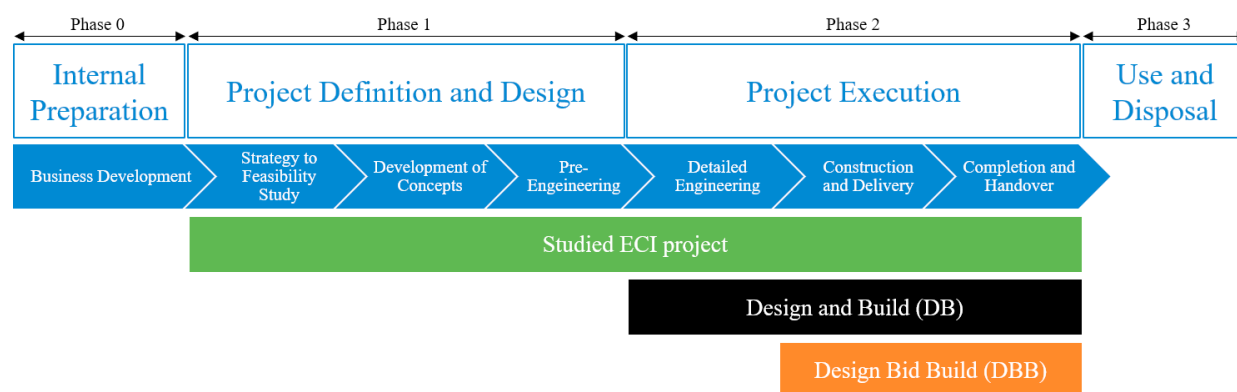


Fig. 3. Illustration of where the contractor entered the studied case, adapted from [5].

During the thematic analysis, six themes were identified as being affected by ECI in the studied case. These were responsibility, implementation, relationship-building, understanding, risk management and innovation. All themes are affected by when the contractor is involved. Responsibility is mostly dependent on how the project is procured and does not affect the project directly in the same way as the other themes do. The project owner always has the responsibility for the project due to legislative instances and this does not change regardless of contractor involvement. Responsibility within the contract is settled before a contractor is appointed since the project needs to be specified before it is procured. Hence, trust was a non-decisive aspect when the public project owner specify responsibility within the contract. Wondimu et al. [7] found that the level of trust between client and contractor was a decisive aspect for how much responsibility the client would put on the contractor and that DB contracts require a high level of trust. Hence, building trust as early as possible during publicly procured DB infrastructure projects is important for project success. During the first phase of the project, the contractor could help the client make decisions which would otherwise be made by the client alone. This made the client feel safer in their decision making due to the client trusting the contractor's knowledge of the project and expertise on the subject. In this instance the client has not regretted decisions made with the help of the contractor, furthering the trust-based relationship. If the contractor would enter the project at a later stage, these trust-building decisions would be taken by the client, and they might be questioned by the contractor later on in the project.

Regarding the way in which this project was procured, the contractor was able to choose which design team to team up with. By choosing a designer they had worked with previously, it could be assumed that a "base trust" was already settled between the two actors. As found in the literature, Af Hällström and Bosch-Sijtsema [8] identified trust

between contractor and designer as one important aspect to achieve the full benefits of the ECI model. The interviewees mentioned that working together for years had created an open atmosphere, a will from all participants to move the project forward and few disagreements (except the target price, which was more connected to the pain/gain- share ratios). This implies that the duration of cooperation between actors has a positive effect on the project. It could be argued that the contractor's early involvement made them more compliant, since the contractor mentioned the risk of working for years in a project and then losing the right to build would be a huge disappointment. On the other hand, if the client and contractor do not agree, the STA must find a new contractor, which would probably result in resource extensive work.

Collaboration has been an important success factor throughout the project with the interviewees mentioning several positive effects stemming from a close collaboration between the contractor and designer. Collaboration between the client and contractor was not mentioned as much and we got the feeling that the client was acting rather passive, only involving themselves in matters which they would traditionally be a part of, discussing decisions internally with their in-house specialists before returning to the contractor and design team with decisions. Being an active client is essential for successful collaboration early in the project [8] which in turn is important to form a shared vision [17] and according to the interviewees: trust. This leads to a better contribution from the contractor [4,6,7] and less unnecessary arguments [17]. We believe the lower level of collaboration than anticipated between client and contractor occurred due to several reasons. Partly because the conservative nature of the STA, the inexperience of working in this kind of model, on everyone's part, and the changing of key personnel in the STA's project organisation during the project. However, both the client and contractor believe that the project will be successful and that their collaboration has been enough to see the expected benefits. Involving the contractor at a later stage than when they were involved could further the collaboration between client and designer but risk losing valuable benefits from contractor – designer collaboration as well as client – contractor collaboration.

Part of why the contractor were to be involved early was to use their construction knowledge when choosing the road corridor. In this case, the contractor was unable to affect the chosen corridor due to cultural and environmental findings. However, by being involved early the contractor gained an understanding of why the corridor was chosen and they could begin identifying challenges and possible solutions. By gaining an understanding of the project and being involved from the beginning of the design development, the contractor could specify the level of design needed when going into the construction phase. The design team felt this made for a more efficient way of working, saving them from doing unnecessary work. At the same time, the designers had a close collaboration with the contractor, discussing possible solutions and challenges surrounding them. If the contractor would enter the project at a later stage, for instance just to check constructability, the understanding of the conditions of the project would not be on the same level as it is in this project. This would risk limiting the contractor to only make suggestions for smaller changes since larger changes would demand a holistic understanding of the project and demands a greater amount of time for investigation and approval.

Since the contractor is the actor who will construct the road, there has been a greater focus on working environment risks and possible risks connected to specific solutions during the development of the design. At the same time, the contractor and design team have had the opportunity to discuss innovative solutions, however, since this project is not that complex, many traditional solutions have been used. However, some new solutions were considered, but because of the STA's requirements and stance, these were not used. This can be related to what is mentioned in the study by Rahmani [16], stating the importance of the clients' mindset. If this project would have been of a more complex nature, and there would have been more challenging circumstances, the early involvement of the contractor would most likely allow for good problem solving together with the design team. This could as well lead to innovative solutions, assuming that the STA approve these solutions and that the contractor is able to be credited for these.

By entering the project during the consultation basis, the contractor can be involved when providing the county administrative board with information about the project. Information such as geographic area, conditional risks and needs of the project and a preparatory project study is information that the contractor can help specify which will further the contractor's understanding of the project. Involving the contractor any later than this would shorten the duration of collaboration and risk losing a part of the project understanding the contractor would gain during the consultation basis. A lower understanding of the project could lead to misunderstandings, proposed solutions which cannot be implemented and an overall reduced impact from the contractor. This does however not mean being involved later than the consultation basis will have no positive impact on the project.

Due to the project being a two-phase procurement it is possible for the project to enter the construction phase with a different contractor. If the client and contractor do not agree on a price for the construction phase, the project will enter a new procurement phase similar to a traditional DB project. If this happens, there is a risk that the new contractor will question the design and try to change design solutions to better fit their organization. Since the new contractor has not been involved early and will not have created a foundation of trust and cooperation, many of the benefits of involving a contractor early will be lost. However, some parts of the design, such as risk management and buildability should be higher than for a regular DB contract.

5. Conclusion

In this project, the contractor got involved in the beginning of Phase 1 and was a part of the whole land acquisition plan process. Due to locational circumstances, the contractor was not able to affect the chosen road corridor as much as the actors expected, but thanks to the early involvement many other aspects were enhanced. The contractor has gotten an understanding of the processes that are included in the land acquisition plan development and the reason why the road will be in the chosen corridor. This is expected to lead to less questions and questioning by the contractor during the construction stage as well as better collaboration through mutual understanding.

Involving the contractor as early as in the studied case has resulted in an extended duration of relationship-building which has led to a project built on trust and collaboration. If the contractor would have been involved at a later stage of the project, this experience and relationship-building time would be lost. In this case, the contractor and design team knew each other from previous projects, however, if they did not, this initial period can be assumed to be of even more importance.

The contractor has been able to contribute with constructability knowledge as well as, with their presence, put an increased focus on work environment risks. As a result of this, the design team has been able to develop a design that from the start has had input from the contractor and has allowed for a smooth transition from Phase 1 to Phase 2, compared to if the project would have been executed with a more traditional project delivery model. This could be accomplished by involving the contractor a bit later than in this case, but proposing substantial changes to the design, which demand an understanding of the project prerequisite, would be challenging. Both due to the lower level of understanding but also due to a lack of time for evaluations.

The understanding of the specific project that the contractor gets by being involved from the beginning of Phase 1 seem to add a qualitative aspect to the project. Raising the quality of risk management, proposed solutions and to some extent it affects the collaboration between the three actors. Hence, involving the contractor in the beginning of Phase 1 is beneficial to the project. To state exactly how beneficial, would require further research and comparisons to other infrastructure projects.

Our conclusion is that involving the contractor as early as possible is beneficial. However, how large part of the contractor's project organization that should be involved from the earliest stage of the project is something that should be further studied. Furthermore, once the project is completed, it would be worthwhile to compare the project to similar ECI and non-ECI projects, regarding cost, quality, and time. Other ECI projects that have different pain/gain-share ratios could also be compared to evaluate how these ratios affect the projects.

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