A construction process model for implementing constructability in construction

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ABSTRACT: In construction, failure of design professionals to consider how a builder will implement the design can result in scheduling problems, cost escalation, delays and disputes during the construction process. The integration of construction knowledge and experience during planning and design is termed here as 'constructability'. Though many design professionals in the Netherlands may informally apply such concept in their works, most design firms however have no formal constructability programmes or procedures in their planning and design activities.

This paper describes a construction process model that has been developed for an engineering firm in the Netherlands in order to implement constructability as a formal programme during its design processes of urban construction projects. The paper describes current problems in urban construction projects and presents a new design model including a constructability programme. The usefulness of the model is validated using opinions of industry professionals. Conclusions on the usefulness of the process model for improving the design process are drawn.

KEYWORDS: Constructability, construction planning, construction process, design process, process model, urban construction project

1. INTRODUCTION

All parties are required to plan a project and control its operation. A successful project achievement in accordance to planned schedule and budget is of vital importance to the owner, who makes plans and commitments on basis of the project anticipated completion date and cost. Failure of design professionals to consider how a builder will implement the design can result in scheduling problems, cost escalation, delays and disputes during the construction process. The integration of construction knowledge and experience during design is called '*constructability'*.

The constructability concept is introduced in 1986 by the Construction Industry Institute [CII, 1987] and is defined as being "the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives".

Originally, constructability was seen as a concept increasing only the productivity during construction phase. Constructability theory has, however, developed to a project concept that is applicable and that offers advantages during the whole construction process [CII, 1992], [Anderson et al, 2000].

By applying constructability in the construction process, the awareness of decision makers regarding the design or construction process is increased. When several parties become more aware of aspects outside their own professional field, it becomes possible to optimise the overall project goals.

When constructability is applied in a right way, it can lead to more awareness, to more interaction between different parties, principles and standards that improve the construction of the project, to provide better feedback to parties involved, and to improve the learning curves for project members [Griffith et al, 1995], [Jergeas et al, 2001].

Several independent studies have indicated that the integration of construction knowledge and experience in the design process increases

considerably the chances for a higher quality, safer work methods, achieving the planned finishing day and the execution of the project within the planned budget [Arditi et al, 2002].

Though many design professionals in the Netherlands may informally apply constructability concepts in their works, the majority of design firms however have no formal constructability programmes or procedures in their planning and design activities.

This paper describes a construction process model developed for an engineering firm in the Netherlands that implements constructability as a formal programme in the construction processes of *urban construction projects*. These projects cope with specific problems that necessitate the integration of construction knowledge and experience in the construction process.

Section 2 of the paper describes the research method and Section 3 describes current problems in urban construction projects. In Section 4 , the developed model is described and the framework for integrating the constructability programme is outlined. The last section draws conclusions on the usefulness of the model for improving the design process.

2. RESEARCH METHOD

The main question this research tried to address was "How to integrate construction knowledge and experience during the construction process of urban construction projects?". The methodology used to help reach an answer to this question involved three major steps.

The first one comprises using interviews to collect information from owners, designers and contractors about current constructability problems in urban construction projects.

The second step involved developing a model for the firm's existing construction process, using Soft System Methodology (SSM), see [Boardman, 2002]. This method is chosen because, in contrast to Hard System Methodology, it supports modelling of processes in ways that allow the roles of actors in these processes to be taken into consideration. In any construction process, roles of people are of major importance and the results of a construction process depend on the performance of those people. Moreover, different participants of a construction process look differently to problems in the process.
For modeling the design process, the seven steps proposed by Checkland is used, see [Checkland, 1993].

The final step entails proposing a constructability programme, which can be tied to the existing process model in order to produce a modified construction process model that integrates construction knowledge and experience into planning and design. The usefulness of the model is validated using opinions of professionals from the industry. They are asked to critically assess the practicability of the model and to examine its suitability for complex projects.

3. PROBLEMS IN PRACTICE

Constructability problems in urban construction projects can be subdivided into problems related to the environment of the construction site and problems related to the construction activities themselves.

3.1 Problems related to the environment

Construction activities in urban areas can cause a great deal of problems and hindrance to people and the surrounding. This is undesirable in the sense that citizens deserve a nice environment and that this can cause considerable hindrance and disturbance to normal living. Moreover, people can ask for compensations for damages or even attempt to stop the construction activities.
Problems related to the environment can be classified according to the followings:

- accessibility;
- living conditions;
- safety;
- communication.

Accessibility: Construction activities in urban areas lead to traffic congestions and re-routing, bad traffic flows and difficult accessibility of stores and facilities.

Living conditions: Loading and unloading locations, household refuse locations, letterboxes, tram and bus locations can fall into disuse and replacement locations are not always arranged. Another type of living problems due to construction is the accumulation of dust on the roads.

Safety: Unsafe traffic situations can arise because of limited construction space and the presence of heavy transport activities. Loading and unloading of construction materials outside the construction site can undermine safety. Pedestrians enter the construction site because of unsecured fences around the site. Absence of adequate street lights can also create unsafe situations.

Communication: Communication and coordination are critical aspects of construction activities in urban environment. Plans have to be communicated between all parties involved as well as with people who might be affected by the construction works. When information is not well communicated to the environment it may lead to claims and counter claims that can cause delay and result in considerable extra costs. It may also lead to halt of construction activities for a period.

3.2 Construction problems

Besides the occurrence of problems related to the environment of the construction site, there are also problems related to construction and construction site. These can be summarized as follows:

- *Construction site layout*: there is limited space for storage of materials, loading and unloading and parking facilities for personnel because of limited space in urban areas;
- *Ambiguities and mistakes in the builder's specification and drawings*: caused by integrating several items resulting in decreased transparency, made too fast;
- *Materials*: some chosen construction materials are heavy to too handle or to process even under good conditions. They may require specific skilled personnel who are difficult to find. Some materials will also affect planning problems because of long delivery periods.

One of the main causes of the above-mentioned problems is the fact that the different parties who contribute to the realization of the final product operate often as single actors in successive and fragmented construction processes. The parties lack knowledge of aspects outside their own working field and thus do not take into account these aspects in their work. As a result, the overall project is not optimised, but instead only sub products and processes are being optimised.

4. THE CONSTRUCTION PROCESS MODEL

4.1 Model

In order to implement constructability concept in projects it is very important to determine how to effectively integrate construction knowledge and experience into each phase of the construction process. In this work, this is carried out using a process oriented framework whereby it is given when, where and how this integration of the knowledge and experience can take place without hampering the regular construction process. The research provides a framework for implementing constructability in all phases of the construction process. This paper however emphasizes only the framework proposed in the design phase.

The proposed model is designed to be used at a project level. If it is decided at an early stage of the construction process; i.e. the feasibility study phase, to apply the constructability concept, the model suggests the appointment of experienced person as a 'constructability coordinator'. The coordinator function will be to facilitate the application of the constructability concept and to coordinate the various knowledge and experience within the project with the help of a constructability team.

Part of the developed model is illustrated graphically as shown in Figure 1.

The model is based on the present design process used by the engineering firm with additional activities that are designed to allow for the implementation of constructability within the process.

The proposed model shown in Figure 1 can be explained as follows:

- At the top left of the diagram, the preceding phase of the process is described.
- At the bottom right of the diagram, the succeeding phase of the process is described.
- The left hand side line of the diagram running, in between, from the top left to the bottom right represents the model of the present process of the engineering firm.
- The loops of lines on the right hand side of the current process line of the diagram represent the modifications required to integrate constructability and hence the entire diagram represents the new proposed model.

4.2 Integrating standard constructability concepts

In the design of the proposed model, a number of standard constructability concepts are adopted. These imply the followings:

- The constructability program forms an integral part of the overall project plan.
- Initial plans are based on construction knowledge and experience.
- Early involvement of construction experts in the development of the contract strategies.
- Project plans are construction oriented.
- Construction methods are considered during the conceptual design approach.
- Early involvement of project team who is responsible for implementing constructability.
- Application of advanced information and communication technology tools within the whole project.

In addition to the above standard concepts, other concepts are also integrated. These are specifically designed for use in urban projects in order to reduce or eliminate the problems described in Section 3.

4.3 Integrating specific constructability concepts

4.3.1 Problems related to surroundings

Accessibility: The purpose of this concept is to improve accessibility from and to the constructions site of urban projects. This is done by considering site accessibility problems in the very early stages of the project. In this respect, considerations are given to the followings:

- there is adequate accessibility around the site;
- temporary diversions and facilities are of good quality;
- the use of diversions and routes that are not used by other projects;
- early consideration of materials delivery routes.

Living conditions: This concept is used to reduce problems related to living conditions in and around the construction site. In here, considerations are given to the followings:

- temporary measures are taken to replace temporary removed public facilities;
- extra measures are taken to clean, organize and maintain the surrounding of the construction site.

Safety: In implementing this concept, the following measures are taking into account;

- construction site and the surroundings are well lit;
- site fences and gates are well secured;
- construction site is well isolated.

Communication: This is to ensure good communication between participants involved. Attention points are:

- early communication over planned activities and their effects on the surrounding;
- provision of construction site information boards and telephone numbers for more information;
- provision of a mechanism for communicating problems and complaints from interested parties.

4.3.2 Problems related to construction

Construction site layout: This concept is meant to provide more efficient construction activities by providing a better project site layout. The points required considerations are:

- design a site layout to ensure that there is adequate space for materials storage, equipments and construction activities;
- access to materials, equipments and personnel;
- sequence of activities;
- planning of major equipments;
- organizing locations within restricted site;
- logistics for supply and transport of materials to and from the site.

Ambiguities and mistakes in the builder's specification and drawings:
In this area, the following points are taken into considerations:

- draw up the project specifications by people who have adequate construction knowledge and experience;
- providing enough time to draw up complete and consistent specifications;
- providing clarity and transparency of the specifications;
- the specifications are drawn up in such a way as to ensure that the use of state of the art cost effective techniques and materials are considered.

Materials: This concept ensures that the opportunity is provided early in the process to exchange ideas between professionals regarding construction materials before 'design by drawing' has started. Attention is particularly given to;

- simplicity of the design;
- the use of standard construction elements;

- maintenance of construction elements;
- the usability of materials during unfavourable weather conditions.

4.4 Validity of the model

The applicability, usefulness and relevance of the developed model were validated using experts opinions through interviews. The experts were asked to assess the model from two aspects; The form of the model and its contents.
All interviewees have assessed the form of the model positively. They have indicated that the model depicts the whole process very clearly. It shows what constructability measures are required next to the normal process.
The fact that the model follows the existing process structure is considered by experts as positive and that integration of constructability with the existing process will lead to improvement in quality in the long term.
The experts also thought that the accumulation of knowledge and experience by the constructability team over the various phases will contribute in improving the process considerably.
The model is also seen as a proactive way of integrating the construction knowledge and experience.
A number of the interviewees have also expressed concerns about the extra cost of implementing the proposed model. This includes the costs of forming the constructability coordinator and team.

5. CONCLUSIONS

Experience shows that many large construction projects suffer from cost and time overruns. There are also other specific problems related to the construction of large urban projects; problems caused by and to the environment around the construction site as well as to construction.
The research has indicated that many of these problems exist because there are little interactions between the various phases of the construction process and that very limited use is made of the construction knowledge and experience in these phases. It has also indicated that it is possible to use the constructability concept to develop a model that can integrates this knowledge and experience in the existing construction process.
Experts have indicated that the developed model is very useful and that it can be applied for the benefit of improving the quality of both the process and the product.

6. REFERENCES

Anderson S.D. (2000), *Integrating Constructability into Project Development: A Process Approach*, Journal of Construction Engineering and Management, American Society of Civil Engineers, Vol. 126, No. 2, pp 81-88.

Arditi D., Elhassan A., Toklu C. (2002), *Constructability Analysis in the Design Firm*, Journal of Construction Engineering and Management, American Society of Civil Engineers, Vol. 128, No. 1, pp 117-126.

Boardman. (2002), *Boardman Soft System Methodology*, http://www.seg.dmu.ac.uk/seg/BSSM/main1.htm, DMU Systems Engineering.

Checkland P. (1993), *Soft Systems Methodology in Action*, Wiley, Chichester, UK.

Construction Industry Institute (CII). (1987), *Constructability concept file*, University of Texas, Austin: CII Constructability Task Force.

Construction Industry Institute (CII). (1992), *Project-level model and approaches to implement constructability*, University of Texas, Austin: CII Constructability Task Force.

Griffith A., Sidwell A.C., (1995) *Constructability in building and engineering projects*, Macmillan, London.

Jergeas G., Put van der J. (2001), *Benefits of Constructability on Construction Projects*, Journal of Construction Engineering and Management, American Society of Civil Engineers, Vol. 127, No. 4, pp 281-290.

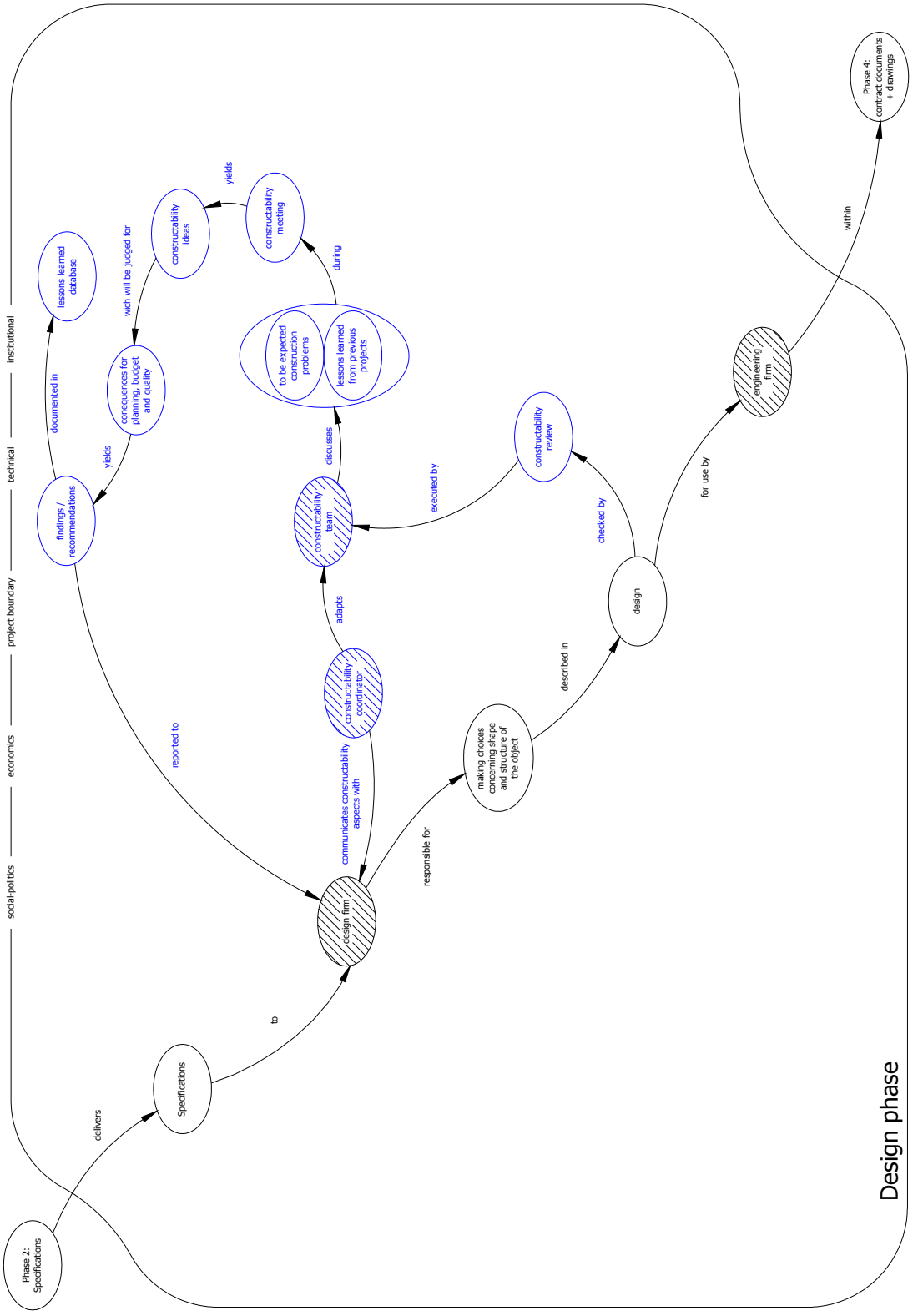

Figure 1: Part of the Proposed Construction Process Model