Concepts of constructability for project construction in Indonesia

M M A Ansyorie

1 Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Malang, Indonesia

mustofansyorie.ft@um.ac.id

Abstract. A study of constructability has recently become one of the research themes that has received much attention. Constructability can be defined as the application and integration of construction knowledge and experience to the process of planning, designing, procuring and implementing construction. The concept of constructability itself began and developed in the United States in the 1970s. In Indonesia, development in the field of construction services is a priority, especially for infrastructure development. The process of construction work can’t be separated from the process of planning and implementing construction which is part of the concept of constructability. Through the application of constructability in construction work can be one analysis for the implementation of construction work to get results a good work in accordance with the desired quality. This study is a review of the concept of constructability and its application in building construction industry. The results of this review are expected to be a source of knowledge and reference regarding the concept of constructability that can be applied by stakeholders in construction work.

1. Introduction

The construction industry in Indonesia is currently growing rapidly, the growth of the construction industry from year to year is increasing. The growth of this industry needs to be balanced with knowledge in the implementation of construction work. One thing that is common in the implementation of construction work and is an important part of the process is constructability. Definition of constructability by the Construction Industry Institute (CII) as the optimum use of construction knowledge and experience in the planning, design, procurement and field operations to echo overall project objectives [1]. Constructability is also defined as the extend to the design facilitate ease of construction [2].

Constructability itself in Indonesia has not been fully implemented by the construction industry players to the full. Some problems in the application of constructability in Indonesia due to lack of understanding of the concept of constructability correctly. This is not only in the construction process in the field, but from the beginning the project design is also not balanced with the implementation of a good constructability concept. Therefore, knowledge about the concept of constructability needs to be understood by the construction industry players from the beginning of the construction project procurement. In many developed countries, much research effort has been directed at improving constructability through the integrated efforts of owners, designers and constructors [3].
An understanding of low constructability is a major factor in the less optimal application of constructability in construction. As the results of a study from Zolfagharian (2012) The major problems in this phase are; lack of knowledge about constructability concepts, unwillingness to devote extra money for this in the initial stages of projects, and shorten of team building and partnering [4]. In addition to the low level of understanding, other factors in procurement of construction projects are related to the procurement process of construction projects that is still simple. In this case, the project owner can determine to use the services of consultants or contractors in accordance with his wishes, without considering the quality of these service providers, both individuals and companies. However, this is quite different when the project owner is part of the government which requires it to be registered as a construction service company. However, not all construction service companies have the capability and a good understanding of constructability. In addition, the main constraint to the implementation of constructability is the problem of coordination and the lack of involvement of the contractor at an early stage, as well as the consultants on the bid build design method not involved in the procurement stage so that planning consultants cannot be involved in the selection of contractors who are really expected to complete the project in accordance with the wishes of the owner and consultant [5].

Some of the problems regarding constructability implementation are also influenced by the absence of good constructability concepts that are suitable for application in Indonesia. Research or studies related to constructability itself in Indonesia have not yet become something important to be carried out. So, to get the concept of constructability in accordance with the conditions of the procurement process of construction service projects in Indonesia. In addition, barriers in implementing improvement in constructability, particularly lack of awareness or appreciation of constructability issues and lack of qualified personnel [6]. Therefore, it needs some studies on the concept of constructability that can be applied to Indonesia optimally.

2. Discussion

2.1. Definitions of constructability

Many definitions of constructability (or buildability) The ability to construct a building efficiently, economically and to agreed quality levels from its constituent materials, components and sub-assemblies. Constructability is often portrayed as integrating construction knowledge, resources, technology and experience into the engineering and design of a project (Anderson et al., 2000). Constructability is a project management technique for reviewing construction processes from start to finish during the pre-construction phase. It will identify obstacles before a project is actually built to reduce or prevent error, delays and cost, The term “constructability” is referred to as [7]:

- the extent to which the design of the building facilitates ease of construction, subject to the overall requirements for the completed building
- a system for achieving optimum integration of construction knowledge and experience in planning, engineering, procurement and field operations in the building process, and balancing the various project and environmental constraints to achieve overall objectives
- a system for achieving optimum integration of construction knowledge in the building process and balancing the various project and environmental constraints to maximise achievement of project goals and building performance overruns.

Constructability or buildability is a project quality improvement technique that if implemented throughout the project delivery process, mitigates these challenges according to Bakti et al. (2003). Improving constructability of construction projects is the responsibility of all project stakeholders: owners, designers and contractors. However, as the owners have the most authority in enforcing the implementation of constructability, the owners’ awareness of the benefit of improved constructability is the most important [6].
2.2. Concept of constructability

Constructability in the United States of America (USA) started a research in the 1970s, with a theme of the construction industry cost effectiveness project. This study was carried out by the Business Roundtable in 1983, and completed a four-year study into how to promote quality, efficiency, productivity, and cost effectiveness in the construction industry [1]. Many of the focus of the study on constructability factor, between a process implementation, method of constructability, and etc. Based on study of a number of engineering projects, they conclude that benefit of 10 to 20 times the cost of implementing constructability could be achieved, and it is essential that project owners participate [4]. Although Business Roundtable initiated the constructability study, it was the Construction Industry Institute (CII) which had been the principal proponent and sponsor of most of the constructability research in the US.

According to Griffith and Sidewell (1995), the American Society of Civil Engineers (ASCE) suggested six principles of constructability to include evaluating the various design configurations to optimize owner requirements, knowing the various project systems and their interface requirements with other project components, understanding trade skills and practices, construction methods, materials, labor and sub-contract resources and plant and equipment, appreciation of local climatic conditions, evaluating site conditions both above and below ground and realizing their possible implications upon construction and finally determining availability of space and access routes on site [8]. The CII identified that, following the Pareto Principle, the ability to influence cost reduces over the life of the project and that constructability saving should be investigated at various stages of the project life-cycle [1] namely,

- Conceptual planning
- Design and procurement
- Field operations

O’Connor and Davis (1988) in further research identified the constructability improvement that can be made during field operation. The first two – project team responsible for constructability are identified early on and the second, advanced information technologies are applied throughout the project for improvement at the conceptual planning phase while the third principle - Design and construction sequencing should facilitate system turn-over and start-up [9].

In other countries, the concept of buildability originated in the United Kingdom and is defined as the extent to which the design of a building facilitates ease of construction, subject to overall requirements for the completed building [10]. In Australia, the term of constructability and buildability are used interchangeably and the concept has been re-defined as the extent to which decisions made during the whole building procurement process, in response to factors influencing the project and other project goals, ultimately facilitates the ease of construction and the quality of the completed project or alternatively the integration of construction knowledge in the project delivery process and balancing the various project and environmental constraints to achieve project goals and building performance at an optimal level [11]. Based on the constructability concepts in many countries, Nima (2001) make a formula to utilities a study for constructability concept in 23 concepts for passes for constructions [12], as follows:

2.2.1. Project constructability enhancement during conceptual planning phase comprises of concepts C1 to C7

- Concept C1: The project constructability programme should be discussed and documented within the project execution plan, through the participation of all project team members.
- Concept C2: A project team that includes representatives of the owner, engineer and contractor should be formulated and maintained to take the constructability issue into consideration from the outset of the project and through all of its phases.
- Concept C3: Individuals with current construction knowledge and experience should achieve the early project planning so that interference between design and construction can be avoided.
- Concept C4: The construction methods should be taken into consideration when choosing the type and the number of contracts required for executing the project.
Concept C5: The master project schedule and the construction completion date should be construction-sensitive and should be assigned as early as possible.

Concept C6: In order to accomplish the field operations easily and efficiently, major construction methods should be discussed and analysed in-depth as early as possible to direct the design according to these methods.

Concept C7: Site layout should be studied carefully so that construction, operation and maintenance can be performed efficiently, and to avoid interference between the activities performed during these phases.

2.2.2. Project constructability enhancement during design and procurement phase comprises of concepts C8 to C15

- Concept C8: Design and procurement schedules should be dictated by construction sequence. Thus, the construction schedule must be discussed and developed prior to the design development and procurement schedule.
- Concept C9: Advanced information technologies are important to any field including the construction industry. Therefore, the use of those technologies will overcome the problem of fragmentation into specialized roles in this field, and enhance constructability.
- Concept C10: Designs, through design simplification by designers and design review by qualified construction personnel, must be configured to enable efficient construction.
- Concept C11: Project elements should be standardized to an extent that will never affect the project cost negatively.
- Concept C12: The project technical specifications should be simplified and configured to achieve efficient construction without sacrificing the level or the efficiency of the project performance.
- Concept C13: The implementation of modularization and preassembly for project elements should be taken into consideration and studied carefully. Modularization and preassembly design should be prepared to facilitate fabrication, transportation and installation.
- Concept C14: Project design should take into consideration the accessibility of construction personnel, materials and equipment to the required position inside the site.
- Concept C15: Design should facilitate construction during adverse weather conditions. Efforts should be made to plan for the construction of the project under suitable weather conditions; otherwise, the designer must increase the project elements that could be prefabricated in workshops.

2.2.3. Project constructability enhancement during field operations phases on concepts C16-C23

- Concept C16: Field tasks sequencing should be configured in order to minimize damages or rework of some project elements, minimize scaffolding needs, formwork used, or congestion of construction personnel, material and equipment.
- Concept C17: Innovation in temporary construction materials/systems, or implementing innovative ways of using available temporary construction materials/systems that have not been defined or limited by the design drawings and technical specifications will contribute positively to the enhancement of constructability.
- Concept C18: Incorporating innovation of new methods in using off-the-shelf hand tools, or modification of the available tools, or introduction of a new hand tools that reduce labour intensity, increase mobility, safety or accessibility will enhance constructability at the construction phase.
- Concept C19: Introduction of innovative methods for using the available equipment or modification of the available equipment to increase their productivity will lead to a better constructability.
• Concept C20: In order to increase the productivity, reduce the need for scaffolding, or improve the project constructability under adverse weather conditions, constructors should be encouraged to use any optional preassembly.
• Concept C21: Constructability will be enhanced by encouraging the constructor to carry out innovation of temporary facilities.
• Concept C22: Good contractors, based on quality and time, should be documented, so that contracts for future construction works would not be awarded based on low bids only, but by considering other project attributes, i.e. quality and time.
• Concept C23: Evaluation, documentation and feedback of the issues of the constructability concepts should be maintained throughout the project to be used in later projects as lessons learned.

Many processes of constructability implementations for construction [13], followings:
• Organizing the design team
• Collecting data
• Identify the constrains
• Developing program
• Framing options evaluation
• Developing preliminary design
• Checking of options
• Final design process
• Developing bid package
• Procedure of bidding
• Procedure of fabrications
• Installation process

2.3. Construction Process in Indonesia
The implementation of the construction process in Indonesia cannot be separated from several stages that must be passed, both from the beginning of the design to the implementation and the end of the construction work. Of all these processes, of course, have a goal of good quality. In order to achieve the planned quality, construction projects should be carried out through systematic steps by combining several aspects. Providers of construction services especially for state buildings according to PERMEN PUPR No 22 Tahun 2018 [14], follow of:
• Construction planning service provider
• Provider of construction implementation services
• Provider of construction supervision services
• Provider of construction management services

Based on PERLEM LKPP No 7 Tahun 2018 regarding procurement planning activities, including goods services procurement activities [15]:
• Procurement Planning starts from the identification of the needs of goods / services based on the Work Plan of the Ministry / Institution / Regional Apparatus.
• Procurement Planning becomes input in the formulation of Work Plans and Budgets of Ministries / Institutions (RKA-K / L) and Work Plans and Budgets of Regional Apparatus (RKA of Regional Apparatus).
• Procurement Planning whose funds are sourced from the State Budget (APBN) is carried out in conjunction with the RKAK / L preparation process after the establishment of the Indicative Ceiling.
• Procurement Planning whose funds are sourced from the Regional Revenue and Expenditure Budget (APBD) carried out in conjunction with the preparation of the Regional Budget Work
Plan after the memorandum of agreement on the APBD General Policy and the Priority and Provisional Budget Ceiling (KUA-PPAS).

The procurement of product/services should be carried out through an identification mechanism to the needs. The identification of goods and services needs is carried out by taking into account the following aspects:

- the principle of efficient and effective procurement of goods / services
- aspects of sustainable procurement
- needs priority assessment
- product / services in the electronic catalog
- consolidation of procurement of product / services; and / or
- product / services that are available / owned / controlled.

Some of the aspects above can be implemented in the process of procurement of products / construction services. Related to construction services, procurement is carried out through several activities. Planning activities include:

- preparation of technical specifications / TOR
- preparation of estimated costs / Budget Plan (RAB)
- the procurement of products / services
- consolidation of procurement of products / services; and
- supporting costs.

Procurement of products and services can be done through a mechanism in the following flow:

![Diagram of procurement process]

**Figure 1. Procurement product and service**

Related to construction project work, the flow of goods / services procurement is marked by a construction work contract [16]. Types of extracts for construction work consist of:

- Lump sum
- Work Prices Unit
- Combined lump sum and Unit Price for the job
- Turnkey
- Umbrella contract

To be able to contract in construction work, each construction work service provider must meet the technical qualification requirements which include:

- Experience of at least 1 (one) job in the last 4 (four) years, including experience of subcontracting except for Providers who have only been established for less than 3 (three) years.
- Have the Basic Ability (BA) for work that is intended for Medium Enterprises and Large Enterprises with a BA value equal to 3 NPt (the highest experience value) on subclassifications,
types of work, and/or key activities (major items) in accordance with the requirements in a 
period of time Past 10 years

- Have at least:
  - 1 (one) Skilled Certified Permanent Personnel (SKT) in accordance with the required 
    SBU Classification (For Small Businesses)
  - 1 (one) Permanent Expert Certified (SKA) in accordance with the required SBU Sub-
    Classification (For Medium and Large Enterprises) (selected according to the required 
    Qualifications)
- experience in similar work in the past 10 years with a weight of 25-40%
- appropriateness of the value of similar work in the last 10 years that has been completed with 
  the value of the work to be competed with a weight of 35-45%
- work experience in the past 10 years in the same location at the Provincial or District / City level 
  (selected) with a weight of 20-30%

2.4. Constructability Concepts for Project Construction In Indonesia

Based on Fischer and Tatum, 1997, constructability is the significant objective in construction projects
[17]. Therefore we need in-depth knowledge of the concept of constructability as a basis in construction.
There is a classification for knowledge of constructability theory to improve project performance:
application heuristics, layout knowledge, dimensioning knowledge, detailing knowledge, and exogenous knowledge
[18].

Constructability concepts for project construction in Indonesia can be done by considering related matters. The existence of owners from the government and the private sector can certainly show the difference in the application. But in general the concept of constructability implementation can be equally applied by maximizing the role of the owner's role. According to Trigunarsyah (2006) examined the role of clients. Clients have the authority in enforcing implementation therefore their role in constructability improvement is most important. The paper describes how construction project owners integrate construction knowledge and experience in planning and design in existing practice. The research was carried out by means of case studies of some notable projects in Indonesia. The results shows that project owners in Indonesia do have some understanding of the importance of constructability. The selection of project delivery method determined the type of constructability input for the respective projects.

Considering this, the implementation of constructability concepts for project construction in Indonesia can be implemented by combining the concepts of constructability and procurement construction services. Implementation of constructability concepts in Indonesia can follow the purpose of constructability [19], following items:
- Fault of design either dimension or select materials indistinct features
- The specifications of the Project will be difficult or high cost to construct based on design
- Exceeding the project features in the capability of industry to properly build
- Project properties that are difficult to understand and also are hard to correctly bid

3. Conclusion

This paper has discussed the concepts of Constructability which can be applied in Indonesia. The results of the study of several articles above can be concluded that:
- The concept of constructability that can be applied in Indonesia can refer to the concept of constructability that has been agreed upon in general.
- The concept of constructability can be combined with several methods of procurement of product / services construction available in accordance with applicable regulations in Indonesia.
- Knowledge of the concept of constructability needs to be conveyed in depth to all construction service performer, including the owner, contractor, consultant and other parties related to construction project work.
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