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# IMPLEMENTATION OF CONSTRUCTABILITY CONCEPTS IN CONSTRUCTION PHASE IN NORTHERN REGION

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## ABSTRACT

*The concept of constructability in the United States or buildability in the United Kingdom emerged in the late of 1970s, which evolved from studies into how improvement can be achieved in overall project objective. It is an approach that links the design and construction process. The summary of definition of constructability is the opportunity in maximizing the use of construction knowledge and experience in planning, engineering, procurement and field operation to achieve overall project objectives. Constructability is use as one of the solution for the many problems that occurs in construction industry such as substantial numbers of changes, poor planning, cost overruns, wastage of materials, poor safety practiced and time delays. The objective of this research is to study constructability concepts in construction project, to identify the level of importance of constructability concepts in construction projects and to identify the level of application of constructability in construction project. It is focused on the construction player in Northern Region. The data were collected by distributing the questionnaire to the construction management player. The data were analyzed using SPSS and average index. From the findings it is found that the first three importance concept are 'Carry out Through Investigation of the site', 'Involves Construction Knowledge and Experience' and 'Site Layout Promote Efficient Construction'. Besides that the levels of importance of constructability concepts are conclude as important since averagely 15-40% of the respondents agreed on its importance. While the level of application is intermediate since the respondents who said it is high application is averagely 15-40%.*

## INTRODUCTION

### Definition of Constructability

Constructability is described as the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives (Constructability, 1986). The Construction Industry Institute (CII) base on in Austin, Tex., defines constructability as ñthe opportunity for maximizing the use of construction knowledge and experience in planning, engineering, procurement and field operation to achieve overall project objectives.ò Constructability is the application of sequencing, scheduling and constraint evaluation to the building of physical structures (Yu and Skibniewski, 1997).

Many studies of construction practice have reviewed the implication of inadequate design and production method within both traditional and non-traditional construction and in variety of type of building. There are many problems will caused by unclear and missing project information, inadequacies in the quality of information provide or lack of complete information and lack of co-ordination of design with construction.

Constructability remits aims to improve the integration within the total construction process of those parties that combine to procure, brief, design, construct, use and maintain the

building or engineering product. Moreover as a concept it seeks to interrelate the various separate phases of construction to produce a set of principle that are implied and accepted and apply constructability thinking to each stage for the benefit of the whole process (Griffith and Sidwell, 1995).

During construction phase constructability is focus and responsibility of the contractor. The responsibility for ensuring that general principles of constructability will be implementing also carried out by the subcontractors and other providers of specialist inputs to the process. The key to effective and efficient constructability on site is good planning, adequate resource and continuous control which add up to good general site practice (Griffith and Sidwell, 1995).

**Constructability Concepts in Construction Project**

Concept is a significant, distinct and executable objective for enhancing constructability. Concepts are not specific or unique with respect to project type or organization. It presents a desperate need and requirement to improve the construction project constructability. (OôConnor et al., 1987) OôConnor et al. also have presented and analyzed seven concepts for improving constructability during the engineering and procurement phases of the project with some applications of each concept. These concepts promote construction-driven schedules, simplified design configurations, standardization of elements, and module/preassembly design, which can facilitate fabrication, transportation, and installation. These concepts also address the accessibility of manpower, materials, and equipment to facilitate construction in adverse weather and specifications improvement

From the study that has been done by Rosli Mohamad Zin (2004), there are eighteen concepts for the design phase which are:

a) Carry Out Thorough Investigation of the Site

Constructability is improved when the information gathered from site investigation is thorough and complete. In This context CIRIA (ñBuildability: An Assessmentò 1983) recommended that site condition and other circumstances are needed to investigate thoroughly to avoid subsequent expensive delays and alteration after construction commenced.

b) Design for Minimum Time Below Ground

Constructability is improved when the design minimize work below ground. According to Adams (1989) when the ground is hazardous, poor or wet, it will facilitate the speed and flow of the project to minimize the amount of time taken by work in the ground.

c) Design for Simply Assembly

Constructability is improved when designs are simplified and configured to enable efficient construction. Adams (1989) mentioned that designer should endeavor to produce the simplest possible details compatible with the overall requirement for building, particular element or group elements. This open the way to efficient, defect free work that will satisfactorily perform its end function.

d) Encourage Standardization/Repetition

OôConnors et.al (1987), stated that the standardization of component is based on recognition that savings can be realized when the number of variation of component is kept minimum.

e) Preassembly and/or Modularization of components

Preassembly is a process by which materials, prefabricated components and equipment are joined together at a remote location for subsequent installation as a unit. Preassembly often involves decoupling sequential activities into parallel activities; and A module is a product resulting from a series of remote assembly operation; it is usually the largest transportable unit or component of a facility. Modules may contain prefabricated components or preassemblies and are usually constructed away from the job site.

f) Analyzed Accessibility of the Jobsite

The effect of accessibility can sometimes be quite serious such as delay in progress, slowed productivity and increased damaged to completed work.

g) Employ Any Visualization Tools to avoid Physical Interference

Constructability improved when visualization tools are employed to visualize any possibility of physical interference during construction. Ghanah et.al (2000) highlighted that computer visualization allows investigations to iron out difficulties that may occur before construction commences on site.

h) Investigate Any Unsuspected Unrealistic or Incompatible Tolerance

Particular attention should be given to the problems of fit which occur at the interfaces between different products, methods of construction, materials and method of manufacture, and suitable jointing methods should be adopted.

i) Investigate the Practical Sequence of Construction

Constructability is improved when adequate consideration of practical sequence of construction is given. The method of construction of project should encourage the most effective sequence of building operations. Simple sequences enable each operation to be completed independently and without interruption. The sequence should assist the coordination or trades and minimized delay.

j) Plan to Avoid Damaged to Work by Subsequent Operations

Constructability is improved when the damage to work by subsequent operation is considered. The design should enable work to be carried out in a workmanlike manner without risk of damaged to adjacent finished elements and with minimum requirement for special protection.

k) Consider Storage Requirement at the Jobsite

Constructability is improved when storage requirement is adequately considered. Consideration should be given during the design stage to be location the material storage and unloading facilities.

l) Investigate the Impacts of Design on Safety During Construction

Constructability improved when the design on safety during construction is adequately considered. The design produced by the designers should enable the contractor to carry out their work in safe manner.

m) Design to Avoid Return Visit by Trade

Constructability improved when the design enable a trade or specialist to complete all its work at a site with a few return visit as possible.

n) Design for the skills and Resources Available

Constructability is improved when the technology of the design solution matched with the skills and resources available. Adams (1989) highlighted that any design is only good as the skill available to execute it ether off-site or on-site. Design must include a realistic assessment of the levels of skill likely to be available from appropriately chosen contractors and specialist.

o) Considered Suitability of Designed Materials

Constructability is improved when suitable and robust materials are used. According to Adams (1989), the product and materials should be carefully selected and must be proven to be suitable

for the use for which they are selected. Product and materials should be selected with utilize normal site assembly methods and sequences. Care should be taken to ensure the manufacturerôs recommendation on handling, storage, application, assembly and protection can be complied with.

p) Provide Detail and Clear Design Information

Constructability improved when thorough and clear presentation of design information before the start of construction. Sufficient time and resources must be allowed for this in design budget. Complete project information should be planned and co-ordinate to suit the construction process and to facilitate the best possible communication and understanding on site.

q) Design for Early Closure

Constructability improved when the design enables early closure of the constructed. Adams (1989), stated that the construction and detailing of a building shell should facilitate the enclosure of the building at the earliest possible stage so following operation can be carried out without hindrance from the weather.

r) Consider Adverse Weather Effect in Selecting Materials or Construction Methods.

Constructability is improved when the effect of adverse is considered. Project constructed in localities where weather conditions are adverse present a great challenge to both designer and constructor.

## RESEARCH METHODOLOGY

### Questionnaire

The questionnaire is created from the study based on Constructability Guidelines and the constructability concepts for the construction phase. For this study, only fourteen concepts that related to the construction field has been identified. The first part consists of the background of the respondent such as the engineering field, year of experience and etc. The second part consist of presenting one constructability concepts in construction project and each requiring only one choice to be made out of five; Very Important, Important, Moderate, Little Important and Not Important. The third part was formulated to collect information regarding the rate of application of each constructability concept in construction project. The respondent would be asking to evaluate the degree of application of constructability concept by choosing one of the following answers; High Application, Medium Application, Little Application and Not Applied At All. The researcher was produced 70 questionnaires then distributed to the potential respondent in Northern Region .The questionnaires were distributed to the construction player and were selected randomly that represent the owners, consultants and contractors. The number of questionnaire returned back to the researcher is 42.

### Analysis

The data that collected were analyzed using the Statistical for Social Science (SPSS) program version 11.0. Frequency analysis is obtained from the SPSS output and average index method is adopted for analysis from the result of frequency analysis. The frequency and the percentage will be representing in the form of table, bar chart and pie chart.

**Average Index**

From part two and part three of the questionnaire the respondents were asked to evaluates the level of important and the level of application of the constructability concepts in construction projects.
The classifications of the rating scale proposed by Abd Majid (1997) were as follows:

ñVery Satisfyò 4.50 < Average Index < 5.00
ñSatisfyò 3.50 < Average Index < 4.50
ñFairò 2.50 < Average Index < 3.50
ñLess Satisfyò 1.50 < Average Index < 2.50
ñNot Satisfyò 1.00 < Average Index < 1.5

## RESULT AND DISCUSSION

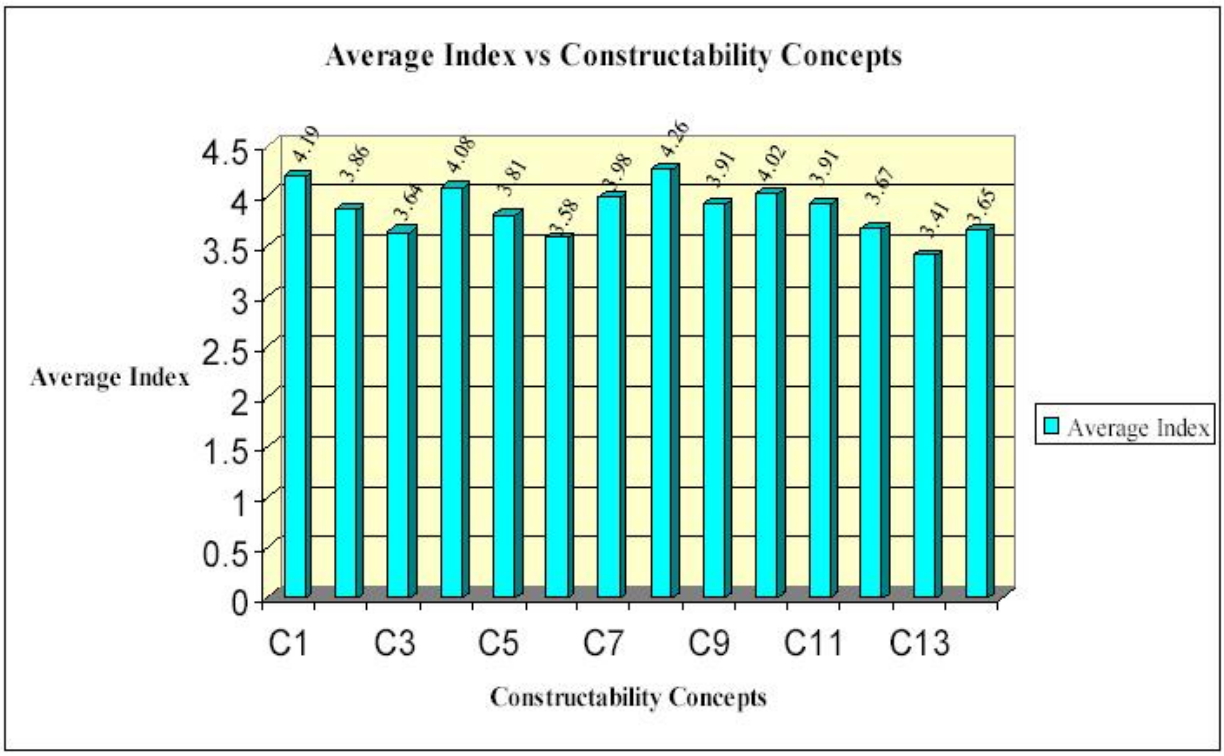
For this study, 14 concepts have been identified that related to the construction phase. Table 1 and 2 shows the result from analysis using SPSS.

**Table 1**: Constructability Concepts due to Respondentôs Opinion based on highest percentage of `Very Important`

| Constructability Concepts in Construction Project | Percentage |
|---|---|
| Plan to Avoid Damaged to Work by Subsequent Operations | 38.1 |
| Involves Construction Knowledge and Experience | 35.7 |
| Carry out Thorough Investigation of the site | 31.0 |
| Project Schedule is Construction sensitive | 31.0 |
| Preassembly and Modularization of Component | 28.6 |
| Minimize Time Below | 26.2 |
| Investigate the Practical Sequence of Construction | 26.2 |
| Project Team Participants Responsible are Identified Early On | 26.2 |

| | |
|---|---|
| Encourage Standardization/Repetition | 23.8 |
| Site Layout Promote Efficient Construction | 23.8 |
| Analyzed Accessibility of the Jobsite | 19.0 |
| Consider Storage Requirement at the Jobsite | 16.7 |
| Advanced Information Technologies are applied | 14.3 |
| Consider Adverse Weather Effect in Construction | 14.3 |

From the table it can be seen that the highest percentage of constructability concepts based on percentage of ñVery Importantò value is óPlan to Avoid Damaged to Work by Subsequent Operationsô and ñNot Importantò is óConsider Adverse Weather Effect in Constructionô. From the results above, it can be conclude that all the 14 constructability concepts are important because there are only one concept is moderate.




C1 Carry out Through Investigation of the site

C2 Minimize Time Below
C3 Encourage Standardization/Repetition
C4 Preassembly and Modularization of Component
C5 Analyzed Accessibility of the Jobsite
C6 Investigate the Practical Sequence of Construction
C7 Plan to Avoid Damaged to Work by Subsequent
C8 Involves Construction Knowledge and Experience
C9 Project Schedule is Construction sensitive
C10 Site Layout Promote Efficient Construction
C11 Project Team Participants Responsible are Identified Early On
C12 Advanced Information Technologies are applied
C13 Consider Storage Requirement at the Jobsite
C14 Consider Adverse Weather Effect in Construction

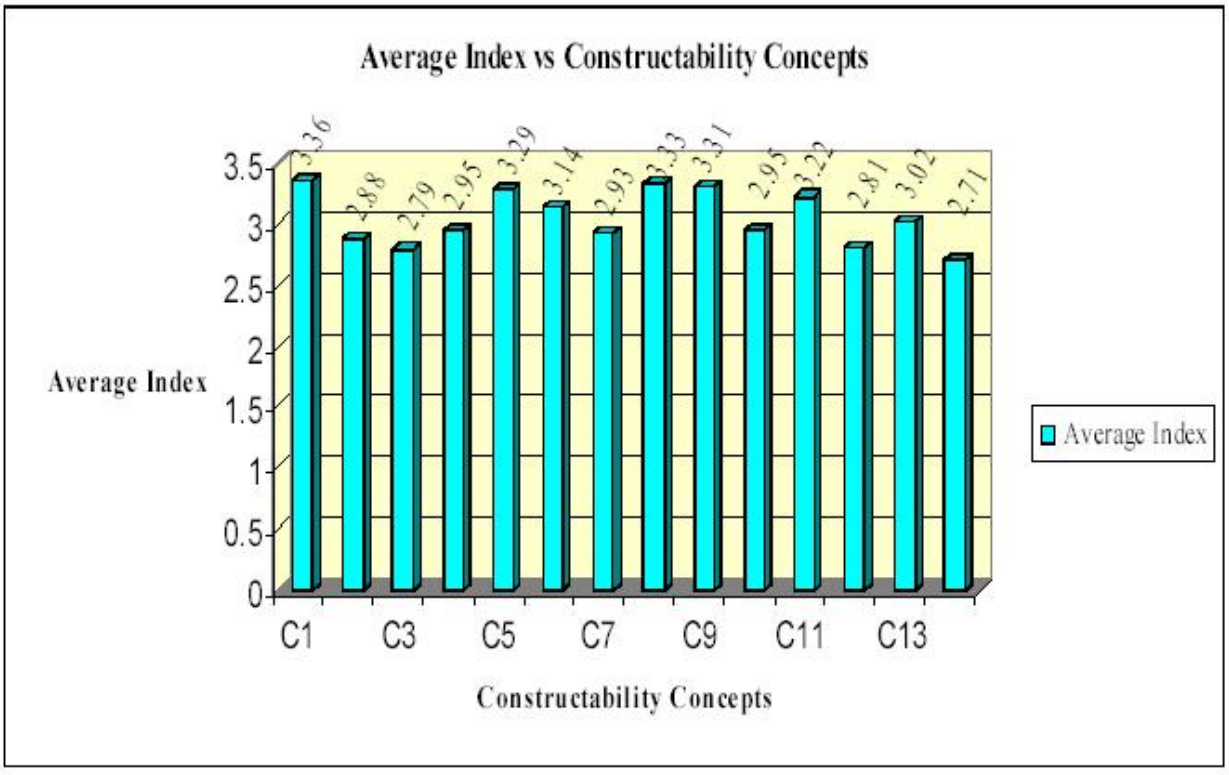
Based on the both of the bar charts that have been plotted for the frequency analysis and average index, it can be concluded that the most important concepts is ôInvolves Construction Knowledge and Experienceô. And from the expert interview with the two experienced engineer, this concepts must be alert among contractors and consultant to avoid any mistake during construction. The respondents were asked to evaluate the degree of importance of constructability concepts in construction projects. The results that were obtained are shown that all of the constructability concepts are important and the construction management teams are understand about these concepts.

**Table 2**: Constructability Concepts due to Respondentôs Opinion based on high application

| **Constructability Concepts in Construction Project** | **Percentage** |
|---|---|
| Carry out Through Investigation of the site | 40.5 |
| Project Schedule is Construction sensitive | 40.5 |
| Involves Construction Knowledge and Experience | 35.7 |
| Analyzed Accessibility of the Jobsite | 33.3 |
| Site Layout Promote Efficient Construction | 33.3 |
| Project Team Participants Responsible are Identified Early On | 31.0 |
| Investigate the Practical Sequence of Construction | 26.2 |
| Plan to Avoid Damaged to Work by Subsequent | 26.2 |

| Constructability Concepts in Construction Project | Percentage |
|---|---|
| Operations | |
| Advanced Information Technologies are applied | 21.4 |
| Consider Adverse Weather Effect in Construction | 19.0 |
| Minimize Time Below | 16.7 |
| Encourage Standardization/Repetition | 16.7 |
| Preassembly and Modularization of Component | 14.3 |
| Consider Storage Requirement at the Jobsite | 14.3 |

From the graph and tables it can be seen that the highest percentage of constructability concepts based on percentage of ñHigh Applicationò are óCarry out Through Investigation of the siteô and lower percentages for ñHigh Applicationò is óConsider Storage Requirement at the Jobsiteô.




C1 Carry out Through Investigation of the site

C2 Minimize Time Below
C3 Encourage Standardization/Repetition
C4 Preassembly and Modularization of Component
C5 Analyzed Accessibility of the Jobsite 6 Investigate the Practical Sequence of Construction
C7 Plan to Avoid Damaged to Work by Subsequent
C8 Involves Construction Knowledge and Experience
C9 Project Schedule is Construction sensitive
C10 Site Layout Promote Efficient Construction
C11 Project Team Participants Responsible are Identified Early On
C12 Advanced Information Technologies are applied
C13 Consider Storage Requirement at the Jobsite
C14 Consider Adverse Weather Effect in Construction

Based on the bar charts that have been plotted for the frequency analysis and average index, it can be concluded that the high application of constructability concepts in construction projects is óCarry Out Thorough Investigation of the Siteô the respondents were asked to rate the degree of application of the all 14 constructability concepts in construction projects. These concepts were categorized in medium application. This shown that the construction management team was applied the constructability concepts in their projects but not fully applied. So the construction management teams do not really aware that constructability concepts can give more benefit to their projects but they know that this concepts is important.

## CONCLUSION

Based on the findings of this study which is the data are analyses to obtain the frequency analysis and the average index and also from the literature review it can be conclude as follows: From the literature review, fourteen important constructability concepts are relevant and applicable in construction projects. These concepts are important to ensure the construction activities are smoothly and progress in well with minima delays of work and give better value of money to the clients. The concepts are found as follows:

a) Carry out Thorough Investigation of the site
b) Minimize Time Below
c) Encourage Standardization/Repetition
d) Preassembly and Modularization of Component
e) Analyzed Accessibility of the Jobsite
f) Investigate the Practical Sequence of Construction
g) Plan to Avoid Damaged to Work by Subsequent Operations
h) Involves Construction Knowledge and Experience
i) Project Schedule is Construction sensitive
j) Site Layout Promote Efficient Construction
k) Project Team Participants Responsible are Identified Early On
l) Advanced Information Technologies are applied
m) Consider Storage Requirement at the Jobsite
n) Consider Adverse Weather Effect in Construction

From the result analysis that has been done, there are variations on percentage of respondentôs opinion on importance of constructability concepts. Averagely, 15 ï 40% of respondents agreed on importance of constructability concepts that included in questionnaire. ôPlan to Avoid Damaged to Work by Subsequent Operationsô and Involves Construction. Knowledge and Experienceô are the most important concepts that agreed by the highest percentages of respondents. For overall, level of constructability concepts importanceôs are intermediate since averagely 15 ï 40 % of respondent agreed on its importance.

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