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# A TECHNICAL STUDY ON ENHANCEMENT OF ABILITY OF CONSTRUCTION MANAGEMENT IN CONSTRUCTION SECTOR

**[1]DUDDELA NAVEEN KUMAR**

[1] M.Tech Student, Dept. of Civil Engineering in Global College of Engineering and Technology, Rayalapanthulapalle, KADAPA, AP.

**[2]NADENDLA RAFI**

[2]Assistant professor, Dept. of Civil Engineering, Global College of Engineering and Technology, Rayalapanthulapalle, KADAPA, AP

**ABSTRACT:**

Ability of construction or architectural ability is the proper usage of construction knowledge and experience in conceptual planning. The construction industry is the largest industry with many problems. One such issue is structuralism, which is a management tool to optimize architectural knowledge and experience at different stages of the project to achieve overall goals. It is developing as one of the most important considerations for project participants, i.e. clients, architects / designers, constructors / contractors and consultants. This documentation is an overview of the structural concept of various researchers. It also discussed the concept among project participants, its benefits, barriers and the need to implement a level of awareness. Construction, if involved in construction projects, can lead to a significant reduction in costs in the early stages and save the country's economy. Reinvention in the process of construction is important factor to improve productivity. This Reinvention refers to the discovery of sophisticated materials and equipment as well as the development of new operating systems for construction projects. Inadequate application of advanced technology can disrupt the operating system.

The purpose of this thesis is to clarify the application of constructional concepts in the design process by providing a relevant case study of a three-story residential building. It was found that the building capacity of the building needed to be improved by accurately calculating the building capacity and then comparing the current standards of construction capacity. Thus, constructional concepts were applied and it was found that if the concepts were implemented during the design phase, the building efficiency of the building would be improved. This thesis concludes with a guide showing relevant suggestions for improving the enhancement of constructional concept.

## I. INTRODUCTION

This research project addresses highway project constructability concerns related to specifications. This one aspect of a highway project constructability study that is being funded by the Texas State Department of Highways and Public Transportation (SDHPT).

The highway project constructability study has been delineated into a number of critical issues for investigation. A study on the issue of pre-construction highway project planning and design was completed in 1988. It served as a pilot study of highway constructability and although no formal report was published, the feasibility of the research methodology was established. In particular a system for logically reviewing constructability concerns was developed. The essence of the findings together with a broad overview of constructability has been published in Highway Constructability Guide (Hugo et al, 1989) which is intended for the information of senior personnel of the Divisions and Districts of the Texas State Department of Highways and Public Transportation.

Concurrently with the pilot study, a study was undertaken of specification improvements that would enhance constructability. This research report completes the study on the issue of specifications.

### OBJECTIVES OF RESEARCH

The prime objective of the study was to enhance constructability by improving specifications. In order to achieve this, the following tasks were identified:

(1) Determine specific problems with specification items and categorize these under appropriate problem types.

(2) Determine the most significant problem types of the specification items with the use of cross classification tables.

(3) Propose recommendations to correct each problem contained in the specification problem mformauon base (SPIB).

(4) Determine the potential causal constructability factors for each problematic specification item contained in SPIB.

(5) Critique and propose recommendations for improving the specification rewrite and updating process.

## OUTLINE OF RESEARCH REPORT

Tradesmen and professionals are technical experts in their respective field and must therefore be allowed to improve constructability through their suggestions, reviews and request for material and methods substitution. Achieving constructability objectives is the responsibility of all project participants and the implementation of its principles cannot be successful without the possession of technical skills by the project team members and the establishment of strong communication routines among project parties (Othman, 2011). According to Highway Constructability Guide (1990), the nature of the construction operation and the higher performance expectations by the clients necessitated the pursuance and enhancement of constructability during the planning and execution of projects; and also, a proactive approach to constructability needs to be taken including greater participation of project parties. Chua (2003) noted that it is important that constructability principles become an integral part team members because constructability enhancement is multidisciplinary and multifaceted and means different things to the project team; and also because the efficiency and effectiveness of construction can only be improved on site through task sequencing, innovative use of resources and equipment.

Constructability input in project design includes knowledge of local factors and site conditions that can influence the choice of construction methods, design and feasible schedule; and only the selection of experienced team members with team working skills and openness to new ideas gives chance for implementation and enhancement of constructability (Construction Industry Institute, 2012; Chua, 2003). A lot of works have been done on the implementation and enhancement of constructability during the design stage. However, few studies have been done related to constructability enhancement during the actual construction stage by the construction team members. Therefore, this study aims to study constructability concepts and enhancement capabilities of construction site team members. In order to achieve this aim, the following objectives would have to be accomplished: identification of applicable constructability concepts on construction sites by the site team members, examination of the technical capabilities of construction site team members, examination of the capabilities of construction site team members to enhance constructability, and assessment of ways of enhancing constructability on construction sites.

Construction industry is one of the biggest industry in the world and contributes towards the GDP (gross domestic product) of the country. The construction industry creates huge infrastructural facilities for the masses to use and enjoy. It generates employment opportunities for the communities. On the other hand it is the biggest source of creating pollution and exhausting the non-renewable resources of energy. It generates waste and has heavy impact on the environment. The Construction sector is responsible for 50% of material resources which are taken from nature. It is also responsible for 40% of energy consumption and 50% of waste generated (Anink et al. 1996). The management of practices in construction industry is also responsible to great extent for the environmental and sustainability related problems. Over the years, the design, construction and management practices have changed in the industry, thus setting up challenging situations for the participants. There is an emergent need to study and focus on certain areas and concept of management, which can enhance the construction processes by bridging up the gap between key participants: the client, the designer, and the constructor. Constructability has evolved as one such management tool, which can save time, money, reputation and can aid with a lot many tangible and non-tangible benefits, when applied at the right time. Constructability is still not a very popular concept amongst the participants, and has not even reached the developing countries, as it should have been. There is a need to understand the concept, its practices, benefits and barriers, so that proper and timely implementation ispossible.

The construction industry is essentially a service industry whose responsibility is to convert plans and specifications into finished products, it is exceedingly complex and highly individual in character (Peurifoy and Ledbetter, 1985:3). Construction industry consumes large amount of energy, water, materials and land. This contributes to the exhaustion of natural resources and consumption of energy (Poon 2000, Shat et al. 2000).

Energy is consumed throughout the lifecycle of a building. During its construction phase, energy is consumed in the form of embodied energy and also by various equipment functioning on site, for the successful completion of the project. With the increasing desires of the society and the complexity of the projects, this energy is increasing at a fast pace. After the completion of the project, when it is handed over to the client, energy continues to be consumed in its running operations, in the form of various appliances. Janda and Busch (1994) have estimated that 57% of electricity used in the developed countries are consumed directly by buildings. Best (2001) has stated that building sector is responsible for one-third of energy usage in most of the countries.

## II LITERATURE REVIEW

### CONSTRUCTABILITY

Constructability may be defined as a measure of the ease or expediency with which a facility can be con· structed (Hugo et at, 1989). Constructability is enhanced by the optimum use of construction knowledge and experience in planning, design procurement, and field operations in achieving overall project objectives (Construction Industry Institute, 1986).

Perhaps because constructability is by nature multidisciplinary and multicontextural, it means different things to the various participants in a project. To the project owner, constructability affords the opportunity, on construction projects, for achieving greater efficiency, with resulting lower cost, reduced schedule, or improved quality.

To the designer, it is the understanding of the methods and constraints of the actual construction required to execute the design being made. To the constructor, it is a combination of effort required to implement the design most efficiently and the opportunity to minimize resource effort and expenditure.

The Construction Industry Institute (CII) has identified a number of constructability concepts applicable to the different phases of a project. Briefly, these concepts address project execution planning; conceptual project planning; specifications; contracting strategies; schedules; and construction methods, including those concerning preassembly, site layouts, design configurations, accessibility; and adverse weather (Constructability: A Primer, 1986). However, while constructability enhancement has been studied and applied to many segments of the industrial construction industry, it has not been researched in the context of highway construction.

## CONSTRUCTABILITY CONCEPTS FILE

The Concepts File is a publication based on the findings of research programs directed by the Construction Industry Institute (CII) Constructability Task Force. Thirteen concepts are contained in the file, along with sample applications of each. The concepts are divided into two groups based on their relation to a phase of construction. The two groups are the conceptual planning phase and the design and procurement phase. The Concepts File is not a "cook book," but it allows individuals to take advantage of the lessons learned by others and apply them in their organizations. "The primary purpose of the Concepts File is to stimulate thinking about constructability and how to make it work" (CII 1987(b)).

The conceptual planning phase involves the definition of functional and performance requirements, theevaluation of project feasibility, and the studying of criteria for preliminary engineering. The concepts contained in this phase are (CII 1987(b)):

It is apparent that Concept 11-4 is of particular interest to this research study because it corresponds with the objective of the research. This concept is concerned with the role of construction input in the development of specifications. Fabrication and construction efficiencies are greatly facilitated when constructability helps to produce specifications that are clear and complete. Several other considerations affect specification development along with constructability, such as reliability, maintainability, etc, but the most important one is constructability (CII 1987(b)).

## ROLE OF SPECIFICATION

The following are typical definitions of specifications:

"A specification is a precise statement describing the characteristics of a particular item" (CSI 1985).

"Specifications are written instructions used in conjunction with drawings to fully describe and define the work that is to be accomplished, along with the methods and quality that will be required" (Jellinger 1981). To this one should add that specified material is of the utmost importance, particularly in highway construction.

"Specifications are the written, technical, engineered portion of the construction contract documents" (ASCE 1988). Thus, specifications can be defined in many different ways with the same essential meaning. Likewise, the purposes of specifications are as widespread as their definitions. The following is a list of some purposes of specifications.

(1) Specifications are a guide for bidders in preparing their cost estimates upon which their proposals are based (Jellinger 1981).

(2) Specifications convey from the design engineer to the contractors specific technical information so that the required materials can be provided and construction can be performed and monitored. They describe the type and quality of materials, methods of construction, testing requirements, design submittals, and general requirements (ASCE 1988).

(3) Specifications form part of the agreement between the contractor and the owner. They are a book of instructions (Jellinger 1981 ).

(4) Specifications serve as the written record of construction instructions to the courts when specifications are in conflict with results (CSI 1985).

Of course specifications are also often employed to stipulate methods of quantity measurement and payment, particularly in highway construction.

## CRITIQUE OF SPECIFICATION TYPES

If the different types of specifications are considered it is apparent that:

(1) The intended purpose of the specification will determine which type is used in a particular instance.

(2) Each type of specification has its advantages and disadvantages.

(3) Guide specifications are probably most useful where specifications have been standardized and are available for a wide l3Dge of uses, each with varying parameters for the respective specification items. The onus is then on the user to complete the specification according to specific needs. When the end result cannot be adequately defmed, descriptive specifications are generally used. Likewise, when new products or processes are required and it is desirable for the contractor to provide creativity for the development, performance specifications are used (ASCE 1988). Bidding is more difficult with performance specifications because of the unknowns associated with developing a process, however, innovation highly favors performance. Descriptive specifications have an advantage with design control since each aspect of design is specified. Cost advantage varies, but for complex projects, performance specifications result in a lower total cost because the contractor is not restricted to a specific procedure. Testing and inspection is more difficult with performance specifications (ASCE 1988).

Descriptive specifications are the most commonly used type, but the advantages and disadvantages of each type must be examined when selecting the best one to use on a particular project.

The FHWA has developed a procedure to determine the acceptance level of a material for certain performance specifications. When specifications provide for material to be tested on a statistical basis, the material will be evaluated for acceptance accordingly. All test results for a lot of material will be analyzed by the Quality Level Analysis-Standard Deviation Method to determine the total estimated percent of the lot that is within specification limits. Quality Level Analysis is a statistical procedure for estimating the percent compliance to a specification and is affected by shifts in the arithmetic mean and by the standard deviation. Analysis of each test parameter will be based on an Acceptable Quality Level (AQL) of 95.0 and a producer's risk of 0.05. AQL is the lowest percent of specification material that is acceptable as a process average. The producer's risk is the probability that when the contractor is producing material at AQL, the materials will receive less than a 1.00 pay factor. As an incentive to produce quality material, a pay factor may be obtained that is greater than 1.00, up to a maximum of 1.05 (U.S. DOT-FHWA 1985).

## III METHODOLOGY

### .RESEARCH METHODOLOGY FLOW CHART

A flow chart, graphically illustrates the procedures employed in conducting the research. Each box represents a logical step in the research process which culminated with a final report to the Texas State Department of Highways and Public Transportation.

The first step of the process was the steering committee scoping which started with a meeting on December 11, 1987. The meeting allowed for the statement of objectives of the highway project constructability study, as well as a discussion of the topics that influence highway constructability. The topics that subsequently were identified to form part of the study are:

(1) Planning and design guidelines for enhanced highway construction,

(2) Specification improvements for enhanced highway constructability,

(3) Effective communication of constructability,

(4) Selection, processing and management of materials,

(5) Constructability enhancement through innovation,

(6) Facilitating construction under traffic,

(7) Facilitating future expansion and upgrade,

(8) Optimal utilization of plant and equipment,

(9) Optimal risk/responsibility allocation, and

(10) Constructability program implementation.

The decision to embark on the specification study was based upon an evaluation of the relative criticality of the topics, which selected specifications as being of major importance. This was further endorsed by the present revision of specification which is being undertaken by the Department

A questionnaire (see Appendix A) that contained the basic critical issues as well as subtopics of the issues was distributed to the steering committee members for their evaluation. The questionnaire allowed for the addition of new problem issues and provided for the prioritization of topics included in the research study.

### PURPOSES OF DATA ANALYSIS

Data analysis is a very critical part of any research study. Collected data have to be presented in an organized format so that they can be interpreted and understood. Once the organized format has been achieved, the data can be analyzed to satisfy the purposes of the research study. This particular research study had several purposes of data analysis.

One purpose of data analysis was to determine the primary potential causal constructability factors for the problem specification Items that were established. For each specification Item that is contained in SPIB, potential causal constructability factors were listed to determine potential causal relationships between problems and related attributes. This information was tabulated to determine the primary factors and where the emphasis should be placed in correcting the problems. Other reasons for analysis included the determination of the major problem types associated with specifications and the determination of the most problematic element~ of highway construction, as well as their frequency of occurrencewith problem specification Items. The problem types were established from the questionnaires given to the members of the steering committee. From the analysis performed, the problem types causing the greatest impact could be determined and studied. Likewise, the elements of highway construction causing the most problems could be identified from the data analysis. The data analysis also allowed the observation of the frequency of occurrence of different problem types with the related elements of highway construction. This identification allows for future effort to be concentrated in those areas of construction with the most problems.

### POTENTIAL CAUSAL CONSTRUCTABILITY FACTORS

Potential causal constructability factors were determined for every Item contained in SPm for the purpose of data analysis. The constructability factors that were chosen for an Item were determined by seeing which factors appeared to be causing the problem associated with the specification Item. Only the three factors impeding constructability. the most, were identified. Once the factors had been determined, they were used in the cross classification tables to help with the analysis of the research study. In this way it was possible to determine to what extent constructability could be enhanced by making specification improvement.

Six major categories of constructability factors were established for the purposes of this research study. The categories are project scoping, resources, processes and methods, controls, information and communication, innovation and environmental systems. Each major category was broken down into more detailed factors which were stated along with the associated major category for each Item contained in SPIB. However, due to the large number of constructability factors, only the major categories were used for the purpose of analysis. Gives a complete listing of the constructability factors which were considered in the compilation of SPIB.

## IV RESULTS AND ANALYSIS

### ANALYSIS BY HIERARCHY OF OBJECTIVES TECHNIQUE (HOT DIAGRAM)

The Hierarchy of Objectives Technique (HOT) is another insightful method of analysis for exploring both high-order and low-order managerial or technical objectives (Fisher 1989). HOT diagrams offer a particularly effective way of communicating the complex and detailed hierarchy of objectives supportive of improved specifications for constructability. Figure illustrates the logic use for the HOT diagram. It can be seen that there are a number of basic tiers. These are: objectives, constraints, tactics and solutions or stated otherwise, concern, problems, ideas and solutions. The objective (concern) is established on the left side of the diagram, and it is constrained by problems that must be solved to appease theconcern. Next, the problems generate ideas which in turn generate solutions for the problems).

Diagram interpretation is thus rather simple. Highorder objectives are listed on the left side of the diagram and low-order objectives or tactics are listed on the right side. The technique possesses a dual system of logic. As one reads from left to right the diagrams address "how?" or the manner of achieving objectives. The "why?" or motivation for objectives or tactics is provided as one reads from right to left. HOT diagrams have proven to be a very effective device for eliciting, structuring, and communicating knowledge.

The following example will demonstrate how the logic of these diagrams works. The primary concern may be to enhance constructability through improved specifications, and a major problem with this concern is to eliminate gold-plated specifications. This problem may be addressed by using the idea of not performing excessive work for aesthetic purposes, and a specific solution may be to eliminate the painting of bridgework below the ground line. This same logic can be applied to any part of the diagram. A HOT diagram is thus an effective method for generating possible ideas and solutions for constructability concerns. Figure 4.2 shows a HOT diagram that was developed from the information contained in SPIB to show in a logical manner how constructability can be enhanced through specification improvements. The HOT diagram in effect summarizes the options which need to be considered for addressing the various problems which were identified in this study.

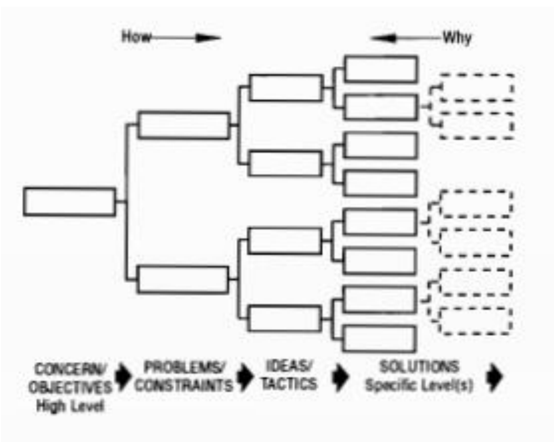


**Fig I. Constructability Hot Diagram Logic**

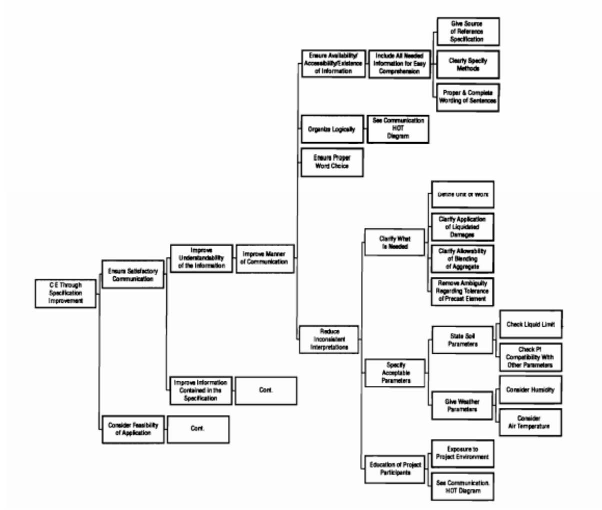

**Fig II. Constructability Enhancement through Specification Improvement Hot Diagram.**

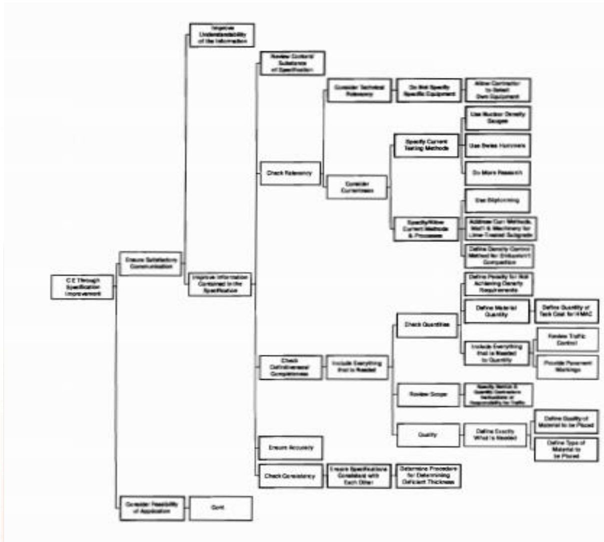

**Fig III. constructability enhancement through specification improvement hot diagram (continued).**

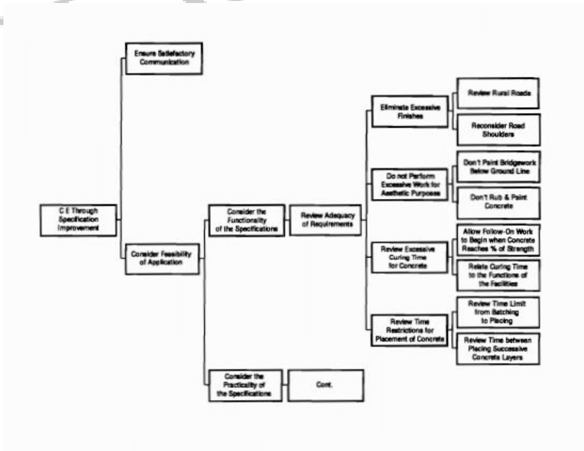

**Fig IV. Constructability enhancement through specification improvement hot diagram (continued)**

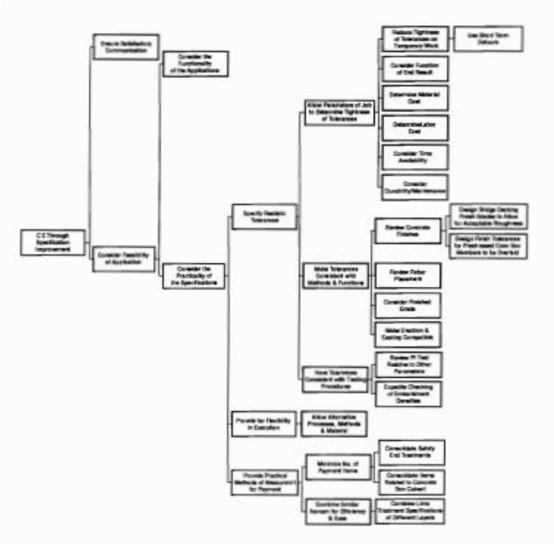

**Fig V. Constructability enhancement tbrough specification improvement hot diagram (continued).**

## V CONCLUSIONS

Pre-engineered buildings have proven to be In this study, the ability to enhance constuctability through improved specifications was considered. From this the following conclusions and recommendations can be made:

(1) Specification problems are common for a multitude of reasons. The structure of desirable attributes of specifications (and corresponding problem types) presented is complex, yet of great value in the insight it affords. The day-to-day professional activities of specification writers should include consideration of these attributes in a rigorous and systematic manner.

(2) Highway specifications appear particularly problematic with respect to "gold-plating," tolerances, definitiveness, and currentness. In general, facility function and significance or criticality should drive project requirements. Additional communication between designer and constructor on achievability of tolerances is needed.

(3) Pavement and bridge/structured specifications deserve particular scrutiny.

(4) Common apparent causal factors that lead to problems include information and communication (documentation) and project scoping (facility characteristics). With regard to the latter it should be noted that facility characteristics are determinants which are generally defined or influenced by the Department. These should be reviewed from time to time to ensure timely changes to specifications.

(5) It is imperative to note that overall, processes and methods and project scoping are the apparent causal factors causing the majority of problems with tolerances and gold-plating. Also "lack of definitiveness" is the major problem related to "control" as apparent causal factor. The need to reconcile these discrepancies is apparent.

(6) Good specifications must be matched with effective inspector training programs if specification interpretation and enforcement are to be successful.

(7) Specifying current or up-to-date methods for construction or testing will continue to be a challenge. Modem information systems must incorporate a capability for tracking the timeliness of such requirements.

(8) The promise of end-result/performance type specifications, for the most part, is not yet a reality. Additional research is needed in testing and inspection procedures and technologies supportive of this approach. In general, the industry is badly in need of more expedient methods for quality control testing.

(9) Periodic updating of specifications should include an aggressive plan for personal interviewing of knowledgeable parties and should address each of the desirable specification attributes in detail.

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