Automation in Construction 18 (2009) 957–965

Contents lists available at ScienceDirect

Automation in Construction

journal homepage: www.elsevier.com/locate/autcon

Automated contract time determination system for highway projects

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ARTICLE INFO

Article history:
Accepted 28 April 2009

Keywords:
Highway projects
Contract time determination system
Automation
Project scheduling
Computer software

ABSTRACT

Contract time is the maximum time allowed for completion of all work described in the contract documents. An accurate forecast of contract time for highway projects is crucial to contract administration by State Departments of Transportation (DOTs) because the predicted duration and associated cost form the basis for budgeting, planning, monitoring and even litigation purposes. This paper discusses a framework for determining contract time for highway projects in Oklahoma and presents a stand-alone computer software package which automates the entire procedure. The system developed in this study can be used as a basis for better project planning for DOTs. It can also provide documentation for a stronger defense in possible contract time disputes and will allow less experienced personnel to gain confidence as they learn how to consistently estimate reasonable and realistic contract time for highway projects.

1. Introduction

Contract time is the maximum time allowed for completion of all work described in the contract documents [6]. An accurate forecast of contract time is important to all concerned parties and is crucial to contract administration because the predicted duration and associated cost form the basis for budgeting, planning, monitoring and even litigation purposes [4]. Excessive contract time is costly, extends the construction crew's exposure to traffic, increases risks of the contractor and the owner, and prolongs inconvenience to the public. Insufficient contract time cause higher bids, overrun of contract time, increased claims, substandard performance, and safety issues.

Federal regulations require States to have adequate written procedures for determining contract time and for establishing project liquidated damages. FHWA must approve both of these procedures, but many DOTs do not have written or approved procedures yet. The current practice of many Departments of Transportation (DOTs) produces incompatibility between the allotted time and actual time to complete a project. For instance, Many DOTs currently rely either on a rule of thumb for determining time for bridge structures (i.e., 90 days for single span bridge, 120 days for double span bridge, etc.) that fails to account for the complexities involved with multiple structures within a project or a manually developed critical path method (CPM) to establish contract time for roadway projects. Moreover, the current system adopted by many DOTs is an outdated inaccurate chart that is based on the dollar amount versus project type. Too often DOTs use unreliable "one size fits all" charts that fail to account for many complexities involved in a roadway project, which produces either excessive or insufficient contract time for a particular project. A reasonable contract time can be estimated by highly experienced personnel using CPM techniques. This method depends highly on the experience of the senior staff and it is very time consuming. But when an inexperienced scheduler tries to estimate construction contract time, it is a hit or miss proposition. Recognizing these shortcomings of the current procedures for determining contract time, this study discusses 1) prior studies on this topic, and 2) a newly developed system to automate and enhance the process of determining or estimating a reasonable contract time for highway projects from the owner's perspective. Highway projects for the Oklahoma Department of Transportation (ODOT) have been used as data sources for this study.

2. Prior studies

Literature review indicates practitioners and researchers have strived to improve the accuracy and efficiency in determining highway project contract times through innovative techniques. NCHRP's synthesis [1] is one of the earliest reports that addressed the importance and need for developing a contract time determination procedure for DOT highway projects. This report developed a general guideline that stressed the need to develop production rates for main activities based on historical data, rather than using thumb rules.

Some states have developed and currently use a manual method for calculating project durations. Florida uses a preformatted form that can be completed by hand. An experience engineer fills out the form

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0926-5805/$ – see front matter
doi:10.1016/j.autcon.2009.04.004

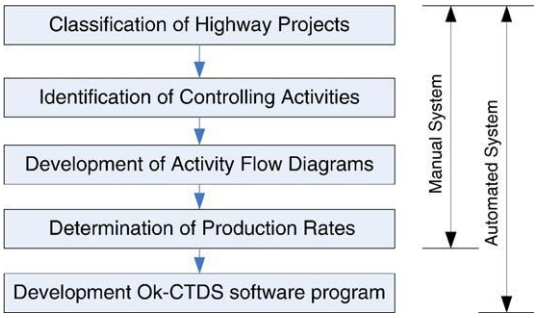

Fig. 1. Research framework.

by identifying controlling activities and the production rate of these activities. A bar chart diagram is drawn to calculate the project duration and a conversion factor, which converts workdays to calendar days, is finally applied to obtain a contract time [6]. Indiana also uses a step-by-step process in which a hand-written form is used to establish contract times [3,7]. The experience of a project engineer is necessary to obtain a reliable estimate of the contract time.

Other states such as Texas, Louisiana, and Kentucky have developed and utilized computer programs for determining contract times. Texas DOT developed a computerized system that uses Lotus 1-2-3, Flash-up, and SuperProject software packages [5,9]. Lotus 1-2-3 is used to calculate the duration of projects. Flash-up links Lotus 1-2-3 and the SuperProject program to generate a bar chart schedule. This system is based on 14 different highway project templates. Several factors such as geographic location, traffic conditions, and variance in quantity are used to adjust the project duration and the contract time [9]. The Louisiana DOT has developed a computerized program that is similar to the computer system developed in Texas. The Louisiana DOT system is computer based that uses both templates for production rate analysis and a computer software package for development of a bar chart schedule to obtain more consistent and accurate contract times [8]. The commonwealth of Kentucky currently has the most advanced computer program for determining contract times. Kentucky developed a computer system that uses Microsoft Excel to analyze controlling activities and their associated production rate, and Microsoft Project for generating a schedule for the project [10]. Six different types of highway project templates are used. The production rates for controlling construction activities were determined from a series of discussions with experts involved in the research project.

3. Framework for developing an automated contract time determination system

Fig. 1 shows the process that was used to develop an automated contract time determination system for this research. It was established through discussions with ODOT schedulers, design engineers and division engineers. The subsequent sections describe research activities, accomplishments, and the findings of each stage.

3.1. Classification of highway projects

Highway projects range from a very simple and straightforward repair project to a very complicated urban highway interchange project. Not all projects can be automated in determining contract time. Specifically, highly complex and large size projects involve unique characteristics which require creative approaches to sequencing construction activities. Thus, there is a need to classify highway projects in order to identify project types that are potentially feasible for automating contract time determination procedure. Through discussions with ODOT project and construction engineers, highway projects in Oklahoma were classified into three different categories, namely, Tier I, Tier II, and Tier III. Tier I projects include highly complicated projects such as most urban or interstate reconstruction projects which are subjected to traffic congestion. Tier III projects are very linear and simple in nature such as bridge painting, surface rehabilitation and country bridge projects. Due to their simplicity, the contract time of these projects can be established using a pre developed table with production rates. In most cases, CPM analysis is not required to estimate contract time for Tier III projects. For instance, many of the county bridge projects use standard designs and similar construction sequences. Therefore contract time does not vary between projects and a standard table works well to establish contact time. Tier II projects constitute projects in between the complexity of Tier I and the simplicity of Tier III. These projects are typically to construct interstates, state highways, and major arterial roads that connect them to state highways and interstates. These Tier II projects are not as complex as Tier I type highway projects, but they require the use of CPM to determine project duration because some activities are conducted concurrently.

Based on actual Oklahoma highway project data, approximately 7.5% of the highway projects that are bid out by ODOT annually, fall within the Tier I classification, 40% for Tier II, and 52.5% for Tier III projects. It was determined that automating contract times would be only applicable to Tier II and Tier III due to the nature of their construction activity sequencing. Tier I projects were not considered in this study. However, the system developed in this study still covers almost 90% of highway projects in Oklahoma. Tier II and III highway projects in Oklahoma are classified as shown in Table 1. Both tiers have eight different project types.

3.2. Identification of controlling activities

Each highway project consists of various construction operations and each operation can be further broken down into a number of activities. Among all the activities required for a project, many of them can proceed concurrently. For example, landscaping and erosion control can be done when pavement construction is being performed. But there are certain activities that are constrained to a given sequence, for example, reinforcement steels and formwork must be in place before concrete is poured.

Even for the same type of projects, the critical path and critical activities may change as quantities for project activities and site conditions are different. In order to automate the contract time determination procedure, the construction activities must be identified which have possibilities to be on the critical path [2]. These activities are called “controlling activities”. This concept of controlling activities was also used by Hancher et al. [5] and Hancher and Werkmeister [10]. The characteristics of controlling activities may

Table 1
Tier II and Tier III highway projects in Oklahoma.

Tiers	Project types
Tier II	T2-a) Reconstruct existing alignment/rural interchange
	T2-b) Widen/reconstruct existing alignment
	T2-c) Reconstruct city street
	T2-d) Construct bridges and approaches
	T2-e) Construct bridge box and approaches
	T2-f) Intersection modification
	T2-g) Bridge rehabilitation/repair
	T2-h) Roadway repair/overlay
Tier III	T3-a) County bridge
	T3-b) Signal installation
	T3-c) Striping or guardrail
	T3-d) Bridge repair/joints
	T3-e) Bridge painting/waterproofing
	T3-f) Bridge deck repair/redecking
	T3-g) Overlay
	T3-h) Chip seal