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REVIEW ARTICLE

Schedule Estimates for Preconstruction Activities of Highway Projects-Review of The Literature

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Abstract: Among the multiple causes of project success in the construction of big projects (such as highway projects), punctually delivering preconstruction activities is increasingly recognized as a important cause that has not received adequate attention. In this research, after providing an introduction about the different phases and activities in a construction project, the reasons behind the importance of preconstruction activities are briefly summarized. Scheduling of these types of activities is complex in nature mostly because of the unclear path toward delivering them; therefore, inaccurate scheduling of them is common. Since it is a very demanding and difficult responsibility to organize the literature efficiently, the literature is classified into five different groups to accelerate this effort. These groups are environmental clearance, design, right-of-way acquisition, utility adjustment, and finally advertising and letting. In this research, these categories and their definitions are provided in detail. After conducting a comprehensive literature review, the results of this study show that there is a lack of a quantitative model for predicting schedules associated with various preconstruction activities. Beside many other causes behind this need, the main reason is that the approach of most of the previous studies was qualitative and the few studies that conducted a quantitative research on historical data, had a small sample size.

Keywords: Transportation projects, Highway projects, Preconstruction activities, Scheduling, Predictive model, Environmental clearance, Right-of-way acquisition, Utility adjustment.

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1. INTRODUCTION

The planning and scheduling of construction activities assist engineers and construction managers in accomplishing projects on time. An accurate schedule minimizes the possibility of failure in delivering the project on time, thereby is a significant tool for practitioners to achieve project goals [1]. Since every project schedule has a related budget, schedule failures result in raising the cost of the project. There are several major differences between delivering highway projects and completing other types of building projects [2]. One of the most significant characteristics of all highway projects is that they need to secure the endorsement of several organizations including federal, state, and private ones for many major tasks (in some cases, more than 200 major tasks) during the project [3]. These major tasks include pre-construction activities, such as Right-Of-Way (ROW) acquisition and utility adjustment, which are required to be finished before the beginning of the construction phase. Based on several reports conducted by various state Departments of Transportation (DOTs), accomplishing such preconstruction activities on time plays a significant role in the success of highway projects [4, 5]. This subject is important for another reason. Mobility within the United States is a competitive advantage to facilitate business trade, national defense, and economic growth [3]. To maintain this advantage, transportation projects (such as highways, tunnels, and bridges) use federal budgets for construction, improvements, and repair [3]. Therefore, it is vital for these projects to be completed and delivered before the due dates. Furthermore, the influence degree of activities on ov,rall expenses falls sharply as the project progresses, while the overall cost of the entire project grows as the project moves forward [6]. Therefore, any failure in the estimated schedule of preconstruction activities may result in huge cost overruns.

All the reasons mentioned above prove the importance of this topic. In general, construction projects consist of five major phases: predesign, design, preconstruction, construction, and post-construction [7, 8]. As shown in Fig. (**1**), once a project is chosen to obtain the required budget ("programmed"), there are two significant phases in front of the project before the construction begins: design and preconstruction phases. These phases contain the following major activities: preliminary design, environmental studies,

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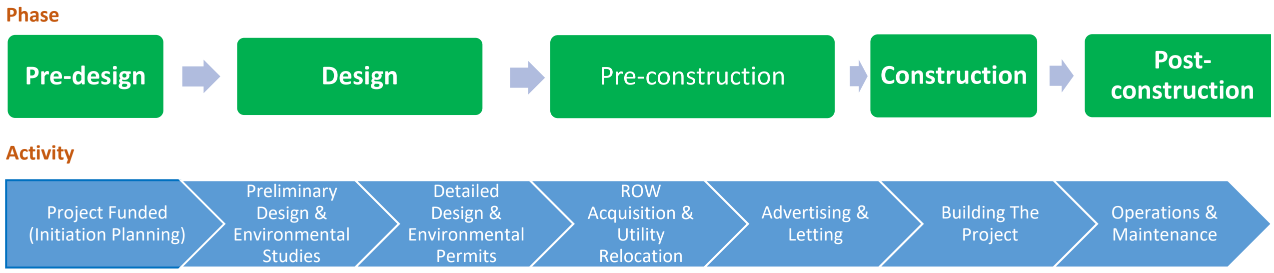

Fig. (1). Different phases of a typical highway project with their equivalent activities.

detailed design, ROW acquisition, utility adjustment, and bidding and letting [7]. When these stages are finished, the project progresses to physical implementation, then to operations and maintenance that establish the construction and post-construction phases of the project [7]

Even though new federal transportation projects constitute barely 3% of all federally funded projects [9], it usually takes a period of 9-19 years to plan, acquire authorizations for, and construct these projects. This is because they may have considerable environmental impacts [9]. A Federal Highway Administration (FHWA) report mentioned that a considerable amount of time is spent on preconstruction activities, which are categorized into two phases: preliminary design with environmental review, and final design with ROW acquisition. These phases often overlap, taking one to five years and two to three years, respectively [7].

More complex and/or larger transportation projects usually require more time to complete, compared with typical transportation projects [3]. In addition to complexity and size, these projects may take longer to complete due to more federal, state, and local government obligations that they must fulfill [10, 3]. Even though various agencies are involved in the construction of transportation projects, the state DOT plays the primary role [3] by collaborating with local governments and Metropolitan Planning Organizations (MPOs). One of the responsibilities of MPOs is to provide lists of solutions to transportation-related issues and propose them to the state DOT [7]. For highway projects, state DOTs are in charge of designing the majority of projects, acquiring ROW, and awarding contracts for constructing the projects in a safe and efficient way [11].

Along with state DOTs, local governments are also responsible for performing several planning tasks for transportation projects (*e.g.*, planning and scheduling of repairs and developments for local streets) [7]. From a federal standpoint, FHWA is generally the central point in decision-making for transportation projects [9]. The main responsibility of FHWA is to manage and supervise state DOTs and MPOs with regard to their transportation planning and project tasks. In order to do this responsibility, FHWA performs various actions, including confirming that states have met the minimum requirements for environmental concerns, certifying state transportation plans, and approving ROW acquisitions for state highway projects [9]. Moreover, since the potential environmental impact of any federally funded project is required to be analyzed, FHWA collaborates with public and various agencies (local, state, and federal ones), to recognize the potential environmental effects and any impacts on historic locations [12].

Due to its significance, the focus in this review is on the activities that take place in the design and preconstruction phases prior to the construction phase. Design and preconstruction phases contain several tasks, the majority of which require approvals from various agencies before the start of construction. This section is followed by the methodology section. In the succeeding section, results are divided into two main parts to present a clear review of the literature: the first part discusses the significance and specifications of preconstruction tasks whereas the second part reviews various practices associated with preconstruction activities. Finally, conclusions and recommendations are made in the last section.

2. METHODOLOGY

In the construction of federally funded projects (such as highway projects), on-time completion of preconstruction activities plays a crucial role in a project's success. In order to provide a better understanding of scheduling for preconstruction activities and its importance in highway projects, this paper explains the results of a systematic literature review on the topic of schedule estimates for preconstruction activities in highway and expressway projects. Fig. (**2**) presents the flowchart of the methodology applied in this review. As shown in Fig. (**2**), the current review consists of studies that have been published between 1985 and 2018. To conduct a comprehensive review, three different databases-IEEE Xplore, Scopus, and Google Scholar-were selected, then several keywords were applied to perform the search in the databases. The keywords were a combination of "scheduling," "preconstruction activities," "environmental permit," "right of way," and "utility" in construction of highway and expressway projects. The search resulted in a wide range of studies and reports. Next, the abstract of each paper was reviewed; as a result, 43 papers related to the topic of this review were selected. Then, a summary of these 43 papers is provided, and based on the summary, conclusions and recommendations are made.

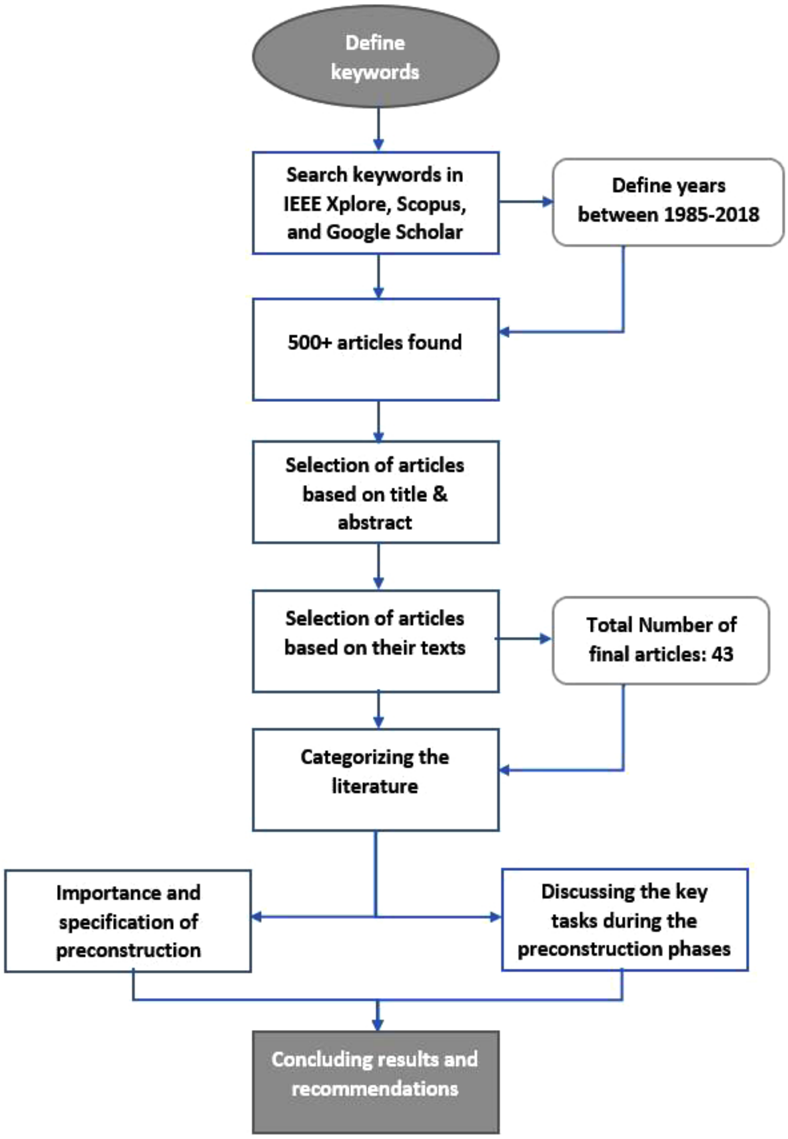

Fig. (2). Flowchart of Research Methodology.

As previously explained, a systematic approach has been applied for this study. This approach was selected based on its several advantages including: first, it uses a larger range of sources compared to other methods [13]. Furthermore, it provides an integrated method for literature review by generating new frameworks [14]. In addition, as opposed to other review methods, a systematic literature review provides a structured, transparent and comprehensive review which helps in minimizing the bias in review [14]. On the other hand, there are some disadvantages regarding this approach; the main disadvantage of this approach is that there is a lack of creativity in this approach due to its nature [15]. Moreover, this method is highly reliable for the abstracts of the literature, while the abstract is typically of around 200 words and an important paper may be overlooked [13]. A summary of the advantages and disadvantages associated with this method is presented in Table **1** below.

Table 1. Pros and cons of systematic literature review.

Pros	Provides a valuable set of studies from a wide range of resources	Aids in the process of future studies through providing a framework	It is more transparent than other literature review methods	A "*Systematic Literature Review*" on a topic offers a sense of particularity and rigor
Cons	Lack of novelty, innovation and intuition	May ignore important "grey literature" such as empirical reports	It is a time-consuming process	Dependent on the quality of abstract (frequently limited to almost 200 words)

Based on the outcomes of this review, it is concluded that there is a need for a reliable and mathematical model capable of providing accurate estimation of time duration regarding the preconstruction tasks of highway and expressway projects. This need has been felt due to several reasons. The most important reason is the fact that the prior studies were case-specific and did not consider planners as the final users of their study. As a result, the techniques provided in these studies were not capable of delivering the information that the end-users wanted. In addition, none of the studies and reports in the literature had a holistic methodology for predicting the overall timeline connected to the design and preconstruction phases, and the studies were primarily focused on a minor section of these processes. Another issue of concern is the approach toward the preconstruction activities: Most of the studies had a qualitative approach toward this topic, and the very few that statistically analyzed historical data had a very small sample size that decreased the reliability of their findings.

For the reasons mentioned above, it is recommended that future studies will be performed on the topic to provide a reliable statistical model based on the analysis of historical data. The proposed model should be capable of predicting durations of preconstruction activities in highway projects and should analyze the validity of any proposed model. A test of validity is required since the effectiveness of any proposed model is a significant parameter. In addition to the validity, the accuracy of the model should be verified.

3. RESULTS

To perform a well-defined literature review, this part is categorized into two major categories. In the first part, the importance and specifications of preconstruction activities are discussed. While the second section reviews various practices in the preconstruction phase by dividing them into the five main parts: environmental clearance, preliminary and detailed design, right-of-way acquisition, utility adjustment, and lastly advertising and letting.

3.1. Preconstruction Activities of Highway Projects

According to a US General Accounting Office report published in 2002 [3], although the time needed to complete a highway project varies based on complexity and size of the highway, it generally takes from 7 to 13 years to complete the pre-design to preconstruction phases of major new highways. The activities that were considered in the report included planning, completing the design, obtaining approvals, and acquiring ROW. A single highway project can contain up to 200 major tasks that must be coordinated effectively in order to avoid any conflict or delay during the project. Such conflicts and delays may lead to extensive time-wasting in completing the project [3]. Among these major tasks, preconstruction activities have an important influence on the successful completion of the highway projects [4, 5]. According to a recent study by Hessami *et al*. [16], cost overruns and scheduling delays are two major issues that consistently adversely affect the transportation construction industry. Furthermore, inadequate project development and approval processes may result in budgets being spent on poorly conceived endeavors, while other more proficient ideas fail to achieve the required funding support [16].

On the other hand, preconstruction activities require a sizable quantity of authorizations from various organizations or other stakeholders associated with the project. The duration of these authorizations/approvals is often underestimated when the project is scheduled [2]. These issues make the distinction between highway and building projects [17, 18].

By comparing scheduling techniques that are used by various states, districts and agencies, it can be realized that these techniques are dramatically different in some cases. For example, the Texas Department of Transportation (TxDOT) implements the Construction Time Determination System [19], While New Jersey Department of Transportation (NJDOT) applies the Capital Program Construction Scheduling Coding and Procedures [20]. Even though in both the systems, designers' skill and knowledge are demanding, these systems are totally different in various ways. For example, the unit of production rate for retaining wall construction in NJDOT is days/meters and depends on five various factors, while that of TxDOT, it is m^2 per day and soil condition is the only element that changes its value. Overall, the main differences in these two systems are in units (area against length), productivity elements, and design-related problems [10]. In addition, research conducted by Lu and AbouRizk found that statistical and simulation techniques were used to attain better-quality results with PERT (Program Evaluation and Review Technique) [21]. PERT is a type of scheduling method that is known for its simplicity. The application of the improved PERT presented in their study [21] resulted in six different values: minimum (or optimistic) duration, maximum (or pessimistic) duration, average, standard deviation, confidence interval, and probability [21].

However, Bonnal, Gourc, and Lacoste [22] focused on the application of fuzzy logic and concluded that this logic and the techniques based on fuzzy logic have become satisfactorily developed to be used for setting timelines in real projects. According to this research, fuzzy logic can be applied to eliminate calculation fuzziness, provide more accurate estimates, and progress the rationality and credibility of the values calculated by the estimation methods [12].

Moreover, Antoine and Molenaar [23] performed a case study to deepen the understanding of the current technical concepts that are applied in highway construction projects [23]. Aziz and Abdel-Hakam [24] reviewed a list of reasons for construction delays collected from literature and then explored the causes of delays regarding road construction projects in Egypt [24]. Based on their study, the most significant group of factors are equipment related group, followed by design-related group and contractor related group. Table **2** shows all 15 categories with their related group importance index [24].

Table 2. Groups importance index for factors affecting duration of preconstruction activities.

Rank	Delay group	Group importance index
01	Equipment related group	0.752
02	Design related group	0.739
03	Contractor related group	0.728
04	Material related group	0.723
05	Contract related group	0.718
06	Consultant related group	0.707
07	Financing related group	0.699
08	Site related group	0.698
09	Scheduling and Controlling related Group	0.686
10	Owner related group	0.680
11	Contractual relationship related group	0.668
12	Labor related group	0.665
13	Project related group	0.660
14	External related group	0.641
15	Rules & regulation related group	0.633

Source: Aziz and Abdel-Hakam (2016) [24]

Hassanein and Moselhi [25] suggested an object-oriented model for planning construction of highway projects. The proposed model divided projects into work zones and segments; it was also combined in a prototype software which can automatically generate the Work Breakdown Structure (WBS), identify critical paths using Critical Path Method (CPM), and store a list of construction activities commonly encountered in highway projects [25]. Furthermore, the model automatically generated the precedence network respecting job logic, which can be modified to satisfy the special specifications of each project. The proposed model applied a resource-driven method of scheduling to adapt to the recurring nature of this type of operations [25]. The model was developed to integrate the scheduling and planning phases of highway projects by accounting for several parameters including preceding and succeeding activities, transverse obstructions, resource availability, tasks with changing quantities of work along the project length, effect of unpleasant weather on labor productivity, and the beneficial effect of the learning curve. At the core of the model, there was a relational database designed to ease the resource allocation to in-progress tasks. The database stored resources with their related unavailability periods [25].

Based on another research project conducted in Taiwan [26], the variations in engineering aspects of embankment roads, viaducts, and tunnels involve investigating and managing geological concerns. This study is based on an assumption which describes that any changes in the design due to geology create extra costs and delays in the highway project, so they tried to explain the causes of these changes and analyze the influences [26]. In the conclusion part, it is suggested to avoid adverse effects of design changes for future roadway projects, site-survey should be improved during the design planning phase and feasibility study [26].

Furthermore, Chong, Lee, and O'Connor [10] concluded that project planners prefer to use a simple and flexible system, and when they encounter a new complicated information technology system, they tend to withstand. The study revealed that the most commonly used software packages for developing timelines are Primavera, Microsoft Project, and Microsoft Excel; This is mainly because a vast number of designers apply the CPM and Gantt chart techniques to organize tasks and resources for their projects [10]. In the methodology part of this study, it is explained that the authors interviewed eight Texas DOT designers regarding their needs for an improved tool so that they could provide better results for scheduling purposes. The study demonstrated that the designers, as the users of the software, needed a method/system that was easy to use, user-friendly, and did not add complexity to tasks of the users [10]. The planners mentioned that prior to the research, there used to be several unpopular tools that dealt with complicated simulation methods and provided complex statistical results [10].

Even though there are numerous studies and reports in this area, a large proportion of schedulers still suffer from the absence of pertinent statistical data [10]. This problem pushes project planners to create estimates within the bounds of their own understanding of project planning and scheduling [9]. Therefore, it can be concluded that there is a significant gap in the provision of a simple and efficient tool based on statistical data that can be used to estimate the duration of preconstruction activities. The next part of this study provides a review of the various practices regarding different preconstruction activities.

3.2. Various Preconstruction Activities

It is a challenging task to organize efficiently all the studies related to the design and preconstruction phases of federal projects. To facilitate this organization effort, these activities are divided into five main categories:

3.2.1. Environmental Clearance

Conducting an environmental study is the first step in a detailed planning and preliminary design for highway projects. The National Environmental Policy Act (NEPA) obligates the environmental impacts' assessment for all federally funded projects. In addition to NEPA, several states demand an environmental investigation on the projects that use state funds. An environmental study investigates several possible options that could achieve the same goals and needs, and thus specify the best conceptual result for transportation development [12], [27]. According to Canter and Canty [28], the proper class of action is determined by the environmental impact significance, not size or cost, of the project. The impact significance specifies the NEPA requirements for documentation of the whole process and involves three classes of action: Categorical Exclusion (CE), Environmental Assessments (EA), and Environmental Impact Statements (EIS). CE is a class of action that involves projects that are expected to have no important impact; however, there is still some documentation that must be submitted. EA is for projects that have uncertainty about their environmental impacts. The findings are documented, and if there is no significant impact, the process is concluded with a FONSI (Finding of No Significant Impact). However, if significant impacts on the quality of the human environment are found, then an EIS is required [28]. Going through the EIS process and preparing its documentation typically takes a lot of time and money.

Predicting the time needed for environmental clearance is one of the most complex steps in construction scheduling due to the uncertainty of the project's environmental impact. DeWitt and deWitt [29] studied environmental clearance data between January 1, 1998 and December 31, 2006. In this study, more than 50 federal executive branch entities made 2,236 final EISs available to the public. More than 50% of these documents are provided by The U.S. Forest Service, FHWA, and the U.S. Army Corps of Engineers [29]. In this study, the researchers analyzed the duration that is required to prepare almost 2,100 of the final EISs. According to their results, the time to prepare an EIS had a wide range from 51 days to 6,708 days (18.4 years), while the mean of duration for all federal entities was 3.4 years [29]. The wide range between the required times to prepare an EIS is proof of the need for a predictive model to estimate timelines.

3.2.2. Preliminary and Detailed Design

According to a research project performed by the National Cooperative Highway Research Program (NCHRP) [12], the environmental review process leads to selecting a context-sensitive solution and design based on a collaborative decision-making process. When the solution is chosen, a preliminary design is developed. In order to help investigate the advantages and disadvantages of potential solutions, functional or even preliminary designs are provided for several options [12]. In other words, various design alternatives are developed during the preliminary design stage, while each of these alternatives contains a collection of structural and management activities [30]. Structural actions clarify geometric and design structures of the infrastructure components and assist in applying the operative enhancement approach of the highway. Managing adjustment activities requires a modification in the use of the present infrastructure. This helps to make it compatible with its physical structures, upgraded through structural improvements, or built along with the natural environment of the highway [30]. During this step, the design of the highway is reviewed and refined by considering several constraints, containing more reduction in the environmental impacts, unforeseen ground conditions, construction phasing, as well as financial aspects [12].

Following the preliminary design stage, there is the detailed design stage, which provides comprehensive information on the exact characteristics of the highway project [12]. It also expands each part of the project through comprehensive explanation based on solid modeling, drawings, and specifications [31]. Differing from the preliminary design stage, the detailed design stage focuses on developing the overall framework on which to construct the project. The elements of the project could change during this stage [31].

According to Hessami *et al*. [7], the type of highway project conducted by the Texas transportation industry may have a substantial effect on the duration of the design activity. In the end, they concluded that it is critical to develop accurate schedules in the planning phase to avoid delays in design duration [7]. Forecasting the duration of design activity is challenging due to its susceptibility to change as a result of environmental impacts [3]. According to the Virginia DOT [32], preliminary and detailed design processes can be separated into 40 different tasks and several schedules can be prepared based on their specifications [32]. The study showed that the preliminary design process can range from 1 month to 1 year and a half, based on the complexity and size of the project. However, the detailed design process generally has a time span of 1 month to 1 year [32]. The study revealed that there is a wide time span for finishing design activity, which emphasizes the need for a predictive model to estimate timelines.

3.2.3. Right-of-Way Acquisition

After obtaining design approval, the ROW and utility office in the state DOT issues a "Notice to Proceed" authorizing its agents to start negotiations with landowners to acquire land for the construction project [32]. ROW acquisition is the overall process extending from the property appraisal to the acquisition of that property and is broken down into several steps: (1) Project scope preparation (conducted during the design phase), (2) Review and appraisal, (3) Acquisition, (4) Adjustment or relocation of property [17]. ROW acquisition is the main task in timely delivery of highway projects and any delays in ROW acquisition may result in significant schedule overruns during the construction phase [11]. In order to avoid delays in ROW acquisition of projects, Aleithawe *et al.* analyzed 35 projects conducted by Mississippi Department of Transportation (MDOT) to identify parameters affecting the duration of this activity [11]. Various statistical methods were applied (such as t-test, scatter plot, analysis of variance, and standard multiple regression) to get a better understanding of datasets, and to quantify the correlation coefficient of the elements that contribute to ROW acquisition [11]. To perform regression analysis, they first assumed the form in Eq. 1.

$$Duration = B_0 + B_1[rural\ ratio] + B_2[in - house\ ratio] + B_3[condemnation\ ratio] + B_4[No.\ of\ parcels] + B_5[No.\ of\ revisions] + [error] \quad (1)$$

$$D = 142 + 738 * Condemnation\ ratio + 2.26 * Parcels + 3.28 * Revisions * \quad (2)$$

Then after conducting the required analysis, three factors namely condemnation ratio, number of changes in the design, and number of parcels per project were recognized as the drivers which have a significant effect on the duration of the ROW acquisition. Then, Eq. 2 was presented as the prediction model for the duration of the ROW:

Source of Eq. 1 and Eq. 2: Aleithawe *et al*. (2012) [11]

Finally, to check the validity and effectiveness of the model, it was applied to five projects, and the results confirm the validity of the model [11]. Even though the results of this research provide a statistical model to predict the duration of ROW, the very small sample size of their work is a drawback regarding the study.

A recent study [33] mentioned that for a long time, the Texas DOT had been struggling with the issue of accurately estimating the schedules of ROW and utility coordination activities for highway projects [33]. These problems caused project cost and time overruns, and thus adverse financial effects on trade and business. During a study published in 2003 [34], a group of researchers analyzed the ROW acquisition and utility adjustment of almost 50 different projects in the state and then developed a tool to assist ROW practitioners in providing an estimate for ROW delivery time for those projects [34]. This tool was an Excel-based program called RUDI (Right-of-Way Acquisition and Utility Adjustment Process Duration Information). RUDI is a user-friendly software which can help practitioners to provide more accurate estimates of ROW and utility coordination processes by inputting characteristics of projects, such as uncertainty level and schedule urgency [34, 35].

On the other hand, the California DOT, also known as Caltrans, applied an approach known as single appraiser/negotiator for acquisition and adjustment tasks to offer enhanced service to the owners of involved lands and estates, while saving a substantial amount of costs [9]. Maintaining a database of experienced and qualified appraisers, application of a wide range of delivery incentives, and decreasing paperwork by the application of electronic technology are all required to maximize the advantages of the proposed approach [9].

In order to identify the issues and reasons behind a delay in the ROW acquisition process, some recommendations for strategic management have been provided by Gibson *et al*. [36] To achieve their goals, the authors conducted a process review and evaluation, and identified the main factors of delay in ROW. Their objective was to minimize the negative impacts of delay in the process of ROW acquisition [36]. Le, Caldas, and Gibson [37] applied the analysis of variance and correlation methods to statistically analyze the effects of different elements on several ROW acquisition projects. The analysis was based on data gathered from 13 projects in Texas [37].

Some other studies focus on ROW staff training and its impact on the duration of the ROW process. A survey taken by the NCHRP explains that the most beneficial approach for expediting ROW acquisition activity, decreasing the duration, and saving costs is adequate staff training [4, 9].

3.2.4. Utility Adjustment

As noted earlier, Utility adjustment is another key preconstruction activity in a highway project. Utility adjustments may include utilities that are placed on the highway ROW or partially on compensable estates [38]. Considering the aforementioned definition, utility adjustment substantially depends on ROW acquisition.

Most state DOTs have some strict rules about ROW acquisition and utility adjustment. Based on a report conducted by the Texas DOT [39], if a local government wants to use federal funds on any part of a construction project, it must pursue the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970. The goal of this act is to ensure fair and reasonable compensation, reimbursement, and support for those whose property is obligatorily acquired for the use of the public. As a result of this act, ROW acquisition and utility adjustment activities face bureaucratic delays and inconveniences during the fulfillment process. This rule applies even if the local government provides the entire land acquisition budget but also receives federal finances for a small part of the design or construction process [39].

Many state DOTs emphasize improvements in utility adjustment to prevent delays and conflicts [40, 4]. The importance of utility adjustment and its key drivers has been an attractive research topic for many researchers. Ellis and Thomas [41] denoted that utility adjustment requires a complex, multiparty coordination and has been frequently cited as one of the main sources of highway construction delays [41]. In another study [42], Chou, Caldas, and O'Connor examined a new method to avoid delays associated with utility adjustment. Based on their research, some DOTs have recently implemented the Combined Transportation and Utility Construction (CTUC) approach to integrate utility adjustment activity into the construction phase of highway projects. According to the study’s results, the CTUC streamlining strategy helps to better implement and manage utility adjustments since both are executed under the supervision of highway contractors [42]. Even though the CTUC technique has a great advantage, this method has some disadvantages as well. According to deWitt and deWitt [29], CTUC simply transfers utility adjustment from the preconstruction phase to the construction phase rather than solve the actual issue of scheduling utility adjustment. As a result, the scheduling of the construction phase can become more complicated.

The application of a decision support model is highly recommended when dealing with utility coordination [43]. Based on a literature review and interviews with professional, a study identifies significant factors on the duration of utility adjustment and their impact levels on the decision-making process [43]. Due to the importance of utility adjustment, several state DOTs recommend the use of computer-aided design and drafting and the geographical information system, which are known as the best methods of improving utility adjustments [40]. In addition, the early involvement of utility corporations in ROW design is recommended by several state departments of transportation for creating useful contact with major practitioners and confirming utility adjustment plans [40].

3.2.5. Advertising and Letting

The final step before initiation of the actual construction is advertising and letting, which is a very important task in a federally funded project. Before a construction project can be placed under contract, the contracting entity must let it, or make it available for bidding. This requires the following activities:

- Request submission of bids by application of public advertisement
- Receive bids
- Select the best bid through a competitive selection method with consideration of various factors such as qualifications, best value, experience, or any other elements named by federal funding agencies [44].

The main advantage of the bidding is that if it is planned and executed effectively, it helps the local government and state DOTs in obtaining the most economical price and provides a fair environment for the companies to compete [44]. In a period of 14 years started from 1981, the Transportation Research Board performed several research projects to examine and provide frameworks to increase the reliability of contract time estimation in highway projects [45]. While projects with federal funds require a minimum of 21 days for advertising, it typically takes longer for this activity to be completed [9].

In a recent project, the Virginia DOT broke down this activity into several processes, including approval of construction plans, preparation for advertisement, biddability review, plan submission date, construction funding review/authorization of funds, and advertising the project. In their project, the Virginia DOT researchers estimated that the duration of this activity could be at least one month, but it varies depending on the specifications of the project [32].

A different study conducted in 2011 [46] analyzed three different methods for advertising and letting that were useful for this type of activity in rural areas. This study was performed with data and information collected on rural road projects [46]. Zhang *et al*. discussed that one of the main drivers affecting the duration of advertising and letting is the method of payment related to project costs; after analyzing 84 successful projects, it is concluded that the payments that are made pursuant to the project's progress have a significant role in the success of projects. By describing Fig. (**3**), Zhang *et al*. explained that in the successful projects, the contract cost is mainly paid pursuant to progress, accounting for approximately 65% of projects; followed by when sub-divisional tasks are completed, accounting for almost 21% [46].

Based on a lately-published paper [47], highway construction projects usually need a huge amount of funds and rely on revenues that primarily originate from transportation-related taxes and charges [47]. Such revenues may experience a significant decrease/increase as time passes because of the uncertainty of the economy. State DOTs need to address such changes in their funding sources. In the paper, a mathematical model was developed to provide guidance in revising the letting schedule when future revenue is expected to experience some changes [47].

Even though the minimum timeline for this type of activity is typically one month, it is still not clear what the maximum duration of this activity would be. Therefore, it is suggested to conduct other studies to provide a more accurate timeline for the duration of advertising and letting as part of the preconstruction activities.

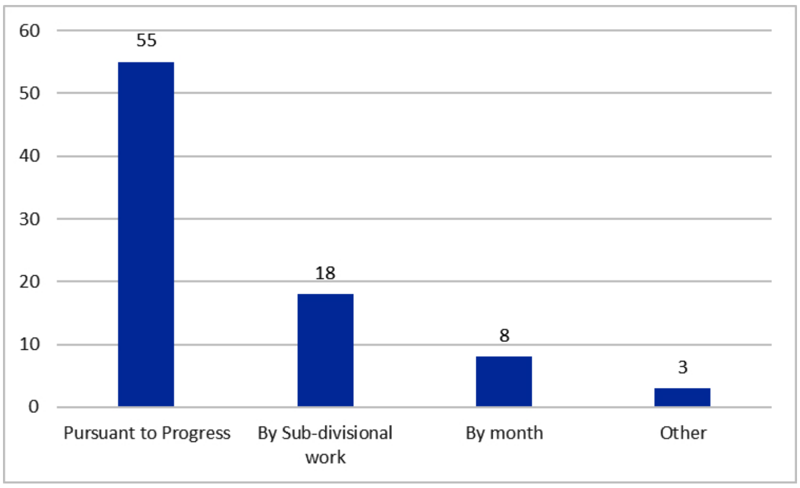

Fig. (3). Payment methods distribution for the contract cost.

CONCLUSION

Delivering preconstruction activities on time plays a significant role in the goal achievement of any construction project. It has a huge impact particularly on the success of highway projects because of the requirement of securing approval from federal, state, and private agencies for several main tasks. Due to the significance of this subject, there is a vast number of studies and reports on this topic.

Despite the importance of this subject and the quantity of studies that have been conducted in this area, many reports have emphasized the lack of a statistical model capable of predicting the durations related to preconstruction activities. There are several reasons for this issue. The main reason is the fact that previous studies were case-specific and did not target practitioners as the end-users of the research; therefore, the studies were not capable of providing the final users with the precise information they needed. Moreover, none of the studies in the literature had a holistic approach towards estimating the overall duration related to design and preconstruction activities and were mainly focused on a small portion of these processes. Finally, the approach of most of the previous studies was qualitative, and the studies that statistically analyzed historical data had a sample size with only a few projects. All the reasons mentioned above prove that there is a need for a statistical model to predict the schedule for preconstruction activities of highway projects.

Therefore, it is suggested to conduct future researches and studies on this subject to provide a mathematical model based on statistical analysis; the proposed model should be applied in the prediction of more accurate timelines for the durations of preconstruction activities in highway projects. In addition, researchers should demonstrate some examples to prove the effectiveness of their method and test the accuracy of the model.

CONSENT FOR PUBLICATION

Not applicable

AVAILABILITY OF DATA AND MATERIALS

The data sets used and/or analyzed during the current study are available from the corresponding author.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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REFERENCES

[1] A.M. Elazouni, and A.A. Gab-Allah, "Finance-Based Scheduling of Construction Projects Using Integer Programming", *J. Constr. Eng. Manage.,* vol. 130, no. 1, pp. 15-24, 2004. [http://dx.doi.org/10.1061/(ASCE)0733-9364(2004)130:1(15)]

[2] T. Waters, *Innovative Practices to Reduce Delivery Time for Right-of-Way in Project Development.,* National Academy Press: Washington, D.C., 2000.

[3] General Accounting Office [GAO], "Preliminary Information on the Timely Completion of Highway Construction Projects", *GAO,* 2002.

[4] AASHTO, *Strategic Plan Strategy 4-4: Right of Way and Utility Guidelines and Best Practices,* 2004.https://www.fhwa.dot.gov/programadmin/suebibli.cfm

[5] Federal Highway Administration [FHWA], *Utility Involvement in South Carolina Design-Build Projects.,* 1999.http://www.fhwa.dot.gov/programadmin/contracts/scdb.cfm

[6] A. Nejat, I. Damnjanovic, and S.D. Anderson, "Effects of Project Cost Reduction Methods", *Transp. Res. Rec.,* vol. 2151, no. 1, pp. 28-35, 2010. [http://dx.doi.org/10.3141/2151-04]

[7] A.R. Hessami, D. Sun, G.J. Odreman, X. Zhou, A. Nejat, and M. Saeedi, *Saeedi, Project Scoping Guidebook for Metropolitan Planning Organization Transportation Projects.,* ABA Book Publishing, 2017.

[8] M. Klinger, and M.B. Susong, *The Construction Project: Phases, People, Terms, Paperwork, Processes.,* Texas A&M University Kingsville (TAMUK): Kingsville, Texas, 2006.

[9] Federal Highway Administration [FHWA], "Acquiring Real Property for Fedral and Federal-Aid Programs and Projects", *FHWA Publications,* 2002.

[10] W.K. Chong, S-H. Lee, and J.T. O'Connor, "Estimating Highway Construction Production Rates During Design: Elements of a Useful Estimation Tool", *Leadership Manage. Eng.,* no. July, pp. 258-266, 2011. [http://dx.doi.org/10.1061/(ASCE)LM.1943-5630.0000135]

[11] I. Aleithawe, R.R. Sinno, and W.H. McAnally, "Right-of-Way Acquisition Duration Prediction Model for Highway Construction Projects", *J. Constr. Eng. Manage.,* vol. 138, no. 4, pp. 540-544, 2012. [http://dx.doi.org/10.1061/(ASCE)CO.1943-7862.0000450]

[12] NCHRP Project 8-68, Transportation Research Board, *A Practitioner's Guide-Chapter 3,* 2010.https://www.fhwa.dot.gov/context/practitionersguide/3_2.html

[13] M. Easterby-Smith, R. Thorpe, and P.R. Jackson, *Management Research, Lonson: SAGE Publication,* 2012, p. 109.

[14] R.J. Torraco, "Writing Integrative Literature Reviews: Guideline and Examples", *Hum. Resour. Dev. Rev.,* vol. 4, no. 3, pp. 356-367, 2005. [http://dx.doi.org/10.1177/1534484305278283]

[15] D. Nakano, and J.J. Muniz, "Writing the literature review for empirical papers", *Production,* vol. 28, no. e20170086, 2018. [http://dx.doi.org/10.1590/0103-6513.20170086]

[16] A.R. Hessami, D. Sun, A. Nejat, G.J. Odreman, X. Zhou, and M. Saeedi, *Enhanced Cost Estimating and Project Development Procedure for MPOs.,* Texas Department of Transportation: Austin, 2017.

[17] Texas Department of Transportation [TXDOT], *Right-of-Way Manual,* 2018.http://onlinemanuals.txdot.gov/txdotmanuals/apr/manual_notice.htm

[18] N. Naderializadeh, and K.A. Crowe, "The effect of the density of candidate roads on solutions in Tactical Forecast Planning", *Can. J. For. Res.,* no. 48, pp. 679-688, 2018. [http://dx.doi.org/10.1139/cjfr-2017-0176]

[19] D.E. Hancher, W.F. McFarland, and R.T. Alabay, *Construction Contract Time Determination.,* Texas Department of Transportation: Austin, 1992.

[20] NJDOT, *Construction Scheduling Standard Coding and Procedures for Designers and Contractors Manual.,* NJDOT: Jersey City, 2001.

[21] M. Lu, and S.M. AbouRizk, "Simplified CPM/PERT Simulation Model", *J. Constr. Eng. Manage.,* pp. 219-226, 2000. [http://dx.doi.org/10.1061/(ASCE)0733-9364(2000)126:3(219)]

[22] P. Bonnal, D. Gourc, and G. Lacoste, "Where Do We Stand With Fuzzy Project Scheduling?", *J. Constr. Eng. Manage.,* pp. 114-123, 2004. [http://dx.doi.org/10.1061/(ASCE)0733-9364(2004)130:1(114)]

[23] A.L.C. Antoine, and K.R. Molenaar, "Empirical Study of the State of the Practice in Alternative Technical Concepts in Highway Construction Projects", *Transp. Res. Rec.,* no. 2573, pp. 143-148, 2016. [http://dx.doi.org/10.3141/2573-17]

[24] R.F. Aziz, and A.A. Abdel-Hakam, "Exploring Delay Causes of Road Construction Projects in Egypt", *Alexandria Engineering Journal,* vol. 55, pp. 1515-1539, 2016. [http://dx.doi.org/10.1016/j.aej.2016.03.006]

[25] A. Hassanein, and O. Moselhi, "Planning and Scheduling Highway

Construction", *J. Constr. Eng. Manage.,* vol. 5, pp. 638-646, 2004. [http://dx.doi.org/10.1061/(ASCE)0733-9364(2004)130:5(638)]

[26] C.H. Wu, T.Y. Hsieh, and W.L. Cheng, "Statistical Analysis of Causes for Design Change in Highway Construction on Taiwan", *Int. J. Proj. Manag.,* vol. 23, no. 7, pp. 554-563, 2005. [http://dx.doi.org/10.1016/j.ijproman.2004.07.010]

[27] W.J. Mallett, and L. Luther, *Accelerating Highway and Transit Project Delivery: Issues and Options for Congress.,* Congressional Research Service: Washington, D.C., 2011.

[28] L.W. Canter, and G.A. Canty, "Impact Significance Determination—Basic Considerations and a Sequenced Approach", *Environ. Impact Assess. Rev.,* vol. 13, no. 5, pp. 275-297, 1993. [http://dx.doi.org/10.1016/0195-9255(93)90020-C]

[29] P. deWitt, and C.A. deWitt, "How Long Does It Take to Prepare an Environmental Impact Statement?", *Environ. Pract.,* pp. 164-174, 2008. [http://dx.doi.org/10.1017/S146604660808037X]

[30] F. Annunziata, and F. Maltinti, "The Goals of Road System Management", In: *IIV Roma MMXII- 5th International Congress,* Rome, Italy, 2012.

[31] A. Ertas, and J. Jones, "The Engineering Design Process", In: *2nd Edition ed,* John Wiley & Sons, Inc: New York, N.Y, 1996.

[32] Virginia Department of Transportation, *How a Road Gets Built,* 2012.http://www.virginiadot.org/projects/pr-howroadblt.asp

[33] T. Sohn, J.T. O'Connor, W. O'Brien, and M. Azambuja, "An Implementation Study of The Right-of-Way Acquisition and Utility Adjustment Process Duration Information (RUDI) Tool", *2009 ASCE International Workshop on Computing in Civil Engineering - Computing in Civil Engineering,* 2009 [http://dx.doi.org/10.1061/41052(346)64]

[34] J.T. O'Connor, W. O'Brien, and T. Sohn, *RUDI User Guide,* 2008.https://ctr.utexas.edu/wp-content/uploads/pubs/5_4617_01_P1.pdf

[35] T. Sohn, *Determining Duration of Right-of-Way Acquisition and Utility Adjustment on Highway Projects.,* University of Texas: Austin, TX, 2009.

[36] E.G. Gibson, J.T. O'Connor, R.L.G. Chang, S.M. Hedemann, and W.K. Chone, *Durations for Acquiring Roadway Right-of-Way and Assorted Expediting Strategies.,* Texas Department of Transportation: Austin, TX, 2005.

[37] T. Le, C.H. Caldas, and E. Gibson, "Significant Factors Affecting Right-of-Way Acquisition Time in Highway Projects", *Construction Research Congress,* 2010 Banff, Alberta [http://dx.doi.org/10.1061/41109(373)122]

[38] J.T. O'Connor, G.E. Gibson, S.M. Hedemann, G.R. Chang, and W.K. Chong, *Duration Quantification and Opportunities For Improvement in the Texas Department of Transportation's Utility Adjustment Process.,* Center for Transportation Research: Austin, TX, 2005.

[39] Texas Department of Transportation, *Right of Way and Utilities: TxDOT,* 2017.http://www.txdot.gov/government/processes-procedures/lgp-toolkit/row-utilities.html

[40] R.D. Ellis, and S. Lee, "Developing Best Practices for Avoiding Utility Relocation Delays", *Proceedings of the Congress,* 2005 San Diego. CA

[41] R.D. Ellis, and H.R. Thomas, "The Root Causes of Delays in Highway Construction", *82nd Annual Meeting, Transportation Research Board of the National Academies,* 2003 Washington, D.C.

[42] C.C. Chou, C.H. Caldas, J.T. O'Connor, A.W. Sroka, and G.K. Goldman, "Identification of Decision Drivers for the Strategy of Incorporating Utility Relocations into Highway Construction Contracts", *J. Constr. Eng. Manage.,* vol. 135, no. 9, pp. 812-818, 2009. [http://dx.doi.org/10.1061/(ASCE)0733-9364(2009)135:9(812)]

[43] C.H. Caldas, C.C. Chou, and J. O'Connor, "Negotiation-based Decision Support Model for Utility Relocations in Transportation Infrastructure Projects", *Construct. Manag. Econ.,* vol. 26, pp. 1079-1090, 2008. [http://dx.doi.org/10.1080/01446190802331388]

[44] Texas Department of Transportation, *Letting and Award: TxDOT,* 2017.http://www.txdot.gov/government/processes-procedures/lgp-toolkit/letting-award.html

[45] Z.J. Herbsman, and R. Ellis, *Determination of Contract Time for Highway Construction Projects.,* National Research Council: Washington, D.C., 1995.

[46] J. Zhang, T. Xub, J. Jia, and H. Wang, "Research on Method of Village Roads Construction Bidding", *International Conference on Transportation, Mechanical, and Electrical Engineering (TMEE),* 2011 Changchun, China

[47] C. Lim, G. Teng, M. Al-Ghandour, and F.H. Bowen, "Let Scheduling for Funding Scenario Analysis of Highway Construction Projects With a Case of NCDOt", *IEEE Trans. Eng. Manage.,* pp. 1-11, 2018. [http://dx.doi.org/10.1109/TEM.2018.2875615]