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Review

Planning and design models for construction industry: A critical survey

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ABSTRACT

Large construction engineering projects involve various types of resources, such as labor, equipment and materials, which require planning and design for efficient operations and economic benefits. Any component of these types of resources demand initial investment, costs, logistics operations, scheduling and many other associated aspects of planning, design and operations of the projects. This paper studies different planning and design models developed for various aspects of construction industry. Most of these studies incorporated mathematical models and simulation based on some real life data. Applications of basic principles of operations research and industrial engineering relating to logistics and procurement have been incorporated for an effective planning and operations of these projects. A critical survey of different important aspects of planning and designing used in construction operations has been pursued here. The general behaviors of design variables and evaluative measures have been presented and discussed in general fashion.

Contents

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1. Introduction

Modern construction involves many aspects of logistics operations that directly affect the effectiveness and economy of the general operations of the related industry. Construction is a major industry in Louisiana and many other states in the United States. After the first planning and design phase, large construction engineering projects involve various types of resources, such as labor force, equipment and materials. Any component of these types of resources demand initial investment, costs, logistics operations, scheduling and many other associated aspects of planning, design and operations of the projects. So the objective of such projects involves the application of basic principles of logistics and procurement for an effective planning and operations of construction projects.

In order to study construction management of civil engineering projects, we view the entire subject area from different perspectives such as (a) classification of construction and procurement projects, (b) construction logistics and service operations, (c) supply and procurement of building materials, (d) transportation for procurement and distribution, and (e) material depot locations.

The construction and procurement projects can be classified into different types of construction engineering such as residential, commercial, public works (sewerage, water supply, utility) and public roads (roads, culverts and bridges). The types of construction process are fixed assembly, prefabrication, and procurement processes. The construction logistics and service operations have milestones and operations sequences, logistical and service involvement; resource and service scheduling, etc. The supply and procurement of building materials involves basic procurement and storage policies such as inventory/stocking of building materials, build or buy policy, material requirement planning, just-in-time supply, etc. Construction materials storages/warehouse is another aspect of civil engineering project which involve material storages systems, construction warehouse design, storing and retrieval systems, crane operations, to mention a few. Transportation for procurement and distribution in construction include materials transporting systems (such as single-loading and inter-modal), construction related network problems (such as transportation and assignment problems, routing, minimal spanning tree problems, and shortest distance problems). Finally, material depot locations for construction look into selecting the storage site or depot location, mass construction/repair zoning, multi-depot locations for public works, etc.

Literature is quite rich enough in each of these topics of construction management. Planning and design models have been proposed by many authors such as Brucker et al. [6], Abourizk et al. [1], Herroelen et al. [30], Fleischmann et al. [19], de Treville et al. [13], Ala-Risku and Kärkkäinen [3], Fan et al. [17], Francis and Miresco [20], Guo [24], Aibinu et al. [2], and González et al. [22] to mention a few. 'Planning' models could be a set of procedures that are to be followed when performing some activities required to complete the project. The planning models always are those instruction models or procedures that are to be followed for future actions to achieve the goal of the project. On the other hand, 'design' models are the prescriptions or optimized values assigned to certain variables the use of which will lead to the best performance of the system. In planning models, parameters may be considered as the plans such that changes in parametric values will change the entire design variable values. For example, volume of a building's air condition space is a parameter which needs to be planned ahead whereas the thickness of the insulation of the wall is the design variable which needs to be optimized given all other building and construction materials' parameters. This category of literature is summarized in Table 1.

Besides these planning and design models for construction industry, several other studies with respect to automation in construction industry have been pursued by Rebolj et al. [59], Christodoulou et al. [10], Mahalingam et al. [45], Isikdag and Underwood [36], Popov et al. [57], Isaac and Navon [35], Cheng et al. [8,9], Jung and Joo [38], and Singh et al. [65]. Most of these studies pursued are either (not necessarily exhaustive) computational verifications or simulation-based comparisons or evaluating the automation effects on the design and some other performance criteria.

The issues relating to inventory and management of construction materials have been discussed by Pheng and Chuan [56], Wang et al. [81], Kapuscinski et al. [39], McCrary et al. [49], Missbauer and Hauber [51], Marshall and Marsh [48], Lam et al. [41], Lee [42], Samaranayake and Toncich [62], Min and Bjornsson [50], Russell et al. [60], Prasertrungruang and Hadikusumo [58], and Lu et al. [44]. Table 2 lists some key specifics of each of these models. Heuristics procedures relating to optimization of the planning models and general management of the projects are research by Zheng et al. [84], Tseng et al. [79], Xu and Wang [86], Subprasom

Table 1
Planning and design models.

Authors	Planning	Design	Type of model	Specifics
[6]	Yes	No	Project scheduling	A survey of resource-constrained project scheduling models/methods
[1]	Yes	Yes	Labor production rate	A artificial neural network model for estimating labor production rate for industrial construction activities
[30]	Yes	No	Project scheduling	Critical review of major shortcomings of project scheduling classification presented by Brucker et al. [6]
[19]	Yes	Yes	Supply chain management	Using return products as source of spare parts in closed-loop supply chains
[13]	Yes	Yes	Supply chain management	Studying the role of lead time reduction in improving supply chain performance
[3]	Yes	No	Material delivery	Efficient material delivery for short-term project schedules
[17]	Yes	No	Equipment management	Data-warehouse-based DSS for construction equipment
[20]	Yes	No	Project planning	A chronographic scheduling method for construction project planning
[24]	Yes	No	Transportation network analysis	Intermodal transportation optimization considering both internal & external costs
[2]	Yes	No	Construction contract management	Enhancing cooperative behavior in administering construction contracts to lessen disputes with contractors
[22]	No	Yes	Design of WIP buffer	Multi-objective design of WIP buffer to mitigate variability in production and improve project performance
[83]	Yes	No	Optimal performance	Optimal performance of building facilities
[53]	Yes	Yes	Site layout plan	Decision making for site layout planning