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Examination of job-site layout approaches and their impact on construction job-site productivity

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Abstract

In all forms of construction project delivery, job-site layout is routinely developed and designed after bid award and prior to the contractors' receipt of the notice to proceed or letter of commencement. Job-site layout decisions are made to locate temporary offices, sanitary facilities, worker rest areas, crane locations, storage and workshop areas, access points and access roads, utilities and other critical features. These jobsite design decisions affect the operational capabilities of the site and have a direct influence on both the costs and schedule through productivity. This paper will examine the various approaches utilized in practice and proposed through research for jobsite layout design and site optimization. Factors and variables considered in the identified approaches are discussed and evaluated with respect to the impact on jobsite productivity and successful contract delivery. Important factors for job-site layout are further explored through a survey of working professionals within the United Arab Emirates (UAE). Survey results are summarized, examined and discussed in relation to the variables and critical parameters identified and their effect on job-site performance and contract success. The paper concludes with a discussion of future directions for job-site benefits.

Keywords: construction; jobsite; operations; productivity

1. Introduction

Construction is a unique project-oriented manufacturing industry where prototype facilities are delivered by general contractors according to owners' requirements. These requirements are articulated in the plans, specifications and other contract documents produced by design professionals, which form the basis for bidding and tendering. Project delivery commences after the tendering process is complete and the successful general contractor is charged with construction delivery at the prescribed quality within the contractual time and cost constraints. Delivery of the project must be undertaken within unpredictable environmental conditions while managing the incorporation and delivery of a wide diversity of materials and equipment and significant capital expenditures. Efforts are further compounded by diverse involvement and interests of stakeholders, which further complicates successful project delivery in the industry.

With significant risks and complexity, the industry has developed and instantiated well-defined processes and procedures to guide the process of construction project delivery for mutual benefit of all parties involved. The industry is truly driven by the well-known motto that 'failure is not an option,' and success stories abound throughout the world.

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Today, the construction industry has pressed through the challenges and complexities to become one of the most satisfying and rewarding environments for engineering practice and an essential metric for gauging economic vitality.

While the construction industry has and continues to be successful in the physical facilities to support societies, it has faltered when considering total and partial (i.e. labor or equipment) productivities. The construction industry, unlike all other comparable economic sectors, has stagnant or even negative productivity growth over the last several decades. This means that less output is being realized for every unit of input. Owners are getting less for their money even while technologic increases and material advances transform the industry. Contractor profit margins decrease, engineers experience less design opportunity, construction disputes increase, labor rates are pressured, and bankruptcies may result. The industry has a productivity problem and positive change is required to make a difference.

When examining productivity, there are numerous avenues that can be pursued and numerous parties that can be focused upon. This includes the owner's selection of project delivery systems, designer implementation of BIM tools to minimize errors and omissions, and regulators incentivizing innovation in project delivery. Contractors can ensure that their productivities are realized and profitability ensured through proactive site-planning, implementation of lean construction principles, and innumerable other areas of consideration which influence the on-site project delivery.

The purpose of this study is to focus on elements which are under direct control of the general contractor. The research performed by Naoum in the United Kingdom [1] identified well over 100 research journal articles covering construction labor productivity. Through this work, a survey of practitioners evaluated 46 factors covering "preconstruction, activities during construction, management-related factors, organization factors and motivational and social factors," which directly impact construction labor productivity. This included process flow variables, such as overcrowding on the site, ineffective site planning and inefficient site layouts, which are the focus of this examination.

Job-site layout and site layout planning is imperative and impacts almost all operations required to deliver the facility. The site layout design process must take into account the number of temporary facilities needed for construction, the size and shape of the site as well as the construction program [2]. Temporary facilities may include but are not limited to: temporary offices, sanitary facilities, crane locations, storage areas for materials and equipment, workshops, access roads, rest areas, safety and health facilities, and security features. When decisions are made regarding the site layout, they can be difficult or costly to change as the project progresses; therefore, developing an effective site layout plan is paramount for efficient construction and ensuring productivity. With a good and efficient job-site layout excess movement of material within the site is reduced, labor productivity increased, costs and durations reduced, worker safety improved and construction quality positively impacted.

There are various approaches can be employed to develop the job-site layout design and to enhance site optimization. Each approach has to take into consideration factors and variables that will lead to job site productivity as well as successful contract delivery. This paper provides a survey of approaches identified through the literature and explores important factors for job site layout design. The importance of the factors identified were further explored through a survey implemented in the United Arab Emirates (UAE) among working professionals. Survey results are contrasted with tasks and priorities identified in the literature where possible.

2. Laying out the job-site: Approaches for design of the site

Job-site layout, as discussed in the introduction, is paramount for construction project success. The site layout must effectively address many concurrent considerations, including:

- Space provided to function on the job site and constraints on space utilizations, such as set-backs.
- Access to the job site for vehicles and as access to work areas within the job site
- Temporary facilities required including temporary offices, storage facilities, sanitary facilities and utilities
- Material handling and movement and associated worker and public safety/security measures.

There are many techniques available for utilization in job site layout development and a literature review was performed to identify current state-of-the-art and state-of-the-practice. A wide diversity of practices were identified including heuristic, rule-of-thumb approaches, optimization, and artificial-intelligence approaches. A detailed overview of research performed in this area previously has been summarized by Sadeghpour and Andayesh [3], whom surveyed nearly 100 technical journal articles from 1987 through 2015. A wide variety of approaches were identified, including knowledge based approaches (inclusive of heuristics), mathematical programming approaches (including linear and non-linear optimization), and artificial intelligence approaches (including neural networks, genetic

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