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Defining a mathematical function for labor productivity in masonry construction: A case study

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Abstract

Labor productivity has a profound impact on construction management. The accurate prediction of productivity is essential to effectively plan operations that depend on time and cost and is critical for the success of a construction project for both the contractor and the owner. However, predicting productivity of operations is challenging due to the multiple characteristics of workers, the interrelationships between workers, and the site conditions that impact the performance of crews and affect project goals. This paper proposes a methodology to quantify the factors that affect productivity in masonry construction. We have considered three factors: compatibility, suitability, and craft. Standardized data-collection techniques are used to consolidate data from three masonry sites and mathematically define a productivity function that relates workers characteristics and crews with site conditions. The function, increasing in its arguments, determines the factors that most affect masonry productivity and the factor's effects. The most interesting part is to be able to identify the convexity properties of this function because its theoretical interpretation will have implications on the impact of the superintendent's decisions when forming crews. The proposed mathematical function can enable superintendents to better plan, schedule, and manage masonry crews.

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1. Introduction

Labor productivity is one of the key factors affecting the overall performance of a construction project [1]. Labor costs usually account for about 30-50% of the total project costs [2] and labor is considered the strategic resource in any project for ensuring improved productivity and industry competitiveness [3, 4]. By effectively managing labor, the productivity of all the other inputs can be simultaneously enhanced and all of the benefits available through improved productivity can be realized. Crew formation is one of the key tasks in labor management [5]. The process of selecting the workers in a crew and assigning crews to different tasks is crucial for ensuring the success of a construction project and improved labor productivity. Florez [6] conducted a review to understand the functioning of masonry crews and determine the factors that impact the productivity of crews. Through extensive site observations and interviews with masonry practitioners, it was found that typically the superintendent in the jobsite considers three factors (that impact productivity) when grouping workers in crews: compatibility, suitability, and craft. This paper aims to define a function that determines the three factor's effects on productivity. The function alongside its theoretical interpretation will provide a means for determining the extent of the superintendent's decisions and can become a powerful tool for the process of planning and managing masonry crews.

2. Masonry construction

Masonry construction is labor-intensive. Processes involve little to no mechanization and require a large number of crews made up of workers with diverse skills, capabilities, and personalities [7]. In masonry construction, management of labor is one of the key factors to balance production and quality [8]. Tasks may require several crews with diverse skills to be completed and crews need to be scheduled to ensure an efficient output and adequate control [4]. This allocation process in masonry construction is challenging. Every time a wall section or part of a wall section is completed, the labor configuration is reorganized [9]. This results in temporary crews that need to be constantly moving and the superintendent is responsible of re-organizing the crews to make sure the masons selected to build the walls have the required characteristics to produce good quality work within the given time constraints.

2.1. Factors that impact crew formation

Results from the exploratory study in [6] indicate there are different characteristics of masons that need to be considered because these have an impact on the quality of the work and the productivity of a crew. These criteria are used by masonry practitioners in forming crews and are used as guidelines when the superintendent is in the jobsite trying to group workers to form the most efficient crew. The three factors that impact productivity found in [6] are detailed below:

- **Compatibility:** masons have different personalities, ways to work, and get things done. Some masons work well together, but some masons just do not work well with certain other masons. They just do not get along and when they work with each other they seem to get less productive. The superintendent tries to form crews with workers that are compatible because grouping masons that work well together can increase throughput [10].
- **Suitability:** masons have different specialties and can be more suitable to work in a specific type of wall. Some masons are very good levelling and plumbing and therefore are efficient working on wall sections that require a high demand of technical work (e.g., openings, intricate corners, details, building leads, penetrations). Other masons are not good with the level and the plumb but are very efficient working in the line and in non-technical work (e.g. straight walls or walls with little to no openings). The superintendent tries to assign a mason to a wall that matches the specialty of the mason to the type of work required in the wall.
- **Craft:** masons learn (and know) how to lay brick and block but are usually faster at one craft than the other. Some masons are good at handling smaller units and are more detailed so they are better brick layers, whereas some masons are stronger and are better at laying block. In other words, in masonry there are bricklayers and there are

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