Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 145 (2016) 654 – 661

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Sustainable Design, Engineering and Construction

Achieving sustainable structural steel design by estimating fabrication labor cost based on BIM data

Arash Mohsenijam[a], Ming Lu[b]*

[a]*Departmet of Civil and Enviromental Engineering, University of Alberta, 116 St & 85 Ave, Edmonton, T6G 2R3, Canada*
[b]*Departmet of Civil and Enviromental Engineering, University of Alberta, 116 St & 85 Ave, Edmonton, T6G 2R3, Canada*

Abstract

Structural steel is heavily utilized in the construction industry from residential and commercial buildings to oil and gas projects. For steel fabrication companies as suppliers of steel structures, submitting competitive project bids requires substantial knowledge of the company's practices on the shop floor and extensive experience to interpret that into credible cost estimations. Being able to make reliable estimates would contribute to the company's competitiveness in the long run. In this study, the total quantity of worker-hours or man-hours required for each major subdivision of a project is considered as the variable of interest in estimating a steel fabrication project, mainly because of the labor-intensive nature of steel fabrication. In collaboration with a partner company, three years of project data, were collected by matching the company's building information modeling (BIM) system with their labor costing system resulting in over 3,000 records, each representing the quantity takeoff for 46 design features and the worker-hours expended in shop fabrication. Stepwise regression and error analysis are used to recognize the most crucial design features in estimating project worker-hours, allowing discovery of the minimized set of inputs for estimating worker-hours and characterization of the estimation uncertainties. This labor cost estimation benefits estimators and shop production planners in that they can configure labor resources to deploy, schedule shop floor production, and recognize estimates' associated errors, based on the company's historical data. This study is an example of using BIM data and providing tools for structural engineers to consider steel fabrication and possibly achieve more sustainable designs.

Peer-review under responsibility of the organizing committee of ICSDEC 2016

Keywords: Steel fabrication; Construction industry; Regression analysis; Worker-hour estimation;

* Corresponding author. Tel.: +1-780-492-5110
E-mail address: mlu6@ualberta.ca

Peer-review under responsibility of the organizing committee of ICSDEC 2016
doi:10.1016/j.proeng.2016.04.056

1. Introduction

In the construction industry, fabricated steel pieces comprise one of the main materials required in typical construction processes [1]. The fabrication process of steel pieces and components encompasses operations of cutting, fitting, welding, and surface processing, which are highly dependable on fabrication setup and crew experience. A confident prediction of fabrication man-hours or worker hours is essential for estimating steel fabrication costs and planning the processes [2]. As a result of labor-intensive nature of steel fabrication, costs for supporting facilities, resources, equipment, wastes and fabrication overhead are generally treated as indirect costs which are correlated to the direct labor costs [2]. There are many types of work and quantities of components, connections and handling involved in steel fabrication projects (e.g. weight, length, weld length, etc.), which need to be translated into worker-hours required to execute a certain project.

BIM has been commonly used in the past decade as a collaborative platform for designing a structure and virtually simulating the construction process. BIM is being adopted in the steel fabrication industry as it offers great advantages from constructability reviews to material quantity takeoffs. There are many long-term incentives in adopting BIM at the company level, such as effective information management. Every steel fabrication project has specific details that give the main indicators of project complexity and difficulty, along with worker-hours and duration it would take to deliver the project in the fabrication shop. Therefore, the project details can be used as predictors in project worker-hours estimation. Project details can be efficiently obtained from BIM models, which can be used as inputs for worker-hour estimation. Thus, the company's historical data could be utilized in developing a data-driven prediction model with project details as its inputs and project worker-hours as the output.

It is a commonly accepted fact that the design stage of the projects presents a great opportunity to consider sustainability concepts to influence construction costs and project life cycle. However, the decision support tools to inform the designers on project performance and sustainability in the early stages of projects have not been fully explored [3]. Guggemos et al. [4] studied the possible enhancements to design and fabrication processes of steel structures to improve their sustainability. In this research, lack of direct communication between the structural team (structural engineer, steel detailer, fabricator, etc.) and early involvement of fabricators in the steel design process are identified as the main areas requiring improvement. Weisenberger [5] studied sustainability in steel structures from a structural engineers' perspective and concluded that a green structural system is not only about the material but also the cooperative design process. BIM, as a collaborative environment, could be used to develop BIM-based tools that take advantage of the information stored and focus on sustainability and resource utilization [5].

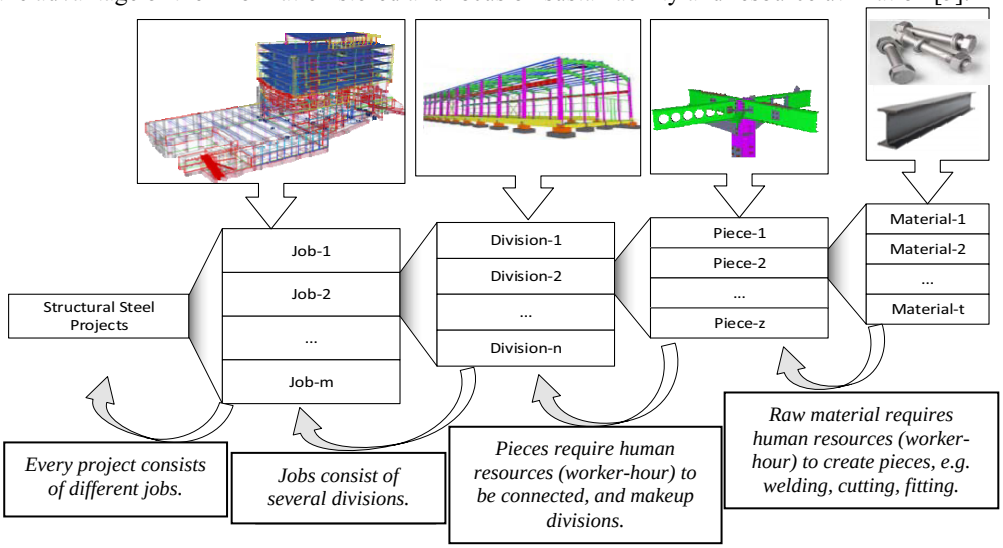

Fig. 1. Steel fabrication project's database structure