# Lean construction and occupational health and safety risks in construction project management: the case of ironworkers: a short literature review

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**Abstract:** Structural steel buildings are used in many construction projects. Lean construction, a new trend in construction building, is an adaptation of lean production to designing, planning and construction of built infrastructures. Based on a contemporary literature review on lean construction, occupational health and safety (OHS) risks in construction project management and trade of ironworkers this paper will describe material, technological parameters and activities of structural steel workers in Europe and North America. It will also describe continuous improvement activities, OHS activities and approaches currently used.Ironworkers work with both structural and reinforcing steel materials. Activities, work organization, environment and equipments of ironworkers are all sources of occupational OHS risks. Ironworkers generally work outside in all weather, although some work indoors in manufacturing plants or underground work sites. The work sites may be in a variety of locations. The work often requires considerable standing, bending, crawling, lifting, climbing, pulling and reaching, and is often conducted in cramped, confined spaces or at heights. Hazards include falls, lifting heavy weights, contact with objects, electrocution or falling objects. Lean production concepts are introduced to enhance construction project management, process synchronization and OHS. Material delivery methods, equipment management and work site organization reduce transportation of steel, unnecessary tasks and human movements, facilitate unloading, organization and lining up of steel ready for assembly, keep workplace clean and safer.This literature review study polishes up the understanding we have of the ironworkers' activities. Lean construction offers great potential to maximize value and minimize waste as well as improve OHS.
**Keywords:** Lean production, occupational health, safety risks, ironworkers.

## 1. Introduction

Structural steel buildings are used in many construction projects (commercial, industrial, institutional and large residential buildings, towers, bridges and stadiums). The management of steel construction projects requires knowledge of modern management as well as an understanding of the planning, design, construction and execution process.

Lean construction (LC), a new trend in construction building in Canada, is an a-

daptation of lean production to designing, planning and construction of built infrastructures. In production management, lean is used to qualify production performance in terms of productivity and quality through continuous improvement and elimination of waste. Waste is caused by excessive production, production delays, transportation and handling, unnecessary tasks, inventory, unnecessary human movement and poor or over quality of products. Lean production is more than a production method, it is a production philosophy.

## 2. Methods

The paper is based on a review of the contemporary literature on lean construction, occupational health and safety risks in construction project management and trade of ironworkers. The review of literature has targeted all type of publications: magazines, newspapers, scientific articles, courses or technical work, research reports and scientific presentations, norms, standards and regulations. It has been directed and conducted in tree (3) steps:

- with an emphasis on the trade of ironworkers: the environment, its materials and specific tasks, safety equipment, personal protective equipment, an overview of the organizational factors and operational risks;
- with an emphasis on occupational injuries and musculoskeletal disorders among workers in the area surrounding the construction site;
- with an emphasis on lean construction.

The retrieval methodology began with a consultation of databases and websites that are intended for publications with medical connotations in the sense of prevention of occupational diseases or for promoting health and safety in the field of construction: PubMed, Medline, Health Canada, CDC, Centers for Disease Control and Prevention, Construction Safety Association of Ontario European Agency for Safety and Health at Work, Occupational Safety and Health Administration, HSE, INRS, CSST, OPPBTP, etc. For this study were used keywords in three languages: French, English and Romanian.

Then, the sites of businesses, professional associations, practitioners, government departments and agencies that have a direct link with the theme have been consulted: structural erection, steel frame and urban structure in Canada, the United States and Europe: National Post Classification (NOC), Canadian Council of Directors of Apprenticeship (CCDA) Red Seal Trades, Service Canada, Canada (Standards Council of Canada NCC), Quebec (Le Bureau de normalization du Quebec BNQ), ISO Standards, The European Agency for Safety and Health at Work (EU-OSHA), The European Commission at Work (EU-WC), Lean Construction institute (LCI), The TBM LeanSigma Institute, European Construction Institute (ECI), etc.

## 3. Results

Generally, ironworkers work with both structural and reinforcing steel materials. They

- install, bolt and weld structural steel components;
- place reinforcing steel;
- erect pre-engineered buildings;
- place and stress various post tensioning systems;

- prepare the construction site by assembling the hoisting equipment and erecting scaffolding, cranes, hoists and derricks;
- unload structural and reinforcing materials and organize the material for installation by connecting cables and slings to the components and directing crane operators in lifts;
- install conveyors, machinery and automated material handling systems.

Our focus is on tasks number 1, 3, 5, 6 and 7.

Activities, work organization, environment and equipments of ironworkers are all sources of occupational health and safety (OHS) risks. Ironworkers generally work outside in all weather, although some work indoors in manufacturing plants or underground work sites. The work sites may be in a variety of locations. The work often requires considerable standing, bending, crawling, lifting, climbing, pulling and reaching, and is often conducted in cramped, confined spaces or at heights. Hazards include falls, lifting heavy weights (musculo-skeletal disorders: low back pain and injuries to upper limbs), contact with objects, electrocution or falling objects. Ergonomic studies with analysis of tasks, workloads and strains in concrete work has been performed some years ago in some European countries (e.g. Netherland, Germany, Finland), United State and Japan as well. The results have been published (e.g. Duivenbooden et al., 1997; Kobayashi K , 1997; Wakula et al., 1997; 2003; Schneider et al, 1997). Also logistics management on construction side and improvement of working conditions has been analyzed (e.g Wegelius-Lehtonen, 1997).

The work process of steel construction projects includes some tactical planning of activities, tools and practices that are normally used in lean production. Specifically, in order to reduce work time and assure a superior operational process synchronization and safe workplace we found these similarities between LC and Lean production (Table 1).

***Table 1:*** *Comparison between work process of steel construction and lean production*

| Work process of steel construction projects | Lean production |
|---|---|
| Steel delivery methods<br>• Use sequenced daily deliveries (sort steel bundles needed for the day's work only);<br>• Delivery quantity and date planned by division;<br>• Detail each parameters of division (mark by bundle and bundle by division). | • Improve the management of on-site deliveries through a constant daily production;<br>• Stabilize a level of daily production with a uniform plant loading;<br>• Eliminate inventory by small lot sizes and<br>• Containers for fixed number of elements;<br>• Quick Setups;<br>• More standardization. |
| Work site management<br>• Have a separate drawing for site administrators, showing exactly where to lay each bundle on work site;<br>• Use big plastic tags and color coded for material bundles identification;<br>• Unload the material in order on site, take each bundle to exactly where crane's going to lift it;<br>• Sort and pack structural steel elements by types, before delivery on site. | • Reduce lead times production by moving two workstations closer together (in our case: one for unloading structural materials and organizing the installation by connecting cables and slings to crane in lifts and one for erecting pre-engineered elements),<br>• Quick Setups by the quality of visual tools;<br>• Reducing queue length (reducing the number of jobs waiting to be processed by sorting and handing of the elements). |

The main benefits of steel delivery methods and work site organization in build production project are:

- keep the workplace clean and safer;

- steel arrives on site better organized and in order in line up to erect;
- easier unloading and reduced number of lifts;
- visual aids help to speed-up installation (workplace and structural steel identifications on site);
- reduce transportation of steel elements on site;
- minimize unnecessary tasks and human movements (less sorting, handling and searching for steel).

## 4. Conclusions

This literature review study polishes up the understanding we have of the ironworkers' activities. To complement our review of literature, we will study and analyze in the next months the learning activities leading to the occupation of ironworkers (skills necessary in the process of metal erection).

The research protocol involves the study of this activity by the participation of students and teachers of the Steel Trades Training Center 'Centre de Formation des Métiers de l'Acier (CFMA)', during the program development skills. The CFMA, through its programs of study, equipment and environment, offers a valid preliminary research field, a real source of information to accomplish the main goals of our project: identify and analyze the work of ironworkers. We will then study and analyze ironworkers activities (work planning, work site management and steel delivery methods) on existing work sites.

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