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ScienceDirect
International Journal of Industrial Ergonomics 38 (2008) 238–246
International Journal of INDUSTRIAL ERGONOMICS
www.elsevier.com/locate/ergon

Ergonomic assessment of suspended scaffolds☆

Tarcisio Abreu Saurin*, Lia Buarque de Macedo Guimarães

LOPP/UFRGS (Products and Processes Optimization Laboratory, Federal University of Rio Grande do Sul). Praça Argentina n. 9, 2. andar. Porto Alegre CEP 90040-020, RS Brasil

Received 3 June 2005; received in revised form 6 October 2005; accepted 17 November 2005

Abstract

Work on scaffolds is usually associated with traumatic type injuries. However, operating that type of equipment can also contribute to overexertion injuries, especially in manually operated suspended scaffolds. Since this equipment is largely used both in Brazil and other developing countries for painting and coating building facades, this study presents an ergonomic assessment on the operation of two types of suspended scaffolds. They are referred to as light scaffold and heavy scaffold—the difference lying in their dimensions and number of gears. The assessment criteria were: workers' perceptions of effort; body posture assessment (OWAS method); heart rate elevations (HRE); percentage of the available heart rate range (PHRR); scaffolds' speed and, repetitiveness of movement in the scaffolds' levers. Workers preferred the light scaffold because it moved up to eight times faster than the heavy scaffold. However, the study's results indicated that the operation of both types is much too physically demanding. For instance, HRE was 52 beats per minute (bpm) and PHRR was 50.7% on average for workers operating the light scaffold. Concerning the heavy scaffold, HRE was 45 bpm and PHRR was 42.2% on average. All of those values are substantially higher than the acceptable limits of 35 bpm for HRE and 33% for PHRR proposed in the literature. Failures in the scaffolds' design as well as the lack of attention directed towards ergonomics in regulations were determined to be relevant root causes for detected poor working conditions.

Keywords: Suspended scaffolds; Construction; Work physiology; Work postures; Safety

1. Introduction

Historically, less emphasis has been focused on health issues in the construction industry in favour of the more immediate, high profile (and perhaps more easily solvable) safety issues. This is due to a number of factors, such as: the sizeable, temporary and mobile workforce; many workers are not directly employed; the lack of health expertise within industry; benefits of health management are not immediate and are consequently difficult to demonstrate (Gibb et al., 1999). However, several studies have pointed out high incidence of health problems in this industry (Everett, 1999; Gibb et al., 1999). In 1995, the UK's self-reported work-related illness survey found an estimated 134.000 construction-related workers reported a health problem caused by their work, resulting in an estimated 1.2 million days lost in a workforce of 1.5 million (Horne et al., 2003). Since construction projects are becoming more complex, with time and cost constraints more severe, professional burnout has also become an increasing concern in this industry (Lingard and Sublet, 2004). Besides, construction work is, by its very nature, a problem in ergonomics. For example, installing floors and ceilings requires work at floor and ceiling height which, by definition, is ergonomically hazardous since ceilings have to be above shoulder level and floors below knee height (Schneider and Susi, 1996).

Despite the little attention that construction industry has given to health hazards, their control measures are fairly well known. In fact, a number of studies have dealt with ergonomic assessments and development of engineering controls for typical construction activities (Everett, 1999; Schneider and Susi, 1996). However, there is lack of studies concerning technologies that are extensively used in

DOI of original article: 10.1016/j.ergon.2005.11.006

☆This article was previously published in Volume 36, issue 3, pp. 229–237.

*Corresponding author. Tel:. +55 51 3316 3490; fax: +55 51 3316 4007.
E-mail addresses: saurin@ufrgs.br, tasaurin@terra.com.br (T.A. Saurin), lia@producao.ufrgs.br (L.B. de Macedo Guimarães).

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doi:10.1016/j.ergon.2005.11.010

developing countries. For example, manually operated suspended scaffolds that are largely used in Brazil for painting and coating building facades have not been examined. In Brazil, both powered suspended scaffolds and tower scaffolds are still used at a minor extent, mostly in major construction projects. In the literature review carried out for this study, no references on previous ergonomic assessments of suspended scaffolds were found. However, Cutlip et al. (2000) and Hsiao and Stanevich (1996) carried out biomechanical assessments on assemblage and disassemblage of tower scaffolds. Those studies identified tasks and activities that increased the risk of overexertion injury associated with the erection and dismantling of frame scaffolds. Also, Fang et al. (2004) compared the level of nervousness of workers at bamboo and metal supported scaffolds in Hong Kong. Based on pulse frequencies measurements, they concluded that people are usually more nervous on bamboo tower scaffolding than on metal tower scaffolding.

Work on scaffolds, whatever the type, is usually associated with fall hazards. An analysis of approximately 3000 accident reports in Brazilian construction sites carried out by Costella (1999), showed that falls from scaffolds, whatever the type, accounted for nearly half of all serious accidents (46.3% of the total). Because of this high incidence of traumatic injuries of this type, NR-18 (Work Conditions and Environment in the Construction Industry), the main safety regulation related to the construction industry in Brazil, focuses mainly on prescriptive requirements regarding the structural design of scaffolds. Ergonomic issues, not only concerning scaffolds, are not directly dealt with by NR-18 (Saurin et al., 2000). Moreover, suspended scaffolds in Brazil are usually manufactured on site using craft methods. Besides that, they are frequently made of reused material often refused and adapted from other construction equipment (e.g. safeguards such as guardrails might become working platforms in scaffolds).

Based on the context described above, it seems necessary to go beyond safety risks and to investigate ergonomic issues associated to the operation of suspended scaffolds. The improvised way that suspended scaffolds are usually manufactured, the fact that their operation is a labor-intensive-task and the absence of ergonomic requirements in NR-18 indicate that relevant ergonomic hazards are likely to exist. Thus, this paper aims to assess the extent to which operating suspended scaffolds is a demanding task as well as to identify the underlying reasons of the detected poor working conditions.

2. Research method

Due to the increasing incidence of musculoskeletal disorders among bricklayers who were coating the building's external envelope using scaffolds, an ergonomic assessment was requested by a major building contractor in Porto Alegre, South of Brazil. Government inspectors also had intensified inspections at the contractor's sites. In particular, they demanded the compliance with a NR-18 requirement that established that working platforms should be capable of supporting a minimum of at least 200 kgf (440.5 lb). Even though site managers pointed out that the compliance with that requirement would result in over sizing the scaffold, the structural design of the scaffold was not focused in this study.

Assessment was based on the following five parameters: (a) workers' perceptions about the working conditions; (b) adopted work postures during both coating activities and scaffolds operation; (c) physical demand of both coating activities and scaffolds operation; (d) estimation of scaffolds' speed; and (e) measurement of task repetitiveness during the operation of the scaffolds' levers. It is worth emphasizing that parameter (d) was considered because the scaffolds' speed could have an impact on both the length of time workers were exposed to hazardous conditions and the type of scaffold they preferred. The data collection procedures are presented in detail below.

2.1. Overview of the working environment and tasks

2.1.1. Description of the scaffolds studied

This study was conducted in two residential buildings where suspended scaffolds were used for facades' coating work. The scaffolds were classified as either light or heavy. Both types could be easily distinguished through visual inspection. This distinction was based on the features presented in Table 1. Heavy scaffolds were fully assembled at the construction site by the contractor's carpenters, except for the gears, which were purchased from an external vendor. Light scaffolds were fully pre-assembled, including gears, planks and the guardrail system and were provided by the same vendor.

Fig. 1a shows the operation of a heavy scaffold. It can be noticed that the worker has adopted a device to make the lever longer. This was required to reduce push and pull forces. Fig. 1b shows the lever of a light scaffold, in which a similar device was also adopted. The dimensional difference between both types of scaffolds is illustrated by Fig. 1c, which shows a frontal view. In this view, the light scaffold (on the left) was in front of a blind wall. Note that both access and loading of materials were limited to an adjoining heavy scaffold.

Table 1
Basic features of the scaffolds studied

	Light scaffold	Heavy scaffold
Width	0.70 m	1.50 m
Length	4.0 m	From 2.0 to 8.0 m
Number of gears	2	4 gears every 2.0 m in length
Length of cable per gear	45, 60 or 90 m	45, 60 or 90 m
Weight of each gear	Not available	40 kg (without the cables)
Guardrail system	Metallic	Wood