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# From construction site to design: The different accident prevention levels in the building industry

Eduardo Diniz Fonseca [a,b,*], Francisco P.A. Lima [c], Francisco Duarte [a]

[a] Department of Production Engineering, Federal University of Rio de Janeiro, Brazil
[b] FUNDACENTRO-MTE, Brazil
[c] Dept. of Production Engineering, Federal University of Minas Gerais, Brazil

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ABSTRACT

The construction industry is responsible for one of the highest incidences of work-related accidents in Brazil, as well as in various other countries. In spite of the dissemination of prevention programs and the proposals for developing safety design for the construction industry, construction sites remain dangerous and unhealthy places. Recently, safety has been proposed to be considered from the development phase of the design (Construction Hazards Prevention through Design), but with little effectiveness in practice. In addition to these more recent proposals, we will demonstrate that the integration between safety and production can proceed through anticipations occurring at several levels of the construction phase, not only in the design phase. Through narratives emerged through techniques of activity analysis at the construction site, it was possible to highlight and categorize 25 cases with implications for the production process development. The results show that this integration between production and safety is possible through anticipations occurring at several levels of the construction phase, from the design analysis conducted by the construction engineer to the implementation. This will allow the development of design situations for implementing safe work situations. The contribution and originality of this paper are based upon the presentation of a model in three levels of anticipation of problems during the construction phase and its effects on improving production and safety.



## 1. Introduction

In order to improve its poor performance in safety, the predominant strategy of the construction industry has been the multiplication of prevention norms and programs (for example: OSHA Law & Regulations in the U.S.; the Program of the Conditions and Environment in the Construction Industry (PCMAT) demanded by NR-18, organized by the Ministry of Work and Employment (MTE) in Brazil; and the actions to improve safety and health in construction promoted by the European Agency for Safety and Health at Work (EU-OSHA)). More recently, such safety practices in the construction industry have been enriched by proposals of design development aiming at safety at construction sites through the implementation of the concept of Construction Hazards Prevention through Design (Gambatese et al., 2005; Toole, 2002; Weinstein et al., 2005; Behm, 2005; Toole and Gambatese, 2008). However, construction sites remain dangerous places, prone to accidents (Saurin et al., 2005; Weinstein et al., 2005; Suraji et al., 2001; Behm, 2005; Haslam et al., 2005). Behm (2005), for example, points out that the construction industry is still the most dangerous industry in the United States in terms of the total number of deaths.

Although the construction industry in Great Britain has presented modest decline in fatalities in the last years (rate from 4 per 100 thousand workers), when compared to other industries, the construction industry has been reported as responsible for 31% of deaths occurred at work in 2002/2003 (see Health and Safety Commission (HSC), 2003). This study shows that the number of fatal accidents dropped from 80 in 2001/2002 to 71 in 2002/2003. However, 46% (33 out of 71) of the total fatal accidents happened with construction industry workers due to falls from heights (see Health and Safety Commission (HSC), 2003, p. 14). Furthermore, the rate of accidents in construction in Great Britain increased from 356 per 100 thousand workers in 2001/2002 to 375

* Corresponding author at: FUNDACENTRO-MTE, Brazil.
*E-mail addresses:* eduardo.fonseca@fundacentro.gov.br, eduardodfonseca@gmail.com (E.D. Fonseca), fpalima@dep.ufmg.br (F.P.A. Lima), duarte@pep.ufrj.br (F. Duarte).

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per 100 thousand in 2002/2003 (HASLAM et al., 2005). This 5% increase represents a backset to frequency rates of five years before (HASLAM et al., 2005).

In Brazil, according to DATAPREV/CAT data, between 2003 and 2006, the number of typical construction accidents increased yearly, from 22,686 in 2003 (Anuário Brasileiro de Proteção, 2006, Tab. 6, p. 26) to 27,147 in 2006 (Anuário Brasileiro de Proteção, 2008, Tab. 6, p. 34). On the other hand, it is possible to see that such increase does not mean an increase in the rate of typical accidents per 100 thousand workers, but shows prevention stagnation: (1) In 2003, the total number of workers in Brazil was 29,544,927, and the total number of typical accidents was 325,577 (Anuário Brasileiro de Proteção, 2006, Tab. 1, p. 20). Thus, it can be estimated that in Brazil in 2003, the total number of typical accidents per 100 thousand workers was approximately 1102. As in 2003 civil construction had a total of 22,686 typical accidents, it can be estimated that the sector contributed with 6.97% of the total typical accidents. Such contribution meant approximately 77 typical accidents per 100 thousand workers. (2) In 2006, the total number of workers in Brazil was 35,155,249, and the total number of typical accidents was 403,264,577 (Anuário Brasileiro de Proteção, 2008, Tab. 1, p. 28). Thus, it can be estimated that in Brazil in 2006, the total number of typical accidents per 100 thousand workers was approximately 1147. As in 2006 civil construction had a total of 27,147 typical accidents, it can be estimated that the sector contributed with 6.73% of the total typical accidents. Such contribution meant approximately 77 typical accidents per 100 thousand workers.

Therefore, the maintenance of the typical accident rate, the increase in the number of these accidents and the maintenance of the high number of deaths in the construction industry seem to put into question the evolution and adaptation of the existing actions and proposals concerning the reality of the construction industry.

The predominant principle behind the prevention proposals and/or programs is that most accidents can be avoided if due attention is given to the norms. Such principle (traditional or classical safety paradigm) has in its root the so-called "domino theory" (Heinrich, 1959), in which accidents are equivalent to a linear sequence of "dominoes", and the third domino represents "unsafe acts" and "unsafe conditions". Mitropoulos et al. (2009) point out, for example, that the current approach to prevent accidents has as basis the violation of OSHA norms and it aims at prescribing and imposing the use of protections. The violation of such norms (defenses) is called "unsafe actions" and "unsafe behaviors" (Mitropoulos et al., 2009). However, the normative approaches do not consider the characteristics of the production process or those of the work teams that influence the behavior at work and may lead to mistakes and accidents (Mitropoulos et al., 2009).

Faced with the limitations of such proposals and principles, various works point to the necessity of studies that try to model the contribution of subjacent factors to the process generator of accidents in the construction industry. Atkinson (1999) suggests that the causes of faults in the construction are not as obvious as they may seem, and that violations are a natural human tendency to improve the work condition within the context presented. Thus, it is necessary to investigate the subjacent causes of the faults, and the analysis must address the whole construction design as a system (Atkinson, 1999). The analysis of the causes of accidents in the construction industry evolve and start to consider organizational and management aspects (Suraji et al., 2001; Saurin et al., 2005; Chua and Goh, 2004; Abdelhamid and Everett, 2000; Lee and Halpin, 2003); design aspects (Gambatese et al., 2005; Haslam et al., 2005; Toole and Gambatese, 2008; Behm, 2005; Wulff et al., 1999; Hale et al., 2007; Mohamed, 2002) and cognitive aspects (Saurin et al., 2008; Mitropoulos et al., 2009).

Still, specifically in relation to design aspects, the implementation of the workers' safety during the design phase presents limitations, as not everything can be anticipated, and accidents happen in conditions not foreseen during the design phase (Hasan et al., 2003; Behm, 2005). The results of a study that investigated the way designers evaluate ergonomic criteria, which are part of the design specifications, indicate that the design specifications are subject to organizational restrictions and that, therefore, the specification does not necessarily ensure its implementation (Wulff et al., 1999). The implementation of specifications of ergonomic criteria in designs is a process of negotiation which faces various logics (Wulff et al., 1999) before going from paper to reality.

The objective of this article is to show how the improvement of the production and safety performance is possible to be achieved by means of anticipation levels (analysis of designs, planning/scheduling of services and implementation) present in the construction phase. This model of anticipation levels materializes, in an original formulation, the principle of experience return, often stated, but still little operationalized in an effective way. Based on the observation of practical examples, it shows how the performance of production and safety can be improved through the expansion of competences, by means of exchange and feedback of experiences (collaborative efforts – see, for example, Karlsson et al., 2008; Weinstein et al., 2005), and through the formalization of the possible experience in these anticipation levels (Jackson Filho et al., 2012; Fonseca and Lima, 2007).

Thus, it is presented here an inversion of the time–influence curve formulated by Szymberski (1997, Fig. 1). On the curve of Fig. 2, it is indicated that, in the design schedule, the competences to influence production and safety performance increase the closer the Design Schedule is placed in relation to the construction phase. On the other hand, it is in the construction phase that the "breaking strength" (a term borrowed from Resistance of Materials) of these competences is found (specifically at the level of work management), which may result in negative consequences for production and safety.

The conceptual model herein proposed aims at describing the management activity of the construction's production process (mainly of the construction engineer), which must integrate safety and production (quality, cost, deadlines, etc.) into the daily management of the construction's production process. The model is represented in different anticipation levels (analysis of design, planning/scheduling of services and implementation), which follow the different management stages of the construction's production process, and offers a holistic approach in order to improve

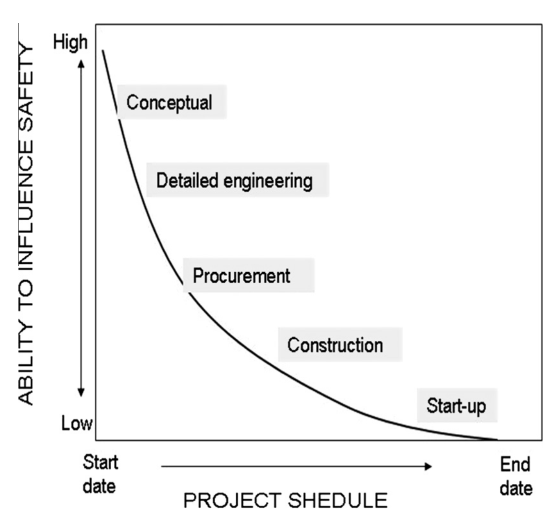


**Fig. 1.** Time/safety influence curve (Szymberski, 1997).