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## BIM-based code checking for construction health and safety

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### Abstract

Rule-based Code Checking validates the design phase comparing Building Information Models against current codes and regulations translated into parametric rules. The proposed paper fits into a wider project for implementing design verification and validation within a BIM environment. The design of construction site layouts and safety plans is an essential part of an effective integrated process but it is traditionally carried out by means of error-prone and inefficient manual observation and, moreover, building designers and health and safety (H&S) coordinators still lack a collaborative working approach. The digitization of the construction site allows virtual inspections and information-based analysis of construction phases. Moreover, interoperable BIM tools allow the semi-automatic review of design compliance against normative texts, improving accuracy and reliability of the validation process. The research project aims to define an H&S BIM-based design and validation workflow, specifying the minimum level of requirements and mandatory informative content for the submission of construction site layouts and safety plans. The paper is focused on the translation into a parametric rule-set of the Italian construction sites' H&S normative text (D.Lgs. 81/2008). A semantic analysis was used in order to translate it into computable parameters to be implemented into checking rules. Object tables have been created for each construction site element regulated by the D.Lgs. 81/2008. Based on those tables, meant as guideline for the design phase, a BIM library for the construction site has been created and a model checking tool has been used for creating rules to check and validate BIM objects and mutual relations. The customized rule-set includes legal references and information requirements specifications. Such an approach aims at including the design of construction safety plans within digital

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practices, anticipating and supporting the decision-making process, analyzing construction phases and identifying potential issues in a virtual environment.

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## 1. Introduction

According to [1], the 90% of workspace injuries are produced by an unsafe construction site. How to manage such a phenomenon during the building design development is a complex matter. The identification of all potential hazards in a building project, in fact, is generally considered the key component of planning for safety, as well as the decision on choosing corresponding safety measures. The problem arises when safety planning is done separately from project execution planning and construction methods decision-making; moreover, critical issues may arise when safety planning involves different actors without a collaborative design approach.

Considering how designers, practitioners and clients are involved and integrated according to the normative context about construction safety and considering standard practices, the current approach to safety planning in construction can be summarized as follow:

- traditional safety planning is carried out by means of manual observations, which result to be labor-intensive, error-prone, and often highly inefficient. The link between safety planning and work task execution lacks accuracy due to the massive use of two-dimensional (2D) drawings and, not less relevant, the massive use of software which loses the connection with the real site simulation.
- building designers and Health and Safety coordinator (H&S Coordinator) still lack a collaborative working approach and the choices of the H&S Coordinator do not affect building design. European Union (EU) directives clearly state the importance of the *safety awareness* during the various stages of the design process and, for this reason, remark the H&S Coordinator involvement in the design phase. Nevertheless, in some European countries the involvement of the H&S Coordinator in the design process is still weak, even if national laws (such as the Italian D.Lgs 81/2008) theoretically agree with EU directives [2].

For these reasons, safety planning and design phases provide a crucial opportunity to prevent hazards and to evaluate possible issues related to the future site conditions within the framework of the normative context about construction safety. Overturning the current safety planning approaches, which are primarily text-based, standalone and based on check-sheet tools to assist designers, seems to be one of the main research topics; moreover, the growing implementation of Building Information Modelling (BIM) in the construction industry could be the right support in changing the way construction site safety can be approached. For example, the New York City Department of Building (NYC-DOB) has already started to use BIM processes and tools to validate construction site safety plans; its process of submission, emendation and review is completely digitalized and BIM-based [3,4]. Following such an example, the proposed research project aims to focus on the translation into a parametric rule-set of the aforementioned Italian Construction Health and Safety (H&S) normative text (D.Lgs. 81/2008) in order to define an H&S BIM-based design and validation process that could be easily implemented by Public Clients.

### Nomenclature

|         |                                     |
|---------|-------------------------------------|
| D.Lgs.  | Legislative Decree (normative text) |
| H&S     | Health and Safety                   |
| BIModel | Building Information Model          |
| IFC     | Industry Foundation Classes         |

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