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RISK MANAGEMENT OF FALLS FROM HEIGHT BY USING THE BIM PLATFORM: A SYSTEMATIC REVIEW

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ABSTRACT

Falls are responsible for around 0.646 million deaths per year, representing more than 30% of worker fatalities in the construction industry. Current risk management methods proved not to be effective enough. The objective of this work was to investigate the applicability of the Building Information Modeling (BIM) as a tool for managing risk of falls from height, and investigate the Brazilian and USA standards in order to identify future perspectives for improving algorithms used in such tools. Two separate reviews were conducted by using the PRISMA method. The first review was conducted by searching the Brazilian platform CAPES, databases Scopus and Google Scholar, while the second through searching the Brazilian and USA legislation related to falls from height. The BIM tool its perspective, although currently still very limited. The included studies applied only risk elimination and some engineering and administrative measures, which means that there is still space for improvement. Only few parameters required by the standards were considered by the included studies. Future studies should improve the algorithms for an automatic identification and management of falls from height, leaving the code opened, so that the users from different countries and legislation might appropriate it to their needs.

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INTRODUCTION

Occupational accidents and work related diseases are responsible for more than 2.78 million deaths and around 374 million non-fatal work related injuries and illnesses each year. The costs of these accidents are estimated at 3.84% of the global Gross Domestic Product each year (International Labour Organization (ILO), 2019). Falls represent the second leading cause of injury deaths worldwide, right after road traffic injuries, with an estimation of 646.000 fatal falls and around 37.3 million non-fatal falls each year (World Health Organization (WHO), 2017). While falls are present in all industries, the construction industry is responsible for around 38.8% of USA worker fatalities (OSHA, 2017). Several studies have analyzed falls from height in the construction industry, where it was concluded that the principal fall locations were scaffolds, holes in floors, structures, roofs and stairs. The occupations with mayor incidence-rate were found to be masons, carpenters, roofers, while site managers and painters were also affected. Through the age distribution, it was found that the accident-rate was highest among workers aged from 35 to 54 years old, while those from 25 to 34 and from 55 to 64 were also significantly affected by falls from height. Interestingly, the accident-rate was correlated to the company dimension, where the companies with less than 10 workers had a highest rate, and in workers with less than one year of experience (Chan *et al*., 2008; Chi *et al*., 2005; Dong *et al*., 2009, 2013; Dong *et al*, 2014; Lin *et al*., 2011; Zlatar & Barkokébas Junior, 2018). However, when the risk management process is applied, the risk can be timely identified, analyzed and accordingly controlled. In order to control the risks, the hierarchy of controls should be applied, following its sequency, but when one measure is not feasible to apply it, go to the next measure in the hierarchy, and when needed, apply several of the control measures simultaneously: (1) Elimination (to physically remove the hazard); (2) Substitution (to replace the hazard); (3) Engineering Controls (to isolate people from the hazard); (4) Administrative Controls (to change the way people work);

(5) Personal Protective Equipment – PPE (to protect the worker). Although falls from height have proved to be a significant loss for the employers and employees, being responsible for various direct and indirect costs, current traditional methods for prevention and controls were found not to be enough effective in minimizing the number of accidents. Therefore, there is a need to explore new technological solutions which might optimize the risk management. Today's technological solutions are applicable to different phases of the working process, from the phase of prevention through design by applying the BIM - Building Information Modelling (K. Kim, Cho, & Zhang, 2016), to automatic verification of Personal Protective Equipment (PPE) which the worker is or should be wearing (Kelm *et al*., 2013). BIM is a tool for digitally construct an accurate virtual model of the building, containing precise geometry and data relevant and necessary for the design, acquisition, fabrication and its construction (Azhar, 2011). The virtual process includes all aspects, disciplines and systems of the installation within a single virtual model, allowing all members and designers to collaborate more accurately and efficiently than using traditional methods. Therefore it could be a technological solutions providing an effective risk management process. The objective of this work was to investigate the applicability of the Building Information Modelling (BIM) in managing the risk of falls from height in civil construction through analyzing existing studies on the topic. Further on, Brazilian and USA standards were analyzed in order to identify future persepectives in improving algorithms for managing risk of falls from height.

MATERIAL AND METHODS

In order to achieve the objectives of this work, it was decided to conduct two separate reviews: the first review analyzing studies related to the topic; and the second review analyzing Brazilian and USA legislation dealing with falls from height. The method used during the reviewing process was PRISMA - Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement (Liberati *et al*., 2009).

Reviewing studies related to the topic: In order to get a greater number of studies to include in this review, the search was conducted in three phases. The Brazilian searching platform "CAPES" was screened by using the keywords: BIM; civil construction; health; construction; risk management; prevention; safety; evacuation; emergency. The Scopus database was screened by using the keywords: BIM; construction; fall; fall protection. The Google Scholar was screened using the keywords: BIM; building information modeling; construction safety.

Selection criteria´s: The studies were excluded if published more than 10 years ago (before 2008), if not published in Portuguese or English language, excluded if duplicates or if didn't have any relation with the civil construction. The studies were included if utilized the BIM platform and if dealing with falls from height or working on heights.

Data analysis: In order to establish parameters and guidelines which can identify risks related to work and falls from height, it was analyzed how each one of the included studies used the BIM platform computational tools and the compatibilization of programs. After this identification, each study was analyzed individually, in order to clarify and discuss each approach and its relevance to the current study. The type of construction was analyzed, dividing them into vertical, horizontal and other types of construction, and the country where the study was applied. Further, it was analyzed how the risk was identified, dividing it into automatic recognition, manual, or semi-automatic. The parameters used for identification of the risk and software were also analyzed and included. Finally, the risk management solutions and procedures proposed by studies were analyzed and divided into four main groups: measures for risk-elimination; engineering measures; administrative; and the PPE measures.

Reviewing Brazilian and USA legislation dealing with falls from heights: The review sought to compare the main characteristics, differences and similarities between the legislation of the two analyzed countries. The USA legislation was analyzed through the Occupational Safety and Health Administration standards (osha.gov), which are also accepted world-wide. The Brazilian legislation was observed through the Federal Constitution of 1988 - CF/88 (planalto.gov.br), which provides legal protection of safety and health for workers (according to the articles 6 and 7 in Sections XXII, XXIII, XXVIII and XXXII,); the Consolidation of Labor Laws – CLT (planalto.gov.br); the Ministry of Labor and Employment – MTE (trabalho.gov.br); the Regulatory Norms – NR (trabalho.gov.br); the Brazilian Association of Technical Standards – ABNT (abnt.org.br); and the Brazilian Standards – NBR (nbr.gov.br).

Selection criteria´s: The standards were excluded if already revoked. The standards were included if mandatory for working at height or when people are exposed to risk of falls from height.

Data analysis: In the included standards, following variables were analyzed: the height necessary for defining a work as *"working at height"* (analyzing it in general and on scaffolds); deck width; distance between two stages; smallest dimension of the horizontal plane of the scaffold; the scaffold distance from the working facade; maximum scaffold height suspended by ratchet; the platform length; and the smallest dimension of the horizontal plane of the scaffold.

RESULTS

Reviewing studies related to the topic: The review process resulted in 148 articles, from which 63, 30 and 55 from CAPES, Google Scholar and Scopus, respectively. After applying the selection criterias, the articles which were published before 2008 were excluded, remaining 147 for further analysis. By applying the language criterion, 143 articles remained. After that, the duplicates were excluded, and articles were screened by title and abstract, which resulted in 51 articles selected for a full download and screening. Finally, after applying all selection criterias and thoroughly reading the remained 51 articles, it was reached the number of 12 articles which were included in this review (Hammad, Setayeshgar, Zhang, & Asen, 2012; H. J. Kim & Park, 2012; K. Kim *et al*., 2016; Liu, Lee, Shiau, & Lin, 2017; Melzner, Zhang, Teizer, & Bargstädt, 2013; Pinto, 2017; Qi, Issa, Olbina, & Hinze, 2014; Setayeshgar, 2014; Wang, Zhang, & Teizer, 2015; Zhang, S., Lee, J.-K., Venugopal, M., Teizer, J., Eastman, 2012; Zhang, Teizer, Lee, Eastman, & Venugopal, 2013; Zhang *et al*., 2015). The applied selection process was illustrated in the following Figure 1. In an attempt to innovate the prevention and control of accidents, the included 12 studies seek better solutions by using the BIM tool. The methodologies were based on the collection of spatial information from construction projects, and the safety legislation of countries in which the work was carried-out, and the manual input of data into computer programs. 2013), two studies considered Canadian (Hammad *et al*., 2012; Setayeshgar, 2014), one Finish legislation (Zhang *et al*., 2015), one considered both the USA and Germany legislation (Melzner *et al*., 2013), one Portuguese (Pinto, 2017), Taiwanese (Liu *et al*., 2017) and South Korean (H. J. Kim & Park, 2012). The following table 2 illustrates how the risk was identified, the parameters for identifying the risk, and the tools and software utilized for the analysis. Although there is a manual way (traditional) to identify risks, most of the included

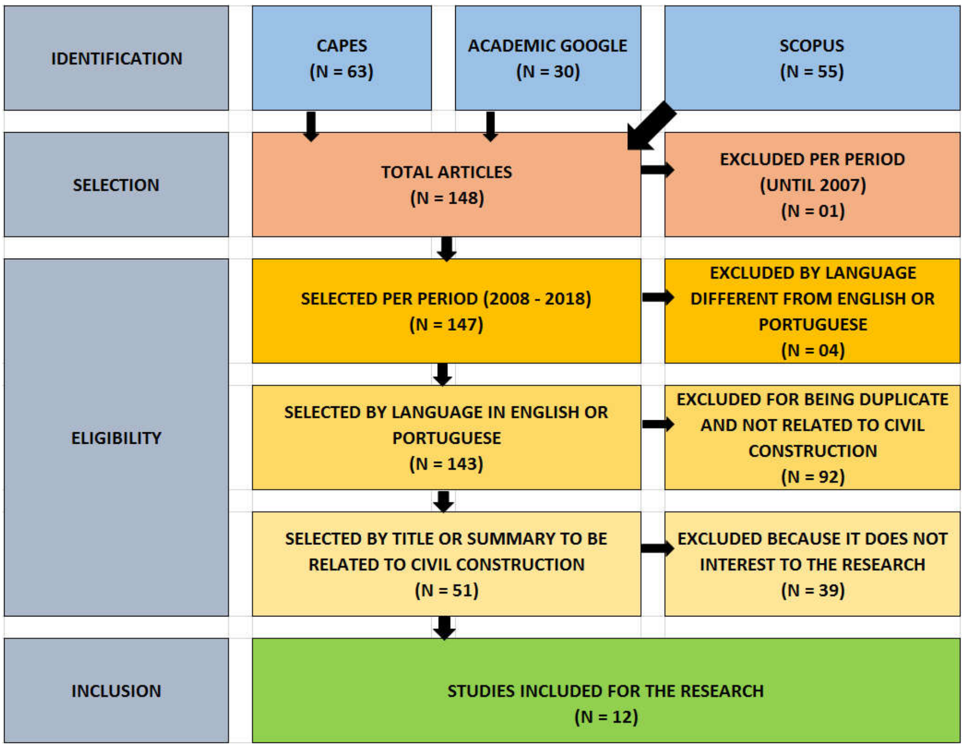

Figure 1. Review Fluxogram

Table 1. The country where the study was applied, the risk of falls and type of construction analyzed

Nº	Reference	Country	Risk of falls analyzed	Type of construction analyzed		
				Vertical	Horizontal	Other
1	Zhang et al., 2015	Finland	Through the window or slab oppening	✓		
2	Kim et al., 2016	USA	From scaffolds		✓	
3	Zhang et al., 2013	USA	Through the window or slab oppening	✓		
4	Setayeshgar, S., 2014	Canada	By colission	✓		✓
5	Pinto, D., 2017	Portugal	Through the window or slab oppening, from scaffolds and platforms		✓	
6	Hammad et al., 2012	Canada	By colission	✓		✓
7	Melzner et al., 2013	Germany, USA	Through the slab oppening	✓		
8	Liu et al., 2017	Taiwan	From scaffolds by analyzing the layout			✓
9	Kim et al., 2012	South korea	Fall and tracking alert system, through the smartphone	✓		
10	Zhang et al., 2012	USA	Through the window or slab oppening	✓		
11	Wang et al., 2015	USA	Sliding of earth during excavation			✓
12	Qi et al., 2014	USA	Through the slab oppening	✓		

Through using BIM, the studies sought to investigate a method for manual or automatic risk identification, for example, by analyzing openings in slabs, walls, elevators and stairs, open peripheries, and the systems of fixation of different types of scaffolds. After the risks were identified and possible solutions were suggested. As it could be noticed from the table 1, the studies dealing with falls from height by using the BIM tool, were carried-out in North America, Europe and Asia, without any study conducted in Brazil. Several types of constructions were analyzed, including vertical constructions (buildings) and horizontal constructions (such as excavations, works of art and bridges). Five studies considered the USA legislation (K. Kim *et al*., 2016; Qi *et al*., 2014; Wang *et al*., 2015; Zhang, S., Lee, J.-K., Venugopal, M., Teizer, J., Eastman, 2012; Zhang *et al*., studies (10/12), applied the automatic identification, through a developed algorithm (Hammad *et al*., 2012; H. J. Kim & Park, 2012; K. Kim *et al*., 2016; Melzner *et al*., 2013; Pinto, 2017; Qi *et al*., 2014; Setayeshgar, 2014; Zhang, S., Lee, J.-K., Venugopal, M., Teizer, J., Eastman, 2012; Zhang *et al*., 2015, 2013). Only one study applied the manual (Liu *et al*., 2017) and one semi-automatic (Wang *et al*., 2015) identification. For developing the algorithms it is necessary to study parameters given by the legislation and standards, which might vary depending on the country. Some examples of parameters to consider in developing algorithms managing falls from height through a BIM tool are: the smallest dimension to consider something as a hole; the smallest dimension to consider

Table 2. Type of risk identification, Identified parameters, Tools and software utilized

Nº	Reference	Type of risk identification	Identified parameters*	Tool/software
1	Zhang *et al.*, 2015	Automatic	OD > ?; HS> ?; H > ?; W > ?	Tekla structures
2	Kim *et al.*, 2016	Automatic	H > ?	Revit, ms project
3	Zhang *et al.*, 2013	Automatic	OD> 1.5m (guardrail); 5.1cm<HS< 1.5m (cover); H > 1.8m	Industry foundation class (ifc); business process modeling notation (bpmn); tekla structures
4	Setayeshgar, S., 2014	Automatic	H > 3.0m; GH< 1.2m; BH> 0.9m	Revit; navisworks; real-time location system (rtls); ultra-wideband technology; unity and softimage;
5	Pinto, D., 2017	Automatic	H > 4.0m	Autocad; revit; navisworks; microsoft excel
6	Hammad *et al.*, 2012	Automatic	H > 3.0m 1.0m< GH< 1.2m	Revit; navisworks; mep; real-time location system (rtls); dynamic virtual fences (dvf);
7	Melzner *et al.*, 2013	Automatic	USA: OD>1.0m (guardrail) 5.1cm<HS< 1.0m (cover) H > 1.8m Germany: OD>3.0m (guardrail) HS≤ 3m (cover) H > 1.0m	Industry foundation classes (ifc)
8	Liu *et al.*, 2017	Manual	---	Revit
9	Kim *et al.*, 2012	Automatic	H > ?	Revit; visual studio; smartphone optimus vu
10	Zhang *et al.*, 2012	Automatic	OD> 1.5 m (guardrail) 5.1 cm< HS< 1.5 m (cover) H > 1.8 m	Work breakdown structure (wbs)
11	Wang *et al.*, 2015	Semi-automatic	H > 1.83m TD< 1.52m: vertical cutting; 1.52m< TD< 6.10m: protection system; TD > 6.10m: specialized consultor Solo rocha: α = 90° Solo Tipo A: α = 53° Solo Tipo B: α = 45° Solo Tipo C: α = 34°	Ladar (laser); tekla structures
12	Qi *et al.*, 2014	Automatic	SO> 0.37 m² (BIM server); SO> 0.37 m² (Solibri)	Ptd baseada em formato ifc; revit; bim server; solibri model checker

** WO= Window opening; SO = Slab Opening; OD = Smallest Opening Dimension; HS = Smallest Hole Size; H = Minimum fall height; α = Slope; TD = Trench depth; GH = Guardrail height; BH = Barricade Height.*

Table 3. Risk management solutions and procedures

Nº	Reference	Risk elimination	Engineering measures	Administrative measures	PPE
1	Zhang *et al.*, 2015	Floor closure	Guardrails positioning	---	---
2	Kim *et al.*, 2016	---	---	Notification to the manager, when the scaffold project pose a risk	---
3	Zhang *et al.*, 2013	Floor closure	Guardrails positioning	---	---
4	Setayeshgar, S., 2014	---	Guardrails positioning	Real time notification to the worker and the manager through the equipment ofthe real-time location system (rtls); Prevention of machinery collision through computational simulation	---
5	Pinto, D., 2017	Floor closure	Guardrails positioning; Scaffolds positioning	Procedural sheets	---
6	Hammad *et al.*, 2012	---	Guardrails positioning	Real time notification to the worker and the manager through the equipment ofthe real-time location system (rtls)	---
7	Melzner *et al.*, 2013	Floor closure	Guardrails positioning	---	---
8	Liu *et al.*, 2017	---	---	Management through layout modification; Signalization of rotes and stairs	---
9	Kim *et al.*, 2012	---	---	Real time notification to the worker and the manager through the smartphone application	---
10	Zhang *et al.*, 2012	Floor closure	Guardrails positioning	Report to provide training	---
11	Wang *et al.*, 2015	---	Guardrails positioning; Supports against land sliding	---	---
12	Qi *et al.*, 2014	Floor closure	---	---	---

something as an opening; the smallest vertical height to be considered as working at heights; the height on which the guardrail should be installed, and other guardrail dimensions. Some of the parameters are very specific to the object of study, such as the slope inclination and the trench depth. The parameters used in analyzed studies were included in table 2, showing also the software used in developing each of the studies. The following Table 3 represents the risk management solutions and procedures which were applied in the analyzed studies. It is observed that the risk-elimination measures were applied in five studies, achieving-it by closing the openings in the floor (Melzner *et al.*, 2013; Pinto, 2017; Zhang, S., Lee, J.-2015, 2013) and at the same time applying an engineering measure (guardrails and scaffold positioning), and one which only applied the risk-elimination measure (Qi *et al.*, 2014). The engineering measures were applied in 8 studies (Hammad *et al.*, 2012; Melzner *et al.*, 2013; Pinto, 2017; Setayeshgar, 2014; Wang *et al.*, 2015; Zhang, S., Lee, J.-K., Venugopal, M., Teizer, J., Eastman, 2012; Zhang *et al.*, 2015, 2013), all of them, by positioning guardrails. In addition, one study (Pinto, 2017) managed to control the risks by positioning the scaffolds, and one with supports against land sliding (Wang *et al.*, 2015). The administrative measures were applied in 7 studies, from which four offered notifications to the interested

Table 4. Parameters defined by standards used in Brazil and USA

Country			Brazil				USA	
standard			NR 18	NR 35	NBR 6494	RTP 01	CFR 1926	CFR 1910
working on heights (m)			---	H>2.0	---	---	H>1.8	---
working on heights by using scaffolds (m)			---	H>2.0	---	---	H>3.1	---
minimal deck width (m)			---	---	DW≥0.60	---	DW≥0.46	---
distance between two stages (m)			---	---	D≥1.75	---	---	---
maximal height (m)			HSS≤4*SS	---		---	---	---
distance between the scaffold and the facade (m)			---	---	DF≤0.30	---	DF≤0.36	---
maximal height for suspended scaffolds used in facades (m)			MHS≤24(OU 8PAV)	---	---	---	---	---
maximal lenght of the suspended scaffold (m)			PL≤8	---	---	---	---	---
suspended scaffold width (m)			0.90≥WS≥0.65	---	---	---	---	---
guardrail dimensions	general	uppercrossing	---	---	---	1.2	---	1.07
		intermediary crossing	---	---	---	0.7	---	0.53
		footer	---	---	---	0.2	---	---
		max distance between two vertical support crossings	---	---	---	1.5	---	---
	scaffolds	uppercrossing	---	---	1.0	---	---	---
		intermediary crossing	---	---	0.5	---	---	---
		footer	---	---	0.15	---	---	---
		max distance between two vertical support crossings	---	---	---	---	---	---

parties, on imminent risks through the worker positioning systems in relation to the predetermined element (Hammad *et al*., 2012; H. J. Kim & Park, 2012; K. Kim *et al*., 2016; Setayeshgar, 2014), two studies offered issuing training reports or procedure sheets according to the risk and activity being carried out (Pinto, 2017; Zhang, S., Lee, J.-K., Venugopal, M., Teizer, J., Eastman, 2012), and one on issuing design and signalization suggestions at the planning level, to avoid or minimize risks of falls from heights (Liu *et al*., 2017). As can be observed, none of the authors proposed as one of the risk management solutions the use of Personal Protective Equipment (PPE). This management measure would include wearing helmets, shoes and clothing for work, as well as the use of a safety belt attached to a fall protective system.

Reviewing USA and Brazilian legislation dealing with falls from heights: The conducted review found that there were 4 standards in Brazil (NR18, NR35, NBR6494 and RTP-01) and two in the USA (CFR1926 and CFR1910) dealing with risk management of falls from height. Particular attention was paid to the risk of falling from scaffolds. In Table 4, it can be observed that the Brazilian standard NR-35 makes no difference in height on whether the fall will be from a scaffold or from any other place. On the other hand, the USA regulation CFR 1926, differ the working activity on scaffolds and other working activities. Some common parameters were found in the analyzed standards, which were illustrated in Table 5. The NBR-6494 defines that the scaffold decking must have a minimum width of 0.60m and the useful height should be at least 1.75m. Further-on, the NR-18 defines that the maximum height of the scaffold as a whole must not exceed 4 times the size of the smallest dimension of the base, if there is no staging for that building. The CFR 1926 defines that the platform of the scaffold must have a width of at least 0.46m. When searching for specific types of scaffolds, it was noted that the NR-18 requires that suspended scaffolds should be positioned at a distance of not more than 0.30m from the working facade, and that the maximum height for suspended scaffolds should be greater than 8 floors or equivalent height (24m). In comparison, the CFR 1926.451 states that the scaffoldsshould be positioned at a distance of not more than 0.36m from the working facade. As illustrated in table 4, suspended scaffolds were only defined by the Brazilian Regulatory norm NR-18, showing that the maximum allowed length of this type of scaffold is 8m, and its useful working width should be at the same time greater than 0.65m and less than 0.90m. The guardrail is one important parameter to consider when dealing with the risk of falls from heights. The Brazilian standards define the dimensions for the upper and intermediate crossings, for the footer and defining the maximal distance between vertical support crossing. The Brazilian Regulatory norm, RTP-01 (NR-18) defines dimensions for guardrails in general, while the Brazilian Technical norm NBR-6494 defines the dimensions guardrails on scaffolds. In the USA, the standard CFR 1910.29 defines only the dimensions for the upper and intermediate crossings, and the guardrails are unilateral, which means that the same dimensions of guardrails are used for any type of construction.

DISCUSSION

As already explained, the risk management measures have its sequence in the implementation priority. First the risk is eliminated, but when this is not possible, the engineering and administrative measures are applied, and if there is still some significant residual risk, the PPE are also applied. Some of the included studies only superficially covered the topic of risks of falls, as their main focus was on the collision of working groups with machinery (Setayeshgar, 2014), or as in one study, the research on excavation dynamics, USA soil safety, accidents and land stability (Wang *et al*., 2015). One study (K. Kim *et al*., 2016) carried-out a research related to the risk of falls from temporary scaffolds. The study was based on USA normative research, and simulated the fall of the scaffolding worker, as well as his conflict with other activities. This research can be better applied on structures with large areas and few pavements. It presents the sequence of scaffolding in the same plan/pavement, typical of sheds constructions present in the Brazilian construction sector. One study (Liu *et al*., 2017) analyzed the layout of scaffolds in a highway project, by applying it manually through Revit and in accordance with the Taiwan standards. The BIM 4D was applied by one study (Pinto, 2017), which carried out a general risk analysis by applying Navisworks, with parameters extracted from Microsoft Excel. Nine studies applied measures of falls from height risk elimination and the implementation of engineering measures (Hammad *et al*., 2012; Melzner *et al*., 2013; Pinto, 2017; Qi *et al*., 2014; Setayeshgar, 2014; Wang *et al*., 2015; Zhang, S., Lee, J.-K., Venugopal, M., Teizer, J., Eastman, 2012; Zhang *et al*., 2015, 2013). Some of the mentioned points were considered and required by the Brazilian standards, while being absent from USA standards, and vice versa.

It could be interesting for future studies to analyze those parameters and to define which should be included in all standards, and the dimensions which would give best results in the prevention of falls from height. The included studies considered only risk elimination and some engineering and administrative measures, which means that there is still space for improvement. A study analyzing a number of cases of falls from height (Zlatar, Lago, Soares, Santos Baptista, & Barkokébas Jr, 2019) found that most commonly failed measures were risk assessment (60.5%) and engineering measures – work platform/scaffold (60.5%), while inadequate PPE or missing PPE was noticed in 56.1% of the cases. That study found that training and certification were missing in 19.3% of the workers. Therefore, future BIM applications should provide solutions but considering all control measures, as selecting some will not solve the problem of falls from height and benefit the community. As probably the standards will not be harmonized that soon, it can be argued that the differences in standards would be even greater if considering more standards from different countries. This could pose some difficulties in offering an unilateral solution for preventing falls from height on a global level. Therefore, future studies which aim to develop tools for automatic identification or management of falls from height should consider leaving the code opened, so that the users might appropriate it to their needs. In addition, the studies which used algorithms to automatically identify risks don't have an option to also automatically notify the user about those risks. There is still much to be done and developed in order to successfully manage risks of falls from height, which is comprehensive as BIM is a recent tool used in civil construction, and considering the the number of possible variables to be included in a programming language. The risk identification (e.g. openings in slabs, walls, elevators and ladders, open peripheries, floor scaffolds and suspended scaffold fastening systems) in future works should be elaborated based on procedures and standards, through:

- manual method, in order to propose a specification with fall-risks identified in a standard vertical work, following their normative specifications and proposed solutions;
- automatic method, in order to propose a method to automatically generate virtual fences around areas which pose risk of falls, following their normative specifications and proposed solutions;

Further on, there is a need to conduct a study on all risks of falls from height to which workers are exposed during a specific activity, throughout the working day. It is necessary to investigate on which of the engineering, administrative and PPE measures are most and less effective in each of the mentioned groups. Finally, there is a need to develop logical diagram for preventing falls from height and to implement it with all of its measures and not only with elimination and/or engineering measures.

Conclusions

Falls from height present a significant risk in the construction industry, affecting all parties involved during the process of construction and afterward. In order to eliminate or minimize the risk of falls, it is necessary to apply risk management measures, according to the defined hierarchy, starting with the elimination of risk, but when it is not possible to eliminate-it, applying engineering, administrative and PPE measures. Nevertheless, traditional preventive and control methods were found not to be effective in applying the risk management measures. The Building Information Modeling was found to be a perspective tool in managing risks of falls from height. However, current solutions are still very limited, contributing in the identification of risks from falls, suggesting floor closures as fall-risk elimination and guardrails as engineering measures, but should be improved in order to consider different control measures. Future studies should improve the identification and management algorithms according to the parameters specified in standards dealing with prevention and control of falls from height. The code developers should consider leaving the code opened, so that users from different countries and legislation might appropriate it to their needs.

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