2000). A module is understood as an independent unit, which has its own functionality, and standardized interfaces that interact according to the systems' definition (Miller and Elgard 1998).

Although some characteristics of the construction industry make it difficult the adoption of modularity in some construction projects, there are potential benefits for its implementation (Doran and Giannakis 2011). Modular buildings can contribute to increase efficiency and improve cost performance, bringing a quick return on project´s investment, which may be an important factor to justify their adoption by the construction companies (Moghadam et al. 2012). However, there is still a lack of construction management studies that clearly address the complexity and scope of a modular application (Gosling et al. 2016).

Some empirical studies in the construction industry point out that there are different types of modularity: product, process, and supply chain modularities (Voordijk et al. 2006; Lessing 2006, Viana et al. 2016, Peltokorpi et al. 2018).

First, the product modularity occurs when the product is decoupled into parts and components (Gershenson et al. 2003). The idea is that a limited number of modules can be combined to produce a wide variety of products (Miller and Elgard 1998, Gosling et al. 2016). Unlike an integral product, a modular product has interchangeable components that have one or only a few functions (Voordijk et al. 2006). Also, the adoption of modularity facilitates the replacement or upgrading of individual components, supporting the development of innovations (Lennartson and Björnfot 2010). Therefore, the use of modularization can go beyond improving the time, cost and quality performance of the project. It can potentially enable the development of innovative products and create flexibility during the use and maintenance stages (Peltokorpi et al. 2018). In addition, several studies point to modularity as a strategy to deliver a customized product to clients (Miller and Elgard 1998, da Rocha 2011, Peltokorpi et al. 2018).

Second, the process modularity is concerned with the adoption of standardized operations with shared interfaces (Lennartson and Björnfot 2010). However, a modular process does not necessarily include standardized components, but rather standardized manufacturing, delivery, and assembly processes (Peltokorpi et al. 2018). Furthermore, a modular process allows the sharing of production technologies, parallel assembly, and the use of standardized work (Lennartson and Björnfot 2010).

The third category of modularity is related to the configuration of the supply chain, which can be defined as a network of companies that transform raw material into supplies, products, or modules, including its distribution (Cheng et al 2010). In construction supply chains, some transformation activities can be moved out from construction sites (Vrijhoef and Koskela 2000). Most construction supply chains are highly fragmented and are connected to a temporary organization, which is composed of a large variety of companies, mostly of medium and small size (Cheng et al. 2010).

In essence, in modular supply chains, management tends to occur outside the production sites (Doran and Giannakis 2011). The degree of modularity is influenced by the degree of separation between design and execution (Voordijk et al. 2006). In an integral SC the companies are more interdependent (Voordijk, et al. 2006). By contrast, in a less integral (loosely coupled) SC, participants have less interaction (Pero et al. 2015), may be

DESCRIPTIVE ANALYSIS

Figure 5 shows the distribution of publications per year. In the 1990s until the mid-2000s, few publications were found, the first being in the year of 1989. From the early 2000s, there has been a substantial increase in the number of publications. Table 2 shows the top five journals in which the papers were published, the number of papers found (N) and the authors and year of publication. Most papers have been published in journals related to construction engineering and management.

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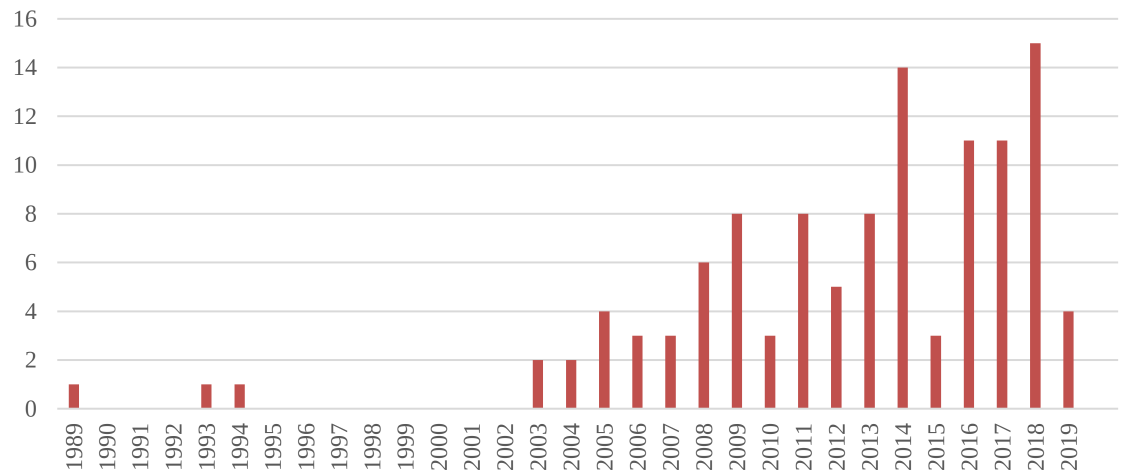

Figure 5: Distribution of relevant papers per year

Table 2: Most cited journals

JOURNAL	N	PAPERS
Journal of Construction Engineering and Management	15	Blacud et al. (2009); Choi et al. (2016); Dzeng et al. (2005); Dzeng et al. (2004); Gill et al. (2005); Goodrum et al. (2009); Gosling et al. (2016); Ikuma et al. (2011); Larsson et al. (2016); Lee and Hyun (2019); Murtaza et al. (1993); Nahmens and Bindroo (2011); O´Connor et al. (2014); Ramaji and Memari (2016); Song et al. (2005)
Construction Management and Economics	10	Agren et al. (2014); Brodetskaia et al. (2011); da Rocha and Kemmer (2018); Jaillon and Poon (2010); Johnsson and Meiling (2009); Meiling et al. (2014); Pan et al. (2008); Peltokorpi et al. (2018); Schmidt III et al. (2014); Wikberg et al. (2014)
Automation in Construction	6	Eastman (1994); Hsu et al. (2018); Martinez et al. (2019); Nasereddin et al. (2007); Olearczyk et al. (2014); Said et al. (2017)
Journal of Management in Engineering	6	Choi et al. (2019); Hall et al. (2018); Hyari and El-Rayes (2006); Liu et al. (2017); Tatum (1989); Yu et al. (2013)
Canadian Journal of Civil Engineering	5	Kim et al. (2005); Li et al. (2013); Moghadam et al. (2012); Wang et al. (2009); Westover et al. (2014)

Figure 6 shows the distribution of papers per country. Most of the studies are concentrated in the United States, followed by the United Kingdom and Australia. Canada, China, Sweden and Korea had also produced some papers.

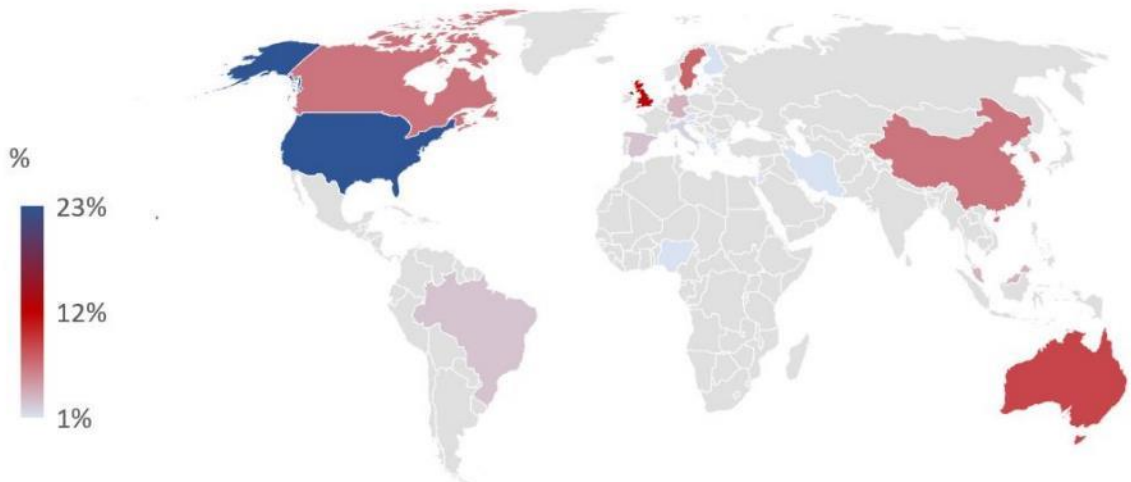

Figure 6: Distribution of papers per country

Finally, the main research methods were classified (Figure 7). Most of the papers are Case Studies, followed by Surveys. 13% of papers were found to have more than one strategy (e.g. Choi et al. (2019) carried out a literature review, a survey, and interviews). These cases were grouped as Multiple Methods. Still, 3% of the selected articles did not make clear the methodology adopted and could not be classified.

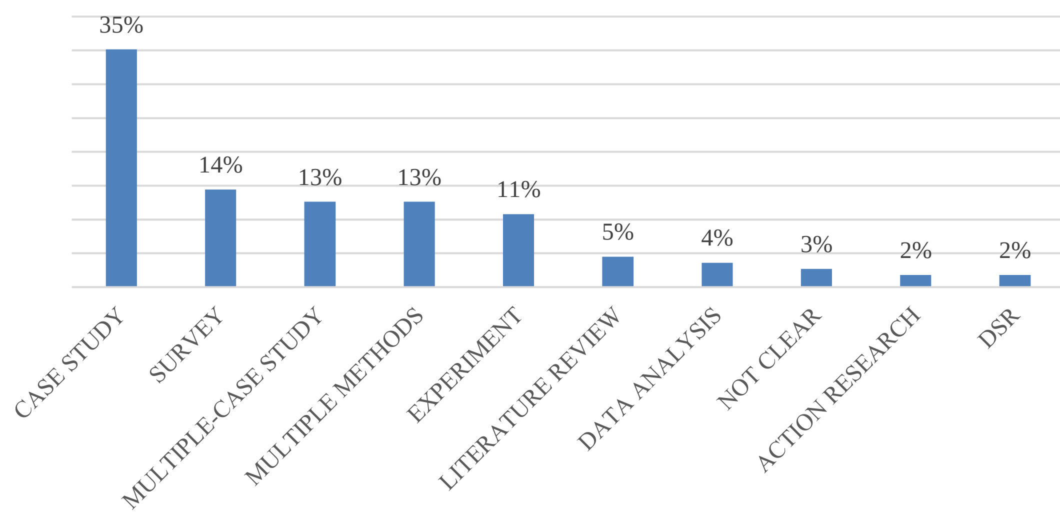

Figure 7: Research Methods

THEMATIC ANALYSIS

In order to analyse the main topic areas covered in the literature on modularity, the following classification was proposed, based on the IGLC 2019 proposed themes (Table 3).

Table 3: Description of the proposed topic areas

Topic Area	Description
Product Development and Design Management	Papers related to the development of modular products, components, or to the management of the design process.
Contract and Cost Management	Papers related to the decision-making process, including risk analysis, real estate market and stakeholders.
Production Planning and Control	Papers related to the process of planning and control of modular projects.
Theory	Theoretical or literature review about modularity, including authors who have identified best practices in the construction industry.
Sustainability	Papers related to the environmental impact of modular buildings and green technologies.
Production System Design	Papers related to the design and execution of modular building systems, including assembly techniques and automation.
Off-Site Construction	Papers related to the manufacturing process of modules or modular component and transportation.
Supply Chain Management	Papers related to the modular construction supply chain.
Safety, Quality, and Health	Papers that investigated the relationship between the use of modularity and safety performance.
Lean and BIM	Papers that specifically addressed the use of BIM and/or Lean in modular construction.

A total of 10 categories were proposed in order to group the diversity of topics addressed by the selected papers. This classification was made in a suggestive way by the authors. The aim of this division into categories was to identify future trends and knowledge gaps (scarce evidences). Figure 8 shows the distribution of the topics covered by previous studies. The category "Product Development and Design Management" had around 40% of the papers.

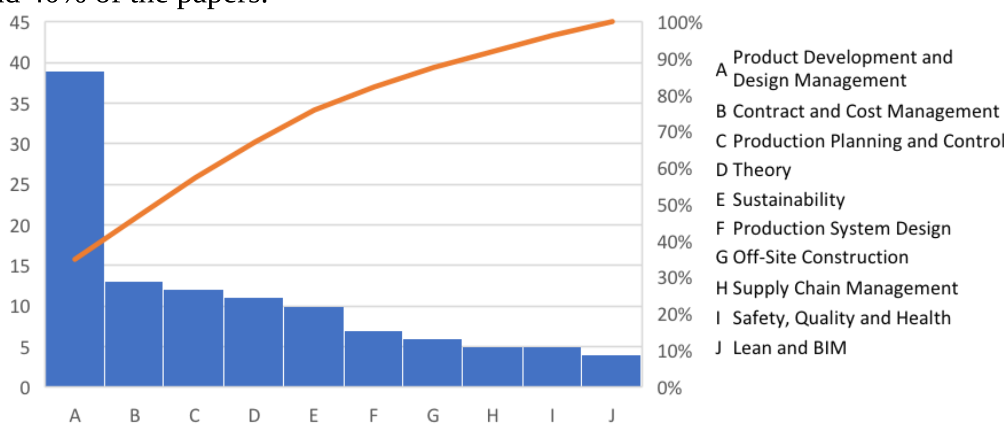

Figure 8: Distribution of papers according to topic area

LEAN PHILOSOPHY AND MODULARITY

An analysis was made on the association between the Lean Philosophy and Modularity. The core ideas that explained that association are presented in Table 4, and these were classified in topics.

Table 4 (cont.): Core ideas that associated the Lean Philosophy and Modularity

Topic	Description	Authors
	A set of lean principles are used to reduce waste over a range of factory activities. It is proposed a modularization production method to improve modular factory production flow based on work activity relationship.	Lee et al (2017)
Sustainability	Relates large-scale lean efficiencies in the design and construction process to sustainability.	Zakaria et al (2018)
	Management based on lean principles optimize carbon emission.	Gong et al (2015)
	By improving the delivery process of modular houses, lean strategies improve the economic, social and environmental dimensions.	Nahmens and Ikuma (2011)

There are different approaches involving the Lean Philosophy and Modularity. To summarize the different lean concepts related to modularity examined by the papers, the ideas presented by the authors were classified into topics, as proposed in Table 4. Of the 113 papers, 34 mention lean principles (30%), although only 19% specifically related lean principle to modularity.

From the analysed papers, lean principles are mainly associated to efficiency in modular construction. It is associate to improvements in production through autonomation (Martinez et al. 2008; Orlowski et al. 2018; Yu et al. 2013), Kaizen (Lee et al. 2017; Ikuma et al. 2011; James et al, 2014; Yu et al, 2013) and flexibility (Barlow et al, 2003; Martinez et al, 2008; Yu et al. 2013; Arif et al. 2011). Authors also link some design process improvements in modular construction to lean: flexibility enables the design of new materials and products (Martinez et al. 2008) and reduction of waste reduces re-design (Martinez et al. 2013). Authors also bring customization, one of a kind modules (Yu et al. 2013) and customer oriented-approach (Barlow et al, 2003) as strategies supported by lean concepts as flexibility (Yu et al. 2013). Other general aspects from lean philosophy are pointed out as enablers of modularization as standardized work, visual management (Yu et al. 2013) and responsivity (Nasereddin et al. 2007).

CONCLUSIONS

This paper presents the results of a SMS regarding modularity in the construction industry, as a preliminary stage of a future Systematic Literature Review effort. The purpose of this study was to identify the primary areas covered by the existing literature and, in addition to, identify the relationship of those studies with Lean Philosophy.

In response to the stated research question, the conclusion was made that most of the papers selected were related to the development of modular products. However, this category involves a great diversity of aspects, since it encompassed both the design process and the development of modules or modular components.

Regarding the Lean Philosophy, only 19% of the papers properly explained the connection of modularity and Lean, although intrinsic characteristics of lean production systems can be found in several papers. The aforementioned Lean topics were grouped into the following proposed categories: (a) Sustainability; (b) Autonomation; (c) Elimination of waste; (d) Flexibility; (e) Kaizen and (f) General.

The next steps of this research will deepen the literature review, identifying the main contributions of these research studies and possible gaps.

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