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INTERNATIONAL GROUP FOR LEAN CONSTRUCTION

USING BIM WITH THE LAST PLANNER SYSTEM TO IMPROVE CONSTRAINTS ANALYSIS

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Introduction

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- Last Planner System (LPS) has been **widely implemented** by construction companies who seek to **improve the reliability** of production at construction sites.
  - **Medium-term planning** as the **main element** that make up the LPS (Ballard, 1997; Ballard, 2000; Hamzeh, 2012; Pikas et al., 2012; Salvatierra et al., 2015; Al Hattab et al., 2017)
    - the main objective of which is to **protect the workflow** by **identify and remove constraints of activities**.
- Empirical studies have shown that **failures to do so** have led to jumps in **wastes emerging in day-to-day production** (Bortolazza; Formoso, 2006; Kemmer et al., 2007; Fireman et al., 2013; Leão et al., 2014; Ibarra et al., 2016, Hamzeh et al., 2012).
- Angelim et al. (2020) recently conducted a **systematic literature review** that identified that one of the major shortcomings when applying medium-term planning lies precisely in the **difficulty of identifying and removing constraints in advance**.

Introduction

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- The **joint application of BIM** (Building Information Modeling) **with LPS** has been **strongly suggested as a way to assist** and streamline the **process of identifying and removing constraints** (Angelim et al., 2020; Fireman et al., 2013; Ibarra et al ., 2016; Sacks et al., 2012).

BIM and LPS

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- Toledo et al. (2016) compare two case studies **one using only LPS** and the **other using LPS and BIM**.
  - Even **without the use of BIM models in lookahead planning meetings**, the coordinated use of LPS and BIM generates:
    - **increase** in Percentage of Plan Completion
    - a **decrease** in reasons for non-compliance
    - a **shortening** of the meeting durations
    - and a **decrease** in the total number of design RFI

Data from **five case studies** from **three different companies** have been analyzed. The main objective is to **analyze how integrating BIM with the LPS system can enable constraints** at the medium-term **and work pa** short-term.

RESEARCH METHOD

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- **Multiple exploratory case studies**
- The **criteria** for **selecting the five studies** were based on:
  - each one of them has a planning and control method based on the elements of Last Planner system;
  - has a history of implementing lean tools
  - provide access to information;
  - the companies are in the initial stage of implementing BIM.
- The work method consists of **two phases**:

Phase 1 - analyze which categories of **constraints** identified in medium-term planning could be modeled in BIM:

a. a **database** was created
b. **categorized** according to its relation to: Material, Labor force, Equipment, Security, Project, and Planning
c. **focus group** regarding the possibility of modeling them

Phase 2 - examine the **percentage of work packages** elaborated in the short-term plan could be modeled in BIM:

a. a **database** was created
b. **categorized** according to construction stage (masonry, infrastru etc..).
c. **focus group** regarding th modeling them

RESEARCH METHOD

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	Market	Case Study	Built area	Characteristics	Constructive Phase	Constraints	Analysis of work-packages
Company 1	Residential High-, Middle- and Low-income	Case 1	13.505,67 m²	127 residential units 1 tower block - 2 stores	Infrastructure	22	91
		Case 2	80.902,05 m²	576 residential units 4 tower blocks	All services	12	815
Company 2	Residential High-, Middle- and Low-income and Commercial	Case 3	10.150,67 m²	Commercial+hotel 1 tower block with 168 private units	All services	-	297
		Case 4	32.405,82 m²	Commercial+health 1 tower block with 423 private units	Finishings	51	-
Company 3	Metallic Construction System	Case 5	24.695 m²	Expansion of Airport (Pier, Processor, Boarding bridges and Annexes)	Superstructure	132	39
					Total	**217**	**1242**

Analysis of medium-term data

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	Equipment	Material	Labor Force	Planning	Design	Safety
Residential 1	100% (3)	0% (0)	0% (0)	25% (1)	50% (1)	33% (1)
Residential 2	80% (4)	28% (10)	0% (0)	25% (14)	83% (10)	100% (3)
Commercial 2	0% (0)	0% (0)	0% (0)	29% (2)	50% (3)	
Industrial	100% (7)	100% (56)	0% (0)	43% (12)	100% (23)	

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Analysis of the Short-Term data

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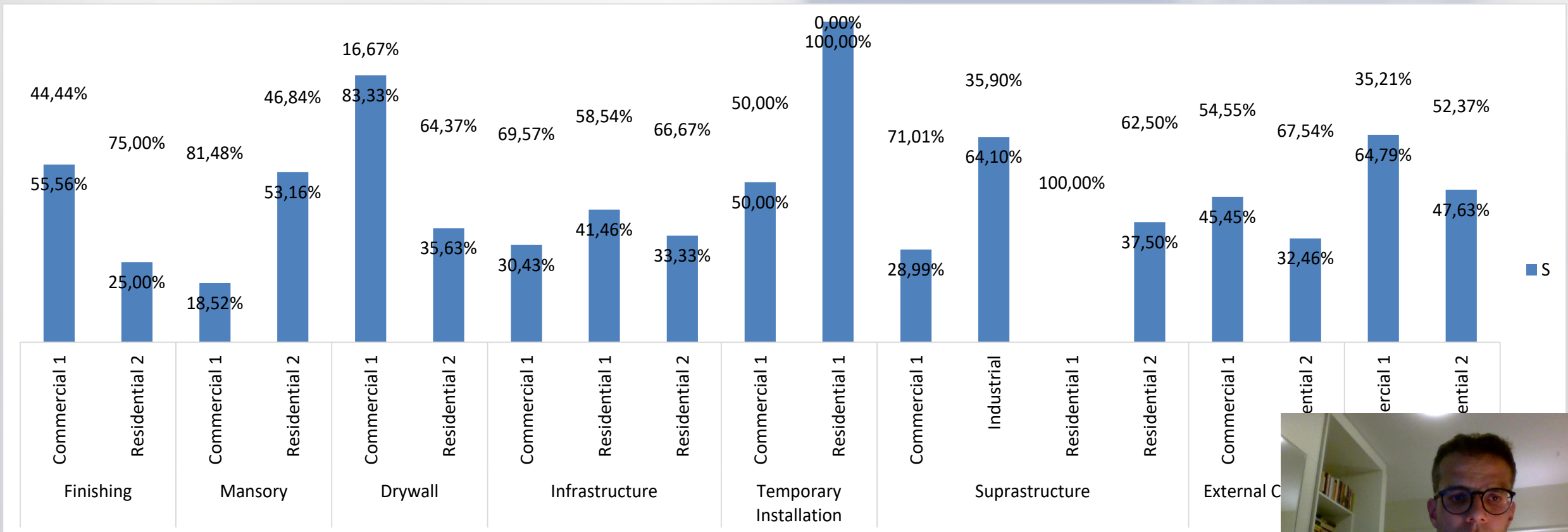

ANALYSIS OF THE SHORT-TERM DATA

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- Analyzing the causes of the non-completion of activities as planned
  - All the causes of **Project** category can be modeled.
  - **Access** category can also be modeled as it represents the interference of the stages of the product, pieces of equipment, and workflows.
  - **Materials** category, only causes of lack of material due to losses above those expected could be modellable, since we would have more precise quantitative estimates of the materials.
  - **Equipment** category, a detailed study in the BIM model could avoid the causes of acquiring inappropriate equipment for the activity or bad dimensioning.
  - **Safety** category, delay in integration are not adjustable, but stoppages due to lack of collective protection.
- The **joint analysis** of medium-term **constraints and causes** of short-term non-completion **are convergent**, with a **high capacity for modeling** the categories of **project, equipment, access, and mate**

CONCLUSIONS

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- Analyzing **constraints** identified in medium-term planning and the **percentage of work packages** elaborated in short-term planning meetings that could be modeled in BIM:
  - We may conclude that **the integration of BIM with LPS** can **let constraints** in medium-term planning be identified and removed in a **more agile and efficient way**.
  - By **using the BIM 4D model** to support the modeling of constraints, it could be seen that the use of the BIM model throughout the PPC process **brings benefits** to the planning of the Construction project.

- Great **potential for modeling** medium-term **constraints and causes** of short-term in the BIM model was identified. This occurs mainly for those that refer to **Projects, Equipment, Work Safety, Materials**.

CONCLUSIONS

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- The **use of BIM can be different in the planning horizons** defined by the LPS.
  - In the **medium term**, BIM can be used to **allow simulations and visualizations** of the position of teams, equipment, and sequence of activities to be simulated and visualized and to understand and visualize workflows.
  - in the **short term**, BIM enables **packages to be visualized in greater detail**, thus facilitating their correct definition, and can let different management systems come under integrated control.
  - We highlight the **use of BIM in planning meetings** both in the medium term (Construction Company 1) and in the short-term (Construction Companies 1 and 2) since the model **allows participants involved to have a common interpretation of the strategies** defined for the enterprise.
- As future studies, it is suggested the **common use of BIM model with LPS** by integrating the **modeling of the attributes and constraints** identified for a comparative case study that lets the potential gains be measured.

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