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BIM AND VISUAL PROGRAMMING LANGUAGE SUPPORTING PROJECT CONSTRUCTABILITY

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AGENDA

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INTRODUCTION

Construction projects need to consider the multiplicity of constructive aspects on its development (Zhang et al. 2016).

The design and execution processes in the construction industry are complex and fragmented (Vrijhoef and Koskela 2005). These two main disciplines are isolated in the traditional construction (Zhang et al. 2016).

Constructability

- Constructability involves the integration of knowledge and constructive experience during the conception, planning, design and execution phases of the project (Mydin et al., 2011).

Visual Programming Languages

- In the context of BIM, It have become progressively important to deal with geometric modeling processes,
- Khan et al. (2019; Ghannad et al (2019) ; Preidel and Borrmann (2016), andhave researched the use of some type of VPL at some stage of their rule checking process)

INTRODUCTION

This research proposes a tool that uses Visual Programming Language to create routines that extract data to calculate constructability metrics and evaluate building projects before the execution phase.

METHODOLOGY

METHODOLOGY - METRICS AND INDICATORS

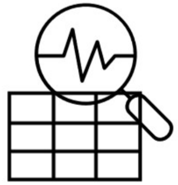
A broad search in the literature for indicators which show relation with constructability

The set of metrics represents the principles of:

- standardization of the project,
- the simplification of the parties,
- the interdependence between activities, and
- ease of access.

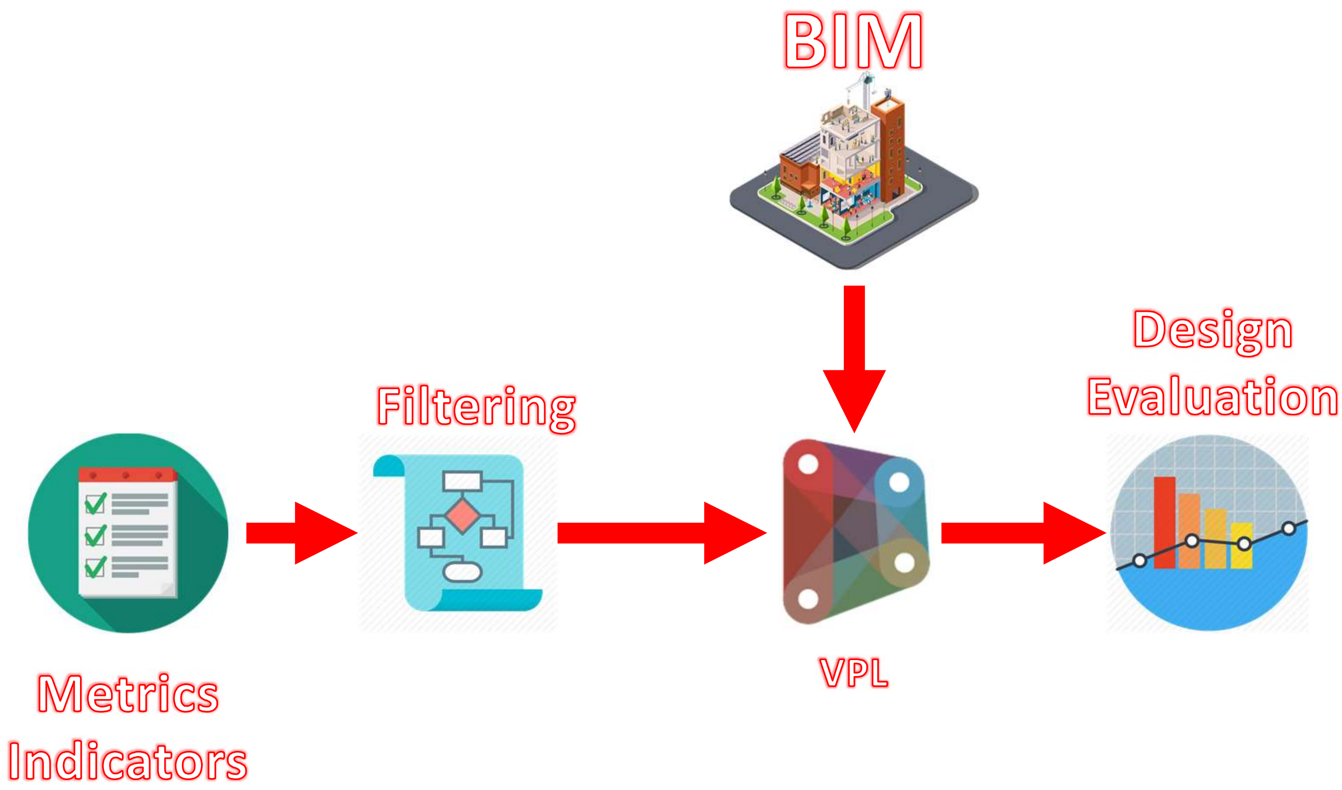
The categorization was performed by the system they comprise.

The filtering processes consider the capability to evaluate metric based on BIM models



Group of Metrics

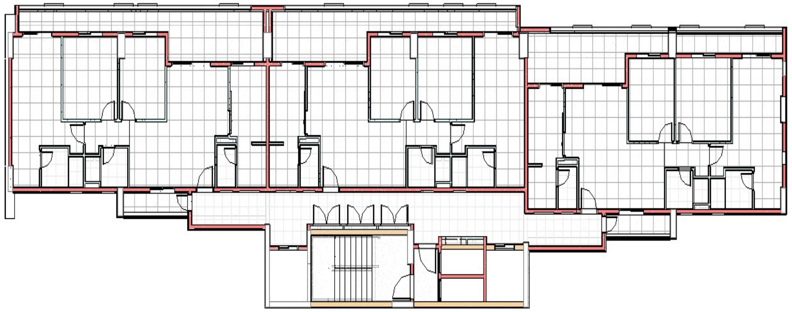
METHODOLOGY - METRICS AND INDICATORS



Tasks

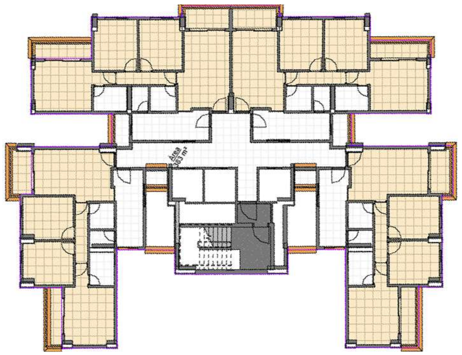
1. read the model
2. collect data
3. manipulate and generate Info
4. calculate the metrics
5. Report results

METHODOLOGY - APPLICATION OF THE MODEL



A residential high standard building of a single tower with two garage floors, 15 typical floors and 1 roof. It has three apartments per floor, with approximately 90 m² each.

Two towers with 22 floors each and 4 apartments per floor. Only one of the towers was selected, having apartments with 95m².

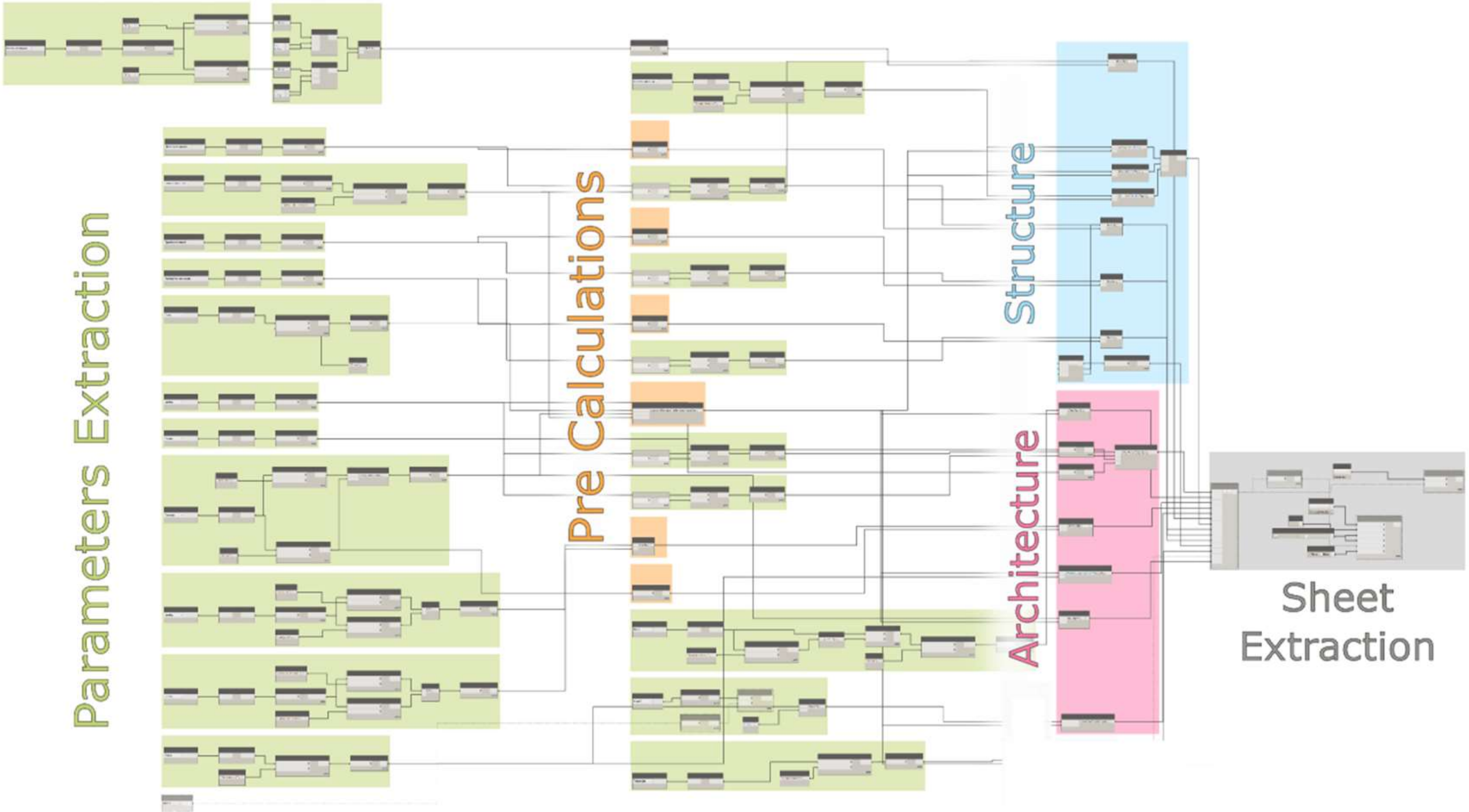


RESULTS

METRICS

	Name/Reference	Equation		Description
		ARCHITECTURAL		
1	Compactness Index Lantelme (1994) Mascaró (2010)	$CI = 2 * \frac{\sqrt{\pi * Farea}}{Fp}$	*Farea:floor area* *Fp: floor perimeter*	It represents the inverse relation of the geometric complexity of the perimeter of the pavement. The further from a square (0.84), the lower the index, and the lower the constructability
2	Wet Area Index Oliveira, Lantelme and Formoso (1995) Narloch (2015)	$WAI = Wa/Farea$	*Wa:wet Area*	Wet areas require more services due to waterproofing, testing and use of ceramics in masonry.
3	Wall Density Oliveira, Lantelme and Formoso (1995)	$WD = Farea/Wha$	*Wha: wall horizontal projection area*	The purpose of this metric is to verify the degree of optimization of the floor subdivisions
4	Facade Index Oliveira, Lantelme and Formoso (1995) Narloch (2015)	$FI = Farea/Fcarea$	*Fcarea: Facade area of the typical floor*	The vertical planes of the facades are more difficult and expensive to build. The indicator reveals the proportion of facades in relation to the typical floor plane of the building.
5	Frame Density Oliveira, Lantelme e Formoso (1995)	$DE = Farea/Wvarea$	*Wvarea: vertical walls area* *Farea: Frames area (doors and windows)*	Windows and doors frames require more services and increase constructive complexity
6	Frame Standard Index Oliveira, Lantelme e Formoso (1995)	$FS = Dfr/Frq$	*Dfr: Dissimilar frames* *Frq: Frames quantity*	The greater diversity of frames affects the complexity of the project, the purchase, the planning and the execution operation.
		STRUCTURAL		
7	Columns Density Index Jarkas (2010)	$CDi = Cpa/Cq$	*CPa: Columns Projection Area* *CAQ: Columns Adjusted Quantity*	Columns restrict movement in the worksite and increase foundation distribution.
8	Beams Density Index Jarkas (2010)	Se $Bl/Farea \leq 0.45$ (1) if not (2) $(1) BDi = Bl/(0.45 * Farea)$ or $(2) BDi = 2 - Bl/(0.45 * Farea)$	*Bl: Beams Length* *Farea: Floor Area*	This metric represents the efficiency of the project. The lower this value, the smaller the complexity of shapes and concreting services, also reducing interferences.
9	Columns Standard Index Jarkas (2010)	$CSi = DC/CQ$	*DC: Dissimilar Columns* *CQ: Columns Quantity*	This metric considers the complexity in the individuality of structural types, through the ratio of different pillars in their cross sections and the total number of pillars.
10	Beams Standard Index Jarkas (2010)	$BSi = DB/BQ$	*DB: Dissimilar Beams* *BQ: Beams Quantity*	This metric measures the complexity in the individuality of structural types, through the ratio of quantities of different beams in their cross sections and the total number of beams.
11	Floor Standard Index Jarkas (2010)	$FSi = \frac{DF}{FQ}$	*DF: Dissimilar Floors* *FQ: Floors Quantity*	This metric calculates the complexity in the individuality of structural types, through the relation of quantities of different slabs in their cross sections and the total number of slabs.

RESULTS – SCRIPT STRATEGIES



The first project Compactness Index has a higher value than the second project. This is because the second project **has several recesses**, obtaining a large per

The index of facades is related to compactness. Thus, the first project has a proportionally smaller perimeter than the second, in turn, has more compartments, increasing the density of vertical planes.

The wet area index of the first project was higher than the second. This is due to the greater proportion of balconies in project 1..

				Project 2	Difference	%
1	Compactness			0,51	0,05	8,4%
	...rea	↑	0,22	0,14	0,08	36,8%
	...sity		0,10	0,12	-0,01	-14,3%
	...icator		1,02	1,10	-0,08	-8,1%
	...nsity		0,20	0,15	0,05	25,8%
	...ndard		0,26	0,18	0,09	33,3%
			...tructure			
	Columns Density	↓	0,30	0,23	0,07	23,0%
	Beams Density	↓	0,83	0,54	0,29	35,2%
9	Columns Standard	↓	0,65	0,27	0,37	57,9%
10	Beams Standard	↓	0,29	0,13	0,16	55,5%
11	Floor Standard	↓	0,29	0,15	0,14	47,5%

Considering the Structure, Project 2 presented good results in the Standard Indexes by having greater symmetry.

The Density Indexes showed that the columns present similar values than beams. This is due to the similarity of vertical loading. Project 1 has larger spans, adopting pre-stressed beams.

CONCLUSIONS

Findings

- The VPS approach allows users to propose solutions that using only a modeling software would require a large number of operations and consume valuable design time
- It is important to promote a parameter and properties stands through all BIM models .
- If properly validated, the construction company can create its own indicators that could be implemented in a script.

Limitations

- The developed routines are governed by the initial definitions, and may not support unforeseen variations.
- The model was tested with a visual programming tool (Dynamo), and may have to undergo some adaptations for correct efficiency in other tools.

Future Research

- Measure the effects of the script application during a project, collecting information from the design and construction stages and understand how its implementation influences the design process

THANK YOU!

Contact Details