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Research Article

Feasibility and Affordability in Brazilian Social Housing according to the Open Building Approach: An Architectural Prospection

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This paper presents results of an architectural research regarding public Brazilian social housing production. Its goal was to evaluate the design, technological-constructive, economic and management feasibility of producing, as well as the financial feasibility for dwellers to access a more adequate dwelling, in light of the Open Building approach. The investigation arises from two issues: [1] spatial rigidity of units and buildings and [2] the absence of dwellers in the decision-making process once currently this producton is the result of the exclusive partnership between State and Market. Besides the inadequacy when meeting families' housing needs, the current rate of housing production is low compared to the predominant housing provision performed by the Autoconstruction. This paper demonstrates that Habraken's Supports Theory is, as a counterpoint, an effective way of reconciling the contradictions mentioned and replacing the obsolete paradigm with a new interweaving of Autoconstruction and State/Market production traditions and possibilities. Based on the distinction between the levels of decision-making, collective decisions (manifested in a Support or Base Building) and decisions respecting the autonomy of individual dwellings (Infill or Fit-out), the Open Building approach solves simultaneously, and interdependently, the physical, but also social and political problems identified in the research.

Keywords*: Brazilian social housing. Autoconstruction. Open Building. Support and Infill. Levels of decision-making.*

INTRODUCTION

The arguments presented in this text arose from the inquiry into the non-participation of dwellers in decision-making processes within formal housing production in Brazil and on the spatial rigidity of the dwellings. These problems are present (1) in different scales - from small multifamily building developments with thousands of dwellings (detatched or condominial), (2) among different producers and managers - public, private, associative or others, (3) with different target consumers - low, medium or upper class or (4) in different city locations. (Morado Nascimento & Tostes, 2011; PRAXIS-EA /UFMG, 2014; Anitelli, 2015; Lamounier, 2017)

This problem worsens in social housing production, the focus of this text, where the issues of spatial flexibility and empowerment of the dweller in the decision-making process become more challenging. Two current production types were studied: that jointly performed by the State and Market, and housing provision through Autoconstruction.

While in the former production involves several institutionalized agents (public and private), it is in the latter, through Autoconstruction, that 70% (Brazil, 2009: 163; Abiko *et al.*, 2003: 49) of Brazilian dwellings are produced by the dwellers themselves. This reality has deep roots in the history of Brazilian housing production, with various explanations: economic, political, cultural, social, technological, academic, professional, among others. (Lamounier, 2017)

In Autoconstruction the same architectural type of housing, recurrently produced by the State-Market without participation of the future dweller, presents itself in a different way, largely more compatible with the housing needs of dwellers, the decision makers in the production process of their own dwellings.

These subfields, which conform to the scenario studied, are discribed below.

THE FIELD OF THE SOCIAL HOUSING PRODUCTION IN BRAZIL

Housing production by the State-Market

The public provision of social housing in Brazil has been performed since 2009 by the federal government through the Minha Casa, Minha Vida (My House, My Life) (PMCMV) Program. Since then, there have been more than 3 million units delivered and more than 5 million contracted (Brazil, 2018).

These numbers are lower than the Brazilian housing shortage and indeed production has not even been effective in combating the targeted deficit relating to the lowest income class (Figure 1). The housing deficit does not decrease and one reason is precisely because dwellers' housing needs are different from each other; increasing or changing over time and in very different ways in the various regions of the country. As, historically, the demand for housing is higher than supply, the awareness of the importance of meeting such needs has not been formed. Hence, a quantitative solution is sought to a problem whose nature is qualitative.

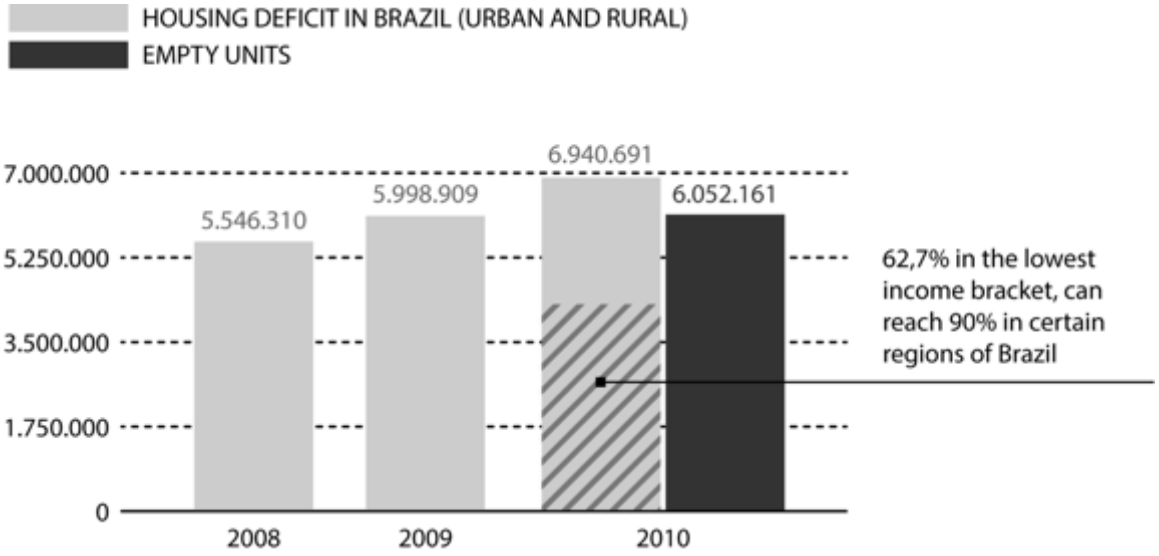


Figure 1: Housing deficit and real estate vacancy in Brazil
Source: Lamounier, 2017.

The PMCMV-Empresas[1] is operated by the interaction between five agents (Figure 2): [1] Ministry of Cities (MC), representative of the federal public power; [2] state and municipal governments and other bodies representing local government; [3] CAIXA (and other banks) - a financial institution in the form of a public company of the federal government linked to the Ministry of Finance, with its own equity and administrative autonomy; [4] builders and developers representing the private sector; and [5] beneficiaries. Public and private power are the dominant agents through the State-Market partnership, which, influenced by neoliberal politics, makes the construction companies the main proponents and profiteers of social developments. While the dwellers are not part of the decision-making process, they receive the state-subsidized standardized and finished housing units.

[1] The PMCMV presents five modalities: Companies; Entities; Municipalities up to 50 thousand inhabitants; FGTS (Guranteed Fund for Length of Service) and Rural, of which the majority of production is in the former. http://www.brasil.gov.br/infraestrutura/2014/04/entenda-como-funciona-o-minha-casa-minha-vida. Accessed 04 December 2017. This article focuses on the first modality.

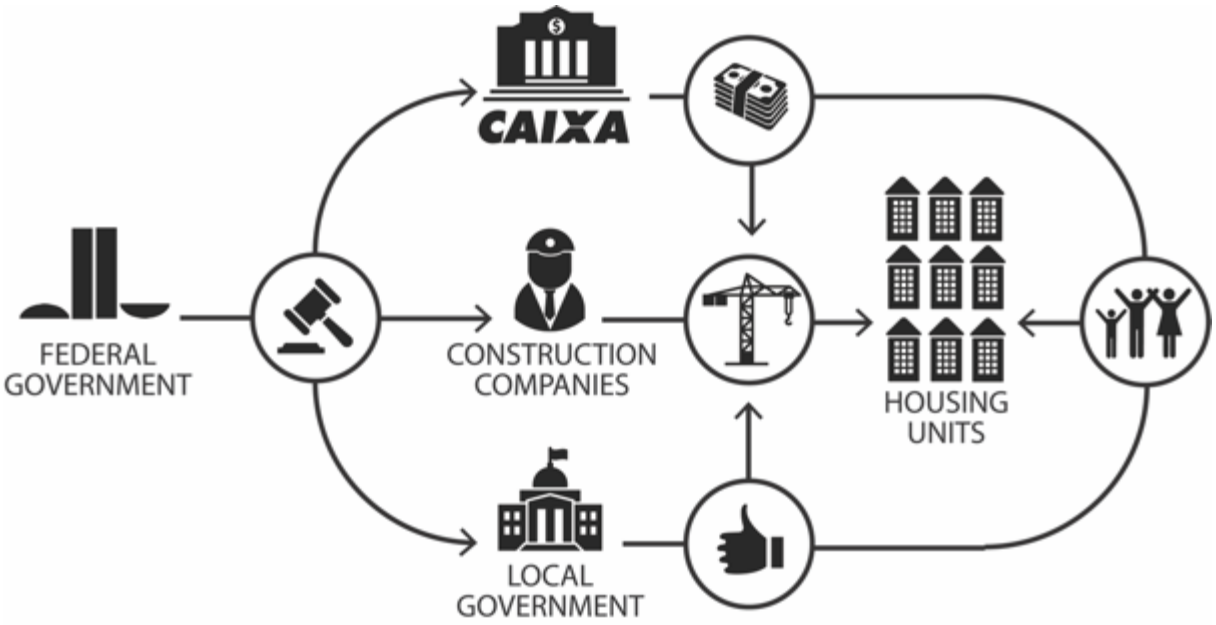


Figure 2: PMCMV Agents
Source: PRAXIS-EA/UFMG, 2014.

The program is in its Third Phase and is distributed in bands, by family income, according Table 1.

Table 1: Income ranges of benefited families by PMCMV per phase

	PHASE 2 (2011-2015)	PHASE 3 (since February/2016)					
RANGE	Family income per month	Family income per month	Monthly Adjustment in 2017 (around 7,69%)	Value paid by Government to Construction Companies (2017, RMBH)	Subsidy value in 2017	Instalment (2017)	Funding time
*Range 1**	Up to 396.26 € (1,600 BRL)	Up to 445.80 € (1,800 BRL)	Up to 445.80 € (1,800 BRL)	Up to 21,794.58 € (88,000 BRL)	Up to 90%	19.81 to 66.87€ 80 to 270€	120 months
*Range 1,5***	—	Up to 582.01€ (2,350 BRL)	Up to 643.93 € (2,600 BRL)	Up to 32,939.54 € (133,000 BRL)	11,764.12 € (47,500 BRL)	<= 30% of the month income	Up to 30 years interest 5% per year
*Range 2***			until 643.93 € (2,600 BRL)	until 42,350.84 € (171,000 BRL)	7,182.31 € (29,000 BRL)	<= 30% of the month income	Up to 30 years interest 5% per year
			until 743 € (3,000 BRL)				Up to 30 years interest 5,5% per year
	Up to 67.76 € (3,100 BRL)	Up to 891.60 € (3,600 BRL)	Up to 990.66 € (4,000 BRL)				Up to 30 years interest 7% per year
*Range 3***	Up to 1238.32 € (5,000 BRL)	Up to 1,609.82 € (6,500 BRL)	Up to 1,733.66 € (7,000 BRL)	Up to 53,248.13 € (215,000 BRL)	Low interest rates		Up to 30 years interest 8,16% per year
			Up to 2,229 € (9,000 BRL)		Low interest rates		Up to 30 years interest 9,16% per year

* Financial System: a kind of Liens. Property can be sold only after the total payment. Before, only if pay the total of the subsidy. The house can't be funded for this program again.
** Financial System: the guarantee debt is the property.
Penalties: Loss property after 3 late instalments. There is a fund [FGHAB] in case of death or disability; and a re-financing in case of unemployment and so on.
1 € = 4,0377 BRL. Source: http://www.bcb.gov.br/pt-br/#!/busca/euro. Accessed in 16/02/2018.

Source: Prepared by Lamounier (2017) based on http://www.minhacasaminhavida.gov.br. Accessed 31 January 2018.

The exclusion of the dweller from the decision-making processes seen from the standardized architectural type and widely reproduced by the State-Market

In terms of architecture design, both the housing unit (UH) and the building scale, the PMCMV is not an improvement on previous programs and has been uniform throughout the country. Either they are apartments within 5 floor "H" blocks arranged in plateaus (Figure 3), or they are detached houses (Figure 4).

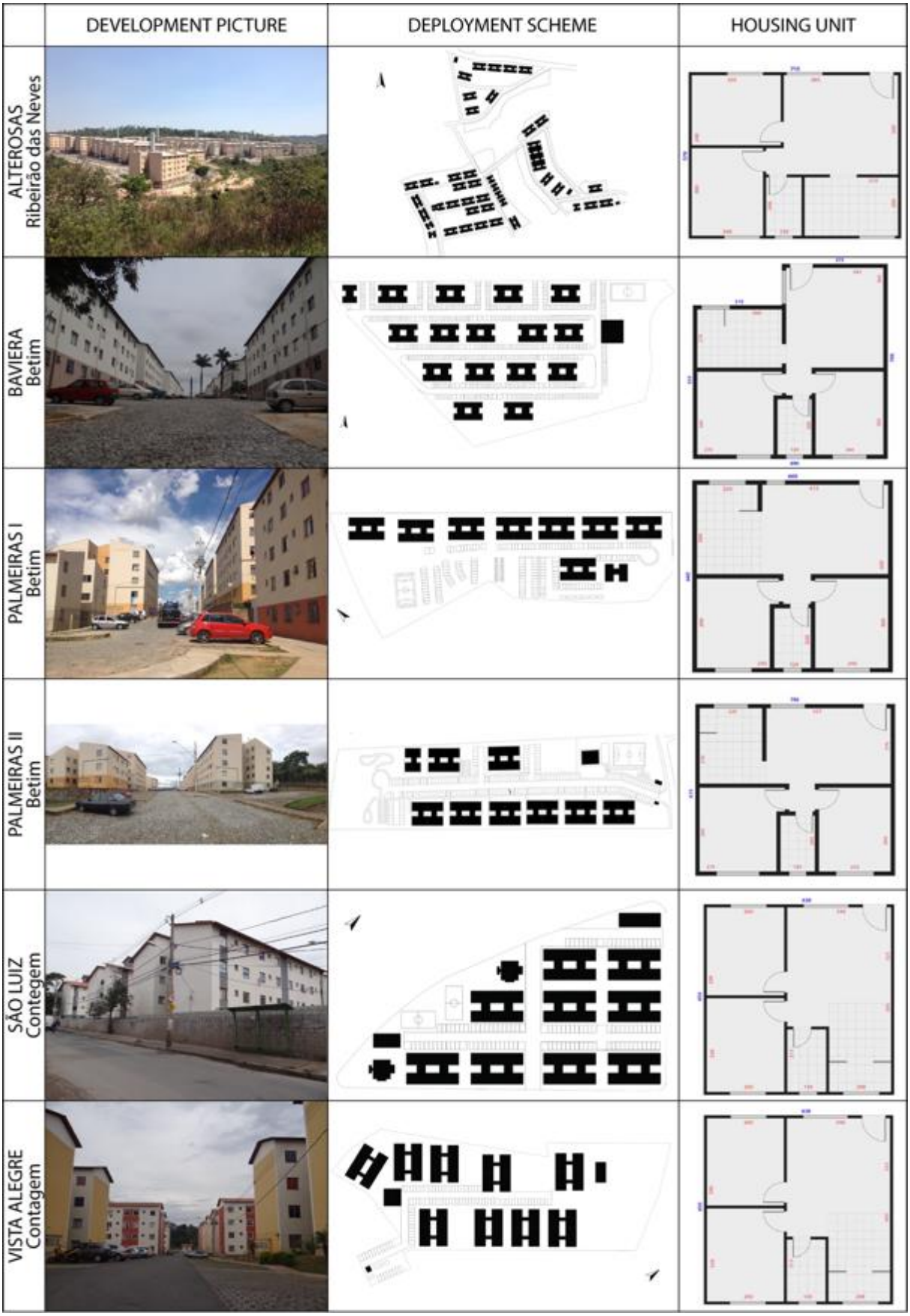


Figure 3: Various PMCMV projects in RMBH
Source: Lamounier, 2017.

Figure 4: Illustrative images of PMCMV production in Brazil (detatched houses)
Source: Lamounier, 2017.

The standard UH production is based on the average nuclear family profile (father, mother and two children), ascertained by a national census, reflecting historical and outdated assumptions of *mass housing* production - repetition and generality. All solutions present the same architectural program (lounge, kitchen/laundary area, 2 bedrooms and 1 bathroom), constituting the "minimum required that becomes the maximum fulfilled" (PRAXIS-EA/ UFMG, 2014). The organization of the spaces only changes with the position of one room in relation to another, totaling no more than 39 to 44m². In short, it has a predetermined design starting point of simply fulfilling the functions of the modern design of living, eating, sleeping, washing and cooking, as if demands could not be spatialized by other arrangements, including by the dwellers themselves. The program's regulatory framework is also legitimized by municipal building codes which, in general, establish the same rules of type, number and size of spaces, and their respective furniture (Lamounier, 2017).

The rooms are immutable because all the walls are structural. The elements are repetitive and standardized, seeking a pseudo "constructive rationalization", because some of the industry-produced components are used, but in a manufactured construction. Low income dwellers are therefore unable to perform costly reforms in a newly constructed and finished space owing to preconceived inadaptability.

The logic of practice in this subfield, capitalist in nature, performed by the Market and legitimized by the State, is therefore motivated by issues that are far from dwellers' true housing needs, preventing them from making decisions about their future dwellings. Thus, the field involves the State, the Market and the population, in which capital wins, governend by consumption and obsolescence, and which historically is uninterested in producing evolutionary spaces or that transform in time. This contrasts with the Autoconstruction practice in the country, highlighting the problematic not only how an architectural or technological issue, but of decision-making power. It is also a political, economic, cultural and social issue.

The majority production of housing in Brazil through Autoconstruction

As previously mentioned, the vast majority of Brazilian dwellings are built, enlarged or renovated by dwellers themselves. This is performed with or without the help of relatives, friends or neighbors, the hiring of labor or qualified technical advice and without regularization from competent bodies. When this practice includes autoconstruct reforms in originally designed or regularized properties, its percentage rises to 85% (CAU-BR/DataFolha, 2015).

Thus, Autoconstruction is present at various levels of intervention, from the exchange of finishings or the internal spatial rearrangement, through renovations that include expansions, to complete Autoconstruction, beginning with land ownership. (Figure 5)

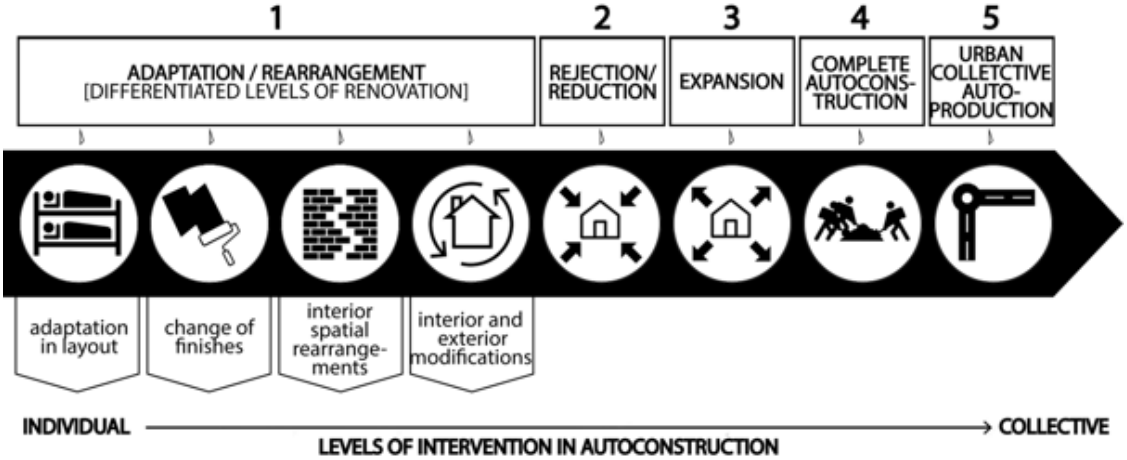


Figure 5: Levels of Intervention in Autoconstruction
Source: Lamounier, 2017.

Geographically, there are autoconstructed spaces in rural, peripheral or pericentral areas; in slums and land-occupations (spontaneous or organized, peripheral or central), constituting action present within different social classes. However, the numerical disproportion of Autoconstruction in relation to public and corporate housing production is more pronounced in lower-income classes (Brazil, 2009: 14 and 163).

Despite all the difficulties, conflicts and problems inherent in this practice (deliberate or not[2]), Autoconstruction still generates solutions that better serve the everyday and domestic lives of different families, as well as the necessary changes in time than much of the heteronomous production. Surely the autonomy present in this practice, guaranteeing dwellers power in the decisions, is one of the factors that contributes to its predominance. This demands attention. Somehow the land, building materials, energy, water, tools and skills are made feasible by autoconstructors. More than basic need, the practice is tied to the way people's daily lives are constructed.

Thus, it is precisely autonomy – dwellers' freedom and independence to produce for themselves -, as opposed to heteronomy - dependence, submission, subordination to that produced by others -, which Autoconstruction offers and that positively differentiates it from the public-business production subfield. In Autoconstruction, autonomy is not a goal to be achieved but is inherent in the process and can be seen in the varied solutions engendered. (Figure 6)

Figure 6: Autoconstructive actions
Source: Lamounier (2017) and PRAXIS-EA/UFMG (2015)

However, the autoconstructed space may seem precarious to the State, the field of architecture and the Market, without a prevalence of exchange value, constituting a value of social use; the decisions taken on it are without external interference, despite underlying external conditions. Such characteristics are what make Autoconstruction important in the effectiveness and feasibility of another housing production practice that considers, for example, principles such as those of Open Building[3].

The main and dominant agent in Autoconstruction is the dweller, who buys, builds or contracts, pays for and uses. Other agents such as builders or local building material stores also participate in the process, but not as major proponents, albeit being important Market representatives in the productive chain of the sector. (Figure 7)

[2] "Deliberate autoconstruction" consists of a choice; a political option in rejecting or confrontation with current public housing policy procedures, rent insecurities and Market financial regulations, and becomes a social pressure mechanism in the securing of other basic urban services.
"Autoconstruction (or Autoproduction) no deliberate" is the construction or production of the own house by the dweller, when this form is their only option - they did not have the resources or profile to claim access to the dwelling by other means.

[3] The six principles of Open Building can be summarized as:
[1] the existence of distinct Levels of intervention in the built environment, such as those represented by *support and infill*, or by urban design and architecture;
[2] users/inhabitants may make design decisions as well;
[3] more generally, designing is a process with multiple participants also including different kinds of professionals;
[4] the interface between technical systems allows the replacement of one system with another performing the same function (as with different fit-out systems applied in a same base building);
[5] the built environment is in constant transformation and change must be recognized and understood;
[6] the built environment is the product of an ongoing, never ending, design process in which environment transforms part by part.
The Open Building methodology is derived from John Habraken's *Theory of Supports*, whose essence lies in the separation of decision-making levels in the process of space production. From the *collective* to the *individual*, the theory distinguishes intervention and control levels under physical (*support* and *infill*), organizational (from community to individual), territorial (from city to room) and temporal (from 10 to 1000 years). It is about who controls what and when, by agreement and negotiation. Such assumptions differ greatly from the characteristics of public production performed in Brazil and converge in many aspects with the production performed by Autoconstruction.

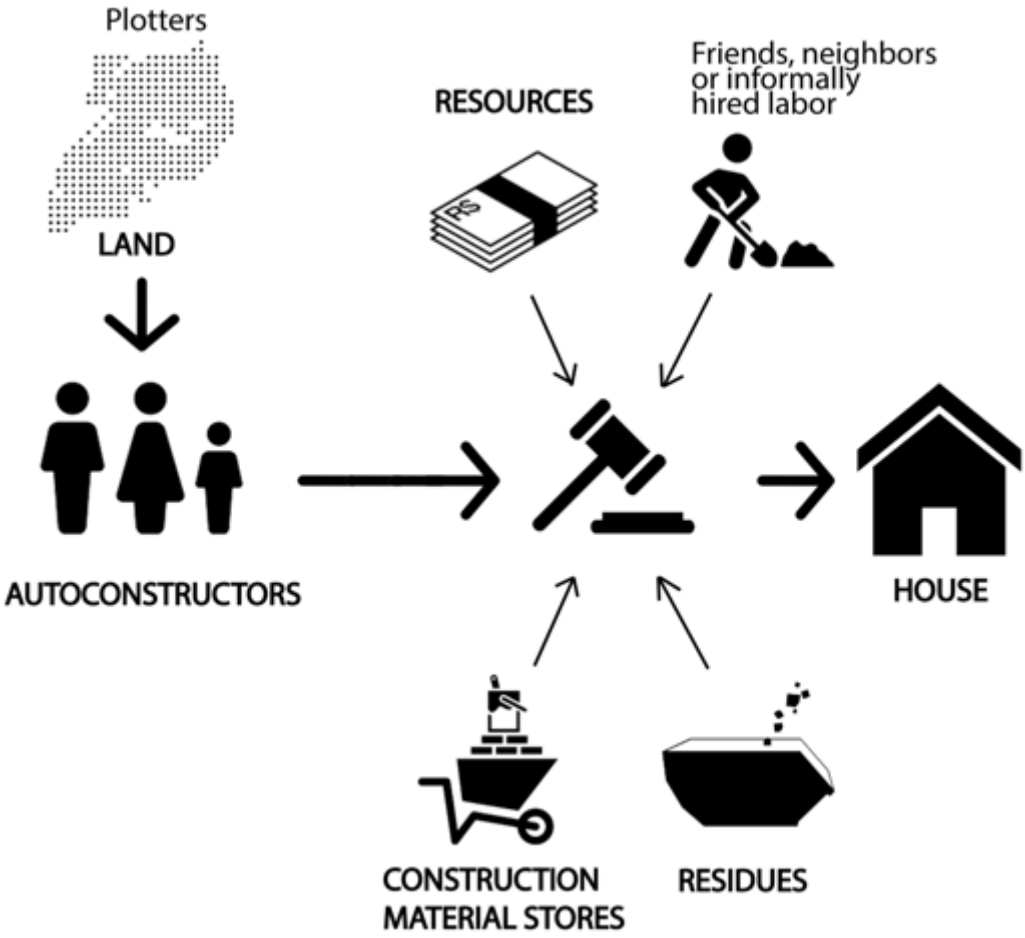


Figure 7: Agents in the production process through Autoconstruction
Source: Lamounier, 2017.

OBSTACLES, POSSIBILITIES AND PROSPECTION GOALS

An extensive and varied empirical research study was performed with the various agents of the three types - public-business production and Autoconstruction in Brazil, and Open Building in the Netherlands and Belgium. The analysis of the data collected, using Bardin's (1977) methodology, mapped both obstacles and gaps for the production of Open Building in Brazilian social housing. They are present in various discourses, including those of dwellers, and observations on visits to housing, buildings, construction sites and workshops. Limitations and possibilities were highlighted within design, construction and technological, political, legal, economic-financial and management aspects. This diagnosis indicated failures or shortcomings in the current productive system, thus evidencing contradictions, sometimes as fissures or fragilities, or as potential subversion to the system itself. (Lamounier, 2017)

As part of the quintessential architect's work, the design, construction, economic-technological and management aspects (involving economic feasibility and affordability, as well as financial availability) for the development of an architectural prospection were listed. However, the results of this prospection can guide public policies contemplating housing production in its various aspects.

Therefore, the objective of architectural prospection was to investigate the feasibility for those producing and the affordability for those buying housing in Brazil, publicly provided and under the Theory of Supports and Open Building principles, on behalf of the dweller's decision-making power and the flexible nature of spaces. This is a counterproposal to current production, taking as a test case a Band 1 PMCMV development, produced in Phase 1 of the program and built by a construction company between 2010 and 2013. The prospection sought to demonstrate that housing needs do not have to be predetermined or controlled, but considered within other principles of production logic – of planning, design, construction and use.

THE ARCHITECTURAL PROSPECTION

Architectural prospection was developed in three phases; the first two within the scope of *support-structure* architectural design, in two scales: a building and a building complex in an urban block, followed by budget studies. In the last phase, an investigation was performed into the management of *support* and *infill*.

Among several PMCMV developments visited in Metropolitan Belo Horizonte (RMBH), the Residencial Alterosa (Alterosa Residential) in the city of Ribeirão das Neves, run by the Direcional Engenharia construction company, was analyzed. The criteria of choice were: [1] higher density development at the time (294.77 UH/ha); [2] the use of 'wall-concrete' technology widely used by leading PMCMV constructors, [3] the existence of a great deal of research data, including surveys with theis dwellers and [4] employment by the constructor of the same design, typological and constructive solution for all PMCMV bands, facilitating future cross-referencing of prospection results with other program strands and market segments. There were 1640 UHs distributed in 11 blocks. (
Figure **8** to Figure 10)

Figure 8: Aerial image of Alterosa Residential, in Ribeirão das Neves, RMBH
Source: Lamounier, 2017, based on Google Earth, 2017.

Figure 9: Aerial view of Alterosa Residential in Ribeirão das Neves, RMBH
Source: PRAXIS-EA/UFMG, 2014.

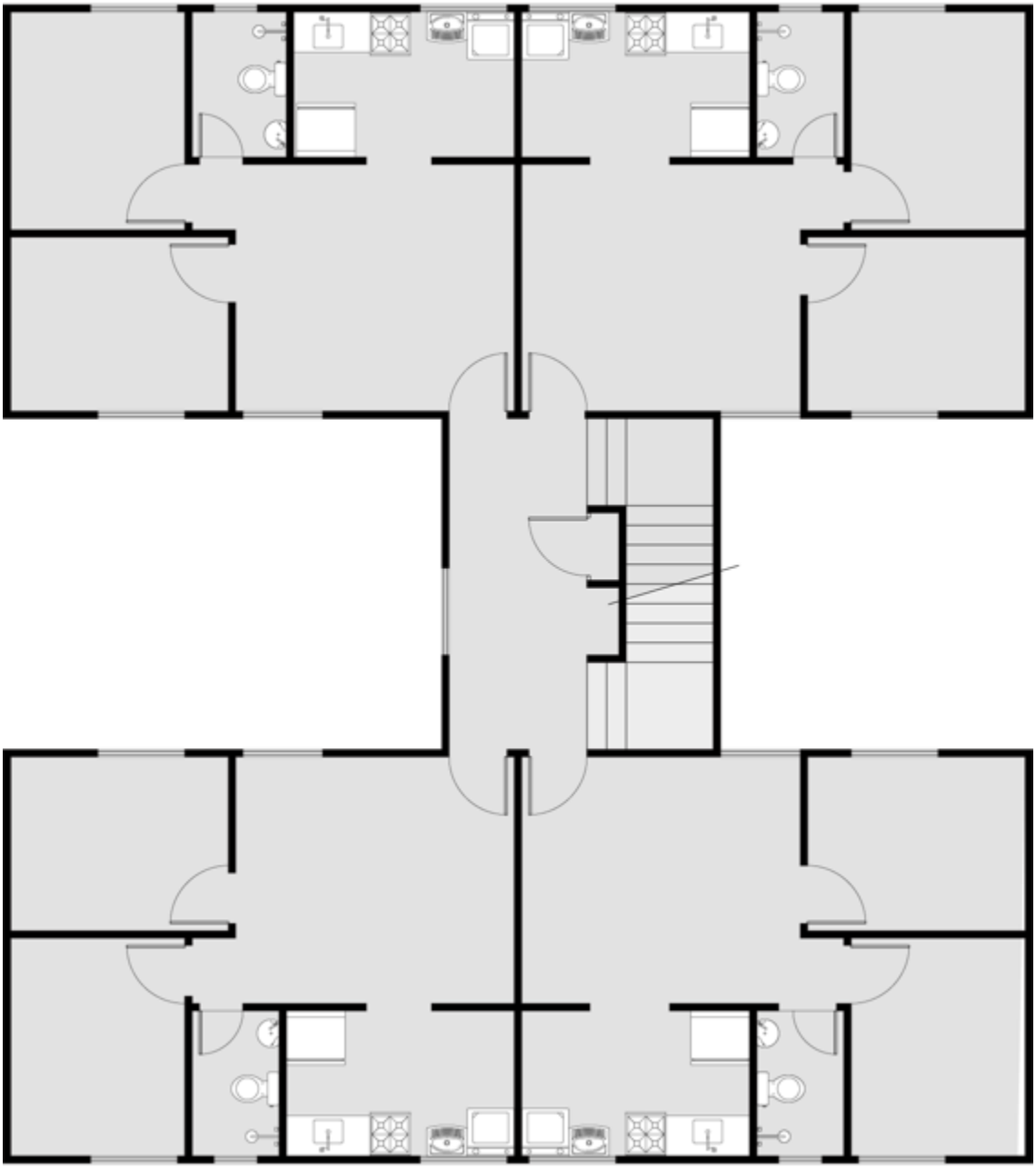


Figure 10: Floor-type of a standard-block of “H” format of Alterosa Residential
Source: Lamounier (2017), based on Architectural Design printed, provided by CAIXA. Collection of PRAXIS-EA/UFMG, 2014.

In order to demonstrate the *demand for spatial flexibility* (Prins, 1992a; 1992b) and for empowerment in the decision-making process regarding the space itself, eleven infographics were selected that reveal research with dwellers (PRAXIS-EA / UFMG, 2014)[4], shown on Lamounier *et al.* 072

Table **2**, left column. From these infographics some design cues were extracted (middle column).

[4] *Minha Casa, Minha Vida: Estudo Avaliativo na RMBH*, 2013-2014. Research coordinated by Prof. Denise Morado Nascimento and financed by CNPq, Edital MCTI/CNPq/MCidades n.11/2012. http://www.arq.ufmg.br/praxis. Accessed 26 February 2015.

Table 2: Correspondence between infographics information of PRAXIS-EA/UFMG and FLEX Method Indicators

DEMAND FOR FLEXIBILITY IN ALTEROSA RESIDENTIAL Source: PRAXIS-EA/UFMG, 2013-2104			DESIGN INDICATORS Source: Lamounier, 2017	FLEXIBILITY INDICATOR RELATED	DESCRIPTION OF THE FLEXIBILITY PERFOMANCE INDICATOR (LEGEND)
	INFO CODE	INFOGRAPHIC NAME		Source: FLEX Method, Rob Geraedts, 2016	
1	3.04	**DEVELOPMENT DENSITY** ➢Occupation Rate (Development) = 26% ➢Occupation Rate (Block 49) = 32% ➢Utilization Coefficient (Development) = 1,19 ➢Utilization Coefficient (Block 49) = 1,36 ➢Land Quota/UH (Development) = 33,93m²/UH ➢Land Quota/UH (Block 49) = 29,63m²/UH ➢Density (Development) = 294 UH/hectare ➢Density (Block 49) = 337,43 UH/hectare	➢ It wasn't found a maximum limit of utilization coefficient established for the land in study by the municipality ➢ In addition, PRAXIS-EA/UFMG (2014) showed the municipal legislation flexibility related this parameter for many municipalities do RMBH. Then, it is possible to build more	1, 2, 3, 4	1.Surplus of site space 2.Expandable site/ location 3.Surplus of building space/ floor space or empty 4.Available floor space of building 5.Access to building: location of stairs, elevators, core building 6.Positioning obstacles/ columns 7.Façade windows to be opened 8.Day light facilities 9.Customisability and controllability of facilities 10.Surplus of facilities shafts and ducts 11.Distinction between *support* and *infill* 12.Horizontal access to building 13.Surplus free of floor height/ higher floor height 14.Modularity of facilities
2	3.05	**UNIT DENSITY** ➢Dwellers Number/UH= 4 people/UH=21% ➢Less then 4 people/UH = 51% ➢More than 4 people/UH = 28%	➢Enable different UH sizes	3, 5, 6, 7, 8, 9, 10, 11, 12	
3	3.35	**FAMILY COMPOSITIONS** ➢There are several family compositions in number, genre, origin, desires, needs, selection criteria etc.	Suggestion of UH sizes: ➢1 to 2 people – 25m² [minimum required by local legislation] ➢2 to 4 people – ~39m² [minimum required by PMCMV] ➢to 6 people – ~55 to 60m2 ➢6 to 9 people – ~70 to 80m²		
4	3.25	**BAD DISTRIBUITION OF PLAN** ➢Small rooms (small kitchen, room and bathroom), bad service area, need another bedroom, no double bedroom	➢Different opinions related to internal partition, spaces size, spatial arrangements. ➢Enable different spatial arrangements ➢distinguish decision levels	3, 6, 7, 8, 9, 10, 11	
5	3.26	**REASONS OF INADEQUACY OF THE APARTMENT SIZE** ➢Small room, bedrooms, kitchen and service area; no adequate to family size			
6	3.27	**ROOM/ AREA ABSENCE IN PREVIOUS DWELLING** ➢External area (yard), service area, balcony, extra bedroom, bigger rooms, leisure area, pantry	➢Different opinions related to internal partition, spaces size, spatial arrangements. ➢Enable different spatial arrangements ➢Distinguish decision levels ➢Predict external areas adjacent to some units ➢Promote spaces for collective use: leisure, mixed use etc.	1, 2, 3, 6, 7, 8, 9, 10, 11, 12	
7	3.28	**APARTMENT PROBLEMS** ➢Noise (acoustic problems); heat/ cooling and humidity (thermal insulation problems); leaks; cracks; Installations problem (electrical, telephone, internet etc.)	➢Improve thermo-acoustics solutions ➢Improve solutions for all facilities ➢Increase floor height (2,50 currently)	6, 7, 8, 9, 10, 11, 13, 14	
8	3.30	**REASONS TO MOVE FROM CONDOMINUM** ➢Security and violence; neighbourhood problems; apartment size	➢Enable different UH sizes ➢Distinguish decision levels	5, 7, 11, 12, 13	
9	3.31.	**WHY THE CURRENT DWELLING IS BETTER THEN PREVIOUS?** ➢Own house, better quality and tidy house	➢Distinguish decision levels, prioritizing the management for purchase / ownership ➢Invest in flexible façade solutions	5, 7, 9, 10, 11, 12, 14	
10	3.32	**WHY THE PREVIOUS DWELLING IS BETTER THEN CURRENT?** ➢Security; good neighbourhood; tranquillity; urban services and infrastructure; bigger space; yard; house typology; better accessibility	➢Promote spaces for collective use: leisure, mixed use etc. ➢Enable different UH sizes ➢Predict external areas adjacent to some units, specially on the ground floor ➢Enable to extend the dwelling ➢Distinguish decision levels	1, 2, 3, 5, 6, 11, 12	
11	3.33	**WHAT DO DWELLERS LIKE LESS?** ➢Insecurity; disorganised condominium management; vandalism; disrespect; bad external areas; noise; without urban services and infrastructure; dirt/ maintenance lack; bad accessibility; UH inadaptability; apartment size	➢Distinguish decision levels ➢Promote spaces for collective use: leisure, mixed use etc. ➢Improve thermo-acoustics solutions ➢Enable different UH sizes ➢Enable different spatial arrangements ➢Predict external areas adjacent to some units, specially on the ground floor	1, 2, 3, 5, 6, 9, 11, 12, 14	
12	3.34	**WHAT DO DWELLERS LIKE MORE?** ➢Own house, good neighbourhood, tranquillity; building infrastructure	➢Distinguish decision levels, prioritizing the management for purchase / ownership	11	
13	3.36	**REASONS TO MOVE FROM PREVIOUS DWELLING TO CURRENT** ➢Conquer the own house; leaving the rent or favour dwelling; leaving the risk area; desire for more adequate housing	➢Distinguish decision levels, prioritizing the management for purchase / ownership ➢Promote public system of social leasing	11	
14	2.11	**APPROVAL OF THE UNIT SIZE AND DISTRIBUTION BY FAMILY SIZE** ➢Families with 1 to 3 people – 45% ➢Families with 4 people – 25% ➢Families with 5 to 9 people – 9%	➢Enable different UH sizes ➢Enable different spatial arrangements ➢Distinguish decision levels	3, 5, 6, 7, 8, 9, 10, 11, 12	

Source: Lamounier (2017), based on PRAXIS-EA/UFMG (2014) and Geraedts (2016).

The infographic of Figure 11 confirms the Residential families' diverse configuration, in terms of number, gender, degree of relationship or social relation. It, by itself, reveals the inadequacy of current production.

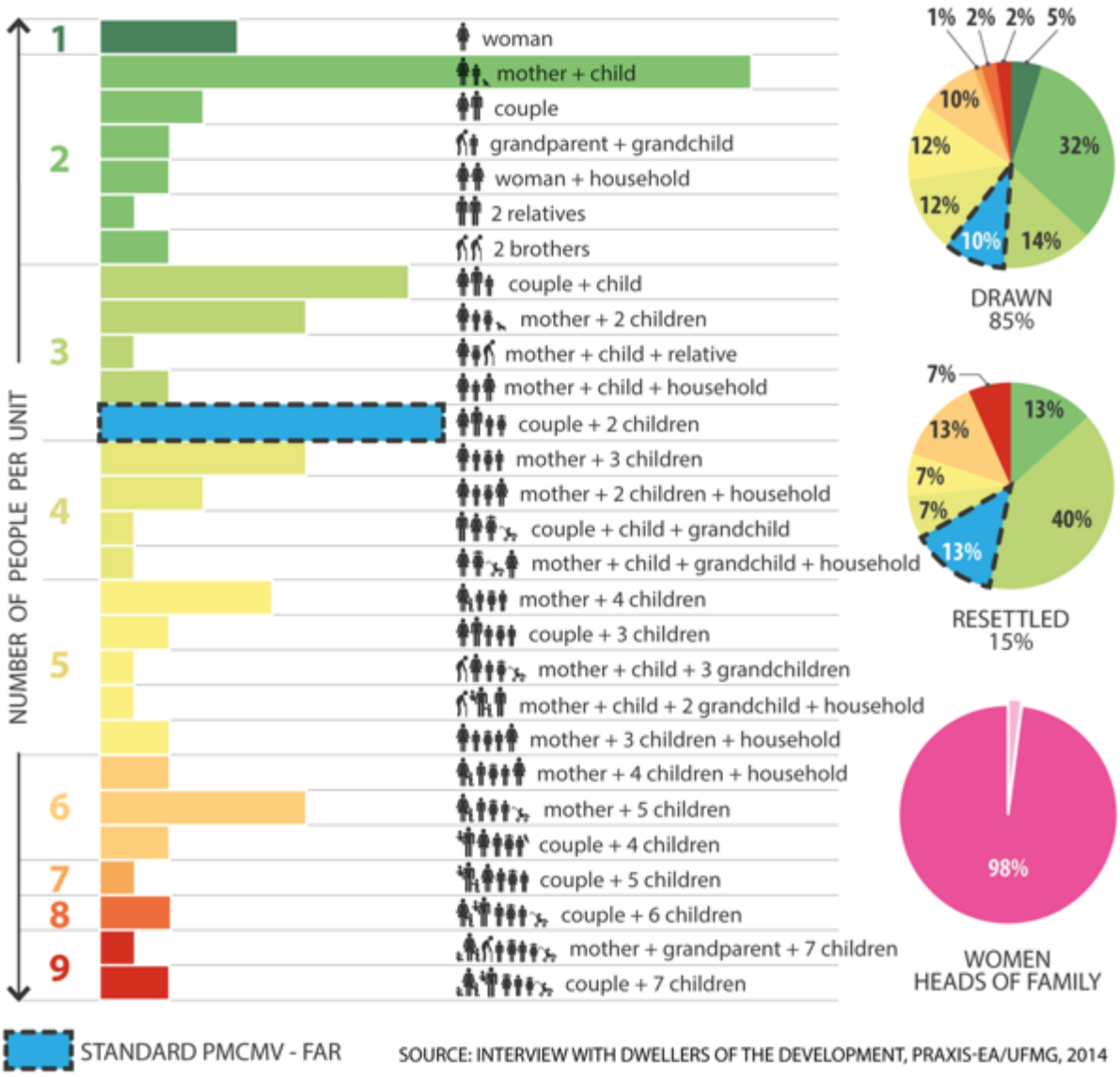


Figure 11: Family compositions of Alterosa Residential
Source: PRAXIS-EA/UFMG, 2014, prepared by Lamounier (2017).

Geraedts *et al.* (Geraedts et al 2014, Geraedts & Prins, 2015 and 2016; and Geraedts, 2016) have developed a practical tool, the FLEX Method, to evaluate the adaptive capacity of buildings or their *potential for flexibility*. The tool is presented in a version with *generic* indicators, applicable to any use; or in the *specific* indicators version, when the use is a hospital, school or office.

One way to identify a possible *demand for flexibility* in the Alterosa Residential was to cross the research data with the dwellers carried out by PRAXIS group, with the FLEX method *generic indicators* (Table 3), which generated the last column of Lamounier *et al.* 072

Table **2** (of correspondence), whose frequency was recorded in Table 3.

Similarly, a correspondence of the indicators with analysis subcategories of our research was recorded, and all this became a design strategy, besides reinforcing the autoconstructive actions as *scenarios of flexibility* (Prins, 1992a; 1992b).

Table 3: 12 generically applicable indicators and their frequency in relation to the demand for flexibility indicated by the information contained in the research infographics of PRAXIS-EA/UFMG (2014) together with the Alterosa Residencial

FREQUENCY OF GENERIC INDICATORS *VERSUS* DEMAND FOR FLEXIBILITY				
LAYER	**Sub-layer**	**Nº**	**GENERIC INDICATORS FLEX 4.0: GENERALLY APPLICABLE** (Rob Geraedts, 2016)	**FREQUENCY**
SITE		**1**	**Expandable site/ location**	**4**
STRUCTURE	**Measurement**	2	Surplus of building space/ floor space	**10**
		3	**Surplus of free floor height**	**1**
	Access	**4**	**Access to building**	**7**
	Construction	5	Positioning obstacles/ columns in load	**9**
SKIN	**Façade**	6	Façade windows to be opened	**9**
		7	Daylight facilities	**7**
FACILITIES	**Measure & Control**	**8**	**Customisability/ controllability faciities**	**9**
	Dimensions	**9**	**Surplus od facilities shafts and ducts**	**8**
		10	Modularity of facilities	**3**
SPACE	**Functional**	**11**	**Distinction between support-infill**	**13**
	Access	**12**	**Horizontal access to building**	**8**

Source: Lamounier, 2017.

Based on Habraken (2017); Geraedts (2016); Duffy (1992 and 1998); Brand (1994) and Kobayaschi & Fujimoto (2003, apud Costa, 2016), Table 4 shows the terminology defined for architectural prospection.

Table 4: Levels of decision-making associated with the use, lifespan and agents position, adopted in the architectural prospection

LEVELS OF DECISION DEFINED FOR THE ARCHITECTURAL PROSPECTION				
	SUPPORT		***INFILL***	
Four Sublevels	Base-building	Common Level	Boundary Level	Interior Level
Components	foundations, *fontanel* walls, slabs, roof, *shafts* with facilities central supply, vertical and horizontal circulations, basic external infrastructure	façades (system definition), walls of division between units, definition of external and common space use	Private expansions on the ground floor or solution by eventual balconies	Infill and modules definition of façades, internal walls, internal waterproofing, finishes, coatings and internal equipment of units, furniture
Space use	Common		Individual	
Adaptability/ Lifespan	Fixed/ Long Lifespan	Adaptable/ Average Lifespan	Adaptable / Short Lifespan	
Decision-making	State [local power] + Autoconstructors* + III Sector/ Architect	Autoconstructors / III Sector + Technical Advisory**		Dweller/ Autoconstructor

* If the families are known previously

** Architect, if requested

Source: Lamounier (2017) based on Kobayaschi and Fujimoto (2003) apud Costa (2016).

In relating the three production types, it was necessary to distinguish between who decides and who produces at each level; there being two different distinctions. The concepts of *support* and *infill* refer respectively to the *collective* and individual levels without corresponding equally to the distinction between what the State or Autoconstruction will produce. There are *collective* decisions to be taken by the State, but there are also others of a *collective* nature to be taken by Autoconstruction.

PHASE 1 – BASE-BUILDING 1

Based on the Keyenburg project, by Frans van der Werf, due to similarities with the selected case, and from the design method of *supports* SAR 65, the block shown (Figure 12 and Figure 13) was proposed for *base-building* 1 as an alternative to the standard "H" format block. Due to technical and economic feasibility, *wall-concrete technology* was maintained for the *fontanel walls* and slabs.

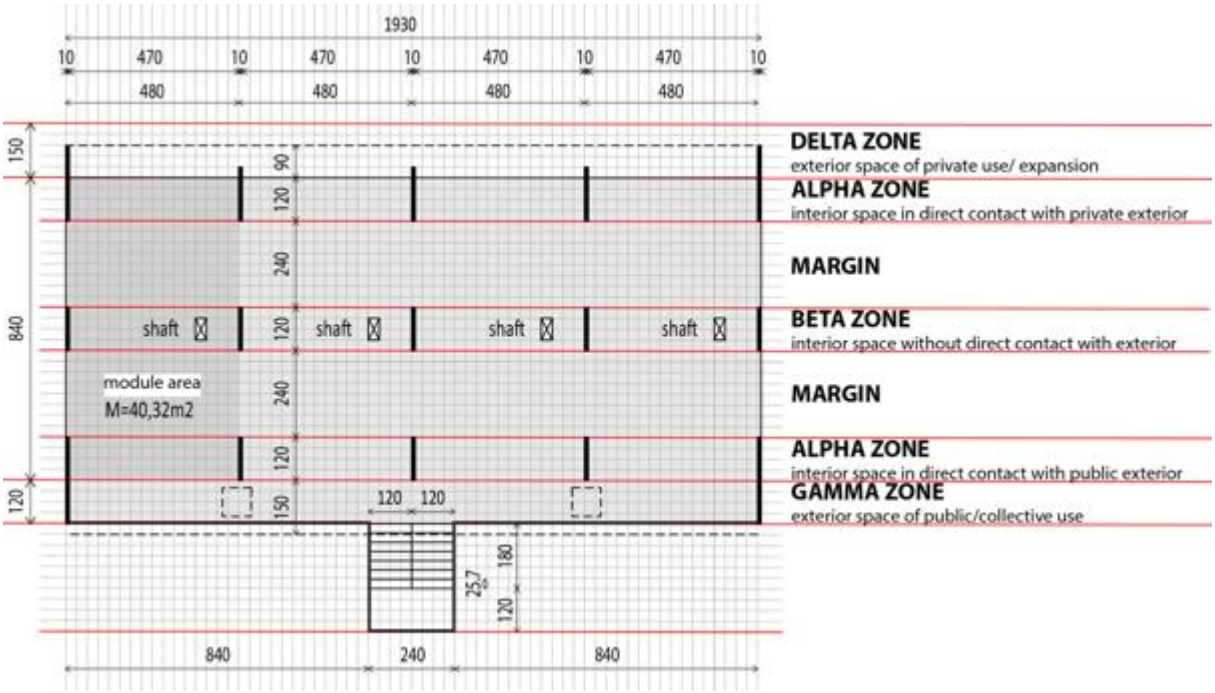


Figure 12: Floor of *Base-building 1*
Source: Lamounier, 2017.

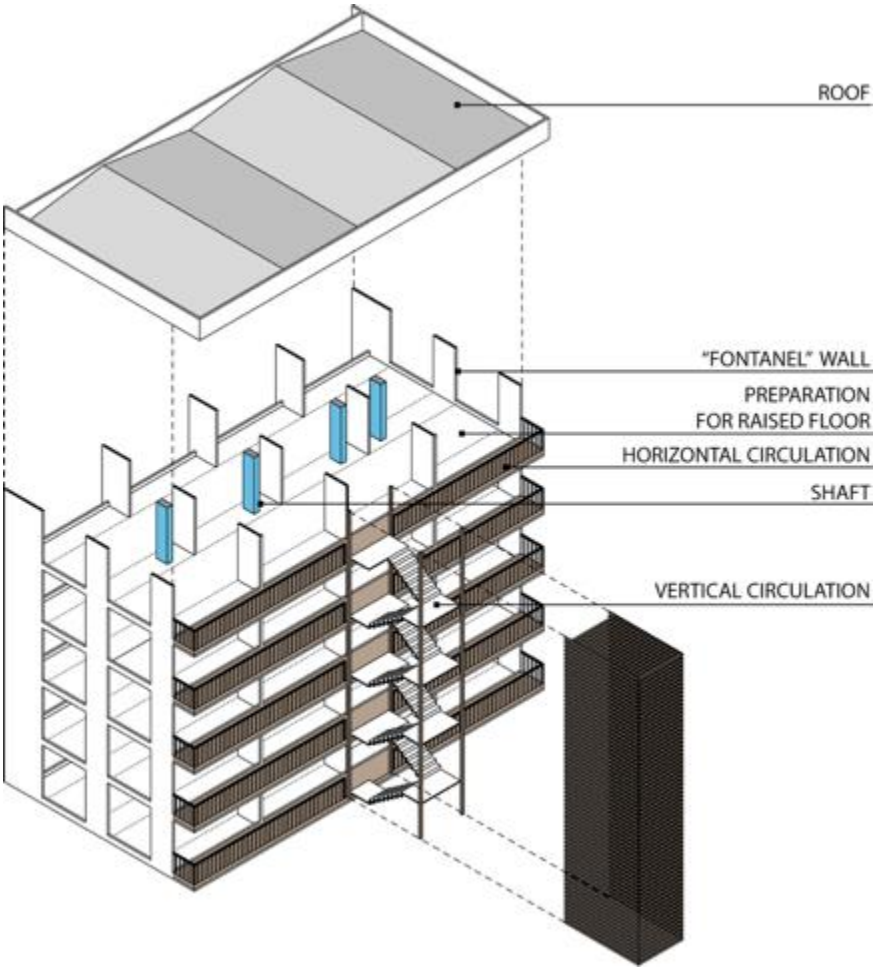


Figure 13: 3D view of *Base-building 1*
Source: Lamounier, 2017.

The *Preliminary Budget* method was adopted to for a global contract regime. The *base-building 1* would cost little more than 50% of an H-shaped block with 20 standard UHs. Even with all UHs of the same size, the set would present minimally the possibility of a variation in the internal division of the units, which could never be accomplished in the units delivered.

If *base-building 1* could be occupied through regrouping modules to accommodate different family compositions, the proposal could also offer variation in the size of the units, at least for the first generation of dwellers. (Figure 14)

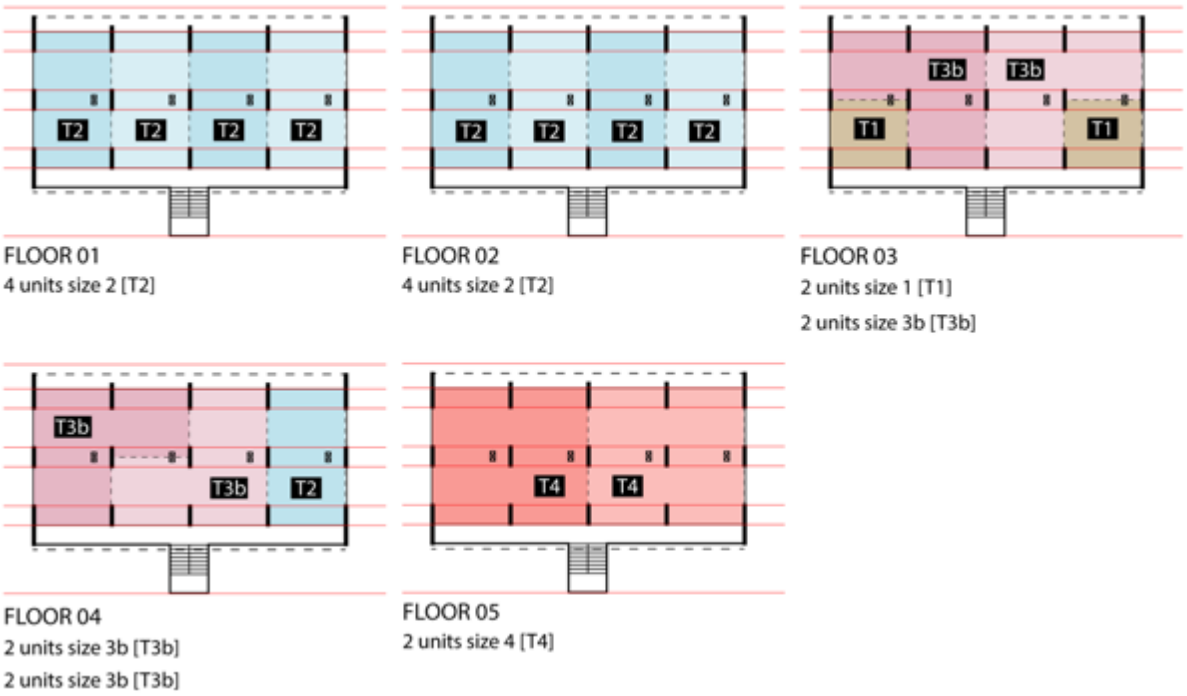


Figure 14: Parcelation scheme of the *base-building 1* modules in different sizes (T) of UHs
Source: Lamounier, 2017.

Returning to the Alterosa Residential family compositions and working with a *fixed scenario of flexibility*, the families' percentages were grouped, considering number of members, gender, kinship or social relation. A reduced number of unit sizes were then generated, prioritizing, for example, a minimum number of rooms. Table 5 presents [1] the area for each dwelling size (Size T1, T2, T3a, T3b and T4), with the respective fraction of the proposed module (M); [2] reference source for the areas, [3] percentages by size and [4] number of dwellings by size. In this table, a module (1M) is equivalent to the *base-building 1* module (4.80m X 8.40m), in turn equaling the standard UH area for 4 people built on site (40.32m2).

Table 5: Dwellings of varied sizes (T) proposed for phase 2 of the architectural prospection

UNIT SIZE	FAMILY COMPOSITION BASED ON PRAXIS INFOGRAPHICS 3.35	AREA (m2)	MODULES NUMBER OF BASE-BUILDING 1	PRE-DIMENSION METHOD	PERCENTAGE PER SIZE (%)	UNITS NUMBER PER SIZE
T1	1 a 2 people [+- 1 quarto]	~ 24m²	~ ½ module **(0.66M)**	Minimum allowed by municipal legislation (Belo Horizonte)	**18,68%**	**307**
T2	2 a 4 pessoas [+/- 2 bedrooms]	~ 40,32m²	1 módulo **(1M)**	Minimum required by PMCMV (39m2)	**43,79%**	**718**
T3a e T3b	4 a 6 pessoas [+- 3 quartos]	~ 53 to 60m²	~ 1,33 a 1,5 modules **(1,33M e 1,5M)**	Habraken (1979) and CAIXA Regulation	**31,36%**	**514**
T4	6 a 9 people [+/- 4 bedrooms]	~ 67 to 80m²	~ 1,66 a 2 modules **(2M)**	Habraken (1979) and CAIXA Regulation	**6,17%**	**101**
	TOTAL				**100%**	**1640 Families**

Source: Lamounier, 2017.

According to Habraken (2017), “type is a social agreement”. You can propose certain sizes that will repeat, when combination, separation or subdivision will occur. However, you cannot define or decide what will happen. You cannot *draw* all the different houses, but you can *think* of structures where different houses are possible.

It has been estimated that for Block 49, for example, 14 blocks would be needed with this type of combination, instead of 12 (such as those that were executed), implying an increase in construction area. This increased the cost of *base-building* to approximately 56-62% of the standard block built. With this, it was need to go forward with the prospection.

PHASE 2 – BASE-BUILDING 2

As it was impossible to access all data related to the complete original project – only from Block 49 (Figure 8), a study of this block’s occupation was developed to continue prospection.

Indicators of the *adaptive capacity* of a building (FLEX method); the method by zones and margins and the *fontanel* walls, remained as presuppositions of the study and other assumptions arose from analysis of the place, concomitantly becoming a priority. The presence of the forest in the southern portion of the terrain was determinant in defining the 2 elements that would structure the project in this block:
[1] the juxtaposed modular *base-building 1* layout, with some stretches offset to shorten circulations, create corners and generate multiple free areas or patios; and [2] the connection of the project with the forest, articulated with the solution adopted for horizontal and vertical circulations of the set. (Figure 15 to Figure 17)

Figure 15: Third floor of the lower wing and second floor of the upper wing, *base-building 2* in block 49 (Forest level)
Source: Lamounier, 2017.

Figure 16: Schematic views of the *base-building 2* differentiating the units
Source: Lamounier, 2017.

The proposed study offers 27% more built area, with more UHs, besides larger units.

The project is developed on 2 plateaus, with north-south façades, promoting direct non-impact sunshine and cross ventilation in all UHs, being important climatic demands in the region.

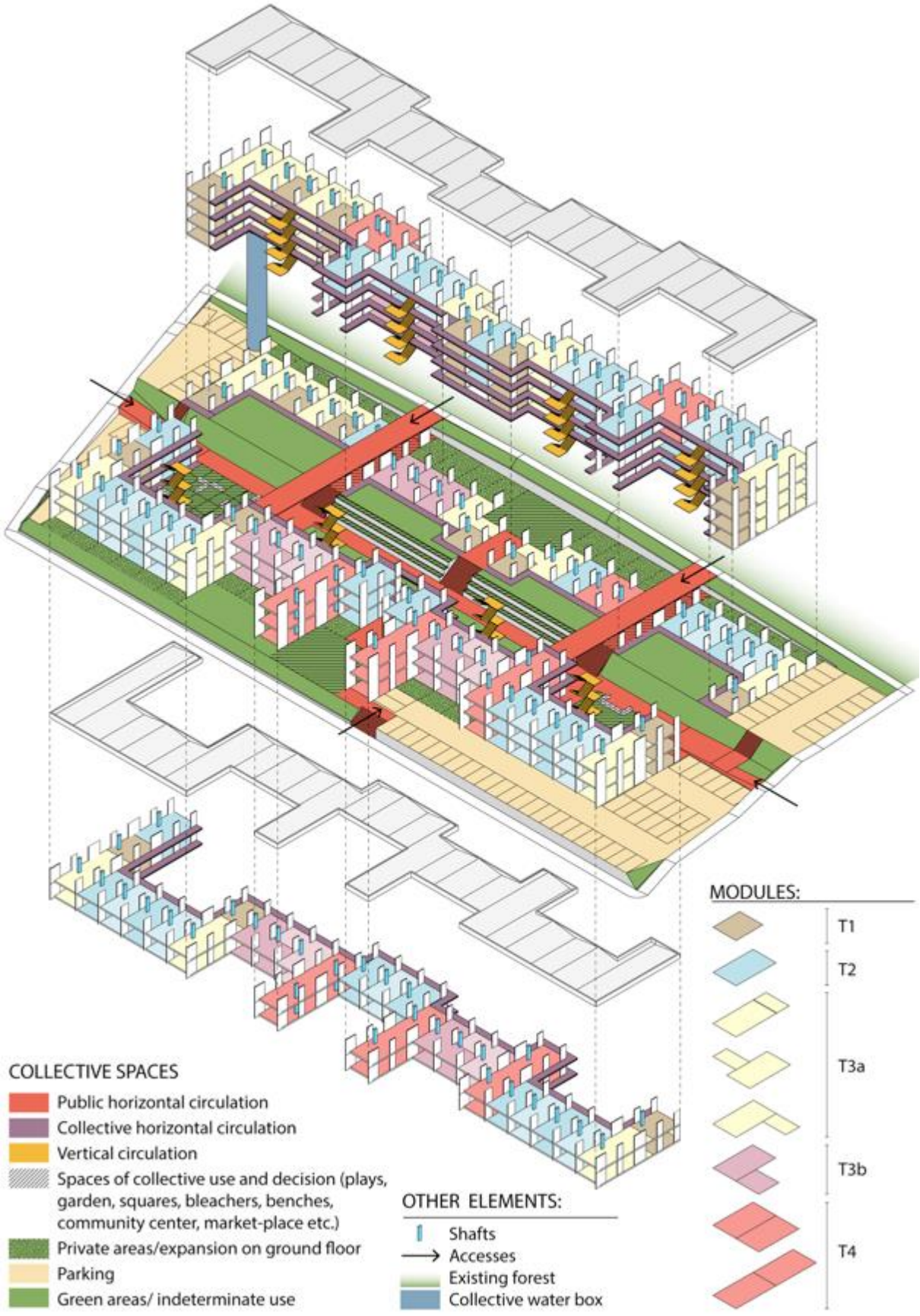


Figure 17: Conceptual diagram, *base-building 2*
Source: Lamounier, 2017.

A central axis, disposed longitudinally generated free areas, whose use would be decided collectively by dwellers. Closing the street that separates the block from the forest, the integration of both occurs through two transverse walkways. These, in turn, articulate with the horizontal and vertical circulations of the building, through voids resulting from the subtraction of some modules. That was the strategy adopted to manipulate the topography, integrating the block with the forest and thus inserting spatial attributes of urban scale to the project. The parking areas were arranged in a fragmented way, shortening distances and located in corners, to stimulate more internalized collective uses. The study's urban planning parameters surpassed those of the project executed in the place. (Table 6)

Table 6: Urbanistic parameters practiced by the *base-building 2* proposal in comparison with the parameters practiced by the Direcional Engenharia company

URBANISTIC PARAMETERS PRACTICED BY THE *BASE-BUILDING 2* PROPOSAL						
	Land area (m^2)	Total built area (m^2)	Coefficient of utilization (CA)	Percentage of occupancy (%)	Share of land by UH/ density (m^2/UH)	Housing density (Nº de UHs per Hectare)
Block 49	7.112,45	11.047,68 (net area)	1,55	40,89%	29,51	338,84
URBANISTIC PARAMETERS PRACTICED BY THE BUILT DEVELOPMENT ON SITE						
Complete development	55.634,96	73455,60	~ 1,32	-	33,92	294
Block 49	7.112,45	9.676,20	1,36	32%	29,63	337

Source: Lamounier, 2017.

The value budgeted for *base-building 2* was compared to the amount currently paid by MC. The figures show a very feasible viability of the proposal. The value of *base-building 2* is around 60 to 63% in relation to the project executed on site, and around 50% of the value currently passed on by MC.

However, just as it was necessary to demonstrate the possibility of minimally seating 240 families in the block under study, it was also important to reveal geometrically the possibility of spatial arrangements, hitherto only mathematically demonstrated. Such layouts are not configured as '*infill* models' or 'offered typologies' for dwellers to choose one. They are only simulations able to accommodate families of 1 to 9 people. (**Error! Reference source not found.**)

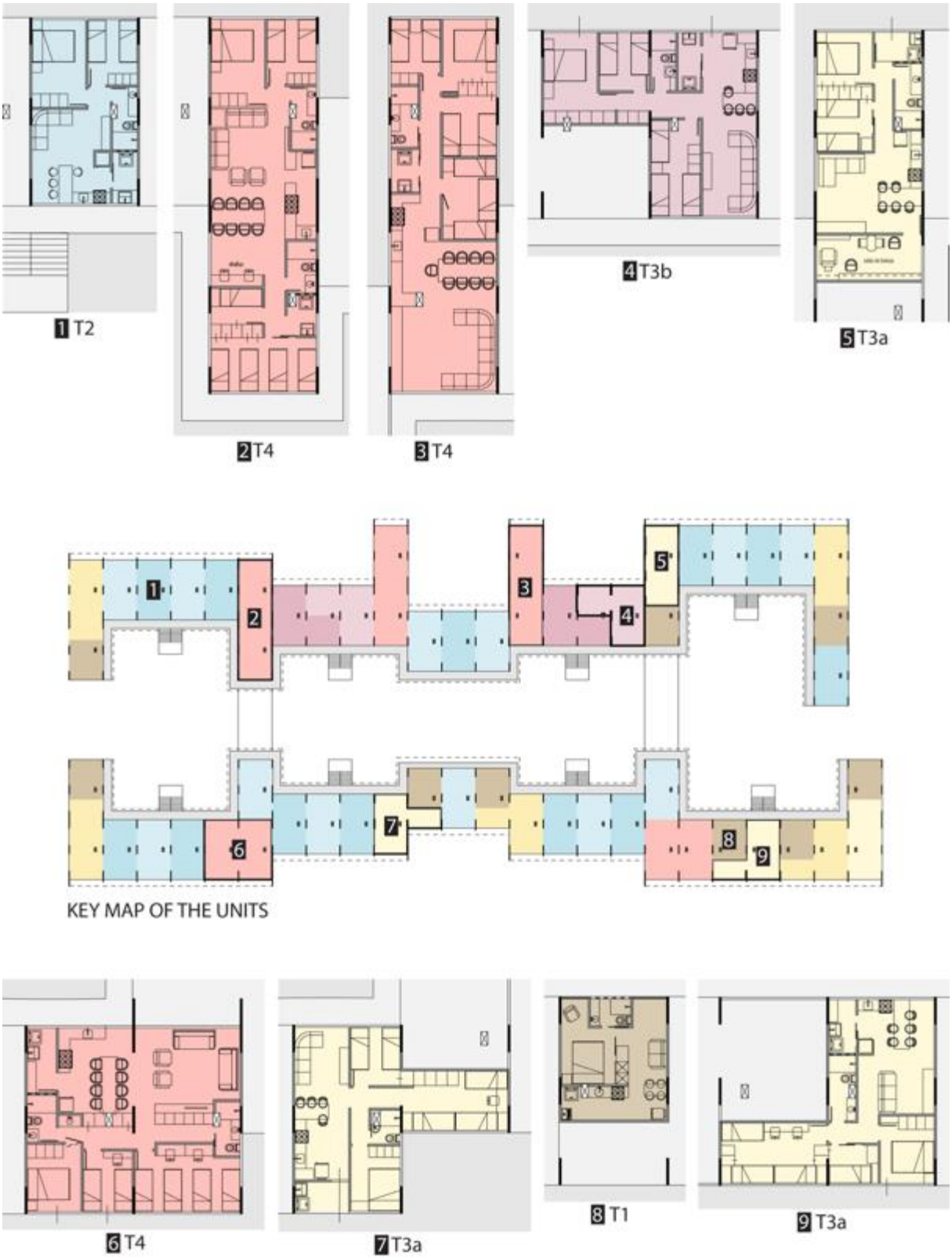
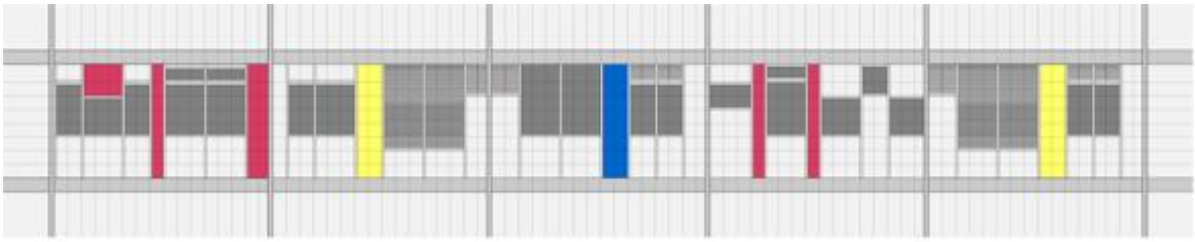


Figure 18: Varied infills simulations in units 0.66M, 1M, 1.33M, 1.66M and 2M with location and identification of the examples in key map of *base-building 2*
Source: Lamounier, 2017.

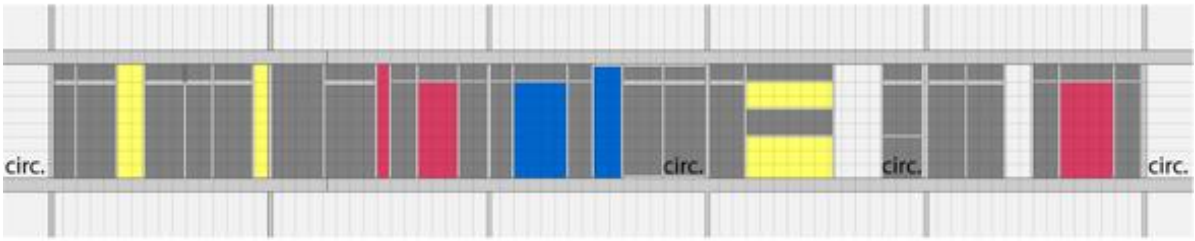
A piece of *infill* was chosen for budgeting. (Figure 19)

Figure 19: Floor of a *base-building* part with *infill*
Source: Lamounier, 2017.

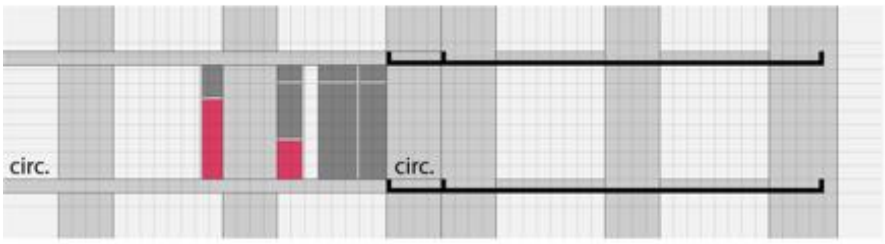
The solution of facades by movable panels (Richard, 2011) was chosen as one that offers openness to the dweller. The façade in this proposal would be, therefore, *infill*, albeit with some elements and guidelines defined as *support*. (Figure 20)



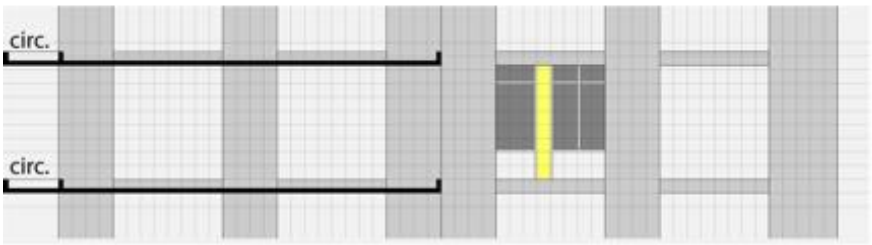
FAÇADE NORTH



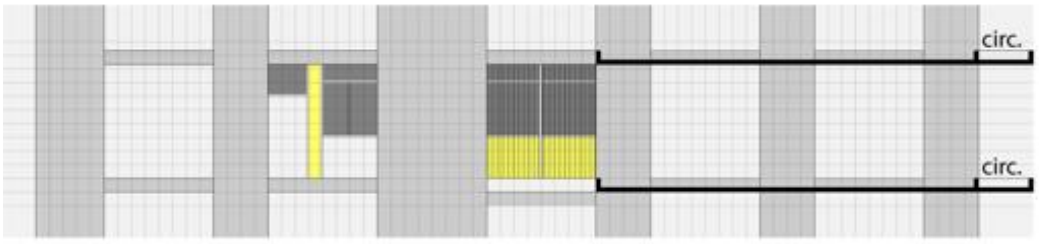
FAÇADE SOUTH



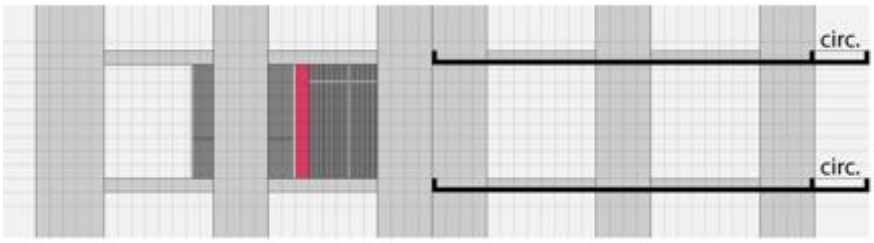
FAÇADE EAST 1



FAÇADE EAST 2



FAÇADE WEST 1



FAÇADE WEST 2

Figure 20: Façades with system in movable/ disconnectable panels
Source: Lamounier, 2017.

Table 7 presents three budget variations for the *infill* and *common support level* of the chosen portion:

[OPTION 1] 1] full budget and with Direct Benefits and Expenses (BDI) featuring the same cost composition and contract regime per global price of the *base-building* 2 budget, as if a construction company were contracted.

[OPTION 2] budget without BDI and without some preliminary services, as if they did not have the costs of a contracted company; a value that approximates the situation hypothetically managed and produced by the autoconstructor, with, for example, direct purchase of materials and contracting only labor.

[OPTION 3] budget similar to the previous one and still eliminating the internal walls (division between bedrooms and living room), in order to offer minimal conditions of habitability.

Table 7: Number of UHs (UH), Modules (M) and variations on relatives values for *support* and *infill* in the Block 49 and in the complete development

NUMBER	VARIABLES DESCRIPTION		BLOCK 49	COMPLETE DEVELOPMENT
UH	Number of Housing Units		241 UH	1641 UH
M	Number of *Infill* Modules		274 M	1864.5 M
€ / BRL	Value paid by MC (in Belo Horizonte since March/2017): 21,794.58 € / 88.000,00 BRL per UH		**5,252,495.23 €** 21,208,000.00 BRL	**35,764,915.66 €** 144.408.000,00 BRL
€ / BRL	Budgeted amount for the *Base-building* 2		**2,672,426.65 €** 10,790,457.11 BRL	**18,185,807.93 €** 73,428,836.76 BRL
€ / BRL	Complete *infill* price (for the *Base-building* 2)	OPTION 1	**3,196,250.66 €** 12,905,501.38 BRL	**21,749,669.32 €** 87,818,639.86 BRL
€ / BRL	*Base-building 2* price + *infill* with BDI		**5,868,677.32 €** 23,695,958.49 BRL	**39,935,477.13 €** 161,247,476.62 BRL
%	Relative percentage between *Base-building 2* price + *infill* with BDI, and transfer price		**111,73%**	
€ / BRL	*Infill* price without BDI and without some preliminary services**	OPTION 2	**2,320,400.05 €** 9.369.079,28 BRL	**15,789,729.52 €** 63.754.190,94 BRL
€ / BRL	*Base building 2* price + *Infill* without BDI and without some preliminary services		**4,992,826.68 €** 20.159.536,39 BRL	**33,975,537.31 €** 137.183.027,70 BRL
%	Relative percentage (%) between *Base building 2* price + *Infill* without BDI and without some preliminary services, and transfer value		**95,06%**	
€ / BRL	*Infill* price without BDI, some preliminary services*** and without internal walls	OPTION 3	**2,104,725.39 €** 8.498.249,74 BRL	**14,322,118.61€** 57.828.418,39 BRL
€ / BRL	*Base-building 2* price + *infill without* BDI, some preliminary services and without internal walls		**4,777,152.04 €** 19.288.706, 85 BRL	**32,507,926.54 €** 131.257.255,15 BRL
%	*Infill* price without BDI, preliminary services and internal walls/ transfer value		**90,95%**	

Label:
* Complete *infill* price per module (M) with BDI = **11,665.15 € / 47.100,37 BRL**
** *Infill* price per module without BDI and without some preliminary services = **8,468.61 € / 34.193,72 R$**
*** *Infill* price per module without BDI, without some preliminary services and some internal walls among rooms and living room = **7,681.48 € / 31.015,51 BRL**
1 € = 4,0377 BRL. Source: http://www.bcb.gov.br/pt-br/#!/busca/euro. Accessed in 16/02/2018.

Source: Lamounier, 2017.

Therefore, the complete proposal presents a cost 11.73% higher than the work performed on site, while the second presents 5% cheaper and the third 10%.

The last two alternatives are economically feasible for current PMCMV producers and are affordable for buyers, as well as maintaining significant relevance in the *offer of flexibility* (Prins, 1992a; 1992b), and those which are more expensive, such as the façade system and the raised floor.

Besides guaranteed affordability, more families could benefit, in better locations, infrastructures, neighborhood, etc.

The argument here is that from Autoconstruction the practice of open architecture in Brazilian social housing becomes more economically feasible than that produced by the Market-State.

Both the set of buildings implemented on site, and the present proposal, were submitted to the FLEX 4.0 method of assessing building *adaptive capacity* (Geraedts, 2016). The first one scored 1 out of 5 while *base-building 2* scored 4 out of 5.

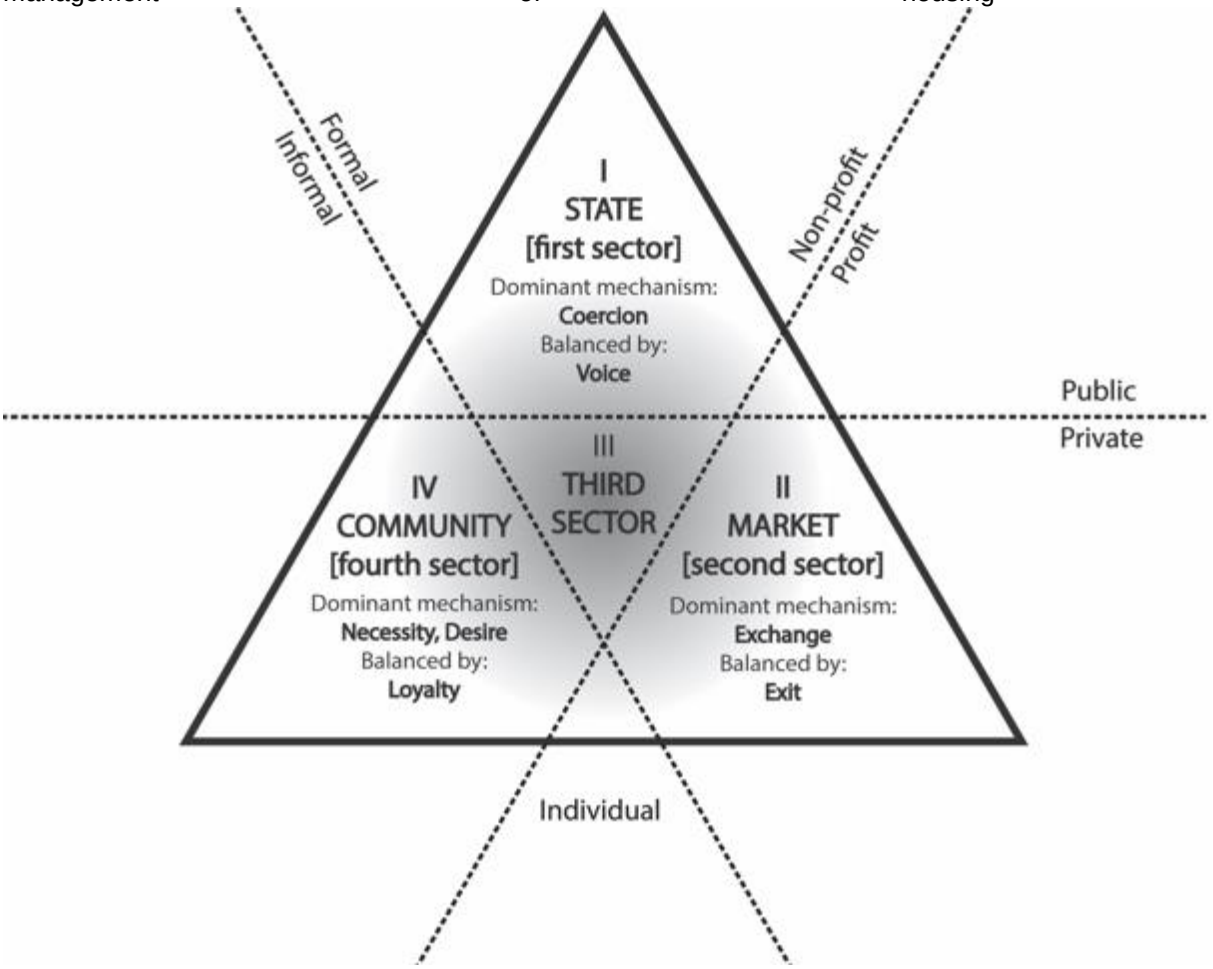
In the production of social housing, *future value* (Geraedts, 2009; Geraedts at al., 2014), generally linked to the systems' useful lives, becomes more important than the initial investment, raising questions about the *costs and benefits of flexibility*.

PHASE 3 – MANAGEMENT ALTERNATIVES IN BRAZIL FOR THE *SUPPORT* AND *INFILL*

The Third Phase of prospection is of a less architectural and more manageable nature. Proposing other methods of design, construction and distribution of roles in the production of social housing, implies thinking about other management processes within another housing policy.

The Third Sector is proposed as the most appropriate way to deal with management by *supports* and *infills*. Non-profit organizations, representing new interests distinct from public-private duality, function as social entrepreneurs - mediators between the community, the private sector, and the State. Ultimately, this other management type suggests the separation of State and Market as dominant partners in social housing production. (Figure 21)

Figure 21 – Position of the Third Sector among State, Market and community organizations as a proposal for another management of housing policy



Source: Lamounier (2017) based on Pestoff (1992: 25); Brandsen, Van de Donk and Putters (2005: 752), apud Czischke (2014: 121).

The auto-management experiences practiced all over Brazil since the 1980s are extremely important in the design of a new *supports* and *infills* management approach, strengthening auto-management processes, precisely because both are impregnated with the Autoconstruction and Autoproduction concepts.

Furthermore, the management of the housing production through *supports* and *infills* enables alternatives for:

1. the type of property: private, common or joint ownership; social leasing. On the one hand, in the production of housing destined for private property, the dweller is free to modify the *infill*; on the other hand, in the social rental system, there is greater flexibility to change the partition between units over time. It would be possible to buy *support* and *infill*; lease *support* and buy *infill*; lease *support* and *infill*;
2. the distinction between decision levels, *collective* and *individual*, and the position of agents in the field. Production may continue to be subsidized by the State, but the *collective* decision level (the *support*) would be divided into two parts, one controlled by the State and the other by autoconstructors. The *individual* decision level would be restricted exclusively to the autoconstruct dweller. The role of the architect in the field would be to design the *support-structure*, guide the process of unit partitioning, advise manufacturers on the component design and advise, if necessary, on *infill* production. The role of the construction companies would be to perform the *base-building*;
3. the physical distinction between *support* and *infill* – *support* is a relative concept, and the boundary between *support* and *infill* may vary from project to project;
4. dwellers previously defined or not;
5. the sizing criteria of units: *modular*, *by area* or *volume*;
6. the family selection criteria: it is necessary to review the current criteria, considering family composition, neighborhood relations, socioeconomic diversity, among others;
7. financing: separate funding is proposed for *support* and for *infill*, as well as adequate planning and management for surplus resources.

CONCLUSION AND RECOMENDATIONS

In countries such as Brazil, where private enterprise is heavily involved in housing production, the practice of open architecture is only possible if it is feasible for those who produce and affordable for those who buy. The present article showed that such feasibility and affordability are possible, especially when complemented by the historical practice of Autoconstruction.

The type and level of rationalization of productive processes, both control and logistical, of construction management with the definition of the phases and their deadlines, employed by the construction companies currently in the production of PMCMV developments, are compatible with and favorable to the implementation of base buidings productive processes, without major changes.

Construction systems can also be used. However, there is another principle of design logic, proposed here as *support-structure*. The more elements that can be configured as *infill*, the more flexible the spaces become. These can be modified, administrated and manipulated by the autoconstructors, who have already proven their ability to produce the *infill*, making use of the purchase, exchange, reuse, recycling, and finally, of the tactical planning.

In *supports* and *infills* construction there could be the standardization of the *support-structure* with rationalization of the productive and constructive processes, but not there is standardization of the architecture and its spaces.

It is possible to achieve high housing densities in Brazil with the *supports* and *infills* logic, both in terms of current business and mass production, as well as that of Autoconstruction. Likewise, the costs of a *supports* and *infills* project do not burden housing costs more than conventional design. In fact, unit costs are lower with the *support-structure*, especially when including *infills* produced by autoconstructors. Moreover, such costs would minimize those practiced by the complete Autoconstruction (direct and social costs it entails); it would present high future value due to their *performance of flexibility*, unlike current production, which has caused irrevocable social and environmental problems.

NEXT STEPS

Going forward, future studies should contemplate the Open Building methodology in Brazil's ample stock of empty or unfinished buildings; in the urbanization of subnormal settlements; in urban scale interventions; in new architectural prospections and in experimental projects, such as the first Open Buildings. This could involve different contexts in order to increase sampling, thus furthering the current results. Furthermore, research on Brazilian constructive systems, subsystems and components adhering to the Open Buidling methodology needs to be developed, including an evaluation of the connectivity potential of these elements and calculations on costs related to their useful life, in order to improve on what is being produced nowadays.

According to Prins (1992a: 150), the development of a standard method for describing *scenarios* and *demands for flexibility*, based on very similar scenarios, significantly accelerates the acceptance (by the State and Market) of flexibility as an indispensable part of a requirements program.

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