A Bottom-Up Social Housing System Described with Shape Grammars

The case of Belapur low-income housing development

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Abstract. *This paper presents the analysis of a bottom-up design system using shape grammars. This research is part of a larger study that proposes the development of a generic grammar to improve the quality of site development in social housing plans, including the improvement of their public spaces. We show the use of shape grammars as an analytical method to study the design of Belapur social housing development, designed by Charles Correa, in 1983.*
Keywords. *Design methodology; shape grammar; analytical grammar; low-income housing.*

INTRODUCTION

This research aims at applying shape grammars as a method for generating improved social housing design systems which may contribute to the development of more diversity in external areas and public spaces, creating identity and appropriation by its dwellers. In order to achieve such goals we start by analyzing social housing plans as case studies to infer design patterns to propose the development of generic grammars, which may enable the generation and management of incremental housing systems with locally captured spatial qualities. In the book A Pattern Language (1977), Alexander and his collaborators define a theory and application instructions for the use of a pattern language at different design scales - from the scale of the city and urban design to the building scale, garden and layout of housing units. The main goal of this research is to define a methodology for developing bottom-up housing systems able to be implemented as incremental urban developments based on the progressive addition of housing clusters and associated community areas. The underlying hypothesis is that we can develop a set of generic parallel grammars which allow (and control) the generation of such housing systems.

OBJECTIVES

This paper is part of a larger study that proposes a development of a generic grammar to improve the quality of low-income housing plans, including the improvement of public spaces and community areas. The generic grammar is developed from analysis of four case studies by capturing the underlying common rules that were used in their design. The four case studies are: Belapur plan – located in New Bombay, India, designed by Charles Correa in 1986,

Jardim São Francisco, – located in São Paulo, Brazil, designed by Demetre Anastassakis in 1989, Proyecto Experimental de Vivienda (PREVI) located in Lima, Peru, designed by Christopher Alexander in 1969 and Quinta Monroy, in Iquique – Chile, designed by Elemental in 2004. This paper is focused on the analysis and grammar development of the Belapur plan.

The structure for developing a generic grammar consists of 4 parts: (1) the inference of a specific analytical grammar from an existing case study; (2) creating a generic grammar by generalizing the grammars obtained from the analysis of the case studies; (3) to improve the quality of the final designs the generic grammar is revised according to qualitative requirements for public and community areas based on urban design and housing plan literature (Pedro, 1999; Barton et al., 2010); and (4) applying the new revised grammar in the development of specific designs for social housing plans. Pedro (1999) developed a systematic methodology of qualitative requirements to be applied in the development of housing complexes in Portugal and Barton *et al* (2010) presents a set of guidelines to design neighborhoods that are safe, friendly and attractive. This literature contributes to define the qualitative requirements to be applied as a control mechanism in the generic grammar. The generic grammar is organized in small thematic generative sets corresponding to design patterns following the principles defined in (Beirão et al., 2012).

DESIGN METHODOLOGY

The design methodology consists on the use of shape grammar as an analytical method applied to study the design of Correa's Belapur plan, to capture the design method used by the architect to obtain emergent community areas as the result of the recursive application of local rules involving spatial relations between plots and common public access areas. The interesting aspect of the Belapur plan is that it succeeds in generating simultaneously housing types and an emergent hierarchized structure of public space. The spatial relations and local rules can be expressed in the form of a shape grammar

describing the Belapur housing system as an incremental system following Correa's cardinal principles of incrementality and malleability as defined in his bill of rights for housing in the third world (Correa, 1999).

From the analysis of the case studies it is proposed to infer a set of generic design patterns codified as shape grammars. The concept of generic grammar was presented by Li (2001) and consists of a widely applicable shape grammar embedding the features of a reasonably abstract language which is able to produce design in several specific languages by adjusting the grammar accordingly. Current researches present the application of generic grammars in different contexts - Benrós et al. (2012) proposed developing a generic grammar applied to housing and Beirão (2012) developed a generic grammar for urban design context. However the novelty of the ongoing research lies in the use of this approach in a different scale – between housing scale and urban design scale, and to present a bottom-up design system for the development of a housing complex which includes emergent public spaces related with the traditional use of public space. The generic grammar obtained by such analysis will then be assessed by comparing its features with the quality requirements defined by (Pedro, 1999; Steiner and Butler 2007; Barton et al., 2010). The goal is to obtain an improved grammar containing heuristics based on the above mentioned quality requirements. Such structure resembles that of a discursive grammar as defined by Duarte (2001).
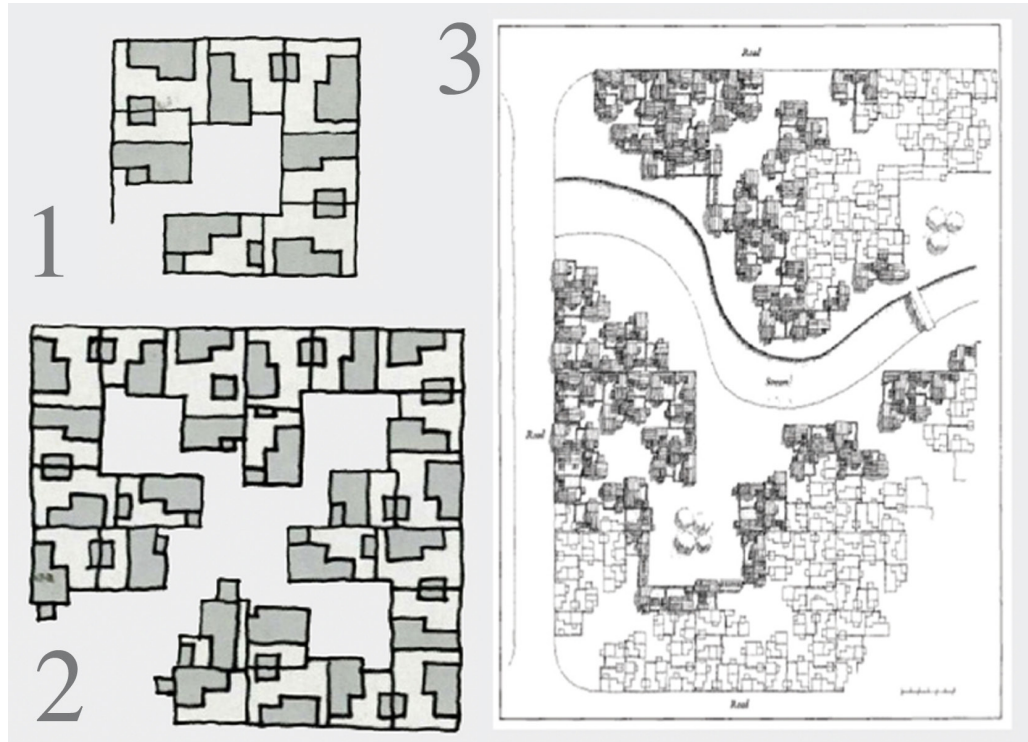
This research is seen as an initial step in the development of a generic grammar for social housing developments, especially regarding the generation of housing plans, public spaces and community areas. It goal is to add to the typical mass production strategy, features of diversity both at housing level and public space level.

CASE STUDY: BELAPUR – CHARLES CORREA

The Belapur Housing was designed by Charles Correa, in 1983-1986 to accommodate more than 90%

of Bombay's low-income profile with a variation from 45m2 to 70m2 on house typology. The project demonstrates high densities – 500 inhabitants per hectare, including external areas, schools, etc (Correa, 1999). The site is located on six hectares of land 1 km away from the city center of New Bombay and the development had to cover almost the entire range of low-income groups – from the lowest to the upper-middle categories (Correa, 1989). This plan presents a hierarchy of community spaces as a fractal structure; it consists of organizing 7 housing units around an intimate courtyard with approximately 8m x 8m (Figure 1-1). This composition is repeated at a higher scale as shown in Figure 1-3 creating a similar composition which can itself be repeated at an even higher scale, hence creating the fractal structure. The first configuration provides more privacy and a sense of neighborhood at the smaller scale. Three of these clusters combine to form a bigger module of 21 houses, surrounding a community space of 12m x 12m (Figure 1-2).

The houses were designed as an evolutionary module, where "units are packed close enough to provide the advantages of high density, yet separate enough to allow for individual identity and growth" – this strategy allows growth from "a single lean-to roof to urban town-houses" (Correa, 1989; 1999) because each dwelling is freestanding and does not share any wall or land with its neighbors, allowing a family to extend its home according to their needs by means of self-construction. Such policy towards house extension resembles that of the Elemental concept developed by Alejandro Aravena (Aravena and Iacobelli 2010). The plan clearly expresses Cor-

rea's principle of incrementality and order becomes an underlying feature which emerges in the growth process.

BELAPUR HOUSING SHAPE GRAMMAR

The Belapur plan was analyzed because this design concept contains qualities that allow growth at a local level through a bottom-up process and contains rules to evolve and generate hierarchical external spaces and community areas. This shape grammar gives rise to a growth system as a fractal structure. In other words, this *bottom-up* approach is capable of responding to growth needs and provide social and community spaces according to populations' needs. According to Correa:

"If there ever is a Bill of Rights for housing in Third World, it would surely have to include – enshrine! – the following cardinal principles: Incrementality, Pluralism, Malleability, Participation, Income generation, Equity, Open-to-sky space, Disaggregation" (Correa, 1999, p.109).

The bottom-up reasoning underlying the design can be demonstrated in the shape grammar that we developed. The system can be described with three parallel grammars: Grammar A, which fills lots with an initial house volume, Grammar 0 which defines the house extension rules within the lots and Grammar B which defines spatial relations between blocks.

In this paper we focused our attention on the emergence of public space order, in particular, in the emergence of the three hierarchical levels of public space. To do so, and due to space constraints some assumptions were considered to simplify the presentation of the argument in discussion here. Furthermore, Correa's drawings actually show less than the real potential underlying his system, even though his claims for incrementality and malleability would suggest a much wider use of the rules and the exploration of other simple variations as it will be argued in the discussion section. As such, the assumptions considered here are basically two. First, that the block - 7 lots organized around a common public space - is always the same, i.e., has exactly the same geometry and is always composed of identical lots although slightly different within each block. This corresponds exactly to Correa's drawings (Figure 1). Second, Grammar 0 is ignored here for it does not play any role in the emergence of public space. However, because some of the block rules (Grammar B) are related with the fact of a lot being already built or not we assume that the Grammar A simply fills a lot with a fixed house shape (Figure 3).

The combination of these grammars generates designs in an incremental way following Correa's cardinal principles by applying the mentioned grammars in parallel. The process is mainly additive and based on local rules which act according to vicinity conditions (Figure 2).

Grammar A

Grammar A consists of organizing 7 housing units by filling lots around an intimate courtyard. In its initial state each lot contains a label (+) defined as "RI 01", which can be replaced with a house. Placing the first house turns off all labels (+) except those in neighboring lots (Figure 3). This rule guarantees that the generation proceeds by following a neighboring condition. The block is filled by replacing labels + with houses and adding + labels to the empty neighbor lots until all lots become filled (see rules RL 01 to RL 07).

The first lot to be filled along a side of a block generates a label (▲) at the side of the block for applying the Grammar B, which may be applied in any iteration since the moment the label is available (Figure 4).

The rule RL 08 defines the insertion of the label (A) whose function is to remove one lot, thereby enabling the permeability of the block. This feature allows the grammar to create different access paths to the housing blocks as well as greater diversity of public spaces (Figure 5).

Grammar B

The set of rules generates urban scale design by defining spatial relations between three blocks (21 houses), around a community space. The Grammar B

Figure 2
Belapur shape grammar
derivation.
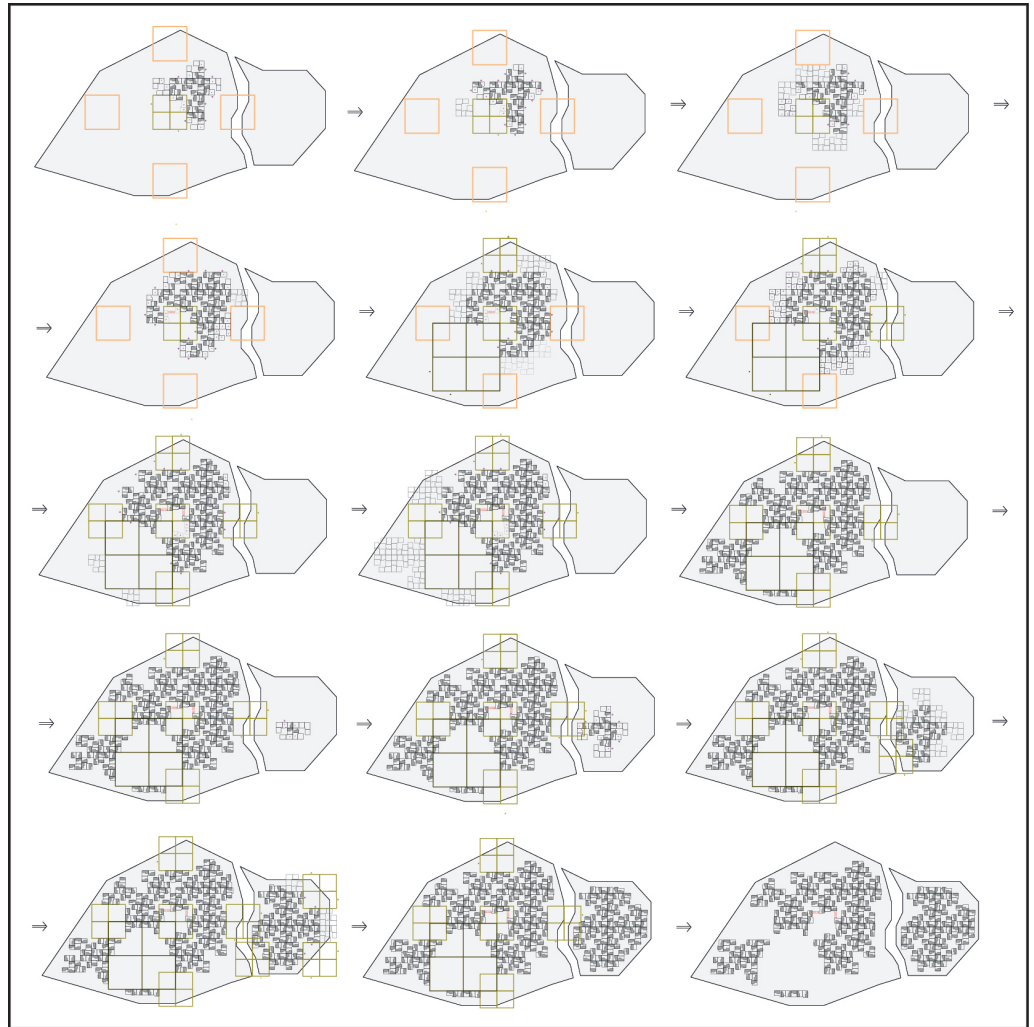
consists in 4 rules by associating two blocks: all rules erase the label (▲) and associate a new block with 7 lots in 4 distinct spatial relations. The rule defined as "Start Block" (RS) replaces the new block in gray and starts the Grammar A placing labels (+) in the existing lots (Figure 6).

Control rules

Control rules deletes labels in the space of one block by inserting optional 4 lots with houses. Thus, the community area allows the insertion of 3 more areas which are constituted as a courtyard. The labels ● and ▲ defines possible association with other
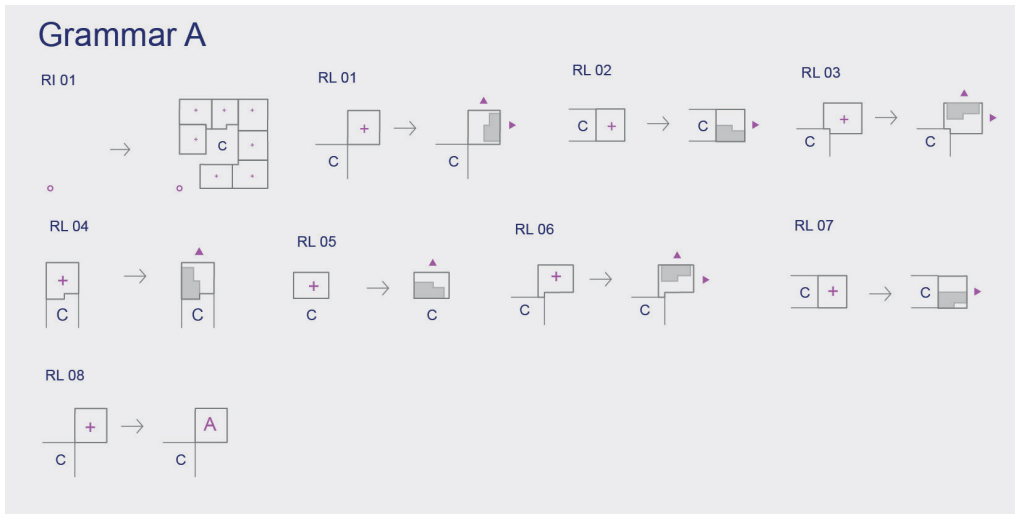
Figure 3
Grammar A.

blocks (Figure 7). Note that labels ● and ▲ concern two different spatial relations regarding the orientation of the blocks. The rule RC 09 removes one of the optional lots inside the courtyard (see Rule - RC 02) and inserts a portico to isolate a neighborhood unit constituted by three blocks. Thus, the rule allows creating different levels of privacy in accordance with the growth of the scale of public spaces.

After applying control rules that generate the common spaces of the housing development, it is possible to apply the rules of Grammar B (see rules RB 05 to RB 08) which allow the continuous insertion of blocks and increase the scale of public space (Figure 8).

The Grammar B' defines association between blocks with corner for the passage and association

of the square and block: all rules off label (▲) and associate a new block with 7 lots in two distinct spatial relationships (Figure 9).

DISCUSSION

The paper presents the Belapur grammar as a design system, which may contribute to the future development of a generic grammar for social housing plans. The development of a generic grammar for housing intends to contribute to the improvement of public spaces and community areas by insertion **of** qualitative requirements as a control mechanism that allows adding public spaces and facilities in a hierarchical structure in accordance to needs.

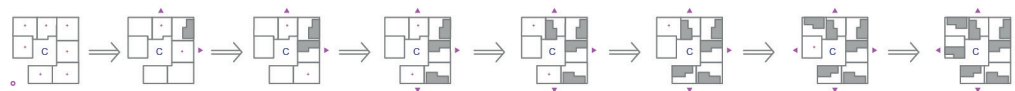The bottom-up grammar's structure explains the concept of incrementality, pluralism and malle-
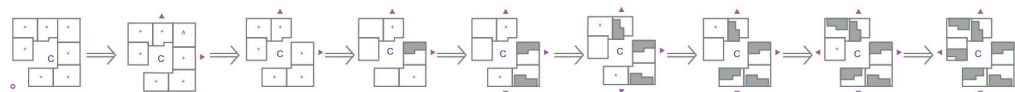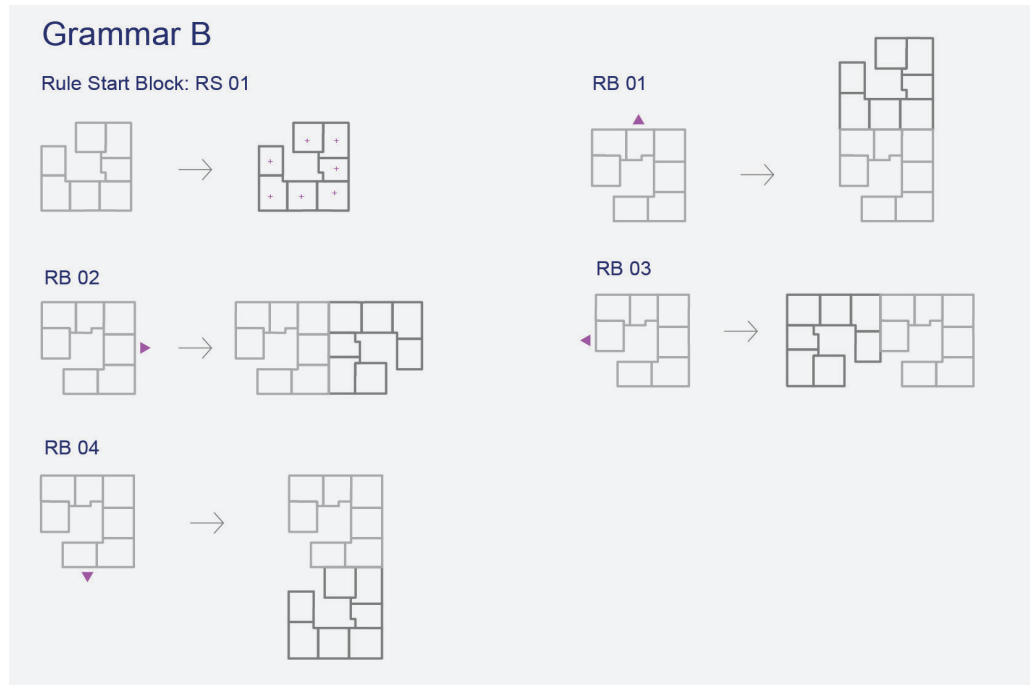

Figure 4
Derivation of a block.

Figure 5
Derivation of a block with an empty lot.

ability (Correa, 1999, p.109) and can transcend the set of design solutions from a few additional rules that are not part of the initial urban plan proposed by Correa. Additional rules can also be set to react to pre-existing features such as natural barriers, rivers, topography and empty spaces, among others. Although not formally expressed such rules are already present in Correa's design.

After analyzing Correa's project and developing a grammar for it an important issue has emerged: although the grammar allows the incremental growth of the housing development, how can the overall result display such an orderly character? This issue leads us the question of the design being a bottom-up or top-down process.

To achieve his concepts of incrementality, pluralism and malleability, Correa, resorts to a design system which is supposed to be implemented in a bottom-up fashion. Similarly to many natural phe-

nomena where order emerges from a multiplication of local interactions eventually represented by a local rule, Correa's plan intensions are best captured by a bottom-up grammar where local rules provide not just the incremental procedure but also the underlying order which is always a goal in planning. This can explain the predictability of the result, despite its spontaneous characteristic. With this in mind, we could argue that, although a hypothetical top-down grammar may computationally generate the same shape and order, from the analytical viewpoint it fails to capture the conceptual principles underlying the system and therefore they cannot be considered equivalent.

Finally, a subject that needs further attention involves considering how the incremental structure of these grammars deal with the subject of neighborhood facilities location. Such theme is present in Correa's plan but rules are not formally expressed
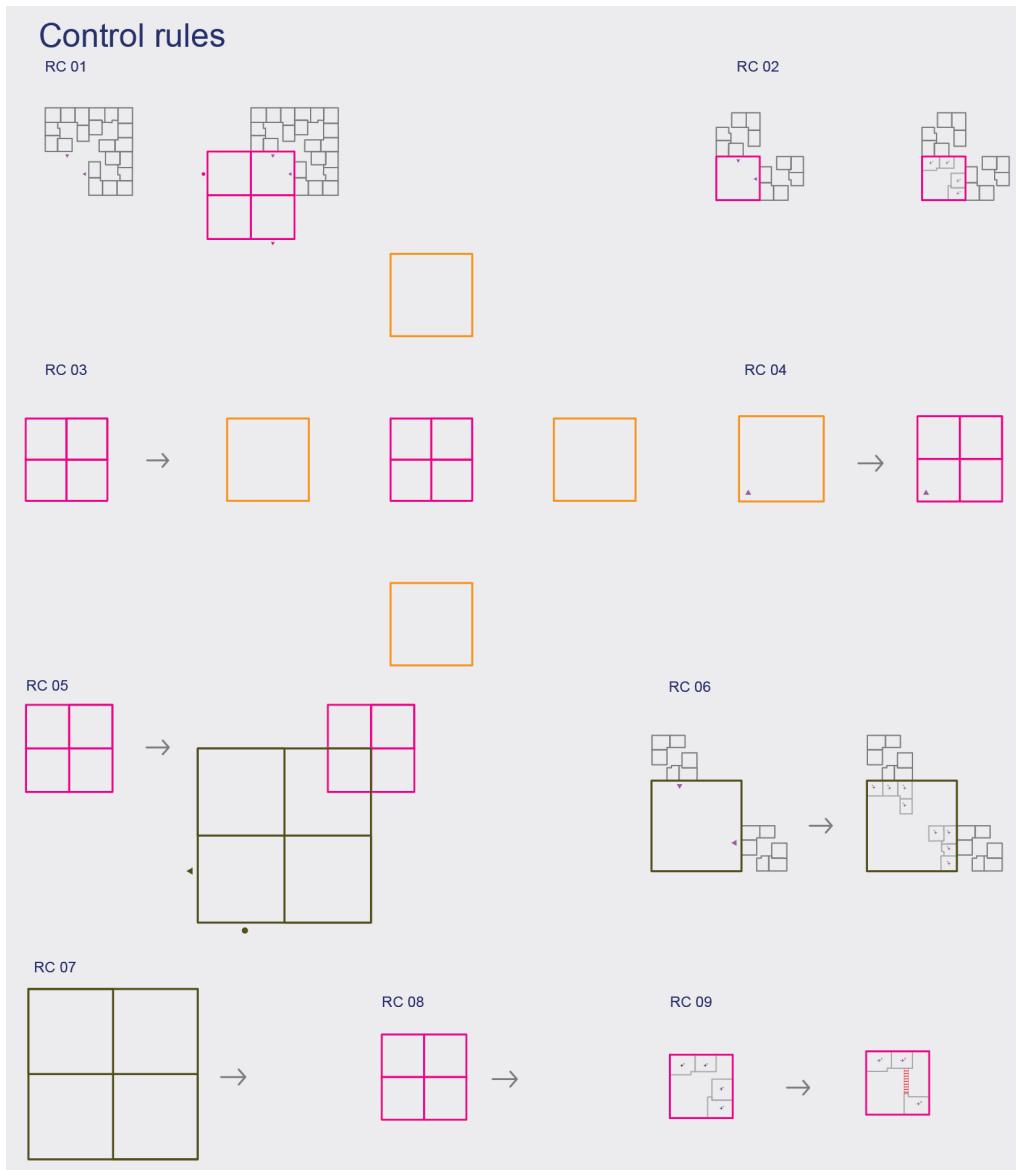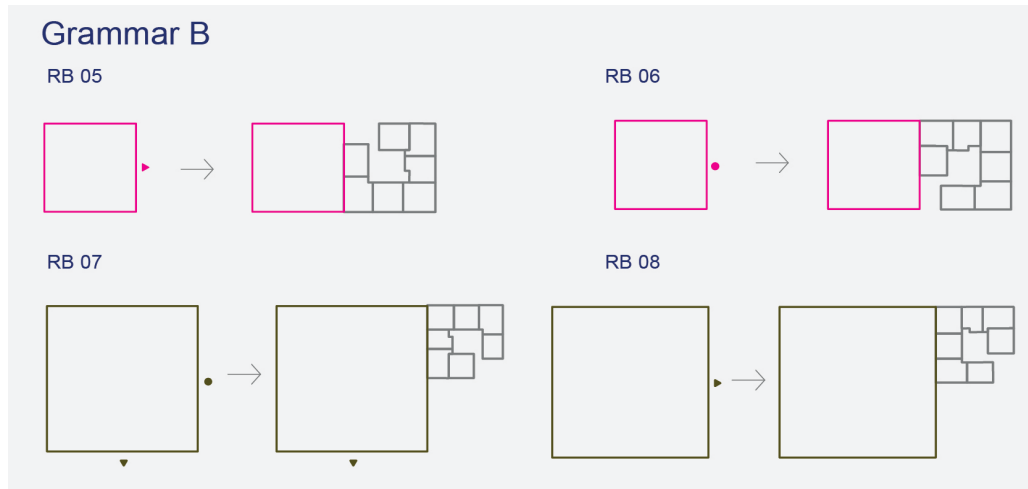
Figure 7
Control Rules.

and as a design attitude it seems that Correa simply decided their location using them as a composi-tional item, therefore in a top-down fashion. However, considering that one of the goals involved in

Grammar B

RB 05

RB 06

RB 07

RB 08

the design is to follow an incremental growth principle, this subject needs a more careful and profound study regarding the definition of facility requirements for community planning social housing developments. This subject will be extensive enough for a future paper.

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Grammar B'

RB 01'

RB 02'
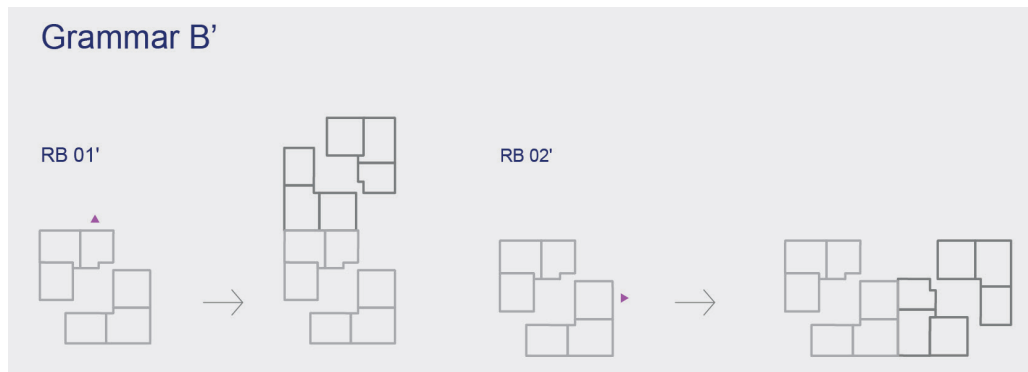
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