

A Shape Grammar for Self-Built Housing

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ABSTRACT

This paper describes the initial results of a grammar study based on bottom-up research carried out in Campinas. The research covers self-built housing and “in situ” projects aimed at creating systems which will help the inhabitants by providing them with “layouts” for housing construction. This paper explores the descriptive and generative potential of shape grammar in order to create a parametric shape grammar for self-built incremental housing in Campinas, respecting tradition, diversity and the inhabitants’ desires.

KEYWORDS: Shape Grammar; Self-Built Housing

Introduction

The self-built housing arises as survival mechanisms and as an answer to housing for low-income population in Latin America (Turner, 1976). Its main feature is the construction of houses by their own owners who have often legally bought the piece of land where the houses are located, and thus providing affordable housing. In this sort of housing the constructor is both the landlord and the person who lives in the house (Pina *et al.*, 2004). The construction of the house is carried out gradually over time depending on the constructor’s savings.

In the 70s the self-built housing gained importance for researchers, it was then that John Tuner (1976) first studied this issue and let architects know its advantages. The main advantages are tied to the bond that owners create with their houses and also the fact that this gives people of low-income a chance to own their houses.

In the 70s the self-built housing gained importance to the researchers when John Tuner (1976), first approached this issue letting architects know its advantages, mainly the bond that owners create with their houses and also the chance of low-income people to get their own houses.

In the 90s several studies on this issue were carried out in Campinas and earlier studies were carried out in São Paulo (Kowaltowski & Pina, 1995a). A group of researchers studied the self-building process in Campinas and also did some “in situ” projects (Kowaltowski *et al.*, 2003) (Pina *et al.*, 2004) creating systems to help locals, providing them with layouts for housing construction and providing “know how” in order to enable constructors to build their houses with better conditions whilst still respecting the local traditions. The analytical study concluded that self-built houses predominantly follow a limited number of basic types of schematic plans. The research concluded that a pre-defined layout increases the difficulty to introduce specific changes when a new problem or goal appears. Thus it was found that some difficulties arose, in terms of number of options available and other parameters, when trying to fulfill all the constructors’ needs and desires. It became apparent that this application should offer a wider range of options, allowing the constructors to make their own choices and to stick to their creativity, as well as providing information to ensure the standard of the housing. Consequently constructors would welcome the project as it would be an obvious answer to their new challenges and needs (Kowaltowski *et al.*,

2007). Variety is an indispensable requisite for freedom and authentic culture and without them, people's needs cannot be satisfied (Turner, 1976). The challenge is "how can we design large projects without necessarily imposing uniformity and rigidity where variety and adaptability over time are desirable?" (Habraken, 1987:)

To introduce an interactive system able to generate tailored self-built design solutions, a descriptive method, shape grammar (Stiny & Gips, 1972) has been adopted. "Shape grammar overcame [typology] this problem by merging the different viewpoints into a set of instructions that specify how to generate new instances of the typology" (Duarte, 2001). Shape grammar allows an algorithmic approach to the creation of design solutions. Design using grammar involves recursively choosing transformation rules and applying them to a schematic structure, until a final structure that satisfies design requirements is generated. (Brown, 1997) Several tools based on shape grammars for customized housing have been developed (Duarte, 2005; Colakoglu, 2005). Using this potential, it was possible to: (1) analyse the self-built housing in Campinas and infer shape rules and syntax; (2) to define a preliminary parametric shape grammar. The main goal is to define a grammar which will generate tailored incremental self-built houses and adapt to individual/family needs without compromising local lifestyle and culture. This approach will lead to the generation of innumerable solutions and increase customization.

Background

Regarded as a positive response to the lack of housing in Brazil some researches have been studying the self-built housing in order to get more information about its architectural, social and cultural features in terms of quality and comfort (Kowaltowski *et al.*, 2003).

Besides being a positive response to these housing issues it also seems to be a convenient response for local inhabitants of low-income. In Campinas the self-built housing includes the concept of incremental housing as the "makeover" is often an ongoing process linked directly to the financial situation of the constructor.

Kowaltosky studied the self-built housing in Campinas, its aesthetic and functional areas and its acceptance by locals involved in this program (Kowaltowski *et al.*, 1998). Most people who occupied pre-designed houses did not enjoy the results (Kowaltowski & Pina 1995a) so they made changes and rebuilt their houses their own way. This means that there is a set of traditional characteristics, related to the space itself that have to be taken into account. Changes in the house project should be planned as constructors keep adding on another room whenever they can afford it. It was detected that 70% of the houses have been added onto over time. This

therefore means that solutions to support "evolutionary" construction should be sought out and developed.

Any plan which pertains to a house makeover, providing sound working knowledge and tools to the constructors should present solutions that meet and keep to local housing traditions otherwise it will not be welcome or put into practice by the locals.

As a response to this challenge, an architectural design tool called AUTOMET (Kowaltowski, 2005) was developed based on CAD (Computer Aided Design) (Kowaltowski, 1995b, Kowaltowski & Ruschel 1995c), This tool was the result of studies for layout creation where; the traditions of the self-construction building are taken into account; there is a selection of its high points and better solutions in terms of location, special organization and evolution are provided (Fig. 1). This computer application allows the constructors to select the items that suit their needs, (such as number of rooms and housing size, among others) so as to provide locals with suitable layouts.

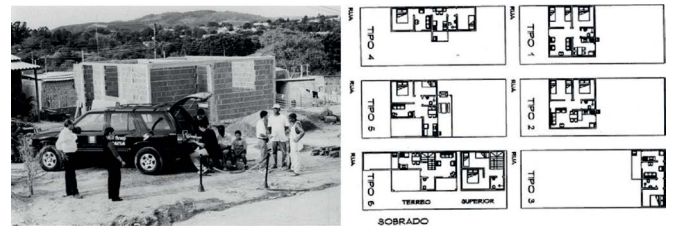


Fig.1. Scene of the mobile technical assistance and house typologies. From: Kowaltowski *et al.*, 2003.

Proposal

This research aims to provide a computer framework, using shape grammar, which will assist the local low-income population in designing specific and individualized solutions and therefore increase the standard of housing. Shape grammar is a set of methods used to create designs through pre-established shapes and rules of relationship between them which are going to create the composition of designs (Colakoglu, 2000) This descriptive and generative method works with direct data processing with shapes in order to get designs that will achieve certain goals. The shape grammar is used, in a conceptual way, to create house plans for locals from Campinas, considering their needs in terms of space and organization. Volumetric and aesthetic issues were left out.

The present shape grammar study is outlined and based on the features of the existing self-built housing in Campinas studied by Kowaltowski and Pina (1995a). The study reveals that most of the self-built housing in Campinas is modified by their owners over time, adding to the total area and to the number of rooms. As a result, these unplanned "makeover" keeps the neighborhood in a permanent change. To develop the shape grammar it

SELF-BUILT HOUSING IN CAMPINAS

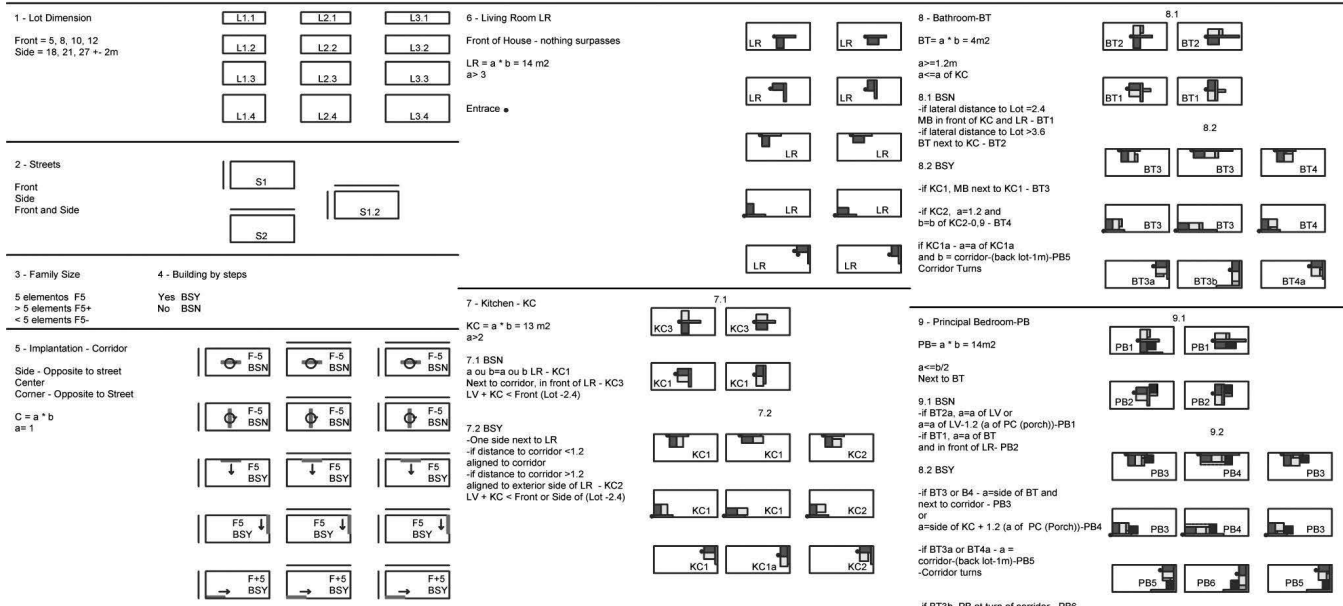


Fig.2. Simplified self-built housing shape rules.

was important to collect data on the studies carried out in Campinas covering: form-making logic, functional logic, incremental logic and constructors' needs and desires.

The design parameters used to choose a pre-defined layout of the AUTOMET have morphed into a set of transformation rules to define parametric grammar for incremental self-built housing. The parametric grammar is based on the premise that designing layouts must allow for the expansion of house over time. The on-going research suggests that parametric dimension variation of the components associated to incremental logic allows for the creation of new layouts for each constructor (Fig. 2). Thus, better personalized layouts would be available increasing the possibility of choosing a design. This would enable the creation of an endless number of layouts by allowing the parametric grammar itself to aggregate a wider range of rules and assumptions put together by the computer system.

Shape grammar study

The descriptive analysis led to the following conclusions: (1) house area should be considered by the constructors in advance to allow for spatial organization as rooms are added on over time; (2) all the data to generate the house is linked to the location, the relationship between different rooms, the total area and number of rooms. The dimensional analysis of the parts of the houses studied allowed for a range of variation to be established.

The parametric shape grammar has been designed in such a way that these items could be combined with the logic of space organization, which allows for good division of room space and, at the same time, for an evolution of the house, respecting the same division

of the space. Elements, such as materials, windows, roofing and aesthetic have been omitted in this phase of the research.

The preliminary results allowed for the development of design derivation through 4 steps. In the first step of the grammar the user defines basic elements. (1) The first item is related to the dimension of the lot. The lots usually have a set of measurements, with a 2 meter variation, which goes from 5, 8, 10 or 12 meters in the front to 18, 21 or 27 meters on the right/left sides; (2) The second item is the location of the streets surrounding the lot; and (3) The following step is to know how large the family is as this will define the logic for space organization (central or linear) (fig. 3). For example, a central space organization of a family of five will not require that incremental logic of the house be carried out, as it will have two rooms and will not increase. For a family of over five elements it is advisable to apply linear organization of the spaces to allow for future evolution. Bearing in mind the three above mentioned items, it is possible to begin the generative design of the spaces.

In the second step of the grammar, the user manipulates the location of the house in the lot. This location is determined by the hallway which determines the direction of the house evolution as well. Therefore it is the first space designed by the self-built incremental grammar.

As far as the houses with central organization are concerned (non-evolutionary houses for a family of under five elements), the hallway is designed in the middle of the lot and perpendicular to the front side or to the left/right sides of the house, allowing the design of the rooms on both sides of the hallway.

In the case of a linear organization, the hallway is designed adjacently to the front side or to the lateral side, allowing for rooms on only one side of the hallway. Here the rooms to be added on over time will be designed along the hallway.

In the third step the user has a set of rules to insert several functional spaces. As research revealed that the living room has prime location at the front of the house it is the room that is placed next. According to studies and data information, the self-construction housing should have the following dimensions: kitchen – 13m²; living room – 14m²; bedroom – 11m²; main bedroom – 12,5m²; bathroom – 4m²; balcony – 14m². Each division has rules set for its dimension in relation to its sides and maximum area and also it's linking to the existing rooms.

Next the kitchen plan and the bathroom plan are laid out, keeping the wet areas together as it facilitates the construction of the infrastructures.

Finally, the main bedroom and the other bedrooms are designed, considering further evolution.

The shape grammar outlined here can also be used to design service areas and/or car shelters. The building of these areas depends on the dimension of the lot.

Discussion and Conclusion

This paper suggests a possible application of shape grammar to incremental self-built housing for Campinas. We have presented a different approach to the problem using a shape grammar as a generative multiple design solution that will respond to the requirement of improvement of the self-construction houses in Campinas.

Initial Shape:
 $a = (18, 21, 27)$
 $b = (5, 8, 10, 12)$

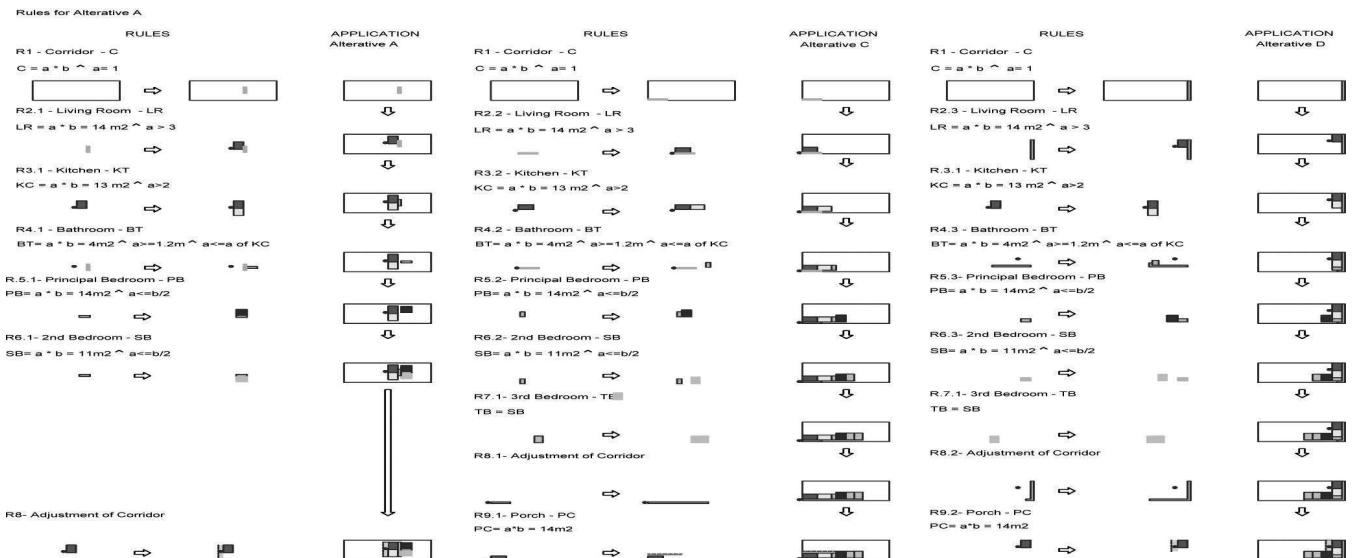


Fig.3. Some examples of partial derivation of self-built housing.

This study does not represent an alternative tool, because no application was developed. Computer system frameworks based on shape grammar will be able to respond to a very large number of hypotheses of design meeting the specific needs of the self-builder. It has thus been shown that the Shape Grammar can contribute to better quality of the self-built housing in Campinas.

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