Amorim's Law

A modern grammar

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In normative or prescriptive theories, architectural requirements are set as parameters to support design decisions. A set of formal parameters is suffice to generate a wide variety of compositions, but associated to the same formal language. This paper looks at the work of the Portuguese-Brazilian architect, Delfim Fernandes Amorim, whose contributions to the dissemination of modern ideas and the development of a particular architectural lexicon is quite relevant, particularly his addendum to the municipal land use and occupation act, which became generally known as the Amorim's Law. It consists basically in allowing spaces of transitory occupation and specific architectural elements to be built beyond the mandatory setback limits. This paper presents the development of a grammar that shows how some of the parameters described in Amorim's law are able to create a strong formal language and influence the building's architectural composition. The grammar was developed in two successive stages: the first allows the generation of the pattern of adjacency of the apartment's rooms; the second, guide the insertion of the openings and architectural elements as defined by the Amorim's Law.

Keywords: *Shape grammar, Parametric design, Design building, Modern architecture*

INTRODUCTION

General principles for architectural composition have been extensively used throughout history as a source to control design processes and, therefore, the architectural objects themselves. They are based on theoretical ideas deeply embedded not only in a particular professional culture and architectural knowledge, but also in shared social values. As Waisman (2011, p. 30) suggests, "architecture is a concrete and practical activity, [an architectural] theory, defined as a system of thought, can take a normative form that is a system of laws or norms that determine how architecture should be".

In normative or prescriptive theories, architectural requirements are set as parameters to support design decisions. A simple set of formal parameters is suffice to generate a wide variety of compositions, but associated to the same formal language, as the Renaissance treatises (Alberti, 1988 [1485]; Palladio, 2009[1570]; Serlio, 1996 [1537-]) and

modern design procedures (Le Corbusier, 1924; Latour, 1991) demonstrate. In this context, the work of the Portuguese-Brazilian architect, Delfim Fernandes Amorim, whose contributions to the dissemination of modern ideas and the development of a particular architectural lexicon in both countries, but more relevantly in the Northeast Brazil, was highly influential, is of particular interest (Amorim et al., 1981; Amorim, 1989; Silva, 1995).

Amorim proposed a set of compositional rules conceived as an alternative to the strict urban regulations, which, in his own words, was an attempt to destroy "the prismatic form that usually leads to obedience to the Building Code of the Municipality of Recife" (Amorim; Maia Neto, 1969: p.11). He highly criticized the local urban regulations that conditioned buildings' envelope to reproduce plots' shape, therefore leaving but a few opportunities to design complex and dynamic compositions, particularly in the context of highly speculative real estate developments.

The Law Nº 7.427 from October 19, 1961, the Urban and Building Code of Recife, Brazil (Prefeitura da Cidade do Recife, 1961) was based on urban indexes associated with urban zones - centre, suburb and rural. The parameters for establishing buildings' setbacks with regards to plots' boundaries were one of the most relevant parameters to restrict the built form. It was based on a progressive setback value according to the number of pavements. The architectural object, thus, assumed the shape of the plot generated by the extrusion of the permitted built area according to the building height.

In middle 1960's, Amorim proposed an addendum to the municipal land use and occupation act, which became generally known as the Amorim's Law (Amorim, 2019). In his view, spaces of transitory occupation (balcony, closet and pantry) and specific architectural elements (brise-soleil, structural element, planter-box, for example) could be built beyond the mandatory setback limits. The proposal was cleverly conceived to attract urban planners and architects, interested to promote appealing urban landscapes and architectural pieces, and real estate developers, awarded with more space area per floor. It was presented to the municipality through a design proposal for an apartment building - the Barão do Rio Branco apartment building (Figure 01), which will be discussed later. With its approval, it became a parameter for building design in Recife. It was later included in the Law Nº 14.117 from January 7, 1980 (Prefeitura da Cidade do Recife, 1980).

The principles that structured the Amorim's Law - to allow sets of spaces, built-in furniture and architectural elements to overcome the setback limits, were changed three years later to conform to the terms of the Law nº 14.511 from January 17, 1983 (Prefeitura da Cidade do Recife, 1983). The Article 24, Paragraph 1, established that they would not be considered in the total built area

[...] the area of the total surfaces occupied by terraces, balconies, balconies, cabinets, stairwells, antechambers, fireplaces, service terraces, laundry tanks and shelves, provided that are located within the perimeter resulting from the setbacks of the property (Prefeitura da Cidade do Recife, 1983: p. 20-21).

These urban regulations established buildings' formal principles that prevailed for almost three decades, not only in Recife, but also in municipalities that adopted similar rules, when an identifiable lexicon emerged, rich in its diversity and unity (Figure 1).

The Amorim's Law principles were firstly applied to the design of the Barão do Rio Branco apartment building (1965-1969), by Amorim and Maia Neto, his partner at the time (Figure 2). They describe the building as:

[...] the first attempt in this city to destroy the prismatic form that usually leads to obedience to the Building Code of the Municipality of Recife. The wardrobe of the rooms (closets) are projected out dynamising the facades, whose composition is based on the use of floor-to-ceiling glazing, interspersed with exposed brick cloths or closets covered in dark blue tiles. (Amorim; Maia Neto, 1969: p. 19)

The square tower have a vertical circulation sys-

Figure 1
Buildings that compose the corpus. From left to right: Barão do Rio Branco, Duque de Bragança (both designed by Delfim Amorim and Heitor Maia Neto), Villa Bella and Villa da Praia (both designed by Wandenkolk Tinoco).

tem and a sanitary unit in its central core, surrounded by two layers of space: a) a circulation ring and b) a set of rooms that house the main domestic activities - living, dining, sleeping, cooking, etc. .To the building original regular envelope it was added a series of enclosed spaces for transitory occupations (pantry and closet) and veranda. The projecting volumes, separated pavement by pavement, surrounded by glass panels, added the much-needed richness to the extruded original volume, resulted, partially, from the plots shape and regulated setbacks. The apartment building was received with great enthusiasm by the community of architects, and considered the best collective housing building in the Annual Award of the Institute of Architects of Brazil - Department of Pernambuco (IAB-PE), in 1969 (Institute of Architects of Brazil, 1969).

The Barão do Rio Branco apartment building was followed by other design projects in which the architects explored some variations within the limits of the formal grammar generated by the Amorim's Law. In the Kanimambo apartment building (1972), for example, vertical brise-soleils were introduced and the cantilevered closets and pantry volumes were replaced by wardrobes, while in the Duque de Bragança apartment building (1970/1971), the projecting volumes, different from the previous ones, are aggregated to form vertical volumes (Figures 1 and 2).

If Amorim and Maia Neto were the first ones to fully explore the compositional rules that result from the principles that structure the Amorim's Law, it was Wandenkolk Tinoco, Amorim's assistant at the Faculty of Architecture - University of Recife (Amorim et al, 1981) who became known for developing innovative applications of the Law, particularly for his ability to integrate all the elements of the vocabulary - balcony, wardrobes, planter boxes, etc. - into distinct compositions (Moreira; Holanda, 2011), such as seen at the Villa Bella (1974), Villa Mariana (1976) and Villa da Praia (1978) apartment buildings (Figures 1 and 2).

A thorough inventory of apartment buildings built during the term of the Amorim's Law revealed patterns resulted from its application, reaffirming how the referred parameters actually constitute a strong formal language. that can be fully describer with the support of generative design procedures, specifically the formalism of the shape grammar (Stiny, Gips, 1972), in order to translate the formal parameters into design rules that can generate a large range of formal compositions. The development of such a grammar highlights the importance of well-designed urban regulations whose constraints favour the emergence of a variety of formal expressions, even though identifiable as members of a same category.

This paper shows the development of the preliminary version of a specific modern grammar that observed the most used spaces and architectural elements, namely, the balcony, closet/wardrobe and planter-box. The corpus Is formed by four buildings

- Barão do Rio Branco and Duque de Bragança, designed by Delfim Amorim and Heitor Maia Neto; and Villa Bella and Villa da Praia, by Wandenkolk Tinoco.

SHAPE GRAMMARS

Generative design can be described as an indirect method of design (Ficher, Herr, 2001), whose final solution aims to respond not only to a particular problem in a specific context, but to solve similar problems in different contexts (Celani, 2011). One of the generative design systems is the shape grammar. Created by Stiny and Gips (1972), it consists on a rule-based form generation system that, applied step-by-step, is capable of generating a design language (Eloy, 2012).

As Eilouti (2019) suggests, shape grammars deals with morphological elements, geometric, topologic and numerical relations that define the process that generate the design. The rules of a shape grammar are formed by elements of a vocabulary; such as the architectural elements that the Amorim's Law deals with, that when applied to an original shape (the building shape), different compositions can be create. This formalism is, therefore, suitable to translate Amorim's Law parameters into shape grammar rules.

Shape grammars have been used to investigate how to generate architectural design from an initial form, through successive applications of shape rules. There are several applications of this formalism for solving design problems in the field of art (Stiny, 1980; Knigth, 1981), architecture (Eloy, 2012; Stiny, 1978; koning, Eizenberg, 1981; Duarte, 2007) or building components, as shown in the work of Eilouti (2019). The author demonstrated the power of shape grammars as a parsing tool in reverse engineering to decode the morphogenesis of visual compositions in architectural façade design.

In general, shape grammars can be classified according to: (a) the way rules are inferred and (b), the logic of rules application. The first one defines the two main classifications described by Duarte (2007) - original and analytical grammars. Analytics are used as a tool for analysing a group of projects - the corpus, which form a single language that represents them. This representation is made by means of rules that are inferred from the analysis of the projects themselves that form the corpus. The original ones are thought to generate new projects and the rules, in this case, are not necessarily created from the project analysis, but based on pre-established requirements and described in texts, standards, etc.

In relation to the logic of application, the grammars can be of several types (Knigth, 1999). The main rules are the basic ones (where only rules of addition are applied), the non-deterministic ones (rules of the grammar are applied in any given order of application), the sequential ones (the rules are applied in a predefined order), and unrestricted (any kind of rule is applied in any order).

Besides, any of these types can be parametric. A parametric grammar is used to neatly encode a wider range of formal variations for the same rule. That is, each rule consists of a set of rules that can encode various attributes of the shape, so that a greater variety of parameters related to the shape can be combined.

The first stage of the grammar developed here is, in part analytic, since it will be created from the analysis of a corpus formed by four buildings. It is also of

Figure 2
Architectural plans that compose the corpus.

the sequential type, as shown below, and, in future works, it will be parametric and implemented to generate a wider variety of building shapes and façade compositions.

A MODERN GRAMMAR

In order to represent the corpus, this particular modern grammar was developed in two successive stages (hence the sequential character of the grammar): (a) the first allows the generation of the pattern of adjacency of the apartment's rooms; (b) the second guide the insertion of the openings and architectural elements as defined at the Amorim's Law. It is worth noting that while the development of the first stage of the grammar is guided by functional requirements, the second stage is centred on aesthetic and formal requirements that define the composition of the façades.

In general, a shape grammar is constituted by four components (Stiny, 1976): (1) a vocabulary of shapes; (2) a set of symbols; (3) a set of rules; and (4) an initial shape. As it was already mentioned, the corpus of the analysis is the four buildings designed by Delfim Amorim and Heitor Maia Neto and Wandenkolk Tinoco. In this preliminary version of the analytical grammar, each stage presents its own vocabulary, symbols, rules and initial shape.

In the room adjacency generation stage- that results on the adjacency diagram , the vocabulary corresponds to the apartment's rooms (living room, bedroom, bathroom, toilet and service area), represented by a generic parametric polygon (Figure 3). The rules are inferred from the apartment building plans and, since the grammar starts from scratch, it does not present an initial shape.

In the second stage, the openings and architectural elements disposition stage, the vocabulary corresponds to the generic polygon that represents the room, plus the openings and the architectural elements (balcony, closet and planter-box) - all represented in a simplified way (Figure 8). The rules are inferred from the formal analysis of the buildings' plans and façades that form the corpus and the initial shape is the diagram of adjacency resulting from the application of the first stage of grammar. In both stages, the symbols will be introduced in the grammar when parameterized.

FIRST STAGE: RULES OF ROOM ADJACENCY

The inference of the room adjacency pattern follows the same logic used in Griz et al (2015); that is, the diagram of the apartment plan is generated from the direct adjacency between rooms. In this sense, the number of rules to generate certain diagram is always the same of the apartment room number. For this grammar, besides the label (which indicates the function of the room), it was also necessary to introduce a marker, whose function is to indicate the direction of the next adjacent room location (Figure 3).

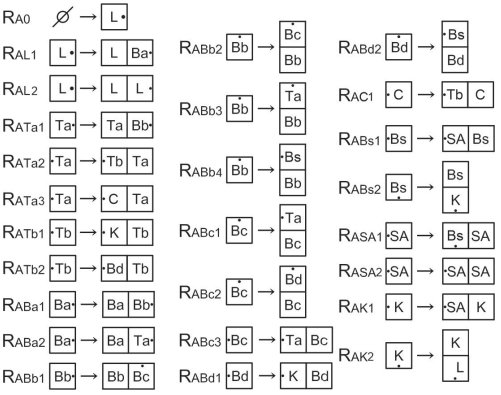


Figure 3
Rules of room adjacency.

Since this grammar starts from scratch, it was defined that the first rule to be used, refers to the living room location (RL0). From it, other rules are applied and the other rooms are being located, according to the pattern of adjacency observed in the analysed plans.

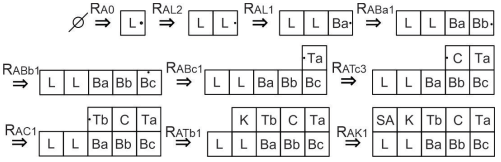
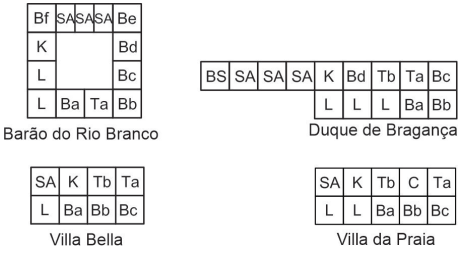


Figure 4
Pattern of adjacency derivation – Villa Bella Building.

In this stage, 26 adjacency rules were identified (Figure 3). Their applications result in the adjacency diagram (Figure 5) and it can be observed in the analysed buildings' derivations (Figure 4).

In general, and keeping the particularities of each case, the rooms arrangement form two types of adjacency diagrams: the linear and the compact one. In the linear, almost all the rooms have at least one wall facing the façade. In the compact diagram, some rooms are located inside the floor area, with no access to the façades of the building.



As commented previously, the Barão do Rio Branco apartment building is an emblematic example that served as the basis for the elaboration of the Amorim's Law. The apartment has two living rooms, three bedrooms, an in-suite, a bathroom, kitchen, two service bedrooms, a service bathroom and a service area divided into three parts. This one apartment per floor building has an approximately square plan shape - a characteristic that justifies the compactness of its adjacency diagram.

The second example of the corpus is the Duque of Bragança apartment building. Its adjacency diagram is linear, leaving the three living rooms and two bedrooms facing south, while the third bedroom, in-suite, kitchen, service area and service bedroom faces north.

The Villa Bella apartment building consists of two apartments per floor with living room, two bedrooms, one suite, bathroom, kitchen, service area and bedroom. The basic plan shape disposes the living room and all the bedrooms and the hygiene and service spaces is opposite façades, resulting in a linear adjacency diagram.

The second example of the corpus designed by Wandenkolk Tinoco, the Villa da Praia apartment building also presents a linear adjacency diagram. Similar to Villa Bella apartment building, the three living rooms, the two bedrooms and the in-suite are disposed in the opposite façade of the bathrooms, kitchens and service area.

The adjacency pattern of the analysed corpus is similar to the one found in previous study (Griz et al, 2015). The most used rules are those resulting from adjacency where the proximity of the rooms happens for thermal comfort reasons (more ventilation for long-stay rooms justify the reason why living rooms and bedrooms face the same façade - rules RAL1, RAL2, RABa1, RABb1), economic reasons (resulting in adjacent bathrooms in order to optimize infrastructure walls, - rule RATa2, or close to the kitchen and service area - rules RASA1, RASA3, RATb1) or functional reasons (resulting in adjacent kitchen, service area and service bedroom - rules RASA2, RASA3, RAK1).

The rules for insertion of architectural elements are applied according to the described adjacency diagrams, as seen below.

Figure 5
Adjacency's diagram.

SECOND STAGE: OPENINGS AND ARCHITECTURAL ELEMENTS DISPOSITION RULES

All the architectural elements to which the Amorim's Law refers - the balcony, closet and planter-box, have a direct influence on the formal composition of the building façade. These elements, as well as the openings, are of different sizes and can be disposed in many positions.

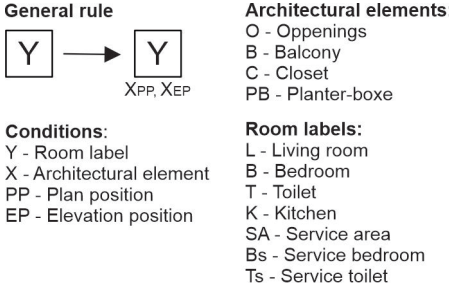


Figure 6
General rule of insertion of openings and architectural elements.

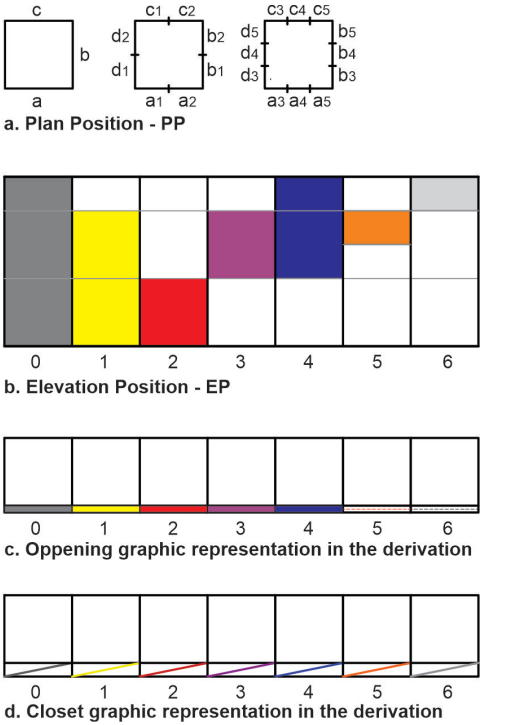
Figure 7
Position in plan (a) and in elevation (b) of the openings and the architectural elements, and their graphic represetantion in the derivation (c and d).

This general rule (Figure 6) takes into account the position and dimension of the openings and architectural elements, presented in the descriptions of the rule, where Y is the label of the room, X corresponds to the architectural element, BP refers to the position in the plan and EP, its elevation position. In general, the plan positions occupy ½, 1/3 or the entire wall (Figure 7a) . In relation to the elevation, seven possible variations are identified (Figure 7b), with their height modulated according to four main dimensional references - the floor, the window sill, the beam and the ceiling, as follows:

- Position X0: the element is inserted between the floor and the ceiling;
- Position X1: the element is inserted between the floor and the beam's inferior face;
- Position X2: the element is inserted between the floor and the window sill;
- Position X3: the element is inserted between the window sill and the beam's inferior face (traditional low window);
- Position X4: the element is inserted between the window sill and the ceiling;
- Position X5: the element is inserted some point above the window sill and the beam's inferior face (traditional high window);
- Position X6: the element is inserted between the beam's inferior face and the ceiling.

It is worth mentioning that this variation of dimensional possibilities in relation to the elevation is applicable only to openings (Figure 7c) and closets/wardrobes (Figure 7d). For this level of detail of the grammar, the variation of the height of the balcony, the pantry and the planter box are not considered relevant. In this sense, all balconies and planter boxes are inserted only in position 2.

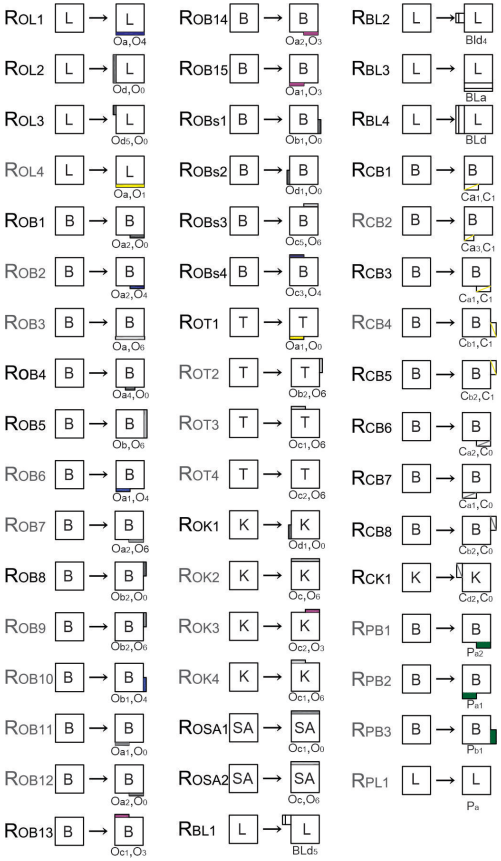
As mentioned, the initial shape of this second stage is the adjacency diagram resulting from the application of the rules of the first stage. From there, the disposition rules (Figure 8) are applied until the schematic diagram of the building envelope is obtained (Figure 9).



In this stage, 50 rules were identified representing different possibilities of openings, closets and planter-boxes disposition in buildings' façades (Figure 8). In relation to the openings, the living rooms have four of these rules, the bedrooms, 15, the bathrooms and kitchen have four, while, the service room and two for the service area have also four. Rules that are concern with the disposition of closets total nine, being eight in the bedrooms and one in the kitchen. The rules that allow the insertion of planter-boxes are only four, the majority in the bedrooms (three units) and the rest in the living room (one units).

The four cases of the corpus show important variations with regards to the grammar rules. The volumetric compositions of the two examples designed by Amorim and Maia Neto, combine vertical and horizontal elements. The architects emphasize some el-

ements unifying them vertically, either physically (in the case of the closets inserted in the Duque de Bragança), or by the maintenance of these elements in the same places in each floor (in the case of the Barão do Rio Branco), which confers a certain illusion of verticality, even if the volumes are separate. The horizontal marking is presented in the balconies and in the continuity of the spaces and openings that maintains an imaginary horizontal line



These features are conspicuously highlighted in their building envelope diagrams (Figure 9). In the case of Duque de Bragança building, the envelope diagram resulted from the architectural elements disposition rules, which almost all elevation positions of closets is the position 0 - corresponds to a closet whose height goes from floor to ceiling and, by overlapping one floor to the other, the closet become a continuous vertical volume. At the Barão do Rio Branco apartment building, the application of the disposition rule in position 1, which, together with the marking of the concrete beam, confers a certain horizontal character to the façade.

Contrarily, Wandenkolk Tinoco uses rules that emphasize the horizontality of the façade, both at the Villa Bella and Villa da Praia apartment buildings. Again, this feature can be seen in the envelope diagrams (Figure 9). These are the result of closets and openings disposition rules that practically do not use elevation position 0. In addition, in Villa da Praia, this horizontality is even more pronounced as the result of the disposition of planter-boxes juxtaposed in adjacent rooms occupying the entire room span (as seen in the two adjacent bedrooms, for example).

Figure 8
Rules of openings and architectural element's insertion.

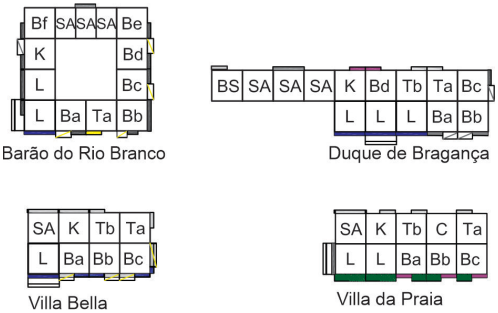


Figure 9
Building's envelope diagram.

As suggested by Eloy (2012), in the early stages of development of a shape grammar, the rules serve to better appropriate and understand the formal corpus pattern, which in future stages should be improved and tested in more examples so that can more accurately represent a formal language. However, it is worth mentioning that even if these preliminary rules were inferred from a relatively small number of examples, they are extremely representative of the set

constructed within the parameters described in the Amorim's Law.

This first version of the grammar shows itself sufficiently rich, in terms of possible rules and possible formal variations. Besides, it is effective to demonstrate the formal intention that the architects adopted in the corpus buildings. The four examples reveal two possible outputs of the Amorim's grammar rules - one emphasizing horizontality, and the other, verticality, demonstrating that, even though they were conceived according to the same compositional parameters, it is possible to obtain a diverse formal outcome.

Finally, the richness of rules and formal variations permitted by the grammar allows the designer to compose more freely the set of openings, recesses and protrusions, thus altering the prismatic volume. That is, the main purpose of Amorim's Law - breaking the prismatic characteristic of the building's volume, was achieved and this is evidenced by the rules of insertion of inferred elements.

FINAL REMARKS

This investigation has, in its origins, the intent to register and analyse modernist particular experiences in Brazil, in this case, the work of the Portuguese-Brazilin architect, Delfim Amorim and his relevant contribution to the creation of a particular modern lexicon based on simple compositional rules incorporated in the urban code and regulations of Recife, Brazil, lately implemented by other municipalities. The principles are quite simple: to allow spaces of transitory occupation (balcony, closet and pantry) and specific architectural elements (brise-soleil, structural element, planter-box, for example) to be built beyond the mandatory setback limits.

A compilation of buildings designed and built under the validity of the Amorim's Law, as implemented by the in the Law Nº 14.117 (Prefeitura da Cidade do Recife, 1980), and adapted to the Law nº 14.511 (Prefeitura da Cidade do Recife, 1983), revealed a strong formal language, reach in unity and variety, here described with the support of shape grammar formalism, taking four representative cases of the large corpus as objects of study.

The identified grammar, modern in its foundations and formal expressions, was developed in two stages - the room adjacency rules, guided by functional requirements, and opening and architectural elements disposition rules, conducted by aesthetic and formal requirements of idiosyncratic nature, i.e., dependent on each designer criteria. Amorim and Maia Neto and Wandenkolk Tinoco's demonstrated distinct compositions: the former, of vertical predominance, is regulated by the extensive use of the elevation position 0 and the non-adjacency of the cantilevered volumes - horizontal position a1 or a2; the latter, of horizontal predominance, by the almost absence of the elevation position 0 and the juxtaposition of closets and planter boxes to form a continuous volume.

The next research phases intend to implement the proposed grammar in order to describe the buildings collected in the referred inventory and to, necessarily, improve the grammar rules in order to represent a wider variety of cases.

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