RUBEM BERTA HOUSING ESTATE: ORDER AND STRUCTURE, DESIGN AND USE

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ABSTRACT

The main goal of this paper is to investigate, through some space configurational based tools, a quite common phenomenon found in many different locations in Brazil, concerning the process of urban changes individually introduced by dwellers of public housing estates. A significant number of housing estates, particularly those designed according to rationalist concepts, seem to be unable to support space related social requirements and are then widely transformed when compared to the original layouts. Beyond the quantitative features, the morphological changes that take place in those housing estates mean a fundamental new approach to understand how completely new urban structures can arise from the space produced by a comprehensive urban design, took as a starting point for the transformations made by the dwellers of those settlements. As a case study is analysed the Rubem Berta Housing Estate which was built in Porto Alegre/RS, Brazil, for 20,000 people in the late 70's. Since the begining of its occupation in 1986 and the invasion that took place in 1987, the urban transformations there have never stopped. It’s possible to realize that the dwellers individually use some constant physical rules to define the new settlement which are very similar within the estate itself and, at the same time, very similar to those found in other transformed housing estates of this sort. The physical rules introduced change the features of the entire settlement in two different levels: a) locally, through the transformations introduced in order to solve individual needs; b) globally, the local rules of physical transformations produce a new overall structure for the whole urban complex. The knowledge of this process makes it possible to bring to the surface of architectural theory some generic configurational codes that can be used as a tool for designing public housing estates in Brazil.

1 - INTRODUCTION

One of the most striking features of the process of use of a large number of housing estates produced in Brazil specially after the creation of the National Housing Bank - BNH in 1964 is the transformation of the morphology of the settlements when compared to the original layouts proposed by designers. We can observe significant differences between the designed layouts and the space built up by the dwellers of those housing estates due to new spatial rules which have been introduced through the increase of the built area, the break up and private use of areas assigned to public spaces by the projects.

This paper intends:

a) to describe the process by which a space created by a comprehensive urban design is taken as a starting point to produce a completely new urban structure;

1 This paper is a short version of my Ph.D. Thesis (Rigatti, 1997).
b) to analyse the social meaning that underlies the urban transformations in those settlements;

c) to identify the physical rules repeatedly and individually used by the inhabitants of the estates.

In order to achieve these goals it is taken the Rubem Berta Housing Estate as a case study once the above mentioned aspects are clearly observed there. In this paper it is observed the spatial features of the estate in two different moments: the project and the situation found in 1995. Nevertheless, it is important to remark that the transformations in the estate is an ongoing process and what we are about to illustrate are two moments of it and not the final situation. We discuss the bases of the changes, their meaning and trends. Differences between a spatial order and a potential social use which underlies both the project and the new spatial order individually built up by the residents of the estate are then compared. About this matter, Hanson (1987:22) says:

“There is a tendency to assume that order yields structure in the experiential reality of the buildings and places we create through architectural means: structure in the sense of making places intelligible through creating local differences which give both a sense of identity and a grasp of the relation between the parts and the whole (...). But order and structure are not the same thing at all. A plan or a bird’s eye view represent buildings and places with a conceptual unity which cannot be duplicated on the ground because we do not experience architecture this way (...). Hence, an apparently disorderly layout may turn out to be well-structured and intelligible to its users whereas a highly-ordered architectural composition may in fact be unstructured when we experience it as a built form. However much we may appreciate order concepts when criticizing architecture in the drawing board, well structured realities seem to be what matter most on the ground, not least by generating and controlling patterns of everyday use and movement.”

The methodological procedures folowed by this paper are: a morphological description of the evolution of the urban fabric of the estate and a configurational analysis, through some computing resources of space syntax (Hillier and Hanson, 1984) developed at The Bartlett School of Advanced Studies, University College London. The syntactic concept of configuration is taken from Hillier (1996:33):

“If we define spatial relations as existing when there is any type of link - say adjacency or permeability - between two spaces, then configuration exists when relations between two spaces are changed according to how we relate one or other or both to at least one other space.”

2 - THE RUBEM BERTA HOUSING ESTATE

Rubem Berta Housing Estate was built in Porto Alegre, capital city of Rio Grande do Sul State, southern Brazil in the late 70’s (figure 1). It is located in an area of about 56 ha, in the border of the eastern city limits (figure 2). The project was developed for low income families who should live in one of the 4.992 flats distributed in four-storey buildings of one, two and three bedroom flats.

After a long period of construction, in 1986 part of the estate - a quarter of the flats - is occupied and the larger part remains incomplete. In April 1987 the part of the estate that still was under construction is invaded and all flats are
occupied (figure 3). The State Housing Agency negotiates with the invaders and those who could not afford to pay for the mortgage had to leave the flats. Part of these people stay in the area and start building their houses in public spaces within the estate, mainly in those assigned to squares or parks by the project. The flat owners also begin building garages in public open spaces, particularly in the surroundings of the residential buildings where they live, and shops along the main streets.

Therefore, the private use of public open space within the estate has its origin in the very beginning of the estate occupation and it is made by two different kinds of people and for different purposes: homeless build their own houses while the flat owners build garages for their cars together with a barbecue on the surroundings of the residential buildings and shops and small business in vacant space along main streets.

Figure 1 – Location of Porto Alegre in Brazil.

Figure 2 – Location of Rubem Berta Housing Estate in Porto Alegre.

Figure 3 – Sketch of Rubem Berta Housing Estate showing the regularly occupied flats – on the top marked area – and the invaded flats – on the bottom marked area.
3 - THE PROJECT OF RUBEM BERTA HOUSING ESTATE

The spatial organization designed for the estate is based on the repetition of an architectural solution for the residential buildings which is spread all over the area and are linked together through a hierarchical street network and mainly through public open spaces, generically called by “green spaces” (figure 4).

Other features of the layout of the estate are:
- a) all buildings are built isolated from each other within a wide open space;
- b) the street network is independent of the built system and different parts of the estate can be reached without using the designed streets;
- c) different land uses are located in specific places;
- d) all non-built space is public and can be accessed both by inhabitants and strangers without any kind of restriction;
- e) it is not clear any topographical restraints: the area, from the project point of view, seems to be ideally flat, which is not.

As in many other rationalist solutions in Rubem Berta Housing Estate the built components are aggregated following a growing complexity rule: three buildings are joined together to make a “block” (figure 5); two “blocks” joined as mirror image make a module (figure 6); two modules joined as mirror image make the cluster (figure 7) and 39 clusters make the estate (figure 8). This is the case where it is clearly observed in the layout the enclosure, repetition and hierarchy solution (Hillier, 1988).

It is possible to distinguish two different kinds of open spaces: those inside the clusters which are precisely formally defined by the perimeter of the buildings and are exactly the same in terms of size and shape for all clusters; the logic that underlies the open spaces inside the clusters seems to disappear when we observe the open spaces which are responsible to unite every cluster to all others, to other uses and to the outside of the estate (figure 9).

Like other elements of the project, the street network is based on a very strict hierarchy which is reflected in the correspondence among function, use and size (figure 10). The whole network is conceived as a blocked system, i.e., main rings connect the estate without linking it to the outside world - with the exception of A ave. and Martim Felix Berta ave. which is a limit of the area. Every cluster is linked to one of these main rings through a dead-end street and there are no streets allowing to pass from one cluster to another by car (figure 11).

The project proposes the cars to be parked in some open space parking lots or in the streets. The assumption that this kind of people seldom have cars and if they do they can be parked in the streets, far from any kind of owner’s control, is responsible for an important part of the large scale transformations within the estate.
Figure 4 – The project of Rubem Berta Housing Estate, redrawn from plans provided by the State Housing Agency/RS.
Figure 5 – Residential buildings joined by staircases to form a block.

Figure 6 – Two blocks joined as mirror image make what the project calls “module”.

Figure 7 – Two modules joined as mirror image make a cluster, the spatial unit used to design the whole estate.

Figure 8 – Sketch of the project of Rubem Berta Housing Estate showing the spatial distribution of the residential clusters and other activities.

Figure 9 – Ground plan map and public open space in the project.
The outcome of almost 10 years of deep changes in the way the estate is occupied can be seen in figure 12. The introduction of new spatial rules in the area is based on:

a) the redefinition of what is public and what is private space through the introduction of semi-private transitional spaces inside the new blocks so constituted (figure 13);

b) the construction of new elements like garages, houses, small shops and offices, creating new forms of spatial relations among these new buildings, the housing blocks and the public and semi-public spaces (figure 14);
c) the use of walls and fences as elements of partition of the previously public space through which many public/private connections are now being made and semi-public spaces are introduced inside the new blocks as well (figure 15);

d) the increase of the built area of flats located on the ground floor (figure 16);

e) the use of public spaces to create courtyards for the private use of the owners of flats located on the ground floor (figure 17);

f) the use of large public areas usually assigned to squares by the project to create entirely new residential areas (figure 18).

These kind of mechanisms are responsible for enormous changes in the space use within the estate. Compared to the 80.44% of public spaces and less than 20% of private spaces proposed by the project, these proportions are now 45.38% and 54.62% respectively.

As new buildings are built up and public spaces are fenced new forms of alignements are created. These new blocks when put together with contiguous ones form a new net of ways, very similar to those found in traditional settlements. Through this process almost every trace of the original layout of the estate has disappeared.
As a result of the individual interferences on the space of the estate by using the above mentioned spatial mechanisms it is possible to say that, as a whole, the changes introduced within the estate tend to:

a) isolate the housing blocks from direct contact and from being under scrutiny of public space as allowed by the conditions imposed by the project;

b) group together residential blocks from different or same clusters at the same time creating new spatial units, very similar to those found in traditional layouts, and breaking up the spatial order of the project centred on the idea of the housing cluster;

c) align new buildings along the existing ways or along the ones created by the physical transformations of the estate;

d) create a street network based on the one of the project but with a more flexible use, and more similar to street networks found in traditional residential areas;

e) define the frontage of the main streets as the most important locations for non-residential activities such as shops, services, offices and small industries like usually is in traditional urban areas.

5 - URBAN STRUCTURE IN RUBEM BERTA HOUSING ESTATE

This part of the paper intends to discuss the urban structure of the estate both in the project and in the situation in 1995. In order to do so it is used configurational analysis based on space syntax techniques (Hillier and Hanson, 1984). Due to the limits of this paper it is not intended to present the whole theory an related techniques on space syntax. Only some basic concepts and tools are explored here. For a full account of the theory it is suggested the following basic works: Hillier and Hanson, 1984; Hanson, 1989; Hillier et alli, 1993; Hillier, Hanson and Grahan, 1987;
Peponis et alii, 1989; Hillier, 1996, among others. Because they deal with configurational features of urban space, these techniques allow:

a) systematically describe the physical dimension of urban morphology;
b) to describe both the particularities of each space in a system and its relations to all others;
c) to describe aspects of spatial culture (Hillier, 1996) that underlie morphological features of the space;
d) to compare different spatial systems both in terms of size and morphology.

Space syntax theory and techniques are based on the following main arguments:

a) every urban settlement can be seen as a continuous system of open spaces whose forms result from the way buildings and other kinds of limits to people’s movement are put together in a whole;
b) every urban settlement, seen as a sequence of open spaces and building system, is the field of the interface and interaction of two social categories: strangers and inhabitants. In this way, settlements are the place of relationships between inhabitants and between inhabitants and strangers.

The main goal of syntactic analysis is to describe urban layouts through their syntactic properties, i.e., how the system as a whole is related to every of its constituent parts and how the multiplicity of these relations produce an underlying structure.

We can identify two fundamental dimensions in the organization of urban morphology:

a) a local dimension, responsible for the closest relations between buildings and the parcel of public space to which they are connected;
b) a global dimension which structures the whole spatial system allowing to understand not only how the parts are organized but also what is the nature of the relations that structure the system as a whole.

These dimensions can be objectively measured through their syntactic properties. The basic source of information about local properties is organized in the form of a convex map (Hillier and Hanson, 1984) which represents the break-up of the open space system into the least number of the larger convex spaces that can be drawn, together with the distribution of the interfaces between building entrances and public spaces. Convex maps can be analysed both in terms of the properties of every convex space and relational patterns among them as well. Convex maps can be reduced to graphs which makes it easier to study and compare configurational features of spatial systems. Global organization is represented by the axial map, basic to syntactic analysis. It consists of the representation of the continuous system of open spaces through the fewest and longest lines of accessibility that cross all convex spaces and connect all open space (Hillier and Hanson, 1984). In this way, it explains about the possibilities of movement to and across the spatial system.

The analysis of local and global patterns allows to compare different spatial systems and to understand how configuration is associated to social use of space, to movement patterns and to conditions in which social interfaces are held.
5.1 - Local Patterns

Convex map can inform us about every space within a particular system. Features such as size, shape, relations of contiguity, presence of building entrances, etc. can explain about differences between one space and another one and, therefore, how they respond to different conditions of social appropriation in the space.

The following measures of convex spaces were studied for Rubem Berta Housing Estate:

a) mean area;
b) mean area per building entrance;
c) number of building entrances per convex space;
d) percentage of convex spaces with no building entrances;
e) perimeter of convex space per building entrance;
f) percentage of public space of the whole settlement.

The results for Rubem Berta Housing Estate concerning local measures can be observed in the table below.

Regarding the situation related to building entrances, we may say that:

a) The mean area of convex space per building entrance in 1995 is almost 5 times smaller than that found in the project and it is likely to find approximately one building entrance per convex space in average. This is mainly due to the introduction of a large number of new buildings all over the estate which are responsible for reducing the length of convex space perimeter from one building entrance to another one.

b) There is still a large proportion of spaces with no building entrances. This is mainly due to a large part of the new buildings introduced in the area to be used as garages and they are not considered as creating social interfaces as do those built for shops and houses, for example. Despite this methodological choice, it is important to remark that most of the garages are used during the weekends as extensions of the flats.

Table 1: Convex Measures for Rubem Berta Housing Estate - Project and Situation in 1995

<table>
<thead>
<tr>
<th>MEASURE</th>
<th>Project</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>nº of spaces</td>
<td>1,041</td>
<td>1,183</td>
</tr>
<tr>
<td>mean area (m²)</td>
<td>435.12</td>
<td>219.56</td>
</tr>
<tr>
<td>mean area/ building entrance (m²)</td>
<td>1,136.33</td>
<td>240.63</td>
</tr>
<tr>
<td>building entrance/ convex space</td>
<td>0.38</td>
<td>0.91</td>
</tr>
<tr>
<td>% convex spaces with no build. entrance</td>
<td>68.30</td>
<td>61.28</td>
</tr>
<tr>
<td>perimeter/ building entrance (m)</td>
<td>149.37</td>
<td>56.23</td>
</tr>
<tr>
<td>% public space/ total area</td>
<td>80.44</td>
<td>45.38</td>
</tr>
</tbody>
</table>
- as a barbecue - and become the places to meet neighbours and friends coming from outside the estate. In this sense, not only the small buildings themselves become intensely used but also is the public space in front of the garages.

In order to improve the analysis, besides the quantitative features of the estate it is important to consider relational features associated to the local dimension of urban space which structures the entire estate through local patterns, i.e., the overall structure created by the physical transformations individually introduced by the estate’s dwellers.

The positioning of every space within a system is crucial to understand how society organizes their spaces to fulfil their social roles, optimizing form and function. The properties of space such as depth, contiguity, degree of constidudiness by building entrances, size, etc. inform us not only about form and relative location of the spaces but, fundamentally, about how social categories use the space as an important instrument for regulating social relations.

The property called steps from building entrances shows us how people moving around a spatial system are positioned regarding building entrances, i.e., the social interfaces that connect public and private spaces which is able to “feed” public space with people moving from or to the buildings. This property deals with the distance in terms of number of steps or different spaces required to move from each space to the next one where it is possible to find at least one building entrance. This tells us about the conditions of scrutiny and control one can experience when moving around in a particular urban area.

Regarding the project, spaces inside the clusters present a repeated situation and are the closest spaces from/to building entrances of all estate. This means that in spaces inside the clusters people are one, two or three steps from building entrances and are, in a great extent, submited to a good control of movement. Nevertheless, outside the clusters the situation is rather different. Actually, the spaces responsible for linking the clusters are the most distant from/to building entrances of the whole system and, therefore, where the scrutiny over dwellers’ or strangers’ movement is more difficult. This spatial pattern suggests that the clusters work as isolated spatial units and that global interfaces are not sought by the project. The central park and the surrounding spaces, for instance, are the most deep in terms of accessibility to/from building entrances of the entire estate. This solution seems quite odd if we take into account that these spaces are supposed to aggregate the use and encounters of the whole collectivity of the estate.

The situation in 1995 shows a quite new relational structure. Similarly to what usually happens in traditional urban fabrics, now it is more likely to pass through a continuous system of spaces constituted by building entrances within the whole estate, mainly along the most important streets. Spaces one or two steps far from building entrances respond now for more than 74% of total spaces while this proportion in the project was around 50%.

The overall results regarding this particular aspect of the analysis can be seen in table 2 below.
Table nº 2: Depth from Building Entrances of the Spaces of Rubem Berta Housing Estate - Project and Situation in 1995

<table>
<thead>
<tr>
<th>Moment</th>
<th>STEPS FROM BUILDING ENTRANCES (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Project</td>
<td>32.23</td>
</tr>
<tr>
<td>1995</td>
<td>40.14</td>
</tr>
</tbody>
</table>

One of the main spatial properties of traditional layouts is the possibility of passing through a sequence of spaces constituted by building entrances. This property is very important as part of controlling and using the space. In order to make a closer analysis of this spatial property two maps were drawn: the decomposition map and the converse decomposition map. In the former, spaces are represented by small circles and contiguous spaces are connected by lines only if there is at least one building entrance in both of them. In the latter, conversely, spaces are represented by small circles and contiguous spaces are connected by lines only if there are no building entrances in both of them. In doing so it is possible to observe how contiguous spaces of a system are connected to each other allowing to grasp an overall picture of forms of spatial use and appropriation of public space from locally produced spatial patterns.

The decomposition map of the project of Rubem Berta Housing Estate (figure 19) consists basically in the representation of the spaces themselves. There are only two situations where contiguous spaces are both constituted by building entrances:

a) along Martim Felix Berta ave. - east limit of the estate - due to the building entrances related to the area outside the estate;

b) along the commercial area.

The access to the residential clusters is always made by unconstituted spaces. This can be best seen in the converse decomposition map of the project (figure 20): most of the spatial relations are among unconstituted spaces.

As a result of the spatial transformations in the estate there is a shift in this property (figure 21 and figure 22). The spatial rules used by the residents tend to form peripherically constituted new blocks instead of enclosing the building entrances in the clusters like it is in the project. A better spatial definition of the street network is followed by their constitution by building entrances. We can say that, more and more, the relations among contiguous spaces are relations among constituted spaces as we usually find in traditional urban areas.

Another approach that we can make in order to understand how specific conditions of use and spatial control and appropriation are related to aspects of space configuration can be grasped by analysing the kind of spatial arrangement of a settlement. In some spaces, control and movement are distributed in the layout through the ringness property which makes possible alternatives of through movement. This kind of arrangement is called distributed (Hillier and Hanson, 1984). In some other spaces, control and movement are strongly ordenated once there are no alternatives of through movement. This kind of arrangements are called non-
distributed (Hillier and Hanson, 1984). In a distributed system of spaces, from one space to another, there is more than one possible route to reach it and, therefore, the spatial control can be dispersed in many of the spaces within the system. In a non-distributed system of spaces, in turn, from one space to another there is only one possible route to reach it and, therefore, this system tends to present an unified spatial control only in part of the spaces. In ordinary urban fabrics we usually find both situations simultaneously, i.e.:
a) public spaces around blocks are connected by permeability relations structuring different rings which allow many alternative routes from/to spaces - distributive arrangements;

b) the access to some spaces can only be made through some other specific intervening ones which work as transitional spaces - non-distributive arrangements.

Spatial control and movement are clearly different depending on the specific kind of space one is within a spatial system and, at the same time, on the spatial relations which are possible to establish from every one of these spaces. Hillier (1996) suggests the following typology of spaces through a simple graph where topological properties of space can be grasped (figure 23):

a) a-type spaces - with a single link and “by definition dead-end spaces through which no movement is possible to other spaces. Such spaces have movement only to and from themselves...” (Hillier, 1996:319).

b) b-type spaces - with more than one link but in the way to/from a-type spaces, forming tree-like structures meaning that there is “exactly one route from each space to every other space (...). This implies that movement through each constituent space will only be to or from a specific space or series of spaces. This in turn implies that movement from origins to destinations which necessarily pass through a b-type space must also return to the origin through the same space” (Hillier, 1996:319).

c) c-type spaces - with more than one link, they are constituent parts of only one ring where there are neither a-type nor b-type spaces. “Movement from a c-type space through a neighbour need not return through the same neighbour but must return through exactly one other neighbour” (Hillier, 1996:319-20).

d) d-type spaces - with more than two links to others belonging to at least two different rings where there are neither a-type nor b-type spaces and “must contain at least one space in common(...) Movement from d-type spaces through a neighbour has the choice of returning by way of more than one other neighbour” (Hillier, 1996:320). Its importance in a system can be seen in figure 24 where the

Figure 23 – Space typology. From: Hillier (1996:318).

Figure 24 – Without the d-type space links the spatial system is reduced to an a- and b-type system. From: Hillier (1996:318).
removal of d-type space links reduces the system to a single string of a- and b-type spaces.

The analysis of space typology of Rubem Berta Housing Estate helps us to understand structural differences between the project and the situation in 1995. In order to do so, justified graphs\(^2\) (Hillier and Hanson, 1984) were made taking the main entrance of the estate as the root of the graphs. Besides the typology of the spaces, in the same graphs were recorded spaces with and without building entrances.

Regarding how deep the spaces of the state are from the point of view of the main entrance, despite the number of spaces remains almost the same - 1,041 in the project and 1,183 in 1995 - the system is shallower in the project and is eighteen steps deep. In 1995 the system is twenty-nine steps deep. The deepest spaces in the project are located in the extremity of A ave., in accordance to metric distance. In 1995, instead, the deepest spaces are located in the centre of the layout in the southeast border of the central park (figure 25). In this case, topological segregation deceives the metric proximity and shows that spatial changes seem to have been introduced in the estate as a strategy to modify the whole accessibility system among spaces, creating different ways to superimpose or to move apart social categories through the built space.

Table 3 bellow presents some figures relating space transformation to space typology in the estate.

In the project, almost 60% of spaces are dead-end spaces - a-type - where almost 95% of the building entrances are located, meaning that they are predominantly located in spaces of to movement and scarcely in spaces of through movement as in traditional layouts. B-type spaces which belong to tree-like sequences of spaces are quite few - less than 2% - and there are no building entrances on them. C-type spaces respond for about a quarter of total spaces but represent less than 2% of those constituted by building entrances. This also confirms the odd urban structure

\(^2\) The graphs are not included in this paper.
proposed by the project because, despite the relative distributiveness of movement and control this kind of space makes possible, there are little interfaces between public and private spaces and, therefore, potential movement and control are reduced. D-type spaces represent almost 13% of total spaces and have about 3.5% of the building entrances of the complex. This features also tells us about the lack of coherece between morphological and functional aspects of the estate from the point of view of the project once locational properties are not explored to structure the whole area.

Urban transformations made in the estate can also be understood by the way space typology changes along time. A-type spaces are widely reduced and respond now for about 20% of the total. In addition, it is not this kind of space the dwellers tend to constitute with building entrances meaning that inhabitants prefer to constitute spaces where through movement is allowed. The proportion of b-type spaces increases to almost 9% of the total but also increases the proportion of those constituted by building entrances - almost 6%. C-type spaces respond now for a little more than 48% of the spaces, increasing their participation in the system both in terms of number of spaces and the presence of building entrances - now responding for more than 43% of the constituted spaces. D-type spaces are also widely used in the transformations of the estate. Their participation increases to almost 23% and respond for more than 26% of those constituted by building entrances. This type of space is used in the spatial changes not only as a way to increase more flexible forms of relations among the various areas within the estate but also as a way to reinforce their role of natural attractors of movement (Hillier, 1996) through the strategy of constituting them with building entrances.

The typology of spaces present the following features as a result of the morphological changes introduced by the dwellers:

a) ranking by number of spaces:
   - Project: a>c>d>b
   - 1995: c>d>a>b

b) ranking by number of building entrances
   - Project: a>d>c
   - 1995: c>d>a>b

We can notice that in 1995 the ranking has exactly the same order. It seems to be a strategy by which the dwellers gradually correct the inconsistences presented by the urban structure proposed by the project.

Table 3: Number and Proportion of Spaces by Type and Constituted in Rubem Berta Housing Estate - Project and 1995

<table>
<thead>
<tr>
<th>Total</th>
<th>a-type space</th>
<th>b-type space</th>
<th>c-type space</th>
<th>d-type space</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>type constituted</td>
<td>type constitute</td>
<td>type constituted</td>
<td>type constituted</td>
</tr>
<tr>
<td></td>
<td>nº</td>
<td>%</td>
<td>nº</td>
<td>%</td>
</tr>
<tr>
<td>Project</td>
<td>1,041</td>
<td>330</td>
<td>31.7</td>
<td>622</td>
</tr>
<tr>
<td>1995</td>
<td>1,183</td>
<td>458</td>
<td>38.72</td>
<td>243</td>
</tr>
</tbody>
</table>

The typology of spaces present the following features as a result of the morphological changes introduced by the dwellers:

a) ranking by number of spaces:
   - Project: a>c>d>b
   - 1995: c>d>a>b

b) ranking by number of building entrances
   - Project: a>d>c
   - 1995: c>d>a>b

We can notice that in 1995 the ranking has exactly the same order. It seems to be a strategy by which the dwellers gradually correct the inconsistences presented by the urban structure proposed by the project.
5.2 - Global Patterns

Concerning global measures, this paper basically deals with one of them: integration and integration core. The property of integration involves the notion of symmetry/asymmetry, concerning the relation of two spaces with a third one. A description will be said symmetric if the relation between two spaces is symmetrical as will be the relation of both with a third one.

The notion of symmetry/asymmetry always involves some notion of depth or, in other words, the number of changes of direction necessary to move from one space to another. Relations of depth can be generalised by the measure of relative asymmetry, or a more complex one, real relative asymmetry (1/RRA), by comparing how deep the system is from a particular space with the deepness it theoretically could be, in a sample of systems of different sizes (Hillier and Hanson, 1984).

The properties of the integration core are of particular interest. The core comprises those spaces more easily accessible in the urban layout as a whole - usually the 10 percent most integrating spaces. In particular, what matters is the type of pattern made by the distribution of the more integrating spaces in a system (Hillier and Hanson, 1984).

The results for Rubem Berta Housing Estate concerning global measures can be observed in the table 4 bellow.

Mean integration value decreases from the project to the situation in 1995. Compared to the original situation which presents a spatial system quite integrated and shallow with a mean depth of about three lines, in 1995 the spatial system is less integrated and deeper presenting a mean depth twice as much, i.e., of almost six lines. The strong spatial integration presented by the project not necessarily means more favorable conditions of space use and occupation. Extremely high values of integration like that of the project are usually found in morphologies where the spatial control is mainly based on the movement of strangers across the spatial system.

In Rubem Berta Housing Estate the steady reduction of integration values and the construction of a deeper spatial system tend to:

a) reduce the role of global control - strangers-related - reinforcing local control - inhabitants-related;

b) balance global and local spatial organization and, therefore, the control between strangers and inhabitants;

c) introduce local spatial control as an important aspect of the process of spatial use and appropriation;

Table 4: Global Measures for Rubem Berta Housing Estate - Project and Situation in 1995

<table>
<thead>
<tr>
<th>Moment</th>
<th>nº of lines</th>
<th>1/RRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>451</td>
<td>3.46583</td>
</tr>
<tr>
<td>1995</td>
<td>544</td>
<td>1.61529</td>
</tr>
</tbody>
</table>
The spatial distribution of integration can be seen in figures 26 and 27\(^3\). In the project we can observe the following features:

a) the most integrated lines are spread all over the estate, a large number of them crossing each other making it difficult to identify a clear integration core;

b) the street system, once is scarcely related to the built system, does not necessarily includes the most integrated spaces. The whole accessibility given by the integration core is practically independent from the one proposed through the street network;

c) the syntactic core in the project lies in the geometric centre of the whole composition, i.e., the central park concentrates most integrated lines. This solution reinforces the importance of an enclosed space instead of producing a better connection to the outside world. In addition, the integration core has no correspondence between the spatial distribution of land use as we usually find in ordinary urban layouts: the more important are the functions the more they tend to be located in the most accessible spaces.

d) the most segregated spaces tend to be concentrated inside the residential clusters, where most of the building entrances are. Practically there is no interfaces between public and private spaces along the most integrated lines.

As the result of the urban transformations introduced by the dwellers of the estate, the following changes in the features of the integration core were produced:

a) the most integrated spaces allow the connection of all spaces through these lines;

b) the most segregated spaces tend to be in the limits of the estate once it still remains relatively blocked to some outside areas mainly in the east and south.

These figures were obtained through AXIAL3 software developed by Luciano Domenico Giordana under the supervision of Prof. Frederico de Holanda from The University of Brasilia, Brazil.
Other segregated lines lie on the interstices of the most integrated lines making clear where are the spaces of global and spaces of local control. In this way, it is possible both the movement of strangers in the segregated areas and their control by inhabitants as well;

c) the residential areas concentrate great part of the spatial segregation. There is a coherence between space use and degree of accessibility;

d) the most integrated spaces recover the syntactic relevance of the main rings of accessibility as proposed by the project. The street network is not only traces in the paper as in the project but structural elements for spatial configuration and social appropriation;

e) most integrated lines tend to cross through spaces constituted by building entrances. Along these lines we find most of the non-residential activities, mainly retail shops, services, offices, etc., similar to traditional layouts;

f) the park in the geographical centre of the area looses its syntactic role in the composition and now there are no most integrated lines crossing it as in the project;

g) the new urban structure introduced by the dwellers of the estate tells us about the relevance of local organization – how segregation is distributed and how it is related to residential land use – and, at the same time, about the relevance of global organization in the sense that it is used as a way to relate integration and segregation and to ensure the connections of the estate to the outside world, denying the strong spatial/social enclosure proposed by the project.

It is interesting to observe that some well integrated spaces in the project are kept in the urban transformations. This aspect reveals that the steady individual changes in the space work in two related ways: they locally alter the whole estate but, at the same time, they keep unchanged some of the spaces which are responsible for the global organization. In this way, local transformations seem to be guided by certain limits that can not be crossed because of the risk of affecting the global organization and, therefore, how the various spaces relate within the estate and to the outside world as well.

If we compare axiality and social interfaces created by the distribution of building entrances in space other particularities of urban structure and potential movement can be grasped.

Figure 28 represents all axial lines along which one can expect to find at least one building entrance in the project. Besides the small number of such lines, it is possible to identify two groups of lines. One group is formed by the spaces inside the residential clusters–X-shape in the drawing. The other group of lines is responsible for the access to all non-residential activities. We can say that the movement related to housing is separated from the movement related to non-residential activities and, through the layout itself, the project segregates movement patterns.

Figure 29 represents the same information for the situation in 1995. Besides the fact that the constituted lines almost correspond to the whole axial map meaning that in almost every line of the system one can expect to find at least one building entrance, the most important feature seems to be the elimination of two
spatially different layers of movement as it is suggested in the project, superimposing local and global patterns of movement. This means that the dwellers structure the potential movement as a system where the housing-related movement can always be connected at the same time to the movement related to other activities. Therefore, the dwellers refuse both the spatial/social hierarchy and the enclosure imposed by the project. In sum, the dwellers refuse the fragmentation – social through spatial through social – in favour of the estate as a whole.

6 - CONCLUSIONS

There are two main issues to be dealt with in this final part of the paper after the analysis of the process of spatial transformations held in Rubem Berta Housing Estate for about 10 years:

a) local patterns of spatial transformations;

b) the construction of spatial integration.

What is intended here is to identify some physical invariants used to build up the new settlement which underlie the individual spatial changes both in terms of what has been locally done and what is the global outcome.

Individual changes produce a new structure for local spaces meaning that there is a new approach to the interfaces between public and private spaces with a response in the way movement patterns and space control can be made and, at the same time, organizing new forms of global accessibility within the estate once the whole accessibility system has been changed.
The spatial repetition and indifferenciation suggested by the project are altered by the dwellers in favor of an urban structure where patterns of integration/segregation are responsible for producing local differences and global structuration, affecting movement and spatial control and how land use patterns relate to the new configuration.

A close analysis of the mechanisms of spatial transformations used in Rubem Berta Housing Estate, including block aggregate in order to understand how private and public space networks are organized, allow us to identify some spatial rules which can be related to three simultaneous forms of alignement (Hillier, 1996:335/68):

a) alignement of blocks – the new blocks tend to be built along the same alignement;

b) alignement of entrances – building entrances tend to follow the same alignement rule along the line;

c) parallel alignement – alignement of blocks and building entrances tend to be made in both sides of the same alignement. Public space tend to be more linear and, at the same time, with bilateral occupation and constitution.

We can notice that, despite the wide range of local differences such as geometry and size of blocks, size and shape of convex spaces and length of their perimeters, the whole new morphology can be explained in terms of how the above mentioned forms of alignement are arranged in space.

The alignement of blocks and parallel alignement produce a series of linear streets, often interrupted, creating a specific kind of urban grid deformation and different degrees of spatial integration once the break-up of spatial continuity, the kind of spatial contiguity and spatial relations within the whole system are responsible for the differentiation in the relative accessibility among spaces.

Regarding the construction of spatial integration we may say that local rules as used by the dwellers of Rubem Berta Housing Estate are primarily related to the way spatial integration is organized in order to achieve a correspondence between form and function, to create a “spatial culture” (Hillier, 1996:337) and, in the case of urban design, to legitimize the design by the potential social use of space created by the way every space is put into relation to all others within a spatial system.

This process of constructing spatial integration as a strategy mediated by spatial regularities can be better understood through some simulations made in order to identify how spatial integration behaves as a settlement grows. Hillier (1996) explains that taking a building with its entrance, building entrances tend to attract the greatest spatial integration. If we associate this building with another similar one creating some sort of alignement we can notice how integration changes. If building entrances are aligned, most of the integration tends to concentrate along the space in front of building entrances. If, on the one hand, the alignement of buildings produce a greater integration along the alignement and not on the sides of the buildings, on the other hand, the alignement of building entrances informs about in what side of the alignement the greatest integration will be formed. If building entrances are located back to each other or one facing the back of the other building, in both situations it is not easy to anticipate where the most integrated spaces will be formed and the
integration along the alignment of building entrances tend to be reduced. As Hillier (1996:359) says:

“Cell alignment ‘means’ the creation of a linear integration structure along the surfaces of aligned cells; entrance orientation specifies on which side is to occur. In the absence of one or other we will not find the invariant pattern we have noted. The two together have the effect of eliminating local indeterminacy in the form and creating a robust emergent pattern of integration in the aggregate.”

In Rubem Berta Housing Estate, one of the principles of designing the housing blocks is that of opening all building entrances facing the internal space of the cluster as it is sketched in the figure below (figure 30).

If we take this small system separately from all others we can notice that the centre of the system concentrates the greatest spatial integration, i.e., the centre is the most accessible place in the cluster. However, if we take more than one of such clusters and put them into relation the whole accessibility system changes. From the point of view of the outside, the centre of the cluster is now the less accessible and, therefore, the most segregated space (figure 31).

We can observe here what Hillier (1996:341) calls paradox of centrality meaning that

“maximising internal integration also maximises external segregation. (...) Growing urban systems must respond to the paradox of centrality because it has the simple consequence that if you try to maximise internal integration then you lose external integration and vice versa, and urban forms seem to need both internal and external integration. The tension between internal and external integration leads settlements to evolve in ways which overcome the centrality paradox.”

It seems exactly to be the case in Rubem Berta Housing Estate where the internal space of the clusters, because of their shape and the positioning of building entrances, tend to concentrate the greater segregation of the entire system as can be seen in figure 26.

The enclosure of the residential clusters is destroyed by the dwellers through the morphological alterations following the above mentioned alignment rules which are responsible for deep changes in the relative accessibility within the estate and between the estate and the outside world.
From the point of view of local organization, dwellers are trying to solve conflicts originated from the morphology of the project through the mentioned mechanisms of spatial alterations. They create a local order by producing some constant relations between a block and its neighbours that are repeated as a structure despite their peculiar shapes and geometries.

The alignment rules used in the space transformation lead to deep changes in the local space typology and, therefore, in the objective conditions of space control, use and movement. In this way, the alignment rules produce a morphological differentiation which is superimposed by a space typology differentiation.

Regarding the global patterns of spatial transformations, global structure in Rubem Berta Housing Estate is obtained by keeping some of the spaces of the estate more continuous which ensures that the greatest accessibility is concentrated in the spaces responsible for connecting different sub-areas in the estate.

If individual changes were made only by taking into account local organization according exclusively to individual interests, this would probably lead to a less intelligible spatial system and the urban grid would tend to be strongly deformed, mainly localized relations could be held and links between sub-areas to the outside would be particularly difficult.

In Rubem Berta Housing Estate morphological transformations and their results in terms of the creation of a spatial integration system follow exactly the dwellers’ concern about individual actions on space. Keeping the main streets continuous the parts of the whole are structured, relations among them are ensured and contacts with the outside world can be easily made.

In sum, there are interfaces between:

a) an interconnected system of spaces more linear, responsible for the global organization of the whole estate and for linking the estate to the outside;

b) a system of smaller and more deformed linear spaces which makes it possible differences in the forms of relative accessibility and a more localized spatial control.

The analysis of the transformations that has been done in the estate allows us to observe that gradually the morphology is becoming more and more distant from the morphology proposed by the project with the introduction of some spatial rules which we can identify all over the estate.

The history of spatial occupation and transformation of Rubem Berta Housing Estate is a clear example of the close relations between social components of space and spatial components of society. We may say that the more the morphological patterns are disconnected from social implications the more we tend to have a strong response against it as is the case of Rubem Berta Housing Estate and in so many other estates.

Spatial simplifications imposed by housing agencies which are responsible for making decisions related to how thousands of people will live, usually based on a simplistic hierarchical disposition of spatial elements fall flat the discussion about fundamental issues regarding designing urban areas like that illustrated in this paper. In this sense, this case study is quite useful to understand the
role of architectural discipline in producing urban spaces and how important is the support of design criticism.

7 – REFERENCES


