A house design assistance program for the self-building process of the region of Campinas, Brazil: Evaluation through a case study

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Abstract

This paper evaluates a technical assistance program for house self-builders in the region of the city of Campinas, Brazil. The assistance given is in the form of an individualized house design, distributed to self-builders, based on an automated computer aided design (CAD) generated design method. A case study is used to demonstrate the efficacy of the assistance program. The transfer process of a population from an environmental protection area to a new location and their need for rapid house construction is the specific case presented. Houses are evaluated as to satisfaction and environmental comfort conditions. As a result, lessons are learnt about assistance programs and their success in improving housing quality.

Keywords: Self-built houses; Technical aid; Environmental comfort

1. Introduction

In Brazil, distinctions can be made between the housing process of low-income groups and middle and wealthy social classes. Due to specific local economic and social structures, as well as urban growth patterns, self-built houses, houses built by owner families, make up a substantial percentage of Brazilian housing production (Nolasco, 1995; Kowaltowski, Pina, & Ruschel, 1995; This paper describes some of the latest results of a research project started in 1995 with funding from FAPESP (92/4525-2) and FINEP (7 898 0351 00).

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Self-built houses are the predominant mode of urban habitation production of a low-income population in other Latin American countries as well (Turner, 1976; Kellett & Napier, 1994). According to Brazilian data around 60% of the local housing production is self-built (Schulz, 1996).

The self-help activity has been hailed by many authors as a correct approach towards solving enormous housing deficits. On the other hand, the acquisition of finished houses is preferred by the public (Hamdi, 1991). A very low-income population, however, cannot afford them. The monthly income level of urban self-builders in Brazil lies between 3 and 10 minimum salaries, the minimum salary (SM) being equivalent to around US$ 75,00. A study on housing characteristics in Brazil divides low-income levels into three groups. Thus a very low-income corresponds to a salary from 0 to 2 SM, low from 2 to 3 SM and from 3 to 6 SM medium low (Brusky & Fortuna, 2002).

In Brazil, 30 times more homes are being built in the informal as against the formal ways of construction (Augusto & Bastos, 1997). A distinction must be made between self-building activities on land without tenure such as invasions and slums or the so-called favelas, and those on lots acquired by families in private subdivisions or through government distribution programs. As in many developing countries, spontaneous housing, without tenure, is synonymous of extreme conditions of poor-quality housing and has a negative impact on the urban environment (Pettang & Tatietse, 1998).

For the self-building process, with tenure on acquired land, the income range of families extends to 10 minimum salaries/year in some areas. A recent study in five government sponsored subdivisions in the city of Campinas, in the state of São Paulo, demonstrates that 12% of self-builders declared incomes above five minimum salaries, 32% stated to be in the range of 3–5 SM and 48% in a lower range from below 1 to 5 SM. (Watrin de Rosa, 2003). Even though the income range of self-builders is wide, these earnings are insufficient for the acquisition of a home through the regular housing market, aimed at middle and upper income level classes.

Local socio-cultural factors also play a part in the preference shown by families in building their own homes. Since 1986 Brazil does not adopt a national housing program which created an enormous housing deficit (Valença, 1992, 1999). During the last 40 years as well, towns like Campinas, a city of around one million inhabitants about 100 km from São Paulo, the largest city today in Brazil, have doubled in size in a decade (Patarra, Baeninger, Bogus, & Annucci, 1994). This growth occurs mainly at the fringes of the city, which are being occupied by low-income populations. Due to the speed of urban growth, land use planning has difficulties in controlling land occupation and construction quality. Access to urban land spurs speedy construction of minimum houses by self-builders. This building process lacks a proper design and planning stage and causes many transformations of houses during the lengthy construction period (Kowaltowski & Pina, 1995). However, most self-built settlements can be described as fairly organized suburbs, after consolidation (Kowaltowski et al., 1995a).

The self-building process has been described as belonging to vernacular architecture or what is termed new traditional environments, but this new tradition must be qualified (Rapoport, 1988; Kellett & Napier 1994). Studies have shown that vernacular architecture in many places is based on profound elements which embody environmental quality. The self-building process in Brazil, however, has specific characteristics and problems. Mainly due to low-quality design solutions, self-built houses present on the whole a low environmental comfort standard (Labaki &
The local new vernacular thus lacks some of the positive elements of many traditional buildings, especially praised for their intelligent solutions to climatic problems.

An extensive study of self-built houses was undertaken, in the region of the city of Campinas in 1994. In this study the characteristics of self-construction, house ownership and income level were considered priority in sample definition. Of the 97 self-built settlements and 33 public housing projects in the region, five settlements and three public housing projects were selected randomly. The final sample was selected according to the total number of residential lots present in each settlement and housing project. Thus a total of 64 self-built houses and 95 single-family units of housing projects were studied extensively. Public housing projects were included in the sample, since owners extensively modify houses after occupation, therefore to some extent self-re-built. The transformation of houses in housing projects has been extensively studied mainly through post-occupation evaluations (Kowaltowski, & Pina, 1995; Tipple, 2000).

Questions on family size, house construction detailing and evolution, satisfaction, preferences and habits were included in the questionnaires. Extensively observed and analyzed houses were classified as to their house plan type, functional area, room numbers, environmental comfort and details of finishing. A shorter questionnaire on preferences of plan type and house fronts was further tested in 404 homes to gain information for the development of a technical aid system.

Data from this survey have been presented in previous publications (Kowaltowski et al., 1995a; Labaki & Kowaltowski, 1998; Kowaltowski, 1998; Kowaltowski et al., 1998; Kowaltowski et al., 2000). As a result of this study, design assistance was recommended for self-builders with tenure of land.

2. Assistance program for the self-building process

The need for an assistance program becomes evident when sketches of design ideas of self-builders are observed. An example can be seen in Fig. 1. Most of these sketches lack technical design qualities and are not adapted specifically to the owner’s lot conditions. Houses are mostly built without prior planning of functional aspects, which can hinder housing quality. Although

![Fig. 1. Example of house design sketch as drawn by a self-builder.](image-url)
owners express high satisfaction in relation to their self-built houses, the participation condition in
this construction process is insufficient in many cases to attain desired standards of physical setting.

Many programs exist which offer help to low-income families in their home acquisition process. Some programs offer financial help, others distribute urbanized lots for individual self-building activities. Many programs are aimed at slum eradication through relocation of populations, especially of slums that occupy risk areas. House construction is often organized through a cooperative building process or what is called Mutirão in Brazil (Cabannes, 1997). Other programs aim to improve spontaneous settlements through the provision of urban infrastructure. NGOs have been involved in housing assistance program throughout Brazil. Most Brazilian city administrations provide programs which distribute standard house plans to families. In Campinas the local administration extended this program through a partnership called PROMORE, to include exemption of fees and access to professionals of the syndicate of civil engineers for families earning up to five minimum salaries (CAMPINAS, 2002). Few self-builders use the standard house plans, for fear of increased taxation on their properties and a general lack of incentives to legalize the construction of houses.

Aware of problems with the self-building process, especially in the Campinas region, a team of researchers from the State University of Campinas (UNICAMP) set out to devise a design assistance program. The team was composed of architects, civil engineers and researchers in environmental comfort.

Results of the study on the local self-building process (Kowaltowski et al., 1995a) were incorporated in the technical aid system as design parameters. Although social and economic conditions can restrict access to better ways of building, simple strategies of design are available, especially through the principles of bioclimatic design, which can be explored in a support system (Labaki & Kowaltowski, 1998).

Other design insights were incorporated into the technical assistance programs. Houses on the back of lots, often used as an economic first shelter, were not recommended. Difficulties occur on narrow lots in accommodating the minimum program. Houses in the center of the lot, where conditions for the construction of a preferred home are more favorable, are recommended. Construction evolution in rational stages is also important to avoid wasteful house transformations.

The two-storey house, although desired, presents technical complexities and difficulties in building in rational stages. Two-storey houses should be an option only for extremely narrow lots and exceptionally large families. The traditional layout, as shown in Fig. 2, was given priority in the design support system. Adequate room sizes, shown to be present in most houses surveyed, were maintained to avoid the dissatisfaction existing in relation to many public housing projects with a 30% reduction in room areas.

With these recommendations in mind, a computerized design method, which can produce individualized designs rapidly, was devised. The method produces simple communication drawings in the form of floor plans and 3D views of the house to facilitate design comprehension, especially of the roof configurations. The architectural design tool is called “AUTOMET”, since it is devised for the self-builders (auto-construtor in Portuguese) to run in “AutoCad”, still the most popular computer aided design (CAD) product used by the profession in Brazil.

The process begins in the CAD program with a dialogue box and the characterization of the house design, according to family size, special desires (inclusion of three bedrooms, garage or shop),
lot description and sun orientation. Self-builders with large families, houses on irregular shaped lots and designs for users with physical disabilities are not automated by the method, but given special design attention. Once parameters are indicated, the program chooses an appropriate
house design for the conditions and desires. Windows, verandas and outdoor stairs, designed as ‘blocks’, are inserted according to solar orientation and topography (Kowaltowski, Pina, Ruschel, & Oliveira, 1995b). Designs can be modified in the CAD program to attend to specific needs and desires.

Once the AUTOMET design tool was implemented and tested, the technical support program, called “TITAM”\(^1\) was created. Teams composed of students and researchers advise families, on-site, on their house design needs. An example of an on-site assistance meeting is shown in Fig. 3. A specially adapted car, donated by General Motors of Brazil for this purpose, is used in this program. Appropriate equipment such as a table, computer and printer are built into the car.

The experience of cooperating with a low-income population through the TITAM program is evaluated in this paper. A specific case study is used to evaluate both the assistance program and the satisfaction of families with their homes. Houses are also evaluated as to environmental comfort standards.

3. Case study

The assistance program has come full circle, from the preliminary study of the self-building process in the Campinas region, to the development of an automated CAD based house design program and the setting up of on-site assistance. The case study used to evaluate the assistance program involved families of the outer city subdivision called Jardim Conceição. These families

\(^1\) Abbreviation from the title of the program: Transferência de Inovação Tecnológica na Autoconstrução de Moradias.
found themselves in the special situation of needing to be relocated and thus necessitating a quick
and efficient primary shelter provision, adequate for local climatic, economic and cultural
conditions.

In developing countries and particularly in Brazil, low-income population groups often occupy
vacant land, close to urban areas, with good infrastructure of transportation and job
opportunities. Often environmental protection areas are chosen and therefore residential building
activities are illegal. In many municipalities these so-called urban invasions fall under the scrutiny
of environmental laws and the population is forced to new locations through government
supervised programs.

The transfer process of one of these groups of population, specifically the families of the Jardim
Conceição, is used to demonstrate the application of the TITAM assistance program. In the
case of Jardim Conceição the local government provided families a new area for subdivision
and organized the distribution of residential lots, with tenure of ownership secured. The
program further offered the option of house constructions through a minimal house ‘Kit’, called
‘COHAB-Embrio’. The Kit supplied builders with the building materials on-site. Families also
had a choice of using the assistance of the TITAM technical aid program. All houses were self-
built by the families.

The COHAB-Embrio consists of a minimal construction of 28 m², with a small multipurpose
room, kitchen and bathroom as shown in Fig. 4. In the particular case of the TITAM assistance
given to the population of the Jardim Conceição, two AUTOMET designs were predominantly
chosen. Fig. 2 shows the preferred house plan with furniture layout possibilities and Fig. 5 shows
the most frequently selected house design. Due to specific lot conditions and family necessities a
large number of house plans are similar in the Jardim Conceição case. The hatched area on the
plan of Fig. 5 indicates the minimum construction, recommended to self-builders, for their first
shelter.

Through this specific aid program 84 families were attended directly, on-site, of the potential
120 families of the new subdivision. Assistance occurred on Saturday mornings. This period
was found to be most productive in finding families at home. The assistance period extended over
2 months, due to the fact that, in some cases, designs were individualized for some families, which
made the scheduling of several meetings necessary.

4. House evaluations

During the first 6 months of building activities in the Jardim Conceição, frequent visits were
made by the TITAM team to assess the construction process and progress. A questionnaire
was applied to all 84 families, to evaluate the construction phase. User satisfaction was assessed
with regard to the design of the house and its construction. Houses were evaluated as to
construction techniques employed and stage of house construction. Design changes, introduced
during the construction phase, were registered in CAD designs and analyzed as to their purpose.

Results showed, after 6 months of relocation of the specific community, that 40% of the lots
were still empty with no building traces. Of the 84 families who had relocated, 45% opted for the
COHAB-Embrio project, 25% of families designed their own houses without reference to either
the COHAB-Embrio or the TITAM models presented to them, 30% of the families assisted in the
TITAM program opted for the AUTOMET designs. The houses, not based on either the COHAB-Embrio or the TITAM assistance plan, have not as yet been evaluated. The 25 TITAM houses were built by families themselves or with some hired help.

Satisfaction was assessed through various methods. Personal responses from the post occupancy questionnaire were registered. An analysis of modifications, introduced to the design during the construction phase, was undertaken as a second measure of satisfaction. Finally, technical environmental comfort measurements were compared to recommended standards.

Of the 38 COHAB-Embrio houses, 58% were modified in the first 6 months period of construction. Modifications consisted in precarious additions, such as an extended roof to locate laundry activities as seen in Fig. 6. The TITAM constructions were true to design outlines in 72% of cases. Some families eliminated the front verandah, present in all AUTOMET designs for privacy and comfort purposes. The verandah area was incorporated into the interior of the house, especially the kitchen. Some families judged the bathroom to be small, although it is larger in area.
than the bathroom in the COHAB-Embrio houses. These changes are shown in Fig. 7. With the incorporation of the small external covered verandahs, at the main entrance and at the kitchen back door, houses lost important transition spaces.

These modifications, according to the assistance team’s technical analysis, reduced the quality of functional aspects of both the living room and the kitchen. Circulation patterns are affected and privacy is reduced. The front and back door, as well, lost their important rain protection element. The living room window, in most site conditions, is no longer protected against excessive sun exposure, a major thermal comfort factor in the local climate. These results caused the TITAM team to reflect on the need for further information to be added to the drawings of

Fig. 5. Floor plan of the “AUTOMET” method most frequently selected house, hatched area indicating first construction stage.
the houses, especially in the form of better furniture arrangements. The distribution of technical assistance material in the form of booklets was seen as important to explain aspects such as privacy, functionality and technical elements of rain and sun protection.

Further analysis of the 84 houses showed that 61% of self-builders used concrete block for the construction of walls. The majority of the 25 TITAM assisted houses were built with ceramic material, a local building material with better thermal resistance. In relation to ceilings, important in the local subtropical climate, as an element to reduce heat gain through the roof, only 30% of constructions introduced this protection through wooden or prefabricated concrete ceilings. Here again, one of the reasons for the low occurrence of this important comfort element is related to the COHAB-Embrio kit, which does not include a ceiling.

The need for more information became apparent after analysis of houses and questionnaire responses. Families see the first shelter of a roof as priority. The thermal comfort that a house can provide, when finished and occupied, is not given special attention when choosing construction techniques.

Ten houses were specifically chosen for a more detailed evaluation. In these cases, environmental comfort conditions were measured with technically appropriate methods and equipment. Due to problems of access one of the houses was finally excluded from this in-depth evaluation. To determine the sample of 10 houses a three-point method was devised for selection. A fairly equal representation of COHAB and TITAM constructions was chosen. Similar siting conditions, to represent equal solar orientation situations, were selected. Further more, houses with similar ventilation conditions and relation to noise sources were selected.

For the technical environmental comfort measurements, some methodological problems had to be overcome so that some comparisons could be made. The house designs, made available in the assistance programs, are different, especially with regard to room sizes. The COHAB-Embrio kit...
houses were evaluated in the main room and the kitchen and in special cases in an added bedroom. The TITAM houses were all evaluated in the living room, kitchen and one bedroom.

The thermal parameters evaluated were air and radiant (globe) temperatures, relative humidity and air velocity. Equipment used for these measurements were: a digital and a globe thermometer, a thermohygrometer and a hot wire anemometer. Three measurement locations were adopted in each case, the center of the room, close to the window and in proximity to the back wall. The satisfaction evaluation was based on the 'predicted mean vote method' (PMV) which used a light clothing factor and relaxing as the metabolic rate (Fanger, 1972). The method evaluates the PMV and the corresponding ‘predicted percentage of dissatisfied’ persons (PPD). The PMV Method was used to obtain an evaluation of the real comfort conditions, since the first satisfaction enquiry yielded predominantly positive responses by self-builders. The positive satisfaction is seen as a
normal reaction in the situation in which these families found themselves, having just gained their own homes through relocation, tenure of an urban lot and the self-building process.

To assess acoustic conditions in the houses the noise level was registered through sound pressure measurements, using an integrated pressure reader with an ‘A’ scale compensatory setting. Measurement procedures followed the Brazilian acoustic code. The equipment was placed at a 1 m distance from walls and a 1.50 m distance from windows, as well as a 1.20 m height. Satisfaction ratings were based on comparisons with recommendations found in the Brazilian code (ABNT, 1987).

Visual comfort conditions were measured through the daylight level, the quantity of lux in the rooms at a 1.20 m height, using a luximeter. Measurements were taken in 5 points, at the center of each room and at a 0.50 m distance from the center of the four perimeter walls of each room. Satisfaction ratings were based on comparisons with recommendations found in the Brazilian Sanitation Code (São Paulo, 1992).

In relation to summer thermal comfort conditions, eight houses have a PPD higher than 50%. Only one house, built according to the TITAM design, as shown by the full plan configuration in Figs. 2 and 8, showed a comfortable PPD rating for summer conditions. This particular house is one of the few constructions with a ceiling and built with ceramic block walls.

Further observations and technical data must be added when analyzing thermal summer conditions. In many instances, houses with closed windows were encountered and in some cases, the position of large pieces of furniture, such as closets, caused window openings to be blocked as shown in Fig. 9. Most houses have no exterior finishing and external colors are dark gray or brick-color, poor conditions for solar radiation reflection. The choices made by the population in relation to roofing material and window sizes also are shown not to be ideal.

Fig. 8. Self-built house under construction and inhabited, based on the preferred “AUTOMET” method floor plan.
In relation to acoustic conditions, results show noise reverberation to be satisfactory in all but one COHAB-Embrio kit-type houses. In the TITAM houses the kitchens showed higher reverberation rates and thus unsatisfactory conditions. A detailed analysis of this data showed that the COHAB-Embrio houses do not have specific separated spaces, since there is only an opening between the small kitchen and the all-purpose room. Since the total house space is very small, in relation to family size, the rooms are very densely occupied with beds, clothing and other sound absorbing materials, like sofas in the kitchen, and mattresses on the floor. The TITAM houses, larger in size, are sparsely furnished and clothing is kept in bedrooms, where acoustic conditions were not compared.

In relation to lighting conditions, all but two of the COHAB-Embrio kit houses could be considered satisfactory. The two inadequate cases are those where the window is blocked by furniture. Since the COHAB-Embrio kit included internal paint on the walls, the light reflection conditions are superior in relation to the “TITAM” houses, none of which at the time of analysis had internal finishing and therefore had dark colored walls.
Owner expressed opinions showed an overall positive satisfaction with the house of either type. When specifically asked about comfort conditions some conflicting results appeared. Thus families with larger houses showed dissatisfaction with the room sizes and families in overcrowded houses indicated no problems with the area of the house. Many owners also were reluctant to express their opinions.

These results indicate that other factors influence satisfaction levels. The community spirit at the time of data collection may have affected expressed opinions. Some dissatisfaction may be due to problems with urban infrastructure in the subdivision. Roads are not paved, the promised sewer system is not installed, and water and electricity connections are unsatisfactory. These conditions can cause friction between the community leadership and individual families, and influence the expressed satisfaction of owners.

Final results show a greater satisfaction with the spaces provided by the TITAM designs. Post-occupancy evaluations and environmental comfort measurements indicate that these houses provide a better quality of life for low-income families, based primarily on adequate functional space provision. Thermal, acoustic and lighting conditions are shown to be related to a wider range of aspects. These include technical choices and user habits. Proper orientation and dimensions of openings, indicated on designs, are insufficient elements to ensure comfort. If windows are blocked or never opened, for reasons of problems with security or dust, thermal conditions will be negatively affected, independent of design orientation.

5. Final considerations

The specific experience of the TITAM assistance program caused the team to modify, both, some attendance procedures and design presentations. As a first consideration, the experience has taught the team that a population of self-builders should be reached at the beginning of the home building process to positively influence the quality of house construction. On-site attendance was considered important for both the participant families and for the research team to include reality in discussions and decisions. A preliminary explanatory visit to a potential community was included in the TITAM program after the Jardim Conceição experience. The house design choices can be presented during such meetings, and functional and environmental comfort goals explained. Questions can be answered and reduced scale, three-dimensional models can be shown to prospective house builders for better design comprehension.

Self-builders need access to information, in various forms, from simple technical manuals or booklets distributed in construction material shops, to on-site assistance on choices of materials and building techniques. Technical reasons behind design features can be made clear, gaining importance and thus avoiding changes that may diminish comfort aspects. Information shown on drawings is of prime importance. Care must be taken in relation to furniture arrangements, shown on floor plans. Perception of room sizes are based on furniture layouts and self-builders tend to interpret empty space on drawings as opportunities for design modifications.

The elimination of verandahs is also an issue to be discussed in meetings or through design manuals. Excess sun exposure in subtropical climates makes shading, through roof overhangs, verandahs and trees, necessary. Verandahs are a traditional element in Brazilian colonial architecture and have positive effects on shading conditions of outer walls (Labaki &
Kowaltowski, 1998). Verandahs protect the front door from rain and increase privacy in small houses by providing a transition space. Other relevant comfort factors, to be discussed, are the importance of ceilings to delay heat gain from the roof, and the size and location of windows to ensure cross-ventilation.

Lot conditions, position and orientation of the house as well as functional aspects of rooms are further discussion issues. Room size relates to adequate performance of activities and arrangement of furniture. Some hints can be given on circulation and privacy in the home, related to the position of doors and the distribution of spaces in a house, as well as the existence of transition spaces.

In retrospect, the Jardim Conceição-TITAM experience has shown that individual dreams of self-builders are diversified and not always possible to be reached. People have expectations of solving more than their own housing problems. Thus, most self-builders have “dreams” of building several houses on the newly acquired lot. These additional constructions are desired to accommodate other than immediate family members or to provide for an extra income, through renting added space or setting up a small shop.

The legal status, achieved through the acquisition of a lot, creates expectations, not always possible to be fully realized by these low-income families. Lot dimensions are small, with a geometry that limits design possibilities. Lots are mainly rectangular narrow strips of land, to reduce street front dimensions and thus subdivision infrastructure costs. Often the subdivision layout is not ideal for the sitting of desirable house designs. Orientation of streets does not take into account sun exposure and ventilation conditions. Possible house design solutions are thus already reduced or flawed through the underlying subdivision design. The basic urban infrastructure also plays an important role in providing adequate living conditions. It affects the urban image and the community spirit.

To this date, assistance has been given to around 400 families, through the TITAM program, including the families of the Jardim Conceição. Individual help has been given to families who seek assistance from the University. Specific joint programs with housing agencies have been developed. In the particular case discussed here the team worked in conjunction with the local city administration and the specific community. The goals of the assistance program were reached. Giving a segment of a low-income population the opportunity for a better quality of life and avoid waste in the construction process of self-built houses were primary goals. The automated design method AUTOMET was shown to be efficient in producing architectural designs appropriate for site, climate and economic conditions and with a degree of individualization. In conclusion it is evident that challenges remain, to assist the numerous low-income families of cities in Brazil. More professionals need to get involved to increase the effectiveness of assistance programs.

References


