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# Self-help retrofitting technologies for low-cost housing construction.The case study of Vila Novo Ouro Preto, Brasil.

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**Abstract**

The paper presents low-tech and low-cost solutions such as, in particular, self-help retrofitting technologies, to improve the quality in spontaneous settlements (favelas) which arise close to the major Brazilian towns. In particular, a critical analysis of the favela Vila Novo Ouro Preto in Belo Horizonte has been elaborated, highlighting both social, cultural and technical aspects to design suitable technological components to be adopted in order to improve environmental comfort.

The study has been developed in order to meet people needs and expectations so as to guide planning and design perspectives aiming at improving the quality of life in a sustainable socio-cultural way. The contribution suggests a selection of interesting techniques and processes achievable in self-help construction; some of them are quite innovative since they use in a new and different way recycled materials and products, thus boosting economic growth and social development.



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*Keywords:* Low-cost, Low-tech Housing, Self-help Technology, Recycling material, Retrofitting, Sustainable socio-technology.

## 1. Introduction

Brazilian social housing may represent a very interesting research field, because of the high economic growth on the one hand, and the housing deficit -now reaching alarming numbers that Public Authority cannot address- on the other hand. According to the IBGE (Instituto Brasileiro Geografia Estatica) in 2020 favelas will hosts 55 millions of people [1]. An improper soil occupation, as well as irregular subdivisions is thus resulting, where self-help construction processes in remote areas close to urban

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metropolis are the only possibility for poor people to build their shelter.

In this alarming panorama it is necessary to manage flexible and appropriate construction methods and processes, so to guide self-construction activities in terms of technology and architecture choices.

The goal is to improve the quality of life in spontaneous settlements according to existing resources, including time, skill and expertise labor availability.

## 2. The favela of Vila Novo Ouro Preto in Belo Horizonte

The *favelas* around Belo Horizonte, one of the most densely populated town in Brazil, arose initially close to building sites to host workers called to build the city. Today there are 226 *favelas* (Fig. 1 a), where about 21% of the population lives [2], [3]. The *favela* of Vila Novo Ouro Preto (Fig. 1 b) is inserted into a sort of natural amphitheater between two hills. It enjoys the presence of freshwater springs, the “corrego”, a small stream that runs down the valley, and a beautiful luxuriant vegetation. Furthermore, Vila Novo Ouro Preto can be considered a “residential island", since services and commercial activities are located outside.

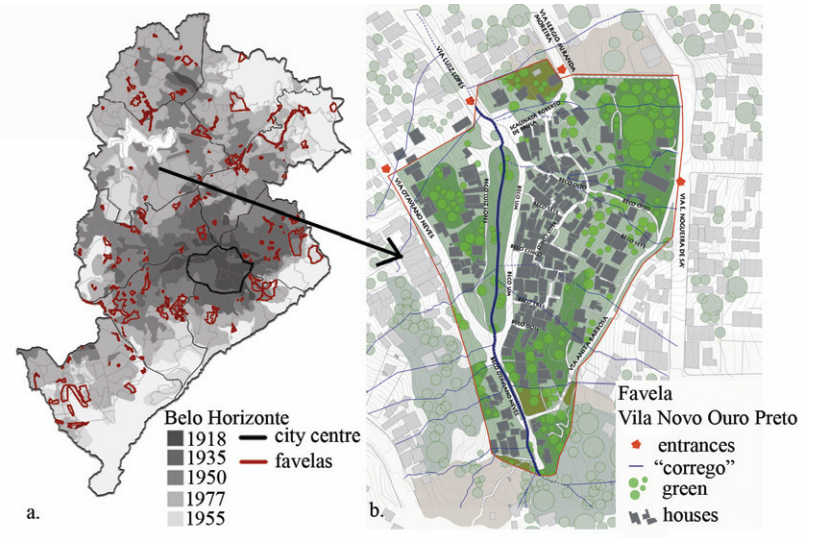



Fig.1 a. Belo Horizonte development and the *favelas* suburban sprawl; Fig. 1 b. The favela of Vila Novo Ouro Preto.

According to PGE, Plano Especifico Global – the favela urban tool, inserted into PHM, the Belo Horizonte residential political Organization, Vila Novo Ouro Preto has 1500 inhabitants distributed in more than 300 houses [4] [5]. Because of the peculiar urban contexts, of building overlapping and density, dwellings, especially those located north down the hill, are poorly lighted and ventilated. Many houses also have problems of humidity.

Nowadays, the particular social and environment situation is actively boosting the adoption of innovative processes in recycling technologies, which can be used also for buildings construction. In fact, the inhabitants have developed a “paid employment” by collecting and selecting waste materials and sell them to recyclers (Fig.2). Within the favela can be find construction materials and products dealers working on recycling processes.

Fig. 2: Some recycled materials re-usable in building construction.

## 3. The urban survey

An analysis phase, consisting of photographs, interviews and questionnaires addressed to residents, has been conducted to understand the urban development and its architectural expansion. The critical study regarding the development of this particular settlement, resulting from simple shelter building addiction processes, shows that any proposed rehabilitation intervention have to consider the fragmented and changing construction activity of the existing building environment [6]. Materials and products can have a provisional character in a coherent manner with the architectural forms, building types and the resulting urban landscape (Fig.3).

A geometrical and dimensional survey has been conducted by means of a small participative process involving favela's owners and inhabitants. Fourteen houses types, built-up by self-help construction, have been selected for further investigation aiming at understanding the structural and technological characteristics, the distribution layout, as well as the socio-cultural features.

The standard questionnaire contains the following questions' issues:

- dwelling profiles and its inhabitants construction experiences;
- building activity, technological features, construction and distribution characteristics;
- people needing and expectations and the possible improvements achievable by a sustainable design approach.

The questionnaire results showed that the average people permanence within the favela is about 30 years. Each house host about 4 people; in most cases they do not have construction experiences and they have been helped by more expert relatives to build-up their own house. In other cases, the house existed and has been modified for simple maintenance.

The most used room is the kitchen / dining room, which represents also the entrance and it is generally placed in the center of the house. Almost all of the interiors are large and empty with very poor furniture. The wealth's state is associated with electronic devices ownership, like television, computer and internet. Inhabitants consider their house as it evolves continuously, so they feel their house construction never ended really. Construction and maintenance activities are strictly related to funds and time availability. Most of them however do not intend to further expand their home unless in some specific cases: to have a work-space, to host more people, to join separate parts of the house or to obtain a living space in unused attics.

The adopted technical solutions are very simple and they are based on cheap and readily available building products and materials, even if they are unhealthy. Generally the structure is made up by a reinforced concrete frame, with rooftop in brick and cement. Usually the flat roof tops of the buildings are

provided of structural iron tools for future elevation, while the pitched roof tops are covered with asbestos sheets supported by a wooden frame.

The simple and small size of the structural elevation and foundation elements allows the use of very simple tools, easy to handle even by one person. Houses do not exceed two-storey height, since this is easy accessible to self-help construction. Inside the houses are all plastered, but they are not outside; the floor consists in a smooth concrete layer and only a few cases there is a ceramic coating.

The collecting rainwater system is absent, while the black water are all more or less abusive and they are channeled into the city sewer system. The most commonly used materials and products are: light and blocks and bricks, concrete and reinforced concrete, metal and asbestos sheets, wooden beams, concrete blocks (Table 1). These are mostly purchased and stored near the favela or collected by the resident.

Table 1. Materials and Products Percentage Use on the total number houses

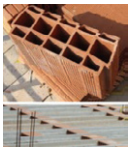
| Materials and Products | Hollow bricks (19x9x29 cm) | Hollow bricks (19x14x29 cm) | Concrete bricks (19x14x39 cm) | Bricks (10x05x19 cm) | Brick and concrete floors (07x20x40 cm) | Iron | Asbestos sheets (120x220 cm) |
|---|---|---|---|---|---|---|---|
| Image |  |  |  |  |  |  |  |
| % | 100 | 14 | 50 | 7 | 85 | 93 | 71 |

Fig. 3: The skyline from the main street “beco um” show the principal building materials employed.

Wall are usually built in bricks used as plugging elements in a reinforced concrete frame or they are used improperly as structural elements.

One of the most interesting and innovative product obtained by recycling processes that can be found just around this geographical is a sheet panel made by hot-work used pressing processes of squeezed toothpaste tubes and “tetrapack” packages, called "telha ecologica" (Fig. 4).

This low-tech and low-cost product can be used both for coating roofs and for ventilated walls. It is a 100% recycled and recyclable product, it is waterproof, resistant to UV and to chemicals; furthermore it is lightweight, fireproof. The "telha ecologica" may be used to create sun reflective elements thus reducing solar heat effects and it can completely replace existing asbestos cement sheets.

Fig.4: The “Telha ecologica”

The majority of the houses has damp, water leaks and overheating problems. Houses are also poorly lighted and ventilated. It is thus necessary upgrading the buildings to improve thermal and comfort conditions; at the same time, this retrofitting process has to properly consider the environmental, social and cultural resources arisen in the survey analysis. Design solutions also need to be consistent with the urban renewal objectives required for this particular settlement [7].

The interest on waste material and product reuse in an innovative way, to produce building components is an effective and efficient response to critical points and constraints emerged during the analysis phase.

One important common feature in the investigated houses is the flexibility, or rather, the social and cultural adaptability to face at the house as a structure that can be easily changed over time.

From the interviews it can be proved that people doesn’t know how to build their own house in alternative or different ways, by means of diverse construction techniques, thus they can’t imagine to be able to build in a different way; they are not even interested in acquiring further knowledge on building techniques and materials; furthermore the 100% of them is very satisfied with their home.

Targeted interventions are thus feasible, but they must reply to the socio-cultural attitudes and values in a way that they do not create separation or superimposition; they have to consider the current rules and habits, accepting them to generate design solutions without producing unsuitable separation between “before and after”; they have also try to respect people expectations which are directly involved in the construction activity.

Nonetheless, in cases of low cost houses built up in poor geographical and social conditions, where skilled labor and technical staff is unavailable, self-help construction to be considered the only possible solution.

## 4. The environmental retrofitting project: a schedule of possible technological strategies

The critical analysis of the current living situation and inhabitants expectations in the favela of Vila Novo Ouro Preto has suggested a methodology to define the technical solutions to improve the built environment [8]. The developed technological solutions or strategies, designed to be easily achievable in self-help construction, have been collected in a schedule (Tab. 2).

The methodological approach has been appropriately designed to maintain a close link between “the place and the people”, to meet basic needs by restricted available resources.

As mentioned above, the main constraints are related to internal comfort. This can be improved by acting on specific building components without changing the building distribution and type.

All the feasible specific interventions are collected in a schedule of appropriate technological solutions

and they are subdivided according to the critical needs they intend to solve [9]. Thus the schedule itself can be used as a guideline for the building re-habilitation in self-help construction, suggesting materials, equipments, labor required at the different construction phases.

Table 2. List of possible retrofitting actions

| | PROBLEMS | Retrofitting options<br>ON THE WALLS | ON THE ROOF | ON THE FLOOR |
|---|---|---|---|---|
| 1 | Insufficient natural lighting and ventilation | Window opening increase | Ventilated roof<br>Solar chimney | |
| 2 | Overheating | Thermal mass/inertia increase<br>Green shaded wall<br>Ventilated wall<br>Reflective surfaces<br>Window's shield | Ventilated roof<br>Insulation<br>Thermal mass increase<br>Vertical air extraction by the roof chimney | Thermal mass increase |
| 3 | Umidity/Moisture/Mould | Ventilated wall<br>Natural ventilation | Ventilated roof | Ventilated ground floor |
| 4 | Water infiltrations | Ventilated wall | Rainproof<br>Ventilated roof | Waterproof ground floor |

The possible retrofitting actions listed in this table are –obviously- closely related to the local climate. In the specific context of the considered geographical area, it has been considered more important to ventilate and to protect the buildings from the solar radiation than insulating the envelope of the building's shell. In this perspective the suggested "ventilated wall" can be considered as a building technical component consisting of a general shielding layer (tends, shelters, green plants, recycled panels, etc.) protecting the existing walls from solar rays and creating an air film between the wall external surface and the layer, which can be more or less ventilated.

A comprehensive abacus, consisting of over twenty technical solutions and architectural components aiming at improving the internal comfort of the buildings have been developed.

We do have to consider that the major number of critical needs the single component is able to solve, the major chances of success it has. For example, the roof chimney is a particular device, easy feasible both on flat or pitched roof, which can help extracting hot air, thus improving both natural ventilation and lighting conditions.

Among the different solutions, two have been selected and reported in the following tables (Tab. 3; Tab. 4; Tab.5; Tab. 6).

Table 3. The ventilated wall

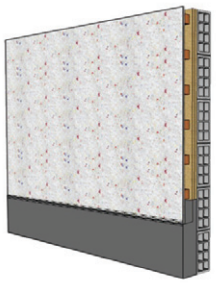
| PROBLEMS | Retrofitting actions | Building Component | |
|---|---|---|---|
| Water infiltrations | Protection from rain and ground water infiltration |  | VENTILATED WALL made by reflective and waterproof shield (i.e. Telha ecologica) to be fixed on the existing wall by a wooden frame. |
| Overheating | Ventilation<br>Solar reflection | | |
| Umidity /Moisture/Mould | Ventilation | | |

Table 4. The Solar chimney

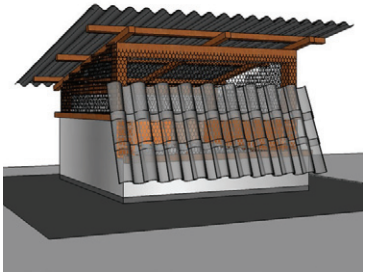
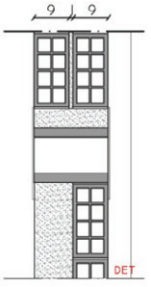
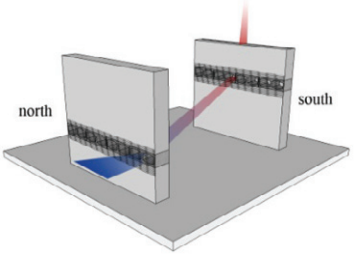
| PROBLEMS | Retrofitting actions | Building Component |
|---|---|---|
| Poor natural ventilation | Increase natural ventilation |  |
| Insufficient natural lighting | Increase natural lighting | |
| Umidity and mould on walls and roof | Increase internal cross ventilation | |
| Overheating | Ventilation to reduce internal temperature | |
| | | SOLAR CHIMNEY<br>passive twofold system (ventilation and lighning)<br>Materials and products:<br>- Metal “ondulina”;<br>- Wood frame;<br>- Protective element in recycled plastic bottles;<br>- Brick blocks;<br>- Waterproof membrane<br>The solar radiation on the metal sheet overheats air on the building top, thus creating natural air ventilation and extraction. Transparent elements help the internal lighting. |

Table 5. The open wall”

| PROBLEMS | Retrofitting actions | Building Component |
|---|---|---|
| Poor natural ventilation | Increase natural ventilation |   |
| Umidity and mould | Increase internal cross ventilation | |
| Overheating | Ventilation to reduce internal temperature | |
| | WALL Thermal mass/inertia increase | |
| | | By using simple products, cement blocks and hollow bricks, is it possible to obtain a more performing wall. The existing wall made only by a layer of hollow bricks, is improved by adding a second hollow brick layer. On the bottom, 30 cm from the floor, some cement block laid horizontally, enhance air penetration in the indoor environment. On the opposite side other cement bricks are laid near the ceiling in the way to extract hot air and to improve natural cross ventilation against air pollutants. |



## 5. Conclusions

This paper, by assuming the social and cultural dimension within the technical solutions’ design process, shows feasible paths to achieve a sustainable built environment in poor and developing countries

[10]. The analysis carried out on the real case study of the favela Vila Nova Ouro Preto, has identified a large set of critical problems to be solved by a consistent number of low-tech and low-cost solutions. These, all conceived to be built in self-help construction, consist of technical tools aiming at improving indoor air hygroscopic and thermal conditions. The paper shows that it is possible to build in a sustainable way by selecting appropriate construction materials and products -such as innovative and environmentally friendly technologies- as a response to the cultural values of self-made urban communities living in spontaneous architecture. In this perspective, the process of building renovation may produce positive results in terms of urban regeneration and job opportunities as well.

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