Conference Paper

SHS (Simple Housing Solution) Methodology: Community (Re) Building in Critical Situations

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Abstract

The SHS - Simple Housing Solution - methodology helps to facilitate the process of (re) construction in critical situations (post-disaster, post-conflict, refugee settlement, relocation of populations from risk areas, among others). It was conceived with the philosophy of gathering basic knowledge that can be useful in the (re) construction of housing units and basic collective equipment (such as schools, health clinics), in a joint effort (community working system), using low cost constructive technologies. The idea is to help communities that are victims of disasters and conflicts to better organize their own recovery, and provide help via the guidance and supervision of qualified technical assistants (engineers and / or architects) who can be hired by the local community, government or NGOs, for these purposes. This paper aims to present the Simple Housing Solution methodology and the main results of SHS Project, focusing on investigations related to the construction technology of partially reinforced masonry with soil-cement bricks. Currently, new research is being conducted to improve the existing model of residency for critical situations, seeking to broaden its working range. After the current phase is concluded, the next step will be the construction of a prototype house in natural scale, on a seismic platform, to study the effects of simulated seismic actions on the house. In order to achieve this task, financial support is sought from sponsors, as well as technical cooperation with LNEC - National Laboratory of Civil Engineering, in Portugal.

Keywords: Disaster recovery, housing recovery, conflict recovery, refugee settlements, risk management

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1. Introduction

There are several critical situations in which one wants to provide housing solutions for vulnerable populations immediately: recovery after natural or technological disasters, post-conflict reconstruction, refugee settlement, relocation of people from risk areas, or simply reducing housing deficit for groups with high socioeconomic vulnerability. In such circumstances, material and financial resources tend to be scarce, but human resources are usually available in abundance, in the form of voluntary work by those affected, who are the main stakeholders in solving the problem.

The interest and availability of the affected population to voluntarily participate in the recovery process itself was investigated after the 2011 mega disaster of the Rio de Janeiro Mountain Region, Brazil, where the rate of adherence to the proposal was 90%, even with the promise, of housing construction by the government [1]. Similar acceptance rates were found in two other disaster circumstances, in Brazil and Haiti.

The SHS - Simple Housing Solution methodology aims to present knowledge with potential to facilitate the (re)construction process in critical situations. It was conceived with the philosophy of gathering basic knowledge that can be useful in the (re)construction of housing units and basic collective equipment (schools, health clinics), in a joint effort (community building), based on the use of low-cost technology, constituting the tripod illustrated in Figure 1. The idea is to contribute to communities who suffer with disasters and conflicts to better organize themselves through their own recovery, with the guidance and supervision of skilled technical assistants (engineers and/or architects) to be hired by the community itself, the government or NGOs for these purposes.

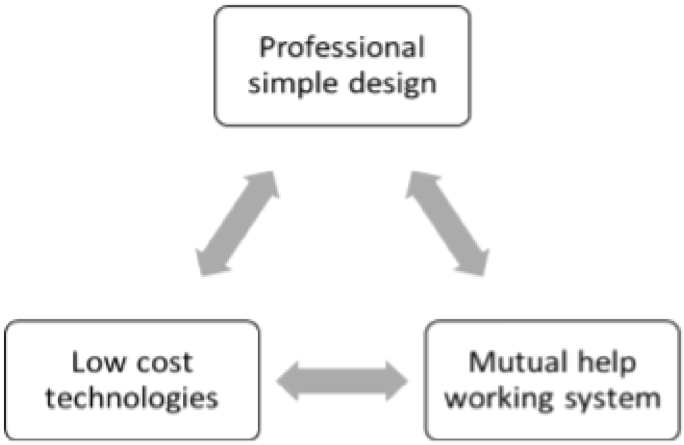

Figure 1: SHS methodology tripod.

The teaching material of the SHS methodology is composed of slides, video lessons, memorial worksheets and drawings related to the construction of low-cost houses (Figure 2), joint effort construction management and project management, which should be evaluated case by case by those who want to implement it. A YouTube channel (PROJETO SHS) was also launched, with about 30 video lessons [2].

At the moment, the constructive technology approached in the SHS methodology is the partially reinforced soil-cement structural masonry, which presents characteristics

Figure 2: Housing and school models for conventional situations (without considering extreme threats). Source: [3]

considered suitable for the situations in which the project is intended, such as: the use of local soil as construction material; the use of manual presses for the manufacture of bricks, which do not require electricity; the relatively simple and fast manufacturing and construction process that can enhance the employment of the community's own labor force; relatively low environmental impact when compared to conventional building technologies; the process allows the involvement of the population and the incorporation of equipment and skills that can be used as generators of work and income for communities after the reconstruction of the houses; among others.

Several empirical and theoretical studies were conducted at Federal University of Rio de Janeiro, Brazil, in order to broaden the knowledge about this technology to use it as structural masonry in buildings of up to two floors [4–6]. Studies are also being conducted to evaluate the applicability of a special one-floor residence model in soil-cement bricks for use in situations involving more critical threats, in particular earthquakes [7] and severe windstorms [8], such as the Haiti case. These studies showed that the proposed residence model would be suitable for earthquakes with relatively small accelerations, such as in Haiti in 2018, which reached a magnitude of 5.9 on the Richter scale, with peak accelerations of about 0.2g.

Currently, new research is being conducted to improve the current model of residence for critical situations, seeking to broaden its working range. After the current phase is concluded, the next step will be the construction of a prototype house on a natural scale, on a shake table, to study the effects of simulated seismic actions on the house. In order to achieve this task, financial support is sought from sponsors and technical cooperation with LNEC - National Laboratory of Civil Engineering, in Portugal.

This paper aims to present the Simple Housing Solution methodology and the main results of the SHS Project, focusing on investigations related to the construction technology of partially reinforced masonry in soil-cement bricks.

2. Housing Provision in Disaster and Conflict Circumstances

“Disaster” means the consequences of an adverse event (man-made and/or nature-induced phenomenon) on a vulnerable environment that exceeds the responsiveness of the affected social system. These consequences are represented by human, material and environmental damages and their consequent socioeconomic, patrimonial and environmental damages. Thus, the disaster is not the phenomenon itself (flood, hurricane etc.), but the adverse effects on the affected ecosystem. The harmful effects of the disaster are directly proportional to the vulnerability and exposure of the elements to the risk in its various aspects: physical, environmental, economic, political, organizational, institutional, educational and cultural [9]. According to the UN, more than 226 million people are affected by some kind of disaster each year [10]. It is estimated that just in 2017, the financial losses associated with them amounted at about $330 billion [11].

Disasters, whether caused by droughts, floods, tsunamis, hurricanes, earthquakes or other natural and/or human events, have an impact on most dimensions of human life, both in the short and long term. In this context, housing plays a major role in addressing basic needs. In all disasters, housing loss is the second biggest concern, right after the loss of life [12].

After humanitarian organizations have completed their relief work and the media has withdrawn, needs for quality shelter and housing remain for months and years. Thus, the attention from emergency services rarely extends to long-term recovery commitments, and the longer and more costly work hardly counts with the same level of assistance and support, even though it may determine the welfare of the community for years to come [13].

Conflicts and natural disasters result in displacement of populations, creating a crisis that does not necessarily remain within the country’s borders, but can occasionally spread across a region, causing refugee flows to neighbouring countries, aggravating political and economic instability [14]. Barakat [15] points out that a post-conflict environment is likely to provide specific difficulties: local authorities or legal structures may have collapsed, legal records may have been lost, and land ownership may be difficult to prove. In conflict situations, it is widely agreed that reconstruction can only begin when the conflict is over.

In the complex process of recovery, we highlight the reconstruction activities, which represent a challenge apart. According to the United Nations Development Program - UNDP [16], the key to the reconstruction process is to develop the capacity of local authorities to promote, supervise and guide planning and construction processes with preventive land use regulations. The author also mentions that, often, long-term reconstruction does not thrive or is considered excessively delayed due to poor execution capacity, political obstacles, lack of donor interest in financing long-term recovery and reconstruction and the emergence of new cities.

Given the pressures for reconstruction, Barakat [15] points out that local skills, preferences, and needs tend to be marginalized under the justification of speed. In this context, little effort is made to document the philosophies, methods, and processes underlying housing reconstruction. The so-called “tyranny of haste” can lead the reconstruction manager to make ineffective decisions for the local reality, making necessary the preparation for this type of situation.

Presently, international humanitarian crises affect millions of refugees, homeless and immigrants around the world, affecting not only countries of origin, but especially countries with potential to be the destination of these populations [17].

3. Methodology

The SHS methodology was initially developed through the technological innovation project “SIMPLE HOUSING SOLUTION”, proposed and coordinated by the first author of this work from 2009 to 2012. It was funded by the Rio de Janeiro State Research Support Foundation (FAPERJ) and the Brazilian microenterprise Interpro Gerência de Projetos Ltda ME (extinct in 2016), as well as personal resources of the project coordinator.

During the first phase of the project, theoretical and practical studies were carried out on the subjects of post-disaster recovery, self-effort housing construction and the construction with soil-cement bricks, with the support of consultants specialized in each subject. In 2010, a mini soil-cement brick factory with a soil analysis laboratory was set up at Interpro’s premises. On-site monitoring of the disaster management of the Rio de Janeiro Mountain Region was carried out, specifically in the municipality of São José do Vale do Rio Preto, where the disaster homeless were interviewed and their interest in participating in a reconstruction along the lines proposed by SHS methodology were verified. In this phase, architectural and engineering projects were developed for five residence models, six school modules and two health care modules, as well as manuals and spreadsheets for registering the affected, self-effort construction management, project management, bricks manufacturing, including the laboratory testing.

In 2013, a doctoral thesis containing proposals for housing recovery after disasters and conflicts was defended, based on the perspective of the affected population [1]. From 2011 to 2013, the first author attended several technical meetings in the context of disaster risk management in Brazil, as an employee of the National Centre for Monitoring and Alerts for Natural Disasters (CEMADEN/MCTIC), when it was possible to know several cities and Brazilian states, their different realities and coping capacities.

In 2017, the SHS Project was resumed in its second phase with the aim of adapting and complementing Phase 1 material in a way to be more easily understood by its users, using features such as slides, animations and video lessons. The way to achieve these goals was the creation of an extension action offered by the Polytechnic School of the Federal University of Rio de Janeiro, in which more than 100 volunteers participated. In this extension action, the didactic material for the application of the SHS Project was developed/improved, which was partially translated into four languages (English, French, Spanish and Haitian Creole), with the purpose of being freely available through the project website (www.shs.poli.ufrj.br).

The second phase team was organized into 14 teams, divided into 5 working groups, with missions detailed in Figure 3. Among these teams, two were responsible for assisting in the study of specific aspects of building technology with structural masonry in soil-cement bricks: the Materials team and the Structures/Foundations Design team. Among the 15 works of completion of the undergraduate degree in civil engineering prepared on the basis of the SHS Project, the topics related to the first group are the works [4], [5] and [6], and in the second group the works [7], [18] and [8]. Currently, the third and fourth authors of this work are studying for a master's degree at the University of Minho, Portugal, with interest in pursuing studies on topics related to the SHS Project.

To perform laboratory tests and fabrication of soil-cement bricks for the experiments carried out during the SHS Project, two mini-factories with manual mechanical press and laboratories were set up by the first and second authors of this work: one at the UFRJ Polytechnic School (located at the Centre for Sustainable Materials and Technologies - NUMATS POLI/COPPE) and another at UFRJ Campus Macaé. Various tests were conducted at these facilities to determine the properties of the soils used in the bricks as well as the post fabrication tests. Two deposits of tropical residual soil located at UFRJ/Campus Macaé were investigated and sent for geotechnical characterization in laboratory (Figure 4).

Soil samples were prepared according to the Brazilian standard NBR 6457 (2016). Tests were performed to determine grain size, true grain density and Atterberg limits, following the standards described in the Brazilian standards NBR 6459 (2016), NBR 6458 (2016), NBR 7180 (2016) and NBR 7181 (2016). An empirical test was also performed to verify soil shrinkage during the air drying process (channel test). Water absorption of soil-cement bricks was verified according to NBR 8492 (2012). The compressive strength was verified according to NBR 8492 (2012) and NBR 10836 (2013). NBR 10836 (2013) was used to describe a testing methodology considered more practical to be performed by disaster-affected communities, as it would not be necessary to cut the bricks in half. The compressive strength of the bricks was measured at 7, 14, 21 and 28 days, in order to investigate the possible strength gain over time (figures 5 and 6).

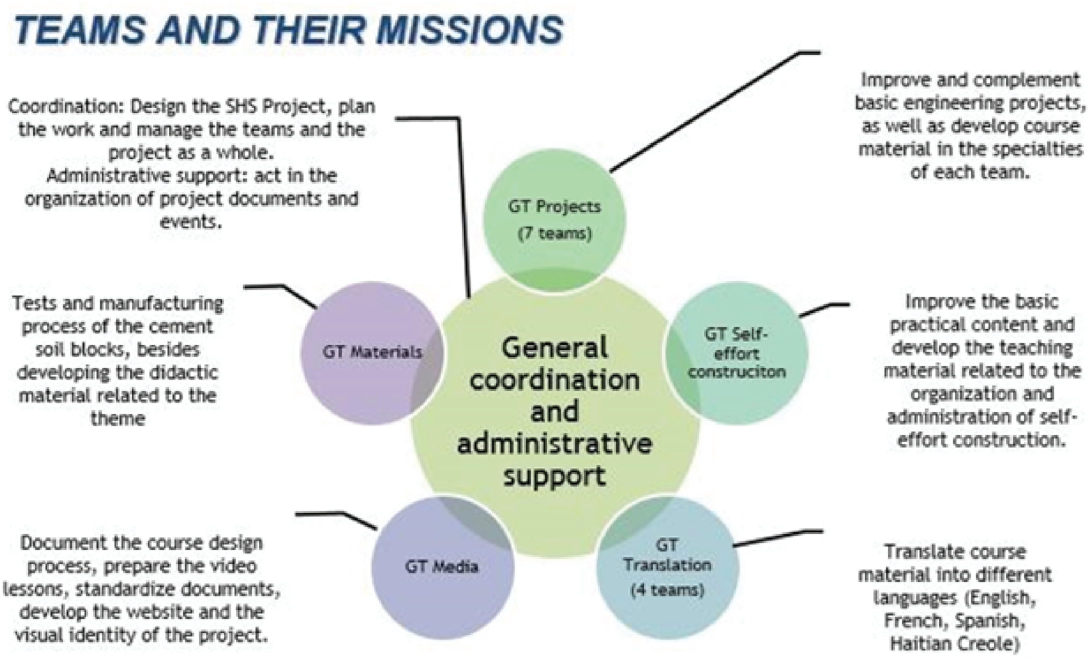

Figure 3: SHS Project teams and their respective missions. Source: [3].

Regarding the structural behaviour of soil-cement masonry, small wall tests were performed to obtain the wall-block efficiency (Figure 6), as well as horizontal load capacity tests (Figure 7), used for inputs of computational models (carried out in the SALT software, developed at UFRJ by Professor Silvio Souza Lima) in the investigation of the dynamic behaviour of the residential model structure under study for seismic

Figure 4: Soil preparation and prefabrication tests carried out under the SHS Project. Source: [3].

situations, carried out according to NBR 15421 (2006). Wind calculations were made according to NBR 6123 (1988).

Figure 5: Manufacture of soil-cement bricks and post fabrication tests carried out under the SHS Project. Source: [3].

4. Results and Discussion

The results and discussion of the SHS Project are quite broad and are presented below in two groups: research/development/innovation, and university teaching/extension. In relation to research/development/innovation we can mention the obtention of:

- Methodology for administration of self-effort housing construction. A methodology for self-effort housing construction management was developed, based on the division of labour into groups and a method of accounting for the working hours of the workers, which prioritizes the work effort of families and the situation of vulnerability;

Figure 6: Shear and axial compression (small wall) tests carried out under the SHS Project. Source: [3].

Figure 7: Horizontal load tests (small wall) carried out under the SHS Project. Source: [3].

- Algorithm for self-effort construction management. It was deduced an algorithm for self-effort construction planning, based on the lean construction philosophy, seeking to optimize the time and cost of the project;
- Properties of soil-cement bricks manufactured by manual press for application in structural masonry. Efficiency parameters were obtained between the resistance of the small wall and the block, and the behaviours of different types of mortars and grouts were tested. In-depth results and discussion in [4];
- Parameters of horizontal load capacity of partially reinforced soil-cement masonry were also obtained;

- House proposal for conventional situations. Residential models, school modules and health posts were proposed aimed at simple construction, involving as few specialized services as possible, in order to enhance the participation of communities in their recovery process;
- House proposal in soil-cement technology for extreme situations (under evaluation). A special house model has been designed with features and construction details to improve performance in earthquake and high wind situations;
- Computational modelling of the house under extreme conditions. Seismic and high wind effects in the proposed house were studied using computational modelling. As a result, the house was able to withstand peak accelerations of around 0.2g, which occurred in the 2018 Haiti earthquake of magnitude 5.9 on the Richter scale. In-depth results and discussion in [7];
- Automated worksheets for self-effort construction planning and controlling, which allow users to set up an enterprise according to their possibilities of volunteer human resources, financial resources and execution time. In-depth results and discussion in [19];
- Methodology for reconstruction under critical situations. The set of knowledge and tools developed make up the SHS Methodology.

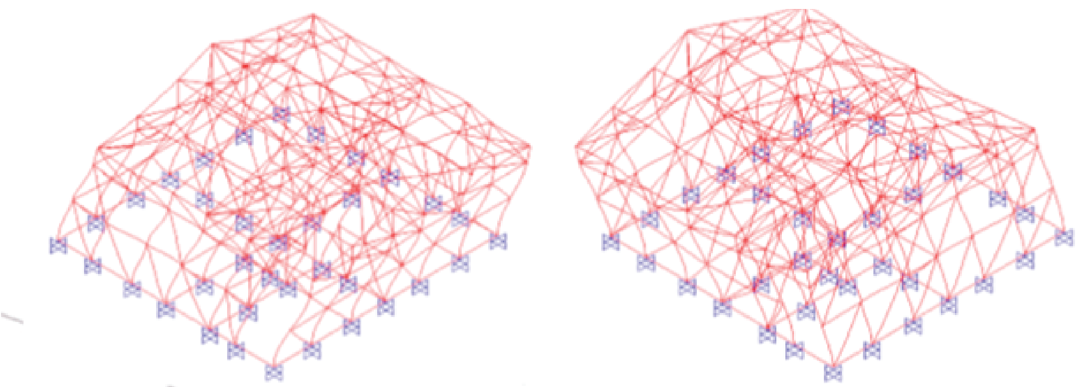

Figure 8: Deformities obtained from computational models for seismic situations under the SHS Project. Source: [7].

Regarding teaching/extension one can mention:

- Project knowledge exchange with POLI/UFRJ undergraduate classes topics: Urbanism I and II, Building Installations I and II, Structural Masonry, Construction Management, Construction Techniques, Construction Planning, Construction Materials;

- Project knowledge exchange with the following postgraduate subjects: Hydrological Risk and Disaster Management (COPPE/UFRJ), Geodynamic Risk and Disaster Management (PEU/PEA POLI/UFRJ), Structural Seismic Analysis (PPE POLI/UFRJ);
- An extension course was held and the first class was given in October 2018 to about 30 people, including Haitians living in Brazil, technicians from two non-governmental organizations with mission to provide housing for vulnerable groups, technicians from two city halls from Brazilian cities with a history of disasters and a Syrian refugee (Figure 9);
- Conducting short courses at the Federal Institute of Maranhão, Brazil, on the manufacture of soil-cement bricks, during the V Maranhense Civil Engineering Symposium, in 2019, and at the Federal University of Pará, Brazil, about SHS Methodology, during the III Brazilian Congress for Disaster Risk Reduction, in 2019;
- Open access material on the website (www.shs.poli.ufrj.br) and creation of a YouTube channel (PROJETO SHS) with about 30 video lessons on the subjects covered in the project;
- Cooperation with other interested universities and research institutes.

Figure 9: Launch event of the SHS Project and conclusion of the first class of the SHS Course. Source: [3].

Currently, the SHS Project seeks to improve the characteristics of the house model in structural masonry in soil-cement bricks for seismic threats, so it is necessary to advance to the construction of natural scale model in seismic platform. Therefore, sponsorship and cooperation are sought to accomplish this task at the National Laboratory of Civil Engineering, LNEC, in Portugal. Still on the subject of seismic engineering, studies are being conducted to verify the possibility of reducing the effects of soil liquefaction in situations where it is not possible to relocate to areas not susceptible to this type of problem.

5. Conclusion

It is noteworthy that the didactic material developed under the SHS Project aims to be a basic material, which must be evaluated and adapted to each implementation reality by the local technical assistance team. However, it is believed that the provided material can greatly speed up the reconstruction work, especially because of the simplicity of the projects, the pre-planned work, the accessible building technology and the tools developed for the self-effort construction and works management.

In the future, the project intends to move forward to incorporate other low-cost technologies, such as concrete block masonry, which would be especially useful where local soil is not suitable for the manufacture of soil-cement bricks.

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