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Rationalization of the Construction System with Ceramic Blocks

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ABSTRACT
The world population is constantly increasing. As a result, the demand for housing consequently increases. In order to meet this demand, fast, efficient, economical and clean construction methods are sought, since a large part of solid urban waste comes from civil construction. Thus, civil construction is one of the industries responsible for current environmental problems and it is necessary to propose actions to mitigate these problems. The present research presents a comparative analysis between the conventional construction system using ceramic blocks and a constructive system also of ceramic blocks with rationalized patterns for popular housing projects, showing its advantages and disadvantages in relation to the conventional system. The construction processes of this rationalized system were raised, avoiding the waste of materials for the non-generation of waste. This construction system has a streamlined execution process, with high productivity, continuous and repetitive execution. Due to its characteristics, the construction method studied collaborates with a quick execution and brings cost reduction and environmental impacts.
Keywords – Ceramic blocks, Clean construction, Construction system, Rationalized system.

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I. INTRODUCTION

The sealing masonry is a constructive system formed by blocks that are superimposed on each other with or without mortar, forming a cohesive and rigid set [1].

According to [2] masonry is everything made of natural stones, blocks, whether or not connected by mortar, needing to offer resistance, durability and impermeability. Conventional masonry satisfies the whole question of strength and durability with the exception of imperfection that is obtained by artificial means. However, there is a major problem of waste generation.

Due to the increase in the world population, there is an increase in the demand for housing buildings. This fact results in the demand for fast and efficient construction systems, in addition to being environmentally correct, considering that civil construction is one of the industries with the highest pollution levels due to the generation of waste and the emission of CO_2 into the atmosphere during the production of the Portland cement [3-5].

In the execution of these constructions, a large number of residues are generated, which are often discarded irregularly by the construction companies, causing even more environmental damage.

The solid waste comes from construction, renovation, repair and demolition of civil construction buildings, and resulting from the preparation and excavation of land, such as: bricks, ceramic blocks, concrete in general, soils, rocks, metals, resins, glues, paints, wood, mortar, plaster, tiles, asphalt pavement, glass, plastics, pipes, electrical wiring [6].

The construction and demolition waste (CDW) are materials from construction. In general, this waste is disposed of inappropriately. They are classified as low dangerousness, the biggest problem being their large volume.

According to [7], the participation of CDW in Urban Solid Waste (USW) can reach 60% in some cities. Their poor management or inadequate final disposition can produce socio-environmental impacts such as intensification of floods, soil degradation, water bodies and water sources. Thus, its importance in handling is essential to avoid damage to the environment, harming the well-being of the population.

There are alternatives for the reuse of CDW, according to [8], as the recycling of concrete and concrete block for the manufacture of sand and recycled gravel. These materials are reused for paving roads and highways and also for reusing landfill coverage.

Another way to minimize environmental impacts is to reduce the generation of CDW, such as the use of rationalized construction systems, for example Light Steel Framing. According to [9], the construction system of steel structures, known in the technical and scientific environment as "steel framing", is a rationalized system of cold formed profiles of galvanized steel. In addition to this system, there are other methods disseminated in the literature and others little mentioned, such as the constructive system addressed in this research.

This research was motivated by the growing use of alternative construction systems in the world. Among the construction systems covered in the literature, it was decided to approach the rationalization of the construction system with ceramic blocks, as this material is the most used in brazilian enterprises.

Thus, the present research aims to compare the traditional construction method of ceramic block masonry executed in a conventional way and the rationalized construction method of ceramic block masonry adopted as a solution for a popular housing project in the state of Goiás, Brazil.

II. METHODOLOGY

For the development of this research, scientific articles were searched with the following descriptors: constructive system, constructive method and rationalization. It was verified the importance of the use of alternative systems to the conventional system of ceramic blocks aiming at the reduction of the generation of solid residues through the rationalization of the construction systems.

From this, a case study of a building construction located in the state of Goiás/Brazil was carried out, which adopted a constructive system with ceramic blocks in a rationalized way. The constructive method used for this study was developed by the engineer Marcos Antunes de Almeida and has a patent at the National Institute of Industrial Property of Brazil (INPI/Brazil).

This construction system is called in portuguese "Casa Rápida – Construção Simplificada", in english "Quick House - Simplified Construction" and is based on three essential principles for civil construction: high speed of execution, low cost and little generation of solid waste. Thus, more information about this constructive method was sought through engineers who worked in the execution of this building construction, where you can find some technical characteristics of the built building.

From these procedures described above, the step-by-step for the implementation of this constructive system through figures was demonstrated, enabling the diffusion of this method among civil engineering professionals. A comparative study was carried out between the conventional ceramic block system and the precast ceramic block system.

III. RESULTS AND DISCUSSION

For the beginning of the construction of the houses, the building was marked by a topography team with theodolite. After this stage, the execution of the radier (type of foundation used in the project) was carried out, as shown in fig. 1. To perform this service, the procedure was similar to that of a conventional construction system. In the base in contact with the soil, a plastic tarp was added to prevent water percolation through capillarity and contamination of the concrete, in addition to the pre-waterproofing function.

Figure 1: Concreting of the radier.

As can be seen in fig. 1, the radier of the present study has no reinforcement, which differentiates it from the conventional radier found in most buildings. Instead of reinforced concrete, concrete with corrugated steel fibers was used. It should be noted that the type of foundation adopted does not depend on the construction system adopted in this case, since the loads of the structure are basically the same. Thus, the type of foundation in radier was the engineer's option depending on the type of soil in the region.

In buildings with the conventional construction system, after concreting the radier, it would be necessary to wait for the concrete to harden and cure, which takes time, and only after the radier has cured would it be possible to start the construction of the masonry. In the construction system used in the building under study, this is not necessary, as the walls are pre-molded in a specific place, as shown in Fig. 2.

Figure 2: a) Assembly of ceramic blocks for the execution of precast walls; b) Execution of masonry in a conventional manner.

The precast method produces 11 cm thick walls, which reduces the cost of materials by 15%-20%. According to the company that executes this method, losses are around 1%. As can be seen in fig. 2a), to form the precast walls, a shape fixed to the ground was used. In this shape, steel sheets were fixed to which release agent was applied for subsequent application of a thin layer of mortar.

It is noteworthy that as the ceramic blocks were executed on a flat surface, the coating mortar layer was thin, being a positive factor in the cost of the construction system. In the conventional system, as the walls are executed vertically, as seen in fig 2b), misalignment can occur, requiring the execution of a roughcast across the masonry area and a thicker layer of mortar to regularize the wall surface.

The ceramic blocks were fixed using hooks on the sides and parts above the forms. These hooks are concreted for subsequent lifting and locking the wall and also for fixing the metallic roof structure as shown in Fig. 3 detail.

Figure 3: Details of the concreting regions for fixing the hooks.

It is also identified in fig. 3 regions of the ceramic blocks spaced apart. These spacing between a row of blocks and another served for the passage of cold water pipes and conduits. Thus, it is not necessary to break the blocks for the passage of pipes and conduits, reducing the generation of waste and disposal in inappropriate places, and consequently the costs of the building.

Theoretically, the regions in which the pipes and conduits pass in this construction system are more fragile, as there is the presence of a tube between the mooring of the ceramic blocks. Despite this, according to [10], it has DATec n ° 013 certification from the National System of Technical Assessments (SINAT), within the scope of the Brazilian Habitat Quality and Productivity Program (PBQP-H). Thus, it is guaranteed that this system meets the requirements of ABNT NBR 15575 [11].

During the execution of the wall, shapes are placed as shown in fig. 4, to later install the frames. The difference between this process and the conventional one is that wooden shapes are used and after the building is done they are discarded. In this method, the shape can be kept until the next building.

Figure 4: Frame of the door.

Looking for quick, practical and space-saving wall executions, after the first wall is executed and reaches resistance, a steel plate is placed on top of the wall so that you can build a next wall on top of the one previously executed, as shown in fig. 5, saving space.

Figure 5: Finished wall for transportation.

After the construction of 4 walls, the last wall built is expected to have resistance to be lifted by the crane. The negative point of this method is that the first wall made that has significant resistance before the others can only be removed until all the others are located. This can be solved if there is an adaptation of the method with the possibility of removing the first wall executed by sliding the shape.

As shown in fig. 6, when released for assembly, the walls are lifted by the crane to a truck that has the proper support to transport the wall to the installation place.

Figure 6: Lifting the precast wall.

After being placed on the truck, the precast wall is secured by its support and by ropes, as shown in fig. 7. Its movement is very slow to reduce the risk of cracks, which would bring problems in the system and the possibility of future pathologies.

Figure 7: Transport from the precast wall to the radier.

The system is assembled by means of a crane that hoists the precast wall and places it on the radier. A team is responsible for straightening the walls and making the locking, as shown in fig. 8.

Figure 8: Mounting the masonry on the radier.

After leveling checks, a team is responsible for welding the hooks as shown in fig. 9, in order to lock the structure. The system itself does not require the execution of columns and beams because it is concretized in the area of the lifting hooks, which differs from the conventional system where the structure is formed by column, beam and slab.

Figure 9: Locking the structure.

To optimize the time, the roof structure is made of metal profiles. It is prefabricated, transported and welded on the hooks that were used by the crane for transportation and installation, as shown in fig. 10.

Figure 10: Roof over metallic structure.

The hydrosanitary installations are carried out between the masonry spaces, avoiding the generation of waste. In spite of this, sometimes due to execution error it is necessary to break a small area of the wall for the splice of the tubes as shown in fig. 11a) and 11b), unlike the conventional system, it is necessary to break the wall to insert the tubes as shown in figure 11c). It is observed that even with the possible execution errors in the precast wall system, the generation of waste to correct the errors is less than in the conventional system.

Figure 11: Hydraulic installation a) and b) precast wall; c) conventional wall.

The sanitary system, the laying of the floors and the execution of the painting are done in a similar way to the conventional system.

The construction method with precast walls brings agility when applied on a large scale. About 4-5 houses are produced per day, with a team up to 65% smaller compared to the traditional one. With that, there is a 65% reduction in the items of provisional installations. On the other hand, there is a need to hire crane, which increases the unit cost of the system.

The building has a decrease of its estimated workforce of 65%, which would include, for example, a decrease in wages and social charges. Items such as preliminary services, foundation, electrical and hydrosanitary installations, window frames, painting, sanitary appliances and miscellaneous (general cleaning) values are maintained because in this system there is no change, but in the items structure, masonry and coverage, reductions are estimated 30%, 20%, 10%, respectively.

Given the above, it is observed that this method is efficient for the construction of several housing units, reducing cost, execution time and waste generation. On the other hand, it is ineffective for small buildings, as the price of machinery as a crane is high.

IV. CONCLUSION

It was possible to observe some differences between the masonry construction system of ceramic blocks studied and the conventional masonry system.

The constituent materials of the studied building system are similar to the materials of the conventional building system. The difference is the presence of concrete and hooks on the sides of the walls so that it can be transported, but the big difference is in the form of execution.

The step-by-step shown for the execution of the studied construction system can facilitate the diffusion of the method among the engineers, enabling the perfect reproduction of the construction system in a building.

The choice of the construction system studied as an alternative to the conventional system is recommended when it is desired to build many housing units in the short term. For a single house, it becomes an expensive and ineffective method due to the machinery and skilled labor, however when applied on a large scale there is a reduction in the overall cost and waste generation of the building.

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