THE USE OF PRECAST STAIRS IN MASONRY STRUCTURES

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The great advantage of using masonry structures today is the rationalization of materials and building methods with quality and at low cost. A way of increasing this rationalization level is using masonry structures together with precast elements. They work efficiently together regarding strict quality control, modular coordination, reduction of waste, and high speed of construction.

An element that has a lot of advantages in been precast is the staircase. It provides benefits in handling, speed and simplicity of assembly.

Amongst the options of precast staircases, the big challenge is to choose which one fits the project best, targeting savings, compatibility with the streamlined construction process, planning and logistics.

The purpose of this paper is to present a comparative analysis of different types of precast staircases that can be used in masonry structure buildings, and create a database that can help in choosing which staircase is best for a variety of projects.

This analysis is made based on documental and survey researches at construction sites, in which the staircase was implemented and the reasons which led to this particular solution. It describes relevant aspects of the general features of the project, the structural viability of the building for each type of staircase, and the interfaces of the construction process, such as transportation, handling, and designing details of the precast elements.

The results show that there is a great advantage in using precast staircases within masonry structures, eliminating construction stages, minimizing interference between subsystems and raising the quality of the final product.

**Keywords:** Precast, staircases, masonry, rationalization

INTRODUCTION

Currently, it’s noticed a tendency towards the construction of buildings in structural masonry. Many Brazilian contractors have become aware of the advantages of this construction system, such as reducing molds, framework, and revetment, offering the possibility of precasting many structural components, helping to keep tidiness at the working premises, reducing waste and lowering the amount of construction procedures. All of which have increased the use of this construction system.

This construction process overcomes successfully the challenge of constructing houses and buildings on schedule, with quality and at low costs. The enhancement of designing methods through the years has made possible the development of buildings of several standards and structures, as well as taller buildings.
When the architectural project of a masonry structure building is received, certain decisions must be made as to the fundamental items related to the project. These decisions are the starting point, and most of them are options that must be made always seeking the best alternative within each project. Amongst these decisions, the contractor may opt for the use of precast elements, whether for flagging, staircases or on square bars over doors. The precast, just as structural masonry, offers as advantages: fast execution, savings in molds and framework, good quality elements, and a rigorous control during execution, therefore providing systems that adjust perfectly.

The precast elements are inserted in the construction process without important changes to the production basis, which characterizes the industry. Notably, in structural masonry precast will fit the particular needs of this construction process in relation to speed of execution, quality control, modular coordination, and the decrease of improvisation and waste.

Currently, there has been progress on the search for rationalization of construction processes, aiming at increased productivity and lowering of construction costs, resulting in a growing demand for construction projects in rationalized masonry structure.

The great competitiveness in current market, however, demands solutions that associated to the construction process and structural masonry, enhance process efficiency. Thus, eliminating construction steps and minimizing interference between subsystems, and raising the quality of the final product. Adopting solutions towards the industrialization, especially with precast, is a path to enhance process efficiency.

PRECAST STAIRCASES

In order to minimize the nuisance inherent to casting staircases “in loco”, precast staircases have come as an alternative. In structural masonry, the precast staircase fits in a very efficient way.

The precast staircase can be made out of large dimension pieces or several light elements.

The large dimension pieces require hoisting equipment on the site, while lighter pieces may be transported many times by a single worker. For high buildings, where there is hoisting equipment at the site, there is great advantage in using staircases composed by large dimension pieces due to the quickness of assembly. Transport by hoisting creates a unique situation for the piece, withstanding different strengths than the ones which will apply during use. These strengths must be foreseen during the dimensioning of the piece.

When the contractor wants to standardize its buildings, keeping the gaps on the staircase and the height of the ceiling, the precast staircase of the “step-ladder” type is a good option, and the precast elements are reusable.

In houses, where there is more flexibility, a precast staircase of the “winding” type may be used, which will allow a more keen architecture, and also fits well to the construction system. The ideal construction solutions for the rationalization of the process are those in which certain tasks don’t interfere upon others, always seeking to minimize the operations of long
duration. Based on this statement, it can be said that the precast staircase helps to rationalize the construction process.

Within the options for precast staircases, the challenge for the designer is to choose which type will fit best the project at hand, aiming for productivity, savings, compatibility with the construction process, and planning.

It should be pointed out that there can be situations in which a precast staircase should not be used. For example, when there is a wall parallel to a precast piece with no adjacent flagging. In this case, by adopting a precast solution, the wall’s local stability may be jeopardized and create problems of buckling, because the staircase would join this wall without any flagging in all floors. These situations will not be mentioned in this work.

TYPES OF PRECAST STAIRCASES AND PROJECT EXAMPLES

Amongst the options of precast staircases currently available in the Brazilian market, the most usual staircases found in structural masonry building are shown in this paper. These staircases can be divided into two main groups: the staircases composed by light elements, and the staircases composed by large dimension elements.

STAIRCASES COMPOSED BY LIGHT ELEMENTS

First, it’s shown the staircases composed by light elements, and examples of application in structural masonry projects, in which each staircase was used and the reasons why it was chosen.

“STEP-LADDER” TYPE STAIRCASE

The “step-ladder” type staircases are those in which the stair steps are supported by pieces anchored to the walls through the use of screws and bushings. These anchored pieces are made in reinforced concrete, exposing one of its indented sides. The stair steps are also made of reinforced concrete, anchored to the pieces screwed to the walls and to the lower stair steps, by the use of mortar.

In figure 1, the parts that compose a “step-ladder” staircase are shown.

![Figure 1: Elements of the step-ladder staircase: stair step [a]; stairhead [b] and stepped or indented beam [c]](image)

The “step-ladder” type staircase is used on stairwells that have central reinforced walls, due to the need of supports to anchor the pieces that support the stair steps. These walls should be able to withstand the strengths from the anchoring of the precast pieces.
The elements of the “step-ladder” staircase are limited to a maximum weight of 50 kg per worker, which leads the designer to reduce the dimensions of the piece.

In figure 2, a project is shown in which a “step-ladder” staircase was chosen on ideal conditions for its use: nearly no variation on the geometry of the stair steps (i.e., the occurrence of repetition for a good use of the mold used for the precast pieces), the presence of reinforced walls on both sides for the anchoring of the indented beams.

![Figure 2: Example of a project where the “step ladder” staircase was used](image)

**“STEP-LADDER” STAIRCASE WITH VARIANT PIECES**

On some constructions, the use of “step-ladder” staircases is possible and feasible. But, in a small portion, where there is no support on both sides, by developing a precast piece slightly bigger composed of two or more stair steps, it’s possible to achieve an adequate, light, and low cost staircase. Figure 3 presents an example of a project that used the “step-ladder” with a variant piece A6. This piece was designed to be supported in one side by one of the stair steps and the other side on the slab of the top floor.

**PRECAST “WINDING” STAIRCASE**

On precast “winding” staircases, the balanced stair steps are anchored to a column by one of their extremities. The stair step itself, containing an open element on one of its extremities, will serve as a mold for the formation of the column. This type of stair can also be part of a staircase, composed partially by a “step-ladder” and partially by a “winding” staircase, to achieve the desired architecture.

The “winding” staircase is mostly used in structural masonry houses, due to its keen architecture, light precast pieces, and therefore very compatible with the constructions system. On Figure 4, an example of project of a staircase used in a horizontal condo is shown, presenting light precast pieces, with the stair steps supported by the stepped beams, and “winding” stair steps. In this project, different colors were used for different precast pieces for better distinction.
Figure 3: Piece A6 from this staircase is an example of a variant for the “step-ladder”.

Figure 4: Ground plan of a staircase composed partially by steps in “winding” and the increased geometry of the stair steps in plan.
STAIRCASES COMPOSED BY LARGE DIMENSION PRECAST ELEMENTS
This type of precast staircase is composed of single, large dimension elements, directly supported on beams, flagging, or consoles on the walls, having or not the stairhead incorporated, as indicated in figure 5.

The weight of the elements makes it impossible for them to be transported manually, requiring the use of special hoisting equipment. Therefore, adopting this kind of staircase basically depends on the assembly equipment available on the work site.

![Figure 5: Precast staircases composed of large dimension pieces](image)

Transporting a staircase composed by large dimension elements by hoisting, is an example of a transitory situation in which the piece will suffer different requests than the ones that will occur in the final situation, and that must be foreseen in the project.

The precast staircases with large dimension pieces have been used in taller buildings that have hoisting equipment on site allowing the logistics in the work premises easier.

The architecture and the ground plan are also important factors in determining which staircase will be used in a construction. Some items cannot be ignored during this stage, as for example how this staircase will be supported, and if it will require any type of closing. On Figure 6, there is an example of a project in which a precast staircase with large dimension pieces was used, and where the architecture did not require any kind of closing.

![Figure 6: Precast staircase composed of large dimension elements](image)
In architectural projects where the flight of steps is positioned in “U” or in “O” shape, composed by 3 or 4 flights of large precast pieces, a central void is formed and needs closing. It can be a closing duct composed of precast pieces. These pieces are positioned one over the other, and fit into each other, as shown on the elevation in Figure 8.

The precast duct is very efficient when built carefully and with criteria. The pieces that make up the duct are composed by thin walls, and after its assembly, the duct is not locked laterally.

Figure 7: Project of a precast staircase with a closing duct
Figure 8: Project of the precast duct
This duct in most cases is dimensioned to support only its own weight, therefore no other charge must be unloaded upon it. The staircase must be built with a 1.5 cm slit from the duct, and when it reaches the top flagging, it must have a 2 cm wedging. Figure 7 shows an example of a project for a precast staircase composed by large dimension elements and with closing in a precast duct.

Table 1 presents a comparison of the types of precast staircases most commonly used in structural masonry projects, which were exposed in this paper:

<table>
<thead>
<tr>
<th>Type of precast staircase</th>
<th>Pictures of the work site</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Step-ladder” staircase</td>
<td><img src="image1.png" alt="Picture" /></td>
<td>Composed by small and light pieces that can be transported by one or two workers. Fits the structural masonry system due to the fact that the walls resist the strengths of anchoring the “stepped” beam. Additionally, this staircase does not require hoisting equipment.</td>
</tr>
<tr>
<td>Step-ladder staircase with variant piece</td>
<td><img src="image2.png" alt="Picture" /></td>
<td>Despite the variant piece being a bit larger than the other pieces of the “step-ladder” staircase, it allows for the use of a lighter precast staircase on a construction that doesn’t have specific equipment.</td>
</tr>
</tbody>
</table>
Because it is more interesting, architecturally speaking, this staircase is composed of light pieces and can be used in projects of houses in structural masonry.

For tall buildings, where the use of hoisting equipment is required, it is an advantage to use a precast staircase of large pieces, which can be easily hoisted and assembled, assisting in the logistics of the construction.

Table 1: comparison between the types of precast staircases most commonly used in structural masonry projects

CONCLUSION
Through the study that was made based on the projects, the solutions that were used and the reasons that led to such solutions for each construction, concludes that there is great advantage in using precast staircases in structural masonry buildings, with the rationalization of the construction processes and the elimination of construction steps, minimizing interference between subsystems, and elevating the quality of the final product.

It should be pointed out that controlling the production of precast pieces is imperative. These are delicate pieces, slim, light, thin layered, and they must be produced with criteria and following certain standards.

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