SLABS CONSTRUCTIVE PROCESS FOR STRUCTURAL MASONRY

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ABSTRACT

The present research focuses on the constructive analysis of the following slab typologies: concrete slabs, small beams expanded polystyrene floor system the stuffing material and, in lattices panels. It goes this purpose, the slab execution service was separated in the several component activities of the production process, identifying the execution of the requirements of execution norm. The intervening factors were analysed according to the Brazilian norm, complemented with the British norm.

The analysed enterprises were in structure wall of concrete blocks and was used the buildability requirements, to improve the process of execution of the construction. These requirements were related with the project simplification, sequence of activities, standardization of components and accessibility to places of the work. The result could be observed that the execution of the requirements of the norm improved the buildability of the construction plans. It also made possible the reduction in the period of execution, the reduction of wastes in the process and the elevation of the quality of the undertaking final product.

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INTRODUCTION

During this research it was studied the constructive aspects of structural masonry and some kinds of slabs. The structural elements were appraised according to the Brazilian norms, complemented with the British norms.The constructive analysis was done to the following typologies: concrete slabs, small beams expanded polystyrene floor system as stuffing material and, in lattices panels. All of them in structural masonry of concrete blocks, placed in the city of Florianópolis/SC – Brazil.

The slab build up activities were separated in six groups: mould assembly, slab assembly, concreting preparation, concreting, surfaces regularization and final services.The slab and walls build up services were subdivided into several component activities of the production process, where it was identified if they fulfill the requirements of the norm.

The research still shows the differences among the constructive processes of the slab typologies studied and how these differences interfere in the sequence of the construction assembly. The theoretical reference used in this research is related to the buildability concepts applied in the constructions, which permit the transparency of the production process and facilitate the increase of quality in the buildings.

The theory was applied through a tool that allowed the comparison between the norm requirements and the ones practiced during the construction, as well as the segmentation of the building constructive process in operational nets, composed by micro-activities that belong to a service, as showed in picture 1.

METHODOLOGY

For the work accomplishment, the constructive process of buildings in structural masonry, with the kinds of slabs mentioned before, was accompanied, since the demarcation of the first block line to the final slab concreting and cure. The dismould was not observed, because each building presented its own procedure This accompaniment took place in the slabs through the division of the process in the six production groups. There were standard groups for the several types of slabs of the research.

It was observed the involved teams, the activities duration, and the possible alterations in the work schedule that can change the order of the activities, interfering, this way, in the constructive process as a whole. The time spent to build up the different types of slabs were compared, considering the standard time for the parts assembly and the work procedures associating them with the existent conditions and materials.

The observation consisted in accompanying the assembly of each stage, with the people involved, their relationship to the activity, the permanent or auxiliary materials used. By that observation it was possible to compare the norm requirements and the

procedures practiced at work. There were interviews with the responsible for the work and structural designer involved, besides informal conversation with the planners.

It is observed that, considering the structural project it cannot make a mixture of different norms, what would lead to structural risks. During the construction, the norms complement themselves, starting from the point that the requirements don't interfere in how the structure will work.

The British norm complements the Brazilian norm because there is a British influence in the south of Brazil. It should be realized that the Brazilian norm works with acceptable tensions while the British norm works with ultimate limit state. In the site, the fulfilling of the norm requirements and their influence on the construction were observed. Then, there was the tabulation of the results for the slabs typologies of the research.

Small and medium companies that work with residential buildings with 2 to 10 pavements and their trade use the observed types of slabs. The slabs assembly was divided into the following groups according to the sequence of activities: mould assembly, slab assembly, concreting preparation, concreting, surfaces regularization and final services.

With this sequence of activities, the general ones were determined and the specific activities for a certain slab type were in evidence. There was a comparison of each duration assembly group, the people involved, the accomplishment of the constructive sequence and its consequences. It was done a qualitative analysis of the microstructure of the several activities of the services.

Technical norms analyzed

The Norms used in this research were:

- NBR 10837 (1989): structural masonry calculation;

- NBR 8798 (1985): construction in structural masonry with hollow concrete blocks;

- BS 5628 (1992) Part 1: Section four. Project: considering the details;

- BS 5628 (1992) Part 3: Section four. Labor quality.

Project considerations and labor quality were based on the Brazilian and British norms. The Brazilian norm is about structural masonry with hollow concrete blocks while the British norm is about both blocks and bricks, considering the kind of material. Both norms try to guide the construction and control of the masonry by already arranged ways for a high quality product. The Brazilian and British norms differ in the calculation aspect. While the British norm considers the construction details because its suppliers control, the Brazilian norm takes the masonry construction control under consideration.

The NBR 8798 (1985) approaches the accomplishment and control of the units of each material in particular. This norm is not about the production of the whole, for example, a wall with its several openings for doors, windows and air conditioning boxes and also for slabs openings for the *shafts*.

Buildability

According to SANTOS (2000), the buildability searches to increase the quality patterns of the final product, improving the production processes and the management of the construction parts. According to O'CONNOR and TUCKER (1986), buildability is " the project conditions ability to allow the use of the construction resources".

These concepts help with the identification and posterior correction of the project problems, through the accompaniment of the process flow, searching for previous solutions to avoid the immediate decisions in the construction site. These problems can be identified through a flow chart of the processes, starting from the process map and the operational nets. This tool allows the productive process understanding by the services segmentation in its several micro activities, in a sequential way or parallel to another services accomplishment. The symbols that represent these activities are shown in picture 1.

According to ROMAN et al. (2000) the operational nets are obtained starting from the flow chart of processes or from the construction sequences described for the several construction services. This flow chart facilitated the representation by the graphic description of a work method and each production step is represented by symbols that form a diagram. It is still a qualitative visualization tool of the productive process, which allows the rationalization, through the minimum of the activities that don't add value to the product. As an example, there is the flow chart for the construction process of the structural masonry represented in the picture 2.

OBTAINED RESULTS

Slabs

According to its construction form, the slabs can be moulded in the place or slab precast. In the first group there are the concrete slabs, beam brick floor system with ceramic blocks and prestressed slab in an adherent way. There are several types of the slabs precast in the market and they suffer alterations according to the maker. The verified types were the slabs with small beams expanded polystyrene floor system as stuffing material and, in lattices panels and concrete slabs moulded in the place and trellis panels. The main differences among the three slab types can be seen in the picture 2. The pre-moulded slabs have their transport until the pavement in a manual way, it means, it was not necessary the crane use. The slabs in trellis panels had widths of 12,5 cm or 25 cm, which allowed the slab transport for two or three workers.

Concrete slabs. Some activities of the concrete slabs were eliminated in the precast ones as: mould cleaning; desmold oil use; and assembly of the positive and negative reinforcements. In this case the trellis already has this function - these slabs only receive distribution reinforcements to guarantee the use of the group. For the concrete slabs, the activity of inert material placement that represents the group assembly of the slabs doesn't exist. It doesn't also exist the activity of placement of the piers prop, because it is brick masonry construction building, the same could be verified in the precast slabs.

Precast slabs. In the case of the precast slabs, the electrical installation was placed at the end, after the assembly of the whole reinforcement besides the one of distribution, with the retreat of the inert local material or with the precast break. The precast slabs have a transparent process and a fast assembly. However they demand a larger care with their handle to avoid accidents. This kind of slabs doesn't present a plane surface that serves as support during its assembly, as in case of the mould. As it has already been mentioned, the precast slabs don't present the activities of the mould use and spacing. They present, on the other hand, the activity precast panel placement. This activity is always in the beginning of the group assembly of the slabs. The precast panel substitutes the placement of the main reinforcement.

The slabs in trellis panel didn't present the activity placement of inert material, group assembly of the slabs and instead of leveling mortar course it was used leveling staff preparation group to concrete of the slab. When the brick masonry wall was built up, it was observed the page organization, the materials placement sequence, the project use, connections among walls, special elements and placement of built-in elements. It was verified that the slabs level interfered in the demarcation of the first block lines.

Comparison of the norm requirements and the ones practiced at the building site

For the comparison of the requirements of construction in structural masonry, it was prepared a table (table 3), with the indication of the common and divergent points between the researched norms and the norms practiced in Brazilian works. There were comparisons among the requirements of the Brazilian and British norms for construction in structural masonry, trying to complement the Brazilian norm in the constructive process. It could be observed that such norms present different parameters related to their environmental and cultural country conditions.

There are no occurrences of earthquake or excessive variations of temperature, in Brazil as in England. These considerations influence the in structural masonry technical norms of these countries. During the projecting it should be used only one norm type to avoid shocks among the considerations of other ones. The constructions in reinforced concrete are part of the Brazilian culture. In the United States and Europe, the structural masonry is dominant. This situation is changing in Brazil, once it can be verified the gains brought from that productive method to improve the use of construction resources.

The Brazilian norm failed with some calculation requirements. It doesn't do a lot of considerations as the one of walls and beams working together and the action of lateral loads, especially loads owed to the wind. Maybe this omission comes from the fact that Brazil is in an excellent geographical situation without the incidence of earthquakes, twisters or other climatic catastrophes. These situations demand project of the structures larger safety. It was suggested to complement the Brazilian norm with the calculation of the moments related to the action of the wind in the structure. At once, there is the NBR 6123 (1985) that makes considerations about the incidence of the wind in Brazil.

The Brazilian norm NBR 8798 (1985) brings more details regarding the storage conditions, besides the addictive and steel than the British norm. However, the blocks BS 5628 (1992) have specifications for different types of blocks and requirements for piling up on the slabs. The Brazilian norm, however, is not about the quality of the labor, because it specifically approaches the quality of the product. In this case the British norm is more developed by existing a partnership between customer and vendor with the use of real quality materials. Neither one are about the industrialized materials, therefore they transfer responsibility in the use of these products for the maker by recommendations contained in the packages.

The British norm indicates the mortar lines to use, while the Brazilian norm doesn't mention any proportion. At work the technical team makes the decision they think it's more convenient. There is no exploration of a mortar that has an appropriate consistency and is economic at the same.

FINAL CONSIDERATIONS

With the segmentation of the constructive process of the researched types of slabs each micro constituent activity could be observed. That division in micro activity can be used for best to program the sequence of execution of the slabs. This segmentation contributes in the programming of the activities, allowing the anticipation of the points problems to the production stage. This comes to contribute with the increase it dates rate of PPC (percentage of concluded programming) in the measure in that allows improve the planning of the enterprise.

When allowing that the programming is executed it is possible to avoid the evil use of the constructive systems, reaffirming the advantages of the structural masonry, especially those associated to the rationalization. The use of the precast slabs presented a better process, for the standardization and modulation of the pieces and assembly easiness, because they release the cast use. Even so, they need care in I handle it for not damaging the piece and to avoid accidents for falls. The investment in the constructive sequence for the slabs with small beam trellis took to the increase of time in the whole process and to structural damages, because the electric facilities and the boxes of passage were placed after the placement of the pre-moulded ones and of the reinforcement of distribution of the same ones, with the consequent displacement of the bars of steel. The activity of assembly of the eletrodutos was hindered below by the passage of these of the treliças and also for the passage of distribution armors in this

same space.

The slabs with trellis panel presented activity of complemental processing, what took the delays in the group assembly of the slabs, for they possess complemental bars of steel as the positive reinforcement. Due to space impossibility these were introduced in the base of the precast, disposed in the whole extension of the empty space.

REFERENCES

ASSOCIAÇÃO BRASILEIRA DE NORMAS TECNICAS. NBR 10837: cálculo de alvenaria estrutural de blocos vazados de concreto. Rio de Janeiro: Nov., 1989. 20p.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TECNICAS. NBR 8798: execução e controle de obras em alvenaria estrutural de blocos vazados de concreto: Procedimento. Projeto 02.323. Rio de Janeiro: Fev., 1985. 29p.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TECNICAS. NBR 6123: forças devidas ao vento em edificações: procedimento. Rio de Janeiro: 1988. 110p.

BRITISH STANDARD, (1992). Code of practice for: use of masonry. BS 5628: Part 1. Structural use of unreinforced masonry. 58p.

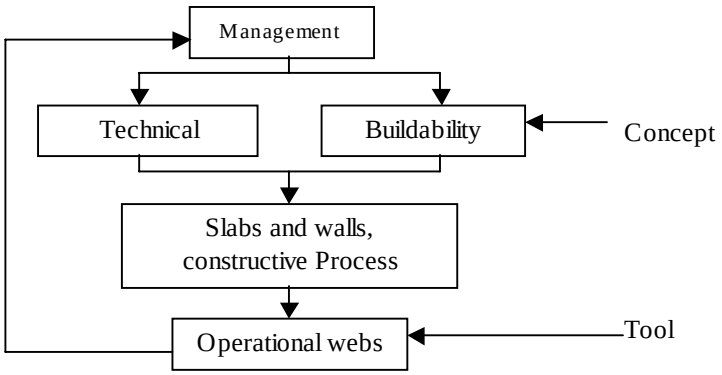
BRITISH STANDARD, (1992). Code of practice for: use of masonry. BS 5628: Part 3. Materials and components, design and workmanship (formerly CP121:Part 1). 99p.

O'CONNOR, J. T., TUCKER, R. L., (1986). Industrial project constructability improvement. Journal of Construction Engineering and Management, v.112, n.1, p.69-81.

ROMAN, H. R., *et al.*, (2000). Alvenaria estrutural - capacitação empresarial. Módulo 1: administrador de obras, CD, Florianópolis.

SANTOS, D. G., (2000). Análise construtiva dos tipos de lajes utilizadas nos sistemas estruturais nas edificações em Florianópolis. 99p. Dissertação (Mestrado em Engenharia Civil) - Programa de Pós-graduação em Engenharia Civil, Universidade Federal de Santa Catarina, Florianópolis.

Figure 1: Diagram for continuous process feedback.



Symbol			
Processing		Moving	
Inspections		Non-documentary precedence	
Storage		Resource	
Transport		Decision	
Pause		Processing (rework)	

Square 1: Flowchart symbols to map out the process.

Differences between the slabs	Cast in place	Precast	
	Concrete slab	Small beam trellis	Trellis panel
Concreting facility			
Security			
Structural strength			
Discontinuity			
Cast use			
Support use			
Concrete use			
Thermal and acoustics properties			
Fire resistance			
Sill in huge spaces			
Short use of steel			
Inert material use			
Central production			
Great number of workers			
Fast construction			
Clean			
Stanching			
Finishing			

Square 2: Main differences in the constitution and execution of the researched slabs.

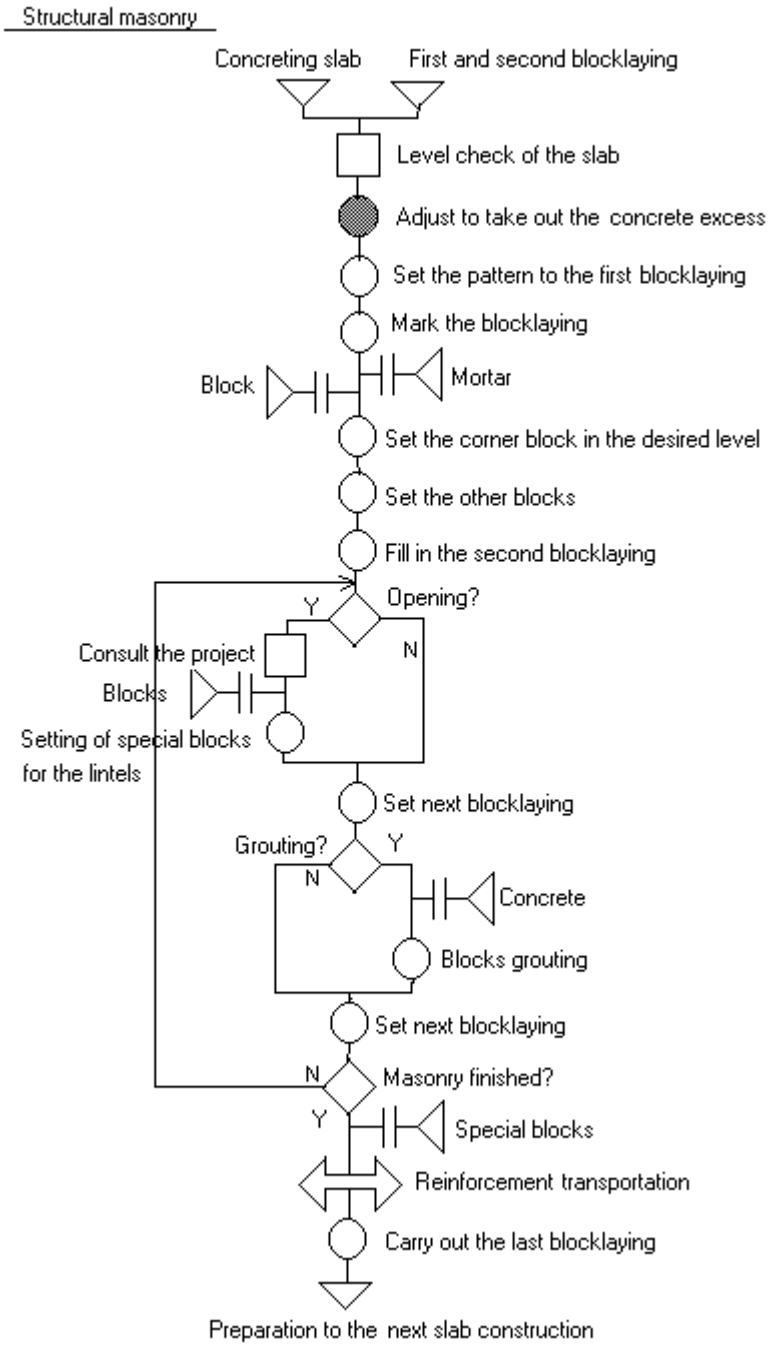


Figure 2: Flowchart of execution of the structural masonry.