Constructive adaptations for implementation of a bank agency in the city of Manaus/AM - case study

Adaptações construtivas para a implementação de uma agência bancária na cidade de Manaus/AM - estudo de caso

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ABSTRACT
For the implantation of a banking institution with installation of Rearmable Strong Box (RSB), object of this case study, it was necessary analysis of the existing structure and implementation of structural steel reinforcement to ensure that the efforts to which the structure of the building was designed had a reinforcement implementation to distribute the loads on the pillars and thus allow the installation of RSB properly and meeting the Brazilian Standards. The study of the initial project and the limit loads supported by the structure in the RSB installation area indicate the need to perform a strengthening in the existing structure, so the type of strengthening and the methodology of implementation are raised in order to compromise as little as possible the existing facilities and allow the RSB to be installed. This case study was performed in a building of four floors and two basements located in the city center of Manaus, Amazonas state, and the intervention was performed in the 1st basement. The results obtained were satisfactory and there is no indication of overload in the distribution of the efforts imposed on the structure after the execution of the structural strengthening project.

Keywords: Structural Reinforcement, Metallic Structure, Rearmable Strong Box

RESUMO
Para a implantação de uma instituição bancária com instalação de Caixa Forte Rearmável (CFR), objeto deste estudo de caso, fez-se necessário análise da estrutura existente e execução de reforço estrutural metálico para garantir que os esforços aos quais a estrutura do prédio foi projetada tivessem uma implementação de reforço para distribuir as cargas
nos pilares e desta forma permitir a instalação da CFR de maneira adequada e atendendo as Normas Brasileiras. O estudo do projeto inicial executado e apontamento das cargas limites suportadas pela estrutura na área de instalação da CFR apontam a necessidade de ser executado um reforço na estrutura existente, com isso levantamos o tipo de reforço e a metodologia de execução afim de comprometer o mínimo possível as instalações já existentes e permitir que a CFR seja instalada. Este estudo de caso foi realizado em um prédio de quatro pavimentos e dois subsolos situado no centro da cidade de Manaus, estado do Amazonas, e a intervenção foi realizada no 1° Subsolo. Os resultados obtidos foram satisfatórios não existindo qualquer indicativo de sobrecarga na distribuição dos esforços impostos sobre a estrutura após executado o projeto de reforço estrutural.

Palavras-chave: Reforço Estrutural, Estrutura Metálica, Caixa Forte Rearmável

1 INTRODUCTION

Financial Banking institutions, in compliance with Central Bank of Brazil Norms, cannot acquire or build their own real estate properties to operate in the market. Therefore, these institutions use the rental method to sell their products and serve the public.

However, the leased real estate needs to be adapted so that it can comply with the purpose of use of banking institutions. These adaptations vary from changes in layout to complex renovations involving the implementation of electrical networks, data network, CCTV and alarms and structural alterations and reinforcements in existing structures.

We deal with a leased property for implementation of a financial institution, in which should be installed a Strong Rearmable Box and self-service equipment.

The weight (permanent load) of these equipments is very significant, so for the execution of this service it will be necessary to evaluate the existing structure, make sure that it supports the load that will be imposed on it and if it does not meet, a solution must be proposed so that we can correctly and in accordance with Brazilian Standards make possible this deployment.

Existing the necessity of the accomplishment of reinforcements complementary projects of reinforcement are elaborated, as well as elaboration of descriptive memorial with the technical specifications in order to accomplish the norms not only for the elaboration, but mainly when the execution of the reinforcements.

In this way the following objectives were traced as guidelines for the materialization of the article, General Objective: To analyze the necessary adaptations for the implementation of the strong house in bank agencies in Manaus/AM. Specific Objectives: Address concepts and standards related to the works of constructive adjustments in construction works; Verify the process of constructive adjustments for the
deployment of a bank branch located in the center of Manaus/AM; Present the project of structural reinforcement proposed to enable the deployment of the strong house in the branch subject of this case study.

This study has an exploratory character and is based on a case study. Initially we will take note of the current conditions of the object of study, and then we will deepen in a specific condition of the problematic which expose the theme.

2 MATERIALS AND METHODS

The object of this case study, is a building with 02 (two) Basements, Ground Floor, Floor 1, and Floor 2, with total built area of 4,497.79 m², located in the Centre of the city of Manaus-AM. This was leased to a Financial Institution with the purpose of being suitable to become a Bank Agency.

2.1 OBJECT OF THE CASE STUDY

The existing structure was designed in 2013. The building has 5 floors, two basements, 1 ground floor, 2 type floors and a roof slab. The foundation structure is composed of blocks with dug piles, the retaining walls are of the type of juxtaposed piles, interlocked by the slabs of the 2 (two) basements and the ground floor. The floor structures are in unidirectional ribbed slabs with prestressed beams, all with 30 MPa fck, including the roof.

The slabs and beams of the basement floors were designed for a permanent action of 100 kg/m² and accidental action of 500 kg/m². The slabs and beams of the ground floor and similar floors were designed for a permanent action of 100 kg/m² and accidental action of 300 kg/m² and the slabs and beams of the roof floor were designed for a permanent action of 100 kg/m² and accidental action of 150 kg/m².

All masonry in the design and execution were dimensioned and executed with the value referring to the use of 8 hole ceramic blocks with 9 cm thickness and mortar coating of 2 cm on each face.
2.2 TECHNICAL REFERENCE PROJECTS

For the verification of the structures, the proposed new layout designs were provided (Figure 02). Below is presented image of the proposed ground floor layout in the indicated design, which will receive the two types of machines (Additional Loads).
2.3 ANALYSIS OF THE NEED FOR STRUCTURAL REINFORCEMENT

2.3.1 Purpose of the building

The purpose of the building object of this case study is commercial use, being put for lease, the large halls could be subdivided into rooms, using Dry-Wall or Naval Partitions, thus adding little load on the slabs and being within the capacity supported by the structure of the building.

However, the lease of this building was given to a financial institution that would adapt it so that it could serve as a bank agency. Therefore, due to the peculiarities of the adequacies that should be performed so that the building could fulfill the new purpose, a study was initiated both to verify the electrical installations (maximum capacity of electrical load) and the load capacity supported by the structure.

![Image Floor Plan](https://example.com/image.png)

Source: DOC. CEF (2020)

Limiting ourselves only to the reinforcement of the structure in the positions where permanent loads of significant weight will be installed and taking into consideration that the construction of this building had an engineering team composed by 3 (three) engineers in its execution and that the norms and regulations were followed, we started our analysis of the need to execute a structural reinforcement to attend the installations which are necessary for the implantation of a bank agency.
2.3.2 Project actions

In the verification we will adopt, besides the loads initially described in the building description, the information given by the technical engineering team, as shown in Table 1:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Weight (Kg)</th>
<th>Base Area (m²)</th>
<th>Distributed Load (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM</td>
<td>1.000</td>
<td>1.14</td>
<td>878</td>
</tr>
<tr>
<td>CFR</td>
<td>10.000</td>
<td>6.25</td>
<td>1.600</td>
</tr>
</tbody>
</table>

We must take into consideration that ATMs will be added 15 units.

2.3.3 Characteristic strength

For the characteristic strength, NBR 6118/2014 and NBR 8681/2003, specifies the weighting coefficients ($\gamma_c$) for the compressive strength of concrete in the U.L.S. (Ultimate Limit State) in:

$$\gamma_c = 1.4$$

The compressive strength and the secant modulus of elasticity of the concrete adopted in the verification were:

$$f_{ck} = 30 \text{ MPa} \quad E_{cs} = 26 \text{ GPa}$$

2.3.4 Structural analysis

The structural analysis stage will serve to evaluate and compare the behavior of the existing structure of the ground floor with the new loads applied to the following items:

- If the requested efforts as bending moment and shear force demand a different and superior reinforcement to the existing one.
- If the deformations of the new load are bigger than the previous ones and if they are or not within the limit.

These evaluations will be done based on the efforts diagrams of the original structure and the current structure with the new loads. The reinforcement details of the beams and columns in the region will also be compared to detect if there is a need to supplement the steel area of the sections.
If it is found that the existing reinforcement is insufficient, an appropriate reinforcement project will be drawn up to increase this area of steel.

Another evaluation will be the deformation of the ground floor with the new loads. The deformation of beams and slabs in the area where the ATM and Rearmable Strong House loads will be applied will be compared to see if there was an increase in deformation in the area and if this increase was greater than the normative limit. Remembering that the structure has prestressing cables already at work and as the deformation can be "negative" (the deflection of the beam or slab being above the structural level) the total differential of deformation will be considered as a parameter for evaluating the limits.

2.3.5 Requesting efforts

Due to the positioning of the machines (Reamable Strongbox and Self-Service Terminals, be in specific locations, not all the beams and slabs suffer changes in their efforts. In the case of shear and bending forces, the structural analysis carried out concluded that only beams V204 and V205 suffer significant change in behavior. In the case of the slabs, only the slabs L1 and L2 suffer changes in behavior, even then it was not throughout its scope, only in the concentration in the places of installation of the machines of Self-Service Kiosks and the Rearmable Strong House was noticed the variation of some form.
In Figure 05 above, which depicts the beam V204 that is directly influenced by the weights of the ATMs and CFR, it was detected that there was an increase in the flexural reinforcement in spans 02-04-05-06 (negative reinforcement) and 03-04-05 (positive reinforcement) in the order of 21% above the original value, in all spans cited. The shear reinforcement did not increase in steel area.

In Figure 06 below, which depicts the beam V205 directly influenced only by the ATM weights, it was detected that there was an increase of the flexural reinforcement in span 03 (negative reinforcement) and 02-03-05 (positive reinforcement) in the average of 24% above the original value, in all spans cited. The shear reinforcement did not increase in steel area.

In other elements, such as columns and slabs, no significant changes in reinforcement were detected, indicating that the load dissipated along the slab and distributed proportionally by the surrounding columns and foundations.

3.3.6 Deformations

The deformations will be evaluated in a bar grid model representing the beams and slabs, as the slabs are ribbed, the bars of the model represent the ribs of the slab.
Because it is a single model for the two elements, the comparisons made between the existing (Figure 07) and the new (Figure 08) will be made in a complete way for the floor.

Figure 07. Deformation Diagram of the Existing Structure on the Ground Floor - Without application of new loads

![Figure 07](image)

As can be easily seen in the images, it can be seen that the maximum deformation in the whole pavement increased from 3.16 cm to 3.79 cm (a 17% increase in the maximum point). This maximum deformation is precisely in the area where the CFR will be installed.

At the other points where the new loads were applied, the values tended to increase as well. In the region of the ATMs the deformation was "negative" due to the prestressing effect, with values close to +0.50 cm, after the loads were applied the values dropped to -0.20 cm (28% difference).

The deformation in the region of the ATMs is within the normative limits, but that of the CFR exceeded the desired limit for the site, which was 2.56 cm according to table 13.3 of NBR 6118/2014.
4 RESULTS AND DISCUSSIONS

In face of the analyses and comparisons made in the normative limit states and according to the values found for the new stresses and strains, it is proposed the adoption of reinforcements in the slabs that support the equipment. The reinforcement has to be able to support the demanded increase of steel area (more steel) and to balance the deformations in the two main points (more rigidity), but mainly in the region of the CFR installation, tending to leave the reinforced slab with final deformation close to the indicated limit.

Thus, a detailed reinforcement project should be prepared to work with the above desired characteristics.

It is important to mention that this strengthening should be fixed "exclusively in the columns, through mechanical anchors", because the beams and slabs have prestressing cables and the fixation of these anchors in them can severely harm their behavior.

For the foundation structures, the increase in load and stress was very small (less than 5% for columns P13 and P14 and even smaller for the other columns) and well distributed in the soil due to the large number of piles per block.

In the case of the columns, although we have an increase in load, they have sufficient capacity to absorb these additional loads without the need for reinforcement.

In this way a detailed project was elaborated together with its Descriptive Memorial, for execution and thus to assist the specified characteristics.

With the presentation of the Structural Reinforcement Project and the Descriptive Memorial, the Contracted Company performed the structural reinforcement as shown in figure 10 to figure 16.
Figure 10. Anchor plates

Figure 11. Metallic beams
Figure 12. Drillings in the Pillars (P17).

Figure 13. Drillings in the Pillars (P16).
Figure 14. Fastening of the Metallic Beams 1.

Figure 15. Fastening of the Metallic Beams 2.
5 CONCLUSION

For the Civil Engineering is of extreme importance the faithful fulfillment of the normative rules which guide in a proper way, correct and aiming safety and quality in the constructions.

To adapt buildings is somewhat of a challenge, given the complexity of changing layouts within the same structure. In this article, the building was rented by a financial institution, which after the proper analysis, in order to meet the use of a Bank Agency, and the installation of equipment needed for the institution, which have a significant load (weight) and not common to the market which the building had been designed.

The results showed that this building needed a strengthening in the structure, considering that when the loads were applied to the definitive points of its installations, certain spans presented variations very close to the Ultimate Limit State and Service Limit State (Limit States of Standard).

At the end of the study, we can conclude that it is extremely important the existence of a qualified professional (Civil Engineer) in any process of reform or adaptation, even if small, the knowledge of this professional will ensure that the constructive processes occur safely and mainly giving the certainty that the initial structure designed will meet or will need strengthening interventions to enable the new purpose to which the building will serve.
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Firstly, to our Lord God, for not only showing me the way, but leading me along it with strength and courage to follow without even thinking of giving up. This conquest is mine, but I did it for your honour and glory Lord, I thank you for everything, from my first breath here, until the last when I do.

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