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PROOF LOAD TESTING IN BRAZIL: A CASE STUDY

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Abstract: In order to analyze the real behavior of the structure, the proof load test provides a very precise analysis of its actual behavior, because it is a test carried out on the structure, thus encompassing all the singularities that the structural element may have suffered during its manufacture and use that may affect its operation (failures in the design and execution of the structure, maintenance omission, incorrect use, exposure to bad weather, among others). The national standard NBR 9607 (ABNT, 2012) prescribes the use of load testing in the following situations: concerns about the quality of construction materials, inadequate use, or maintenance, or even a new use of the building, different from the one initially planned in the project. This study aims to present the most important criteria that must be considered in a load test. The procedures recommended by norms are exposed, highlighting the following topics: load test, load test guidelines, applied load intensity, how to apply the load, and the test evaluation criteria. On the basis of the theoretical foundation, a case study was made applying such criteria, analyzing its results, and defining the load to be supported by the structure analyzed.
Keywords: Structural assessment, load testing, structures, and concrete.

INTRODUCTION

Reinforced concrete structures must be designed and built to meet safety, functionality and aesthetic requirements that are demanded as a result of the environmental stresses and influences that act on them during their service life. In recent years it has been observed a great degradation of structures due to certain pathological manifestations, associated with the use or environment in which these structures are inserted. Throughout the world, a significant degradation of reinforced concrete structures has been observed, either due to exposure to aggressive environments, aging or even modification of the use initially foreseen in the project.

The construction of new structures is an arduous task, especially considering the large volume of capital and time involved. However, many structures can be used without safety implications, through a structural assessment. In this perspective, according to Plewes and Schousboe (1967) two alternatives can be used in the evaluation of an existing structure: the analytical method or the experimental method.

Thus, Doebelin (1990) emphasizes that analytical methods require applications of mathematical hypotheses, with the real problem simulated through numerical modeling. Regarding the experimental methods, the author observes that they reveal the real behavior of the structure under load. Direct loading test on these structures - the so-called "load test" is the recommended way to solve the problem. Thus, it must be noted that the judgment of the resistant capacity of structures, in order to guide probable reinforcements (when necessary) cannot be exclusively based on analytical procedures. The direct loading test is the recommended way to solve the problem, because when we place the structures in the conditions for which they were designed, we will be able to observe their real behavior.

Looking for to contribute to the theme involving loading tests in structures, this research made a general survey of the normative aspects established in NBR 9607 (ABNT, 2012) - "Hardened concrete - load proof in reinforced and prestressed concrete structures" and, as relevance pragmatics presented results obtained in a real test of a structure.

THEORETICAL FOUNDATION

Describes in this chapter the main concepts involving a test load test, its definition, recommendation of when such test must be used, intensity of the test load, forms of application, the test evaluation criteria to obtain the correct results and the procedures for performing the test.

LOAD TESTING

According to NBR-9607 (ABNT, 2012) load testing is defined as a set of activities aimed at analyzing the performance of a structure through the measurement and control of effects caused by the application of external actions of previously established intensity and nature.

There are two types of load test: the static load test, which consists of observing the behavior of the structure under static load, and the dynamic load test, which basically consists of vibrating the structure and observing its behavior when vibrating. This study will be limited to the first case.

A static load-proof test can be classified as destructive or non-destructive. The destructive test is used when the objective is to evaluate the behavior of the structure until failure, in the ultimate situation of loading, while in the non-destructive test the structure or structural element is loaded at service levels, without reaching failure, thus allowing that the structure can be put back into use if the results are acceptable.

Thus, the test involves analyzing the response of the structure under the influence of loads and interpreting the results. As a rule, the response of the structure is through deformations and displacements.

RECOMMENDATIONS FOR CARRYING OUT A PROOF-OF-LOAD TEST

In some countries there are regulations that establish that certain structures for public use (such as bridges, for example) must be delivered upon proof of load. Likewise, they also establish specific situations where a load test must be performed.

In Brazil, the attitude adopted in relation to the usual concrete structures is that if they are executed according to the project and if the materials used are approved in the quality control tests, the automatic acceptance of the structure is admitted. For road works, the same criteria relating to the quality of materials are used, with a parallel verification of the structural design.

According to the Brazilian standard NBR 9607 (ABNT, 2012), a load test is recommended in cases of any change in the conditions of use of the structure, in the case of constructive phases that entail exceptional demands on part of the structure, after accidents or anomalies. observed during the execution or use of a structure, in the total or partial absence of design elements, when the constructive conditions are unknown or for the purpose of studying the behavior of structures.

TEST LOAD INTENSITY

According to the national standard, initially the test loads must be dimensioned based on the project and, in the absence of this, the originally intended use of the structure must be taken into account.

This way, it proposes a numerical value called the loading factor, which aims to indicate the level of stress that a section or point of the structure must undergo during a load test. The loading factor ψ is expressed by:

$$\psi = \frac{Fe}{Fd} \quad (1)$$

Where Fe is the theoretical requesting effort due to proof-of-load loading and Fd is the theoretical requesting effort due to design loading. Two parameters are also established: the loading efficiency and the test safety factor (Fs). The loading efficiency is the lowest value obtained for the loading factor. The factor of safety (Fs) is the lowest value obtained for the relationship between the resisting forces (Fu) and the stresses (Fe) caused by the test loading, and is expressed by:

$$Fs = \frac{Fu}{Fe} \tag{2}$$

being, Fu the theoretical last tough stress of the section.

Thus, the tests are classified into three categories: basic, rigorous, and exceptional, depending on the load intensity. Table 1, presented by the Brazilian standard, establishes the loading efficiency factor as a function of the type and use of the load proof test.

Tests	Charging Efficiency	Job
Basics	0,5 < X [1,0	- reception of structures under normal design and construction conditions; - study of the behavior of the structure.
Rigorous	1,0 < X [1,1	- dimensions, quality and/or quantities of materials do not meet the design requirements; - lack of knowledge of the project and/or construction conditions; - alteration of the conditions of use foreseen for the structure; - after accidents or anomalies observed during the execution or service life of a structure.
Exceptional	X > 1,1 (A)	- passage of exceptional loads; - construction phases that cause exceptional stresses on parts of the structure.

(A) The safety factor of the test in relation to the ultimate limit state of the structure must be greater than 1.4, except in conditions of causing the structure to fail, for research purposes. (NBR 9607: 2012).

Table 1 – Classification of load tests. Source: NBR 9607 (ABNT, 2012).

An important aspect to be highlighted is that NBR 9607 (ABNT, 2012) designates requesting efforts by "F", contrary to NBR 8681 (ABNT, 2003), in which the designation "F" is given to resistant efforts.

FORM OF APPLICATION OF THE LOADING

The standard primarily specifies that the actions imposed on the structure can be static or dynamic in nature, and in terms of permanence they can be fast or slow. The number of partial loads or load positions on the structure must depend on the nature of the test and the knowledge of the work. In fact, it does not clearly specify the required number of load increments to be applied but recommends that at least four load application steps must be controlled before conclusive proof loading is reached. The analysis performed after each load increment is essential to release the structure for the subsequent load stages.

An aspect highlighted by the standard is the immediate analysis of the results. This analysis must be carried out after each loading step and draws attention to the analysis of the residual values of displacements obtained after unloading, as these values can indicate the elastic behavior of the structure.

ACCEPTANCE CRITERIA ACCORDING TO NBR 9607 (ABNT, 2012)

The referred standard establishes that the acceptance criteria and the calculations of the forecasts of the effects must be made on the basis of the project. Therefore, the following aspects must be analyzed in the calculation memory: design criteria, standards used, specified materials, design loads, safety factors and relationships between the quantities of materials resulting from the design and those existing in the structure.

In cases where technical records are insufficient or not known, investigations into the structure must be carried out through inspections of the work and consultations regarding the time of its execution, and the following aspects must be evaluated:

> a) Geometric features: execution of "as-built" plans, formwork, connections, joints, etc.;
>
> b) Originally intended use of the structure: the original purpose or class of road or rail for which it was designed;
>
> c) Conditions of requests to which the structure has already been submitted: intensity and frequency of the acting loads;
>
> d) Structure age;
>
> e) Rules in force at the time of its execution: calculation hypotheses, available materials, prescribed safety factors;
>
> f) Analysis of similar works built at the same time.

EXECUTION OF A STATIC LOAD TEST

PLANNING

In the work of Bares and Fitzsimons (1975), it is observed that the load test itself can start only after the entire procedure has been planned.

The first clear definition is what is intended to be analyzed with the test, as the load tests are parameters both to verify the ultimate behavior and in service, of a structure or structural element.

Once the purpose of the test is defined, the planning process of all stages of the process begins. In this sense, in the cases of tests on structures, a wide interaction between the team responsible for the test and the design engineers (when possible) is suggested.

Thus, calculations are made for a previous guarantee of orientations before the tests are conducted, as they will be used to estimate the loading intensity and the value of the deformations to be measured. They can also be used to judge the expected load test procedure and the expected response of the structure.

PRELIMINARY WORK TO THE TEST

In the preparation phase, the structure must be subjected to a preliminary analysis carried out in the first instance visually. This analysis must be convincing in showing the need for the test itself, as it will determine in which direction the work must be carried out.

The NBR 9607 standard (ABNT, 2012) specifies that:

> "To carry out a load test, it is necessary to know the real conditions of the work in all its aspects, such as design, materials, execution control and state of conservation and use."

A structural assessment is a complex interaction between environmental and structural data, visual inspection data, in-situ test data and research laboratory data.

To achieve the proposed objectives, the structure and all its parts must be inspected in detail to verify that the construction meets, at least visually, all the requirements shown in the project (if any). Attention must be paid to the state of conservation of the constituent materials and whether there are any apparent signs of deterioration of these materials.

INSTRUMENTATION OF THE STRUCTURE AND TYPES OF LOADS USED

Cánovas (1988) notes that load tests are, in general, expensive, and complex and can, in some cases, be dangerous. And that is why it

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is necessary to study in great detail the entire arrangement of instruments, as well as the loads, with the aim of simplifying the process as much as possible. Likewise, measures must be taken to prevent structural collapse in the event of failure in the tested area.

Special attention must be given to the installation step of the measuring instruments. Much equipment requires exceptional care in the installation, in case of using sensors, the fixing surface must be prepared. Mechanical equipment must be fixed to the structure in a level manner.

The reliability of a load test according to Palazzo (2002) is related to the quality of the instruments used, it is therefore necessary that the use of a certain type of instrument has been previously determined in accordance with the objectives of the test and the results.

A general plan must be prepared, clearly containing sections and details of the points to be instrumented, containing: locations, quantity, and detailed installation of each instrument. Specifications must identify those responsible for each activity (installation, calibration, maintenance, data collection, and evaluation) and provide detailed instructions for each activity. Another key step is the type of loading to be used in the test. It must be reiterated that the test loading is associated with the availability of materials and is a function of the type of element to be tested, in the case of Ground floor slabs, for example, water, hydraulic jacks, aggregates or sandbags can be used. In the case of road and rail bridges, own (or adapted) vehicles are routinely used for this purpose.

EXECUTION OF THE TEST

Palazzo (2002), describing the execution of static load tests, comments that the test is only carried out after all the verifications and studies necessary to know the design of the structure, its theoretical behavior in relation to the loads foreseen for the test and finally to the planning of all logistics such as types, numbers and positioning of equipment, team involved, activity involved by each team member, type of loading to be applied, test duration, loading stages, control of results, verification of observed effects, collection and data storage.

Once the type of load to be used is defined, the loading process of the structure must be done continuously, so as not to impact the structure. After the application of each increment the structure must have its behavior analyzed, verifying the deformations and displacements, and comparing with the analytical model. Attention must be paid to the existence of signs of breakage in the elements. This analysis allows observing the appearance of cracks and whether the structure is behaving as expected.

When applying the entire load, the structure must be submitted to evaluations and comparisons of the data collected with the expected response, based on acceptance criteria. After this step, we move on to the unloading phase, which must also be carefully analyzed through data collection and comparison with the behavior in the loading phase. Comparisons in the discharge phase allow the verification of the elastic behavior of the structure.

The Brazilian standard for design of concrete structures, NBR 6118 (ABNT, 2014) “Design of concrete structures - Procedure” notes that when the final non-compliance of part or all of the structure is found, one of the following alternatives must be chosen:

a) Determine the restrictions on the use of the structure;

b) Provide the reinforcement project;

c) Decide for partial or total demolition.

END OF ACTIVITIES

Once all activities are completed, a test report must be prepared containing the information observed in the structure. NBR 9607 (ABNT, 2012) recommends that the report must include: identification (of the structure, owner, test performer, etc.), objective of the test, state of construction of the structure, previous theoretical studies, test loading, measures, controls carried out during the loading of the structure, definitions of the conditions of use of the structure and completion.

From the decision to perform a load test, its execution, control and final test report, the standard draws a flowchart shown in figure 1 below that can be used as a parameter for a brief script of the activities developed in a test load.

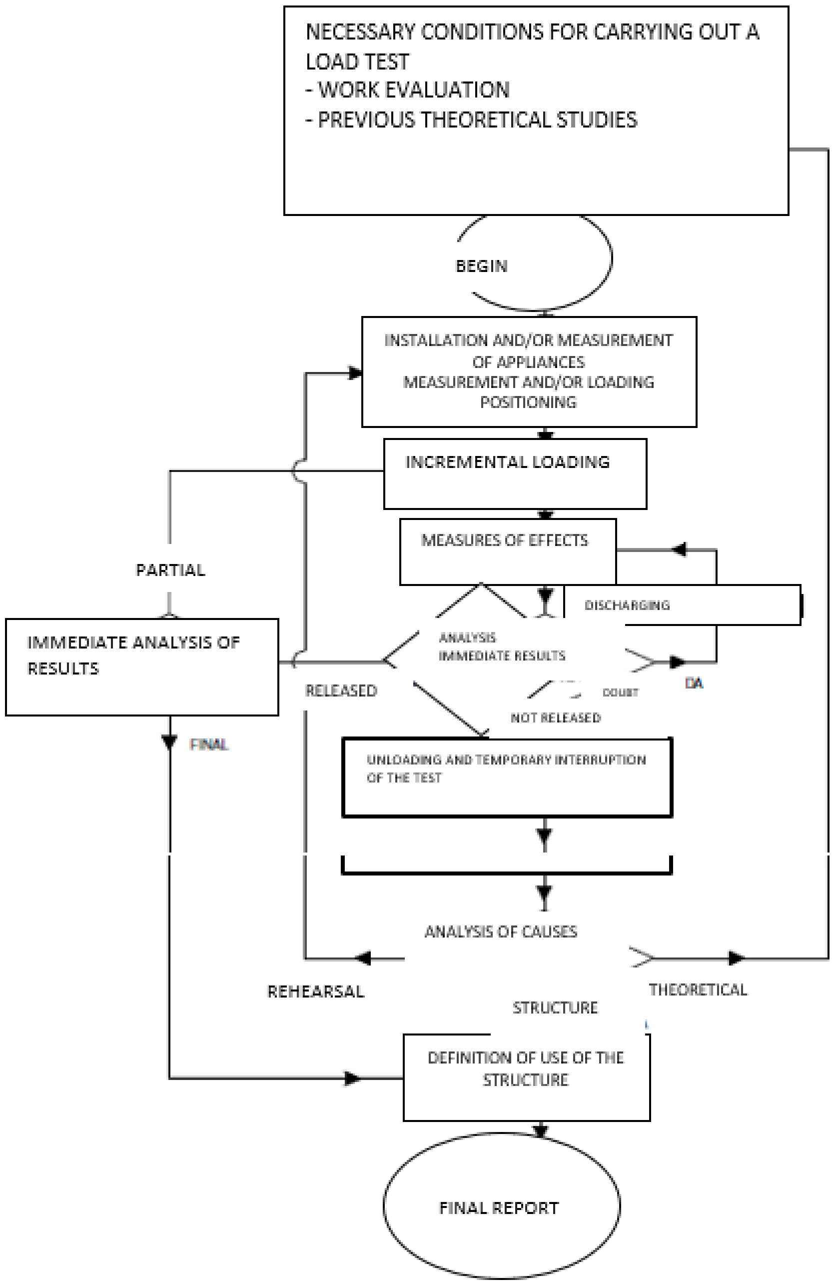

Figure 1: Flowchart of load test control activities. NBR 9607 (ABNT, 2012).

RESEARCH METHODOLOGY

This article can be considered as bibliographical research, in view of the theoretical framework present in chapter 2. However, from the point of view of practical application, it can be conceptualized as a case study since an example to be used is presented. analyzed in the subsequent chapter. Therefore, to fulfill the proposed objectives, the methodology developed in the preparation of this work was divided into two stages, namely:

- Bibliographic survey: At this stage, it sought to raise the main concepts and definitions of the Load Proof test, presenting all the recommendations proposed by the Brazilian standard;
- Case studies: From the theoretical basis described, it was possible to present an example of a load test performed by Prof. Dr. Armando Lopes Moreno Júnior, proving to be feasible to expose the entire procedure and criteria adopted.

CASE STUDY

It is of significant importance for scientific development to present practical examples from theories and recommendations extracted from technical standards, books, and recommendations from renowned authors. With this thought in mind, we present a practical example of a load proof test on solid Ground floor slabs in reinforced concrete, carried out by Prof. Dr. Armando Lopes Moreno Junior.

The panel, in which the test was carried out, corresponds to the intermediate level of an industrial building, as shown in figure 2. The environment below the panel was occupied by industry laboratories and in its upper environment were deposited materials used in the production of the industrial.

Figure 2: View of the lower and upper floors of the Ground floor slab panel to be analyzed

The pavement in question did not have a structural design, that is, it did not have specifications of the dimensions of the structural elements, details of their reinforcements, resistance of the concrete and steel used during the execution of the panel and, also, the type of foundation used in the work was unknown.

The "layout" of the factory underwent constant changes. The upper region of the panel was being used to store material from the factory, it was always an unknown in the elaboration of any "layout", since specifications regarding the loading limit allowed to the region did not exist.

Before being subjected to the load test, a load corresponding to approximately 300 kgf/m² was acting on the panel, referring to the raw material stock of the industry. All over the panel, forklifts whose total load (forklift weight + transport load) could reach 4,700 kgf with free movement.

Thus, in opposition to what is described in item 2.3 about the level of stress that a section or point of the structure must be subjected to during a load test as established in the national standard, the test in question was performed with the objective of determining the maximum load uniformly distributed that the analyzed pavement could be safely subjected to.

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Figure 3 illustrates the layout, in plan, of the structural elements constituting the panel. Columns, beams, and Ground floor slabs in reinforced concrete of the analyzed panel are illustrated below.

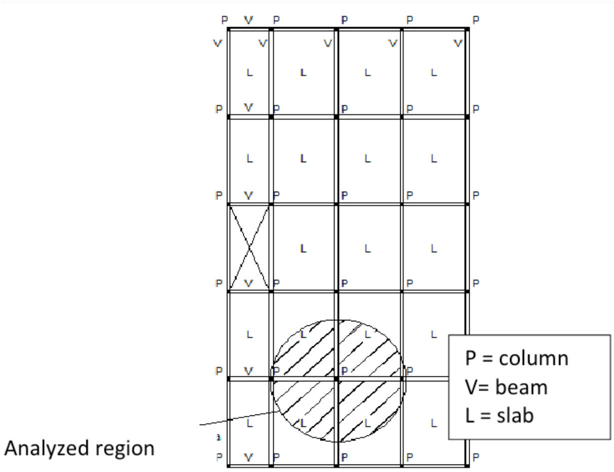

Figure 3: Plan layout of the panel structure under analysis

Analyzing the arrangement of the structural elements of the panel illustrated in Figure 3, a convenient symmetry was noted. This symmetry was used in the definition of a region of the panel that, once submitted to the load test, could represent the behavior of the panel as a whole, that is, the results of the load test of this region could be taken as representative of the general behavior of the panel.

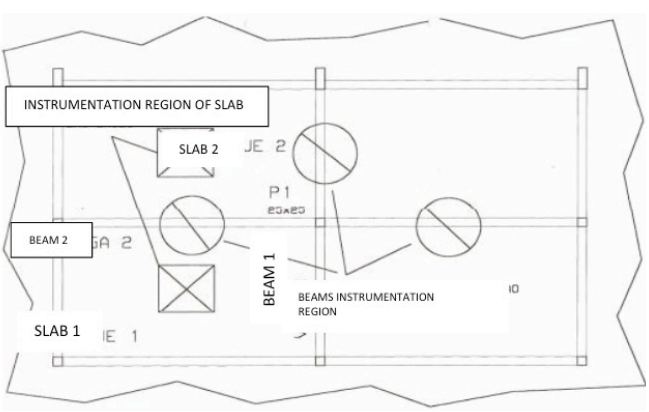

Figure 4: Representative panel region - load region

PHASES OF THE LOAD TEST

The works related to the load test of the reinforced concrete Ground floor slab panel of the industrial building were divided into specific phases, listed below.

- <u>Inspection Works</u>: where the structural elements of the panel were characterized in relation to dimensions, gauges, and arrangement of longitudinal and transverse reinforcements;
- <u>Instrumentation</u>: where chosen points of the structural elements were instrumented in order to obtain, basically, values related to the deformations in the reinforcement and in the concrete (vertical displacements (arrows) as a function of the applied load). In the installation of the electrical strain gauges, it is worth mentioning, with the aid of a manual chisel, the concrete cover was removed by perforating and the instruments were fixed;
- <u>Characterization Tests</u>: where mechanical characteristics of the materials involved (concrete and steel) were obtained;
- <u>Loading</u>: where the chosen region was loaded; with load increments and controlled loading position.

In order to monitor the variation of deformations in the reinforcement of the structural elements with the evolution of the loading in the representative region of the panel, the longitudinal and/or transverse reinforcements of these elements were instrumented with electrical resistance strain gauges. The instrumentation points chosen were shown in Table 2.

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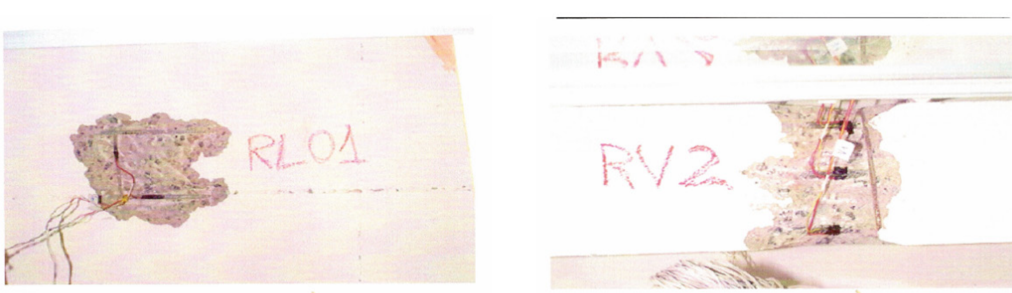
Deformation measurement point with the evolution of loading	Location of measuring instruments
V1 (middle of the span of the first span)	In the longitudinal reinforcement of BEAM 2 (first of the 3 bars of 16.0 mm);
V2 (mid span of the first span)	In the longitudinal reinforcement of BEAM 2 (second of the 3 bars of 16.0 mm);
V3 (mid-span of the first span)	In the longitudinal reinforcement of BEAM 2 (third of the 3 bars of 16.0 mm);
V4 (middle of the second span)	In the longitudinal reinforcement of BEAM 2 (first of the 3 bars of 16.0 mm)
V5 (middle span of the second span)	In the longitudinal reinforcement of BEAM 2 (second of the 3 bars of 16.0 mm);
V6 (middle span of the second span)	In the longitudinal reinforcement of BEAM 1 (first of the 3 bars of 16.0 mm);
V7 (middle span of the second span)	In BEAM 1 reinforcement (second of the 3 bars of 16.0 mm);
L1	In the longitudinal reinforcement of GROUND FLOOR SLAB 2 (6.3 mm bar – xx direction);
L2	In the longitudinal reinforcement of GROUND FLOOR SLAB 2 (10.0 mm bar – yy direction);
L3	In the longitudinal reinforcement of GROUND FLOOR SLAB 1 (6.3 mm bar – xx direction);
L4	In the longitudinal reinforcement of GROUND FLOOR SLAB 1 (10.0 mm bar – yy direction)
P1	In the longitudinal reinforcement of COLUMN 1 (first of the 12.5 mm bars);
P2	In the longitudinal reinforcement of COLUMN 1 (second of the 4 bars of 12.5 mm)
P3	In the transverse reinforcement (stirrups) of COLUMN 1 (6.3 mm bars every 20 cm).

Table 2: Instrumentation Points

Figures 5 and 6, they show instrumentation details.



(A) (B)

FIGURE 5: (A) Instrumentation of Ground floor Ground floor slab 01 (deformation in longitudinal and transverse reinforcement). (B) Instrumentation of beam V2 (deformation in longitudinal reinforcements)

FIGURE 6: Instrumentation of central column reinforcements (recovery after instrumentation)

In order to monitor the variation of deformations in the concrete of the beams and the column with the evolution of the loading in the panel region, the compressed edge of the beams and the column in the support region of the beams were instrumented with electrical resistance strain gauges. The instrumentation points chosen are shown in Table 3.

Deformation measurement point with the evolution of loading	Location of measuring instruments
V11 (in compressed edge)	In the mid-span region of the first span of BEAM 2 - left face;
V13 (in compressed edge)	In the mid-span region of the first span of BEAM 2 on the right side;
P11	On COLUMN 1 – positioned at the meeting of the first span of BEAM 1 with the COLUMN;
P12	On COLUMN 1 – positioned at the meeting of the second span of BEAM 2 with the COLUMN;
P13	On COLUMN 1 – positioned at the meeting of the second span of BEAM 1 with the COLUMN;
P14	On COLUMN 1 – positioned at the meeting of the first span of BEAM 2 with the COLUMN.

Table 3: Instrumentation Points

The variation of the vertical displacements of the beams and Ground floor Ground floor slabs and the settlement of the internal column with the evolution of the load in the representative region of the panel, was observed by installing mechanical deflectometers on the lower face of the beams and Ground floor Ground floor slabs and in the region of support of the beams with the column. internal, as shown in Table 4.

Measurement point of vertical displacements	Location of measuring instruments
RL01	In the middle of GROUND FLOOR SLAB 01
RL02	In the middle of GROUND FLOOR SLAB 02
RV01	In the middle of the span of the second span of BEAM 1
RV02	In the middle of the span of the first span of BEAM 2
RV02B	In the middle of the span of the second span of BEAM 2
RP1	In the support region of the first span of BEAM 1 with COLUMN 1
RP2	In the support region of the first span of BEAM 1 with COLUMN 1

Table 4: Instrumentation Points

Figure 7 shows the column instrumentation with the mechanical deflectometer to determine the evolution of the vertical displacements with the loading of the panel.

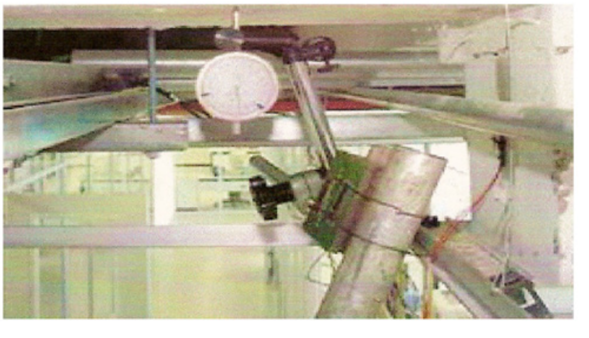


FIGURE 7: Column instrumentation (foundation settlement)

PHASES OF THE LOAD TEST

The panel was loaded with 50 kgf sandbags arranged in such a way that the loading in each square meter of the panel Ground floor slabs was known. This way, the loading of the representative region of the panel to be tested was divided into stages.

The first step consisted of loading Ground floor slab 2, the next step corresponded to loading Ground floor slab 1 plus Ground floor slab 2. Step 3 corresponded to the total load of the panel. In the fourth stage, two of the factory's largest forklifts, with a total load of approximately 4,700 kg each, were set in motion over the analyzed region. Figure 8 shows steps 2 and 4.

(A)

(B)

FIGURE 8: (A) (A) Loading of Ground floor slabs L01 and L02. (B) Movement of forklifts on the panel

In each of the steps, the region was loaded in controlled load increments up to a maximum load value corresponding to 70% of the strain at the beginning of yield of some of the instrumented reinforcement and then, unloaded.

In the case of the Ground floor slabs and the column, the maximum load interruption strain was taken as 0.14%, that is, 70% of the column reinforcement yielding strain, taken for safety, as 0.203%.

In the case of the beams, the maximum load interruption deformation was taken as 0.075%, that is, half of the maximum deformation (0.14%) adopted for the 16 mm beams of the beams, since these deformations were being taken in region of maximum positive moment in the beam (corresponds to approximately half the value of the maximum negative moment that would occur in the beam, in the region over the support of the inner column).

The deformation in the reinforcements was limited to 70% of the deformation corresponding to the beginning of yielding of the respective reinforcement. This procedure was adopted in order to prevent eventual residual deformations in these reinforcements at the end of each loading stage.

At the end of each load increment of each step performed, the readings of deformation in the concrete deformation reinforcement and vertical displacements were recorded, evaluating the capacity of each structural element, and observing the occurrence of cracks. During any of the predicted loading steps none of these cracks were observed.

RESULTS AND DISCUSSIONS

Based on the results obtained during the test, it could be seen that the limiting load to be applied to the panel was conditioned to the limiting deformation in the longitudinal reinforcement of the beams. Because, of the structural elements analyzed - Ground floor slabs, beams, column and foundation block, the beam that showed the lowest resistance

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capacity, in this case, to bending.

The longitudinal reinforcement of BEAM 02 was the first to reach the maximum deformation stipulated (0.075%) for load interruption in the representative region of the panel. This fact was repeated for the three loading stages, STEP 1, STEP 2, and STEP 3.

Discounting this limit deformation, the maximum deformation obtained for the longitudinal reinforcement referring to STAGE 4 of loading the panel, that is, referring to the effect of the loaded forklifts could be taken as 0.023%, obtaining a maximum limit deformation for the longitudinal reinforcement of 0.078%.

This deformation of 0.078% corresponds to a distributed load of 950 kgf/m^2. This maximum load is representative of a panel failure situation, that is, once subjected to this load the structure can be damaged.

According to the current procedures for designing reinforced concrete structures, the rupture or design loading would be the acting load plus the coefficient of increase of the efforts, that is, 1.4.

This way, the maximum load safely allowed in the analyzed panel is the value of 950/1.4, that is,650 kgf/m^2. This maximum load allowed on the panel was limited mainly by the flexural strength of the beams. Loads higher than those suggested would be possible as long as measures are taken regarding the reinforcement of the structural elements of the panel - beams and columns - and regarding the reinforcement of the foundations.

CONCLUSIONS

It has been verified in several nations, including Brazil, a degradation of reinforced concrete structures due to aging and/or for reasons associated with the change of use initially foreseen. But it is also clear that many of these structures can be reused through a structural assessment.

A load proof test is the most suitable test when there are doubts about the structural behavior, in addition to being more efficient in case the structure has been affected by an accident or is put to another use for which it was not designed. This test makes it possible to analyze the behavior of the structure in service and also to estimate future actions to be taken in eventual repair measures.

Although they constitute a great tool for the experimental evaluation of structures, a test to be efficient and safe must be performed within normative standards and specifications.

This way, trying to provide a great service to the technical/scientific community in the area, this work presented the main procedures for applying and evaluating the results of the test known as "load test," specified by the national standard NBR 9607 (ABNT, 2012).

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