Influence of the Speed of Charging and Discharging of the Test Machine in the Determining of the Compressive Strength of the Concrete

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Abstract: *This paper presents a comparative analysis of the results obtained for the test of compressive strength, through a program of interlaboratory tests on hardened concrete, the Company developed Carlos Campos Consultoria e Construções Ltda., in the School of Civil Engineering Federal University of Goiás and in the Department of Technical Support and Control of Furnas Centrais Elétricas S.A., located in Goiânia-Goiás, to identify and evaluate the influence of some factors involved in test compressive strength. For this, we sought to verify the result of compressive strength, the influence of the type of processor (A and B) and upload speed (0.3 and 0.6 MPa/s) body-of-proof cylindrical size 150 mm x 300 mm in the concrete class C30. It was concluded that the type of laboratory significantly affect the results of compressive strength. Furthermore, it is noteworthy that the body-of-evidence dimension 150 mm x 300 mm concrete class C30, tested with a loading speed of the testing machine of 0.3 MPa/s presented the results to the larger dispersions.*

Keyword: *Interlaboratory; Concrete; basic dimension, speed of loading and unloading; Compressive Strength; Dispersion.*

I. Introduction

The research aims to study and evaluate the influence of variables: influence of laboratory and loading speed (0.3 and 0.6 MPa/s) in bodies of the cylindrical specimens of size 150 mm x 300 mm Class C30, in particular, in the result of the compressive strength in hardened concrete and to check the variability of the experimental results.

II. Experimental Program

The experimental program was developed from an interlaboratory evaluation of compressive strength of concrete, the Company developed Carlos Campos Consultoria and Construções Ltda., in the School of Civil Engineering Federal University of Goiás and in the Department of Technical Support and Control of Furnas Centrais Elétricas S.A., located in Goiânia-Goiás.Considering the characteristics of interlaboratory program where it is not possible to fix all the independent variables, so we decided to study the following situation:

- type of concrete (in a level: class C30);
- size of the body-of-proof to a level: 150 mm x 300 mm;
- load speed (in two levels: 0.3 MPa/s and 0.6 MPa/s) body-of-proof cylindrical dimension 150 mm x 300 mm in the concrete class C30.

The body-of-proof standard used in Brazil follows the model of the body-of-proof standard of the United States which is a cylinder of 150 mm x 300 mm (Figures 2.1 and 2.2).

Fig. 2.1 Compressive Strength Test, conducted at the Laboratory of Building Materials Company Carlos Campos Consultoria and Construções Ltda. in Goiânia-GOIÁS

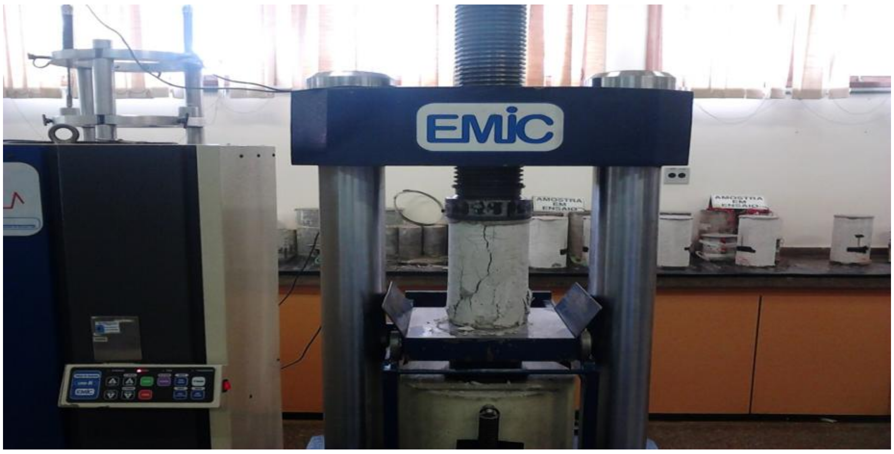

Fig. 2.2 Compressive Strength Test, conducted at the Laboratory of Concrete Department of Technical Support and Control of Furnas Centrais Elétricas S.A. in Goiânia-GOIÁS

As limitations of the study have been:

- Kept all the bodies of the race in the same moisture condition;
- Testing machine with load control with load speed (in two levels: 0.3 MPa/s and 0.6 MPa/s) in bodies of the cylindrical specimens of size 150 mm x 300 mm in the concrete class C30, during the study;
- Materials used in the manufacture of concrete: CP V ARI Portland cement (high early strength), lithology and size of coarse aggregate (granite maximum dimension of 19 mm) and sand type (artificial sand);
- Compressive strength fc (28days) of 30 MPa;
- Type of finishing top of the body-of-evidence (capping with sulfur).

To reduce the influence of the humidity of the body-of-evidence, they were demolded 24 hours after mixed, identified and stored in storage tanks for 28 days, with controlled humidity and temperature as specified by ABNT NBR 5738:2008. Once this term storage, the body-of-evidence were taken from the storage tank and stored in a dry environment at room temperature.

The dosage concrete set concrete class for the sample C30 was obtained by adjustments of concrete mixtures resistance (fc) of about 30 MPa.

Through the graphical behavior of concrete was obtained dash for concrete strength estimated at 28 days at 30 MPa. This trait is presented in Table 2.1.

Table 2.1 - Concrete mix for fc = 30 MPa
Material Proportioning by m³ of concrete Mix design (1 : 3.78 : 4.23)W/C ratio = 0.73

Materials	Conventionally Vibrated Concrete
	Quantity per m³
Cement CP V ARI	236 kg
Artificial sand	891 kg
Gravel size 1 (19 mm)	999 kg
Water	172 kg
Polyfuncitonal Additive	1.65 kg (0.7% of cement)
Superplasticizer	0.94 kg (0.4% of cement)
Silica Fume	18.9 kg (as replacement for 8% of cement in weight)
Fresh Concrete Properties:	
Consistency	130 mm
Air	2 %

Were molded nine (9) body-of-proof for the property compressive strength for each laboratory to meet the test methods ABNT NBR 5739:2007.

2.1 TECHNICAL EVALUATION

Was applied to the statistical analysis technique of variance (ANOVA) contained in Statistica Statsoft Software 7® to the results found in individual laboratories for the concrete samples Class C30 separately and together. The test methodology consists of the application of the Fisher test (F).

III. Presentation And Discussion Of Results

As for the main analysis of this study, it is emphasized that the bodies of the test piece were tested in randomized replicas, before running the test for resistance to compression. This randomization minimizes the effects of

variables that were not or could not be considered in the experiment, as the molding process of the body-of-evidence, distribution of aggregates in concrete, installation of the measuring instrument, among others.
In addition, if any dependency mechanism between the results of subsequent experiments, the randomization of the execution of experiments allows this dependency is diluted among all study situations and thus not favoring either situation.

In Table 3.1 presents the means, standard deviations and coefficients of variation of the results for all study situations obtained for the sample with molded concrete class C30, with a confidence interval of the mean (for 95% confidence) and a level of 5% significance for the property compressive strength.

Table 3.1 - Statistical analysis of the test results - Compressive Strength.

Situation of Study				N°. of Specimen	Compressive Strength (MPa)		
Size (mm)	Type of Laboratory	Type of Concrete	Speed of the Testing Machine (MPa/s)		Average (MPa)	Standard Deviation (MPa)	Coefficient of Variation (%)
———	———	———	———	18	30,9	2,3	7,3
———	———	———	0,3	8	30,1	2,8	9,4
———	———	———	0,6	10	31,5	1,6	5,0
———	A	———	———	9	32,3	0,81	2,5
———	B	———	———	9	29,5	2,4	8,1
150X300	A	C30	0,3	4	31,9	0,82	2,6
	A		0,6	5	32,7	0,66	2,0
	B		0,3	4	28,3	3,1	10,8
	B		0,6	5	30,4	1,4	4,6

OBS.: - Concrete types: concrete class C30 for dimensions 150 mm x 300 mm.
- None of the individual results were considered as spurious values.

We performed a statistical analysis of variance (ANOVA) of individual results of compressive strength to determine the factors statistically significant with a confidence level of 95%.

In Table 3.2 is the analysis of the significance of factors studied for the compression resistance property.

Table 3.2 - ANOVA - Analysis of the Global Experiment - Compressive Strength

Factors Studied	SQ	F	p	Resultado
Model Study	47,90	5,64	0,010	significant
Error (residual)	39,63	———	———	———
Total	87,53	———	———	———
Coefficient of Determination Model (R^2) = 0,55				
Speed of the Testing Machine	———	3,38	0,087	not significant
Laboratory	———	13,36	0,003	significant
Speed x Laboratory	———	0,68	0,424	not significativo

Where: SQ = sum of squares; F = parameter of Fischer to the test of significance of the effects; p = probability of error involved in accepting the observed result as valid, this is, as representative of the sample; Result = result of the analysis, indicating that the effect is significant or not, R^2 = (1 - SQerro/SQtotal).

The analysis of variance showed compression strength of the resulting value of the coefficient of determination adopted (R^2) was 0.55, which means that 55% of the total variance of the data of the second stage of compressive strength can be explained by the variables adopted. Therefore, uncontrolled factors accounted for approximately 45% of the variations observed in the study.

With respect to the influence of intensity, taking as a basis the magnitude of F values, it can be seen great influence on the results of the laboratory compressive strength.

The interaction effects were not statistically significant, that is, for each type of laboratory used, depending on the speed of loading and unloading of the machine test, the compressive strength of the concrete shows no difference result (similar behavior).

In column F values of Table 3.2, the interactions involving the effect of speed of loading and unloading the machine test lab x had the lowest values, indicating less influence of this variable on the results of compressive strength. It should be noted, also, that the individual effect of the variable speed loading and unloading of the testing machine is not significant, ie the charging and discharging speeds of the testing machine studied (0.3 MPa/s and 0.6 MPa/s), alone and interacted with the laboratory did not influence the results of compressive strength, but it is noteworthy that the analyzed sample is composed of only 18 body-of-evidence, is necessary to perform further testing on a larger sample of bodies-of-proof to confirm if this situation repeats.

As a result of ANOVA - Compressive Strength (Table 3.2) have revealed the statistically significant effects of variable laboratory held the grouping of homogeneous medium by the method of Duncan, in order to observe the similarities and differences of the results obtained.

In this method, it was shown that laboratories show similar results, as the average overall compressive strength of the laboratory was 32.3 MPa and average overall compressive strength of laboratory B was 29.5 MPa, that is, the lab had overall average compressive strength 9% higher than the laboratory B. Thus, depending on the laboratory used for the test of compressive strength value approaches.

After making the grouping of mean speed factor loading and unloading of the machine tested by the method of Duncan, was demonstrated for the two types of speed of loading and unloading of the testing machine studied, that they do not influence the strength values compression, as the overall average compressive strength of the body of the test piece size 150 mm x 300 mm tested with the test machine speed of 0.3 MPa/s was 30.1 MPa and average overall resistance compressing the body of the test piece size 150 mm x 300 mm tested with the test machine speed of 0.6 MPa/s was 31.5 MPa/s, that is, the body of the test piece 150 mm in size x 300 mm tested with the test machine speed of 0.6 MPa/s differ only 5% of the general average compressive strength compared to the body of the test piece size 150 mm x 300 mm tested with the test machine speed 0.3 MPa/s.

Figure 3.1 shows the graphical analysis of the study, showing the results for each variable.

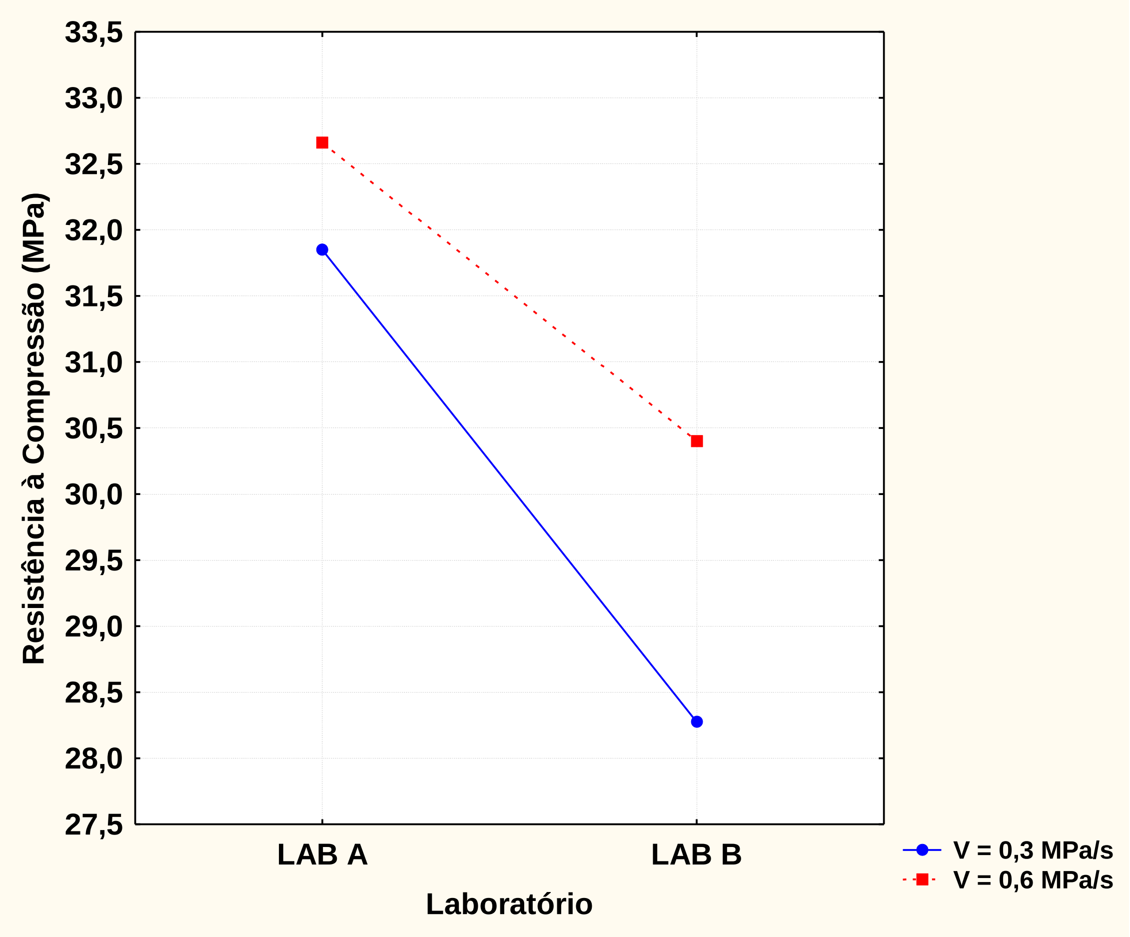

Figure 3.1 - Graphical presentation of study situations, divided by speed of loading and unloading of the testing machine and laboratory.

Figure 3.1 shows the values of compressive strength are shown apart, exhibiting behavior upward between laboratories A and B.

As the bodies of the test piece size 150 mm x 300 mm, tested speeds of loading and unloading of the testing machine of 0.3 MPa/s and 0.6 MPa/s, the results of compressive strength in the laboratory, shown in Figure 3.1, showed averages of 31.9 MPa and 32.7 MPa, and the coefficients of variation were 2.6% and 2.0%. As for the bodies of the test piece size 150 mm x 300 mm tested with the test machine speed of 0.3 MPa/s and 0.6 MPa/s in laboratory B the results showed average compressive strength of 28.3 MPa to 30.4 MPa and their coefficients of variation were 10.8% and 4.6%. As regards the size 150 mm x 300 mm, it was found that the body of the test piece tested with loading and unloading speed of the testing machine of 0.3 MPa/s was dispersed in laboratory B, ie, the body-the proof-tested with the test machine speed of 0.3 MPa/s was 8.2% higher coefficient of variation B in the laboratory with the laboratory A. But the body-of-proof 150 mm x 300 mm tested with speed loading and unloading of the testing machine of 0.6 MPa/s showed greater dispersion in laboratory B, ie, the body-of-proof tested with speed testing machine of 0.6 MPa/s was 2.6% higher coefficient of variation B in the laboratory compared with the laboratory A.

It was found that the lab B used had the greatest resistance to compression dispersions for changing the speed of loading and unloading of the testing machine.

IV. Conclusion

The true scope of a search is to provide data capable of supporting answers and solutions for the unknowns in the different fields of human knowledge.

Thus, the final considerations aimed at compiling the most important information, cast off the results and settle the practical aspects of the study, facilitating access through technical scientific discoveries.

The final considerations drawn from the presentation and analysis of results presented earlier considered: the influence of laboratory and speed of loading and unloading of the testing machine, and the comparison between these variables obtained in the study and their applicability in the analysis and inspection of structures concrete.

The knowledge of the compressive strength of the concrete is a matter of fundamental importance both in the stages of design and implementation, as in any assessments about the quality of the structures in use. It is necessary to understand the concepts of the test requirements and the variables that influence, to interpret the results and to rule out possible discrepancies caused by deficiencies of the test equipment or operator.

1. After taking the average of the grouping factor loading and unloading speed of the testing machine by the method of Duncan, it was shown for the two types of loading and unloading speed of the testing machine studied that they have little influence values compressive strength, because the overall average compressive strength of the body of the test piece size 150 mm x 300 mm tested with the test machine speed of 0.3 MPa/s was 30.1 MPa and average overall resistance compression of the body of the test piece size 150 mm x 300 mm tested with the test machine speed of 0.6 MPa/s was 31.5 MPa/s.
2. It was found that the body of the test piece tested with loading and unloading speed of the testing machine of 0.3 MPa/s was dispersed in laboratory B because it had more than 8.2% coefficient of variation B in the laboratory with the laboratory A. The body-of-proof tested to speed loading and unloading of the testing machine of 0.6 MPa/s showed greater dispersion in laboratory B because it had more than 2.6% coefficient of variation in laboratory B compared with the laboratory A. It was found that the lab B used had the greatest resistance to compression dispersions for changing the speed of loading and unloading of the testing machine.

In general, the steps inspection of concrete structures involve a series of activities ranging from the collection and analysis of designs and specifications, to the planning and development of research methodology. Furthermore, the effectiveness of the evaluation depends on the knowledge and experience on the part of the researcher. The successful application of the correlations obtained in this study is deeply associated with the professional expertise and prior knowledge about the method of determining the compressive strength of concrete.

It is noted that the results obtained here are valid for materials and test conditions adopted, so you should consider this limit the search.

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