EVALUATING THE POSSIBILITY OF USING DRY MATERIALS TO REPLACE CEMENT PASTE CAPPING ON CONCRETE BLOCK TESTING

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ABSTRACT

Compression strength is the most common quality control test of concrete blocks. Before testing, a flat and perpendicular surface on each face of the block is necessary to allow a reasonable low dispersion of results. Cement paste is the most commonly used capping material in local Brazilian tests, where recently the permission of grinding instead of capping was added to local codes.

This work is aimed to experimentally evaluate the possibility of using dry materials – such as hardboard, plywood and fibreboard, with thickness of 2.5 mm, 3 mm, and 12 mm respectively – on capping, to replace cement paste. The tests have also included the use of grinding. A total of 90 blocks were tested for every type of capping, divided into three nominal resistances of blocks (4 MPa (B4), 8 MPa (B8) and 16 MPa (B8), gross area). Data and results were analyzed, and it was possible to notice the influence of capping on blocks strength.

A statistical analysis was carried out to evaluate the influence of each capping on the compressive strength of blocks.

The block tests' results have indicated low variation coefficient for each kind of capping. In general, results of characteristic values are similar, except for cases of low resistance blocks (B4) with fiberboard and plywood – whose differences exceed 10% when compared to cement paste. The use of dry materials for capping can ease of use the test procedure with great reduction time and laboratory space (in the case of capping with cement) when compared to cement paste and grinding.

KEYWORDS: capping, concrete block, compressive strength

INTRODUCTION

Different types of capping have influenced the test results of axial compressive strength of specimens. Other materials have presented satisfactory results on many other literature reported studies.

According to the Brazilian ABNT NBR 12118:2011 standard, the top surface of concrete block can be prepared by the use cement paste or be grinded. Since water is usually used while grinding, issues can occur if the concrete block is tested wet, being this a disadvantage of this procedure.

Canadian CAN/CSA-A165 standard indicates that uneven surfaces shall be hard capped with mortar, sulfur, or dental plaster, or alternatively, the surfaces shall be ground flat.

Sulfur paste was considered the best performance capping but its use has ended due to health problems. Dental plaster is a type of gypsum whose disposal brings an environmental problem.

For the reasons above, sulfur and dental plaster capping was not considered in this study.

Ballad (2012) studied the viability of several unbonded caps for testing on masonry prism. The author used hydrocal gypsum cements as the control method that was compared against recycled rubber, neoprene, fiberboard, and laminated foam. The results of this work are indicated in Table 1.

Table 1 - Summary of Prism Compression Results (Ballad, 2012)

Capping Method	Mean Strength (psi)	Standard Deviation (psi)	Relative Strength of Control (%)	Coefficient of Variability (%)
Gypsum	3168	268	100	8.45
Rubber	3077	261	97	8.47
Foam	2322	260	73	11.2
Fiberboard	3328	196	105	5.90
Neoprene	3581	114	113	3.18

The author observed that rubber caps provide nearly identical strengths compared to the control capping (gypsum), with a 3% reduction in observed strength. The fiberboard caps also produced comparable strengths to the control with a 5% increase in observed strength. The neoprene cap results had a small coefficient of variation (3.2), but strengths were 13% greater than the control's. The significant increase in strength was likely a product of high confining stresses at the prism ends. The laminated foam exhibited the lowest strength with a 27% reduction compared to the gypsum. Based on results, authors indicate that rubber caps of a durometer hardness of 65 with proper confinement could be adopted as a suitable alternative to hard capping.

Mauricio et al. (2004) reported result on block testing using cement paste, cement-sand mortar, fiberboard, gypsum, sulfur and softboard capping. The results indicated higher and similar compression strength for the gypsum and sulfur capping. Fiberboard results were 13% smaller, with the other capping resulting in even smaller strength values.

OBJECTIVE

The main objective is to study the possibility of eliminating cement paste capping in concrete block testing by replacing it with a dry material – such as plywood, hardboard and fiberboard.

The advantages of dry capping over the cement paste capping include a lesser influence of laboratory technicians on the test results, and a reduction of laboratory space and time while testing.

METHODOLOGY

Methodology consisted on testing three different nominal strengths of concrete blocks of 4, 8 and 16 MPa, with different capping types: cement paste, hardboard, plywood, fiberboard and grinding. Table 2 shows a summary of the tests. Figure 1 illustrates the dry materials used in the tests. Figure 2 shows the cement paste capped and grinded blocks.

Table 2: Summary of the Test Program

Capping	Nominal strengths of concrete blocks		
	4 MPa	8 MPa	16 MPa
	No. of block		
cement paste	6	6	6
grinded	6	6	6
hardboard	6	6	6
fiberboard	6	6	6
plywood	6	6	6

Results were statically compared using the nonparametric Kruskal-Wallis test.

Figure 1: Illustration of the caps used in the tests, respectively: plywood, fiberboard and hardboard.

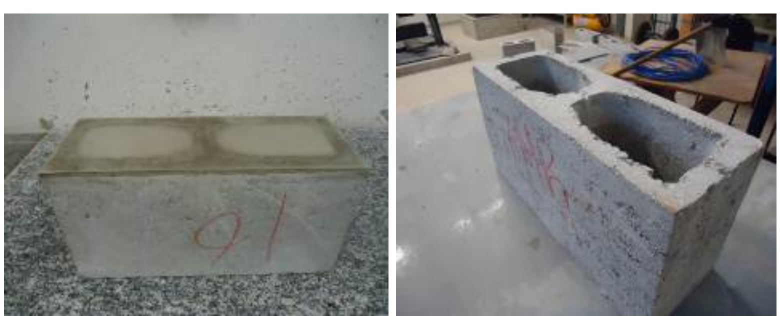

Figure 2: Blocks capped with cement paste and grinded

RESULTS OF AXIAL COMPRESSIVE STRENGHT

The average compressive strength, characteristic compressive strength and the variation coefficients of each test are presented in Table 3. It should be noted that strengths are related to gross area, as it is common practice in Brazil. The net-area strength will be roughly double the value reported here.

Table 3: Summary of test results for blocks with different types of capping

Capping	Designation	N° of block	f_{bm} (MPa)	f_{bk} (MPa)	coefficient of variation (CV) %
Fiberboard	B4	6	8.1	6.9	5.7
	B8	6	13.1	11.7	4.4
	B16	6	17.3	16.6	2.5
Cement paste	B4	6	8.1	7.7	3.1
	B8	6	12.2	11.5	3.5
	B16	6	15.4	14.1	5.1
Hardboard	B4	6	7.9	7.4	4.1
	B8	6	12.7	11.8	4.1
	B16	6	16.6	15.7	4.8
Plywood	B4	6	6.5	5.6	6.4
	B8	6	11.1	10.5	4.7
	B16	6	16.7	15.3	5.0
Grinded	B4	6	8.6	8.0	5.4
	B8	6	11.8	12.2	1.6
	B16	6	15.9	15.1	2.1

f_{bm} – average compressive strength (gross area)

f_{bk} – Characteristic compressive strength (according to ABNT NBR 12118, gross area)

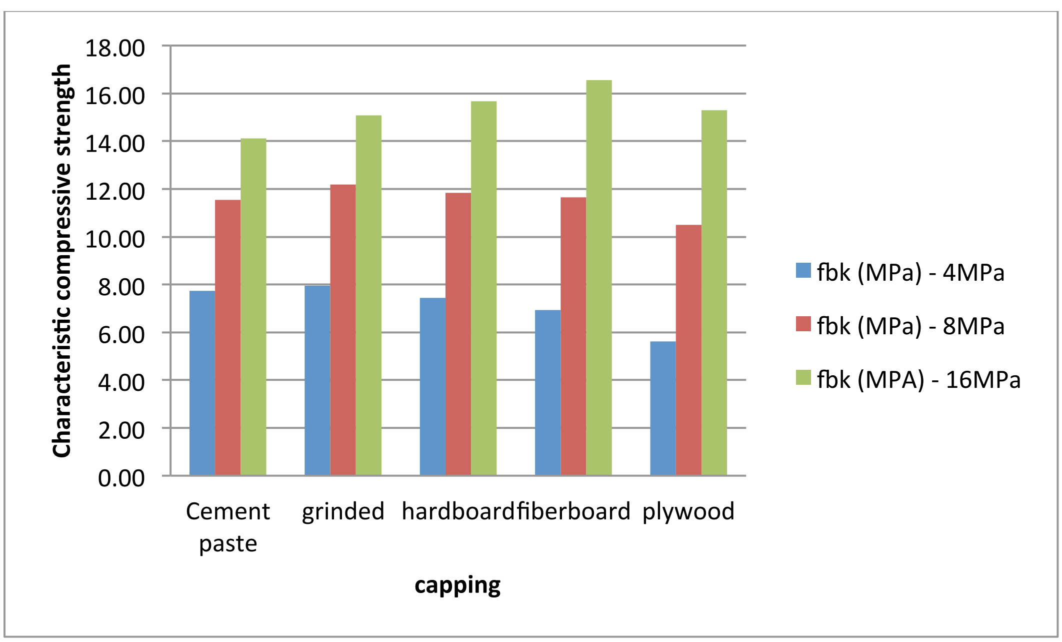

Figure 3: Characteristic compression strength of each block (gross area)

Looking at Figure 3, it can be noticed that the values of strength for nominal block (B4) remain similar, except for plywood, whose value is lower than other capping materials. Grinding shows higher strength values with this block strength.
Results of B8-blocks show similar values, indicating the possibility of using of any type of capping for this block strength.
In the case of the higher-strength block, the cement paste results were slightly smaller than the others.

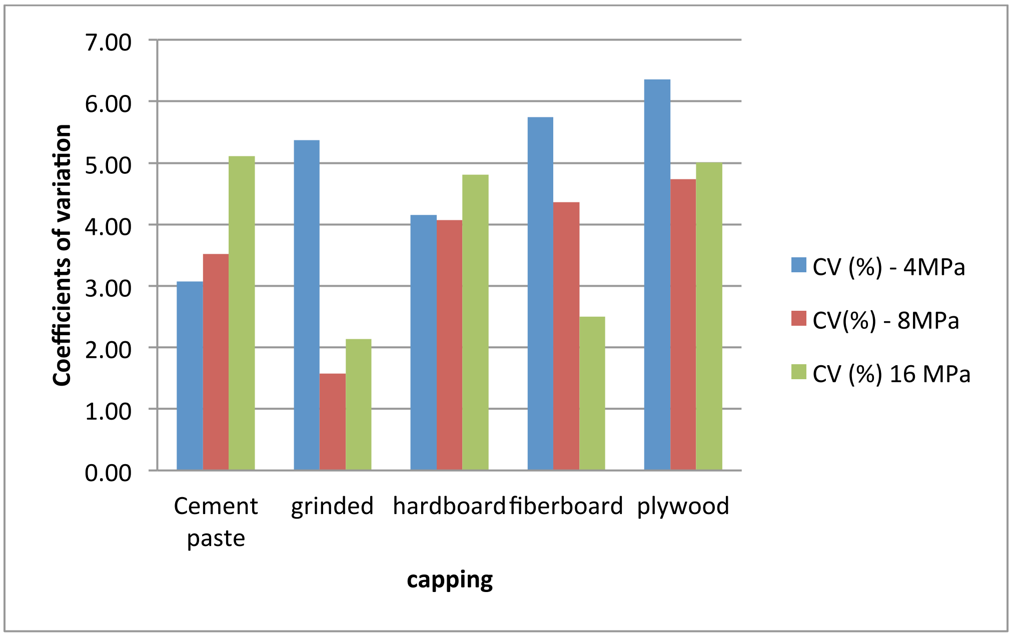

Figure 4: Coefficients of variation of each test (gross area)

The variation coefficients are considered low for every test result (Figure 4). Tables 4 to 6 bring the statistical Kruskal-Wallis test results for B4, B8 and B16.

Table 4 - Block statistical Kruskal – Wallis test results for B4

B4				
Statistical test-Kruskal - Wallis				
Capping	Kruskal - Wallis chi-squared	df	p-value	Comparison
All capping	17.467	4	0.001568	There is a significant difference
Cement paste vs fiberboard	0	1	1	No significant difference
Cement paste vs hardboard	1	1	0,2623	No significant difference
Cement paste vs plywood	8.3368	1	0,003885	There is a significant difference
Cement paste vs grinded	2.8368	1	0,09213	No significant difference

Table 2 - Block statistical Kruskal – Wallis test results for B8

B8				
Statistical test-Kruskal - Wallis				
Capping	Kruskal - Wallis chi-squared	df	p-value	Comparison
All capping	21.41	4	0.000263	There is a significant difference
Cement paste vs fiberboard	5.7692	1	0,01631	There is a significant difference
Cement paste vs hardboard	3.1466	1	0.07609	No significant difference
Cement paste vs plywood	6.1819	1	0.01291	There is a significant difference
Cement paste vs grinded	2.0842	1	0.1488	No significant difference

Table 3 - Block statistical Kruskal – Wallis test results for B16

B16				
Statistical test-Kruskal - Wallis				
Capping	Kruskal - Wallis chi-squared	df	p-value	Comparison
All capping	15.729	4	0.003405	There is a significant difference
Cement paste vs fiberboard	7.4103	1	0.006485	There is a significant difference
Cement paste vs hardboard	5.0256	1	0.02497	There is a significant difference
Cement paste vs plywood	5.7692	1	0.01631	There is a significant difference
Cement paste vs grinded	3.6923	1	0.05466	No significant difference

For comparisons in which is obtained a "p-value" lesser than 0.05 (5%), the hypothesis that the capping options are similar is not supported, hence, they are considered as statistically different. But when the "p-value" is greater than 0.05 (5%), the capping options are considered equivalent. Looking at these tables, when comparing to regular cement paste capping, it is possible to conclude:

- the plywood option would lead to different results for all block strengths,
- fiberboard capping would lead to similar results only for the smaller strength block;
- grinding the blocks leads to similar results for all strengths;
- hardboard capping leads to similar results for B4 and B8, but not for B16 whose result was about 10% higher;

Among all dry capping options hardboard would be the one with closer results.

CONCLUSIONS AND RECOMMENDATION

Results of tests on blocks indicated low coefficient of variation for all types of capping. In a general, results of characteristic values did not differ more than 10% for all capping and block strength combination, except for the cases of low strength blocks (B4) with fiberboard and plywood.

Based on the results obtained, it is recommended the use of hardboard capping as an alternative to cement paste for compression testing of concrete blocks.

REFERENCES

1. Brazilian Standards Association (NBR). Standard hollow concrete masonry blocks – Test methods – NBR 12118. Rio de Janeiro, Brazil. 2011.
2. Ballad J. R,; Analysis of Unbonded Capping Materials Used in Determining the Compressive Strength of Concrete Masonry Prisms. Department of Civil and Environmental Engineering Brigham Young University. Master of Science. 24 p. April 2012.
3. Maurício, R. M.; Camacho, J. S.; Andolfato, R. P. Resistência à compressão axial de blocos de concreto capeados com diferentes materiais. In: CONGRESSO BRASILEIRO DO CONCRETO, 46. 2004, Florianópolis. Anais... Florianópolis: IBRACON, 2004. v.6, p. 1271-1280.
4. Canadian Standards Association. CAN/CSA-A165 SERIES-04 (R2009) - CSA Standards on Concrete Masonry Units (Consists of A165.1, A165.2 and A165.3), 2004.
5. Association Brazilian of Standards (NBR). Structural Masonry – Concrete blocks Part 2: Execution and works control– NBR 15961-2. Rio de Janeiro, Brazil. 2011.
6. Association Brazilian of Standards (NBR). Mortar for settlement of walls and wall cladding and roofs – Determination of compressive strength – NBR 13279. Rio de Janeiro, Brazil. 1995.

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