AN EXPERIMENTAL STUDY ON TESTING OF ASSESS TIME-DEPENDENT STRESSES USING VIBRATING WIRE GAUGES (VWG) ON CREEP CHAMBER

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Abstract: Creep is defined as the time-dependent distortion that occurs as a consequence of a continuous tension. It is the time-dependent strain that happens when there is no external stress applied. The combination of elastic, creep, and shrinkage stresses in a concrete specimen is known as the total strain of the specimen. Creep and shrinkage tests were conducted in the laboratory on specimens constructed from the same materials and in the same proportions as those used on the project. These specimens were subjected to the testing. The temperature profile that was collected from the test beams when the specimens were being steam-cured was used in the production of match-cured samples for laboratory testing. In preparation for testing, we created two batches with a match cure, as well as two batches with. The analysed after being subjected to loading equal to thirty percent of their post-cure compressive strength and then being placed in the creep chamber. A relative humidity of fifty percent was present in the creep chamber, which was maintained at a temperature of 23.0 1.7 degrees Celsius (73.4 degrees Fahrenheit). In order to facilitate comparisons, specimens of. A Whittemore gauge was used for the purpose of taking the measurements, and it was used to measure both the creep and shrinkage specimens. In addition, four of the cylinders were outfitted with vibrating wire gauges (VWGs), which enabled a comparison to be made between the internal and exterior stresses that were present in the same cylinders. Both the Whittemore and the VWG were able to measure the same values for elastic and creep stresses; however, the VWGs saw a much less amount.

Keywords: Vibrating Wire Gauges, Creep Chamber, High Strength Concrete, ASTM

I. INTRODUCTION

In recent years, high strength concrete (also known as HSC) has developed into a highly sought-after construction material as a direct result of the consistent growth in its application. High-strength construction is often defined as concreting that has a compressive strength after 28 days of at least 41.4 MPa (6000 psi). 3 It is required to make use of a low water-to-cementitious materials ratio in order to achieve high compressive strengths. This, in turn, needs the use of water-reducing admixtures in order to provide an acceptable level of workability in the concrete.

Both creep and shrinkage are examples of time-dependent deformations that may take place in concrete structures, and both can be seen. The deformation of a viscoelastic material over time that is higher than the initial elastic strain that happens as a consequence of the application of a sustained stress is referred to as creep. This phenomenon is described as the deformation of a material over time. On the other hand, shearing is a time-dependent deformation that may take place even in the absence of any external force being applied to the material. As a consequence of this, the initial elastic strain, creep tension, and shrinkage tension that are experienced by a concrete specimen at any particular moment are added together to determine the total strain that it is subjected to at that time.

The creeping of concrete may be broken down into two distinct categories: basic creep and drying creep. The bulk of the creep is attributable to the basic creep, whereas the remaining portion is attributable to the drying creep. The most fundamental kind of creep in concrete takes place when a building is totally shut off from its surroundings and there is no flow of water between the concrete and the environment. The process through which water moves into the surroundings around it is referred to as drying creep. The core part of a big concrete member experiences mostly basic creep. This is due to the fact that only a tiny quantity of water is lost to the environment around it.

Drying shrinkage, autogenous shrinkage, and carbonation are the three main processes that cause shrinkage to occur. Excess water that is not eaten during hydration diffuses into the surrounding environment, resulting in a net volume loss. Autogenous shrinkage is the water loss that occurs as a result of the cement's continued hydration. Under wet conditions, carbonation shrinkage is the reaction between $CO2$ in the environment and $Ca(OH)2$ in the cement paste, causing the cement paste to shrink.

II. TECHNIQUES AND SUBSTANCE

The American Society for Testing and Materials (ASTM) does not give a standard for this sort of test.

Table 1: The HSC Exam Matrix

Curing Method	Batches	Age at Loading	Specimens/Batch
			8 Compressive Strength
			4 Tensile Strength
	HSC8-1A		1 Modulus
Standard	HSC8-2A	7 days	3 Shrinkage
			3 Creep
			3 Shrinkage Prisms
			5 Compressive Strength
			2 Tensile Strength
Accelerated	HSC8-3A		1 Modulus
	HSC8-4A	1 day	4 Shrinkage Cylinders
			4 Creep Cylinders

Mixing

Throughout the mixing process, the bulk mixing standards set by ASTM C192 were strictly adhered to. 15 Using a 55.2 MPa (8000 psi) design component, which was leased to the Bayshore test pillars, the percentage of compounds calculated. The test beams were in Bayshore.

In Table 2, you can see how these values are distributed. In order to obtain the expected decrease in some collections, it was necessary to increase the amount of HRWR used in other collections. The specific batter weights used to build the laboratory models are given in the table which can be found in Appendix B. This text also includes Appendix B. The laboratory parameters are new and fast-acting composite concrete. The most common treatments are shown in Tables 3 and 4, respectively, in the following sections. Table 3 covers both the new concrete features of the precast precast beams and the process established by VDOT.

Table 2: Bayshore Mixture Proportions

Materials	SSD weights, kg/m^3 (lb/yd^3)
Portland Cement	303 (510)
Slag Cement	202 (340)
Course Aggregate	1157 (1950)
Fine Aggregate	586 (988)
Water	149 (252)
AEA (Daravair)	580 ml/m^3 (15 oz/yd^3)
WR (Hycol)	1044 ml/m^3 (27 oz/yd^3)
HRWR (Adva)	6764 ml/m^3 (175 oz/yd^3)
CI or Accel (DCI)	19.8 L/m^3 (4.0 gal/yd^3)

Table 3: Accelerated Cure Laboratory and beam Fresh Concrete Properties

Properties	HSC8-1A	HSC8-2A	Bayshore	VDOT Specs.
Slump, mm (in.)	152 (6)	152 (6)	203 (8)	0-178 (0-7)
Air Content, %	5.6	4.4	6.2	3-6
Temperature, °C (°F)	24.4 (76)	25.6 (78)	25.0 (77)	4.4-32.2 (40-90)
Unit Weight, kg/m^3 (pcf)	2468 (154)	2484 (155)	----	----
Yield	1.02	1.03	----	----
w/cm ratio	0.30	0.30	~ 0.33 *	< 0.4
Curing Method	Match Cure	Match Cure	Steam	N/A

Table 4 Standard Cure Laboratory Properties Fresh Concrete

Properties	HSC8-3A	HSC8-4A
Slump, mm (in.)	216 (8.5)	114 (4.5)
Air Content, %	3.5	3.5
Temperature, °C (°F)	25.6 (78)	23.9 (75)
Unit Weight, kg/m3 (pcf)	2549 (159)	2549 (159)
Yield	1.05	1.05
w/cm ratio	0.30	0.30

III. RESULTS

Detailed findings of the HSC diminished investigation can be found in the following sections: Sections 4.2 and 4.3, respectively, Section 4.4 provides the findings of the elastic modulus test, while Section 4.5 provides the results of thermodynamic coefficient measurements. Section 4.6 covers the estimates of the difficulties obtained by the tests and the expected types found in the models. The remnants of the speculative models are shown in Section 4.7.

Heat molds for immediate treatment were used in groups 1A and 2A, while wet cures were used in groups 3A and 4.

If possible, test results are compared with field data obtained from Bayshore Concrete Products. Bayshore-derived cylinders are used to perform field pressure measurements, performed at Virginia Tech using Bayshore-based cylinders. Specific values or design values of ACI and AASHTO are used to compare specific outcomes,

Compressive Strength

Accelerated Cure

Figure 1 shows the results of tests performed by the pressure forces of accelerated clusters 1A and 2A in the HSC laboratory. Also included are wild data collected at Bayshore. In the discovery of a one-day laboratory, a two-dimensional scale is displayed, but for some results, individual ratings are given. For Bayshore, each result is a three-dimensional scale.

After pressing for one day, the compressive strength of group 1A and group 2A was obtained 68.3 MPa and 68.1 MPa, respectively. This was determined after the collections were pressed (9910 and 9870 psi). After being stored in storage for one week, the compressive strength of group 1A was tested to be 71.0 MPa, while the compressive strength of group 2A was measured to be 74.1 MPa. These numbers correspond to 10300 and 10740 pounds per square inch (psi), respectively. After several extensible tests over a month and a half, which analysed the results, the compressive strength of batch 1A and batch 2A was determined to be 86.9 MPa and 85.5 MPa, respectively (12600 and 2A). 12400 psi). After being placed in storage for 90 days, the compressive strength of group 1A and group 2A was determined to be 82.1 MPa and 83.4 MPa, respectively. These results were obtained after the collections had been tested (11900 and 12100 psi). According to the experiments, the compressive strength of Bayshore samples after one day, seven days, and 28 days, respectively, was 45.3 MPa, 50.0 MPa, and 59.0 MPa. This was determined by the length of the age samples (6570, 7250, and 8560 psi).

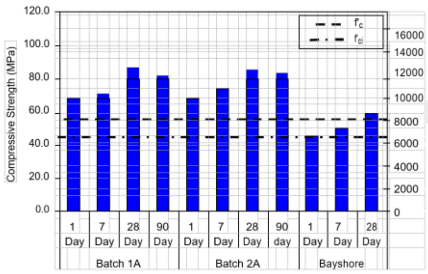

Figure 1: pressure forces of accelerated clusters

Standard Cure

Findings from the compressive strength tests performed by the HSC laboratory in groups 3A and 4A that were presented in standard treatment are shown in Figure 2. The findings shown here are a measure of the results of two separate pressure tests. those are done in quick succession. A comparison was made between the required compression strength (f'c) of material after 28 days, specified as 55 MPa (8000 psi), and the required release capacity (f'ci) after 28 days, specified 44 MPa. Pressure power is measured in megapascals (MPa), and output power is measured in megapascals (Mpa) (6400 psi).

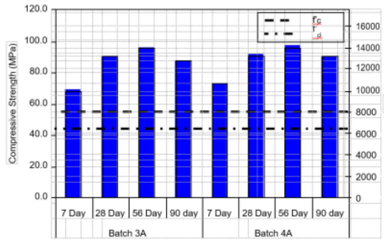

Figure 2: Standard cure Compressive Strength

Tensile Strength

On the same day, the dynamic strength of batch 1A and batch 2A was tested, and the results came in at 6.3 MPa and 6.5 MPa, respectively equal to 940 and 910 psi. Both results were recorded on the same day. Both batch 3A and batch 4A were included in the seven days of hard testing, and the results showed that their strength was 7.3 MPa and 7.2 MPa (1060 and 1040 psi, respectively). Following a 28-day healing time, the strength of the clusters were 1A, 2A, 3A, and 4A, respectively, 6.9 MPa, 7.4 MPa, 8.0 MPa, and 7.8 MPa (1000, 1070, 1160, and 1135 psi.). In both groups A, one measurement was taken, and data from those measurements were calculated (1A and 2A). The calculations provided for groups 3A and 4A averages of two different measurements made simultaneously. These measurements are designed to provide accurate information.

Figure 3 shows the link between the HSC solid force and the square root of the compressive force of an object. The third element is included in the AASHTO design modulus of rupture, which is indicated by the formula 7.5 * SQRT (f'c).

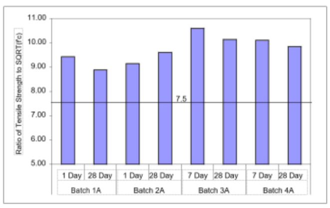

Figure 3 Ratio of Tensile Strength to SQRT(f’c)

Modulus of Elasticity

Accelerated Cure

The HSC module results for rapid expansion group 1A and 2A data are provided by data from the Bayshore study, which can be seen in Figure 4. In reference to laboratory compounds, estimates were taken from one sample for each group aged 28 days, respectively, respectively. Estimates were taken. At the end of the 28 days, ratings were obtained from three different Bayshore samples, and the next section presented an estimate of that study. This figure shows the modulus of the AASHTO flexible design, which was calculated at 39.1 GPa (5650 ksi), and provided for comparison purposes.

After one day, the measured expansion module was 44.2 GPa and 44.6 GPa (6400 and 6500 ksi, respectively) in clusters 1A and 2A, respectively; However, the measuring module was 44.2 GPa and 44.6 GPa for group 3A, respectively (6400 and 6500 ksi). Its expansion module for both group 1A and group 2A was determined to be 43.7 GPa following the completion of the 28-day test (6350 ksi). After 28 days of monitoring, the stretch modulus at Bayshore was found to be 38.9 GPa. This value was obtained after site identification (5650 ksi). Over 90 days, the expansion module of group 1A is rated at 44.65 GPa (6500 kg / m2), and the rigidity module 2A is rated at 42.1 GPa (6100 kg / m2).

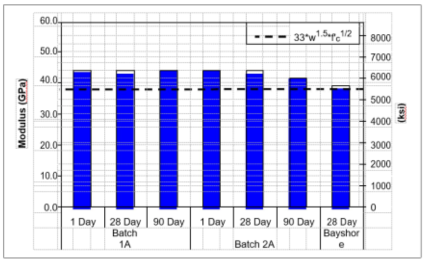

Figure 4: Accelerated cure Modulus of Elasticity

IV. DISCUSSION AND ANALYSIS

The results of the analysis of HSC increases and decreases can be found in the previous chapter, and this chapter is devoted to examining the findings in more detail. Pressure force, strong force, elastic modulus, and object thermal coefficient are the emphasis.

Compressive Strength

The American Concrete Institute (ACI) 214 establishes laboratory control parameters for compressive strength testing, and these criteria range from excellent to inadequate. If the standard deviation between batches is less than 1.4 MPa (or 200 psi), then the quality of the product is considered to be outstanding. On the other hand, if the standard deviation between batches is higher than 2.4 MPa (or 350 psi), then the quality of the product is considered to be bad. These values are separated by control ranges that correspond, respectively, to very good control, fair control, and medium control. These control ranges may be found in the intervals of 1.0 MPa (150 psi) that are found in between these values. 7 In summary, the requirements for adequate control in terms of overall consistency were satisfied by the compressive strength data that was collected for this investigation. This was the situation for the whole of the investigation. The results of the rapid test for stressful strength tests are shown in Figure 1. At 7, 56, and 90 days, the normal deviation between groups falls into the "good" category, while in 28 days, it falls into the "correct" category.

Pressure values recorded after 90 days in each of the four sets were lower than pressure measured after 56 days in all four sets. Despite the fact that things were getting old at the same time, it was. ACI 214 requires a multi-variable coefficient to be more than 5% in the laboratory before it can be considered acceptable. 7 Considering that the difference between the 56-day and 90-day outcomes is less than 5.0 percent for each set of accelerated treatment outcomes, this can be deduced from the data. This indicates that the difference is within the predetermined range of variability for the stress test. On the other hand, the general treatment results in these years have different coefficients that exceed the given limit. From time immemorial this has been the single cylinder of all the cakes that go through the standard treatment process.

At 90 days, the strength of the cylinder was substantially less than the strength of the other three cylinders at 56 and 90 days. The difference coefficients of the standard 3A curing group and the 4A compound are both less than 2.0 percent at 56 days and 90 days, respectively, if we subtract two values outside the normal range from the calculations. Normal cure batches became stronger with time, despite the fact that their average strength after seven days of curing was almost comparable to that of the other curing methods. Accelerated curing results in larger pores in the hydrated cement matrix than standard curing because it utilises more water than the standard curing approach. It's for this reason that the rapid curing process is chosen. This is why the accelerated curing method is preferred. After curing, the specimens that were subjected to standard curing had a greater amount of surplus water compared to the specimens that were subjected to rapid curing. This enabled continuous hydration, which led to an increase in the cement matrix's density. The use of fast curing makes it possible to build initial strength rapidly; nevertheless, the prospect of continuous strength increase after curing is drastically limited by using this procedure.

Figure 1 demonstrates that the compressive strengths that were obtained at Bayshore were 30 percent lower than the compressive values that were measured at the laboratory's accelerated curing process. This disparity might be partially explained by differences in the amounts of water that were included into the various formulations of concrete. However, the material that was utilised in the laboratory combinations was most likely in SSD condition. This is in contrast to the fact that Bayshore's concoctions were most likely produced using aggregate that had been dried before combining. Due to the fact that the absorption of aggregates in the laboratory mixes was not taken into account, the w/cm ratio ended up being 0.30. Considering that the aggregate was in SSD state, the w/cm ratio ought to have been 0.33 rather than 0.33There was only a gain of 13.8 MPa (2000 psi) in compressive strength when the w/cm ratio was reduced from 0.33 to 0.30, according to data in the book "High Performance Concrete: Properties and Applications." 3 There was also less air in the laboratory mixes compared to Bayshore concrete (see Table 3). However, the water-to-cement ratio and air content do not completely explain the variations in strength between the two types of concrete. It is possible that the findings might be explained by the fact that the Bayshore mixture included a greater quantity of water than was specified in the mix design. This is one of the potential reasons. Because the Bayshore mixture had more air in it than the laboratory mixes, it is in line with the idea that a higher water content improves a mixture's fluidity as well as its air content.

Tensile Strength

the findings of the robust power test were discussed in detail. The strength of the force exceeds that stated by the AASHTO with broad genes. Normal end-to-end therapeutic strength was 9.8% of normal end-to-end compression strength, with the exception of one case. Compared to the depressing values, the strength strength tested after 28 days made up 8.5% of the depressing values. This means that the ratio between the tensile force and the compression force is expected to decrease as the compression force increases.

Modulus of Elasticity

Find a quick treatment module for the results of the expansion test on the next page. Unit weight and compressive strength of accelerated laboratory therapeutic groups are required to calculate the AASHTO design module (8000 psi). If the compressive strength exceeds the design value of AASHTO, one can expect that the modulus values rented may be greater than the design value. This is in line with what might be expected. In the experimental modulus of accelerated treatment, no change was observed over time. The researchers found that in most cases, the observed modulus dropped dramatically over time. This may indicate a test error.

Using a quick solution and Bayshore models, the link between the stretching modulus and the compression force is shown in Figure 58. Apart from the findings of the first test day, the

AASHTO design equation always predicts the expansion modulus.

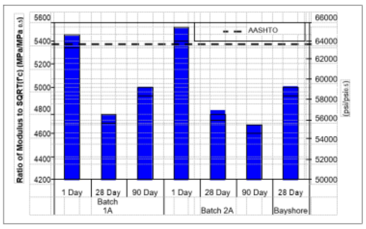

Figure 5: Accelerated Cure Ratio of Elasticity Strength to SQRT(f'c)

Accelerated Cure Rankings

The level data for each model is included in Table 5. The ACI 209 Modified strain model is very accurate for the model models available.

Table 5: Accelerated cure Prediction Model Ranking

	Total Strain	Creep	Shrinkage	Sum
ACI 209 Modified	1	1	1	3
Tadros	2	2	2	6
ACI 209	4	4	4	12
AASHTO-LRFD	3	3	7	13
B3	6	6	3	15
CEB MC-90	5	5	6	16
GL2000	7	7	5	19

Standard Cure Rankings

Table 6 shows the most often used models for predicting the probability of an event. Using the ACI 209 Modified test, the most precise estimations of total strain and overall performance may be obtained. When it came to creep strain, AASHTO-LRFD was shown to be the most accurate predictor, whereas shrinkage strain was best predicted using B3. Swelling and contracting strains

Table 6: Standared cure Prediction Model Ranking

	Total Strain	Creep	Shrinkage	Sum
ACI 209 Modified	1	2	2	5
Tadros	2	3	4	9
AASHTO-LRFD	3	1	7	11
B3	6	6	1	13
CEB MC-90	4	5	5	14
ACI 209	5	4	6	15
GL2000	7	7	3	17

Table 13 Standard Cure Prediction Model Rankings

Applicability of Prediction Models

The creep and shrinkage behaviours of a concrete mixture are significantly influenced by the compressive strength of the concrete mixture. Creep and shrinkage are both caused by the concrete mixture. When compared to regular strength concrete, high strength concrete has a denser cement matrix and contains less free water than standard strength concrete. As a result, the amount of time-dependent water movement inside the cement matrix is restricted. In order for a prediction model for high strength concrete to accurately forecast creep and shrinkage stresses, the compressive strength should be included as a necessary input component in the model.

Models that did not use compressive strength as an input parameter significantly overpredicted the actual stresses in this investigation, according to the findings. In several situations, the models took compressive strength into account but did not take shrinkage into account, and vice versa (AASHTO-LRFD and GL2000).

As a result, it is not envisaged that the Bazant B3 and Gardner GL2000 prediction models will be correct for the laboratory mixes since the compressive strengths in the laboratory mixtures exceed the limits of application for each model. Compressive strength is taken into account in B3, however if the model is to be used to concretes with compressive strengths more than 69.0 MPa, this parameter must be changed (10000 psi). Compressive strength is not taken into account by the GL2000 creep model.

V. CONCLUSIONS AND RECOMMENDATIONS

For Accelerated Cure Applications

1. As far as we know, the HSC-accelerated cure combination's total strain was 1342 49 macrostrain with a 95% confidence level at 20.7 MPa (3000 PSI) after 97 days. There is a citation required for this.

2. The total, moving, and decreasing pressures of the Bayshore HSC compound below 20.7 MPa are accurately predicted using the ACI 209 Modified by Huo model. This model also has a very low error rate (3000 psi).

3. Accelerated curing creates a wider variety of time-dependent stresses in comparison to conventional curing.

4. Embedded It is possible to assess time-dependent stresses in the laboratory using vibrating wire gauges (VWG). Compared to Whittemore Gage measurements, the VWG elastic and creep strain readings are equivalent to one other.

For Standard Cure Applications

1. There were 1276x38 macrostrains weighing in the standard HSC treatment compound loaded at 20.7 MPa (3000 pounds per inch square), equivalent to a 95 percent confidence level in its performance.

2. Uploaded at 20.7 MPa, the ACI 209 Modified by Huo model is the most accurate prediction of total weight in the Bayshore HSC combination. In addition to being a very

accurate model, this is the largest prediction in general. The second number is an example of this (3000 psi).

3. Using the AASHTO-LRFD, the Bayshore HSC creep strain compound can be accurately predicted using a pressure of 20.7 MPa in the laboratory (3000 psi).

4. With the Bayshore HSC combination, B3 is the best predictor of cylinder shrinkage strain, while GL2000 is the best prism shrinkage strain. Both of these effects can be seen in the table below.

5. After ninety days, the total and shrinkage strains that Meyerson measured for the VDOT A5 Gravel GGBFS combination were measured at 1560 132 and 340 57 macrostrain, respectively. After 77 days, the HSC has experienced a total strain of 1246 x 36 macrostrains as well as a shrinkage strain of 228 x 4 macrostrains.

Blast furnace slag is a component used to provide cement consistency in all of these mixtures. The average weight and volume were 0.35 after 28 days, with a compressive strength of 51.0 MPa (7400 psi). Specimens are under pressure of 16.6 MPa, allowable limit (2400 psi). 6 The HSC compound worked better than the other two in terms of weight-to-cm (0.30) and 28-day strength (91.0 MPa) (13200 psi). By combining the effects of these two elements, we can reduce time-dependent degeneration. Combined HSC pressures were low despite an increase in applied load of 25%. This is because there were too many HSCs in the HSC compound. Meyerson's specimens were loaded on most of their 28-day compression capacity (32.4% vs. 22.7%). charges. A greater percentage of Meyerson templates were loaded on their 28-day compression capacity (32.4 percent) than Meyerson (22.7 percent).

REFERENCES

1. ACI Committee 363, “State of the Art Report on High-Strength Concrete.” American Concrete Institute, Detroit, MI (1992) p. 3.
2. MacGregor, James G., “Reinforced Concrete: Mechanics and Design,” 3rd ed., Prentice Hall, 1997, p. 49,71.
3. Shah, S. P. and Ahmad, S. H., “High Performance Concrete: Properties and Applications,” McGraw-Hill, Inc., New York, 1994.
4. Tadros, et al. “Prestress Losses in Pretensioned High-Strength Concrete Bridge Girders,” Final Report (2002).
5. Vincent, Edward C., “Compressive Creep of a Lightweight, High Strength Concrete Mixture,” Master of Science Thesis in Civil Engineering, Virginia Tech, January 2003.
6. Meyerson, R., “Compressive creep of prestressed concrete mixtures with and without mineral admixtures.” Master of science thesis in Civil Engineering, Virginia Tech, February 2001.
7. ACI Committee 214, “Recommended Practice for Evaluation of Strength Test Results of Concrete, ACI 214-77, American Concrete Institute, Detroit, 1977, pg. 7.
8. Waldron, Chris, meeting in May 2003.
9. ACI Committee 209 (1990), “Prediction of creep, shrinkage and temperature effects in concrete structures.” Manual of Concrete Practice, Part 1, 209R 1-92.
10. Gardner, N. J. and Lockman, M. J., “Design Provisions for Drying Shrinkage and Creep of Normal-Strength Concrete,” ACI Materials Journal, v. 98, March-April 2001, pp. 159-167.
11. Huo, X. S., Al-Omaishi, N., and Tadros, M.K., Creep , Shrinkage, Modulus of Elasticity of High Performance Concrete., ACI Materials Journal, v. 98, n.6, November-December 2001.
12. CEB-FIP Model Code, “Evaluation of the Time Dependent Behavior of Concrete,” September 1990.
13. Bazant, Z.P. and Baweja, S., “Creep and Shrinkage Prediction Model for Analysis and Design of Concrete Structures – Model B3,” RILEM Recommendation, Materials and Structures, v. 28, 1995, pp. 357-365.
14. American Association of State Highway and Transportation Officials, “AASHTO-LRFD Bridge Design Specifications,” Second Edition, Washington, DC, 1998.
15. ASTM C192 Making and Curing Test Specimens in the Laboratory. American Society of Testing and Materials, Philadelphia, PA.
16. ASTM C157 Length Change of Hardened Hydraulic-Cement Mortar and Concrete. American Society of Testing and Materials, Philadelphia, PA.
17. ASTM C39 Compressive Strength of Cylindrical Concrete Specimens. American Society of Testing and Materials, Philadelphia, PA.
18. ASTM C496 Splitting Tensile Strength of Cylindrical Concrete Specimens. American Society of Testing and Materials, Philadelphia, PA.

