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ALKALI ACTIVATED CEMENT AND CONCRETE

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RESUMO:

Neste trabalho, o Concreto de Cimento Geopolimérico (CCG) foi desenvolvido com proporções adequadas dos componentes que compõe o geopolímero. As características foram comparadas com Concreto de Cimento Portland (CCP), através de parâmetros estabelecidos no estudo como o consumo de ligantes, relação água aglomerantes e teor de argamassas. O desempenho mecânico dos concretos foi realizado com ênfase no comportamento em fadiga. Foram testados os diferentes efeitos de tensão de resistência máxima (crescente e decrescente). Os resultados dos ensaios de fadiga mostraram que o CCG apresenta um melhor desempenho quando comparado ao CCP. A sua resistência a fadiga foi 15% maior em relação ao CCP, quando a tensão aplicada foi 70% da tensão estática de ruptura do concreto em flexão. Tensões em torno de 80% de SR resultaram em um desempenho 96% superior para o CCG. A análise microestrutural (MEV) mostrou que o CCG tem uma forte interface matriz/agregado, quando comparado ao CCP, provavelmente devido a natureza maciça da matriz geopolimérica.

ABSTRACT:

In this work, a Geopolymeric Cement Concrete (GCC) was developed through adequate portions of geopolymer components. Its characteristics were compared with Portland Cement Concrete (PCC), through of the establishment of some parameters of design, as consumption of binders, water/aggregates ratio and mortar content. The concrete mechanical performance was evaluated with emphasis to the fatigue behavior. Were tested the effects of different tensile strength maximum (increasing and decreasing). The results of fatigue tests had shown that GCC presents a better performance when compared to PCC. Its fatigue strength was 15% higher than that of PCC, when 70% of rupture tension of the concrete in static bending (SR), was applied. Tensions of about 80% SR resulted in 96% of increase, when compared to GCC. The SEM microstructural analysis showed that the GCC has a matrix

1.INTRODUCTION

Energy savings and the reduction of CO2 emissions are a constant worry of the Portland cement industry, leading to the development of more efficient processes and the use of residues and byproducts of other industries2,5,7,8. Geopolymer cements are a new class of high performance materials that can advantageously replace Portland cement in several structural applications2,3,4,6. The inorganic polymeric cement called geopolymer or poly(sialate-siloxo) (PSS), has been studied in recent years as a binder for mortar and concrete2,9.

To use as a pavement application, the behavior under fatigue is a very important parameter to evaluate some parameters as a load tensile application for the load traffic that lead to a structure deterioration along the time1,8.

MATERIALS AND METHODS

The pozzolan used in this work was the metakaolin (Si2O5Al2O2), an oxide-aluminossilicate that presents amorphous structure and aluminum atoms in four-fold coordination number. For the alkali activation was used a commercial soluble silicate and a commercial potassium hydroxide (Vetec P.A) as a supplementary source of alkali. The calcium source was a granulated blast furnace slag (GBFS) supplied by Belgo Mineira S.A. The mixture of the basic constituents and the molding of the specimens followed the procedures described in the NBR 7215 Brazilian standard. The prismatic specimens (100 x 100 x 400) mm was moldings in a single layer vibrated for a fifteen seconds in a vibrator table. The flexural tests followed the procedures described in the NBR 12142 (1991). The fatigue tests followed the PCA/84 method, in the MTS universal machine. The figure 1 show the position of the support and the load positions.

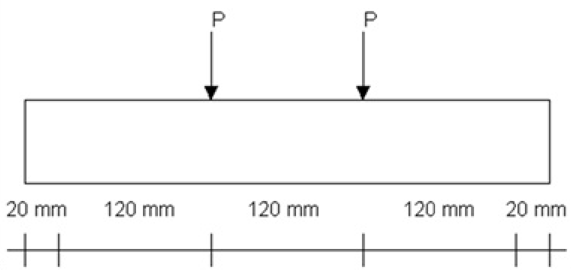

Figure1 – Load and support position to the fatigue and flexural tests.

After the determination of fracture properties some samples are selected for scanning electron microscopic observation (SEM-Jeol 5800 LV) to determine the damage mechanisms.

MATERIALS AND METHODS

The results of the flexural strength tests to Portland Cement Concrete (CCP) shows that the medium value was 5,4 MPa and served as base for the fatigue tests. To the Geopolymer Cement Concrete GCC the average was 5,7 MPa.
In the flexural study of beams with reduced dimensions4, the deformation was analyzed to both concrets when submitted to the application of static loads. The results showed the end deformation to the GCC 50% above the PCC. This results are presented in the figure 2.

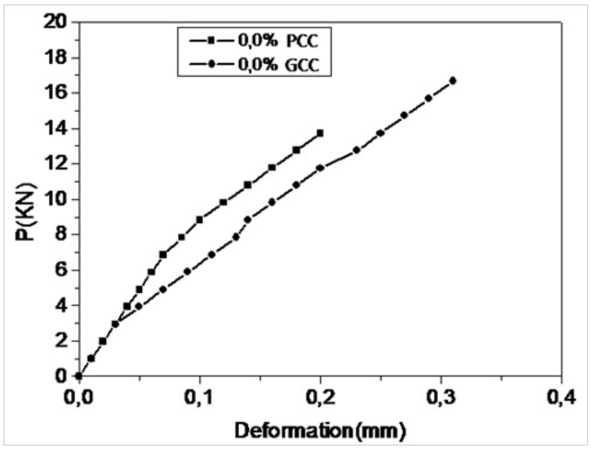

Figure 2 – Load – deformation relation for both concretes.

The figure 3 shows the relation among strength and the number of cycles in the fatigue tests with constant strength to both concretes. It is possible to notice that in the case of relationships among tensions (RT) of 0,70 (70% of static strength), the GCC presents values 15% above the values showed to the PCC under the same conditions. For relationships among tensions of 0,80 the GCC showed values 96% above the PCC. This results indicates a favorable behavior under fatigue of GCC, not only in low tensions, as well as in higher tensions.

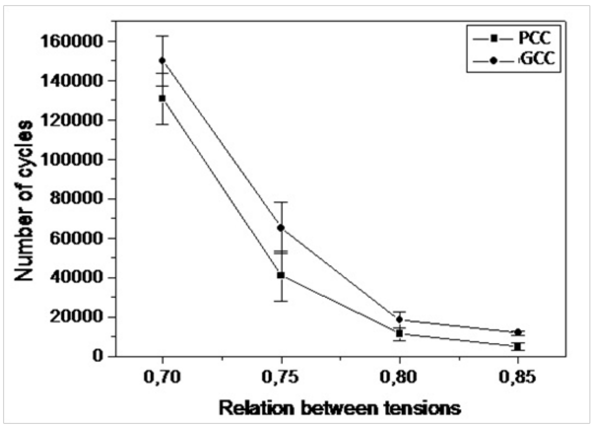

Figure 3 - Variation of the Number of cycles of fatigue with the Relation between the applied tensions.

In the fatigue tests with variable tension is possible to observe the small influence of the variation of tensions when this was applied in a increasing way. However, when applied in a decreasing way this influence is more significant, as show the figure 4.

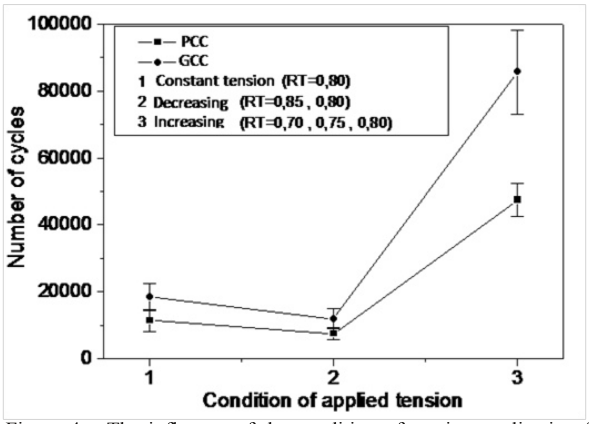

Figure 4 – The influence of the condition of tension application for both studied concretes.

The good adherence between the matrix of CCG and the aggregate can be noticed in figure 5, starting from the smallest degradation of the interface aggregate/matrix due to the inexistence of gradients of concentration of Portlandita in this area. The figure 6 shows that the cracking tends to outline the aggregate at the aggregate/matrix interface, as well as it happens in GCC, however, in PCC, a larger degradation is observed in the transition area due to the great number of porous and the presence of Portlandita crystals, that limits considerably the mechanical properties of the Portland concrete.

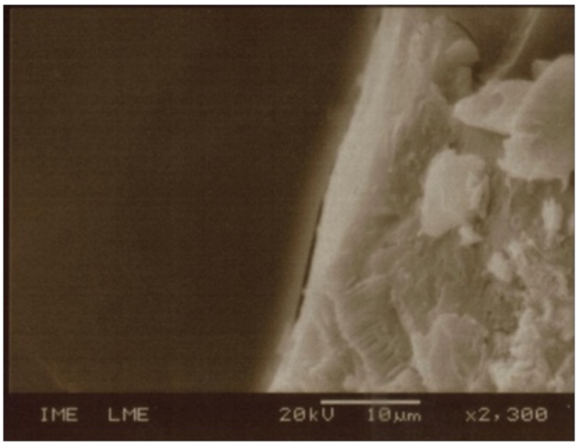

Figure 5 - Interface matrix/agregate - GCC.

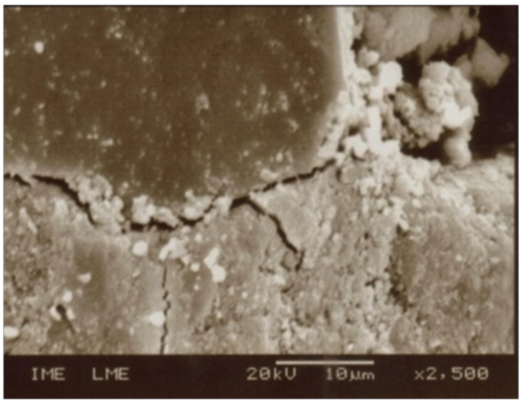

Figure 6 - Transition area - PCC.

CONCLUSIONS

The results of fatigue tests in the several accomplished variations, shows a better behavior in fatigue of the GCC. In the case of relationships among tensions (RT) of 0,70 (70% of static strength), the GCC presents values 15% above the values showed to the PCC under the same conditions. For higher tensions, about 80%, the results of the GCC showed values 96% above the PCC. For the testes with variation of the applied tension, the resistance to the fatigue was larger for the tests with increasing tension that for the tests with constant tension.

REFERENCES

CERVO, T.C.; J. T. Balbo; R. Curti; C. Silva; Estudo sobre medidas de resistência à tração na flexão de concretos para pavimentos com emprego de amostras reduzidas. in 46º Congresso Brasileiro do Concreto - IBRACON (CD Room), Florianópolis, 2004.

DAVIDOVITS, J., "Ancient and Modern Concretes: What is the Real Difference", Concrete International, 9, 12, 23-351987, 1987.

DAVIDOVITS, J., "Geopolymers Inorganic Polymeric New Materials", Journal of Thermal Analysis. 37, 1633 –1656, 1991.

HAMOU, A. T., CORIC, M. S., RIVARD, P., "Internal deterioration of concrete by the oxidation of pyrrhotitic aggregates", Cement and Concrete Research, 35, 99–107, 2005.

HARDJITO, D., WALLAH S. E., SUMAJOUW, D. M. J., and RANGAN B. V., "On the development of fly ash-based geopolymer concrete", Materials Journal, 101, ACI, 2004.

HARDJITO, D., WALLAH S. E., SUMAJOUW, D. M. J., and RANGAN B. V., "Fly ash-based geopolymer concrete: study of slender reinforced columns", J. Mater Sci, 42, 3124-3130, 2007.

HARDJITO, D., FUNG, S. S., "Fly Ash-based geopolymer mortar incorporating bottom ash", Modern Applied Science, 4, 1, 2010.

RIOS, A. C. S. 2006. "Comportamento do Concreto Geopolimérico para Pavimento sob Carregamento Cíclico", Master Thesis, Instituto Militar de Engenharia, Rio de Janeiro, Brasil, 184p.

SILVA, F. J.; DIAS, D. P.; BARBOSA, V. F. F.; OLIVEIRA, M. C.; THAUMATURGO, C. High-Performance Mineral Polymeric Binder for Civil Applications. II International Conference on High-Performance Concrete, and Performance and Quality of Concrete Structures, Gramado, 1999.

ZHANG, Y. S., SUN, W., LI, Z. J. "Hydration process of potassium polysialate (K-PSDS) geopolymer cement", Advances in Cement Research, 17, Nº 1, 23–28, 2005.