American Journal of Environmental Science 10 (1): 44-47, 2014
ISSN: 1553-345X

doi:10.3844/ajessp.2014.44.47 Published Online 10 (1) 2014 (http://www.thescipub.com/ajes.toc)

DURABILITY OF MIXED MORTAR LINING CONTAINING DREGS-GRITS

Zanella, B.P., E.B. Sá, N.O. Acorinti, I.C.B. Trannin and S.J.C. Simões

Department of Civil Engineering,
Universidade Estadual Paulista "Júlio de Mesquita Filho", Guaratinguetá, Brasil

Received 2013-04-12; Revised 2013-07-16; Accepted 2014-02-15

ABSTRACT

The improper disposal of industrial waste and exploitation of natural resources has resulted in the scarcity of river sand and environmental degradation, such as river erosions and pollution. This study aimed to assess the durability of mixed mortar lining walls and ceilings, containing 0 (default), 10 and 20% of dregs-grits compounds-waste of the pulp industry-in substitution with river sand. This was done with tests that simulated both natural and artificial conditions: Direct solar incidence (testing ultraviolet radiation), attack by spraying solution (salt spray test), natural warming of the walls and ceilings incidence by indirect solar (thermal degradation) and residential fires (thermogravimetric test), in compliance with both national and/or international standards. The grout containing dregs-grits compounds showed similarity to standard (0%) for testing thermal degradability, thermogravimetric and ultraviolet radiation, but shows significantly less durability when exposed to salty environments.

Keywords: Recycling, Industrial Waste, Salt Spray, Ultraviolet Radiation, Thermogravimetric

1. INTRODUCTION

The improper disposal of industrial waste and exploration of natural resources by the productive sector bring, as a consequence, a shortage of natural resources and environmental degradation. Nowadays, the industries are responsible for the quality of their product, as well as attending the environmental legislation, being able to be fined by self-regulatory and inspecting organizations if they don't respect the laws. The industrial sector has tried to reduce the generation of residues, adopting recycling technologies, such as using industrial waste for supplementary purposes, so they fulfill legal requirements and obtain environmental certifications. Trying to minimize environmental impacts, it is observed that proposed by Zamora *et al.* (2008), the enhancement of water treatment sludge as a raw material in the production of concrete and mortar and this sludge can be a supplementary cementing materials and sand substitute. The pulp and paper industry, by means of the Kraft process, processes pulp and generates large amounts of industrial waste, some of which is dregs and grits. To minimize environmental impacts and fulfill the legal requirements, studies have been developed to evaluate the viability of the use of these residues in civil construction products. These studies positively indicate the potential of the use of dregs-grits compounds in the production of Internal mixed mortar lining for walls and ceilings, replacing up to 20% of the mass of the fraction of medium-fine sand. This use favors the reduction of the riverbed sand extraction (Zanella, 2011). However, there are quality standards by which civil construction materials must be fulfilled. As such, it will be necessary to evaluate the durability of the mortal containing dregs-grits compounds which replace up the sand.

The durability of the material is, in general, the stability of a material's properties-including, but not limited to physical and mechanical properties-to resist an aggressive environment. Furthermore, this property is reflected in the period of the coating use in the hardened state, taking into account the external environment actions throughout the time of its use (Farias *et al*., 2011; Maciel *et al*., 1998). The difficulty with examining the durability of an alternative material, produced with

Corresponding Author: Zanella, B.P., Department of Civil Engineering, Universidade Estadual Paulista "Júlio de Mesquita Filho", Guaratinguetá, Brasil

recycled residues, is associated with the complexity of the constituents of the residues, which depend directly upon the environment where they originated, to the stage of their generation, the kind or treatment done to the material that produced the residues, as well as its interaction of the agents and mechanisms of environmental degradation, which will be submitted for evaluation of the durability indicators (Farias *et al*., 2011). It is also necessary to consider that certain factors affect the durability of the coating, such as cracking of the coating, the excessive thickness, proliferation of microorganisms, the quality of the mortar and lack of maintenance (Maciel *et al*., 1998).

In this context, the objective of this study was to evaluate the durability of mortar mixed lining walls and ceilings, containing 0% (standard), 10 and 20% compound dregs-grits in replacement the river sand mass through tests that simulated natural and artificial effects, such as direct solar incidence (ultraviolet radiation test), attack by salty air (salt spray test), natural heating of wall and ceiling for indirect solar incidence (thermal degradation test) and residential fires (thermogravimetric test), seeking to meet national and international standards.

2. EXPERIMENTAL PROCEDURES

The dregs and grits residues are generated in the pulp manufacturing process. The dregs is a solid material, dark in color, similar to blast-furnace slags and is removed after sedimentation. The grits are impurities which include sand, limestone and other drosses introduced by the recovery of limestone (Modolo, 2006). When removed from the industrial process these two wastes are mixed, forming dregs-grits compounds.

The proportions of the components of the mixed mortar (cement/lime/river sand and compound/water) in the 0% sample the proportions were (1/1,41/6,59/1,78); in the 10% sample they were (1/1,05/6,95/1,91); and in 20% sample they were (1/0,66/7,34/2,09), as determined by the calculation method proposed (Lara *et al*., 1995). In order to perform the laboratorial tests, which included: Salt spray, thermogravimetry, ultraviolet and thermal degradability; 30 proof bodies were produced with dimensions of 5 cm diameter ×10 cm high, being 10 proof bodies for each sample.

The test bodies in triplicate for each trace were cured in a humid chamber for 49 days for the thermal degradation test. This experiment was performed in a hothouse, quimis Q819V2, programmed to remain at a temperature between 40 and 45°C for 7 days. The test bodies were weighed on an analytical balance before and after 4 days and upon completion of the test, to compare the mass loss.

The preparation of samples for thermogravimetric analysis included scraping each trait to obtain a powder, which was cured for 45 days. This test, required for fire simulation was performed in the SII Nanotechology equipment-seiko model EXTAR6000, previously calibrated with alumina, with a heating rate of 10°C min^{-1} until 1000°C in a cell of platinum in an inert atmosphere of nitrogen (ASTM, 2011a).

To determine the material's resistance to ultraviolet radiation, the samples, in triplicate, for each mixture of mortar were placed in an aging chamber, which operates using fluorescent UVB, alternating cycles of 8 h of UV radiation and 6 h of condensation (ASTM, 2006).

The test of resistance to salinity was performed in salt spray equipment, SS-600e-SS100 of corrosive process simulation (ASTM, 2011b) using the NaCl salt. Upon conclusion of the test, the samples-in triplicate-were weighed three days post-experiment to prevent any interference from excess humidity.

3. RESULTS

The test results of thermal degradation indicated that higher weight loss occurred in the first four days of testing, due in large part to humidity loss **(Table 1)**.

According to the thermogravimetric test results, presented in **Fig. 1**, it was found that the water loss from the mortar until a temperature of 230°C was 10.06% for the trace of 0%, from trace 10% was 10.76% and from trace 20% was 10.67%. Increasing the temperature to 500°C, the loss in weight was 12.86% for the trace 0%, was 13.33% for the trace 10% and 13.25% for the trace 20%. The total loss of mass in mortar with the trace 0% was 17.10%, the trace 10% was 19.50% and the trace 20% was 20.98%. Based on this data, it was found that the loss of humidity and mass to the temperature of 500°C is comparably similar for all traces of mortar. There is no difference between the standard and the mortar containing the compound dregs-grits. The biggest losses occurred at temperatures above 600°C, probably due to decomposition/alteration of the inorganic fraction of mortars.

Thermogravimetry was also performed for each material used in the production of mortar proof bodies evaluated to check its contribution to mass loss in the studied traces. Those most responsible for mass losses were lime and dregs-grits compound, which showed total mass loss of 31.11 and 31.29%, respectively. Thus, by means of thermogravimetry, it was possible to verify that the incorporation of the compound into the mortar did not significantly affect their durability at high temperatures.

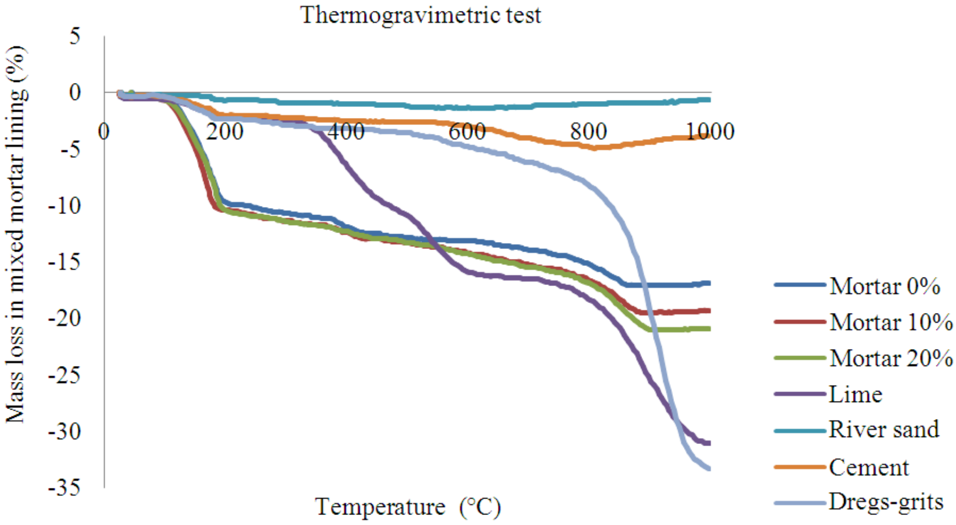

Fig. 1. Mass loss in mixed mortar lining containing dregs-grits versus temperature obtained by thermogravimetric test

Table 1. Thermal degradation of mixed mortar lining walls and ceilings, containing dregs-grits in replacement by mass of sand

Mortar	Date of weighing (g) Outset	4th day	7th day	Mean losses day on the 4th (%)	Mean losses day on the 7th (%)
Standard (0%)	396.83	367.68	363.73	7.28	8.25
	399.85	370.95	367.10		
	398.43	369.50	365.63		
Dregs-grits (10%)	392.63	356.67	351.78	9.02	10.55
	393.43	356.60	350.40		
	394.37	360.68	353.72		
Dregs-grits (20%)	391.34	359.85	351.35	8.61	10.71
	402.62	366.71	358.62		
	387.08	351.94	344.60		

Table 2. Mass loss of mixed mortar lining containing dregs-grits at 7 and 10 days of salt spray testing

Mortar	Date of weighing (g) Outset	7th day	10th day	Mean losses on the 7th day (g)	Mean losses on the 10th day (g)
Standard (0%)	400.499	396.73	392.05	4.64	7.59
	387.320	379.52	379.10		
	386.980	384.64	380.88		
Dregs-grits (10%)	385.110	371.69	366.48	13.30	20.28
	391.160	378.64	373.24		
	396.340	382.38	372.05		
Dregs-grits (20%)	386.140	372.63	361.75	11.24	24.37
	388.420	378.02	363.58		
	386.810	377.02	362.93		

Based on the data obtained in salt spray testing presented in the **Table 2**, it was observed that the mass losses of mortars containing 10 and 20% dregs and grits were higher than those of the standard mortar, at 7 and 10 days of salt spray tests. This behavior probably occurred due the permeability of the saline solution into the mortar microfissures and subsequent crystallization of the salt. Crystallization of NaCl salt inside these microfissures may have favored the breakdown the mass of proof bodies containing the compound.

Table 3. Weight loss of the mortar mixed liner, containing dregs-grits of ultraviolet radiation test at 7 days

Mortar	Outset (g)	After 7th day (g)	Mass loss on the 7th day (g)	Mean losses on the 7th day (g)
Standard (0%)	350.125	343.817	6.308	8.160
	353.805	344.923	8.882	
	371.957	362.667	9.290	
Dregs-grits (10%)	347.321	341.436	5.885	7.943
	349.485	338.695	10.79	
	350.454	343.300	7.154	
Dregs-grits (20%)	341.292	335.454	5.838	5.010
	335.860	330.843	5.017	
	332.727	328.548	4.179	

Some of the solutions to decrease the permeability of chloride in mortar may be the incorporation of bagasse-rice husk-wood ash like additive (Horsakulthai and Paopongpaiboon, 2013) and the incorporation of alkali resistant glass fiber, according Chandramouli *et al.* (2010). By means of the data obtained in the ultraviolet tests, shown in **Table 3**, it was found that the loss of mass by mortar containing the residue dregs-grits were similar to standard mortar. The mean weight losses for the mortar 20% were smaller than 10% and standard mortar.

4. CONCLUSION

The mixed mortar lining walls and ceilings containing dregs-grits compound in proportions of 10 and 20% mass replacement of medium-fine river sand, showed durability similar to that standard mortar by tests of thermal degradability, thermogravimetric and ultraviolet radiation, but were less resistant in salty environments. A limitation of the study is the fact that in the composition of proof bodies was used only one type of cement (CPIII), so for future possibilities can be used others types of cement and the research can be extended for mortar behavior in cold weather.

5. ACKNOWLEDGEMENT

Foundation for Scientific and Technological Development (FDCT) for their support in developing this science project.

6. REFERENCES

ASTM, 2006. Standard practice for operating fluorescent light apparatus for UV exposure of nonmetallic materials. American Society for Testing and Materials.

ASTM, 2011a. Standard test method for mass loss and residue measurement validation of thermogravimetric analyzers. American Society for Testing and Materials.

ASTM, 2011b. Standard practice for modified salt spray (fog) testing. American Society for Testing and Materials.

Chandramouli, K., P.S. Rao, N. Pannirselvam, T.S. Sekhar and P. Sravana, 2010. Chloride penetration resistance studies on concretes modified with alkali resistant glass fibers. Am. J. Applied Sci., 7: 371-375. DOI: 10.3844/ajassp.2010.371.375

Farias, J.F., R.R. Menezes, H.S. Ferreira, L.N.L. Santana and G.A. Neves *et al*., 2011. Estudo da durabilidade de argamassas alternativas contendo resíduos. Cerâmica, São Paulo, Brazil. 57: 395-403.

Horsakulthai, V. and K. Paopongpaiboon, 2013. Strength, chloride permeability and corrosion of coarse fly ash concrete with bagasse-rice husk-wood ash additive. Am. J. Applied Sci., 10: 239-246. DOI: 10.3844/ajassp.2013.239.246

Lara, D.N., A. Macedo, G. Gallo and L. Pereira 1995. Dosagem de Argamassas. In: Brasileiro de tecnologia das argamassas, Simpósio, I., Ed., Goiânia. Brazil, pp: 63-72.

Maciel, L.L., M.M.S.B. Barros and F.H. Sabbatini, 1998. Recomendações para Execução de Revestimentos de argamassa para paredes de vedação interna e externa e tetos. São Paulo. Brasil.

Modolo, R.C.E., 2006. Valorização de resíduos do sector de pasta e papel em produtos da construção civil. University of Aveiro.

Zamora, R.M.R., O.C. Alfaro, N. Cabirol, F.E. Ayala and A.D. Moreno, 2008. Valorization of Drinking Water Treatment Sludges as Raw Materials to Produce Concrete and Mortar. Am. J. Environ. Sci., 4: 223-228. DOI: 10.3844/ajessp.2008.223.228

Zanella, B.P., 2011. Aproveitamento de resíduos da indústria de celulose e papel em argamassa mista de revestimento interno. Universidade Estadual Paulista, Bauru. Brazil.