MECHANICAL PROPERTIES OF TEXTILE WASTE REINFORCED POLYMER CONCRETE

L.P.N. Silva, leiznunes@yahoo.com.br
UFF - Universidade Federal Fluminense
PET-MEC – Programa de Educação Tutorial
Rua Passo da Pátria, 156 Bl. E sala 214, Niterói, RJ, Brasil

J.M.L. Reis, jreis@mec.uff.br
UFF - Universidade Federal Fluminense
PGMEC – Programa de Pós-Graduação em Engenharia Mecânica
LMTA – Laboratório de Mecânica Teórica e Aplicada
Rua Passo da Pátria, 156 Bl. E sala 216, Niterói, RJ, Brasil

Abstract. *Textile cuttings wastes are mixed with foundry sand and thermosetting resin, epoxy, as binder to produce a unique kind of composite material that looks likes concrete. It exhibits certain physical and mechanical properties indicating its potential for low-cost lightweight construction. The composite material tested is produced from a mixture of textile waste cuttings, foundry sand and thermosetting resin. Textile cuttings are taken from disposed trimmings of a garments producer and a textile manufacturer. Experimental cylindrical blocks are fabricated and tested for compression tests. However, unlike concrete, the samples tested for compression do not exhibit a sudden brittle fracture even beyond the failure load, indicating its high energy-absorbing capacity. The result of the laboratory test indicate a sturdy lighter-than-concrete building material with various potential uses, for pavements, wooden board substitute, or as an economical alternative concrete block.*

Keywords*: Textile Fibers, Fiber Reinforcement, Polymer Concrete*

1. INTRODUCTION

Polymer concrete (PC) have gained an increasing research interest due to their wide range of possible applications in civil construction (Fowler,1999, Czarnecki, 2001, Letsh, 2002, Rebeiz and Craft, 2002). Over the last years, research of and improvements to polymer concrete mix design have resulted in an increase of three to fourfold in available polymer concrete strengths. The initial applications of PC, in the late 1950's, were the production of building cladding and cultured marble, but its excellent properties rapidly widespread its application fields. Its rapid curing, excellent bond to concrete and steel reinforcement, high strength and durability made it a very attractive repair material. As a mortar it can be placed with thickness less than 10 mm. Overlays in PC, for bridge surfaces and floors, have also become widely used because of the ability to use thin layers, fast curing time, very low permeability, and high resistance to chemical and frost attack. Precast components are another excellent use of the material. The high strength to weight ratio, good damping properties, moldability and ability to form complex shapes make PC and PMs particularly attractive for these applications (Fowler,1999). With respect to columns, a larger compressive strength means a smaller cross-sectional area required, resulting in better utilization of available space and materials. These higher strength columns, however, have been shown to contain weaknesses. As the compressive strength increases so too does the brittleness and while increasing the amount of lateral reinforcement reduces this brittleness, it also increases the columns susceptibility to early cover spalling (Foster and Attard, 2001). In parallel the increasing demand for environmentally friendly materials and the desire to reduce the cost of traditional fibers (i.e., carbon, glass and aramid) reinforced petroleum-based composites, new bio-based composites have been developed. Researchers have begun to focus attention on natural fiber composites (i.e., biocomposites), which are composed of natural or synthetic resins, reinforced with natural fibers or waste residues from industries (O'Donnell *et al.*, 2004).

Wang conducted previous researches on ordinary cement concrete reinforced with carpet cuttings waste. He performed several tests, compression, flexion and split to evaluate if such reinforcement improves concrete performance. Those studies demonstrated that such reinforcement can effectively improve the shatter resistance, toughness and ductility of concrete (Wang *et al.*, 1994, 2000).

Aspiras (Aspiras and Manolo, 1995) conducted a similar tests using textile cuttings from shirt and garment factory in Philippine. In that tudy different fiber-cement ratio by weight, water-cement ratio by weight and textile length were used to evaluate the performance of portland cement concrete.

Research shows that textile waste cuttings when mixed with thermosetting polymer as binder produces a unique kind of composite material that can be used for low-cost lightweight construction. The research is timely and relevant in the light of statistics showing that the disposal of textile waste cuttings would soon become a major problem. Textile composites for engineering structures draw on many traditional textile forms and processes. These textiles are generally those that most effectively translate stiff, strong yarns into stiff, strong composites. The textile cuttings are usually disposed of s waste product which become an environmental nuisance because of its non-biodegradability, or burned in heaps thus releasing highly toxic fumes in the surrounding air. Due to the influx of these voluminous wastes in our environment, turning them into useful materials serves a dual function: elimination of wastes, and introduction of a new product.

The aim of this study is to explore the technical properties of a new product produced from textile waste cuttings in order to determine its usefulness as a new building material.

2. MATERIALS

In this study, the textile waste cuttings are taken from the most important lingerie industry in Brazil, localized at the Nova Friburgo City (Rio de Janeiro state). The textile waste consists of cotton, polyester, silk and rayon. A homogenous single type of textile usually consists of a combination of these materials in various percentages. In the textile polymer composite material under study, foundry sand is mixed with a thermosetting resin, epoxy, which is used as binder. The textile cuttings may not be conceived as either an aggregate or a reinforcement. It does however contribute to the increase in volume of the mixture (which is the major function of an aggregate) less the weight, and intent to contribute to the increase in the compressive resistance (which is the major function of the reinforcement) due to its fibrous nature.

The aggregate was foundry sand which consists in quartz sand, designed by 40/50, used in the foundry industry, with a uniform granulometry.

The epoxy resin system used is based on a diglycidyl ether bisphenol A and an aliphatic amine hardener, it processed with a maximum mix ratio to hardener of 2:1 with low viscosity (500- 700 MPa s), which cluster the sand, giving high strength and cohesion.

PC formulations were prepared by mixing foundry sand with the thermosetting resins. Resin content varies from 10 to12% by weight. Textile fiber reinforced polymer concrete were prepared in the same way as plain polymer concrete, with the incorporation of 1% in weight of chopped textile fibers. The textile waste cuttings are trimmed into average lengths of 2 cm.

With these binder formulations and mix proportions, polymer mortars were mixed and moulded to cylinder (ø50 x 100 mm) specimens, as illustrated in Fig. 1, according to the RILEM standard CPT PC-2 (CPT PC-2, 1995).

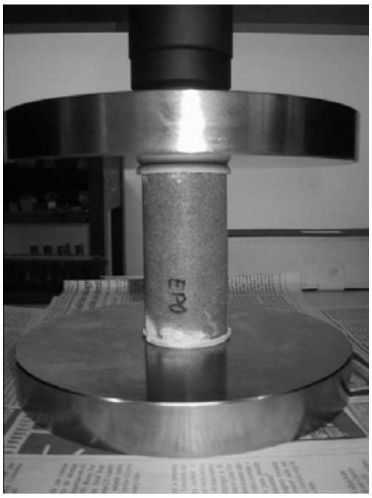

Figure 1. Compressive Test Set-up

For each formulation five cylinder specimens were cast. All specimens were allowed to cure for 7 days at room temperature. Cylinder polymer mortar specimens were tested in compression at the loading rate of 1.25 mm/min according to ASTM C469-94 standard (ASTM C 39-93a, 1997). Compressive strength and chord modulus of elasticity in compression were calculated according the Eq. (1):

$$\sigma_C = \frac{F}{A} \tag{1}$$

where σ_C is the compressive strength; P is the maximum load recorded; and A is the cross-sectional area of cylinder specimens.

2. TEST RESULTS

Laboratory results from tests conducted at Universidade Federal Fluminense (UFF) and Instituto Politécnico do Rio de Janeiro IPRJ) is presented in table 1.

Table 1. Epoxy Polymer Concrete Compressive Tests Results (MPa)

Specimens	10% Resin No Fiber	10% Resin 1% Fiber	12% Resin No Fiber	12% Resin 1% Fiber
1	34.358	22.376	36.457	30.072
2	33.073	22.048	51.932	30.837
3	27.601	20.431	44.095	24.095
4	37.726	23.166	51.078	18.852
5	31.708	22.090	46.243	26.928
Average	32.893	22.022	45.961	26.157
St.Dev.	3.7062785	0.9963223	6.2394716	4.8846426
COV	11.267613	4.5241726	13.575578	18.674465
CI (95%)	3.8901335	1.0457462	6.5489891	5.1269519

Statistic analysis demonstrated a good performance of the material under tests. Confidence Interval at 95% shows a low level of variation on the compressive strength.

Epoxy polymer concrete tests results are plotted in Fig. 2.

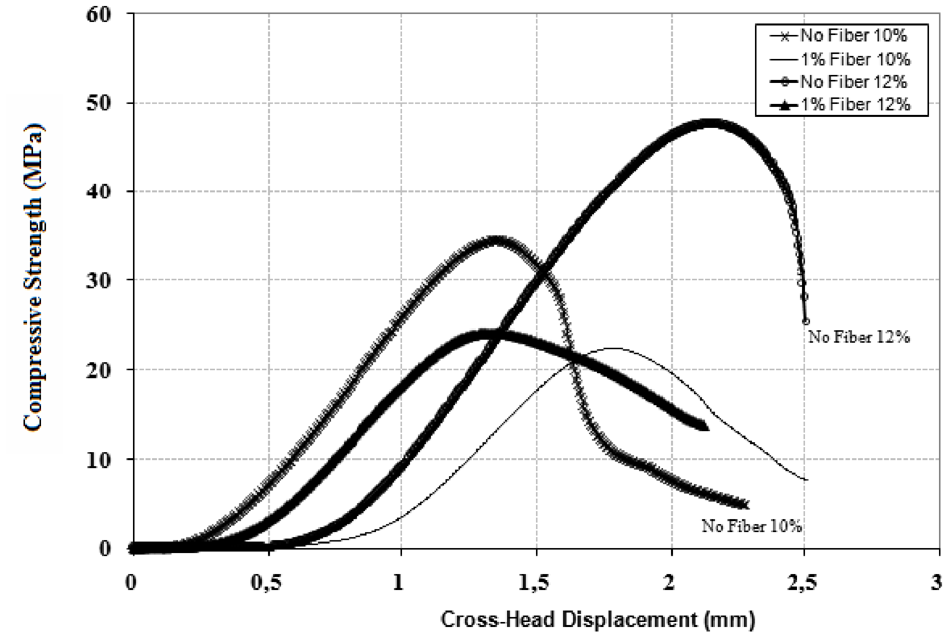

Figure 1. Epoxy Polymer Concrete Comparison

Results show that textile reinforcement material behaved differently for every controlled variable. The displacement rate of every test is constant according to RILEM standard. The compressive strength is analyzed for every percentage of fiber content. Since polymer concrete is more subjected to compression like ordinary concrete, the compressive strength is presented. 10% content of epoxy polymer concrete reinforced with textile fibers decreases its compressive strength in 30.33%. The decrease is higher when 12% content, are analyzed 41.77%. Comparing unreinforced epoxy polymer concrete, the increasement of 2%, in weight of epoxy thermosetting resin, increase 45.84%.

As expected and according to researchers (Ribeiro *et al.*, 2003, Rebeiz *et al.*, 1993) the increase of resin content increases the strength of reinforced and unreinforced polymer concrete.

4. CONCLUSIONS

The textile cutting waste, when mixed with thermosetting, epoxy and polyester, resin and foundry sand produce a unique composite material the can be used for lightweight construction.

The composite material produced exhibits lower compressive characteristics when reinforced with textile cutting wastes. According to different results from the past performed by the author, textile reinforcement does not accomplish the expected reinforce, i.e., as least has the same strength of unreinforced polymer concrete.

More tests should be performed for a more conclusive explanation of the behavior of polymer concrete reinforced with textile waste. Compressive strength gives a high qualification about the performance of this specific material. Tests like flexural and impact are going to be performed in the near future for a complete understanding of the material behavior.

Therefore besides textile cuttings waste is not advised to use as reinforcement, the use of those fibers, in specific applications, may solve two problems, namely, elimination of an environmental pollutant and provision of an alternative material for the construction industry.

5. ACKNOWLEDGEMENTS

The financial support of CAPES under the PRODOC scholarship are gratefully acknowledged and the Head of Materials Engineering Department of IPRJ/UERJ.

6. REFERENCES

Aspiras F.F. and Manolo J.R.I., 1995, Journal of Materials Processing Technology, vol. 48, pp. 379-385.

ASTM C 39-93a, 1997, Standard test method for Compressive Strength of cylindrical concrete Specimens in compression. ASTM, USA.

CPT PC-2, 1995, Method of making polymer concrete and mortar specimens. TC 113, RILEM, UK.

Czarnecki L., 2001, Polymers in concrete on the edge of the millennium. In Proceedings of 10th International Conference on Polymers in Concrete, Honolulu, Hawaii, USA, May, , paper 93.

Foster S.J., Attard M.M., 2001, Strength and ductility of fibre-reinforced high-strength concrete columns. Journal of Structural Engineering vol.127, n°1, pp.28-34.

Fowler D.W., 1999, Polymers in concrete: a vision for the 21st century. Cement Concrete Composites ;vol.21, n°5-6, pp.449-52.

Letsh R., 2002, Polymer concrete properties and structural applications. In Proceedings of International Conference on Polymer Concretes, Mortars and Asphalts, Oporto, October, , p. 31-43.

O'Donnell A., Dweib M.A., Wool R.P., 2004, Natural fiber composites with plant oil-based resin. Composites Science and Technology, nž64, pp.1135-1145.

Rebeiz K.S., Craft A.P., 2002, Polymer concrete using coal fly ash. Journal Energy Engineering, vol.128, nž3, pp.62-73.

Rebeiz K.S., Shearl, S.P., Fowler, D.W.,1993, Recommended design procedure in shear for steel-reinforced polymer concrete, ACI Structural Journal.

Ribeiro M.C.S. , Tavares C.M.L., Figueiredo M., Ferreira A.J.M., Fernandes A.A., 2003, Bending Characteristics of Resin Concretes, Materials Research, Vol. 6, No. 2, 247-254.

Wang Y., Zureicka H., Cho B.S., Scott D.E., 1994, Properties of fibre reinforced concrete using recycled fibres from carpet industrial waste. Journal Of Materials Science vol.29, pp.4191-4199.

Wang Y., Wu H.C., Li V.C., 2000, Concrete Reinforcement with Recycled Fibers. Journal of Materials in Civil Engineering. Vol. 12, No. 4, pp. 314-319.

7. RESPONSIBILITY NOTICE

The author(s) is (are) the only responsible for the printed material included in this paper.