

**ANÁLISIS TÉCNICO DEL IMPACTO EN LA SUSTITUCIÓN PARCIAL DEL
CEMENTO ENMEZCLAS DE MORTERO MEDIANTE LA INCLUSIÓN DE
LADOS PAPELEROS.**

Nombres y apellidos
Daniela Fernanda Castrillo zapata
Alejandro López De la cruz
María José Ocampo Perdomo

Código estudiantil:
202013125561
202011620078
201923119548

Trabajo de Investigación del Programa Ingeniería Civil

Tutor(es):
Nemesio Daza Márquez

RESUMEN

El cemento es uno de los materiales más utilizados en el mundo y es muy versátil para la construcción. Su producción es poco económica y responsable con el medio ambiente. Para mitigar estos problemas, se implementan materiales alternativos que tengan un menor impacto ambiental como también en la producción, transporte y costos. De manera que este estudio tiene como objetivo investigar los efectos de los lodos papeleros usados como material sustituto del cemento en las mezclas de mortero. Por lo tanto, se investigó la incidencia de los lodos de papel con reemplazo del 5% y 10%. Se estudió su efecto en ensayos en estado fresco de trabajabilidad y densidad y en estado endurecido de resistencia a la compresión a las edades de 7, 14 y 28 días de curado, y absorción por capilaridad a la edad de 28 días. Los resultados de este estudio muestran que el reemplazo de lodos papeleros (LP) aumenta la trabajabilidad de las mezclas, reduce su peso final y disminuyen la resistencia a la compresión hasta un 87% para mezclas con 10% de sustitución. Se observó una menor absorción por capilaridad para el 5%. En conclusión, el uso de lodos papeleros como reemplazo parcial del cemento en mezclas de mortero proporciona ventajas en términos de densidad, aunque afecta la resistencia a la compresión. La reducción en la absorción por capilaridad de lodos papeleros indica un beneficio potencial para ciertas aplicaciones de construcción, promoviendo así una alternativa más sostenible para el manejo de estos residuos industriales.

Palabras clave: Lodos papeleros (LP), mortero, residuos sostenibles, construcción sostenible, sustitución parcial, cemento.

ABSTRACT

Cement is one of the most widely used materials in the world and is very versatile for construction. Its production is uneconomical and environmentally unfriendly. To mitigate these problems, alternative materials are implemented that have a lower environmental impact as well as in production, transportation and costs. So this study aims to investigate the effects of paper sludge used as a substitute material for cement in mortar mixtures. Therefore, the incidence of paper sludge with 5% and 10% replacement was investigated. Their effect was studied in fresh state tests of workability and density and in hardened state of compressive strength at the ages of 7, 14 and 28 days of curing, and capillary absorption at the age of 28 days. The results of this study show that the replacement of paper sludge (PL) increases the workability of the mixes, reduces their final weight and decreases the compressive strength up to 87% for mixes with 10% substitution. A lower capillary absorption was observed for 5%. In conclusion, the use of paper sludge as a partial replacement of cement in mortar mixes provides advantages in terms of density, although it affects compressive strength. The reduction in capillary absorption of paper sludge indicates a potential benefit for certain construction applications, thus promoting a more sustainable alternative for the management of these industrial wastes.

Keywords: Paper sludge (PL), mortar, sustainable waste, sustainable construction, partial substitution, cement.

REFERENCIAS

- [1] Malhotra VM., (1983). Use of fly ash, slag and condensed silica fume in North America and Europe. In: Ryan WG, editor. Proc concrete workshop 88. Int workshop on the use of fly ash, slag, silica fume and other siliceous materials in concrete July 4–6, Sydney, Australia; 23–55

- [2] Swamy RN., (1998). Designing concrete and concrete structures for sustainable development. In: Malhotra VM, editor. Proc sixth international conference on fly ash, slag, silica fume and other natural pozzolans in concrete. Bangkok, Thailand; ACI SP-178; 1: 245–55
- [3] Sumit, A. B., S. P. Raut., (2013). Utilization of Wastepaper Pulp by Partial Replacement of Cement in Concrete. International Journal of Engineering Research and Applications (IJERA), Vol. 1, pp. 300-309
- [4] Yun, H., Jung, H., Choi, C. (2007). Mechanical properties of papercrete containing waste paper. Korea: Architectural Institute of Korea.
- [5] H. S. Wong, R. Barakat, A. Alhilali, M. Saleh, and C. R. Cheeseman, “Hydrophobic concrete using waste paper sludge ash,” *Cem. Concr. Res.*, vol. 70, pp. 9–20, 2015, doi: 10.1016/j.cemconres.2015.01.005
- [6] P. Y. Prabhat Vashistha a, Vivek Kumar b, S.K. Singh c, Dharm Dutt a, Gaurav Tomar b, “Valorization of paper mill lime sludge via application in building construction materials: A review,” *Construction and Building Materials*. Accessed: Jun. 06, 2024. [Online]. Available: <https://www.sciencedirect.com/science/article/abs/pii/S0950061819305689>
- [7] J. Malaiskiene, O. Kizinievic, and V. Kizinievic, “The influence of primary paper sludge on concrete properties,” *Ceram. - Silikaty*, vol. 63, no. 3, pp. 321–329, 2019, doi: 10.13168/cs.2019.0027.
- [8] H. Gupta, “PAH determination in effluent and sludge samples of paper industry,” *Environ. Technol. Innov.*, vol. 9, no. November 2017, pp. 115–121, 2018, doi: 10.1016/j.eti.2017.11.009.
- [9] S. O. Amiandamhen and S. O. Osadolor, “Recycled waste paper–cement composite panels reinforced with kenaf fibres: durability and mechanical properties,” *J. Mater. Cycles Waste Manag.*, vol. 22, no. 5, pp. 1492–1500, 2020, doi: 10.1007/s10163-020-01041-2.
- [10] ASTM International, ASTM C109/C109M - 20b: Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube

Specimens). West Conshohocken, PA: ASTM International, 2020. doi: 10.1520/C0109_C0109M-16A.

[11] ASTM International, ASTM C136/C136M-14: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates. West Conshohocken, PA: ASTM International, 2014. doi: 10.1520/C0136_C0136M-14.

[12] ASTM International, ASTM C511-19: Standard Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes. West Conshohocken, PA: ASTM International, 2019. Accedido: 5 de mayo de 2020. [En línea]. Disponible en: <https://www.astm.org/Standards/C511>.

[13] ASTM International, ASTM C1437-20: Standard test method for flow of hydraulic cement mortar. West Conshohocken, PA: ASTM International, 2020. Accedido: 5 de mayo de 2020. [En línea]. Disponible en: <https://www.astm.org/Standards/C1437>.

[14] BSI, BS EN 1015-6:1999: Methods of test for mortar for masonry. Part 6: Determination of bulk density of fresh mortar. London, UK: British Standard Institution, 1999. Accedido: 5 de mayo de 2020. [En línea]. Disponible en: <https://shop.bsigroup.com/ProductDetail?pid=000000000030151085>.

[15] BSI, BS EN 1015-10:1999: Methods of test for mortar for masonry. Determination of dry bulk density of hardened mortar. London, UK: British Standard Institution, 1999. Accedido: 5 de mayo de 2020. [En línea]. Disponible en: <https://doi.org/10.3403/01905430>

[16] ASTM International, ASTM C1403- 15: Standard Test Method for Rate of Water Absorption of Masonry Mortars. West Conshohocken, PA: ASTM International, 2015. [En línea]. Disponible en: https://compass.astm.org/EDIT/html_annot.cgi?C1403+15

[17] Shivangni, K., Kishan, L. P., and Mukul, k. (2015). International Journal of Combined Research & Development (IJCRD) eISSN: 2321-225X;pISSN:2321-2241 Volume: 4; Issue: 6; June -2015

[18] S. Wang, M. Chen, L. Lu, P. Zhao, and C. Gong, “Investigation of the Adaptability of

Paper Sludge with Wood Fiber in Cement-Based Insulation Mortar,” *BioResources*, vol. 11, no. 4, pp. 10419–10432, 2016, doi: 10.15376/biores.11.4.10419-10432.

[19] Ingale, S. D., & Nemade, P. D. Effect of paper sludge ash on properties of cement concrete: A review. Department of Civil Engineering, Dr D.Y. Patil Institute of Technology, Pimpri, Pune, Savitribai Phule Pune University, Pune 411018, India. Department of Civil Engineering, MVPS’s KBT College of Engineering, Nashik 422013, India.

[20] Azevedo, A. R. G. de, Alexandre, J., Xavier, G. de C., & Pedroti, L. G. Recycling paper industry effluent sludge for use in mortars: A sustainability perspective. UFV - Federal University of Viçosa, DECEDepartment of Civil Engineering, Av. P.H. Rolfs, 36570-000, Viçosa, Brazil.

[21] [[Kosmatka, S. H., Kerkhoff, B., Panarese, W. C. (2003). *Design and Control of Concrete Mixtures* (14th edition ed.). Skokie, Illinois, USA,: Portland Cement Association.