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# Studying the Effects of Water to Cement Ratio on the Mechanical Properties of Concrete

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**INDEX TERMS** Pervious concrete

## I. INTRODUCTION

RAPID urbanization has led to extensive construction of impervious surfaces such as asphalt and conventional concrete pavements, which disrupt the natural hydrological cycle. These surfaces prevent water infiltration, resulting in increased surface runoff, urban flooding, and reduced groundwater recharge. In response to these environmental concerns, there has been a growing interest in sustainable construction materials that support stormwater management. One such material is pervious concrete, a special type of concrete with a high void content that allows water to pass through its structure.

Pervious concrete is composed of coarse aggregates, cement, water, and little to no fine aggregates. Its interconnected pore network enables infiltration of rainwater, making it suitable for sidewalks, parking lots, driveways, and low-traffic roads. In addition to hydrological benefits, pervious concrete can reduce the urban heat island effect, improve skid resistance, and contribute toward LEED (Leadership in Energy and Environmental Design) credits in green building certification systems.

Despite its advantages, the widespread use of pervious concrete has been limited due to challenges in achieving an optimal balance between permeability and mechanical strength. In this study, we focus on the effects of the water-cement ratio on the physical properties of pervious concrete. To this end, two batches of 6 pervious concrete cylinders, with the second batch having a lower water-cement ratio, were made, and tested for compresssive strength, split tensile strength, and permeability. Superplasticizer (SP) was used to increase the workability of the mixes made with the second recipe.

## II. EXPERIMENTAL SETUP

Two batches of 6 cylinders each were cast. Common to both batches were the cementitious material which was a mixture of cement and fly-ash in the ratio of 4:1 by mass, coarse aggregates whose sizes ranged from 4.75-9.5 mm, and polypropylene fibres (PPF). The rest of the ingredients are given in table 1.

**TABLE 1. Mix Design**

| | Batch 1 | Batch 2 |
|---|---|---|
| Cement, $kg/m^3$ | 280 | 280 |
| Coarse Aggregate, $kg/m^3$ | 1420 | 1420 |
| Fly-ash, $kg/m^3$ | 70 | 70 |
| Water, $kg/m^3$ | 119 | 95.2 |
| SP, %[1] | — | 0.5 |
| PPF, %[2] | 0.2 | 0.2 |

[1] of cementitious material
[2] of aggregates

## III. TESTING METHOD

The samples were tested after 14 and 28 days for tensile and compressive strenghts, and after 28 days for permeability.

### A. COMPRESSIVE STRENGTH

The sample was placed in the universal testing machine (UTM) on one of its circular faces, and compressed. The pace rate was set to 1.8 KN/s. The compressive strength $f_c$ is calculated with the formula

$$f_c = \frac{P}{A}$$

where $P$ is the maximum force on the sample, and $A$ is the area over which the force is applied.

### B. TENSILE STRENGTH

The tensile strength was found using the Brazilian test, in which, the sample was placed horizontally, in between two metal bars oriented parallel to the axis of the sample, inside the UTM. The tensile strength $f_t$ was calculated with the formula

$$f_t = \frac{2P}{\pi LD}$$

where $P$ is the force at the point of failure, and $L$ and $D$ are respectively the length and the diameter of the sample.

## IV. SOME COMMON MISTAKES

The word ''data'' is plural, not singular. The subscript for the permeability of vacuum $\mu_0$ is zero, not a lowercase letter ''o.'' The term for residual magnetization is ''remanence''; the adjective is ''remanent''; do not write ''remnance'' or ''remnant.'' Use the word ''micrometer'' instead of ''micron.'' A graph within a graph is an ''inset,'' not an ''insert.'' The word ''alternatively'' is preferred to the word ''alternately'' (unless you really mean something that alternates). Use the word ''whereas'' instead of ''while'' (unless you are referring to simultaneous events). Do not use the word ''essentially'' to mean ''approximately'' or ''effectively.'' Do not use the word ''issue'' as a euphemism for ''problem.'' When compositions are not specified, separate chemical symbols by en-dashes; for example, ''NiMn'' indicates the intermetallic compound $Ni_{0.5}Mn_{0.5}$ whereas ''Ni–Mn'' indicates an alloy of some composition $Ni_xMn_{1-x}$.

Be aware of the different meanings of the homophones ''affect'' (usually a verb) and ''effect'' (usually a noun), ''complement'' and ''compliment,'' ''discreet'' and ''discrete,'' ''principal'' (e.g., ''principal investigator'') and ''principle'' (e.g., ''principle of measurement''). Do not confuse ''imply'' and ''infer.''

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## V. GUIDELINES FOR GRAPHICS PREPARATION AND SUBMISSION

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#### 3) Author photos

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### B. MULTIPART FIGURES

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Format and save your graphics using a suitable graphics processing program that will allow you to create the images as PostScript (.PS), Encapsulated PostScript (.EPS), Tagged Image File Format (.TIFF), Portable Document Format (.PDF),

**TABLE 2. Units for Magnetic Properties**

| Symbol | Quantity | Conversion from Gaussian and CGS EMU to SI [a] |
|---|---|---|
| $\Phi$ | magnetic flux | 1 Mx $\rightarrow 10^{-8}$ Wb $= 10^{-8}$ V·s |
| $B$ | magnetic flux density, magnetic induction | 1 G $\rightarrow 10^{-4}$ T $= 10^{-4}$ Wb/m$^2$ |
| $H$ | magnetic field strength | 1 Oe $\rightarrow 10^3/(4\pi)$ A/m |
| $m$ | magnetic moment | 1 erg/G $=$ 1 emu $\rightarrow 10^{-3}$ A·m$^2$ $= 10^{-3}$ J/T |
| $M$ | magnetization | 1 erg/(G·cm$^3$) $=$ 1 emu/cm$^3$ $\rightarrow 10^3$ A/m |
| $4\pi M$ | magnetization | 1 G $\rightarrow 10^3/(4\pi)$ A/m |
| $\sigma$ | specific magnetization | 1 erg/(G·g) $=$ 1 emu/g $\rightarrow$ 1 A·m$^2$/kg |
| $j$ | magnetic dipole moment | 1 erg/G $=$ 1 emu $\rightarrow 4\pi \times 10^{-10}$ Wb·m |
| $J$ | magnetic polarization | 1 erg/(G·cm$^3$) $=$ 1 emu/cm$^3$ $\rightarrow 4\pi \times 10^{-4}$ T |
| $\chi, \kappa$ | susceptibility | 1 $\rightarrow 4\pi$ |
| $\chi_\rho$ | mass susceptibility | 1 cm$^3$/g $\rightarrow 4\pi \times 10^{-3}$ m$^3$/kg |
| $\mu$ | permeability | 1 $\rightarrow 4\pi \times 10^{-7}$ H/m $= 4\pi \times 10^{-7}$ Wb/(A·m) |
| $\mu_r$ | relative permeability | $\mu \rightarrow \mu_r$ |
| $w, W$ | energy density | 1 erg/cm$^3$ $\rightarrow 10^{-1}$ J/m$^3$ |
| $N, D$ | demagnetizing factor | 1 $\rightarrow 1/(4\pi)$ |

Vertical lines are optional in tables. Statements that serve as captions for the entire table do not need footnote letters.

[a]Gaussian units are the same as cg emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

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Most charts, graphs, and tables are one column wide (3.5 inches/88 millimeters/21 picas) or page wide (7.16 inches/181 millimeters/43 picas). The maximum depth a graphic can be is 8.5 inches (216 millimeters/54 picas). When choosing the depth of a graphic, please allow space for a caption. Figures can be sized between column and page widths if the author chooses, however it is recommended that figures are not sized less than column width unless when necessary.

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Multipart figures should be combined and labeled before final submission. Labels should appear centered below each subfigure in 8 point Times New Roman font in the format of (a) (b) (c).

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Number footnotes separately in superscript numbers.[1] Place the actual footnote at the bottom of the column in which it is cited; do not put footnotes in the reference list (endnotes). Use letters for table footnotes (see Table 2).

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- *Article number in reference examples:*
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## ACKNOWLEDGMENT

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## REFERENCES

[1] G. O. Young, "Synthetic structure of industrial plastics," in *Plastics,* 2nd ed., vol. 3, J. Peters, Ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15–64.
[2] W.-K. Chen, *Linear Networks and Systems.* Belmont, CA, USA: Wadsworth, 1993, pp. 123–135.
[3] J. U. Duncombe, "Infrared navigation—Part I: An assessment of feasibility," *IEEE Trans. Electron Devices*, vol. ED-11, no. 1, pp. 34–39, Jan. 1959, 10.1109/TED.2016.2628402.
[4] E. P. Wigner, "Theory of traveling-wave optical laser," *Phys. Rev.*, vol. 134, pp. A635–A646, Dec. 1965.
[5] E. H. Miller, "A note on reflector arrays," *IEEE Trans. Antennas Propagat.*, to be published.
[6] E. E. Reber, R. L. Michell, and C. J. Carter, "Oxygen absorption in the earth's atmosphere," Aerospace Corp., Los Angeles, CA, USA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.
[7] J. H. Davis and J. R. Cogdell, "Calibration program for the 16-foot antenna," Elect. Eng. Res. Lab., Univ. Texas, Austin, TX, USA, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.
[8] *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, USA, 1985, pp. 44–60.
[9] *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, USA, 1989.
[10] G. O. Young, "Synthetic structure of industrial plastics," in Plastics, vol. 3, Polymers of Hexadromicon, J. Peters, Ed., 2nd ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15-64. [Online]. Available: http://www.bookref.com.
[11] *The Founders' Constitution*, Philip B. Kurland and Ralph Lerner, eds., Chicago, IL, USA: Univ. Chicago Press, 1987. [Online]. Available: http://press-pubs.uchicago.edu/founders/
[12] The Terahertz Wave eBook. ZOmega Terahertz Corp., 2014. [Online]. Available: http://dl.z-thz.com/eBook/zomegaebookpdf_1206_sr.pdf. Accessed on: May 19, 2014.
[13] Philip B. Kurland and Ralph Lerner, eds., *The Founders' Constitution.* Chicago, IL, USA: Univ. of Chicago Press, 1987, Accessed on: Feb. 28, 2010, [Online] Available: http://press-pubs.uchicago.edu/founders/
[14] J. S. Turner, "New directions in communications," *IEEE J. Sel. Areas Commun.*, vol. 13, no. 1, pp. 11-23, Jan. 1995.
[15] W. P. Risk, G. S. Kino, and H. J. Shaw, "Fiber-optic frequency shifter using a surface acoustic wave incident at an oblique angle," *Opt. Lett.*, vol. 11, no. 2, pp. 115–117, Feb. 1986.
[16] P. Kopyt *et al.,* "Electric properties of graphene-based conductive layers from DC up to terahertz range," *IEEE THz Sci. Technol.,* to be published. DOI: 10.1109/TTHZ.2016.2544142.
[17] PROCESS Corporation, Boston, MA, USA. Intranets: Internet technologies deployed behind the firewall for corporate productivity. Presented at INET96 Annual Meeting. [Online]. Available: http://home.process.com/Intranets/wp2.htp
[18] R. J. Hijmans and J. van Etten, "Raster: Geographic analysis and modeling with raster data," R Package Version 2.0-12, Jan. 12, 2012. [Online]. Available: http://CRAN.R-project.org/package=raster
[19] Teralyzer. Lytera UG, Kirchhain, Germany [Online]. Available: http://www.lytera.de/Terahertz_THz_Spectroscopy.php?id=home, Accessed on: Jun. 5, 2014.
[20] U.S. House. 102nd Congress, 1st Session. (1991, Jan. 11). *H. Con. Res. 1, Sense of the Congress on Approval of Military Action*. [Online]. Available: LEXIS Library: GENFED File: BILLS
[21] Musical toothbrush with mirror, by L.M.R. Brooks. (1992, May 19). Patent D 326 189 [Online]. Available: NEXIS Library: LEXPAT File: DES
[22] D. B. Payne and J. R. Stern, "Wavelength-switched pas- sively coupled single-mode optical network," in *Proc. IOOC-ECOC,* Boston, MA, USA, 1985, pp. 585–590.
[23] D. Ebehard and E. Voges, "Digital single sideband detection for interferometric sensors," presented at the *2nd Int. Conf. Optical Fiber Sensors,* Stuttgart, Germany, Jan. 2-5, 1984.
[24] G. Brandli and M. Dick, "Alternating current fed power supply," U.S. Patent 4 084 217, Nov. 4, 1978.
[25] J. O. Williams, "Narrow-band analyzer," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, USA, 1993.
[26] N. Kawasaki, "Parametric study of thermal and chemical nonequilibrium nozzle flow," M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.
[27] A. Harrison, private communication, May 1995.
[28] B. Smith, "An approach to graphs of linear forms," unpublished.

[29] A. Brahms, "Representation error for real numbers in binary computer arithmetic," IEEE Computer Group Repository, Paper R-67-85.
[30] IEEE Criteria for Class IE Electric Systems, IEEE Standard 308, 1969.
[31] Letter Symbols for Quantities, ANSI Standard Y10.5-1968.
[32] R. Fardel, M. Nagel, F. Nuesch, T. Lippert, and A. Wokaun, "Fabrication of organic light emitting diode pixels by laser-assisted forward transfer," *Appl. Phys. Lett.*, vol. 91, no. 6, Aug. 2007, Art. no. 061103.
[33] J. Zhang and N. Tansu, "Optical gain and laser characteristics of InGaN quantum wells on ternary InGaN substrates," *IEEE Photon. J.*, vol. 5, no. 2, Apr. 2013, Art. no. 2600111
[34] S. Azodolmolky *et al.*, Experimental demonstration of an impairment aware network planning and operation tool for transparent/translucent optical networks," *J. Lightw. Technol.*, vol. 29, no. 4, pp. 439–448, Sep. 2011.

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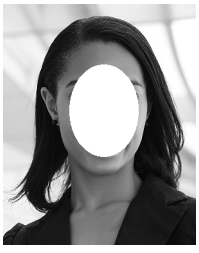

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