

## Appendix G

### Description of $w/c$ ratio determination methodology

A set of three mortar cylinders were cast with  $w/c$  ratios of 0.40, 0.50, and 0.60, and moist cured for 28 days. The cylinders were cut into billets, and the billets impregnated with epoxy resin spiked with a fluorescent dye (DayGlo Tigris Yellow D-043 solvent yellow 43 added at a dosage of 0.5 wt% to Epoxy Technologies EPO-TEK 301 resin). The impregnated billets were prepared in thin section, and images collected in epifluorescent mode with an Olympus BX-60 System Microscope equipped with an Optronics DEI-750 CCD video camera. The G-band was extracted from each 640 x 480 pixel, 2.612 x 1.959 mm, 24 bit, RGB image, and the fine aggregate and air voids manually masked to isolate fluorescence due to the uptake of the dyed resin into the capillary pores of the hardened cement paste. Figures A-1 through A-6 show images collected from each of the standards both before and after the masking operation. Figure A-7 compares histograms of cement paste fluorescence from the standards. The average intensity from each masked image was used as measurement of cement paste fluorescence, as summarized in Table A-1, and used to develop the calibration curve shown in Figure A-8. This calibration curve was applied to measurements collected from field concrete samples to yield equivalent  $w/c$  values as compared to the 28 day moist cured mortar standards. For more detailed treatments of epifluorescent microscopy and its application to  $w/c$  estimation, the following references are suggested:

Walker, H. N., and Marshall, B. F., "Methods and Equipment Used in Preparing and Examining Fluorescent Ultrathin Sections of Portland Cement Concrete" *Cement, Concrete, and Aggregates*, Vol. 1, No. 1, 1979, pp. 3-9.

J. Elsen, N. Lens, T. Aarre, D. Quenard, V. Smolej, "Determination of the  $w/c$  ratio of hardened cement paste and concrete samples on thin sections using automated image analysis techniques" *Cement and Concrete Research*, Vol. 25, No. 4, 1995, pp. 827-834.

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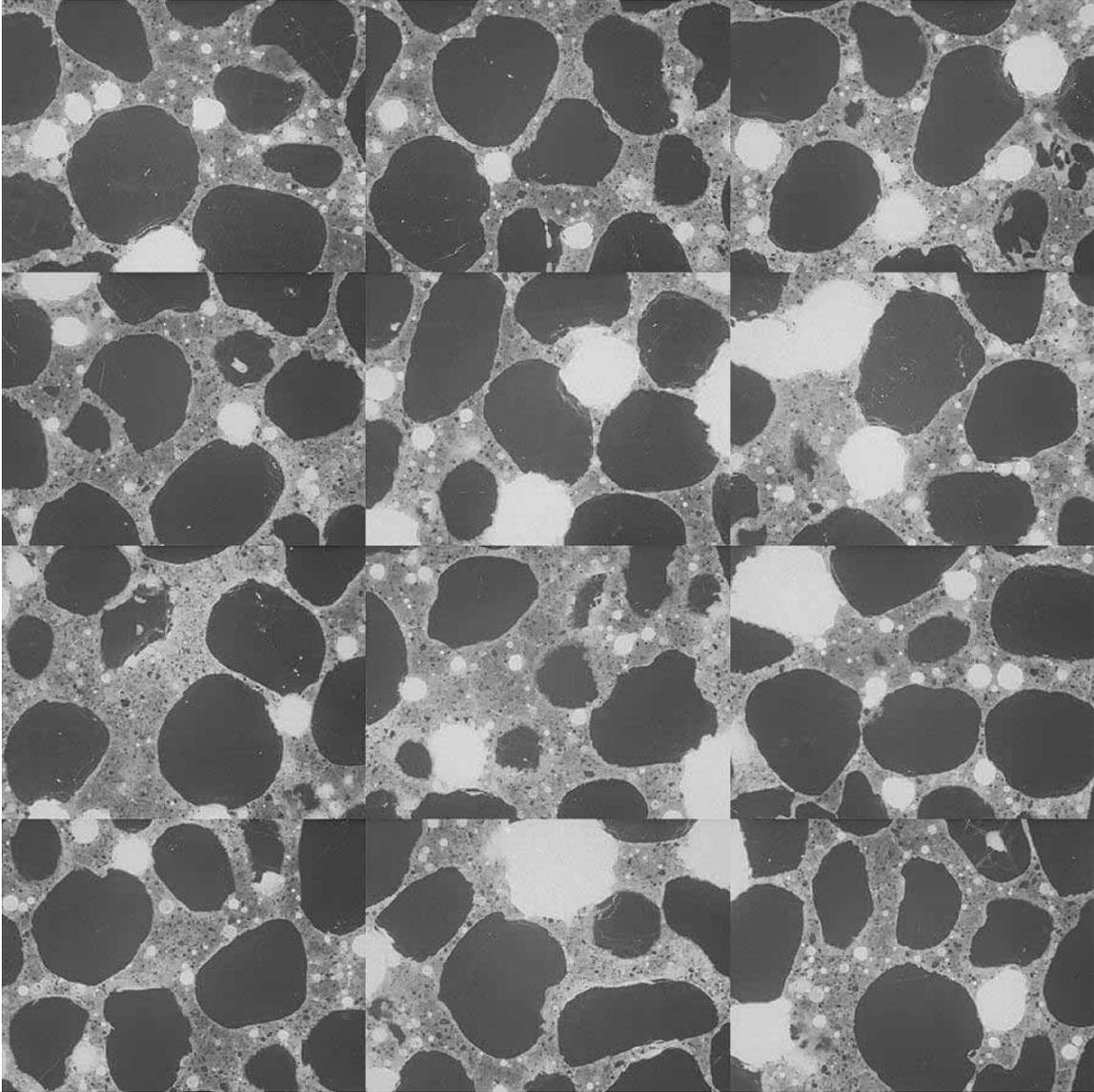


Figure A-1: Mosaic of 12 frames collected from 0.40  $w/c$  28 day moist cured mortar standards (each individual frame measures 2.612 x 1.959 mm).

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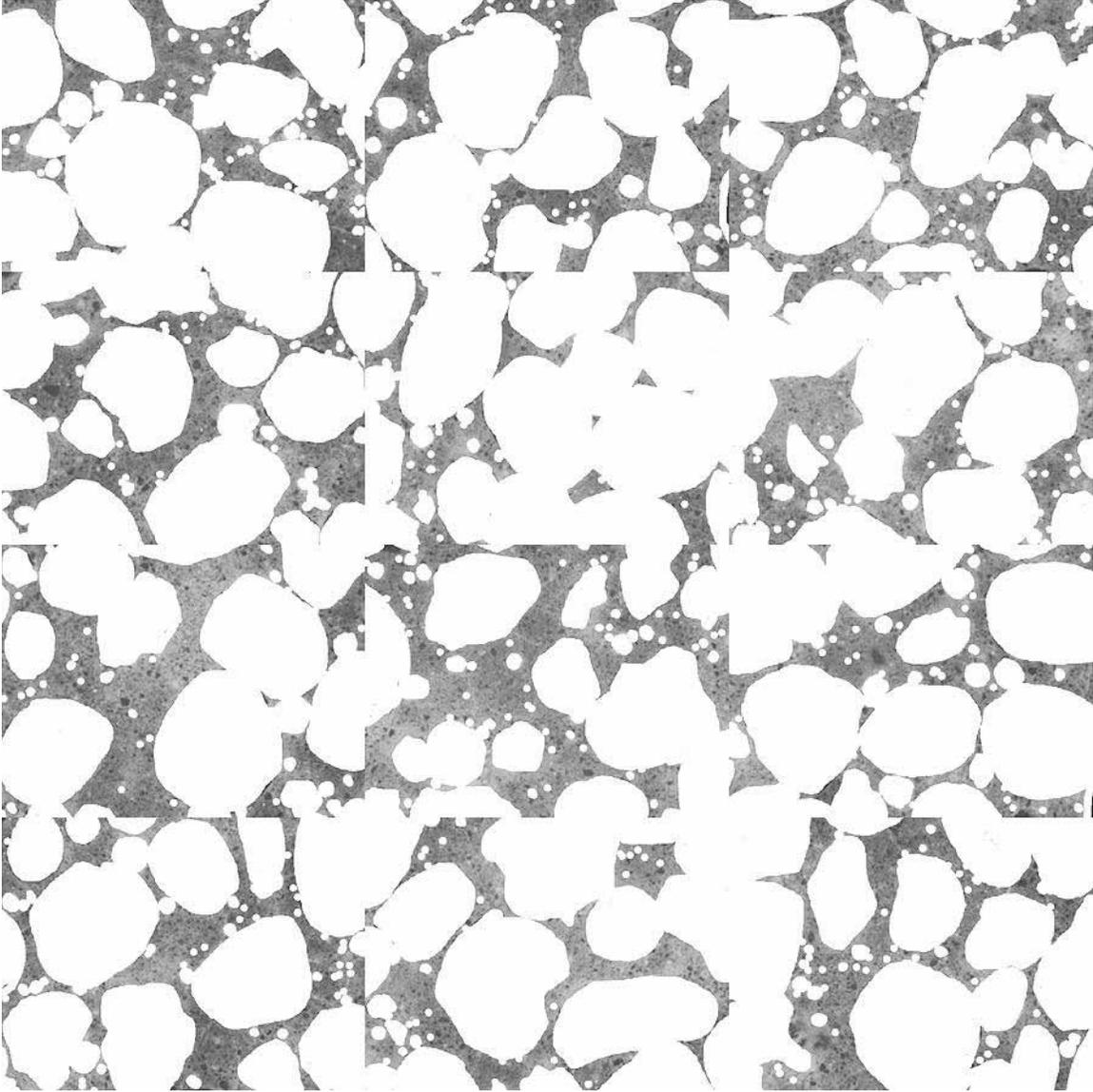


Figure A-2: Mosaic of 12 frames collected from 0.40  $w/c$  28 day moist cured mortar standards after masking out air voids and fine aggregate to isolate cement paste (each individual frame measures 2.612 x 1.959 mm).

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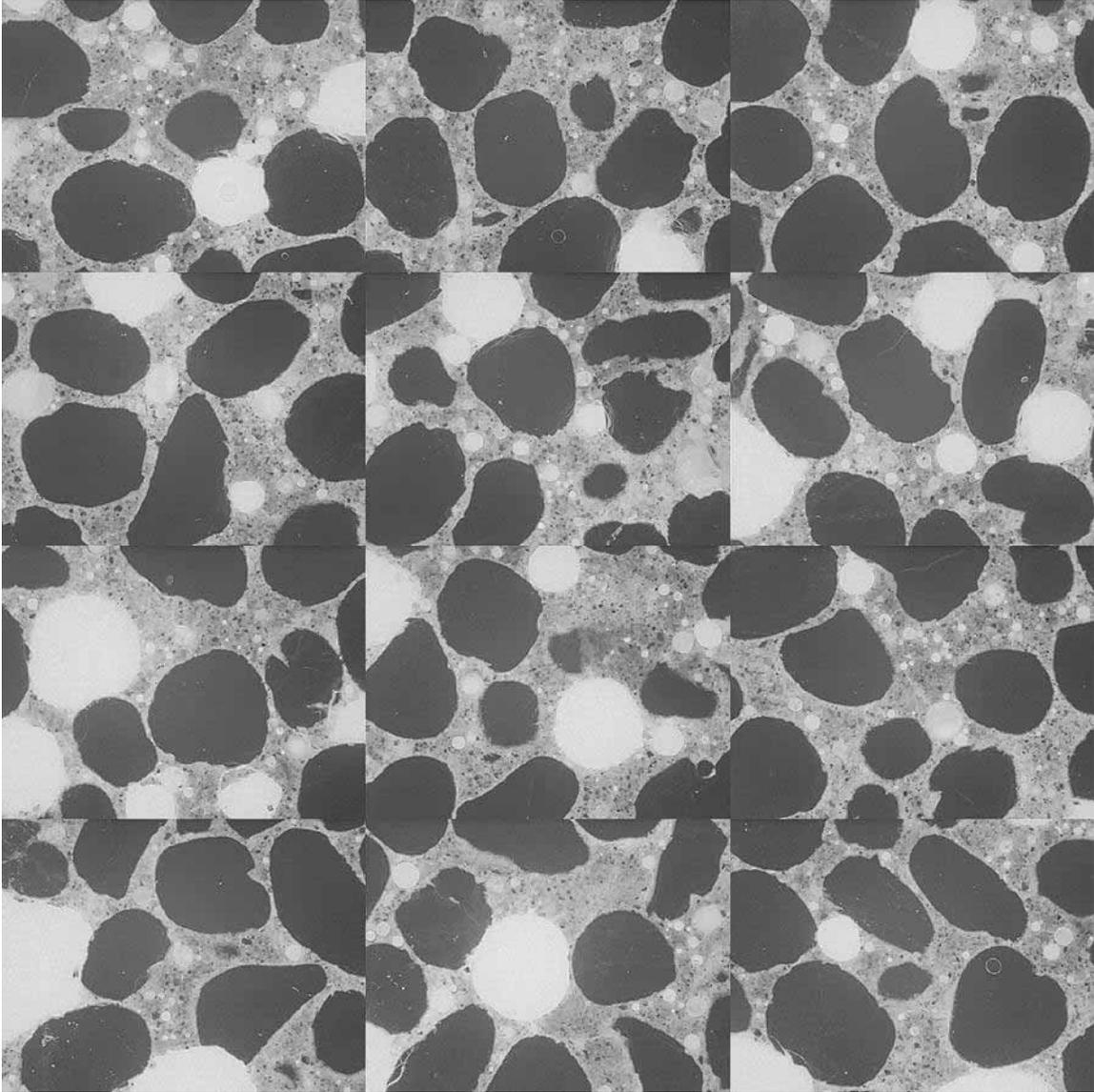


Figure A-3: Mosaic of 12 frames collected from 0.50  $w/c$  28 day moist cured mortar standards (each individual frame measures 2.612 x 1.959 mm).

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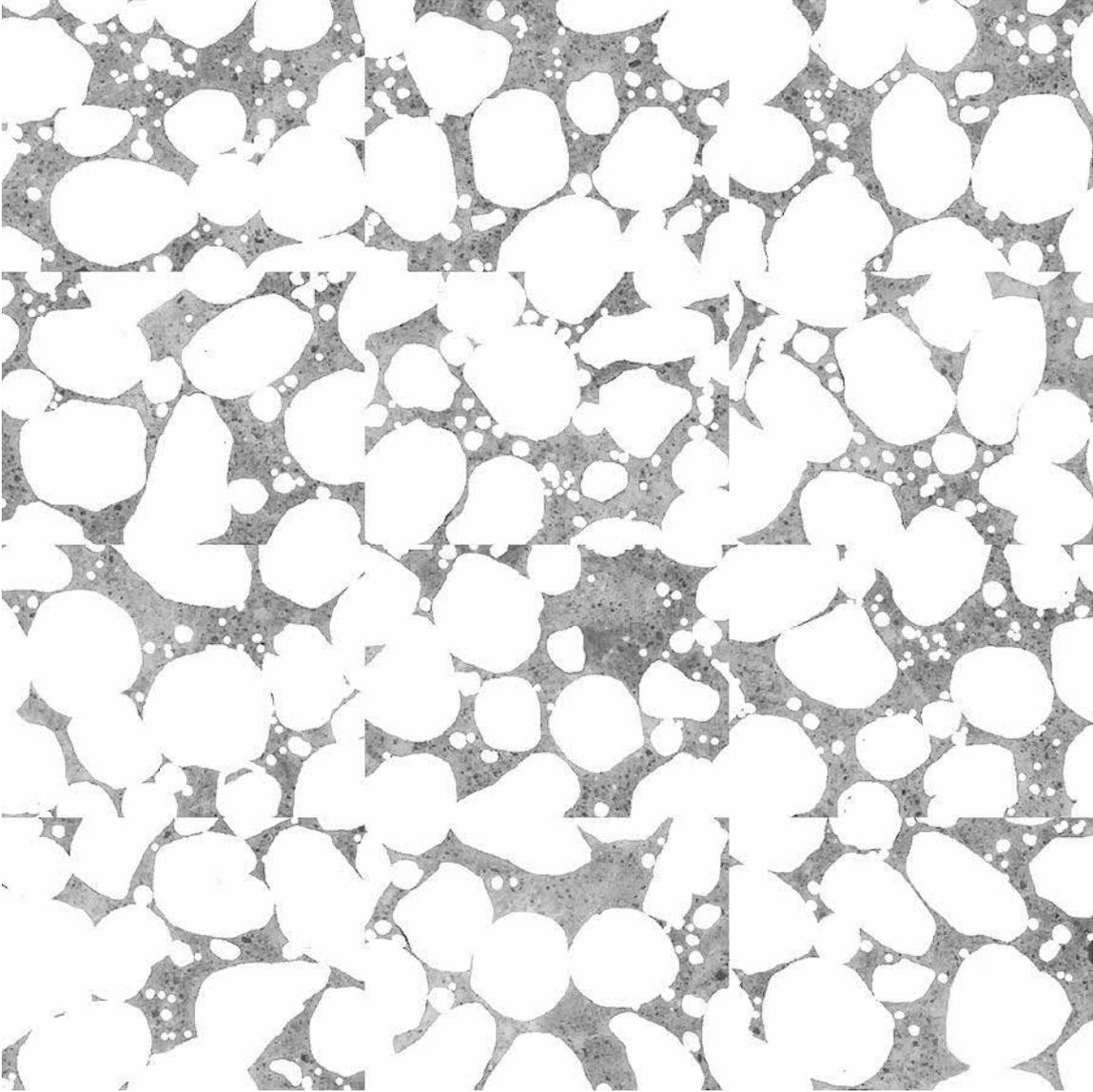


Figure A-4: Mosaic of 12 frames collected from 0.50  $w/c$  28 day moist cured mortar standards after masking out air voids and fine aggregate to isolate cement paste (each individual frame measures 2.612 x 1.959 mm).

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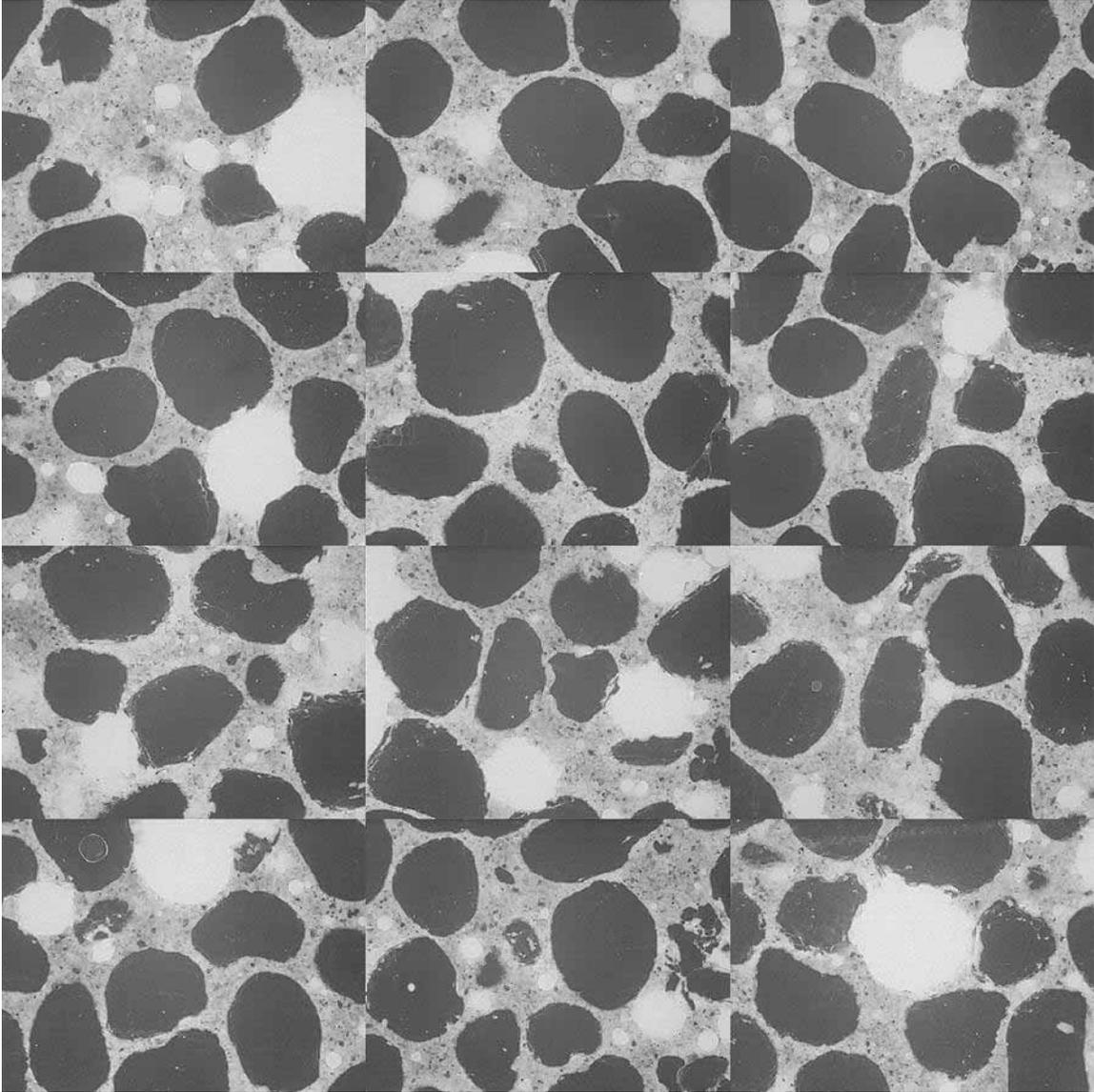


Figure A-5: Mosaic of 12 frames collected from 0.60  $w/c$  28 day moist cured mortar standards (each individual frame measures 2.612 x 1.959 mm).

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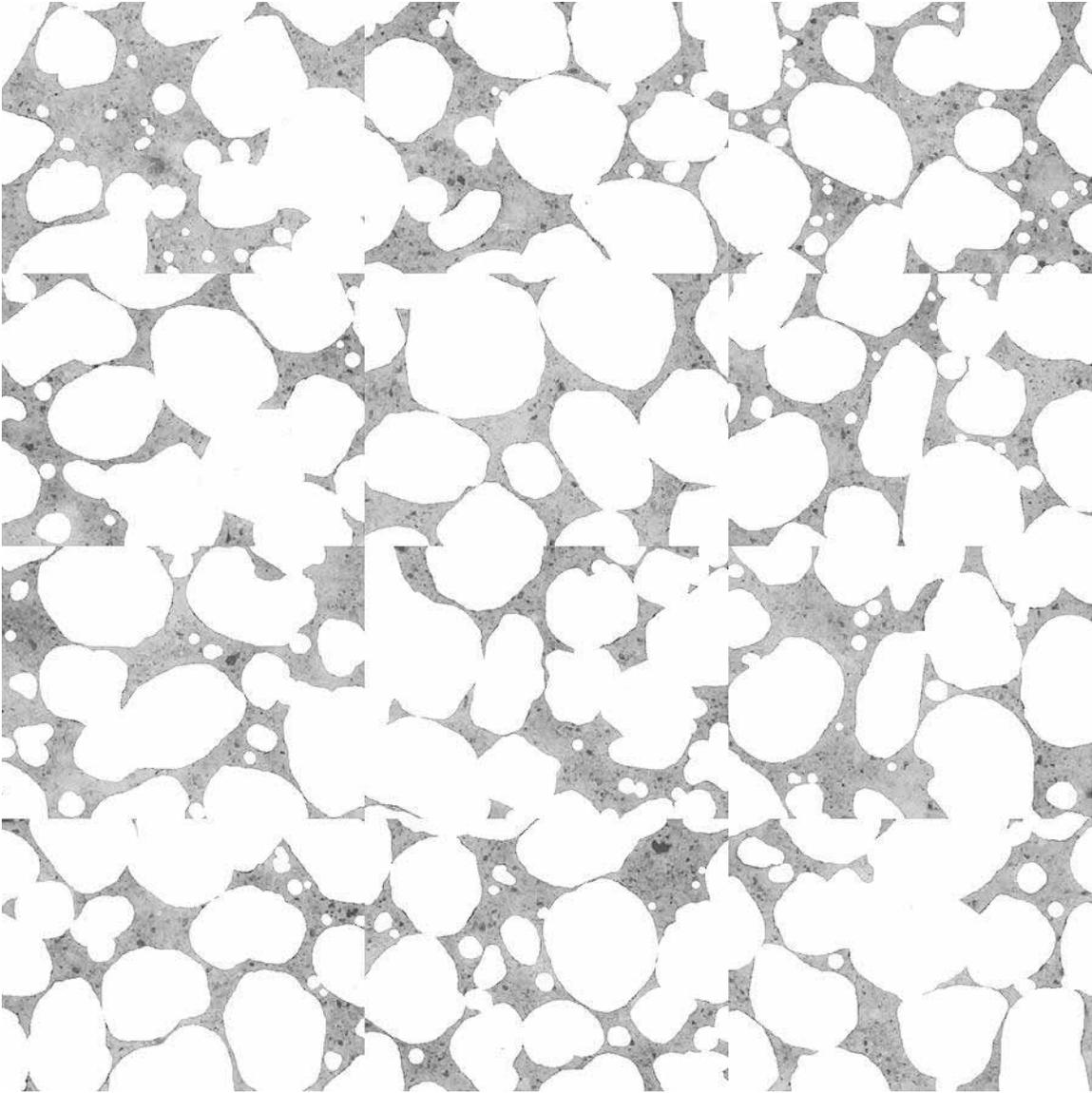


Figure A-6: Mosaic of 12 frames collected from 0.60  $w/c$  28 day moist cured mortar standards after masking out air voids and fine aggregate to isolate cement paste (each individual frame measures 2.612 x 1.959 mm).

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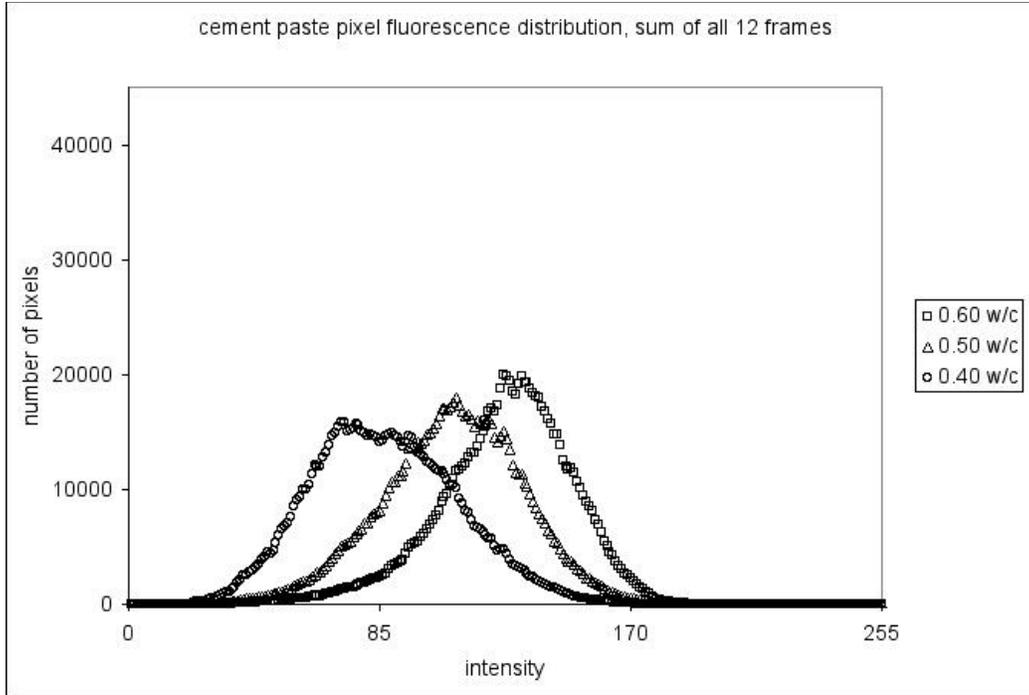


Figure A-7: Histogram plotting cement paste pixel intensities using all 12 frames collected from each of the 28 day moist cured mortar standards.

Table A-1: Average cement paste pixel intensities per frame collected from  $w/c$  standards.

$w/c$	cement paste pixel fluorescence measurements (average intensity per frame)			
0.6	130	118	122	132
	123	132	127	134
	119	121	124	134
0.5	106	118	110	106
	103	114	114	113
	106	106	103	108
0.4	80	94	79	87
	93	86	99	93
	78	86	77	77

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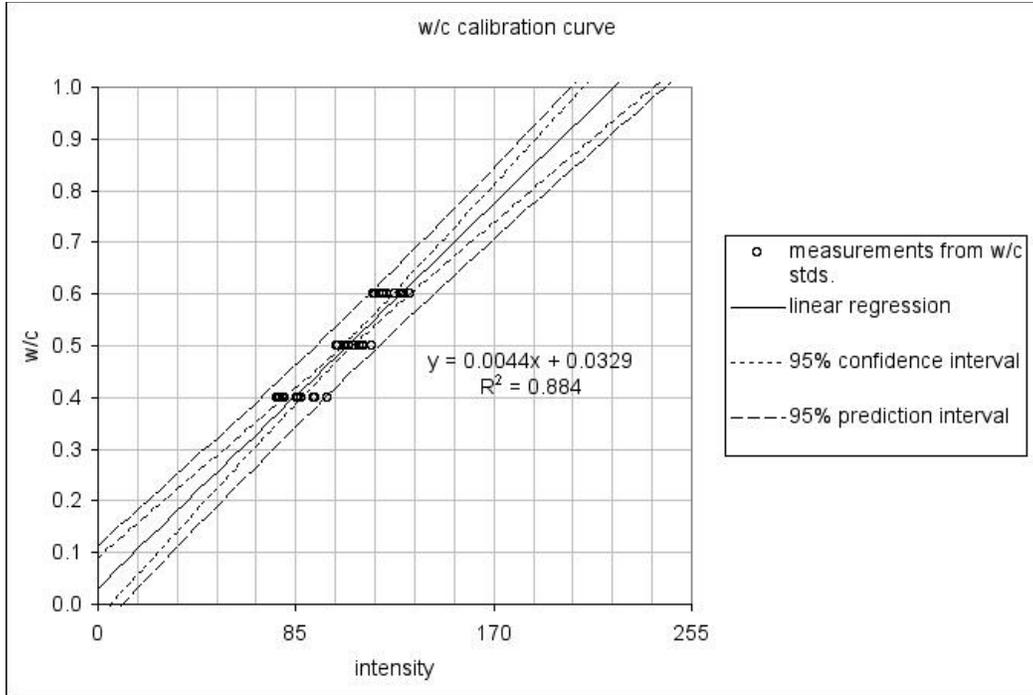


Figure A-8: Calibration curve plotting average cement paste pixel fluorescence intensity per frame versus w/c.