

CMC has the nation's top-ranking petrographic laboratory with various state-of-the-art equipments for conducting detailed petrographic examinations of construction materials. The petrographic laboratory houses various stereomicroscopes, petrographic microscopes, metallurgical microscopes, automated computerized image analysis, and point counting facilities. Optical microscopes have capacities for instant digital imaging of constituents while examination at various magnifications, either by using a high-resolution digital camera, or by a sophisticated image analysis software with image capture facilities (e.g., Image Pro Plus).

Stereomicroscopes - CMC's petrographic laboratory houses advanced trinocular Nikon SMZ-10A, popular Bausch and Lomb Stereo Zoom 7, and research-grade Olympus SZX 12 stereomicroscopes with digital photomicrographic facilities that can examine a material up

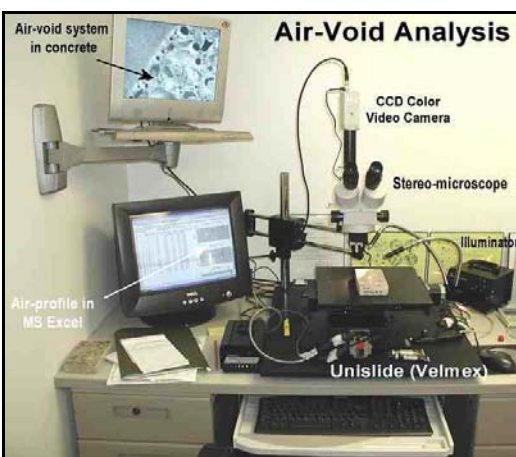


to a magnification of 100X and at the same time store digital images of as received, freshly fractured, saw-cut section, or lapped sections of materials. The microscopes use ring-type and dual goose neck fiber optic illuminators, which produce excellent clarity and brightness of the final images. The Olympus SZX 12 stereomicroscope has reflected, transmitted, and fluorescent-light facilities. Stereomicroscopes are extremely useful to examine a wide variety of materials at their pristine (i.e., as-received) conditions. Each microscope is equipped with high-resolution Nikon Coolpix 990 and DMC digital cameras for photomicrography.

Metallurgical Microscopes - CMC has two dedicated Olympus metallurgical microscopes (BHMJL and VANOX AH-2) equipped with Nikon Coolpix 990 digital cameras for examinations of stained, etched, and polished sections of clinker, concrete, and other building materials. Both microscopes take digital images of polished, stained, and etched sections. The microscopes also use various fluorescent and other filters for examinations of materials in UV light. The 5X, 10X, 20X, and 50X objective lenses in BHMJL provide examination of samples at magnifications from 50X to 500X. The VANOX microscope has auto-focusing and transmitted, reflected, and fluorescent-light facilities and can magnify objects up to 1000 times. Some petrographic microscopes (described below) have the reflected-light facilities.



Air-void analysis by ASTM C 457 - CMC has state-of-the-art equipments for air-void analysis of concrete according to the linear traverse and modified point count methods of ASTM C 457. The entire set up uses a trinocular head high resolution stereomicroscope



with magnifications from 10X to 100X, a high-resolution CCD color video camera, automated stage movement at a regular interval along x-y directions with Velmex Unislide stage and VXM controller for the modified point count method, Velmex stepper motor with rotary encoder & Micronics LCD display for measuring the chord intercept and traverse lengths in the linear traverse method, a high-resolution flat-panel TV screen for air void analysis and capturing the digital images, a dual goose neck fiber optic illuminator, a dedicated PC with software for downloading the air-void counts in MS Excel during the examination and for simultaneous calculations of the air-void parameters. At the end of a run, detailed profiles of air-void parameters can be plotted in MS Excel. Digital images of air-void variations in a slab from top to bottom can be stored in the PC. In each run, separate proportions of entrained and entrapped air voids are counted. Individual images of air-void system at each stop can also be digitally stored by the image capture board; air-void parameters of each image can be measured by an image analysis software, which can eventually integrate the parameters from the individual images to provide the cumulative parameters of the overall air-void system.

Rapid Air-void analysis by Digital Image Analysis - Along with ASTM C 457, CMC also provides rapid air void analysis in hardened concrete by digital image analysis of a lapped section of concrete treated with black ink and then with white wollastonite (or barium sulfate, or zinc oxide) powder to fill and highlight the air voids against the dark background of other components. A high resolution flat bed scanner (Epson Photosnap, 4800 by 9600 dpi resolution) or a research grade stereomicroscope equipped with color CCD camera is used to capture the images in PC, which is then processed by Adobe Photoshop CS and air void analysis software to calculate the air void parameters and display the results in MS Word and Excel. Compared to 3-4 hours analysis time in the manual (ASTM C 457) methods, the entire analysis (excluding sample preparation) by image capture takes 10 to 15 minutes.

Petrographic Microscopes - Since petrographic microscopes stay at the nucleus of petrographic examinations, and petrography is our specialty, CMC has several state-of-the-art advanced petrographic microscopes (e.g., Nikon Labophot-2, Olympus BH2-BHTP, and Olympus BX-40 microscope with infinity optics system. All these microscopes have various attachments for fluorescent-light microscopy, digital photo-micrography, 35-mm color film photo-micrography, Polaroid photo-micrography, and examinations in both transmitted and reflected-light modes. The Nikon Labophot 2 and Olympus BX-40 petrographic microscopes have simultaneous reflected, transmitted, and fluorescent light facilities for examinations of polished, thin, and fluorescent sections, respectively.



Antique Petrographic Microscopes - The petrographic laboratory houses various antique polarizing microscopes from the early twentieth century, which include models such as Winkel-Zeiss, Busch and Lomb, Unitron, Wards, and MP-Lomo. All these microscopes are in exceptionally fine conditions with facilities for both orthoscopic and conoscopic examinations.



Fluorescent (UV)-light Microscopy - The Olympus SZX 12 stereomicroscope, Olympus Vanox AH-2 reflected-light microscope, and Nikon Labophot 2 Pol petrographic microscopes have intermediate attachments, which house fluorescent and other filters for reflected-fluorescence-light (epi-fluorescence) microscopy. The Olympus BX 40 petrographic microscope have separate excitation and barrier filters below and above the sample stage, respectively for transmitted fluorescence (UV-light) microscopy. Fluorescence (UV-light) microscopy is helpful for highlighting cracks, voids, open spaces in concrete and for semi-quantitative estimation of water-cement ratio from standard-to-unknown sample comparison of the degree of fluorescence from thin section (which depends on the degree of porosity of the samples). For fluorescent-light microscopy, a sample is impregnated with a fluorescent dye mixed, low viscosity epoxy.

Photography and Photomicrography - Since petrography is a pictorial-based science, a variety of equipments and facilities are available for detailed photographic documentation of various macroscopic and microstructural properties of materials such as: (a) high-resolution flat bed scanners, (b) 35-mm cameras and 3-5 mega pixel commercial digital cameras by Olympus, Sony, and Nikon, (c) USB cameras, (d) research-grade advanced high-resolution digital cameras from Optronics, Diagnostic Instruments, and DVC, (e) color CCD cameras with image capture boards, and (f) various image analysis softwares (Paint shop Pro, Adobe Photoshop CS, Adobe Illustrator, Image Prop Plus, and various custom-made softwares for image analysis of concrete). All optical microscopes have trinocular heads with digital camera attachments for simultaneous examinations, capture, and download of high-resolution digital images at various magnifications.

SEM and XRD - Along with optical microscopy, in many projects, the Petrographic laboratory uses: (a) Camscan Series II Scanning electron microscope equipped with a Robinson backscatter detector, an x-ray detector for elemental analysis, and 4Pi Revolution software for digital image acquisition in secondary and backscatter electron modes, and elemental analysis; and (b) Siemens D5000 X-ray powder diffractometer running with JADE-PDF2 softwares. Details of these instruments are mentioned in the flyers of SEM and XRD laboratories.



X-Ray Analytical Microscope - Horiba's table-top x-ray microscope XGT-5000 is the latest development in simultaneous microscopy and elemental analysis, which is sometimes used in petrographic examinations of concrete. While the sample is being scanned, the x-ray tube irradiates the sample with an x-ray beam, with the CCD camera and x-ray detector working in linked operation. The result is a completely seamless merger of optical microscope observation and the elemental analysis functions of the x-ray analyzer. The unit has a significant potential for a variety of imaging and elemental analysis of concrete constituents, including high resolution imaging of a pristine sample with minimum or no special sample preparation, such as conductive coating required for SEM-EDS analysis.



For various petrographic methods see,

Jana, D., Petrography - A Powerful Tool for Quality Assurance and Failure Investigation of Construction Materials, In Proceedings of International Seminar on Non-Destructive Testing, American Concrete Institute, India Chapter, pp. 117-131, 2006.