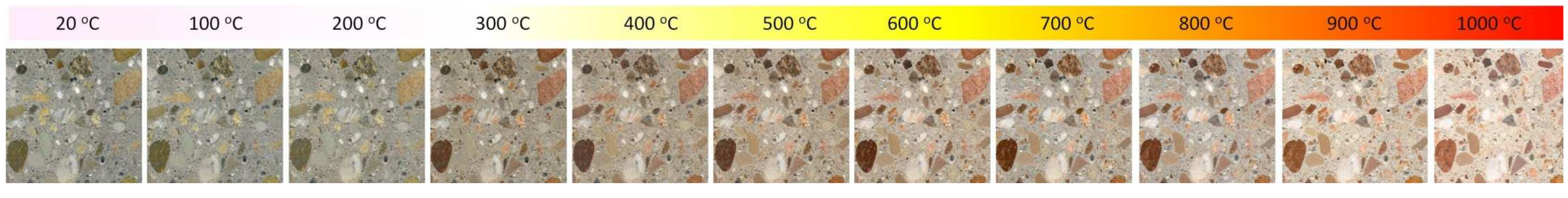
Application of Structural Fire Design, 29 April 2011, Prague, Czech Republic

COLOUR CHANGE OF HEATED CONCRETE

RGB colour histogram analysis as a method for fire damage assessment of concrete

Izabela Hager
Cracow University of Technology, Cracow, Poland, ihager@pk.edu.pl

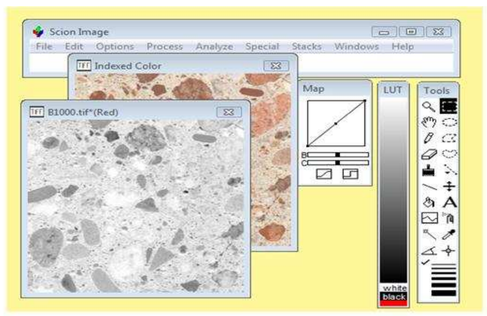


INTRODUCTION: During a real fire, temperatures within a concrete section do not generally reach equilibrium values. A thermal gradient is established where the temperature of the outside layers is drastically increased, while the temperatures of the inner concrete may be relatively low.

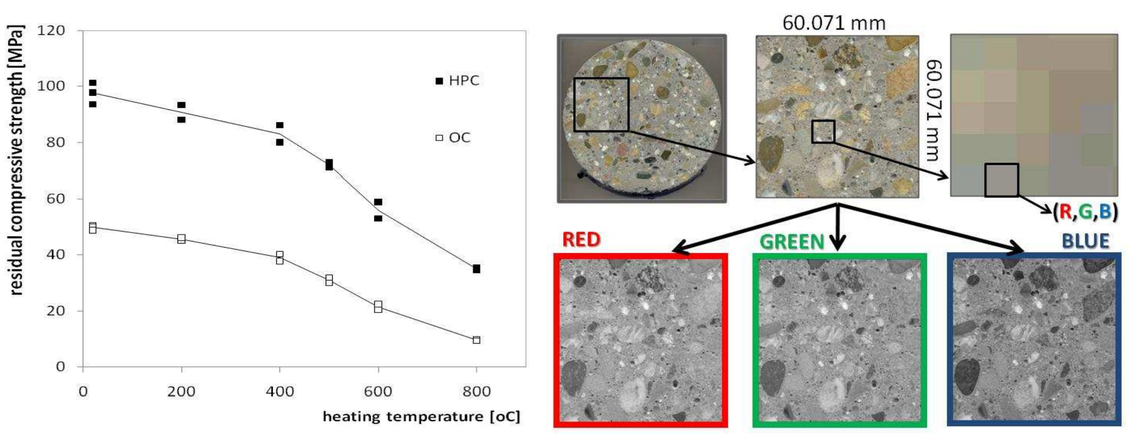
COLOURIMETRY: is an indirect method of damage assessment that uses the fact that when concrete is heated, its colour changes. Colour changes caused by temperature within construction concrete are easy to identify by means of visual comparison with concrete unaffected by high temperature.

Concrete samples heating

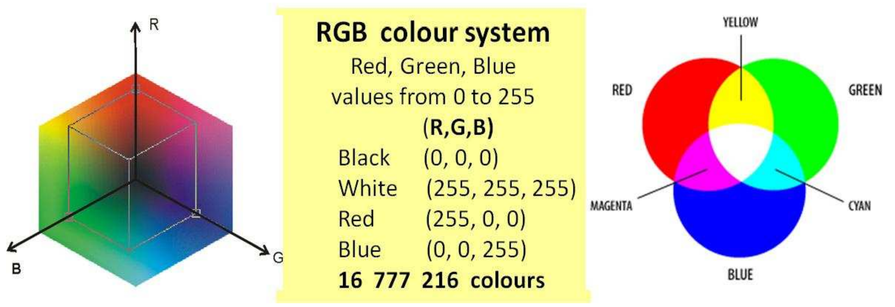
Flatbed scanner
for samples scanning



Scion Image



Temperature data can be used for a quantitative estimation of properties such as the compressive strength or modulus of elasticity when the fc(T), and E(T) relationship are identified.



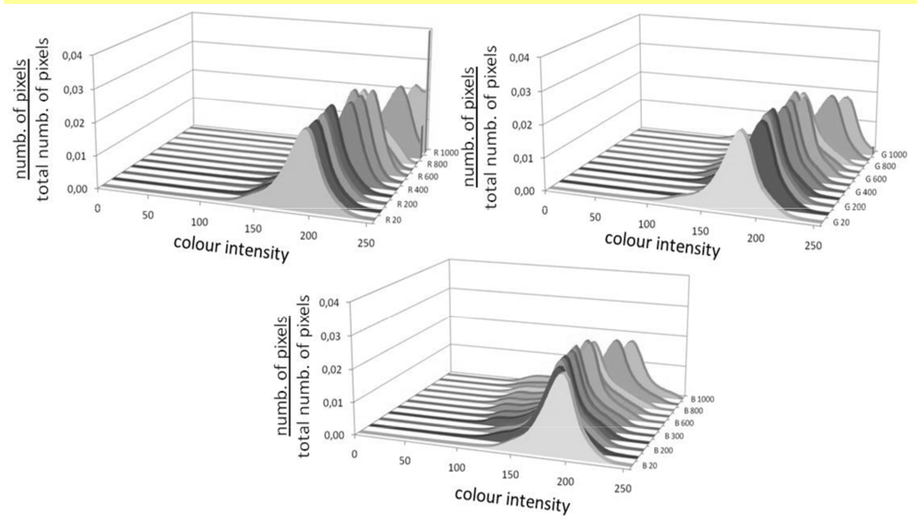
RGB colour system
Red, Green, Blue
values from 0 to 255
(R,G,B)

Black	(0, 0, 0)
White	(255, 255, 255)
Red	(255, 0, 0)
Blue	(0, 0, 255)

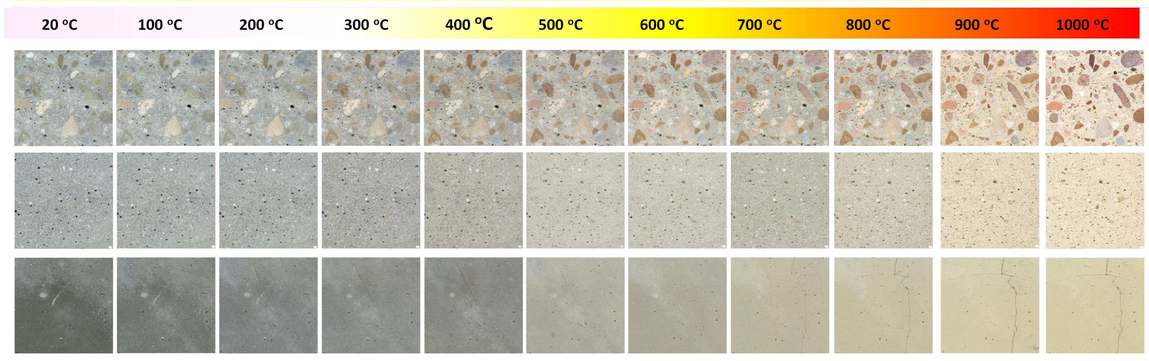
16 777 216 colours

TESTING PROCEDURE: The flatbed scanner is used to obtain constant lighting conditions while pictures of heated and cooled down concrete samples are taken. No expensive measurement equipment and/or colour analysis computer software is necessary to perform these measurements. The pictures taken are analysed using a freeware tool an image analysis software package (Scion Image, v. 4.0.3, Scion Corporation ©, USA). The digital image is split into three RGB colour components – red, green and blue – then presented as a histogram using counts of pixel intensity.

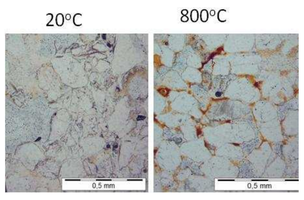
Normalized RGB histograms - calibration scale



Colour change of HP concrete, mortar and cement paste

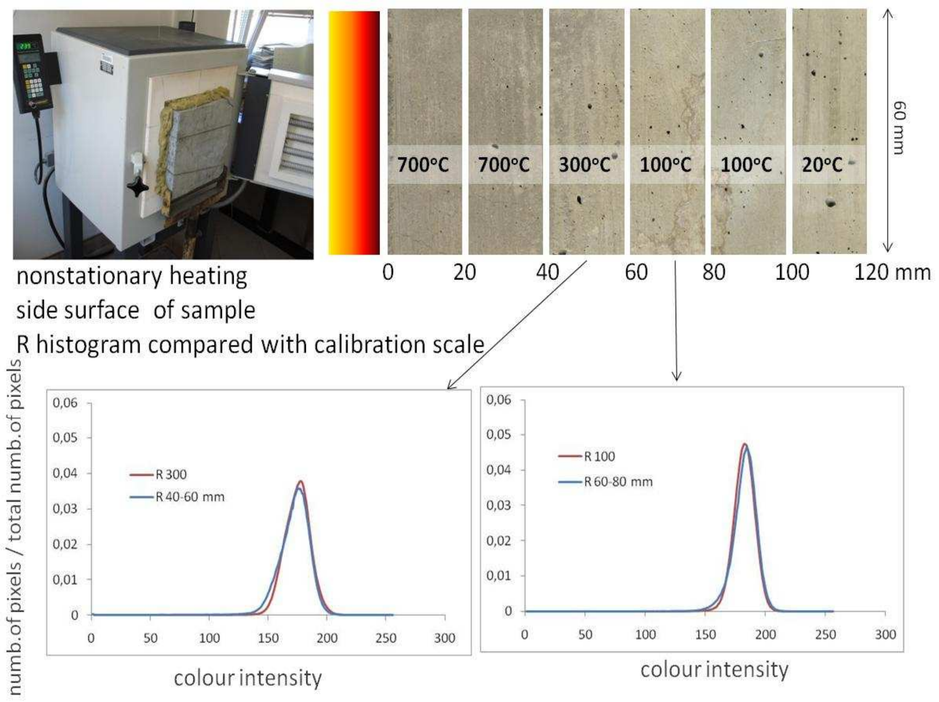


Colour changes observed as a result of heating are mainly caused by water evaporation and dehydration of cement paste and chemical reactions in the mineral components of the aggregate. The most intense colour change is observed in components containing minerals including iron (jarosyte, goethite - redish colouration (sandstone, 80x, polar. microscope, Fot. →).



CONCLUSIONS The method described in the paper is the useful technique for estimating the maximal exposition temperature of concrete subjected to fire by using an analysis of the colour image. A scanner seems to be a useful and simple tool for making digital images of samples/cores resulting in guaranteed consistent lighting conditions. The scanner requires no special preparation of the samples. A similar degree of usefulness and simplicity was established with regard to the colour analysis using the RGB model and the readily available software package Scion Image. A calibration scale was produced by taking images of concrete samples heated to temperatures across the 100 - 1000 °C range. The scale can be used to estimate the exposition temperature of concrete in structures subjected to a real fire. In practice, several techniques should be combined in order to obtain a complete and accurate picture of the concrete member damage.

RESULTS The results of the histogram show colour distribution in unheated concrete and in concrete heated across a temperature range from 100 °C to 1000 °C. Histograms from laboratory-heated concrete provide a scale which is then used to determine the temperature actually reached by concrete in a structure. This is done by comparing the scale images with the images of cored samples taken from the structure.



ACKNOWLEDGMENT The study was supported in part by the Polish Ministry of Higher Education Grant N N506 045040.

Prepared by I. Hager