



Detecting Fire Damaged Concrete Using Laser Scanning

Craig Hancock, Gethin Roberts, Luke
Bisby, Martin Cullen and James Arbuckle



FIG WORKING WEEK 2012

May 6-10 2012
Rome, Italy

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Overview

- Basic background information concerning concrete in fire
- Story of how the idea came about
- Some preliminary testing



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Why Use Concrete?

- Concrete is the single most used building material in the UK and the world.
- A major advantage of concrete construction is its inherent resistance to fire
- Concrete provides insulating layer to protect steel reinforcement



Concrete in Fire



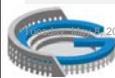
Steel deforms in fire



Wood deforms in
fire



Concrete??

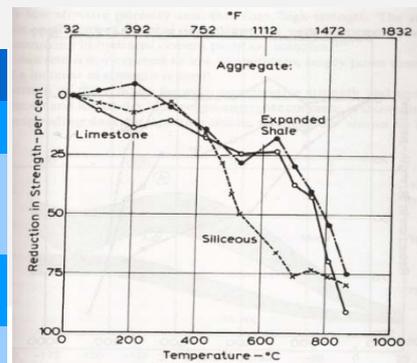




Concrete in Fire

- Although concrete performs well in fire if heated above certain temperatures it starts to lose its strength

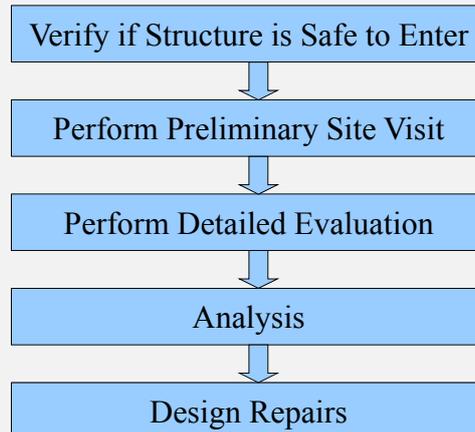
Temperature	Effect
<300°C	Full strength
>300°C	Starts to lose some strength, concrete may need to be removed
500°C	Starts to lose load bearing capacity
>600°C	Does not function to design



Assessing Damage to Concrete

- Visual examination
- Taking core samples
- Geophysical techniques
- Impact echo techniques
- Thermoluminescence studies
- Combined while drilling techniques

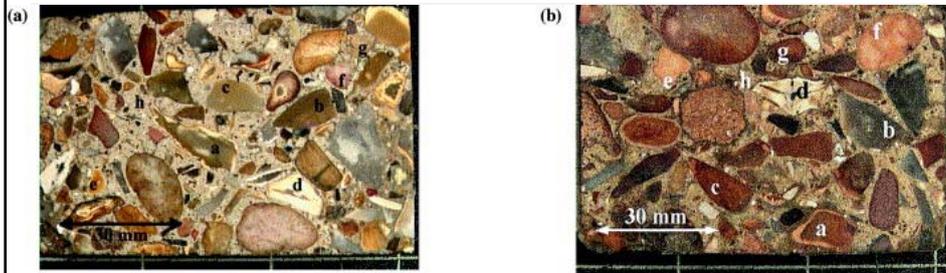




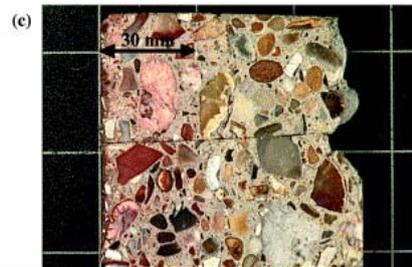
Using Colour to Detect Fire Damaged Concrete

- Previous research by Short et al has used change in colour of concrete as a means of assessing damage
- As a method of preliminary assessment this has proved more consistent and cost effective than visual inspection
- But, different concrete types change colour differently

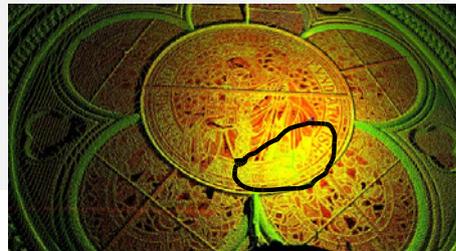
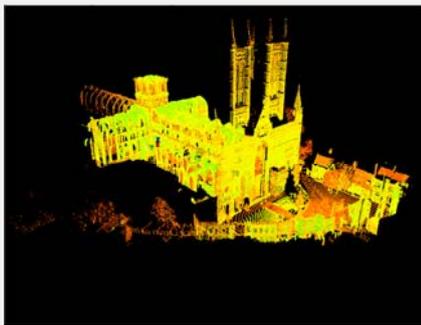




Polished slices of concrete heated from left to right taken from Short et al 2001



Laser Scanning of Lincoln Cathedral



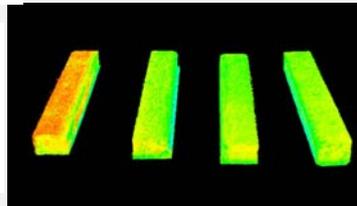
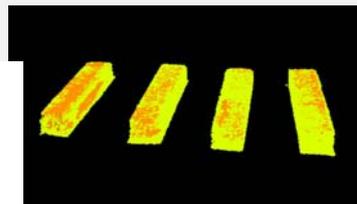


Initial Testing

- 4 concrete samples manufactured by University of Edinburgh
- 1 sample was used as the control sample and therefore kept at room temperature
- 3 samples were heated gradually in a kiln from 220°C to 990°C for a period of 3 days
- Scanned with Leica HDS3000 (pulse scanner)
- Scanned with Leica HDS6000 (phase scanner)



Initial Testing - Results



Tests Continued

- 4 concrete samples manufactured by University of Nottingham
- 1 sample was used as the control sample and therefore kept a room temperature
- 3 samples were heated in a kiln to 300°C, 600°C, and 900°C respectively for a period of 2 hours
- Scanned with Leica HDS3000 (pulse scanner)
- Scanned with FARO Focus 3D (phase scanner)
- Done Twice, June 2011 and March 2012



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Visual Inspection

Crumbled to Dust!

Exploded in the Kiln!

Heated to 900°C

Heated to 600°C

Heated to 300°C

Not Heated



2011



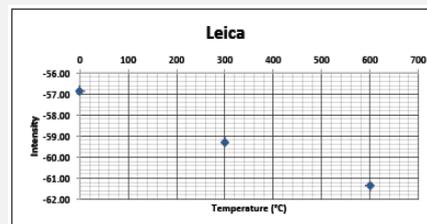
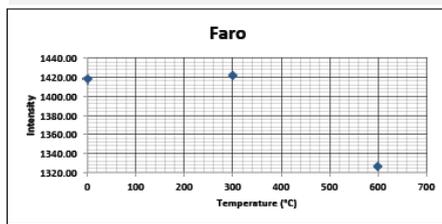
2012

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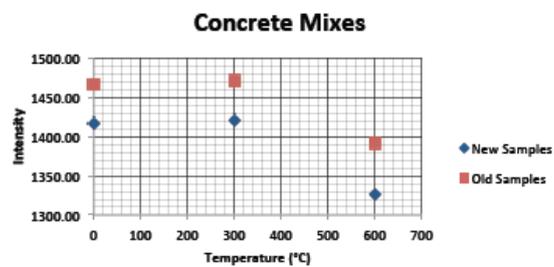
Results from Laser Scanning

Temp. (°C)	Faro		Leica	
	Mean Intensity	Standard Deviation	Mean Intensity	Standard Deviation
0	1417.67	43.15	-56.85	4.58
300	1421.50	43.24	-59.30	4.91
600	1326.02	42.07	-61.38	5.83



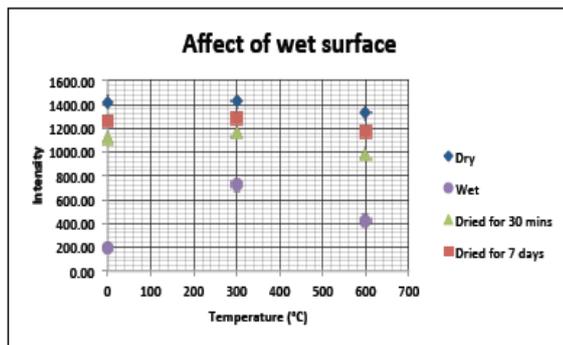
Results from Laser Scanning

Temp. (°C)	New Samples		Old Samples	
	Mean Intensity	Standard Deviation	Mean Intensity	Standard Deviation
0	1417.67	43.15	1467.54	48.22
300	1421.50	43.24	1471.58	54.33
600	1326.02	42.07	1391.91	45.92





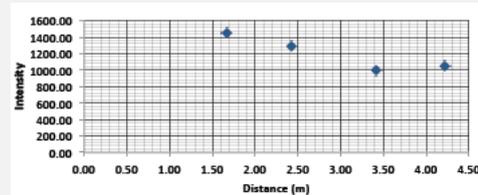
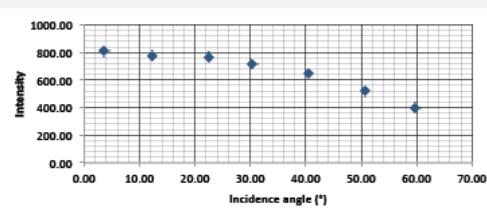
How Does Water Change the Results?



If a concrete building has been in a fire, then it is likely it will have been soaked with water



Angle and Distance Considerations

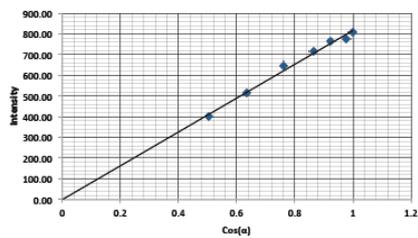




Angle Normalisation

Standard Deviation of
Normalised Angle ≈ 50

Faro - Intensity vs. Cos(α)



Faro - Normalised Angle

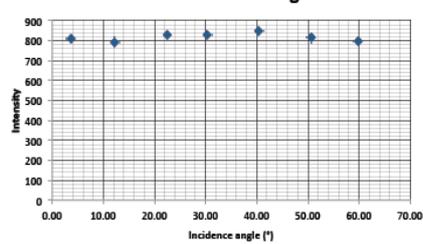


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Additional Considerations

- Angle and Distance
- Ambient Light
- Type of Laser
- Type of Concrete
- Paint on Concrete

- Can Water Damage be Detected?



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Conclusions

- Initial results are promising
- It is possible to distinguish between concrete heated to different temperatures using intensity return from laser scanning
- However, there are many other factors to take into account



Thank you!!

