Detecting Fire Damaged Concrete Using Laser Scanning

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Overview

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

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;300°C</td>
<td>Full strength</td>
</tr>
<tr>
<td>&gt;300°C</td>
<td>Starts to lose some strength, concrete may need to be removed</td>
</tr>
<tr>
<td>500°C</td>
<td>Starts to lose load bearing capacity</td>
</tr>
<tr>
<td>&gt;600°C</td>
<td>Does not function to design</td>
</tr>
</tbody>
</table>

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 at 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

Visual Inspection

- Crumbled to Dust!
- Exploded in the Kiln!
- Heated to 900°C
- Heated to 600°C
- Heated to 300°C
- Not Heated
Results from Laser Scanning

<table>
<thead>
<tr>
<th>Temp. (°C)</th>
<th>Faro Mean Intensity</th>
<th>Faro Standard Deviation</th>
<th>Leica Mean Intensity</th>
<th>Leica Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1417.67</td>
<td>43.15</td>
<td>-56.85</td>
<td>4.58</td>
</tr>
<tr>
<td>300</td>
<td>1421.50</td>
<td>43.34</td>
<td>-59.30</td>
<td>4.91</td>
</tr>
<tr>
<td>600</td>
<td>1325.02</td>
<td>42.07</td>
<td>-51.38</td>
<td>2.83</td>
</tr>
</tbody>
</table>

Concrete Mixes

New Samples vs Old Samples
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 $\approx 50$

Additional Considerations

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

- Can Water Damage be Detected?
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!!