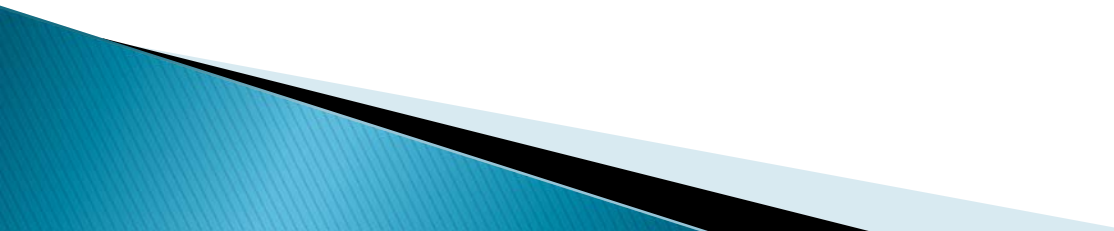


# Assessment of fire damage to RC and steel structures using laser scanners

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# Overview

- ▶ Structural fire damage
    - Review of what we know.
    - Review of what we do.
  - ▶ What about post fire.
  - ▶ Laser scanners – what do they do?
  - ▶ What we have tried.
    - What did we find?
  - ▶ What about steel?
  - ▶ What next?
- 

# Structural Fire Damage



# Review of what we know

## ▶ The 3 main structural materials are effected by fire, such as:

- Steel
  - increased likelihood of buckling
  - regains strength post fire
  - density decreases
- Concrete
  - cracking due to evaporation of free water
  - spalling due to isotherms/compressive stress
  - density decreases
  - delamination due to post fire water absorbsion
- Timber
  - It is combustible!

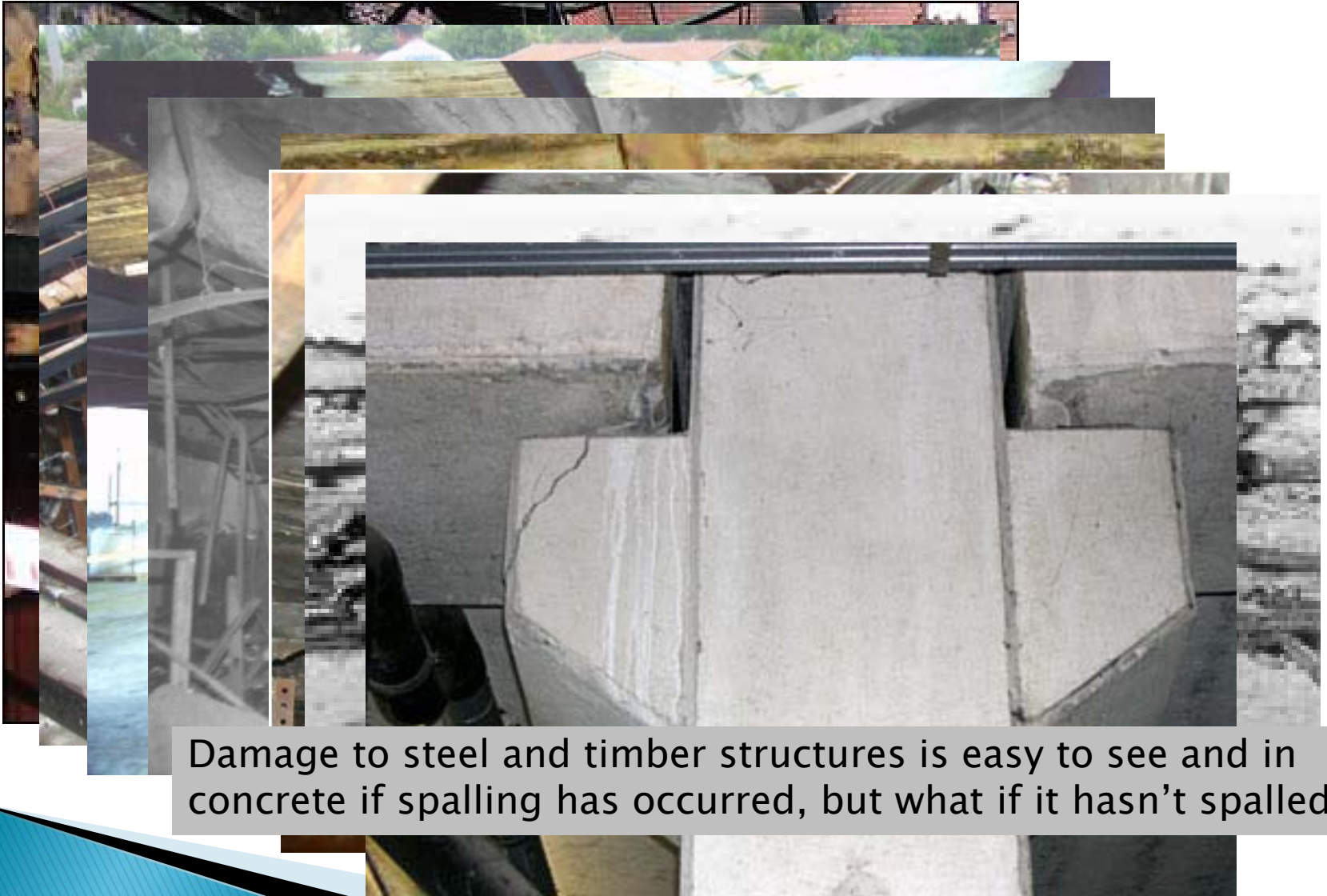
	Brinell Hardness Number	Vickers Hardness Number	Ultimate Tensile Strength N/mm <sup>2</sup>
Grades S355	187	197	637
	179	189	608
	170	179	559
	163	172	539
	156	165	530
Grades S275	149	157	500
	143	150	481
	137	144	481
	131	138	461
	126	133	451
	121	127	431

Table 2  
Brinell and Vickers hardness numbers  
with equivalent ultimate tensile strength  
values.

# What do we do?

- ▶ Provide protection
  - Steel protected by coating or coverings
  - Timber by fire retardant or covering
  - Concrete by increasing depth of cover to reinforcement.
- ▶ *But these actions don't necessarily prevent damage*

# Examples of fire damage



Damage to steel and timber structures is easy to see and in concrete if spalling has occurred, but what if it hasn't spalled?

# Damage to concrete.

## ▶ Quote

- “The damage to concrete caused by fire can range from minor cosmetic blemishes to more serious damage such as external cracking, delamination and spalling, internal microcracking, and chemical changes.”

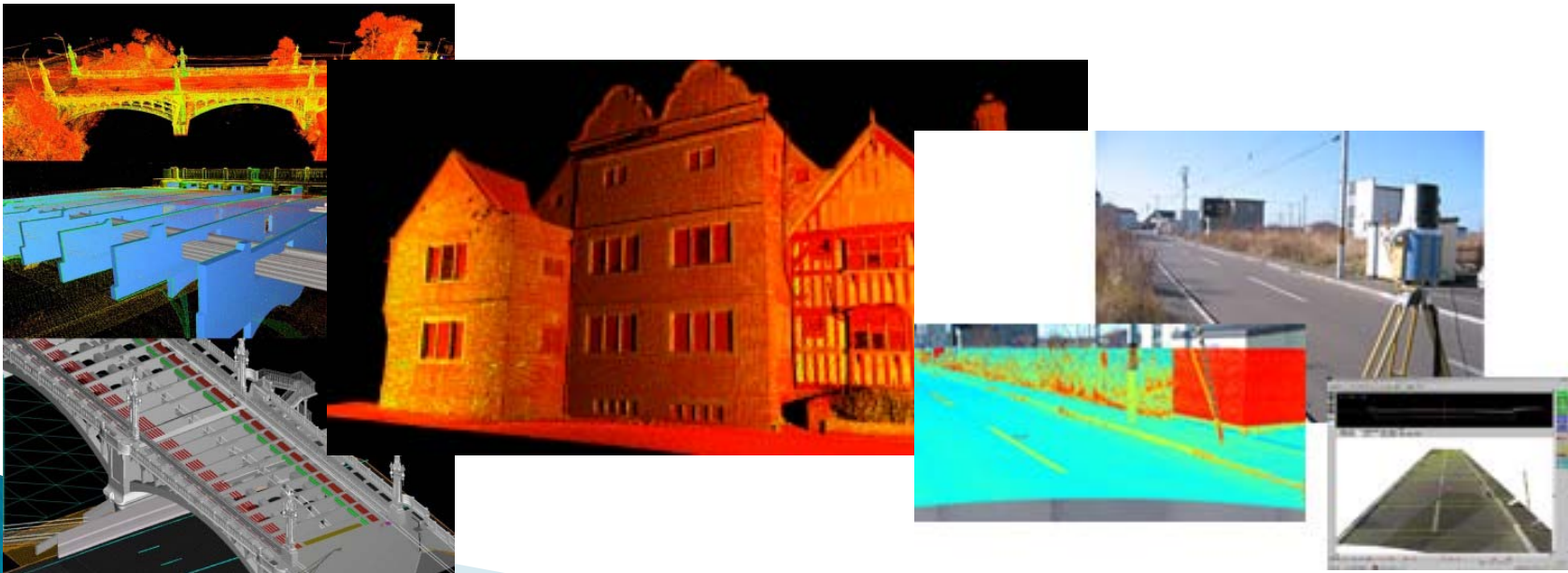
- Gosain, Narendra, Concrete International 1<sup>st</sup> April 2006

## ▶ How do we detect delamination?

- Name dropping time!
- Jim Quinterre and Kristian Hertz: the toffee hammer story!

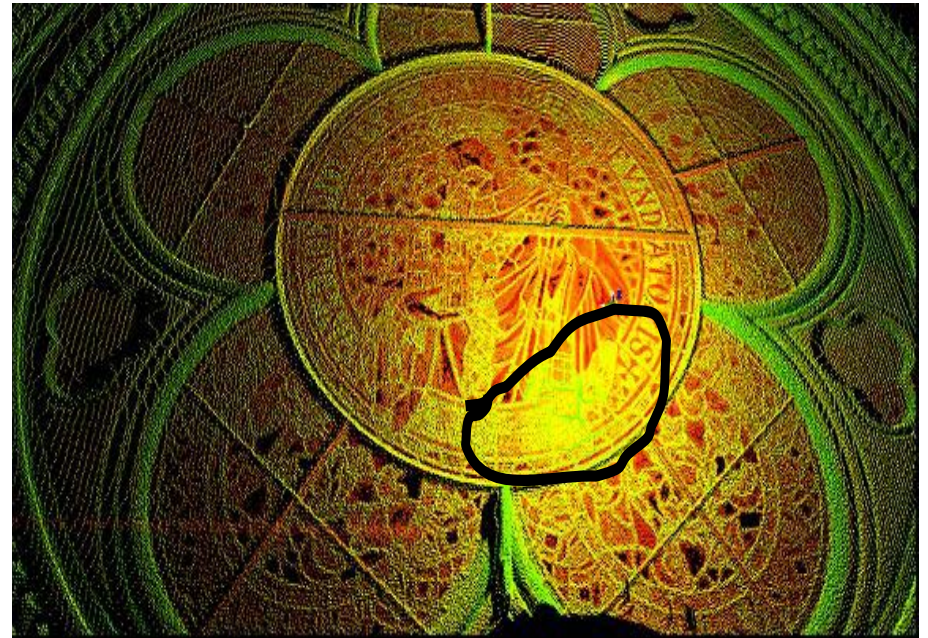
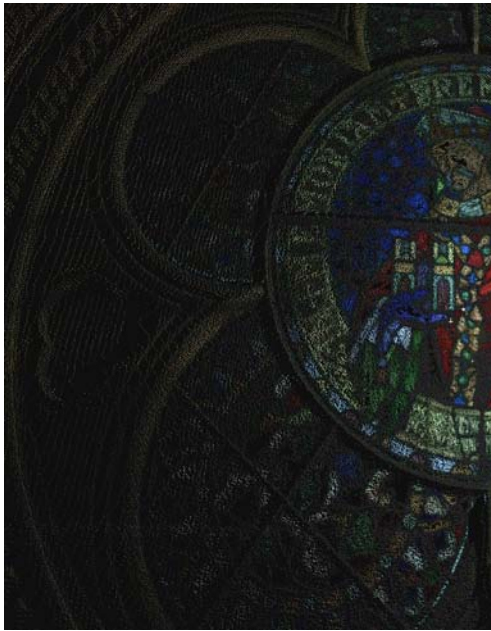
# Laser scanners

- ▶ What do they do?
  - Remote sensing measuring the 3 dimensional location of objects that reflect the emitted laser light and records the intensity of the reflection.
  - Used on bridges, buildings, road accidents, etc.



# What is the link?

- ▶ Lincoln Cathedral stain glass window



If the intensity of reflection can represent different densities can fire damaged concrete be detected remotely?

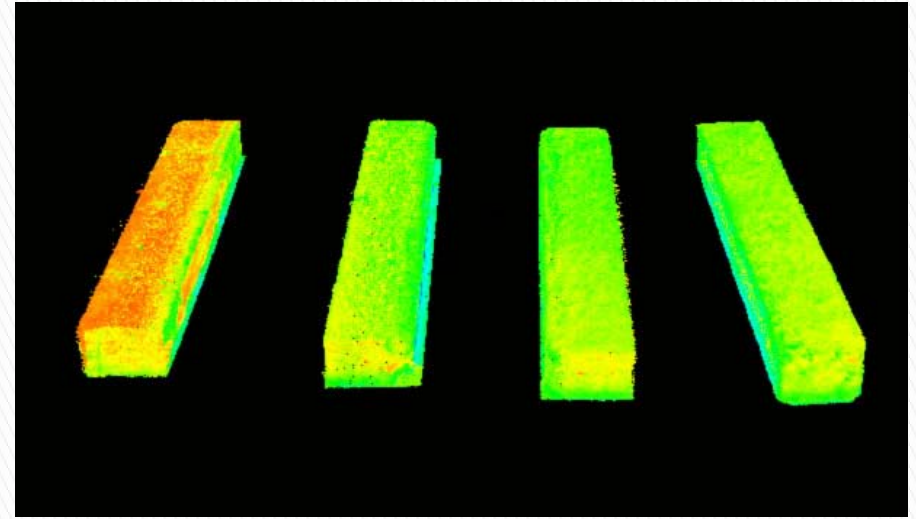
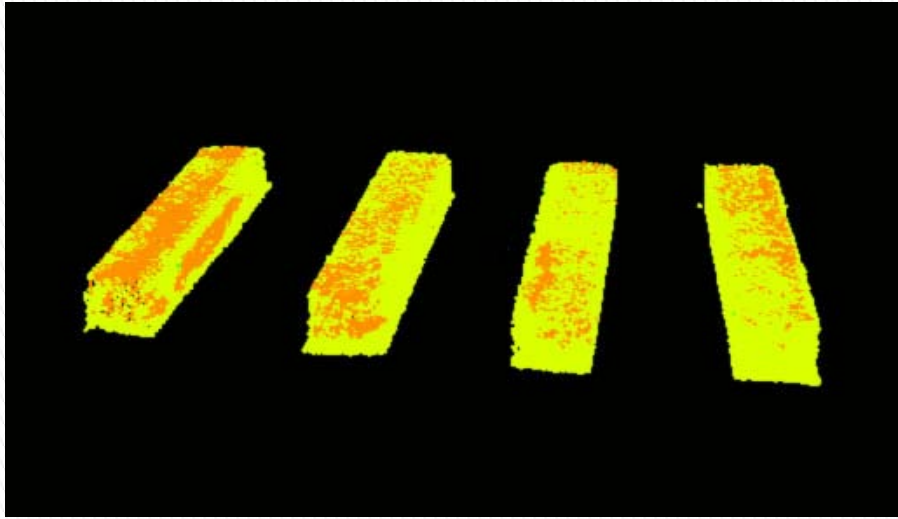
# The test pieces

- ▶ Use of a commercially available precast concrete lintel.
  - Cut in to 4 equal parts:
    - 1 used as a control sample and the others placed into a brick furnace for 3 days with temperatures above 900°C.

Post-heat



# Test results



Test 1: Leica HDS3000  
pulse laser scanning

Test 2: Leica's HDS6000  
Phase scanner

# Not all good news

- ▶ Laser scanners must have clean line of sight.
- ▶ Corners are difficult to define
- ▶ Equipment bulky and expensive.
- ▶ What about damage caused by less extreme temperatures?
- ▶ Will soot on the structural element affect results?

Not all bad news because there is portable radar equipment that can “see through” smoke.

# So what about steel?

- ▶ Major damage, such as buckling, is self evident.
- ▶ Post fire strength determination?
  - Not sufficiently different enough to be detectable with laser scanner.
- ▶ Connection failure?
  - Measurable 3D profile could indicate where deformation has occurred.
    - Beam to as horizontal as it should be.
    - Column not as vertical as it should be.

# Next stage

- ▶ More test on sample that have been exposed to different temperatures and durations of exposure.
- ▶ Various type/supplier of laser scanner.
- ▶ Radar.
- ▶ Possibly deformation assessment as the next project.
  - Favoured by Strathclyde Fire & Rescue to help assess post-fire structural integrity remotely.

Thank you, any questions?