New laser scanning test to assess fire-damaged concrete

December 12 2016

Credit: University of Nottingham

Engineering research at The University of Nottingham, UK and Ningbo, China (UNNC) has found laser scanning is a new and viable structural safety technique to detect the damaging effects of fire on concrete.

Concrete is the most extensively used construction material worldwide with an average global yearly consumption of 1m3 per person. Fire is one of the most serious potential risks to many concrete structures such as bridges, tunnels and buildings.

While concrete is known to be a material with high fire-resistance, capable of retaining much of its load-bearing capacity; its physical, chemical and mechanical properties do undergo severe modifications when subjected to high temperatures. A significant loss in strength occurs when concrete is heated above 300°C.

A structural safety assessment provides information needed to evaluate the residual bearing capacity and durability of fire-damaged concrete structures. They are also used to propose the appropriate repair methods or to decide if demolition is needed.

There are several conventional on-site and off-site techniques for assessing fire-damaged concrete. Some on-site methods include visual inspections of colour change and physical features whereas off-site methods involve invasive tests such as core drilling or lab-based techniques, however all methods have their merits and drawbacks.

Wallace Mukupa, PhD student at the Nottingham Geospatial Institute at UNNC, Reader in Geospatial Engineering at The University of Nottingham, Gethin Roberts and Assistant Professor of Geospatial Engineering at UNNC, Craig Hancock studied the use of terrestrial laser scanning (TSL) as a non-destructive way to assess and detect fire-damaged concrete in a structural safety appraisal.

Wallace said: "Scanning can be done at a distance, which improves site safety. Scanning is also quick, with millions of points measured in a few seconds and spatial resolution acquired in short time. This is advantageous for engineering structures considering their scale or magnitude."

'A non-destructive technique for health assessment of fire-damaged concrete elements using terrestrial laser scanning' was published in the *Journal of Civil Structural Health Monitoring*.

The study investigated the influences of scanning incidence angle and distance on the laser intensity returns. Concrete colour change was also studied. Data was collected and interpreted on unheated and heated concrete to establish the baseline condition of the material.

Study experiments were carried out in a controlled laboratory and used two-phase shift terrestrial laser scanners (Leica HDS7000 and FARO Focus 120) to scan the concrete specimens before heating and then after they were cooled again.

The concrete specimens were heated in a furnace to elevated temperatures of up to 1,000°C as the temperature attained is an important factor in assessing fire-damaged concrete.

To assess colour change in the heated concrete, specimen images were captured using the M-Cam attached to the Leica HDS7000 laser scanner. A flatbed scanner (HP Scanjet G2410) was also used to scan heated concrete surfaces and capture images. It is these images that were used for analysis due to their better resolution.

During the experiments, the measurement of the incidence angles for the concrete blocks was found to vary with distance. As the scanning distance increased, the incidence angle decreased and both scanners used showed the same trend.

"The measurement of the scanning incidence angles from the various distances was found to be wavelength independent for both scanners and this is a promising factor in terms of developing standardised analysis tools for the incidence angle although several scanners need to be tested," said Dr Roberts.

Wallace said: "A comparative analysis of the laser intensity for heated and unheated concrete showed that the recorded intensity values for heated concrete are higher than those of unheated concrete. In fact, the laser intensity values of heated concrete showed a remarkable increase in the concrete exposure temperatures from 250°C to 1,000°C.

"Such a correlation between the intensity and the exposure temperature is of cardinal importance in assessing the condition and extent of damage to concrete. This finding implies it could be possible to use laser intensity to detect the state of concrete whether it has been heated or not."

The study has also shown that RGB data improves the visual identification of features and provides a rough idea of the concrete condition after a fire. Laser scanners have an advantage in that most of them have either an internal or external camera that can be used to capture concrete images if good resolution can be achieved.

"Although the laser scanners used have different wavelengths, the results demonstrated the feasibility of using TLS as an approach to assessing levels of fire-damaged concrete and provide an understanding of the condition of concrete in relation to the strength changes of concrete when it is heated to elevated temperatures," said Wallace.

More information: Wallace Mukupa et al. A non-destructive technique for health assessment of fire-damaged concrete elements using terrestrial laser scanning, *Journal of Civil Structural Health Monitoring* (2016). DOI: 10.1007/s13349-016-0188-1

Provided by University of Nottingham