Digital image correlation gives results for concentrated loading

Digital image correlation (DIC) offers vital insights and understanding into the performance, durability and failure analysis of materials, products and structures when interacting with external forces, weights, strains and stresses. Traditionally, it has been used in heavy engineering sectors, eg, aerospace and power engineering, on components such as turbine blades where a high level of stress analysis and numerical modelling are used. It is now also finding use in the construction industry. ***Geoff Edgell*** *of* ***Lucideon*** *reports.*

In the UK, Lucideon has recently used the DIC technique recently in two projects where concentrated loads have been applied to walls. In both cases a speckle pattern, which consists of plaster or paint with a large number of randomly positioned black dots, is produced on the face of the wall to be loaded. Two cameras are set up to face the wall in order that stereoscopic images can be processed electronically. As the wall is loaded and strain appears on the face of the wall, the random dots move relative to one another. The degree of movement may be tiny but can be detected by the movement of the dots pixel by pixel across the field of view.

The movements can then be analysed to give tensile or compressive strains on the horizontal and vertical axes, and – from those strains – principal strains and maximum shear strains can be calculated from basic strain analysis relationships (Mohr's circle).

The output is a series of images showing the development of strain on the face of the wall by means of areas of different colours, with each colour representing an area where the strain is within a 67 micro-strain range, eg, 595–662 micro-strain. This is most usefully done for principal strains; small right angle shapes can be used to show the directions of the principal strain.

Concentrated loads on masonry

Eurocode 6[1] includes rules for dealing with isolated loads on the top of masonry walls. The rules essentially allow an enhanced stress beneath the concentrated load on the basis that at the mid-height of the wall the load has spread out. This is idealised as an area defined by lines at 60° to the vertical from the edges of the loaded area, where particular provisions apply at the ends of the wall. The approach was based upon a review many years ago of the results of tests to destruction.

Eurocode 6 is currently under review and new evidence produced by Germany made the 60° angle of load spreading questionable. As a result, the Concrete Block Association and the Aircrete Products Association combined resources and commissioned Lucideon to do some concentrated load tests including DIC.

Two walls were constructed, one from autoclaved aerated concrete (AAC) blocks and the other from dense aggregate concrete (DAC) blocks. Both were 100mm thick,

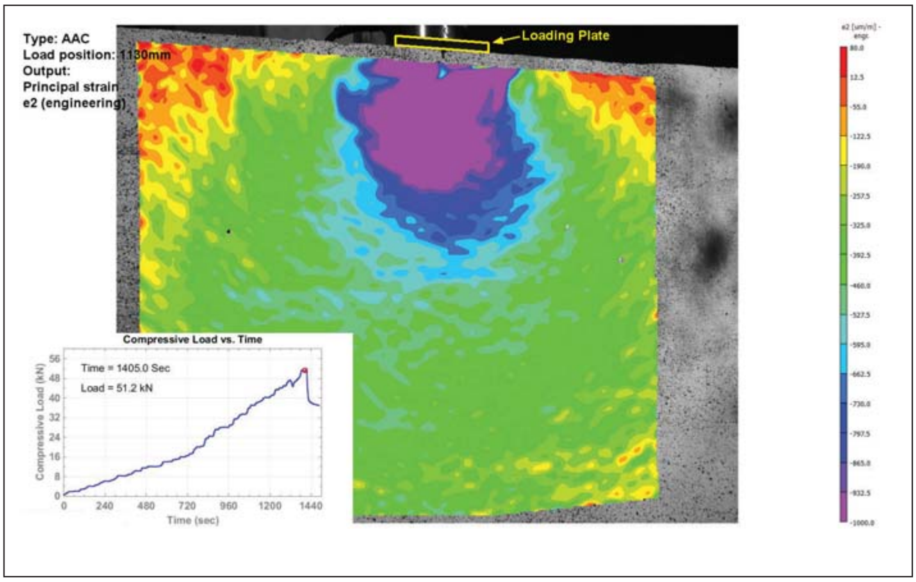

Figure 1: 'Bulb' of pressure in AAC wall.

five courses high and five blocks long, and built with a general purpose 1:1:6 cement:lime:sand mix. The walls were loaded through a 100mm-square plate, initially at 100mm, then 500mm from the wall end and then at the centreline.

Each load was taken to a working load level and then at the centre of the AAC wall to failure. The test was stopped for practical reasons on the DAC wall.

The key output in each case was the principal compression strain patterns where, even at low load, the strain distributed as a bulb of pressure beneath the loading plate. Figure 1 shows the strain distribution in the AAC wall at peak load where clearly the maximum compression is beneath the plate (in purple) but distributing through the shades of blue to green and yellow, eventually falling to zero or slightly tensile near the corners of the area instrumented.

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Figure 2 shows a similar situation for the DAC wall – the distribution bulb and some quite high strains existed in the mortar joint around the loaded block, possibly because of the mortar having a lower stiffness than the block. Nevertheless, the distribution is clear. There is much more to be learned but the fact that the distribution occurred has highlighted the issue that the recent German data was from blockwork with unfilled vertical joints and the guidance has now been tailored accordingly.

Storey-height wall panels

H+H Celcon is interested in the performance under load of its storey-height aircrete panels. Although the vertical joints are filled with a rapid-hardening thin-joint mortar, the design for vertical load includes no allowance for load spreading from one panel to its neighbour. Tests were carried out on full-size

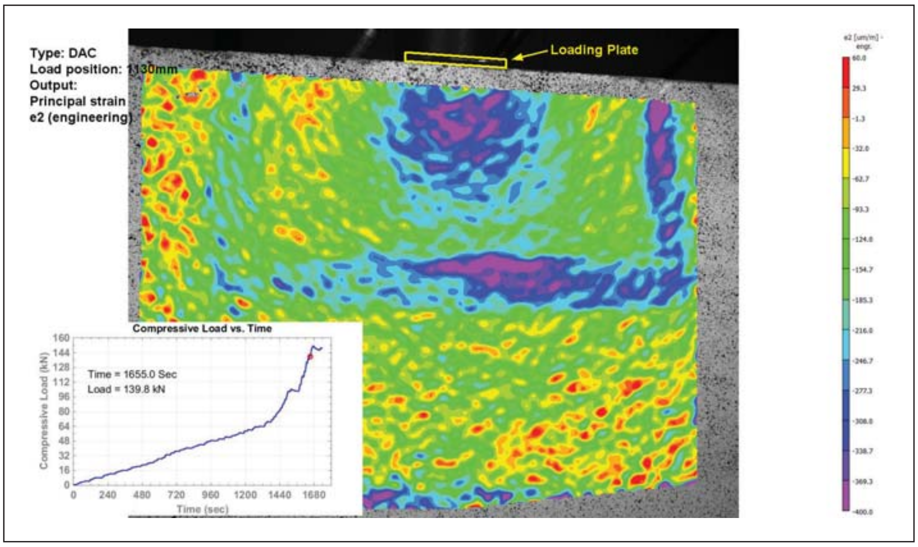

Figure 2: ‘Bulb’ of pressure in DAC wall.

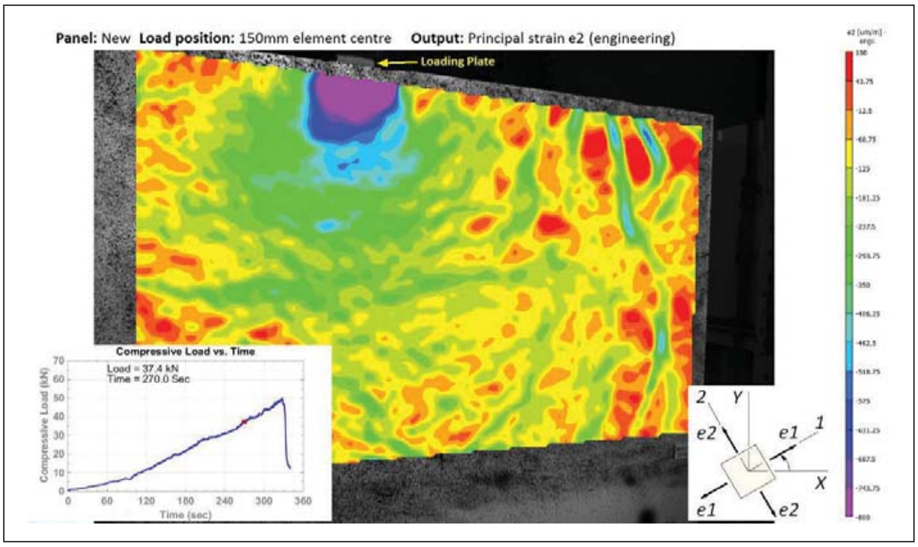

Figure 3: ‘Bulb’ of pressure in storey-height panels.

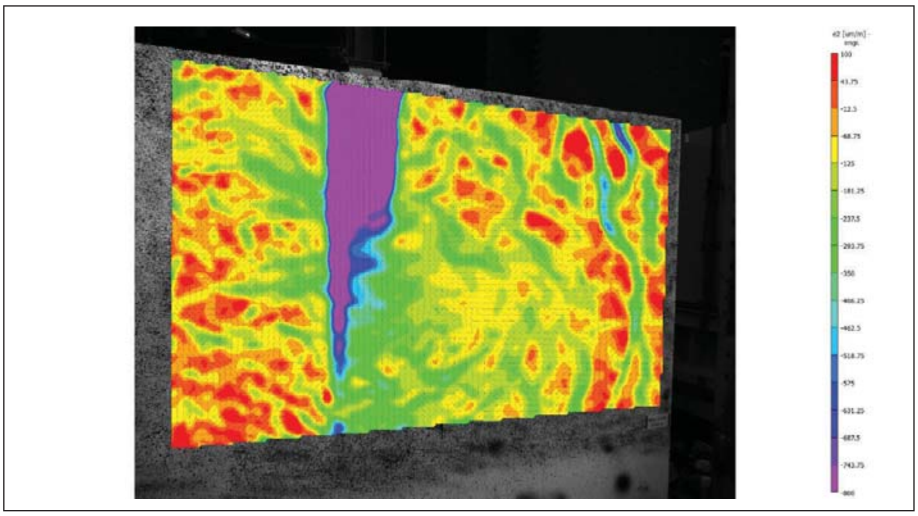

Figure 4: Localisation of pressure at failures.

walls consisting of three 600mm-wide panels and one 'make up' piece 150mm wide. The loading tests were similar to those for the masonry and in particular one load position was on the 150mm 'make up' piece, ie, close to two vertical joints.

Figure 3 shows clearly that the compressive strain is distributing itself at 75% of the ultimate load as if the joints are providing complete continuity, ie, the panel is behaving homogeneously.

It is only when we get to the ultimate failure that we can see that the major principal strain is confined to the 'make up' panel (Figure 4). The minor principal strain shows that we have generated large tensions in the region of the joints (Figure 5). The strain axes are at 45° to the horizontal, indicating that the joints have failed in shear. The extent of failure, as suggested in Figure 5, is echoed exactly by the cracks that occurred at failure.

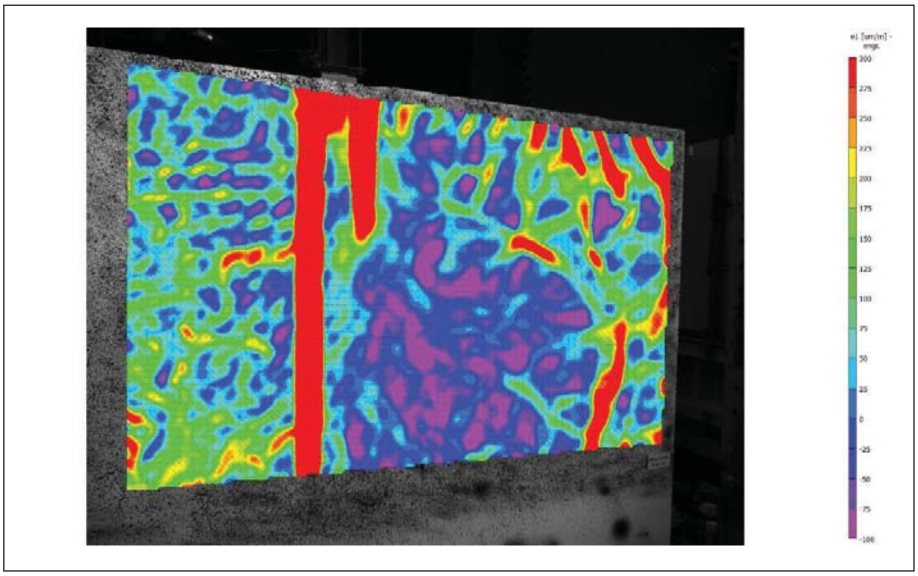

Figure 5: Location of major shear strain and cracks at failure.

Useful tool

Digital image correlation has proven to be a most useful tool in these projects. It shows in clear detail what is happening in the specimens and can generate vast amounts of data. The key to its usefulness will be in selecting critical data for study. Clearly there is a huge potential in validating or adjusting numerical models so that they better reflect reality. ■

Reference:

1. BRITISH STANDARDS INSTITUTION, BS EN 1996-1-1. *Eurocode 6. Design of masonry structures. General rules for reinforced and unreinforced masonry structures.* BSI, London, 2005+A1:2012.