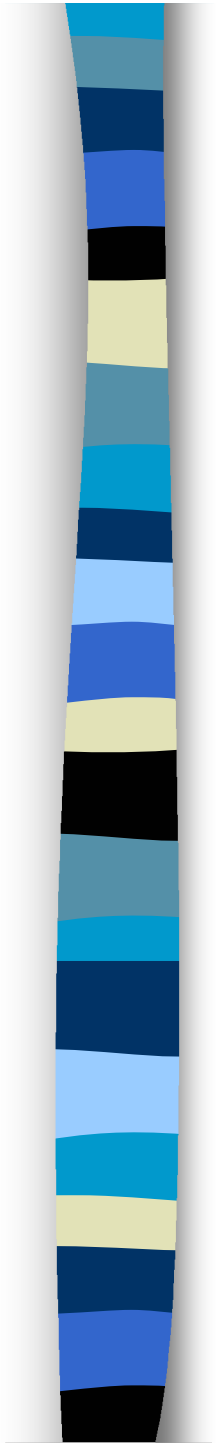

LCFI Interim results

The Mechanical Design Aspects

by

Oxford University

23 / 08 / 2001

LCFI Interim results

The aim of this exercise is to study the mechanical behaviour of the CCD caused by a differential shrinkage rate between the jointing materials. Several cases were looked at:

- Silicon to silicon butt joint at mid-span with the following gluing area. 4 cases were studied:-
  - 2 mm wide by 0.05 mm thick;
  - 2 mm wide by 0.1 mm thick;
  - 5 mm wide by 0.05 mm thick;
  - 5 mm wide by 0.1 mm thick

- Silicon to ladder block joint with the following gluing arrangement. 2 cases were studied:-
  - two patches of glue, each 2.4mm by 6.5mm separated by a distance of 15mm across the CCD plate width;
  - A continuous line of glue of 6.5 mm wide by 18mm long;

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The silicon-silicon butt joint uses a 3-D model with brick elements to simulate the off set effect of the joining strip and the glue. The following Mechanical properties were applied:

Silicon: CTE: 5.2E-6; Young's Modulus: 131 GPa
Glue: CTE: 47E-6; Young's Modulus: 3.3 Gpa
Temperature change: 90 C

A linear static analysis, which does not take into account the stiffness changes due to geometry change of the structure, was applied. A linear analysis in this instance would over-estimate the displacement value. The following results were obtained

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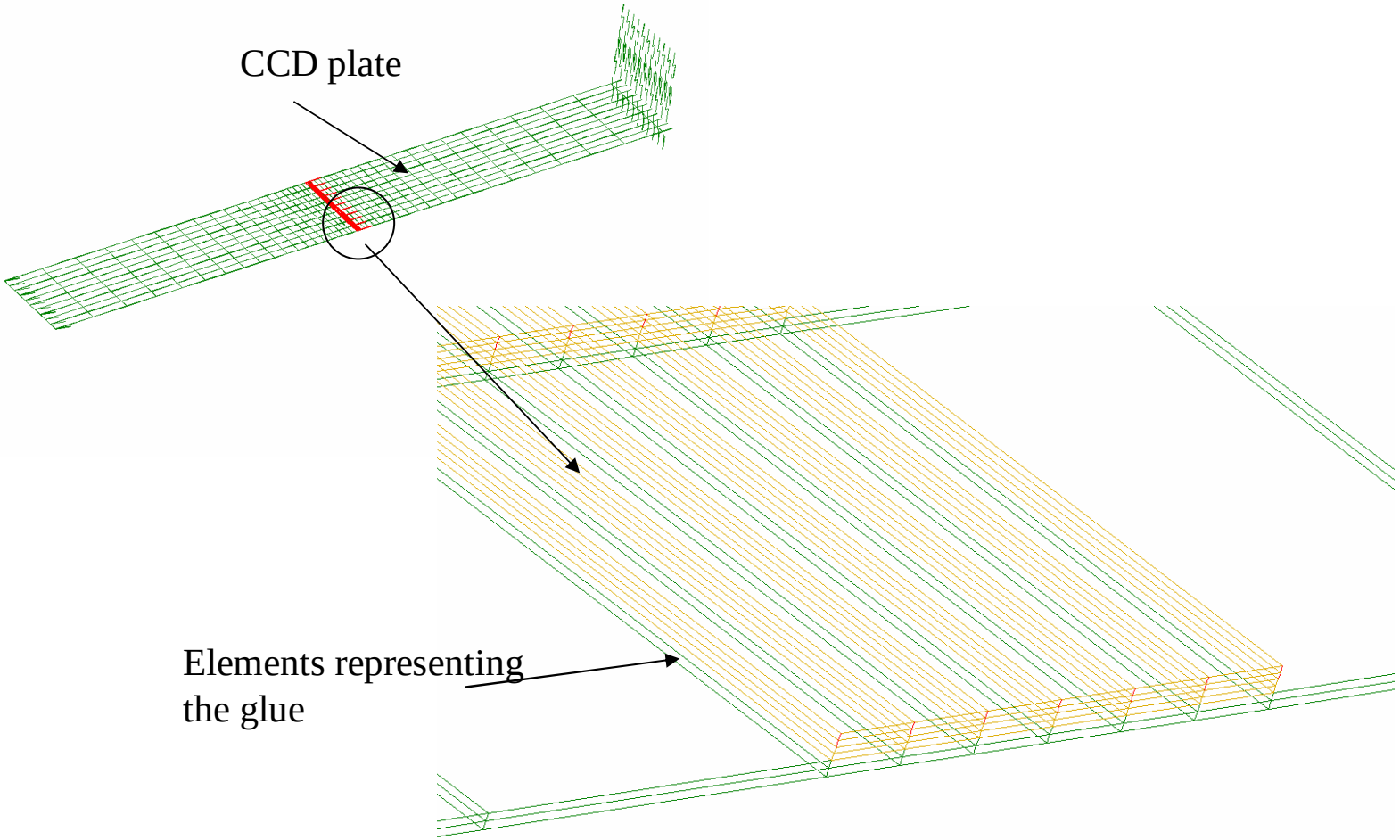
The FE Model:



Details of the FE model local to the glue

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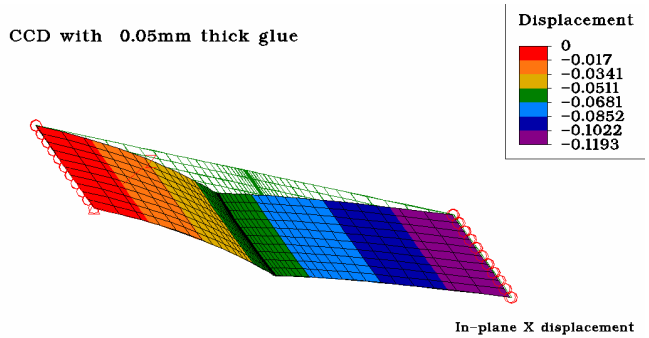
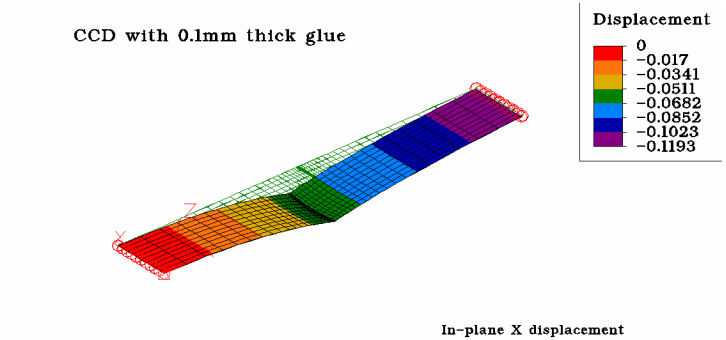
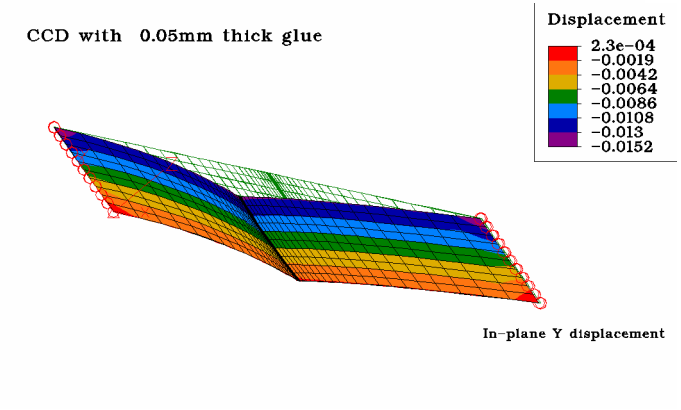
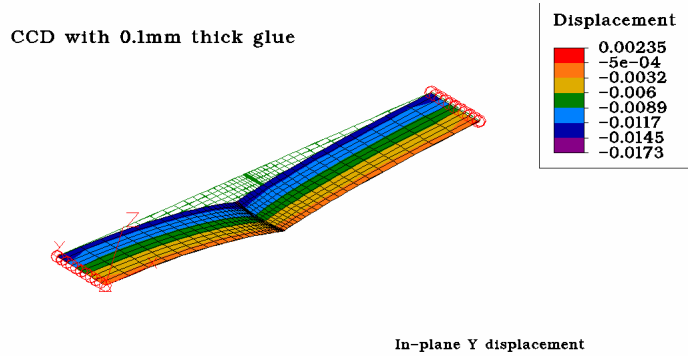
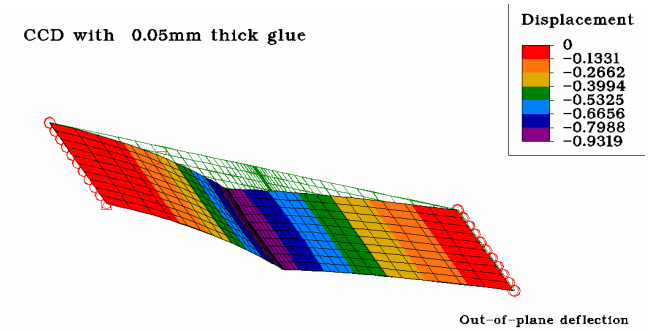
The results:

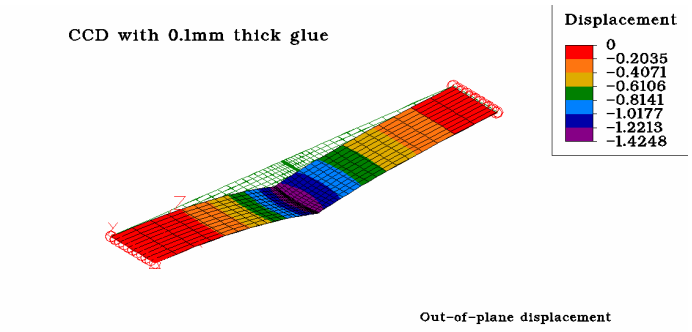












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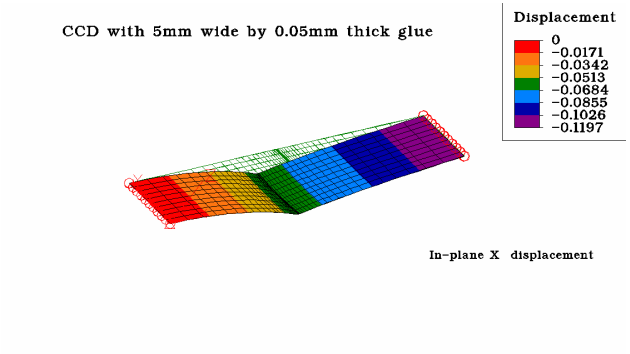
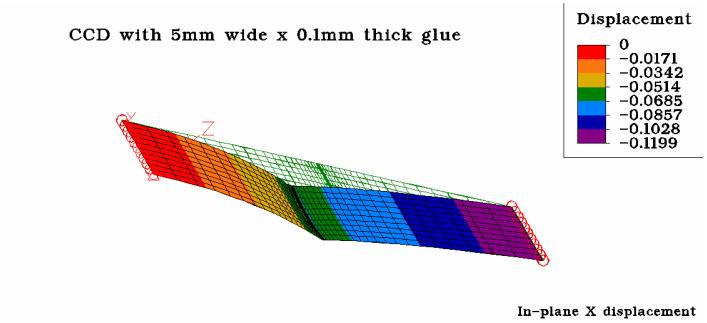
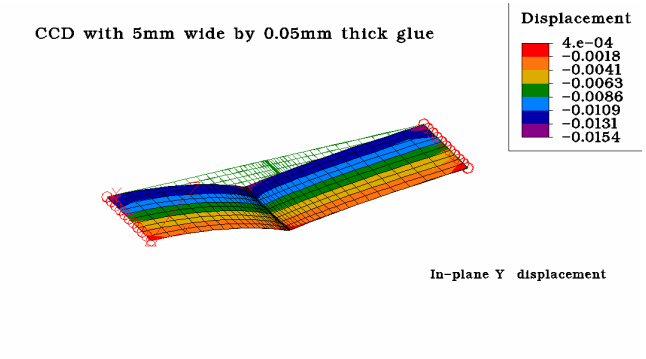
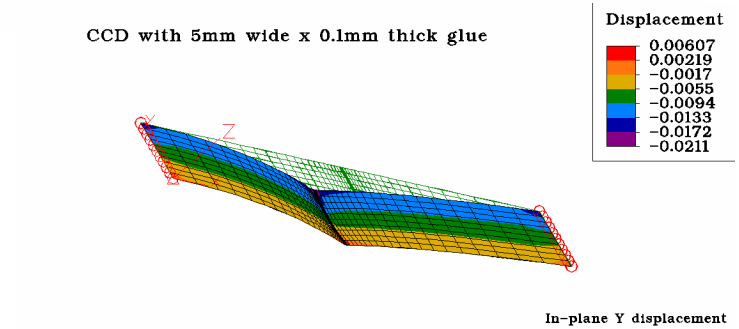
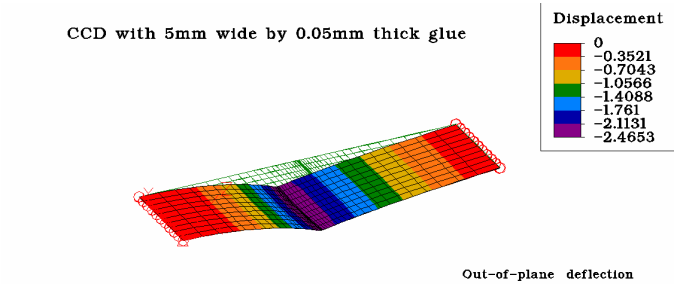
The results:

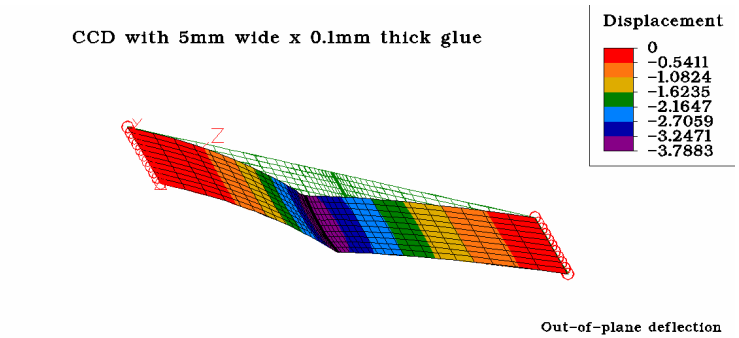












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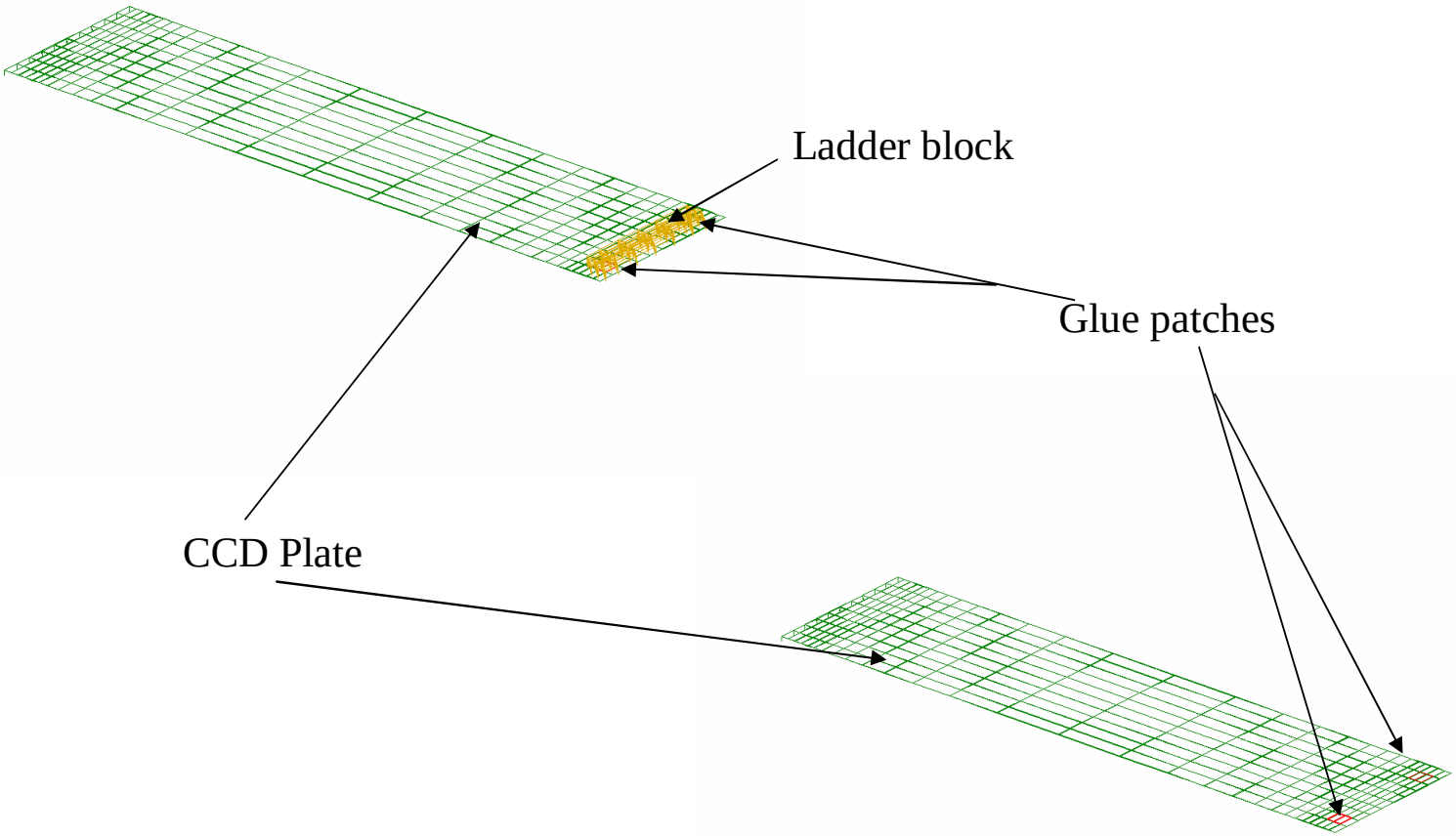
Two further non-linear FEA studies were carried out; one on a CCD plate joined to ladder block by two “blobs” of glue, and the other by a continuous line of glue. Aluminium with a CTE of 20E-6 and a Young’s modulus of 70 GPa were used to model the ladder block while the material for the rest remains the same as those described previously.

The use of non-linear FEA allows the computation of a time-dependant deformation and the update of the stiffness changes during each stage of the shape re-development.

In these analyses, a ΔT of 90 C was applied to simulate the temperature change during the curing of the glue. A deformation history was recorded and compared with those measured at RAL.

LCFI Interim results

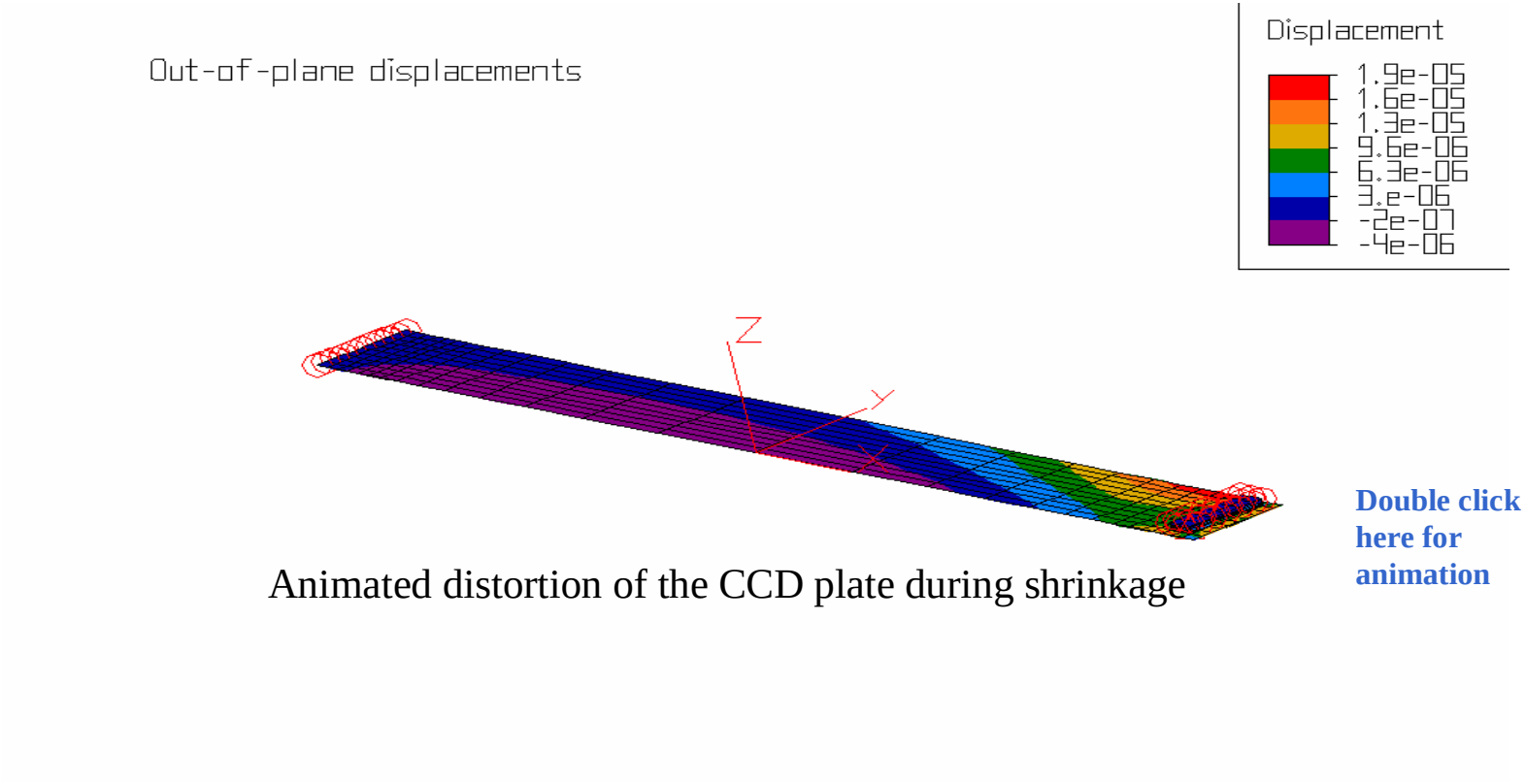


FE model of the CCD plate with ladder block and Glue

LCFI Interim results

Deflection of the CCD due to a differential shrinkage between the silicon and the ladder block during gluing

Case 1:- Silicon held by two patches of glue across its width

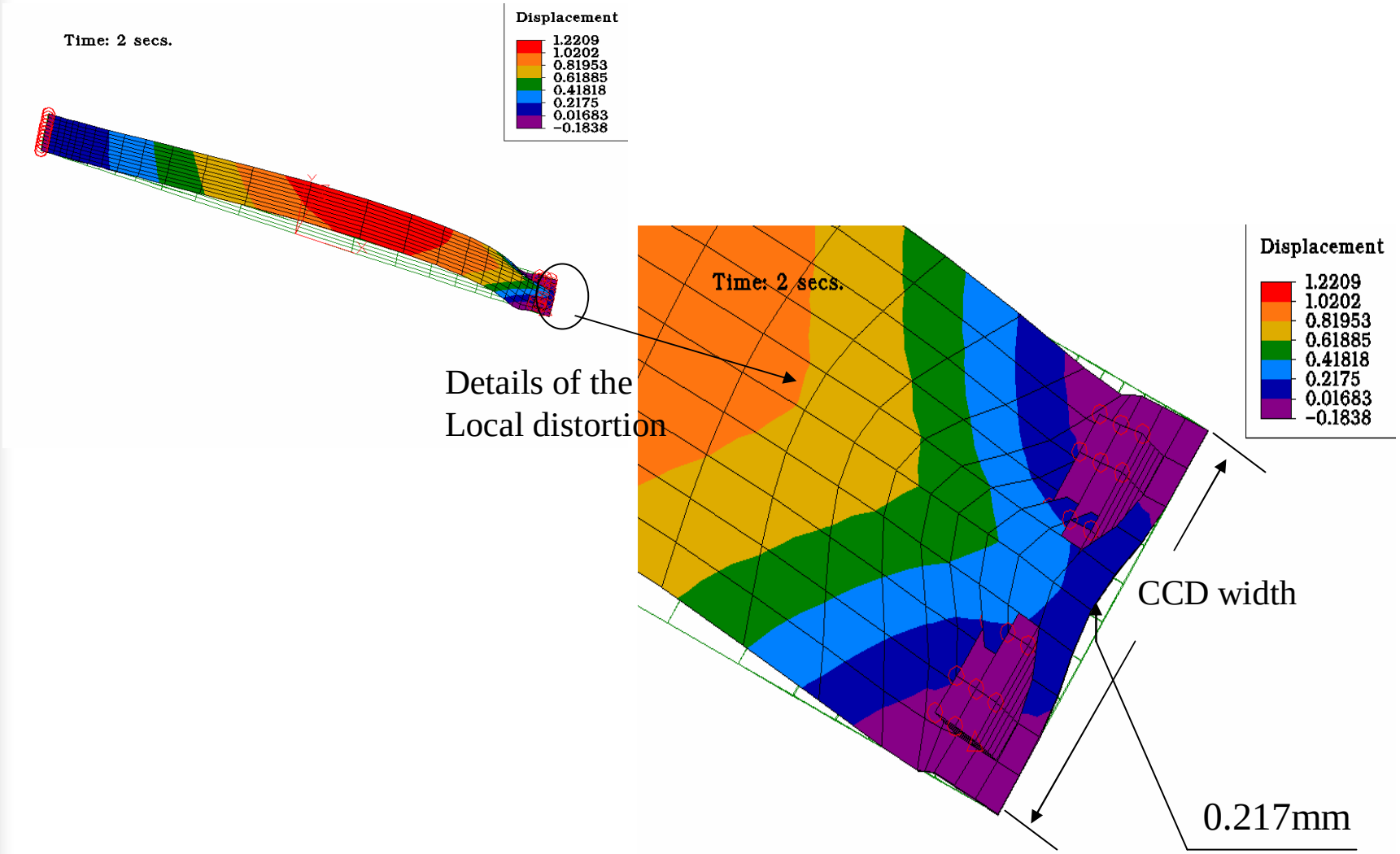


Animated distortion of the CCD plate during shrinkage

Double click here for animation

LCFI Interim results

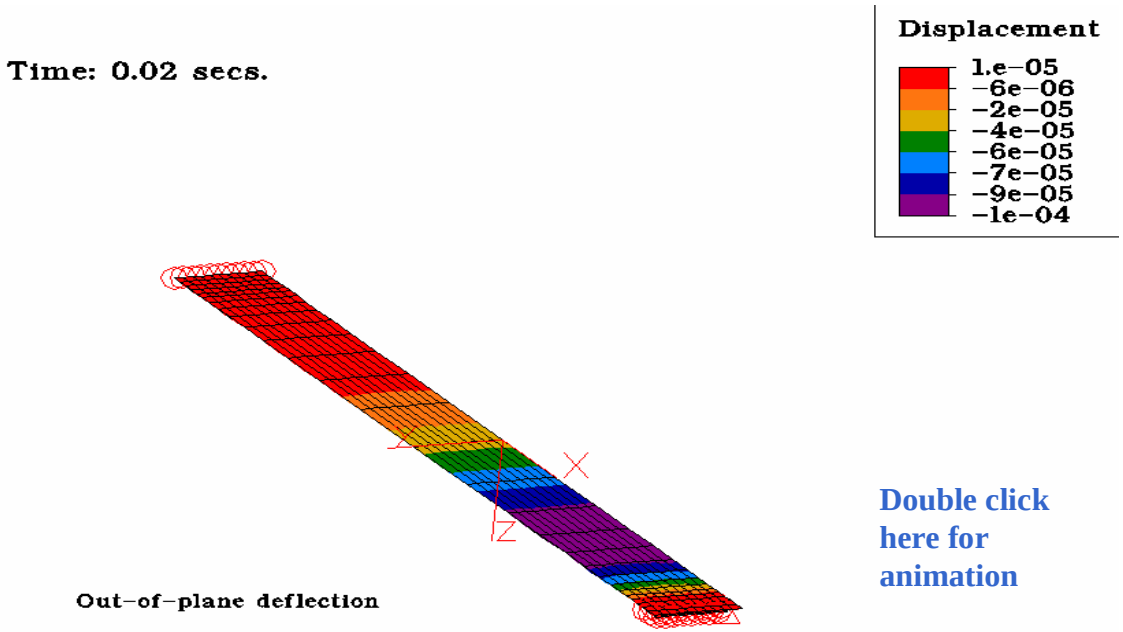
Details of the deflection local to the CCD plate end



LCFI Interim results

Deflection of the CCD due to a differential shrinkage between the silicon and the ladder block during gluing

Case 2:- Silicon held by a line of glue across its width

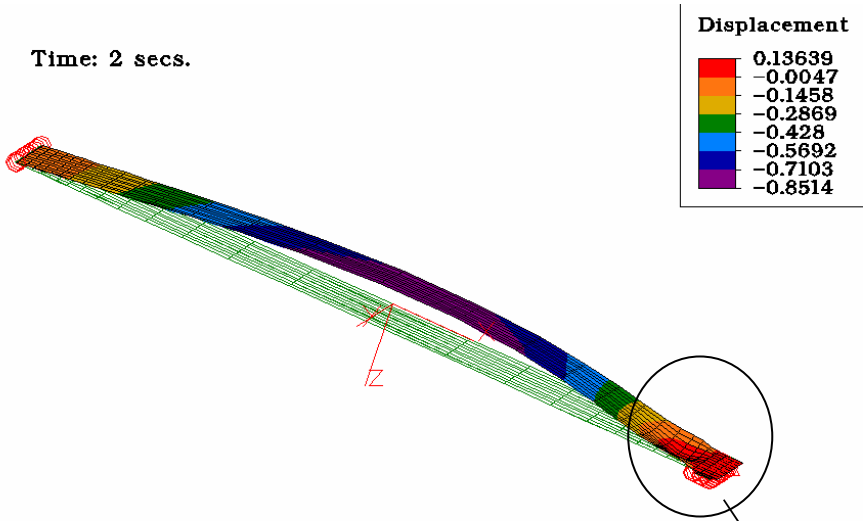


Double click here for animation

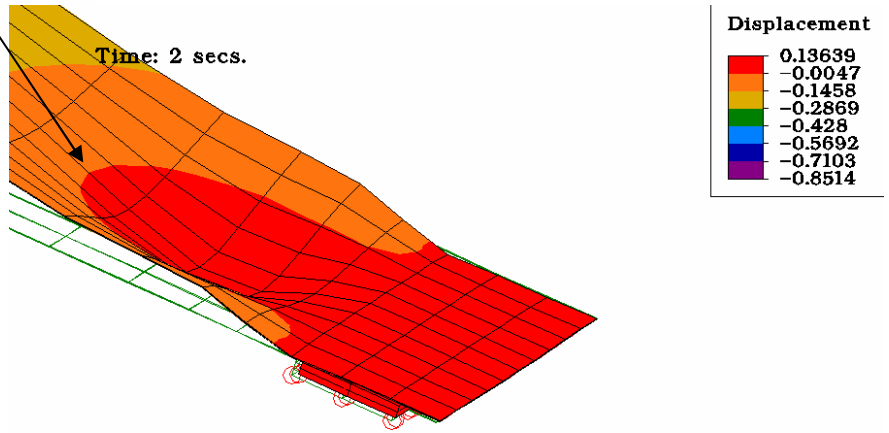
Animated distortion of the CCD plate during shrinkage

LCFI Interim results

Case 2 results cont-



Distortion details
local to the glue joint



LCFI Interim results

Summaries:

The FEA result, especially the animated one which shows the step-by-step shape changes, offers a good understanding of how the local deformation affects the global shape change of the thin CCD plate.

For the FEA model with two “blobs” of glue, it shows a local bowing of 0.217mm at the plate end across the ladder block, compared closely with a figure of 0.25mm measured by RAL.

Both models shows a significant bending along the plate length caused by the local “buckling” of the plate end across its width. In practice, it may be able to correct this deflection by applying a pre-tension force at its ends.

LCFI Interim results

Summaries (Conti-):

Further studies are needed to determine if the existing FE model is of sufficient detail to be used for further thermal analyses.

At a separate discussion prior to this meeting, it was agreed that Oxford will work with RAL to find an optimum gluing arrangement for the CCD plate.

It is hoped that once a feasible gluing method / pattern is identified, an FE model will be set up and analysed at length before validation by test is carried out at RAL.