MEC-E6007 - Mechanical Testing of Materials

Digital Image Correlation Lab Report

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Table of Contents

1.Introduction and Background 1
2.Method 2
2.1 Measurement Setup 2
3.Experimentation and Discussion: 4
4.Conclusions: 6
References 7

1. Introduction and Background

Digital Image Correlation (DIC) is a powerful technique used in experimental mechanics to measure the displacement and deformation of materials and structures. It utilizes digital image processing algorithms to analyze consecutive images of an object undergoing deformation [1].

Digital Image Correlation offers a non-contact, full-field measurement technique to accurately capture the deformation of a cantilever beam under various loading conditions. The process involves the following steps:

Image Acquisition: High-resolution digital cameras capture images of the cantilever beam at different loading stages. The beam's surface is often speckled or marked with a random pattern to aid in image analysis.

Image Preprocessing: Before analysis, the acquired images may undergo preprocessing steps such as noise reduction, contrast enhancement, and image registration to ensure accurate correlation between consecutive frames.

Correlation Analysis: In this step, DIC algorithms analyze pairs of images to track the displacement and deformation of the speckle pattern on the beam's surface. The correlation process involves dividing the images into small subsets called interrogation windows and comparing the intensity variations within these windows between consecutive frames.

Displacement Calculation: Based on the correlation results, the displacement field of the cantilever beam is computed. This provides a detailed map of how each point on the beam's surface has moved in response to the applied loads.

Deformation Analysis: DIC can also provide information about the strain and deformation of the cantilever beam by analyzing the changes in shape and size of the speckle pattern.

2. Method

2.1 Measurement Setup

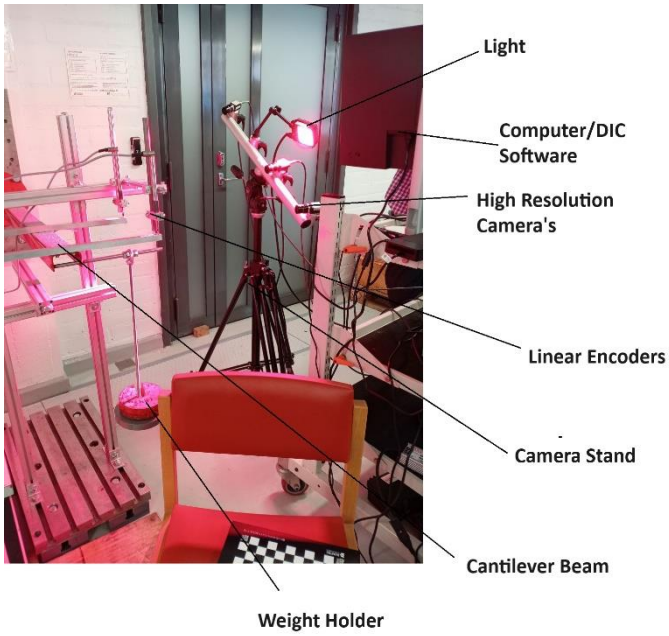


Fig 1: DIC Setup

Camera System:

We used a high-resolution digital camera capable of capturing detailed images of the cantilever beam's surface. The camera had high frame rate. Consider factors such as resolution, frame rate, and sensitivity to lighting conditions.

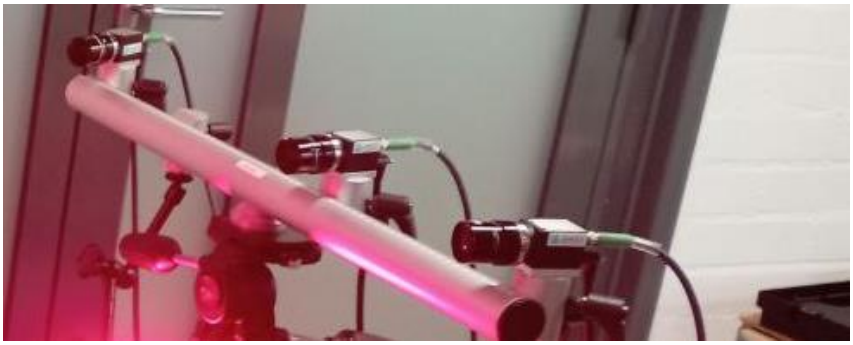


Fig 2: Camera Setup of DIC equipment

Lighting Setup:

It needs uniform and adequate lighting across the cantilever beam's surface to minimize shadows and reflections. Diffuse lighting is used to avoid glare and specular reflections that can interfere with image analysis.

Fig 3: Lighting Setup

Speckle Pattern:

We pasted a speckle pattern onto the cantilever beam's surface. The speckle pattern enhances the contrast and aids in tracking surface deformation during DIC analysis. Techniques such as spray painting with speckle paint can also be done.

Fig 4: Speckle pattern

DIC Software:

Utilize specialized DIC software to perform correlation analysis and calculate displacement fields from the acquired images. DIC software packages typically offer a range of tools for image preprocessing, correlation analysis, and visualization of displacement and deformation results.

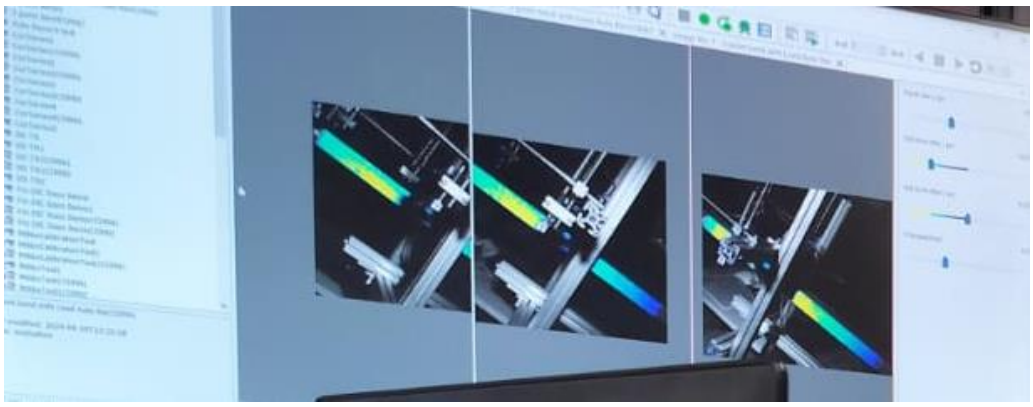
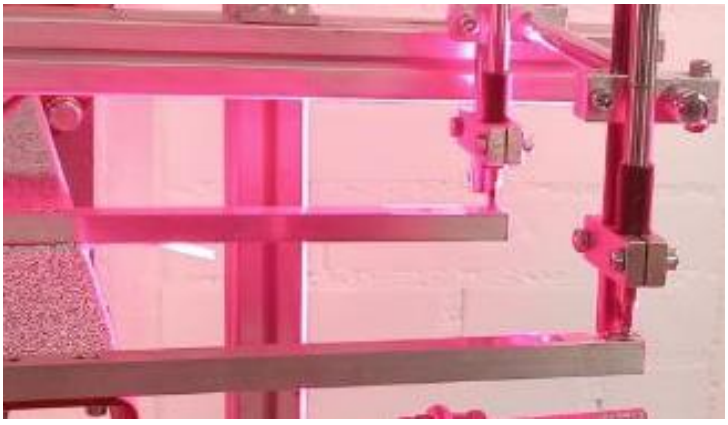


Fig 5: DIC Software

Linear Encoders and Sensor Measurements:



3. Experiments and Discussion

When all the setup has been done, force was applied to the beam using the application of weights. The deflection values were noted from a computer for all the four points where the LVDT's were present.

Similarly, the deflection values shown by the DIC were also noted. The weight was increased and for each weight the deflection values were recorded. After the loading is completed, the unloading phase begins, and all the weights are removed one by one and the corresponding deflection values are noted from both the DIC equipment and from the LVDT. A total of 16 steps were performed, 8 for loading and 8 for unloading. The data from the DIC were obtained in the form of images and text files. From the DIC we see that the maximum displacement occurs at the end of the cantilever beam which is loaded.

Table 1: Displacement measurements

Job	Step	Weight (lb)	Displacement (mm)
Loading	1	1	1.08
	2	3.2	3.76
	3	5.4	7.11
	4	7.6	9.94
	5	9.8	11.28
	6	13.87	12.33
	7	17.94	13.32
	8	22.94	14.19
Job	Step	Weight (lb)	Displacement (mm)
Un-Loading	8	22.94	1.08
	9	17.94	3.76
	10	13.87	7.11
	11	9.8	9.94
	12	7.6	11.28
	13	5.4	12.33
	14	3.2	13.32
	15	1	14.19

Following Fig_7, depicts the loading at step 9, this shows the values of the displacement is near 4mm at maximum. The contour also demonstrates that the left side has been attached to the fixture where is the high stress concentration and there is high displacement that ranges between 1.6mm to 4mm.

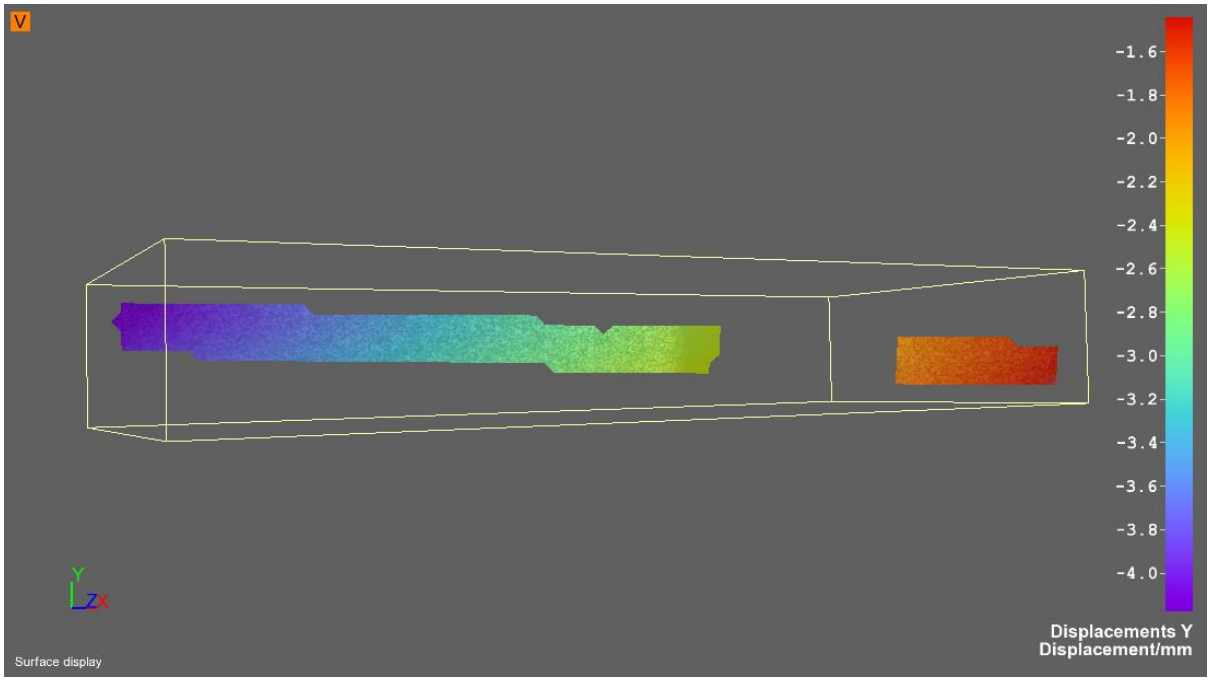


Fig 7: Step 9 displacement

Now during the unloading phase at step 16, following figure shows how the displacement decreases and reduces the stress at the fixed side. At this step the displacement is now ranging between 0.003mm to 0.016mm. This is because the initial displacement has somehow affected the return of the beam to the normal position at the unloading phase.

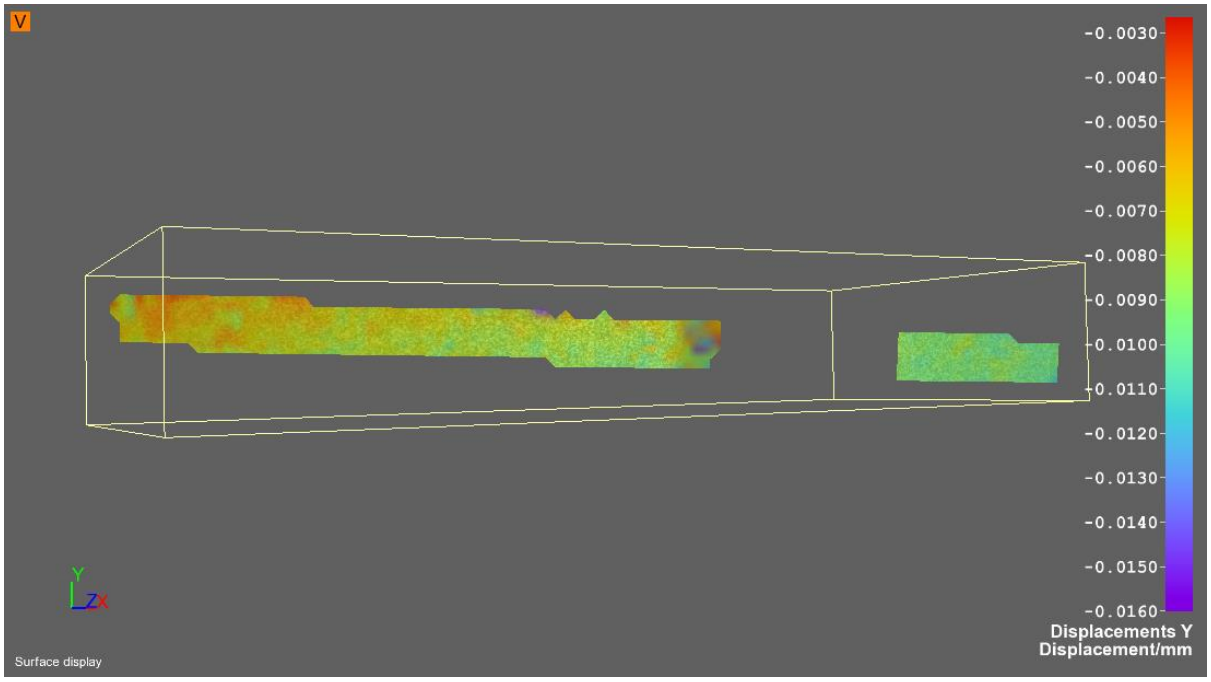


Fig 10: Step 16 displacement

4. Conclusions

We performed a DIC test on cantilever beam. In the start we faced some issues regarding the setup. The camera positions play a vital role in DIC experiment. Also, the lighting setup play important role. When the issues were fixed we took some readings while loading and unloading the cantilever beam. In this report we have discussed the values of displacement at different steps while loading and unloading the beams.

References

[1] www.dierk-raabe.com. (n.d.). digital image correlation, DIC strain map, mechanics, deformation. [online] Available at: https://www.dierk-raabe.com/digital-image-correlation-dic/.