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DESIGN AND USE OF NOVEL COMPRESSION DEVICE FOR MICROTOMOGRAPHY UNDER APPLIED LOAD

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Abstract: *This paper deals with modification and usage of custom-designed compression device, that allows real time X-ray tomography scanning of specimen under applied pressure. In this case microtomography is used to obtain data required to determine specimens morphology and to develop 3D material model (especially for cellular materials such as bones, metal foams and quasi-brittle materials or particle composites such as concrete or cementitious composites). Important design changes were made in the existing device frame to increase its load capabilities, stiffness and to accomodate a larger specimen. Finally device displacement measurements were conducted and calibration experiment was carried out.*

Keywords: ***X-ray, microtomography, compression device, optical strain measurements***

1. Introduction

X-Ray tomography models under applied load can be used to study material morphology and additionally to use the data for development of finite element (FE) model of a studied material, e.g. trabecular bone [Jiroušek et al. (2011)] and quasi-brittle materials. Such material testing method is specific and the testing device has to be constructed with utilization of a custom design. Significant upgrade of previously designed machine capable of performing material measurements in X-rays is described in this paper.

2. Modified design

New design with bayonet lock has been introduced. Bayonet lock allows better manipulation with specimen and easier change of machines experimental setup. Bottom part of the device consists of three parts: bottom bayonet, flange used for fastening to the base desk and a composite tube. The composite tube is made of carbon fibre composite. This material exhibits excellent mechanical characteristics in tension while quaranteeing very low X-ray absorbtion. The bottom parts of the body has been permanently glued together by PL20 epoxide. First experiment have proved that device is very stiff and can be used for loading up to 25 kN. Overall view of the new machine design and its parts in detail are shown in Fig. 1.

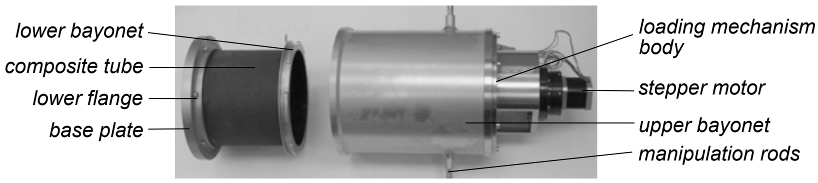

Fig. 1: Overall view of new design and description (left). Detailed view of assembly parts (right)

3. Experiment - displacement measurement

Displacements were measured optically using digital image correlation (DIC). All image data were acquired using macro objective (Canon EF 180 mm f/3.5L Macro USM, Canon, Japan) mounted on a

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15 MPix body (Canon EOS 7D, Canon, Japan). Composite tube was measured by DIC without any modifications to the surface because of its natural texture. Polymeric body was markered by dots required for correlation feasibility. Verification experiment was carried out by displacement driven loading with loading rate of 5 $\mu\mathrm{m/s}$ up to maximum force value 10 kN. Images have been then processed by digital image correlation toolkit [Jandejsek et al., (2010)]. Displacement and deformation in vertical direction were determined and the results were compared with numerical and/or analytical calculations. Results and comparison with digital image correlation data are displayed in Tab. 1. Linear behaviour of device was proved and it is graphically shown in Fig. 2.

Tab. 1: Comparison of overall z-direction displacement calculated and measured

	Composite tube	Polymeric body
Analytic solution	0.0697 mm	not calculated
Numerical solution	0.0694 mm	0.141 mm (relevant to measured place), max. 0.188 mm
Digital image correlation	0.0741 mm	0.764 mm

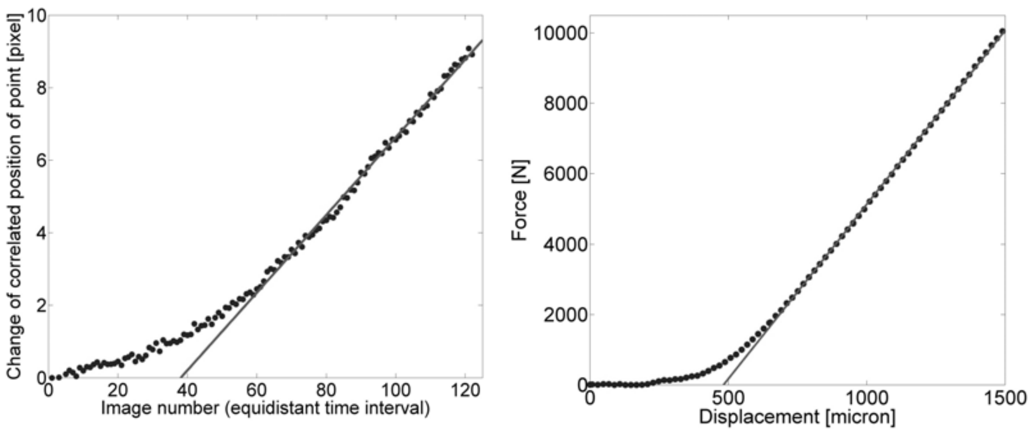

Fig. 2: Displacement and force diagram

4. Conclussion and discussion

New design makes the device significantly stiffer which is important not only for higher loads but also for fracture toughness tests. Material more transparent for X-rays has been used to obtain more precise, more relevant and more accurate data. Linear behaviour of the device and its stiffness was measured. To conclude, prospective behaviour of device has been verified and device is suitable for considered experiments.

5. Acknowledgements

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