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A MECHANICAL ANALYSIS OF CANCELLOUS BONE IN FEA SIMULATION RESEARCH AND EXPERIMENTAL TESTING WITH THE µCT CONTROL

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ABSTRACT

This paper presents the results of experimental and FEA simulation research, which purpose was to study of the cancellous bone under compression load. Samples of 25 mm diameter swine cancellous bone were prepared. In experimental tests, bone specimens were loaded with a 1000N force under the control of the µCT. As a result of µCT imaging, the CAD model of bone specimen was obtained and displacements of cancellous bone were measured as function of the force. A systematic series of tests were performed in order to study and introduce the nature of the damage caused by compressive load. A finite element study was proposed to evaluate mechanical stress in porous material of bones specimen. Obtained results in experimental and numerical studies were compared and mathematical relationships were shown.

Keywords: biomechanics, µCT, FEA, cancellous bone.

INTRODUCTION

Mechanical bone tests have been conducted for a long time, but until now a model describing all the phenomena occurring in the bone material has not been worked out (Draughn, 2000). The development of microtomographic techniques allows accurate imaging of bone microstructure, which allows to accurately assess bone quality in vivo and is essential for evaluating of mechanical properties of bone (Tozzi, 2012; Zhang, 2014). The test stand for experimental research was developed; this is a platform consisting of an actuator as well as force and displacement sensors, which can be placed in the measuring space of the phoenix microCT Computed Tomography System. This allows to simultaneously conducting mechanical tests and µCT imaging.

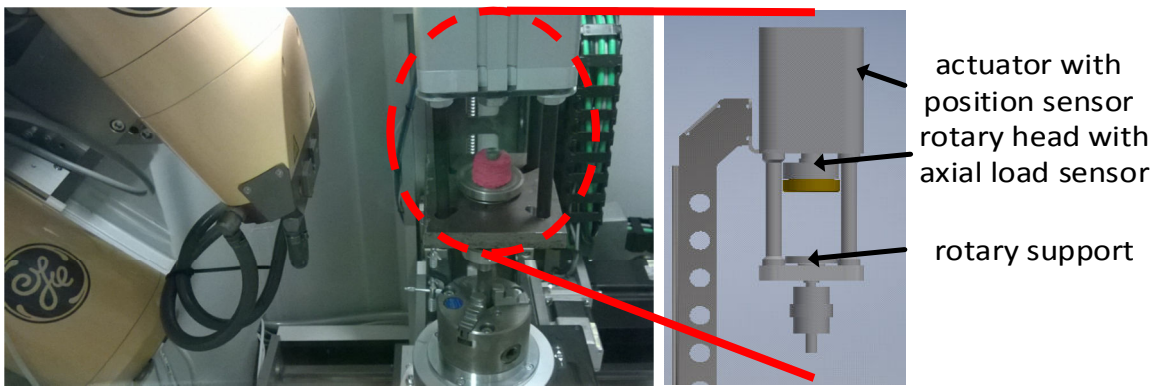

Fig. 1 - The test stand for experimental research of bone specimen under µCT control

RESULTS AND CONCLUSIONS

The results of μCT imaging are shown in Figure 2. The μCT imaging allows on quantitative and qualitative analysis of the microstructure of cancellous bone. The results from the experimental tests are shown in Figure 3. The linear behaviour is proved in load-displacement curves. Non-linearity of the curve by 200 N and 600 N of load are caused by micro-cracking already in the linear range of deformation.

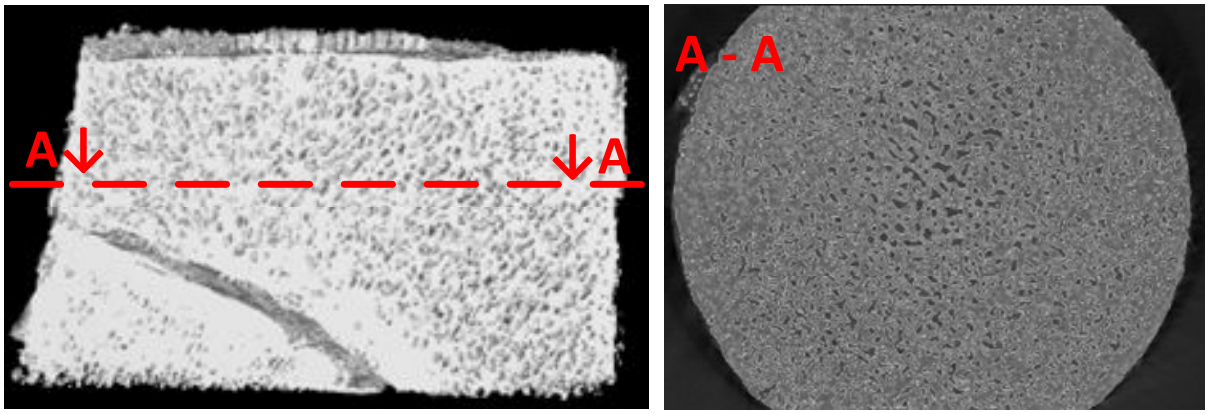

Fig. 2 - The view of bone specimen with the exemplary cross section of bone specimen extracted for qualitative analysis.

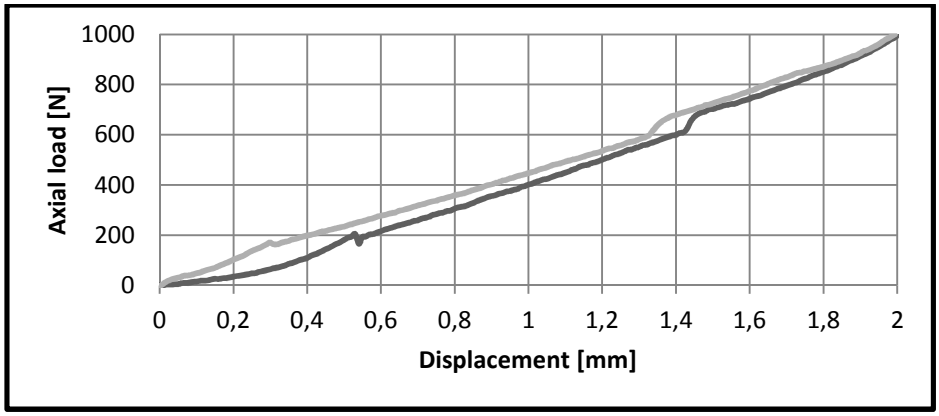

Fig. 3 - Experimental results of compressive test of bone specimens.

This study shows that FEA are necessary to evaluate mechanical stress in porous material of bones specimen. The maps of Huber-Mises-Hencky (HMH) stress in bone specimen are determined.

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