Stand and preliminary testing results on disc-shape hardwood specimens obtained with video image correlation method

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INTRODUCTION

The authors are involved from several years ago in the disc-shape hardwood specimens' testing. In this sense, they conceived and realized several stands, destined for Photo-elastic Thin Layer Technique, for Moiré-Fringe Technique, respectively for Holographic Interferometry, too. Some of these published experimental results are mentioned in the References.

It is well-known fact that for anisotropic and orthotropic materials (how is also the hardwood), on can apply from the Photo-Elasticity, only the so-called reflection method. In this sense, the thin layer technique, was developed and patented by Vishay Company, and named PhotoStress. Using this reflection method, we are able to analyze specimens made of different kinds of materials. This method became very useful especially in the case of materials with anisotropic or orthotropic behaviours, like wood and wood-based materials. So, the point-by-point analysis of such specimens' stress-state offers within the limitations of the accuracy of the method, certain useful information. In this case, on apply a relatively thin layer (2 to 3 *mm*) of photo-elastic material (by gluing it using some special reflecting material), and using a special kind of Polariscope, on perform experiments similar to the transmission Photo-elasticity. Some very interesting and useful results were obtained at the University of West-Hungary, Sopron, co-ordinated by Szalai (Borbás et al. 2001, Hantos 2007, Szalai 1995, 2001a, 2001b). Amongst others, the dependence of the stress-state of disc-shaped wood specimens on the fibre orientation was analysed using PhotoStress.

Naturally, the PhotoStress method has certain limitations due to the following drawbacks:

- ✓ The relatively thin layer of photo-elastic material (2 to 3 *mm*), can still influence the stiffness of the analysed specimen and, consequently, the accuracy of measurements will decrease;
- ✓ The photo-elastic material is rather expensive, so, for a relatively large number of specimens this method becomes costly;
- ✓ The gluing process of the photo-elastic layer can introduce moisture, which affects the properties of wood-based materials and, consequently, the accuracy of the measurements decreases.

The Holographic Interferometry is a special, exclusively laboratory method, destined to test only in some special (vibration-insulated) conditions the specimens. Of course, its accuracy is much higher as than the PhotoStress, but also is much more expensive technique.
Based on these facts, the authors looked for another, more efficient method (less expensive than Holographic Interferometry and more precise than PhotoStress) to investigate wood-based materials.
The Moiré Grids Method was chosen, more exactly: the Geometric Moiré Grid Method was used for in-plane displacement evaluation. Several interesting and useful results were obtained with uni-axial testing stand. The disadvantages of this method consist of:

- ✓ Accuracy dependence from the used grid pitch;
- ✓ Difficulties in applying of the specimen grid (by some special technique, for example: that patented by Daniel Post, USA), which will allow/assure a relatively large displacements field;
- ✓ The out-of-plane displacements cannot be determined by this method.

In the last period, the authors, from the Transilvania University of Brasov, achieved a **Video Image Correlation System,** which **3D version (VIC-3D)** allows to eliminate (practically) completely the above-mentioned disadvantages.
The system allows measurements in normal working conditions, due to the fact, that on can eliminate the rigid body movements form the displacements field.
In principle, the two captured video images are analysed step by step (with an accuracy of 9x9 pixels quadrates) from their grey-scale code's point of view during the loading process.
The system is able to recognize all of these small quadrates (having unique grey-scale-codes) and, based on a preliminary calibration, will offer the displacements field point-by-point.
After the preliminary image analysis, on can obtain not only the displacements (in 3D) but also the strains (in 3D, respectively the main values and Tresca, and Von Mises strains, too).
The VIC-3D allows to evaluate a relatively large field of displacements (starting form some *microns* up to several *mm*), even point-by-point, even along a line, a circle etc.
These results are offered even in colour graph, even can be exported in Excel-files, destined to draw-up several useful graphs.

STAND DESCRIPTION

For this kind of testing, using the VIC-3D, was conceived and achieved (worked out) a simply testing device (Fig.1). The top rigid plate (5) is attached to the stationary element, while the bottom rigid plate, with octagonal force transducer (1), is attached the movable crosshead of the tensile testing machine.
The disc-shaped wood specimen (3) is subjected to force F by means of the specially shaped components (4).
The self-conceived octagonal force transducer allows to monitories (with high accuracy) the magnitude of the applied force.
For the evaluation of the total displacement of the disc (its diametric contraction), we conceived an electrical strain gage lamella (6), fixed to plate (5) and leans upon on the vertical rod, fixed at the lower rigid plate (2).

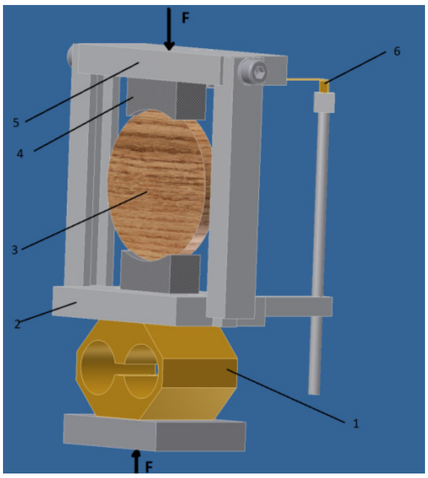

Figure 1: Testing device.

Both the octagonal force transducer (1) and the lamella (6) have four electric strain gages connected in a full Wheatstone bridge.
By means of one self-conceived MatLab program the force and displacements' data are transferred to the video images.
So, became possible to monitories/follow, during the loading-unloading process, not only the VIC-3D's data, but also the transducers' values, too.

PRELIMINARY TESTING RESULTS

The authors performed several tests on lime-wood disc-shape specimens. Were monitories in 9 points ($P_1,\ldots,P_9$), from the real load-transfer area (under the pressing parts (4) during loading and unloading process the above-mentioned variables (see Fig.2).
Fig. 3 shows the comparative diagrams of the von Mises strains during loading and unloading process. The notations $h00 \ldots h90$ refers to the fibers' orientation with respect to the vertical direction (y-axis). On can observe significant changing of the stiffness with the fiber orientation.

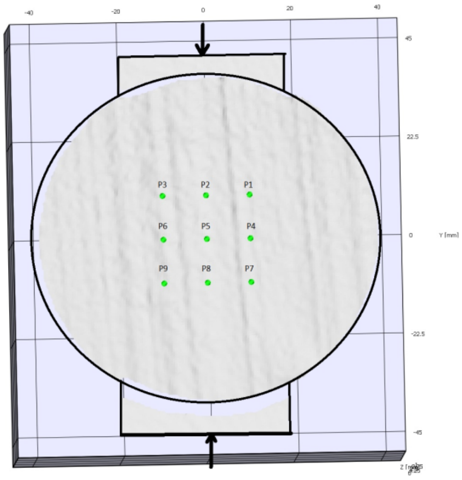

Figure 2: The tested points.

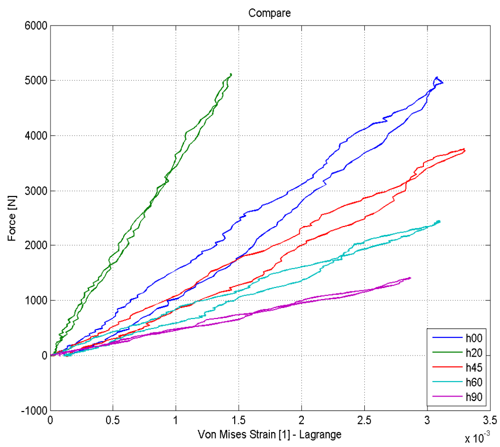

Figure 3: Loading-unloading comparative values of von Mises Strains in point P_7.

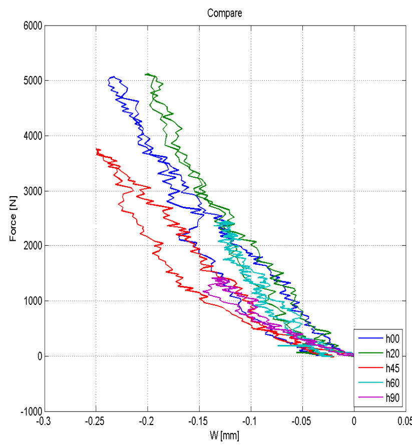

Figure 4: Loading-unloading comparative out-of-plane displacements in point P_7.

CONCLUSIONS AND FURTHER GOALS

- ✓ The presented method of Video Image Correlation seems to satisfy (to full-fill) in very good conditions all requirements of the orthotropic materials' NDT testing;

- ✓ Due to the fact, that in case of the orthotropic materials, the strain-field analysis is more convenient as the stress-field's, this investigation method proves again its advantages;
- ✓ In comparison with the PhotoStress and Geometric Moiré-Fringe Methods, the VIC-3D allows also to analyze the out-of-plane strain-field, which represents an other great advantage of the method;
- ✓ By the similarity with the concrete materials' tensile strength (ultimate stress) establishing /determination, where are used some cylindrical specimens compressed along their generator-line, it is known that along the horizontal diameter the σ_x normal stress has always positive values, when the loading is produced along y -axis. In case of the hardwood specimens, if the fiber orientation is identical with the y -axis (the loading axis), that became possible to establish the ultimate tensile stress for the fiber detachment (along the normal direction to the fibers orientation).

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