ADAPTATION OF A CRUCIFORM TESTING MACHINE ZWICK/ROELL Z050 FOR BIAXIAL COMPRESSION CREEP EXPERIMENTS

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1. Introduction

The cruciform testing machine Zwick/Roell Z050 (Fig. 1) is designed for uniaxial or biaxial experiments on sheet metals, elastomers, plastics, etc. Four electromechanical testing actuators provide maximum forces up to 50 kN. They are installed in a vertically oriented support frame. Two actuators are positioned vertically, the other two horizontally.

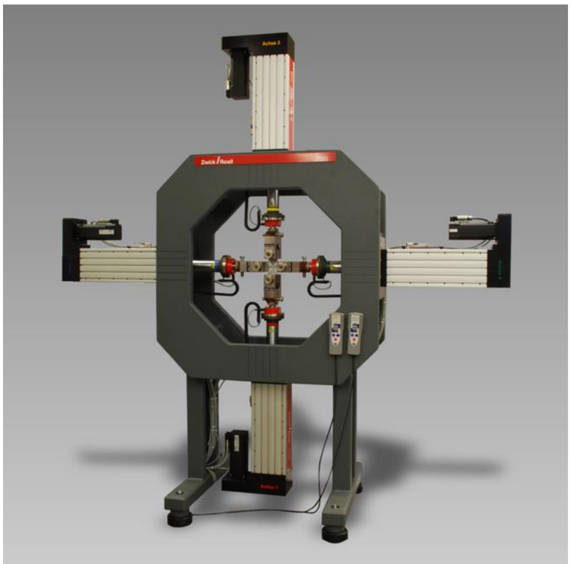

Fig. 1. Cruciform testing machine Zwick/Roell Z050 [1]

2. Adaptation for biaxial creep testing in compression

The test machine shown in Fig. 1 shall be used for biaxial creep tests of building materials in compression. Thus, the target is to achieve spatially *uniform* stress and strain states inside the test specimens. This is a challenging task, because it requires highest precision standards regarding the test samples, the load application system, and the measurement equipment used to quantify the deformation of the specimens.

2.1 *Test samples*

The test samples are rectangular platy prisms (Fig. 2). It is of great importance that opposite faces of the specimens are coplanar and that the differently oriented faces are mutually orthogonal. This represents a challenge for the manufacturing of the specimens.

2.2 *Load application system*

The application of the loading shall be uniform. In order to avoid significant in-plane bending of the specimens, it is important that the load platens are coplanar to the loaded faces of the specimens. This calls for a very accurate positioning of the specimens relative to the load platens.

Friction in the interfaces between the load platens and the loaded faces of the specimens must be reduced to the possible minimum. The principle of Saint Venant [2] implies that the self-equilibrated shear stresses decrease with increasing distance from the interfaces between the load platens and the specimen. They reach insignificant magnitudes in a distance amounting to one-times the side-length of the specimens. This implies that the *entire* volume of the specimen is affected from the influence of undesired friction-induced shear stresses activated at the surface of the specimen. In this context, brush platens enjoy great popularity (Fig. 2). Their design will be explained in more detail in the poster.

In order to avoid significant out-of-plane bending of the specimens, the out-of-plane motion of the actuators, the brush platens, and the specimen must be reduced to the possible minimum. To this end, it is important to support all four of the brush platens such that they are initially positioned inside *one* plane, and that they stay inside this plane also during testing. In this context, it must be accounted for that the actuators (and, hence, also the brush platens) will move during testing in their axial direction. The out-of-plane support must allow this axial motion and, at the same time, it must not introduce significant axial forces into the actuators, because this would render the measurement of the forces based on the in-built load cells inaccurate. The proposed solution to this problem is a support system based on columns hinged at both ends. One end is supporting the brush platens, the other is fixed to a stiff frame construction (Fig. 2). The design of this add-on equipment will be explained in more detail in the poster.

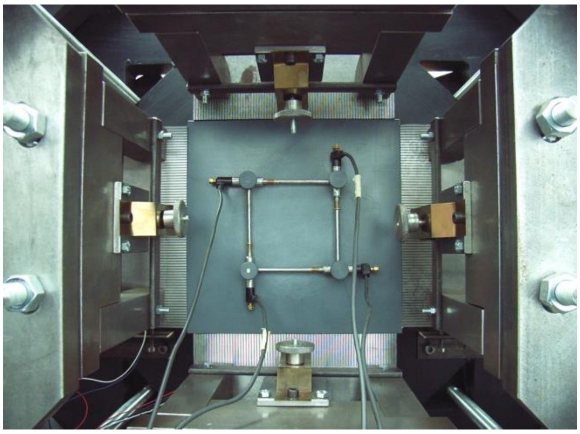

Fig. 2. Test setup showing the specimen, four Linear Variable Displacement Transducers, four brush platens, and eight columns hinged at both ends; the latter prevent out-of-plane motions of the test setup.

2.3 *Measurement equipment*

The testing machine provides averaged signals of the forces of two opposite actuators. In this context, it must be taken into account that undesired friction forces could be activated in the interfaces between the brush platens and the specimens. Provided that this happens, the forces of two opposite actuators could be different. This would remain unnoticed, because the testing machine does not provide the force readings of each actuator separately. This issue calls, once more, for a very careful positioning of the specimen inside the testing machine. A more detailed discussion will be provided in the poster.

A Linear Variable Displacement Transducer (LVDT) is used in order to monitor the out-of-plane motion of the center of the specimen (not shown in Fig. 2). This is part of the implemented quality management approach. The corresponding readings allow for a quantitative assessment of the functionality of the out-of-plane supports described above.

Eight LVDTs are used to measure the deformations of the test specimens. They are directly attached to the surface of the specimens. Four at the front-side (Fig. 2) and the other four at the backside of the specimen. Two out of the four LVTDs, which are positioned on the same side of the specimen, are aligned with the vertical loading axis, the remaining two with the horizontal loading axis. The chosen setup allows, again in the sense of a quality management approach, for quantifying both in-plane bending and out-of-plane bending of the specimens. In addition, it allows for compensating of the bending, as long as it appears to be acceptably small.

2.4 *Reference samples*

In order to be able to perform highest-quality experiments, standard test with a reference sample will be carried out always before and after actual testing. Given the interest in carrying out biaxial creep tests in compression, the reference sample shall also be creep active when subjected to biaxial compression. Therefore, polyvinylchloride was used as the material for the reference specimen (Fig. 2).

3. Conclusions

Biaxial creep testing is a rather challenging task, provided that highest precision standards are required. This calls for a very careful design of the test samples, the load application system, the measurement equipment, and, last but not least, for interdisciplinary cooperation with desirably strong contributions from experienced physicists, mechanical engineers, and civil engineers.

Acknowledgements

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References

[1] Specifications of the Zwick/Roell cruciform biaxial testing machine Z050. Available online at: https://www.zwickroell.com/en/biaxial-testing-machines/cruciform-testing-machine. Last access: April 15, 2019.
[2] Barré de Saint Venant. Mémoire sur la torsion des prismes, [Memory on twisting prisms], Mémoires des Savants étrangers [Memoires of foreign scholars]. Comptes rendues de l'Académie des Sciences, 14:233-560, 1855.