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TRIAXIAL CYCLIC COMPRESSION TESTS FOR PARAMETER IDENTFICATION OF ADVANCED RHEOLOGICAL MODELS TO PREDICT RUTTING POTENTIAL OF ASPHALT MIXES

Dipl. Ing. Bernhard Hofko[1] and *Univ. Prof. Dipl. Ing. Dr. techn. Ronald Blab[2]

[1] Institute for Road Construction and Road Maintenance
University of Technology Vienna
Gusshausstraße 28/233
A-1040 Wien
bhofko@istu.tuwien.ac.at
www.istu.tuwien.ac.at

[2] Institute for Road Construction and Road Maintenance
University of Technology Vienna
Gusshausstraße 28/233
A-1040 Wien
rblab@istu.tuwien.ac.at
www.istu.tuwien.ac.at

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ABSTRACT

For modelling hot mix asphalt (HMA) rutting behaviour at high temperatures several rheological material models, i.e. Huet's and Huet-Sayegh's model, are described in literature. In order to facilitate such models in finite element method (FEM)-simulation for rutting prediction, the models' parameters have to be identified from experimental data. This data are usually derived from cyclic stiffness tests at different temperatures and load frequencies. However, stiffness tests at low strain amplitudes stimulate the visco-elastic characteristics of HMAs but do not address plastic material characteristics. Therefore, FE simulation results of HMA structures using material parameter derived from stiffness tests cannot reflect field performance since the plastic parts of the material behaviour of HMA are not taken into account when deriving model parameters from stiffness tests. This paper presents a new approach how to derive reasonable parameters of advanced rheological material models from cyclic triaxial material tests, i.e. triaxial cyclic compression tests (TCCT), that also take into account plastic material characteristics at high temperatures.

Triaxial cyclic compression tests (TCCT) are used to simulate the stress & strain situation of asphalt mixes under traffic load by applying a sinusoidal compressive axial load and a constant radial pressure. A TCCT usually produces three phases of deformation as shown in Fig. 1. The first phase is characterized by a decreasing gradient of the curve. Most of plastic deformation occurs in this phase. The second part of the deformation curve shows a constant rate of deformation. After the inflexion point (4) the specimen moves on into the phase of fatigue. This third part is characterised by an increasing rate of deformation. While the strain controlled stiffness tests do not produce plastic strains, the TCCT induces plastic deformation.

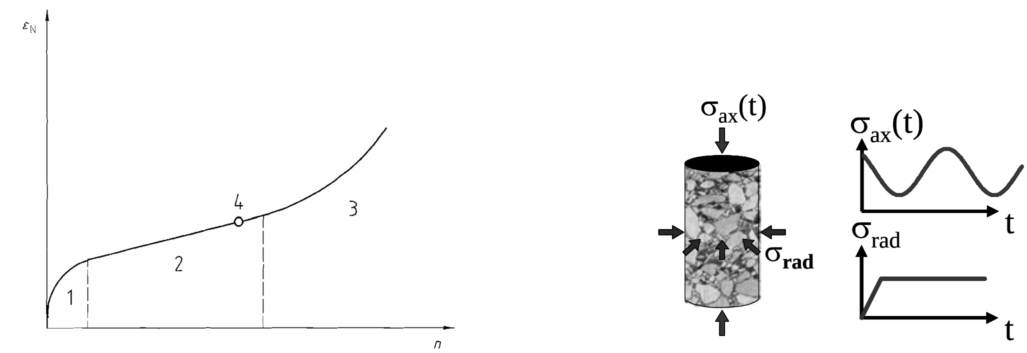

Fig. 1: Phases of deformation in a TCCT (left) and scheme of the TCCT (right)

In an ongoing research project at the Christian Doppler Laboratory of the Institute for Road Construction and Road Maintenance at the University of Technology Vienna TCCTs are carried out on representative HMAs at various temperatures and load frequencies within a comprehensive testing effort. The dynamic material characteristics, i.e. the complex modulus E^*, the complex creep compliance J^*, and the phase angle δ are derived for the different parts of the creep curve (see Fig. 1).

The actual dynamic material characteristics can be depicted in a Cole-Cole- and Black-diagram to describe the material's behaviour against load temperature and frequency. An analytical model curve for the most adequate rheological model can be fitted to the test data by systematic parameter variation. The so fitted model parameters are the input for FEM-simulation.

Fig. 2 shows the Cole-Cole- and the Black-diagram of stiffness test results at different temperatures and load frequencies for an AC 11 layer 70/100. It also contains test data derived from TCCTs for the same material in the second phase of the creep curve. It is obvious, that the material behaviour is – as expected – significantly different, if the plastic deformations have already been activated. The material shows the same values in a stiffness test at 10 °C and 2.0 Hz as in a TCCT at 2 °C and 20.0 Hz (see Cole-Cole-diagram in Fig. 2). The maximum of the viscous part of deformation shifts to lower temperatures and higher frequencies, if the material is tested in a TCCT. These first results of the research project are promising: This new approach is considered to better describe and predict the high temperature performance of HMAs on the basis of TCCT material tests.

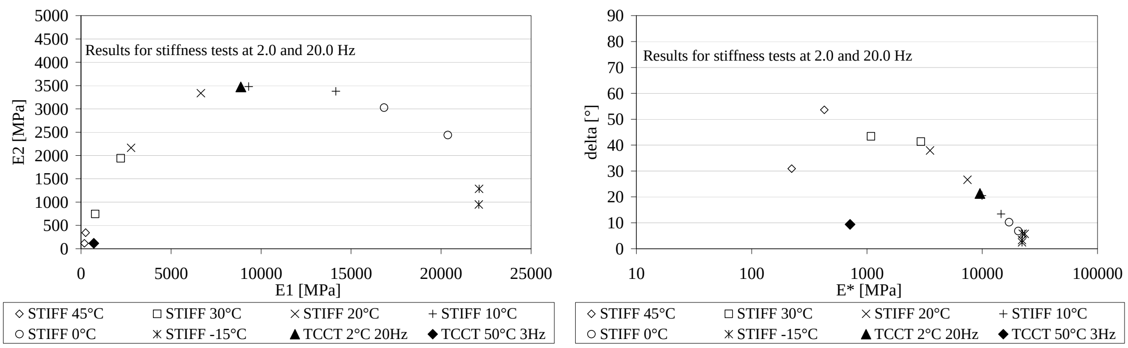

Fig. 2: Cole-Cole-Diagram (left) and Black-Diagram (right) for an AC 11 layer 70/100

The test programm will be completed within the next months. After data evaluation and parameter-fitting for Huet-Sayegh's model, FEM-simulation will be carried out to verify the thesis of the research program.

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