SHEAR MODULUS TESTING METHOD FOR ELASTOMERIC BEARINGS

Ana Skender, Domagoj Damjanović, Ph.D., Želimir Šimunić, Ph.D.

University of Zagreb, Faculty of Civil Engineering, Kačićeva 26, 10000 Zagreb, Croatia

Corresponding author: askender@grad.hr

1. Introduction

Shear modulus represents the main material property related to the load bearing capacity of elastomeric bearings. Laminated elastomeric bearings have low shear stiffness but are very stiff under compression due to steel reinforcing plates (Fig. 1). Current method of determining the apparent shear modulus of elastomeric bearings is provided by EN 1337-3:2005.

Fig. 1: Cross section of a laminated elastomeric bearing 200x300x41 mm

2. Testing procedure and equipment

Shear modulus testing consists of two identical elastomeric bearings sandwiched between three press platens and subjected to a combination of compressive and shear loading. First, the compressive force F_z is applied (mean compressive stress of 6 MPa) in order to prevent the slippage of the bearings and then the corresponding deflection v_x (Fig. 2). The maximum test deflection v_{xm} depends on the total thickness of the elastomeric material T_q ($0{,}7T_q \le v_{xm} \le 0{,}9T_q$).

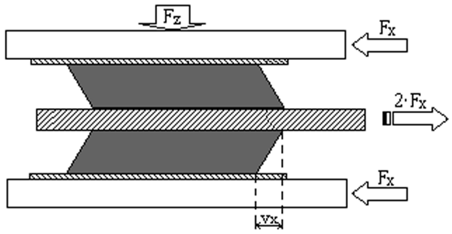

Fig. 2: Schematic diagram of shear modulus testing equipment

Shear loading is applied during three cycles in both directions at a constant loading speed of 100 mm/min. Shear modulus is determined as a secant modulus from the loading part of the second cycle according to the following equation

$$G = \frac{\tau_{s2} - \tau_{s1}}{\varepsilon_{qx2} - \varepsilon_{qx1}}, \qquad (1)$$

with the values of shear stresses (τ_{s1}, τ_{s2}) and shear strains (ε_{qx1}, ε_{qx2}) corresponding to deflections $v_{x1} = 0{,}27T_q$ and $v_{x2} = 0{,}58T_q$, respectively. Elastomeric materials are almost incompressible, viscoelastic materials that demonstrate hysteretic behaviour as well as material degradation (Mullins effect) under cyclic loading.

Testing equipment is shown in Fig. 3. It is adapted to the static testing machine in the laboratory.

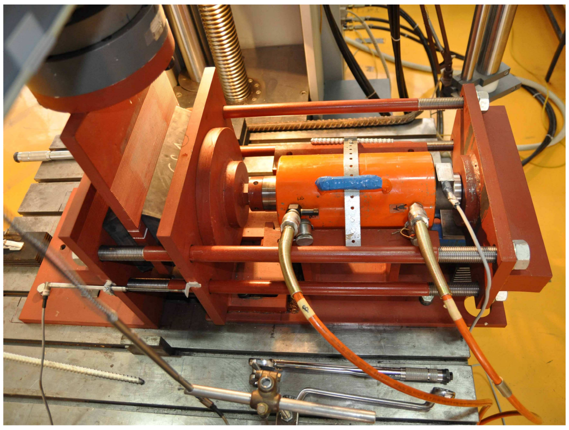

Fig. 3: Testing equipment

Compressive force is applied in the horizontal direction with a hydraulic cylinder (±600 kN), while the shear loading is applied in the vertical direction with a static testing machine (±600 kN). Bedding under the testing equipment has to be coated with a lubricant in order to enable movements of the whole system. Press platens holding the bearings have to be serrated in order to prevent the slippage of the bearings. Bearings have to be centred on both loading directions. Before applying the horizontal force it is necessary to completely separate the testing equipment from the static testing machine by releasing all the screws.

Following the compression loading phase, the whole system is transferred to the required position and fixed to the static machine. Finally, the vertical cyclic load is applied. Displacement measurements were performed using inductive displacement transducers, two in horizontal (LVDT HBM WA50) and one in vertical direction (LVDT HBM WA300).

3. Experimental Results

During the selection of adequate test pieces for the described testing method, design rules provided by the current standard are used. Basic design criteria are the total nominal design strain due to different load effects ($\varepsilon_{td} < 7$) and buckling stability. Furthermore, it is necessary to consider limited bearing capacity and dimensions of the testing equipment and machine, especially the static testing machine.

Three pairs of rectangular laminated elastomeric bearings shown in Fig. 1 were tested under the testing conditions in Table 1.

a (mm)	b (mm)	T_b (mm)	T_q (mm)	F_z (kN)	v_{xm} (mm)
200	300	41	29	360	±26,1

Tab. 1: Size and testing conditions of test pieces

Compressive force-deflection-time curve for one pair of bearings is shown in Fig 4.

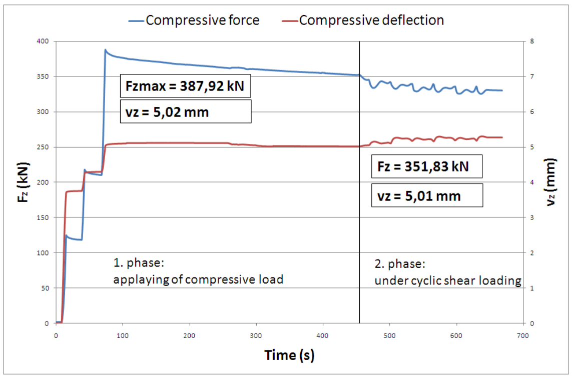

Fig. 4: Compressive force-deflection-time curve (3d-II-L)

Shear force-deflection curve with the shear modulus value is shown in Fig. 5.

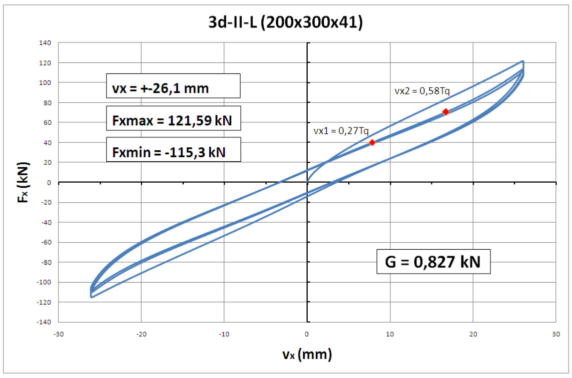

Fig. 5 Shear force-deflection curve (3d-II-L)

Values of shear modulus for all three pairs as well as values of compression force at the beginning of the cycling loading phase are given in Table 2. Shear modulus values comply with the tolerance for the concerning rubber hardness 60±5 IRHD ⟶ G_g = 0,9 ± 0,15 MPa.

<table>
<tr><th>Sample</th><th>F_z (kN)</th><th>u</th><th>G (MPa)</th><th>u</th></tr>
<tr><td>3d-I-L</td><td>349,34</td><td rowspan="3">347,17±6,04</td><td>0,808</td><td rowspan="3">0,816±0,0098</td></tr>
<tr><td>3d-II-L</td><td>351,83</td><td>0,827</td></tr>
<tr><td>3d-III-L</td><td>340,34</td><td>0,813</td></tr>
</table>

Tab. 2: Testing results

4. Conclusion

Testing equipment used for the shear modulus testing method for elastomeric bearings is very complex. It is necessary to consider many different parameters. Even though the compressive force has a significant influence on the testing system design it has a minor influence on the resulting value of the shear modulus.

5. References

[1] EN 1337-3:2005, Structural Bearings - Part 3: Elastomeric Bearings, CEN, (2005).

[2] Šimunić Ž., Dolanjski A., Elastomeric Bearings, Faculty of Civil Engineering, University of Zagreb, (2007).