The resistance of an aluminium self-tapping screw groove connection

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In this paper a special jointing system for an extruded aluminium profile is considered, namely a self-tapping screw groove connection, Figure 1.

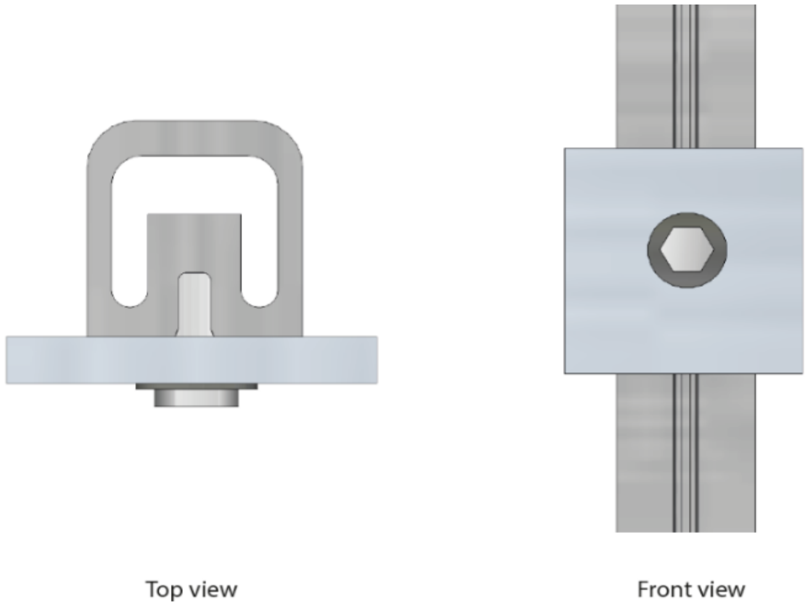

Figure 1. Aluminium screw groove connection.

The connection consists of an extruded aluminium profile with a groove in which a screw can be secured, that connects the profile to an aluminium plate (Macillo, 2013). The screw is driven into the groove and can be placed anywhere along the length of the groove. Additionally, a plate with threaded holes can be introduced to define the screw positioning.

Figure 2 displays three ways in which the connection can be loaded. However, only research into the pull-out strength and shear perpendicular to the groove have been investigated to date. Design equations for the resistance of these loading types are included in prEN 1999-1-1.

This leads to the following research question:
What is the parallel shear resistance of the connection consisting of an aluminium extruded profile of type EN AW 6082 T6 and a self-tapping screw in its groove?

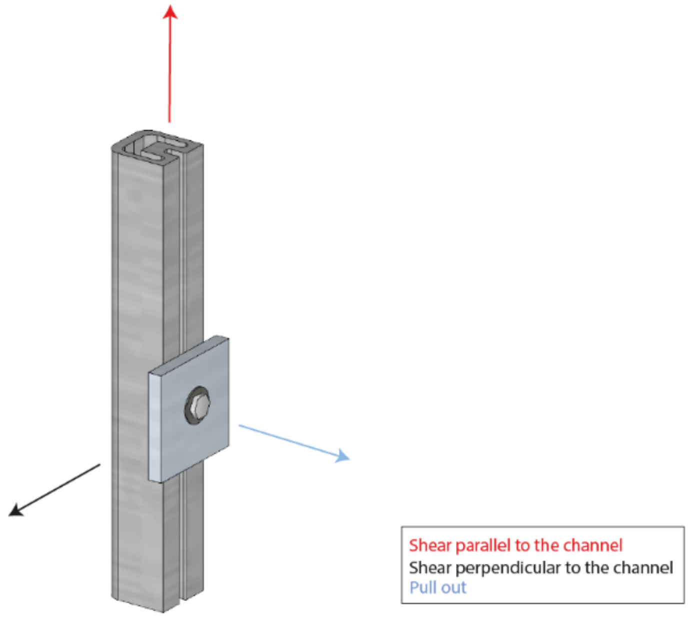

Figure 2. Three types of loading.

Test set-ups

Three different tests have been executed to gain insight in the shear parallel to the channel behaviour of the connection in different loading states. In this research the extruded profile, EN AW 6082 T6, is investigated for shear parallel to the groove.

The first test set-up was used to investigate pure shear resistance parallel to the groove. However, this situation of applying loading in this direction to the connection screw is hard to achieve in practice, as the groove is often small. To investigate the effect of an eccentric load on the connection, two additional test set-ups have been designed.

The second test set-up tested for shear resistance in combination with a small bending moment.

The third tested the effect of shear resistance in combination with a large bending moment.

All tests have been executed with similar test set-up (Figure 3). However by using different load appliers (Figure 4 till 6), the difference in testing was achieved.

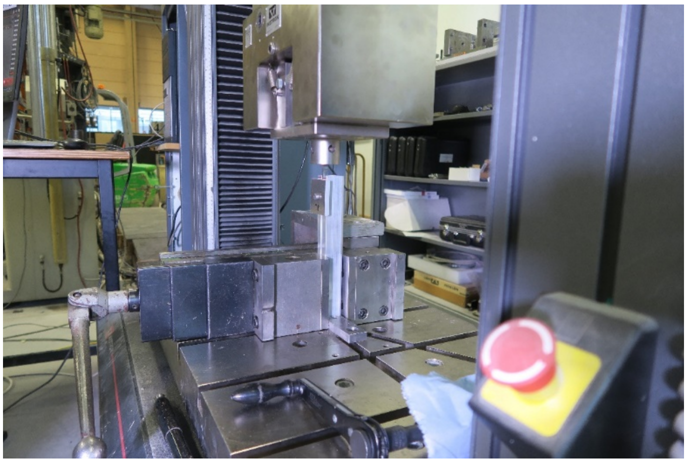

Figure 3. Standard test set-up.

Figure 4. Loaded on screw thread.

Figure 5. Loaded on plate.

Figure 6. Loaded on screw head.

Results

The results of the three standard tests are shown and explained.

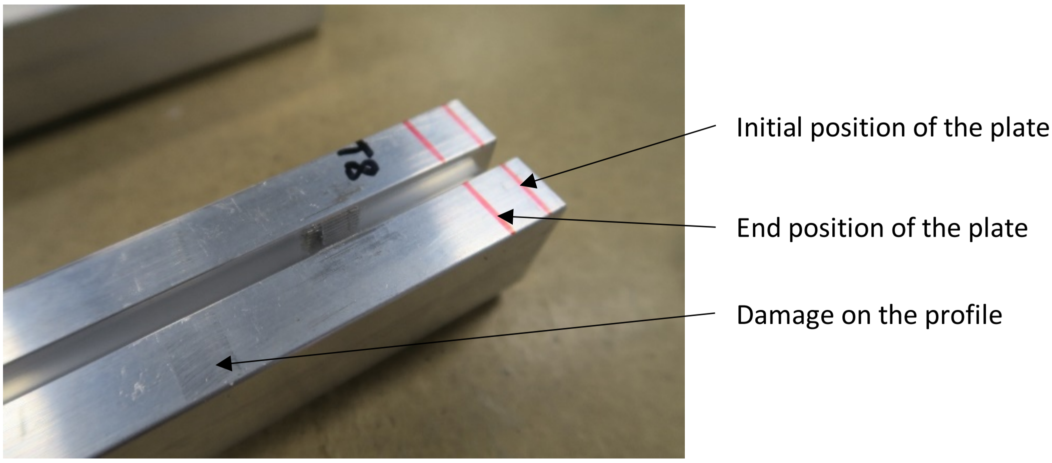

Figure 7. Test 1.1 Loaded on the screw thread (standard case).

Figure 7 shows that the failure mode is cutting of the screw through the profile. In addition to the cuts caused by the screw thread, damage at the front face of the profile can be seen.

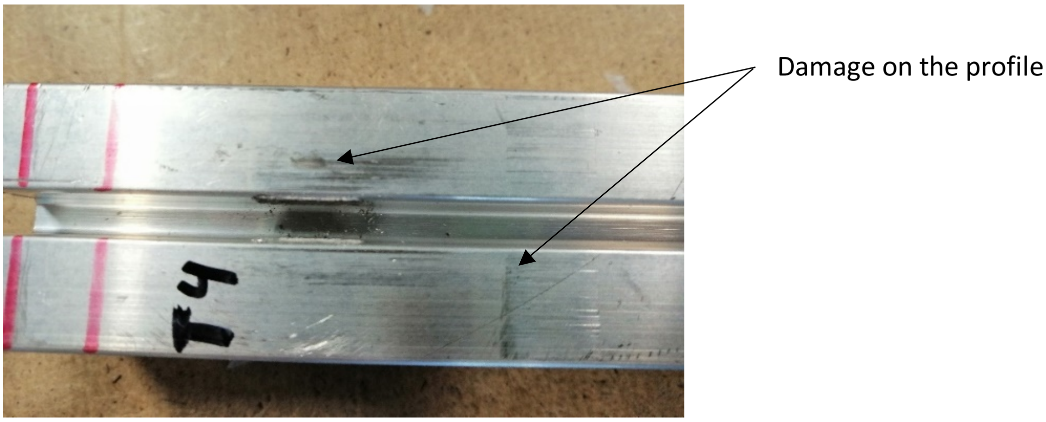

Figure 8. Test 2.1 Loaded on the plate (standard case).

Damage on the profile is in this case more than in Test 1.1. This may be caused by the loading of the plate whereby a small moment is applied.

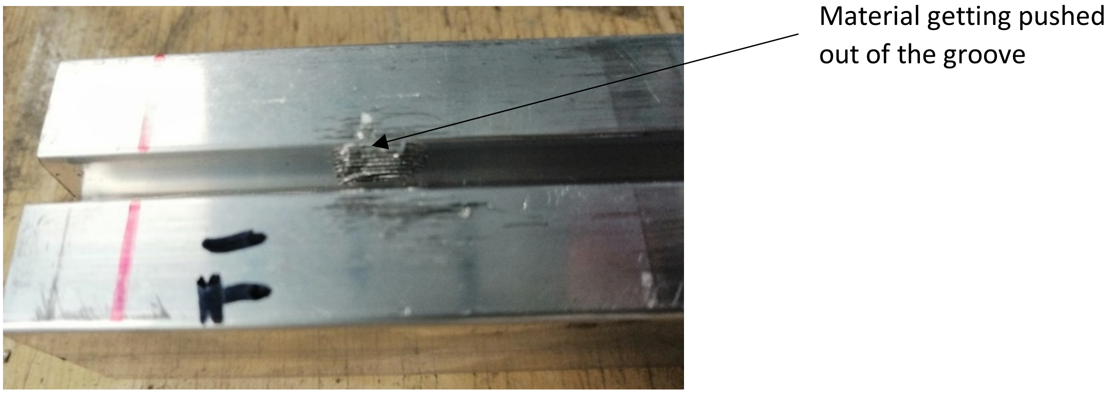

Figure 9. Test 3.1 Loaded on the screw head (standard case).

The failure mode of test 3.1 is cutting of the screw through the profile. Additionally, the screw slightly rotates in the plate and the profile.

For all tests that were executed, force-displacement graphs were drafted. These are shown in Figure 10.

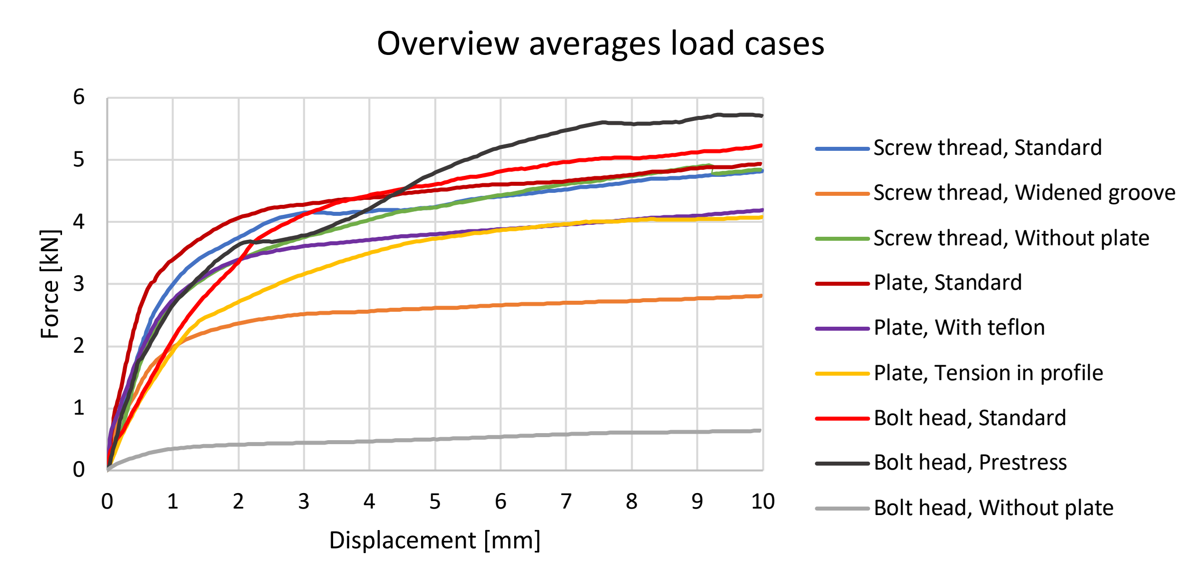

Figure 10. Overview average test results.

Looking at the curves, a parabolical shape can be seen. This implies that the transition of elastic to plastic deformation is not clearly distinguishable. In addition the graph indicates that the material is exhibiting work strain hardening, since the strength keeps increasing at increasing deformation.

Translating the results to the practical application, it can be stated that the case of 'Plate, standard' is most common.

For the determination of the resistance, a linear function of the average slope until 3 kN is determined. With this linear function an arbitrary selected offset of $0{,}5\ mm$ is taken into account to allow the first development of plasticity within the design load to occur. The resistance is at the intersection of the force-displacement curve with the linear function. Figure 11 shows that this resistance is at $3{,}6\ kN$.

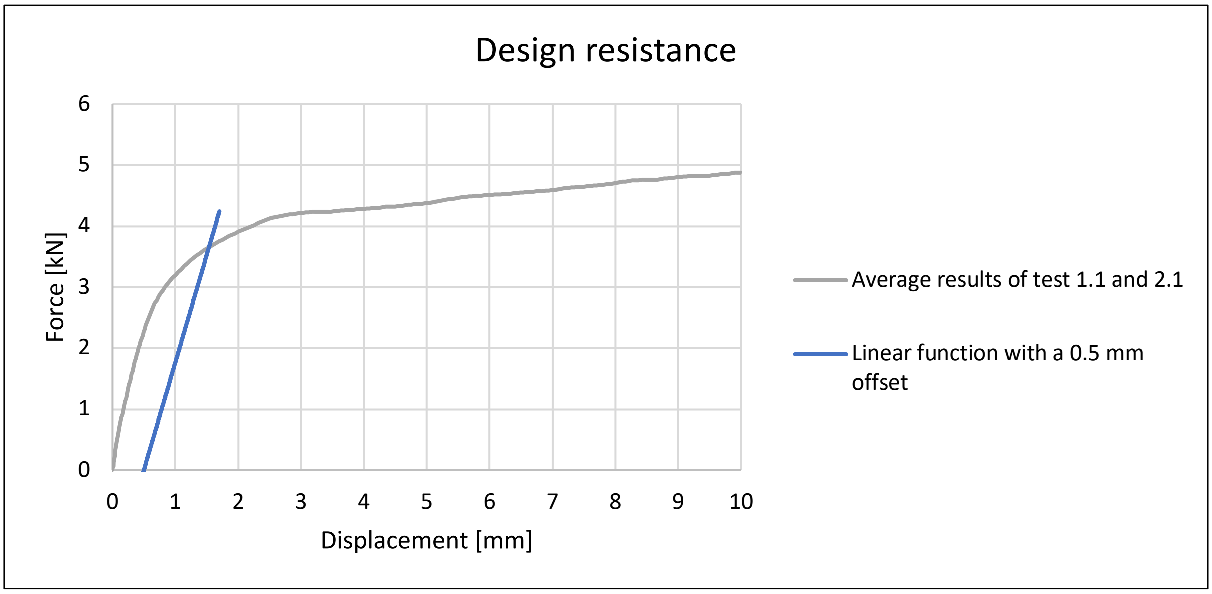

Figure 11. Determined design resistance.

The influences of the investigated parameters can be seen in Figure 12.

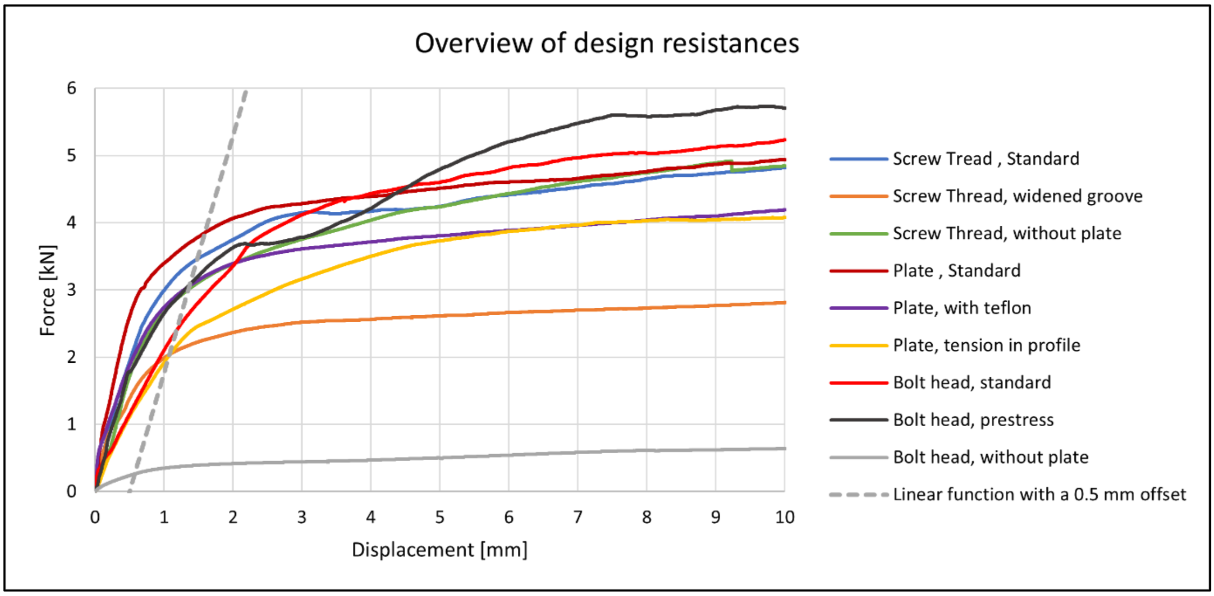

Figure 12. Overview of all determined design resistances.

Conclusion

After conducting all tests on different test set-ups, varying results of the parallel shear resistance of the self-tapping screw in a groove can be found. This is due to the many parameters that influence this strength. The parameters that were tested in this research are:

- Groove width
- Friction between the elements
- Prestress of the screw

Especially the parameter “groove width” and the area of friction, show a large influence on the shear resistance of this connection. This contrary to the prestressing of the screw, which showed no significant influence in the test that were conducted.

As this is the first experimental research on this topic further research needs to be conducted to validate results.