Zukunft Bau

BRIEF REPORT

Title: OptiHaP

Implementation of an optimised test for adhesive shear strength in masonry construction based on the hitherto European test procedure as per DIN EN 1052-3

File no.: SWD-10.08.18.7-16.43

Occasion / Starting point

The transition to the European test standard necessitates the testing of adhesive shear strength in accordance with DIN EN 1052-3. The resulting values are about half as low as the former German test procedure as per DIN 18555-5. It has so far been impossible to establish the causes for this. The research project has the remit to test and further optimise a suitable test set-up based on the European test procedure.

Objective of the research project

Research started with a comprehensive analysis of the new European test procedure as per DIN EN 1052-3 and a comparison with the former German procedure as per DIN 18555-5. These analyses established that a considerable bending moment occurs in the test set-up that falsifies the results. No purely shear-based loading occurred. The test specimen cracks where the bending tensions occur, which is why the test surface reduces in the joint and thus also reduces the test results of the adhesive shear strength.
Making minor load initiation alterations to the test set-up which was proposed at the beginning of the project failed to remedy the problem. The bending moment could not be eliminated by these means alone and it was also established that a kinematic chain occurred during the test procedure without side loading. A harness around the test specimen intended to counteract one of these two phenomena managed to prevent the stones from rolling apart at the breaking stage, but was insufficiently stiff to be capable of achieving a statically undetermined offsetting of the influence of the bending moment in the harness.
In the procedure with side load it was established that, as a rule, the lower side load stages were too low to override the bending moment. Only at complete override can the adhesive shear strength be extrapolated via a regression line.

The comprehensive FEM analyses established that the type of mounting and the initiation of the side loads exerted a considerable influence on the test results.

After mechanical and experimental theoretical considerations, it was decided that

- procedure A as per DIN EN 1052-3 with side loads from the override of the bending stresses and
- procedure B with steel plates bonded on both sides was to be mechanically as well as experimentally pursued.

The required side loads for procedure A with side loads from the override of the bending stresses were calculated both manually and by FEM. However, the problem was revealed to be somewhat vague because it is assumed that the joint can actually transfer stresses to a limited degree. However, the adhesive shear stresses are also not tested in the experimental investigations.
The disadvantage of procedure A is that high adhesive shear strengths call for high side loads that might be incapable of being borne by the stone anymore. In the phase between transition of non-override to override, test results can display a considerable spread, something that is micromechanically founded.

Procedure B with the steel plates attached laterally was verified by manual calculations and a FEM calculation. A choice of a suitable adhesive was made which excludes breaking between bonded surfaces and stone before the failure of the mortar joint.

Both modified procedures were tested experimentally on selected stone/mortar combinations. The resulting recorded values for the adhesive shear strength were on a scale with the expected values known from the literature and based on the old German test procedure.

Test set-up B without side load is extremely prone as regards the installation of the test specimen and the execution. They deviated greatly from test series to test series and also within a series. The modified set-up with the bonded steel plates managed to reduce the differences between the test series, because the test specimens were securely mounted via the steel plates. Moreover, this also considerably reduced the test result spread.

The tests showed that execution was practicable. Procedure A merely necessitates the required side load stages to be determined on the basis of the expected value of the adhesive shear strength. It needs to be verified whether this can be borne by the intended stones. Procedure B requires the addition of stiff steel plates in the procedure set-up (12 per series). The adhesive tested was “Sikadur 30 Normal” from the company Sika Schweiz AG, Zürich. This is a 2-part epoxy, resin based adhesive. The adhesive can be easily removed from the steel plates by heating without the plates requiring any post-processing.

Conclusion

After both extensive mechanical and experimental investigations, the research project managed to explain the difference between the old test procedure as per DIN 18555-5 and the new one as per DIN EN 1052-3.

Finally, the following modifications for the procedures as per DIN EN 1052-3 were pursued:

- Test as per Procedure A with heightened side load stages to compensate for the bending stresses
- Test as per Procedure B with two steel plates bonded laterally

These were further worked and successfully tested. The adhesive shear strength values hereby experimentally attained were extremely close and within the expected envelope known from the literature.
The results were made available to the building inspection authority to initiate practical introduction.

Key data

Brief title: Optimised testing of the adhesive shear strength in masonry based on DIN EN 1052

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The project was also supported by:
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Azendorf 63, 95359 Kasendorf
Ziegelwerk Freital Eder GmbH
Wilsdruffer Straße 25, 01705 Freital

Total costs: 92,556.00 euros

Federal support: 47,700.00 euros

Project duration 09/2016 - 10/2018

PICTURES/ILLUSTRATIONS

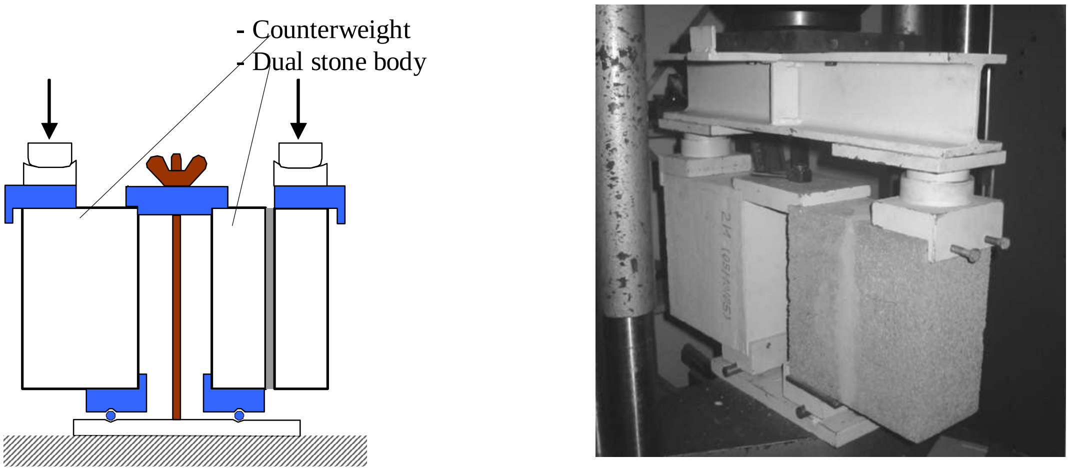

Figure 1 Test set-up for the German test procedure as per DIN 18555-5

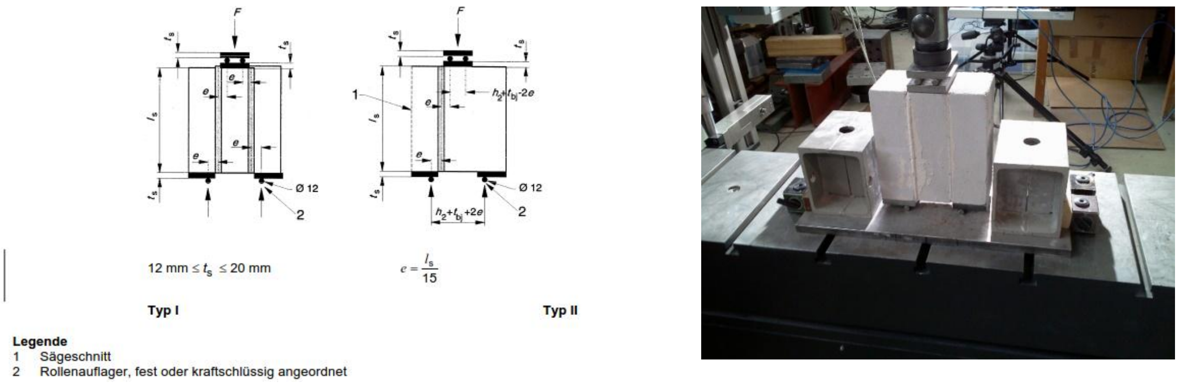

Figure 2 Test set-up – European test procedure B corresponding to DIN EN 1052-3

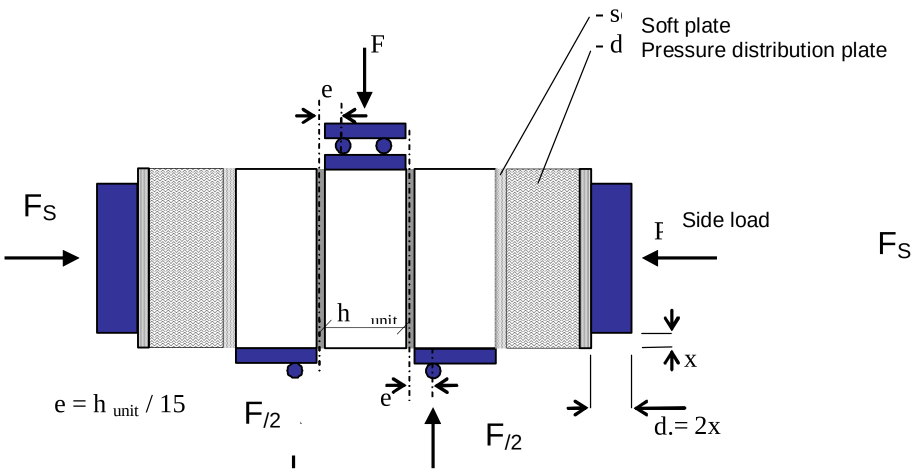

Figure 3 Test set-up – European test procedure A corresponding to DIN EN 1052-3

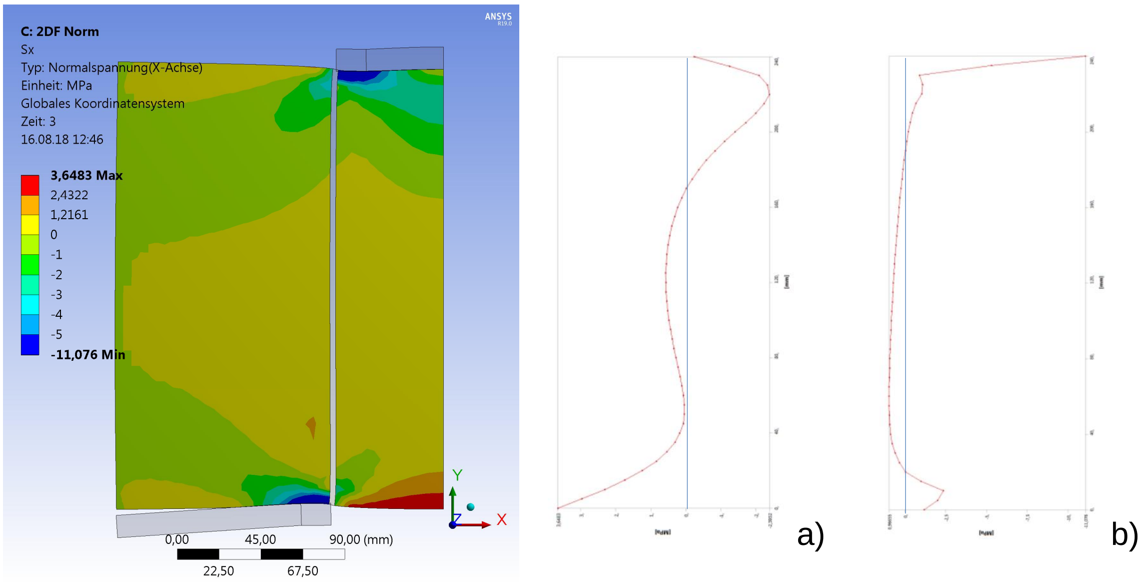

Figure 4 Results of the FE Analysis (2D) of the normal stresses $s_{x\,;}$ left FE model with stress distribution; right normal stresses s_x in the symmetrical axis ($s_{x,\,max,\,z}$ = 3,65 N/mm²) a) and on the mortar joint ($s_{x,\,max,\,z}$ = 0,97 N/mm²) b) (total load 100 kN), roller bearings

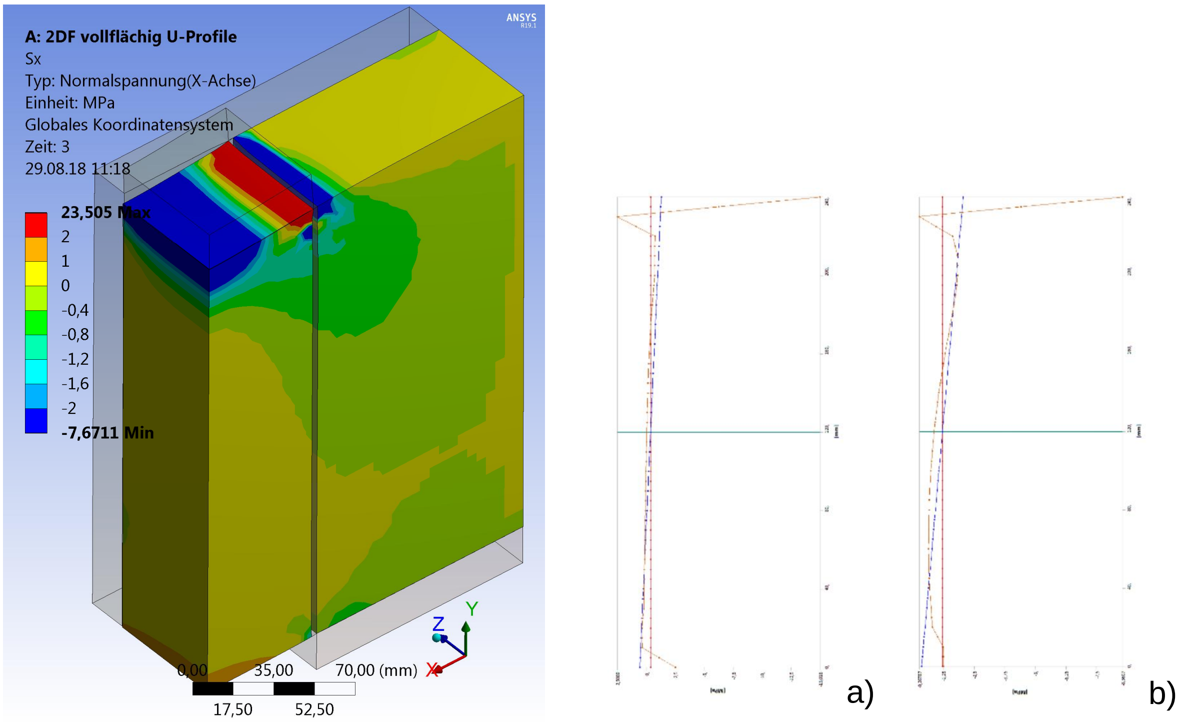

Figure 5 Results of the FE analysis (3D) of the normal stresses $s_{x\,;}$ left FE model with stress distribution; right normal stresses s_x in the symmetrical axis a) and on the mortar joint b) (total load 100 kN),surface mounting without indentation (ochre – actual course; red reference line s_m = -0.42 N/mm² or t_m = -1,24 N/mm² ; blue – linear idealisation)

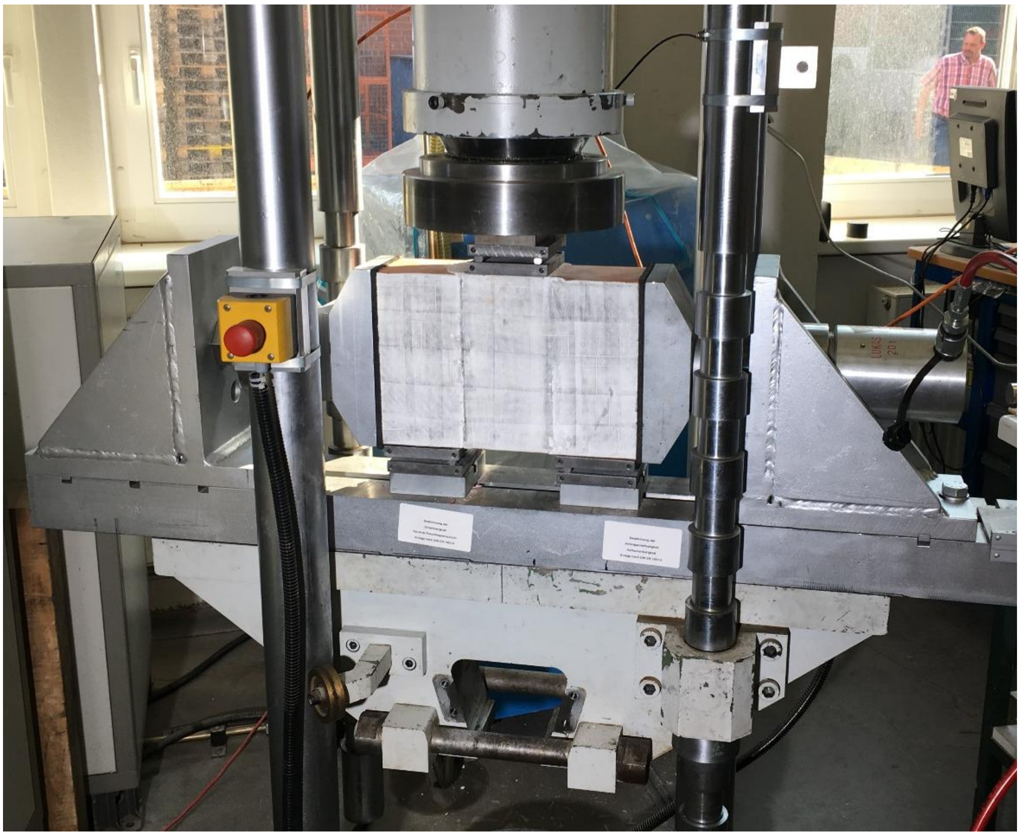

Figure 6 Three stone body 2DF with side load in the test machine (Procedure A as per DIN EN 1052-3)

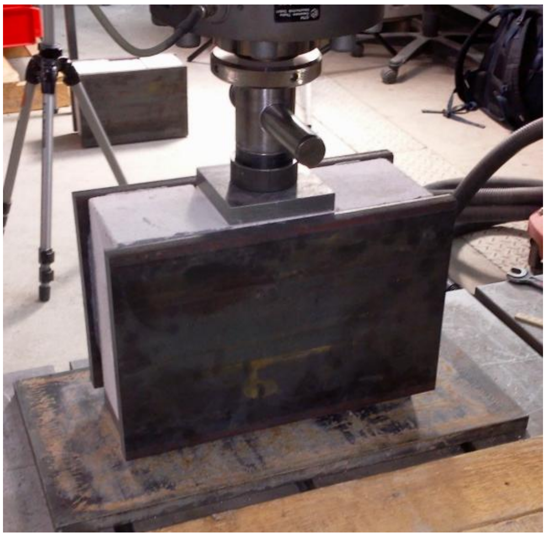

Figure 7 Modified test procedure B with bonded steel plates before load Initiation left and after failure right