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ABRIDGED REPORT

Fibre reinforced basement masonry (FBKM)

Title: **„ Textile reinforcement in the bed joint of basement masonry to increase the load capacity against earth pressure “**

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Head of project: **Prof. Dr.-Ing. Wolfram Jäger**

Processor: **Dipl.-Ing. (FH), Dipl.-Kfm. Maik Erler**

Date: **30.11.2018**

1 Title

„Textile reinforcement in the bed joint of basement masonry to increase the load capacity against earth pressure"

2 Inducement/ initial situation

The verification of basement walls under earth pressure is often difficult because of the lack of vertical loads. In such cases, the lateral loading has to be resisted in a horizontal direction. Since however the horizontal flexural strength capacity of unreinforced masonry is low, it will be possible to increase it by using a textile reinforced bed joint with longitudinal fibres of alkali-resistant glass or carbon fibre.

3 Subject of the research project

Used materials:

Carbon fibre and alkali-resistant glass fibre textiles are being investigated for this project. The masonry consists of various formats in the masonry unit types of calcium silicate, autoclaved aerated concrete and vertically cored clay masonry units. Thin bed masonry was solely examined.

As a first step the following small-scale tests were performed:

It were planned bending tests in the form of reinforced beams subject to bending. The basis for this is a representative excerpt of the masonry with a tension zone (a reinforced bed joint) and a compression zone (in each case half a masonry unit height above and below the bed joint). In order to represent this geometry, beams were prepared of half-height masonry units with a textile-reinforced bed joint between them. In order to ensure the mechanics of the masonry, the masonry units were laid with an overlap. The tests were performed as a 4-point flexural test (Fig. 1). All test samples with textile reinforcement, clearly increased uniaxial flexural strengths could be determined compared to unreinforced masonry (factor of 5 to 10, depending on the combination of materials).

Textile pull out tests were planned and performed for the determination of the characteristic bond strength based on DIN EN 846-2 (Fig. 2). Tests with and without imposed loading were planned. Good to very good bond strengths could be verified for all investigated combinations of materials.

The determination of the adhesion shear strength for masonry is regulated in DIN EN 1052-3. The procedure B without initial load was selected for the tests (Fig. 3). No separation layer effect arose. The usual value of 0.22 N/mm² for the initial shear strength of thin bed mortar was reached or exceed in all the performed tests.

After the small-scale tests the large-scale tests followed:

Large-scale tests were performed on textile-reinforced, realistic basement masonry (2.5 m x 6 m) and subjected to loading from earth pressure (Fig. 4). The tests covered different wall thickness with and without a textile insert. A biaxial load transfer revealed itself on the test walls. The load transfer was performed vertically via the arching effect, horizontally via the flexural strength of the masonry or the increased flexural strength through textile reinforced bed joints.

Due to the uncertainty by means of exposure to earth pressure, as well as the unscheduled controllability or arbitrary ability to increase the load, further experiments with mechanical load application (airbags) were performed (Fig 5 and 6). These airbag tests correspond here most closely to the application case of infill masonry subject to wind pressures. But due to the fact in the case of the earth pressure it can be assumed that the load application is evenly distributed across the height for the dimensioning, the airbag tests can also be applied to this case. The test setup is based on an enclosed air pressure system. It is thus possible to apply a precisely defined, evenly distributed surface pressure on the test walls. The acting force can basically be increased as you please here and measured very accurately. A biaxial load transfer reveals itself on the test walls. The textile reinforcement develops its full effectiveness with increasing deformation, as a result of which significantly greater forces can be absorbed. The essential load absorption takes place in the area of the fault lines, where sufficient deformation is applied to activate the bending moment resistance of the material.

Dimensioning and modelling:

Based on stress-strain relationships, a series of different design formulas and dimensioning tables have been prepared for relevant dimensioning cases, which can be made available for practical use. On the basis of the small series of tests that were carried out, it was possible to calculate calibrated flexural strengths parallel to the bed joint for different wall thicknesses.

Finally a fully discretised FE model was produced with the simulation software ANSYS (Fig. 7). The bed and head joints were simulated with the non-linear contact “friction adhered”, i.e. opening of the joints is possible. Within the bed joints, textile reinforcement is taken into account.

4 Conclusion

It has been shown that the large number of input parameters has an influence on the achievable loadbearing capacity of a masonry wall which is textile-reinforced in the bed joint. For the CS and AAC masonry bending strengths are determined in tests. The worked out approach is transferable to other combinations of materials. The calculation of the out-of-plane flexural capacity by means of bending moment coefficient tables according to DIN EN 1996-1-1 provides well-approximated values that are on the safe side and can be used for the dimensioning. The out-of-plane flexural capacity can be at least doubled in the case of low vertical loads with textile reinforcement in the bed joint.

5 Basic Informations

Short title:	FBKM
Head of project:	Prof. Dr.-Ing. Wolfram Jäger
Processor:	Dipl.-Ing. (FH), Dipl.-Kfm. Maik Erler
Cumulative cost:	257.800,48 €
Subvention BBSR:	132.905,18 €
Project duration:	36 month

6 PICTURES/ IMAGES

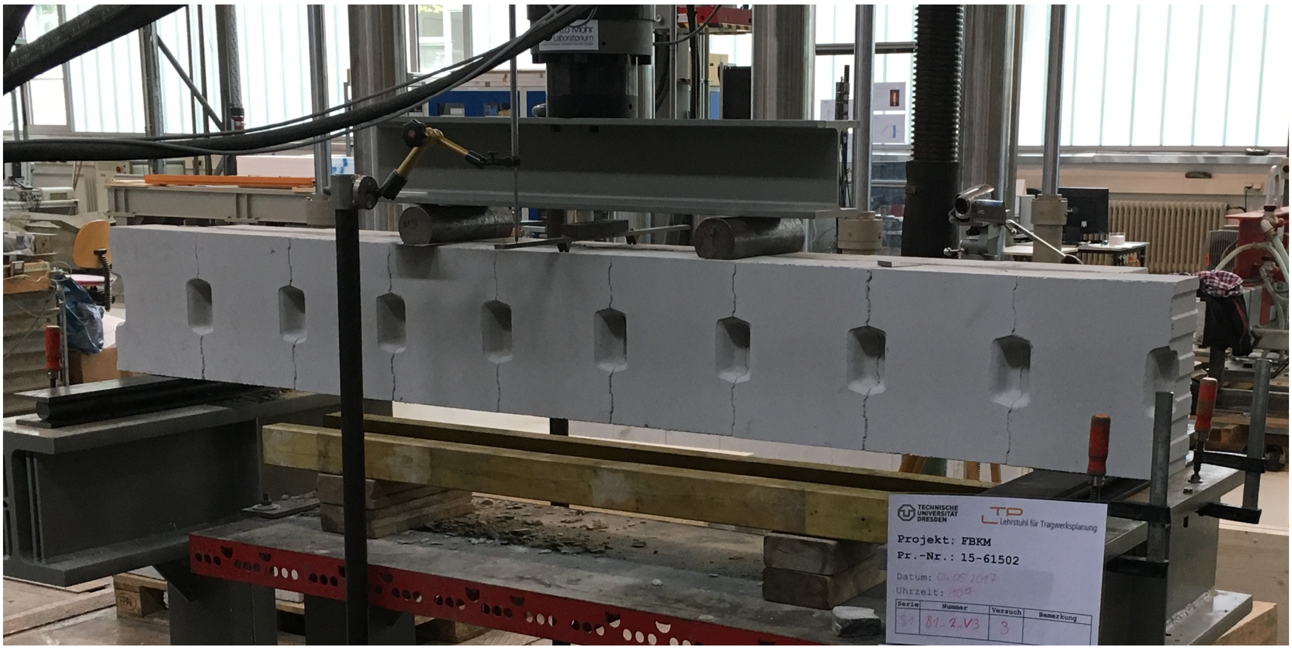

Fig. 1 CFRP textile reinforced bending beam made of calcium silicate masonry units

Figure by Maik Erler, Bild01.jpg

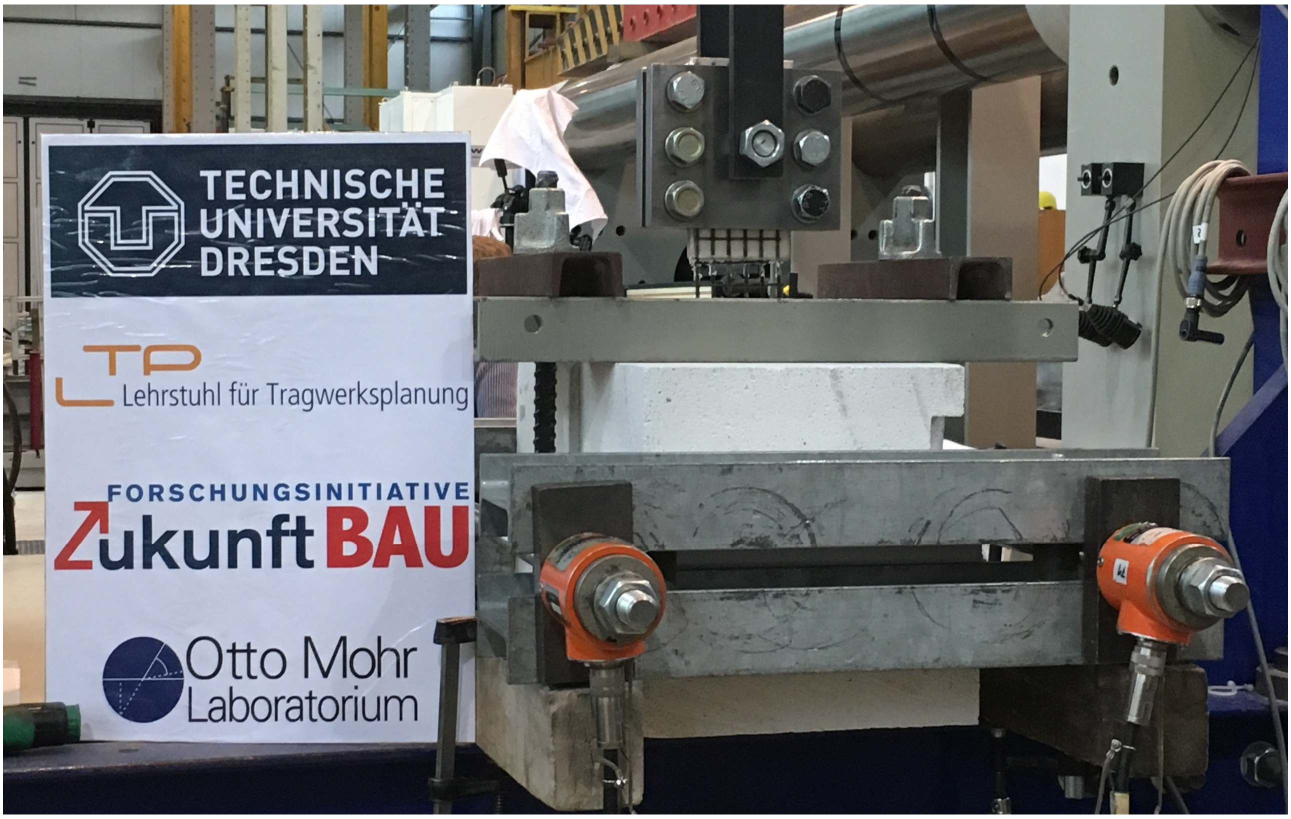

Fig. 2 Textile pull out test of CFRP textile out of autoclaved aerated concrete bed joint with imposed load

Figure by Maik Erler, Bild02.jpg

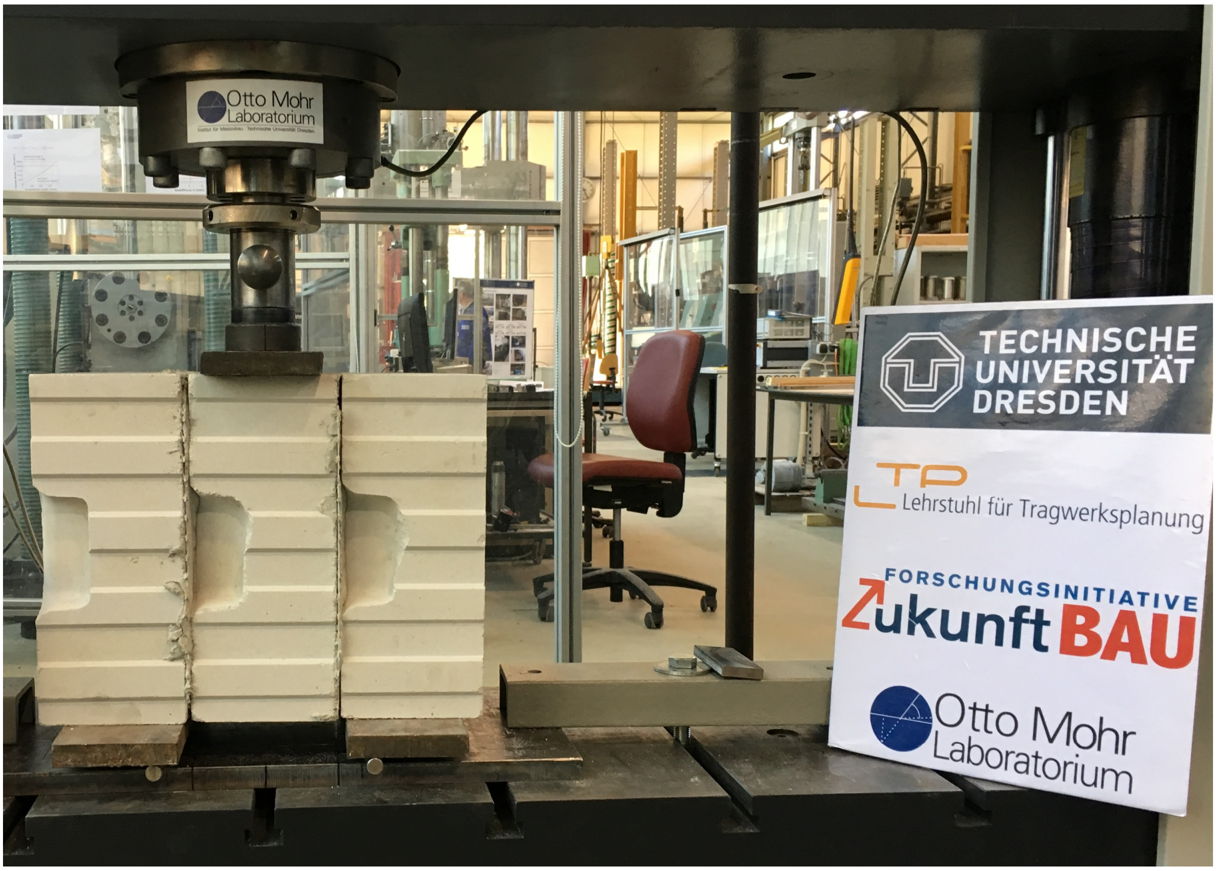

Fig. 3 Test rig for the adhesion shear strength tests with textile-reinforced bed joints

Figure by Maik Erler, Bild03.jpg

Fig. 4 Large−scale test setup of textile reinforced basement masonry under earth pressure after the performance of the test

Figure by Maik Erler, Bild04.jpg

Fig. 5 Test framework of airbag test without test wall (the airbags become completely inflated between the interspace in the installed state)

Figure by Maik Erler, Bild05.jpg

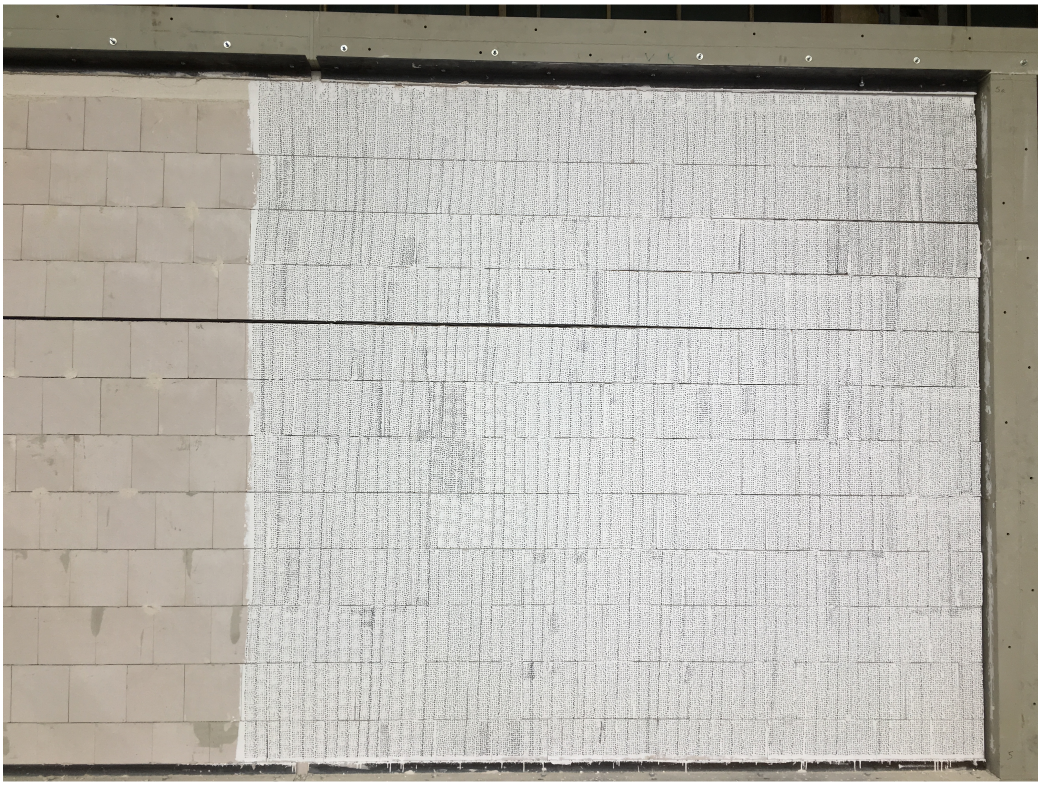

Fig. 6 Test setup of 24 cm calcium silicate masonry test wall with CFRP textile insert

Figure by Maik Erler, Bild06.jpg

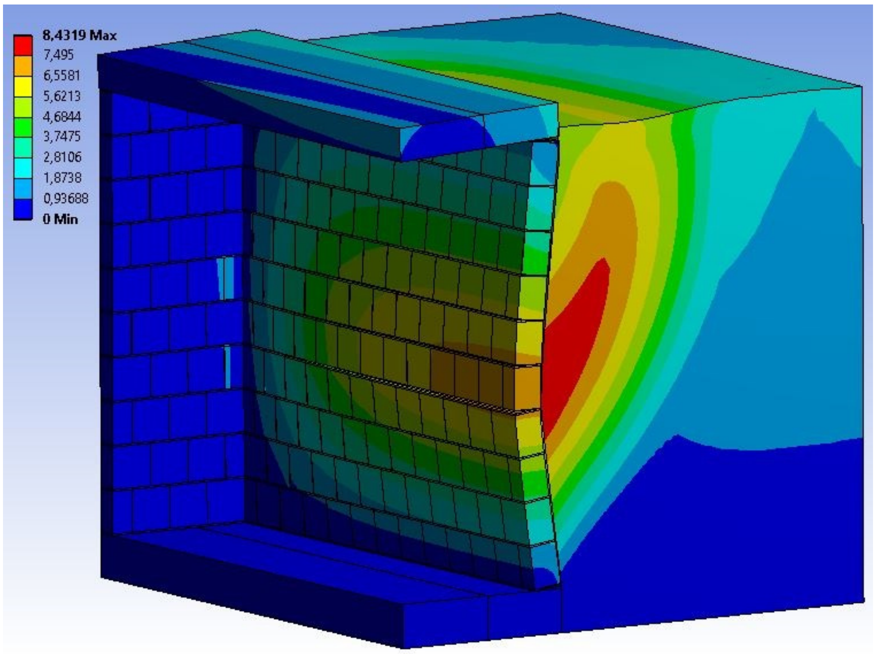

Fig. 7 Simulation of basement masonry under real earth pressure

Figure by Maik Erler, Bild07.jpg