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Sim

TEXTILE REINFORCED MASONRY

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ABSTRACT

Numerous fields of application advocate the use of textile-reinforced masonry. In comparison with unreinforced masonry, the load-bearing capacity is much higher, even in the presence of low imposed vertical loads.
The use of textile-reinforced masonry is therefore of great advantage in seismic areas where non-reinforced constructions are restricted due to missing ductility.
This opens a new market for masonry construction, that is not accessible with plane masonry. It includes the use with basement walls of prefabricated houses or massive stone houses during construction, because in those cases the eccentricity resulting from the horizontal loads cannot be centered accordingly by means of high vertical loads. Furthermore, it is possible to apply textile-reinforced masonry in cases where wind loads have strong effects upon tall walls. Masonry reinforced by steel did not prevail in many cases for the above-mentioned purposes with regard to economical reasons.
The following paper shows the capacity of textile-reinforced masonry and describes the state of development of this new composite material, which consists of components that are already applied on site.

1. INTRODUCTION

Looking back in history you will find that the use of fibres for the upgrading of otherwise brittle material is thousands of years old. For example, straw was used to reinforce bricks and horsehair supplement wall-plaster.

As far back as in the 1940's tests have been carried out to ascertain if carbon fibres could replace steel.

Glass fibres have almost linear-elastic characteristics, refer to figure 1 [5]. The brittleness of the material, however, is a disadvantage because the impending breakdown of a construction element is not been given away by noticeable deformations. Another problem is given by the alkaline cement matrix because usually glass is not resistant to alkali.

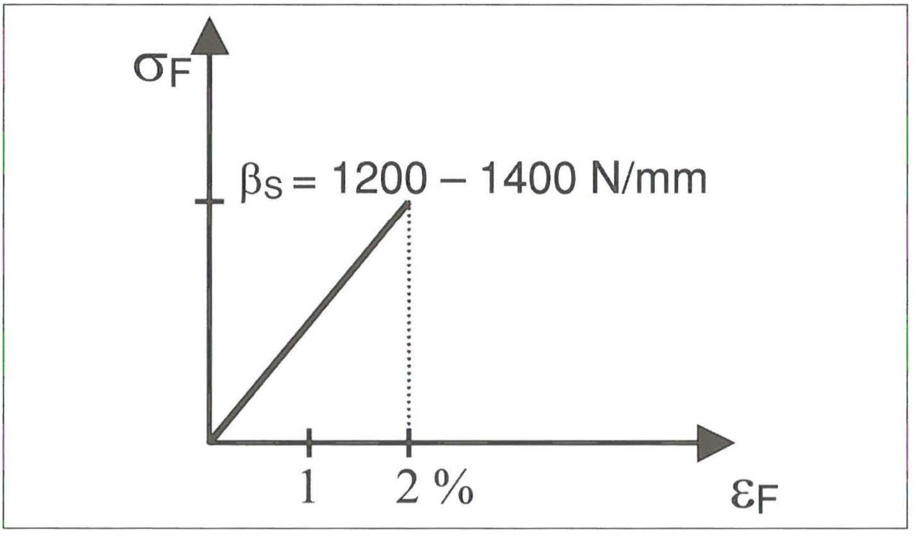
There are different options to avoid this problem:

- use of alkali resistant fibres
- coating the glass fibres with synthetics
- reducing the alkali level in cement matrix

Alkali resistant fibres were developed in 1966, named Cem-FIL glass fibre. They have now been used succesfully in construction business for many years.

The process of coating glass fibres with synthetics is still confronted with the problem of applying a uniform layer of coating onto the glass surface and maintaining a lasting durability of the diffusion quality of the synthetics.

Figure 1. Stress-strain-diagram of glass fibres.



Depending on the production process, reducing the alkaline level of the cement matrix can have an effect on the physical characteristics such as strength or stiffness.

The fabrication of textile structures with the inclusion of glass fibres is new. The combination of these structures and masonry opens up many new areas of application.

- Use of textile-reinforced masonry in seismic areas where unreinforced constructions are restricted due to missing ductility.
- The reinforcement by textile components could be taken on both sides of shear walls.
- Furthermore the use with basement walls of prefabricated houses or massive stone houses during construction, is possible.
- A major advantage of textile reinforced masonry is the post strengthening of important masonry buildings.

Masonry reinforced by steel did not prevail in many cases for the above-mentioned purposes with regard to economical reasons. Unreinforced masonry cannot be used too, because of the horizontal loads.

2. GLASS FIBRES

The traditional raw materials for glass fabrication, like quartz and limestone are also used to manufacture glass fibres. A mixture of these materials will be melt by a temperature of 1.400°C.

This liquid material is flowing through nozzles with more than 1000 drillings of a diameter from 1-2 mm, at a minimum temperature about 1.250°C

Some other processes of production are necessary to realize a diameter of the glass filaments between 9m and 24m. The unit of these stranded filaments is called tex. One tex is defined as follows:

$$1\ tex = \frac{1g}{1000\ m} \qquad (1)$$

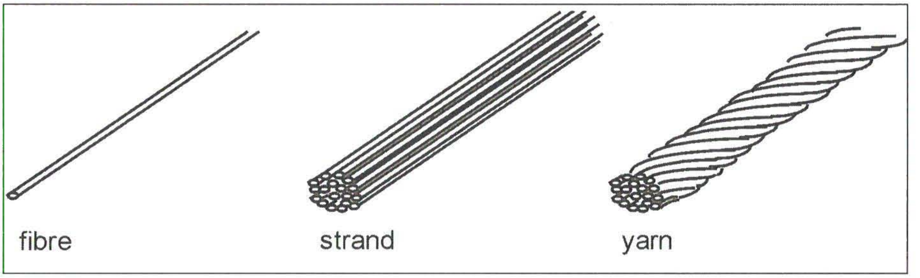
$$1\ Titer = \frac{1g}{9\ km} = 0{,}1111\ tex \qquad \text{(old unit)} \qquad (2)$$

The following fineness are common:

160 tex, 320 tex, 600 tex, 900 tex, 1200 tex, 2400 tex, 3600 tex, 4800 tex und 9600 tex.

The glass fibres are produced in different shapes. The particular fibre is named filament. Several parallel bundled up filaments are called glass strand. A glass yarn consists of 80 to 1000 fibres. If this yarn is not rotated we talk about a glass roving.

figure 2. different shapes of glass fibres.



3. TEXTILE STRUCTURES

There are four different types of textile structures.

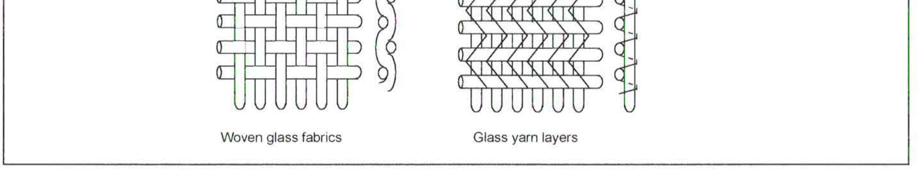
The first group is called surface mats. The strength of these products is very low, so that they cannot be applied in technical areas.

Knitted structures are combined in the second group of fibre products. The quality of these products is very high. There are lots of different technical solutions. Never the less the strength is low.

Braids are two-dimensional or three-dimensional structures with a regular set and a closed fabric appearance, the braiding threads cross at an adjustable angle. It is possible to produce three-dimensional braided fibre structures, e.g. as T-, I- and U-profiles in one single production operation.

Glass yarn layers and woven glass fabrics (see fig. 3) belong to the third main group. The fibres are placed orthogonal. Flat woven fabrics are used to reinforce plaster. Glass yarn layers are textile fabrics which are produced by laying thread systems one on the top of the other, with or without fixing the intersection points. The exploitation of the tensile strength is much better as if the fibres are weaved. It is possible to orientate the filament groups in different directions. These types could also be suitable to reinforce concrete and masonry.

figure 3. textile structures.



In comparison to reinforced concrete, textile reinforced masonry could be an alternative way of construction, because the costs of formwork become no longer necessary. In the following chapter the results of a study about the economical use of textile reinforced masonry are shown.

4. ECONOMICAL USE OF TEXTILE REINFORCED MASONRY

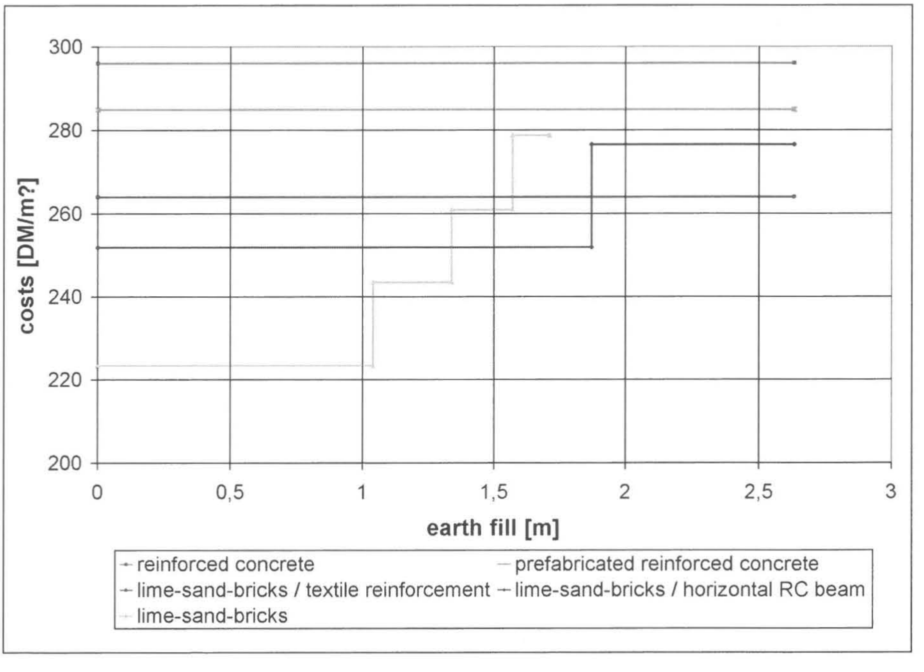
In addition to all the technical questions which have to be answered, also the questions of the economics of a new innovative construction have to be considered.

First the costs of walls below ground built of different materials and constructions, which are described in follow, are calculated:

- Reinforced concrete wall
- Prefabricated reinforced concrete wall
- Lime-sand-brick wall
- Lime-sand-brick wall with horizontal reinforced concrete beam
- Textile reinforced lime-sand-brick wall

Figure 4. shows the calculated costs of the different systems depending on the height of the wall below ground.

Figure 4. costs of different basement walls.

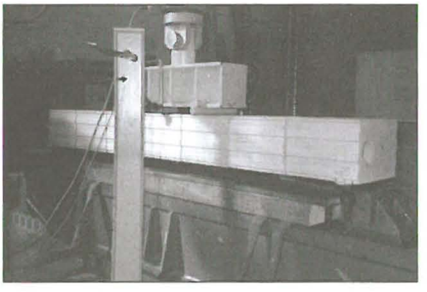


It could be seen above, that the reinforced concrete wall and the prefabricated one are the most expensive systems. If the earth fill is as high as the storey height, the textile reinforced wall is the cheapest one. If the horizontal loads caused by the earth fill are low the two unreinforced walls are cheaper than the others.

5. FIRST EXPERIMENTAL STUDIES

There are a lot of technical questions which have to be investigated. First studies were made on textile reinforced masonry beams (see figure 5) by the Institute for Concrete Structures at Darmstadt University of Technology.

Figure 5. Textile reinforced masonry beam before testing.



Totally there were tested nine reinforced beams. First results of the investigation are shown in the following diagrams (figure 6a-6c). The diagrams show the bending moment depending on the displacement of the tested beams. The horizon-

Figure 6a. bending moment – displacement – diagram.

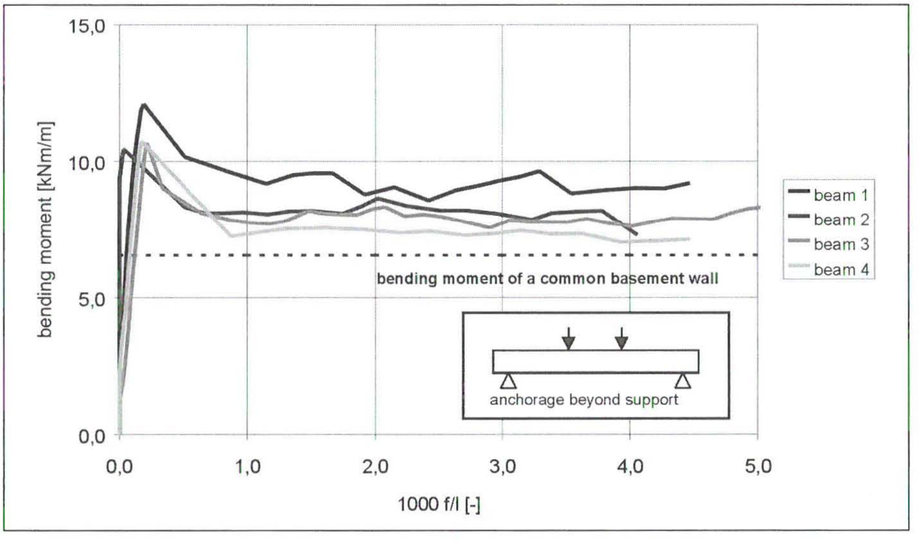


Figure 6b. bending moment – displacement – diagram.

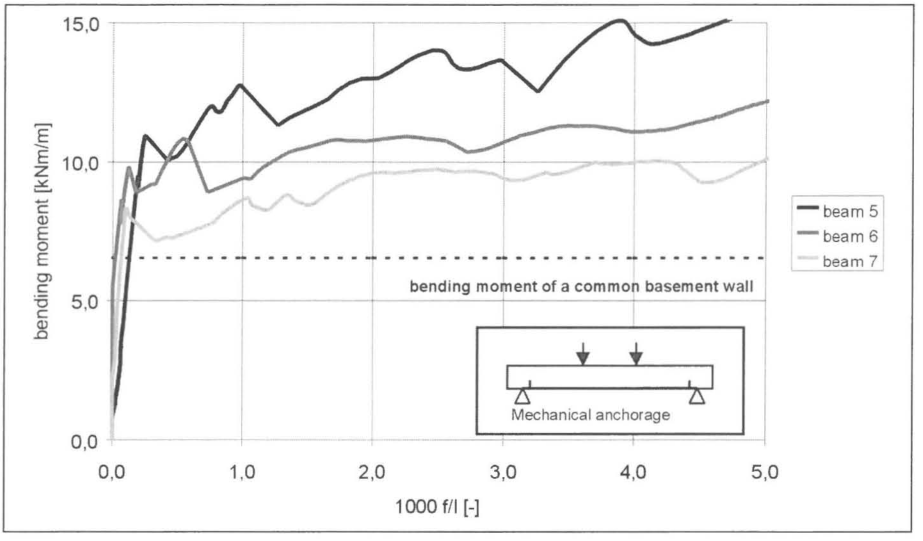
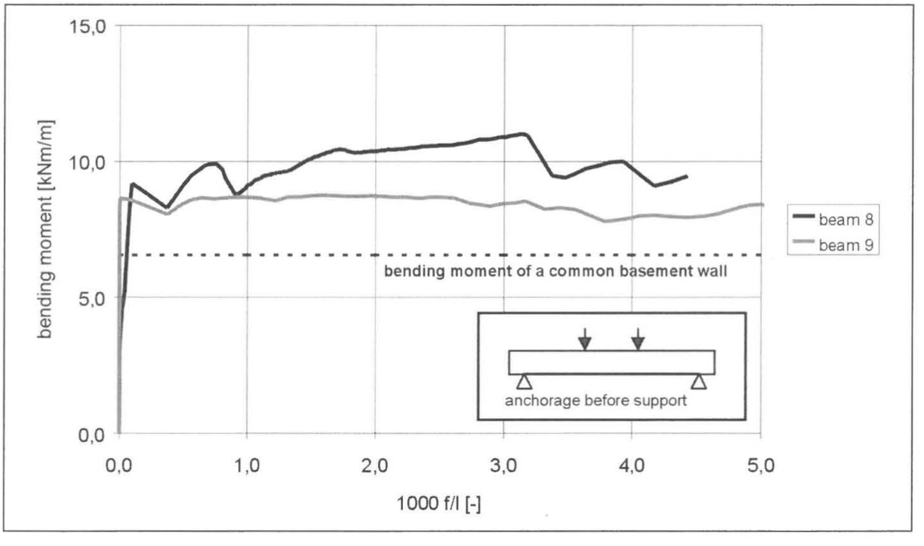


Figure 6c. bending moment – displacement – diagram.



tal line describes the bending moment of a defined wall where the earth fill is as high as the storey height. Different approaches concerning bond and anchorage between textile reinforcement and masonry surface are investigated.

Figure 6a-6c show that the ductility of textile reinforced masonry is very good. It can also be seen, that there is a difference between the tested bending moment and the bending moment which results of the horizontal loads of a common masonry wall below ground. The greatest difference is about factor 1.6, so that there is enough potential for further studies.

6. BOND TEST

The study according to chapter 5 on reinforced beams shows, that the bond between textile and mortar is of great importance. The following bond tests should help to solve these problems. Therefore, a new testing device has been built. The principle construction of the new testing device, could be seen in figure 7.

A picture which shows the real test situation, could be seen below:

Figure 7. Principle construction of the bond test.

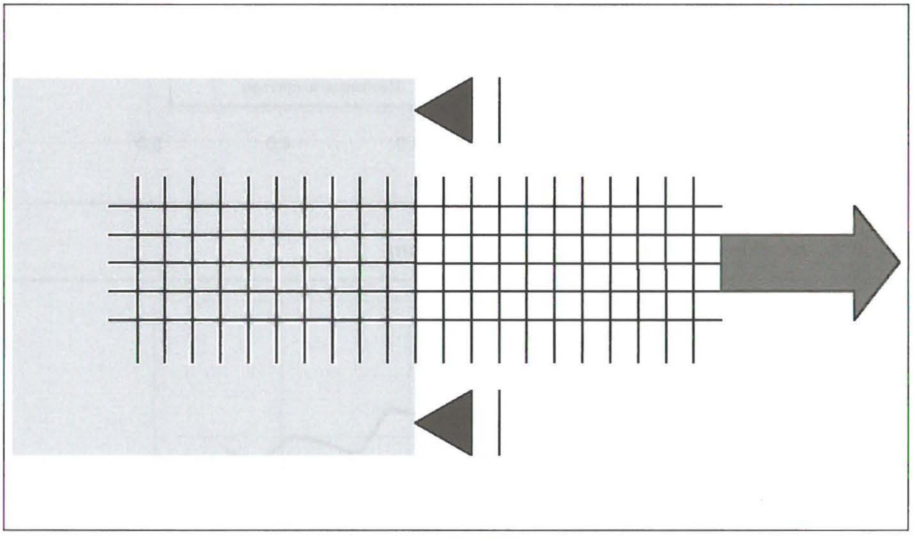


Figure 8. Shear load test.

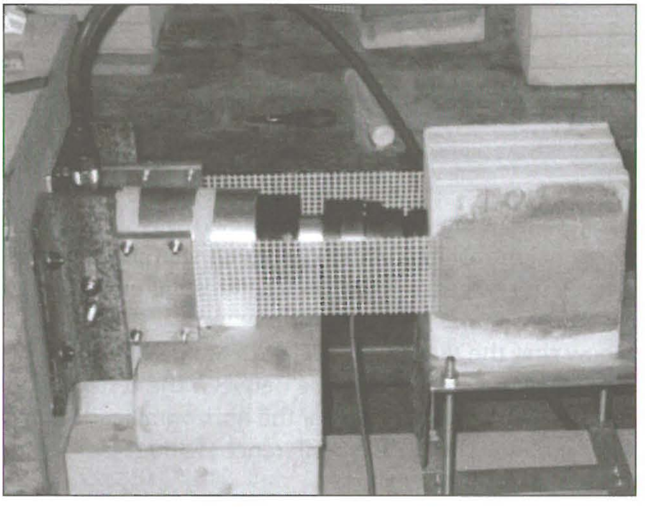
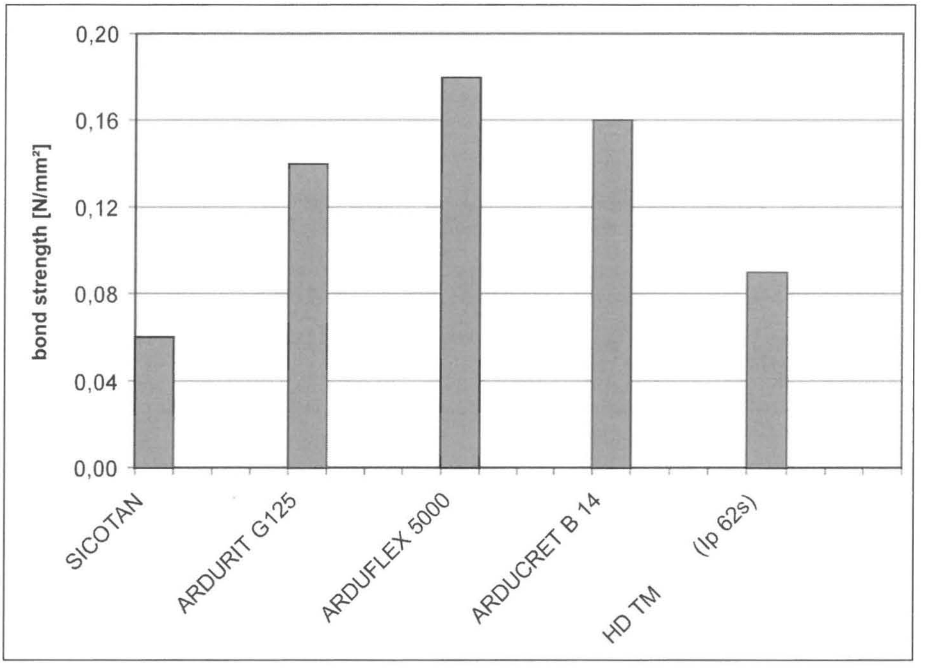


Figure 9 shows the results of the second test series.

Figure 9. bond strength.



Five different combinations of material were tested. The failure of the first and the last series was due to a lack of bond strength. The second series failed of the same reason only at a higher strength. The fibres of the third and the fourth series failed, because the bond strength of both mortars exceeds the tensile strength of the fibres. The real maximum of bond strength could not be measured.

To find out more about the bending strength a third test series is planed. The new tests are based on the results of theoretical studies and the preceding series. Now glass yarn layers are used instead of woven glass fabrics and only the mortar arducret B 14 is used because of its high bond strength.

7. CONCLUSIONS

The economical assessment shows that in many cases textile reinforced masonry could be cheaper than reinforced concrete structures.

The ductility of textile reinforced masonry allows the use for flexural members.

In future the masonry mentioned above could be able to resist seismic loads.

Further tests are necessary to measure the bond strength.

Tests on shear resistance against wind and seismic loads have to be done.

New market fields could be opened, because of the high bending and bond strength of textile reinforced masonry.

8. REFERENCES

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