Zukunft Bau

ZUKUNFT BAU
FÖRDERN FORSCHEN ENTWICKELN

SHORT REPORT

Title

„Application of anchors and needles made of fibre materials in the rehabilitation of historic buildings"

Occasion / Starting position

The anchoring and needling of masonry with steel bars are often used today when renovating historic buildings. The disadvantage is that corrosion protection must be used with black steel or stainless steel. Cement-based grouting mortar as corrosion protection leads to compatibility problems with masonry containing sulfate. The use of stainless steel is associated with high costs. Fiber-reinforced polymers are an alternative here.

Object of the research project

The research project was intended to explore essential foundations for the use of fiber composite reinforcement for anchoring and needling of historic masonry and to provide the relevant data and design algorithms for practical application.
The investigation was started on the essential materials, namely the fiber composite material, the masonry and the injection grout. Based on the knowledge of the behavior of different historical masonry, the requirement profile for the anchor and needle material was determined on the basis of an extensive material analysis.
Based on the masonry requirements, the suitability of the possible materials has been examined. The surface shaping of the re-bars also played a role in terms of the bond strength. In addition to theoretical considerations, FEM analyzes were carried out for the final anchoring by means of a bond. In order to ensure the full effectiveness of the needles and anchors, the question of posttensioning had to be examined.
Following the theoretical considerations, the following experimental investigations were carried out:

- Grout and strength: Checking a suitable grout and determining the material characteristics
- Bond tests: Between masonry and grout and between grout and reinforcement made of fibre materials. The aim was to study the association behaviour and to create a corresponding database. The investigation of the bond behaviour were examined depending on the profiling of the bars and on the coverage with grout

  Since the basics of reinforced masonry according to the European masonry standard EC 6 can be used for the design of anchors and needles, the design rules and the bond stresses shown there were subjected to a critical review. The bond-strength in EC 6 and thus the basis for their determination have been taken from the reinforced concrete. This is not permitted because of the significantly different conditions in the masonry. In Germany it has been controversial so far which bond length should be used for the pull-out tests. The question had to be answered if 10 ds should be applied like Brameshuber/Sänger did it or if the recommended value of Rehm 2 ds or 5 ds the value according to the CEB guideline should be used. For this purpose, touch tests with a short bond length were necessary in order to be able to use the relevant and applicable bond length of 2 ds respectively 5 ds for the research project.
- Pull-out tests have been carried out on whole anchors and needles in masonry test pieces.
- Tensioning tests were necessary to derive the appropriate posttensioning technology. Furthermore, the behavior of the materials under post-tension should be examined and the resulting tension losses determined.
- With regard to the technology of the post-tensioning, the introduction of the force had to be clarified. In addition, the application of the tensioning force was to be examined using a torque wrench. The aim was to select a practicable process for the tensioning that does not require any special personnel to carry it out.
- Fiber-reinforced composite anchors are sensitive to transverse tension and drilling stress. That´s why the aim was to select suitable anchors and to check the resistance against torsion.
- So far, there has been no experience with the long-term behavior under initiation of a torsional moments (torque wrench), which is why this simple variant of post tensioning has so far been excluded. Appropriate long-term tests have therefor been carried out.

The technological testing was carried out on two concrete objects in practice, e.g. the Steinort palace in Poland and the safeguarding of the Western Ivan in the Tahkt-e Soleyman World Heritage Site in Iran. Orica FRP anchors with end plates and with

bond anchoring were used in both cases. Cracks were needled with the Combar FRP rods from Schöck. The same material was used as transverse tensile reinforcement at the load transfer points on the anchor ends. While a commercially available grouting mortar from MAPEI was used to safeguard the north-west tower in the Steinort palace, a specially designed and mixed mortar from local gypsum sources was used for grouting in Tahkt-e Soleyman. Appropriate rules and instructions have been derived from both projects.

Conclusion

It was shown that fiber composite reinforcement can be successfully used in the strengthening of historic masonry. .
Commercial fiberglass rods have been identified as appropriate material for anchors and needles. Lime-based injection mortars with hydraulic additives in case of lime based masonry or gypsum-based mortars in case of gypsum based masonry are suitable for grouting. Depending on the absorbency of the surrounding material, adjustments are necessary for each specific application.
The algorithms for determining the bond behavior have been provided for this purpose.
If the anchors used are to be tensioned with the torque wrench, they must be approved for this in accordance with the declaration of performance.

Key data

Short title: Fibre anchors and needles

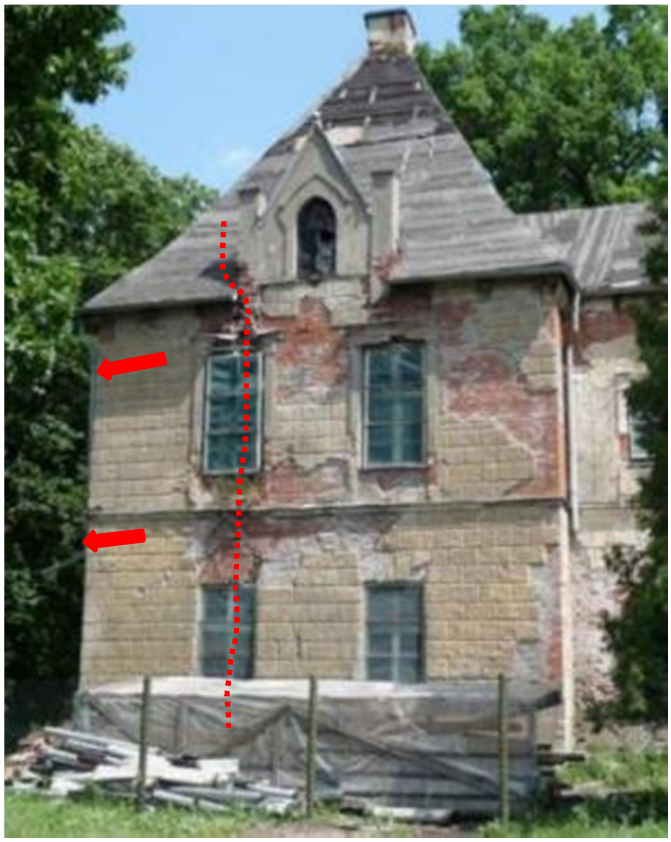
Researcher / Projectmanager: Prof. Dr.-Ing. Wolfram Jäger, Technische Universität Dresden, Faculty of Architecture, Chair of Structural Design, 01062 Dresden

Total cost: 170.300,00 € €

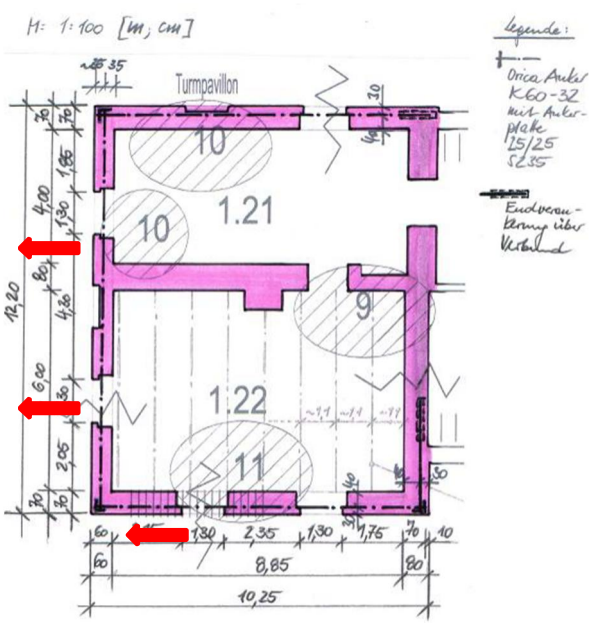
Part of the Federal grant: 106.100,00 €

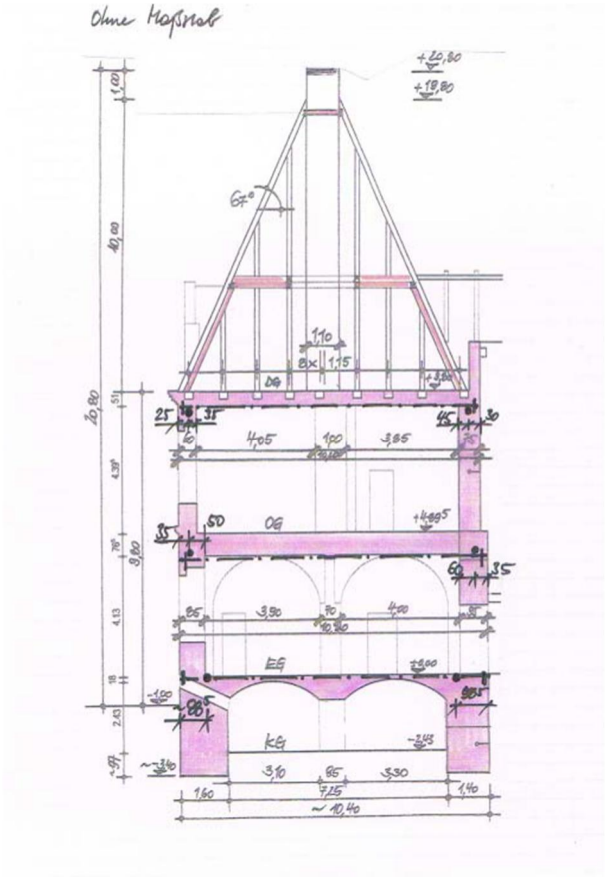
Project duration: 34,5 Months

Pictures:

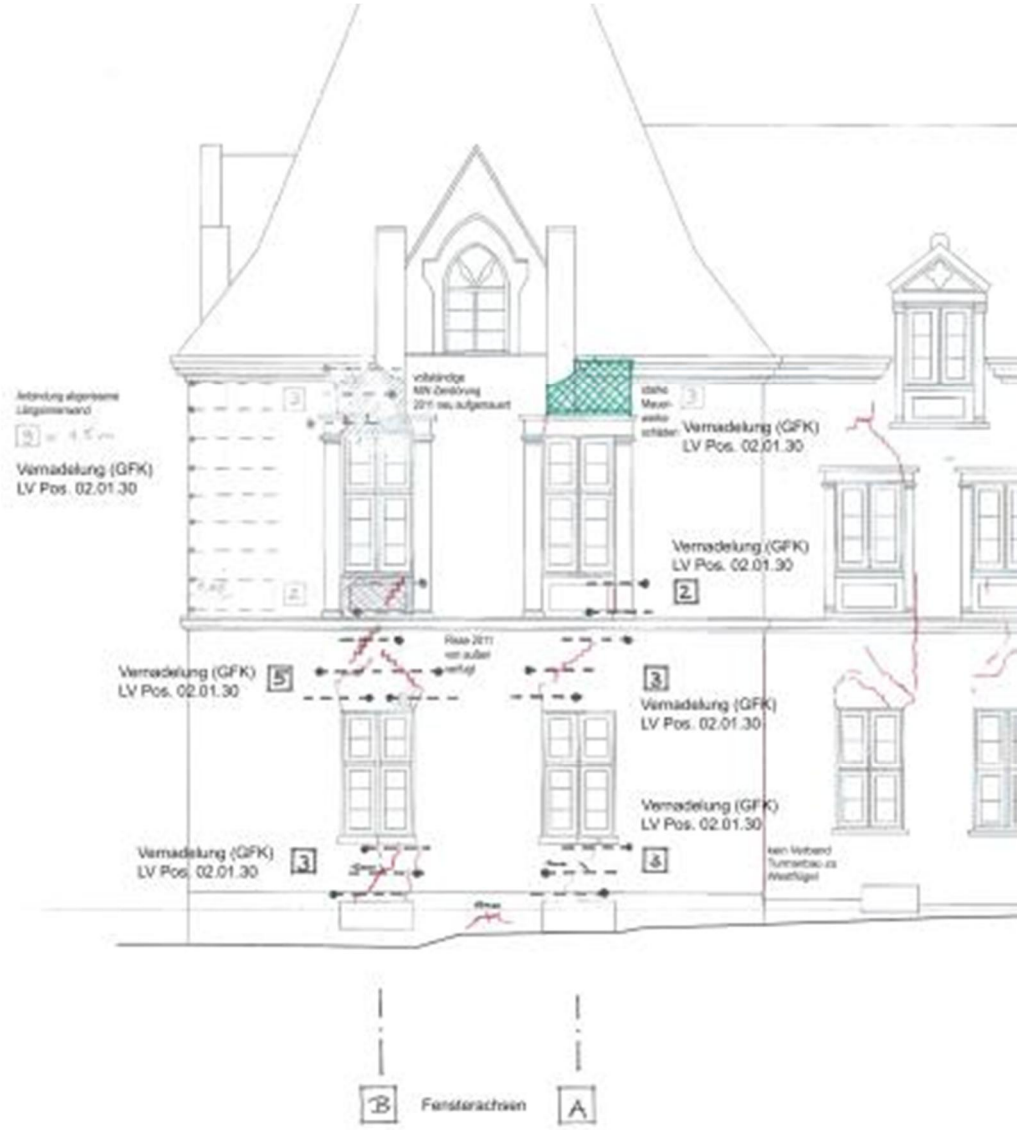


Picture 1 Bild-1-Ansicht-Nordturm-IMG_0628.jpg
Use of anchors and needles on the northwest tower of Steinort palace to anchor the drifting corner of the building

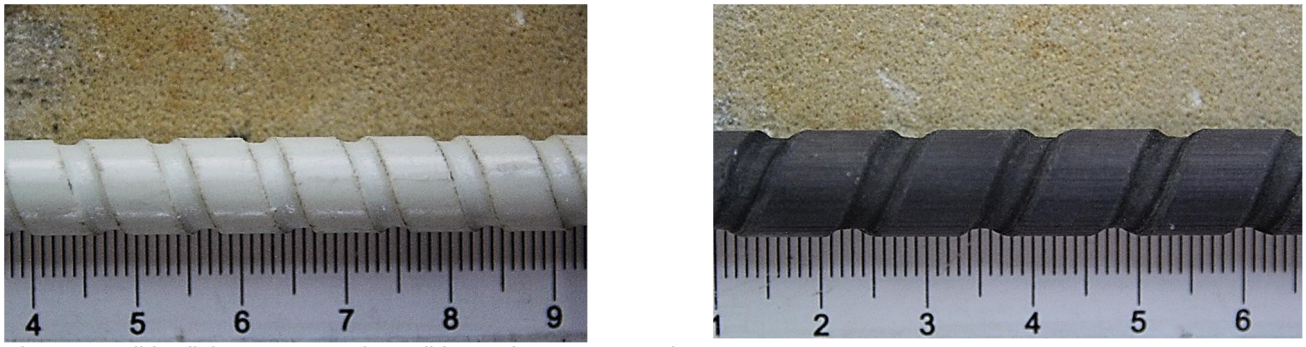




Picture 2 Bild-2-links.jpg Bild-2-rechts.jpg
Planning the anchor positions with the Orica anchor K60-32 with a diameter of 32 mm (Steinort palace)



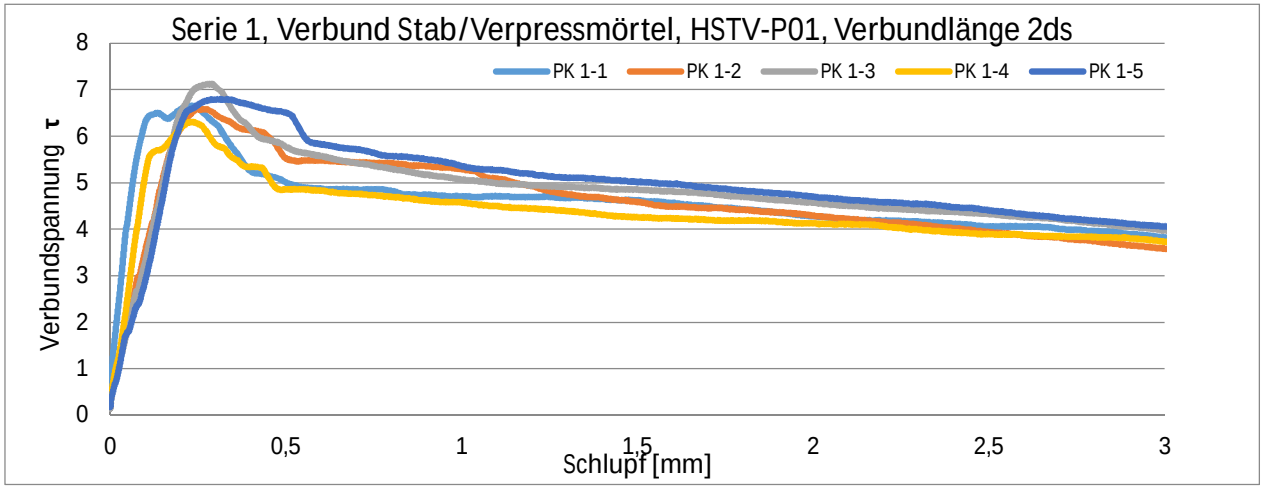
Picture 3 Bild-3-Planung-Nadeln.jpg
Planning the needling of existing structural cracks (Steinort palace)



Picture 4 Bild-4-links-IMG_2735.jpg; Bild-4-rechts-IMG_2731.jpg
Exemined needle material Schöck ComBAR GFRP-rebar dm = 8 mm (left) and Thyssen/Krupp Carbon4reBAR(C4R) FRP-rebar dm = 8mm (right)

Picture 5 Bild-5-links-IMG_0160.jpg Bild-5-rechts-IMG_2645.jpg

Glass fibre rods with insulated contact surface prepared for tests with 2 ds and 5 ds bond length in the middle of the rods (left) und test specimen in the test machine in the pull-out test for the short bond length of a carbon fiber rod (right)



Picture 6 Bild-6-Diagramm.jpg

Typical diagram of the measured bond stress- slippage-relation between bar and grout

Picture 7 Bild-7-IMG_0138.jpg

Glass fibre anchor in torsion test in the multi-axial testing machine Instron TT 8800