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## ABSTRACT

### Rehabilitation of Flowed Masonry Constructions – Influence of Water on the Properties of Masonry and Facings, Dry Up Methods and their Effect – F 917

Reference: Z6 – 10.07.03 – 04.12

## 1 INTRODUCTION AND SCOPE OF THE RESEARCH PROJECT

In recent years, more and more frequently, flash floods caused substantial damage to buildings and infrastructure. Due to these extreme weather occurrences, masonry constructions are often imbued for a long time or completely water-saturated respectively. So far, it is not well-known to what extent the strength and serviceability of masonry are affected negatively. Findings about appropriate restoration measures as well as measures for a fast and preferably complete drying still aren't fully understood or their effectiveness hasn't been proven yet. Besides, the damage caused by floods is only partly comparable with conventional moisture damages due to high moisture penetration and contamination rates of masonry components.

Within the scope of the research project /Bra07/, which has been financed by the Bundesamt für Bauwesen und Raumordnung, the influence of an intensive and long-term water-storage on the substantial mechanical properties of masonry should be examined and analysed, in order to be able to avoid incorrect or insufficient damage evaluations in future as well as structural damages resulting from inappropriate restoration measures. Besides, an overview of the literature concerning the topic "flood" should be given by a comprehensive literature research. The project shall contribute to a reduction of needless costs caused by damage evaluations and restoration measures of flood damages.

## 2 SELECTED APPROACH AND USED MATERIALS

At first, the literature available referring to the topic was collected, reviewed and evaluated. During the experimental investigations, changes of the substantial mechanical properties of masonry components by storage in water should be determined in comparison to the substantial mechanical properties of dry specimens. Hence, first the properties of the dry specimen were determined after a storage for at least 30 days in the laboratory climate 20 °C/65 % humidity. Afterwards, the substantial mechanical properties were determined on specimens which have been stored in water up to mass constancy. Following, the remaining specimens were sealed in such a way so that the drying process of the units could take place analogue to the drying process possible in a masonry wall. The drying process of the specimens took place in a custom-built drying chamber. The specimen mass was determined during the drying procedure in regular time intervals. After reaching about half of the maximum humidity content of the saturated specimen, the substantial mechanical properties were determined again. Finally, the same properties were determined when the specimens reached their initial humidity content before the water admission. All test results were recorded and presented as tabulations and graphics.

## 3 CONDUCTED TESTS

The investigations were carried out on all 4 kinds of masonry units – hollow clay units, calcium silicate units, aerated concrete units as well as lightweight aggregate concrete units -, in each case on representative unit types with meaningful mortar combinations and commonly used plasters. The tests were carried out on non-plastered single units, single-sided and/or double-sided plastered single units as well as on non-plastered 2- and 5-units-specimens. The fundamental aim of the investigations was to examine and evaluate the influence of an intensive and longlasting waterstorage on the substantial mechanical properties of masonry components experimentally. For this, the following properties were determined:

### non-plastered single units:

- dimensions, mass, flatness and parallelism of bed faces
- gross dry density and unit moisture content
- compressive strength und tensile strength

### plastered single units:

- dimensions, mass, unit moisture content
- gross dry density und plaster moisture content
- adhesive tensile strength of the plaster according to DIN EN 1015-12 [2]

### 2-units-specimen:

- unit moisture content
- bond strength between mortar und unit according to DIN EN 1052-5 [3],
- joint compressive strength following method III according to DIN 18555-9 [4] and gross dry density of the mortar joint

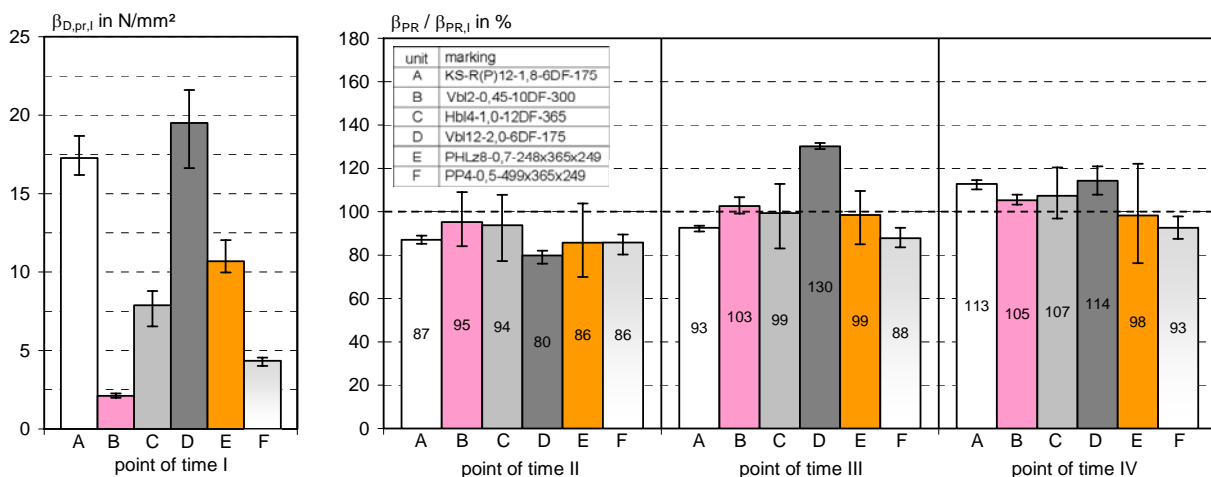
#### 5-units-specimen:

- dimensions, mass
- masonry compressive strength, moisture content

## 4 SELECTED TEST RESULTS

The tests on non-plastered single units have shown that the long-term water-storage and the following drying process up to the original humidity of the units in most cases tends to result rather in a favourable effect on the mechanical properties (compressive strength and tensile strength). With four out of six unit types, higher compressive strength values were measured than before the water-storage. With the other two unit types, the strength values in the original state were almost reached. The results of the tensile strength tests displayed similar tendencies, whereby only two out of six unit types in the dried condition achieved higher tensile strength values than before the water-storage. However, only slightly lower test values than at the beginning of the investigations result for the remaining unit types with one exception.

In Fig. 1, an overview of the compression test results is presented exemplarily. Here shown is the temporal change of the compressive strength during the water-storage (point of time II) as well as during the following drying process (point of time III and IV), related to the properties of the untreated specimens (point of time I).



**Fig 1:** Compression test results; overview

The tests on the internal plasters have shown that the adhesive tensile strength values on different backgrounds partly fall to very low values after the water-storage (up to 15 % of the initial values). However, in many cases the adhesive tensile strength values "recovered" after the drying process to the initial humidity content and only insignificantly lower values were reached than before the water-storage. In two cases, even 11 % and 83 % higher test values were reached after the back drying process than before the water-storage. The tests on the external plasters resulted in similar values. Only in one case, slightly lower values than before the water-storage resulted from the tests. With the remaining unit-plaster-combinations either the same or clearly higher mechanical properties were reached at the point of time IV than at the beginning of tests.

The tests carried out on 2-units-specimens have shown that the water-storage up to water saturation of the masonry units and the following drying to the initial humidity content mainly affects the bond strength between mortar und unit as well as the joint compressive strength in a positive way or there is no recognizable influence on the respective strength values. After finishing the tests on single units and 2-units-specimens, two unit-mortar-combinations were selected to carry out further tests on 5-units-specimens, the combination that has been affected least and the one that has been affected most strongly by the water-storage and the following drying process. To a large extent, similar results as in the case of the tests on single units were obtained.

## 5 SUMMARY

According to the results of this project, it can be concluded that the influence of an intensive and long-term water-storage on the mechanical properties of masonry components is to be rated as relatively small after they have dried to the initial humidity content. Both, compressive strength and tensile strength tests showed, that the mechanical properties of water-saturated and dried specimens were not affected at all or rose to a higher level than before the water admission. Tests on plastered single units revealed that not only the external but also the interior plasters reached the same as or higher adhesive tensile strength values after the drying process than before the water-storage.

## 6 LITERATURE

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- /DIN00/ DIN EN 1015-12:2000-06 + 1982-09. Prüfverfahren für Mörteln für Mauerwerk - Teil 12: Bestimmung der Haftfestigkeit von erhärteten Putzmörteln
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- /DIN99/ DIN 18555-9:1999-09. Prüfung von Mörteln mit mineralischen Bindemitteln - Teil 9: Festmörtel; Bestimmung der Fugendruckfestigkeit