

Investigation on the behaviour of a restoration plaster applied on heavy salt loaded masonry

Barbara Lubelli ^{a,b,*}, Rob P.J. van Hees ^{a,b}, Caspar W.P. Groot ^a

^a *Delft University of Technology, Delft, The Netherlands*

^b *TNO Building and Construction Research, Delft, The Netherlands*

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Abstract

The present paper reports the results of a series of investigations and monitoring performed, during a period of more than three years, on an ancient church flooded by the sea 50 years ago. This building can be considered representative for many other brick-masonry monuments in the flooded areas in the Netherlands. The church, restored several times in the past 50 years, shows a serious decay mainly affecting the restoration plaster applied in the interior; the damage appeared few years after the application of the plaster and has considerably increased in time.

The research described in the present paper aims to reach better understanding of the mechanisms through which damage occurs in order to find out the reasons of the unsuccessful repairs performed in the past and to propose possible solutions to stop or slow down the decay process.

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1. Introduction

Weathering of building materials due to sea salt is a well-known phenomenon in coastal environment. The origin of sea salts in masonry can be different: rising damp, sea-salt spray, salt present in building materials and sea flooding. Some of these sources act continuously during long periods, other have a cyclic or exceptional occurrence, but they all may cause serious decay.

In the Netherlands, lying partially under the sea level, sea flooding occurred several times in the past. In 1953, the province of Zeeland, in the southwest of the Netherlands, was subjected to a sea flooding during which most of the buildings were under seawater up to several

meters. After 50 years the consequences of this calamity are still visible in the serious decay affecting the buildings.

Restoration performed in the past proved to be most of the time not effective and even so-called restoration plasters, introduced on the market in the last decades, show often damage when applied on masonry with heavy salt load. The reason of these repeated unsuccessful restorations is often the absence of a preliminary investigation (of the material properties and the micro-environmental condition) allowing a more conscious definition of a suitable intervention.

The following paragraphs report the results of a series of investigations and monitoring, performed during a period of more than three years, on an ancient church located in a small centre in Zeeland (Brouwershaven): this building can be considered representative of many other ancient brick-masonry buildings in the flooded areas in the Netherlands.

* Corresponding author. Tel.: +31 0 15 2763 170; fax: +31 0 15 2763 017.

E-mail address: b.lubelli@bouw.tno.nl (B. Lubelli).

2. Notes on the history of the building and of the renovations

The construction of the church of St. Nicholas in Brouwershaven started probably in 1293 [1] and went on until the 17th century. The nave dates back to the 14th century, the aisles and the choir to the beginning and to the end of the 15th century, respectively. The first church-tower dated from 1667 and contained three bells; this tower was renewed in 1734 before being taken down during the French period. A new tower was built in 1883 and enlarged in 1932. The structure of the church is constituted by brick masonry on elevated walls and limestone on the basement of the columns.

In 1953, due to the flooding, the church was submerged in the seawater up to the window sills (Fig. 1). Because of the wall being saturated with seawater during the flooding, a serious decay developed when the masonry dried out. The church required an extensive restoration of the interiors that was completed only in 1963: a tar like layer was applied on the brick walls and on this a plaster was applied. The aim of the application of the tar layer was to keep the salt inside the masonry. The tar layer, being not permeable, avoids the liquid water transport, and therefore the salt transport from the masonry to the plaster. Due to detachment of this plaster occurring after several years from the application, a new restoration was necessary (1991–1994): in this occasion the plaster and the tar layer were removed and a new plaster was applied. This new plaster is a ready-to-use cement based restoration plaster for salt loaded substrates, and should transport the salts from the substrate to the surface of the plaster where they should crystallize without producing any damage. When the monitoring started and the first investigations took place (July 2000), the plaster already showed a serious decay that considerably increased in the following three years.



Fig. 1. The church submerged in sea-water during the flooding in 1953.

3. Description of the damage

The decay mainly affects the plaster covering the interior of the church. The limestone constituting the basement of the columns shows only a white salt patina and little sanding.

The damage of the plaster is mainly located up to 4 m from the ground level, and is particularly serious on the walls (Fig. 2) and the columns of the choir. The damage appears at the beginning as peeling of the paint layer and formation of cracks and increases then with sanding and crumbling of the plaster. This development of the decay seems to be typical of this type of plaster, if applied in very severe situations and it has been observed on several occasions [2]. In some spots in the church the plaster layer is completely weathered and the brick substrate starts decaying. Efflorescences are visible on the plaster and on the substrate during periods of low RH.

4. Sampling

Sampling was performed, on several locations and at different times, in the interior of the church. Different types of samples were taken, aiming to give a complete analysis of the cause and process of damage (Fig. 3):

- Sampling by powder drilling: powder samples were drilled at different locations in the church. For each location the drilling was performed along a vertical profile at several heights and depths. These samples were used to assess the moisture and salt profile in the wall in order to define the moisture source.
- Sampling by core drilling: cores of 5 cm diameter were drilled from the wall. These were used for determining the material properties.
- Sampling of efflorescence: salt efflorescences present on the stone and the plaster surface were collected to assess the type of salts present.



Fig. 2. South wall of the choir showing serious damage.

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