Properties of Sealed Joints After Exposure to Water

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Abstract. In practice, sealed joints in the construction industry are very often exposed to adverse climatic influences. One of these climatic influences is the effect of water, for example in the form of rain or humidity. This article is therefore devoted to the sealing of joints of problematic base materials, which are then exposed to the effects of water and subsequently tested according to the recommended test standards. For this research, a problematic substrate based on cement is selected, and glass cement is specifically chosen for its shortcomings. The main disadvantage of this material is the existence of small particles on its surface, which due to their insufficient wettability disrupt the adhesion of both the primer and subsequently the sealant to this substrate and thus significantly reduce the quality of the sealed joint. Furthermore, representatives of several types of sealants and primers recommended for them available on the Czech market are selected for this experiment. Test specimens are made using glass cement plates treated with the appropriate primer and the sealant. These test specimens are then the goal of a test procedure to verify the properties of the sealed joint of the problematic material and the selected primer and sealant that is exposed to the water element. The results of these tests are then presented in the article.

1. Introduction

The problem of connecting various materials in construction work has accompanied humanity virtually from the birth of civilization, and even today we can find sealant joints almost everywhere. Until the beginning of the 20th century all material used as sealant was of natural origin. However, over time the development of technology and specifically the chemical industry has led to sealant materials becoming complex chemical compounds. This is one factor which led over a huge leap forward in the technology and application of sealant in construction over the last two decades. [2]

The primary purpose of sealant is to prevent air, water and other substances from entering or leaving a certain structure and to allow the basis to move in a certain range. Sealant incorporated into the joints of buildings also contribute to thermal and sound insulation and often contribute to the fire safety of structures. [1] Joints and openings between structural elements can also be found in many various parts of buildings or structures, for instance between prefab concrete elements in facades, around windows in doors, in the clefts between floors and ceilings etc. Even though the joints are present in many parts of buildings, it is clear that there are significant differences between them. [1,3] These and other additional reasons are why it is necessary to always design sealant joints in a way ensuring that they can resist all internal and external effects, whereas some of the most problematic effects originate from weather conditions. [3]

If we expect a sealant joint to be exposed to such weather conditions, it is recommended to choose a sealant that will be resistant to its effects. But due to the large number of products available on the
Czech market and the fact that not all recommendations of manufacturers match the actual resistance of the sealant against such effects, it is not an easy task to select such a sealant. The aim of this work is hence to compare the quality of sealant specifically after exposure to weather effects and in terms of their subsequent cohesion with the base material, using suitable test procedures that follow approved standards.

2. Material
In order to carry out the study outlined in this article, it was necessary to select the base material as well as the sealant and the manufacturer’s designated primer for the sealant.

The base material was selected specifically by focusing on the fact that this should be a problematic material, i.e., one where it is possible to expect weak cohesion with sealant. It should also meet the condition of being frequently used in construction practice. Based on previous studies focusing on sealant joints for problematic base materials and careful consideration, glass cement was selected as a suitable base material for testing. This material is problematic for sealant especially due to the reduced cohesion of sealant to the base. This property is caused notably by the presence of fine particles on the surface of the glass cement, which due to their low wettability cause weak cohesion of the sealant to the base material even after the application of the primer. These particles then disrupt the cleft treated with sealant and lead to weak cohesion, which can even lead to the complete separation of the sealant from the base.

The selection of the sealants was then carried out based on a comparison of publicly available sealants and their price range. The author of this article carried out a survey of the Czech market in the area of sealant, based on which three prominent sealant manufacturers were selected. For these three manufacturers, sealants were selected which the manufacturers claimed can be used for the selected base material, and these were then compared based on their technical sheets. This then led to the selection of two common sealants, one as a representative of acrylic sealant and one as a representative of neutral silicones, both of which are recommended by the manufacturer for the selected base material.

3. Methodology
The test methods are based on valid Czech technical standards, specifically ČSN EN ISO 10590, which defines both the parameters of the test body for the given test as well as the exact procedure for the test.

The test body is defined via its composition and dimensions and is depicted on Figure 1. The base material can also have different dimensions, assuming that the dimensions of the sealant profile and the adhesion surface remain the same. For the purposes of the study, a test body was selected consisting of two base desks made of glass cement, with dimensions of 50 x 30 mm and a width of 12.5 mm. Furthermore, wooden stretchers with layout dimensions of 12x12 mm and a height of 50 mm, which together with the base desks made of glass cement border the applied sealant. Five test samples are created per test, all produced at a constant temperature of the sealant and foundations of (23±2) °C. It is necessary to follow the instructions of the sealant manufacturer during the production of test samples. This means that it is necessary to use a base coating and apply the following measures: exclude the creation of air bubbles, push the sealing sealant against the contact surfaces for the foundations and smoothen the surface of the sealant using auxiliary bodies and stretchers.

Before the actual testing, it is necessary to also prepare the samples using the prescribed procedure as defined in the standard. First, it is necessary to install the samples for 28 days at a temperature of (23±2) °C and relative humidity of (50±5) % in order to ensure the correct maturing of the sealant. After that, the test samples are subjected to the following preparation cycles, three times:

1. 3 days in the drying oven at a temperature of (70±2) °C
2. 1 day in distilled water at a temperature of (23±2) °C
3. 2 days in the drying oven at a temperature of (70±2) °C
4. 1 day in distilled water at a temperature of (23±2) °C

The standard then describes the procedure of the test which was used for this study. In particular, this is the test for determining the cohesion at maintained extension after submersion in water. After the preparation cycles described above, the test samples are immersed in a water container, where they are left for five days at a temperature of (23±2) °C. After five days, the samples are removed from water and left in an aerated environment at a temperature of (23±2) °C and with a relative humidity of (50±5) %. Subsequently, the test samples are placed into the test device and are elongated by 20 % of their original width at a speed of (5.5±0.7) mm/min. This elongation is maintained for a period of 24 hours. After the release of the test samples from the testing device, the lengths and positions of cohesion errors are recorded.

![Image](image_url)

**Figure 1.** Test sample [9]

4. Results

Five test samples were used for each selected sealant. The test results were evaluated via a visual inspection of the test samples and their measurement using a sliding gauge. The results are provided in Table 1 below, which also describes the observed defects of the sealant joint. In order to increase the accuracy for the evaluation of the results, the length of the defect of the sealant joint is also recorded.

A joint evaluated as “Pass” is not damaged, meaning that it does not exhibit any defect. An undamaged joint is depicted on Figure 2, located below the table of results. A joint marked as “Fail” is one where one side of the sealant was torn off from the base material. The length of the fissure between the sealant and the base material is listed in the table. One of the samples marked as “Fail” is
depicted on Figure 3, also provided below the table of results (specifically, this is the sample marked in italics in the table).

### Table 1. Table of test results

| Sealant type       | Sample No. 1 | Sample No. 2 | Sample No. 3 | Sample No. 4 | Sample No. 5 |
|--------------------|--------------|--------------|--------------|--------------|--------------|
| Sealant A          | One-sided    | One-sided    | One-sided    | One-sided    | One-sided    |
| (Acrylic sealant)  | tear-off     | tear-off     | tear-off     | tear-off     | tear-off     |
|                    | 48 mm        | 45 mm        | 30 mm        | 50 mm        | 49 mm        |
| Sealant B          | One-sided    | None         | None         | One-sided    | One-sided    |
| (Neutral silicone) | tear-off     |              |              | tear-off     | tear-off     |
|                    | 34 mm        |              |              | 28 mm        | 30 mm        |

**Figure 2.** Sealant B, sample No. 2  
**Figure 3.** Sealant A, sample No. 1

### 5. Analysis of Results

As can be seen in the table of results provided in the Results section above for both tested sealants, only a single defect was observed during testing – notably the one-sided tear-off of the sealant from the base material. This tear-off exhibits various lengths of the one-sided tear-off, as shown in Figure 4 below. Acrylic sealant exhibits significantly worse values – the lengths of the tear-off are greater than for the tested neutral silicone, and this can also be seen by comparing the graphs. For one sample, the crack passes along the whole length of the sealant joint. On the other hand, for neutral silicone the fissures are usually smaller than for acrylic sealant, and for two samples there was no visible damage to the sealant joint whatsoever.

**Figure 4.** Length of one-sided tear-off
6. Conclusions
Even though the manufacturer claims that the sealant is well suited for the selected base material, the test results demonstrate that its cohesion is insufficient and that being exhibited to water sources leads to significant damage to the sealant joint. It is hence not possible to recommend any of these sealants for glass cement base materials.

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