DETERMINATION OF SELECTED TENSILE PROPERTIES OF THE SEALED JOINT ON A REAL JOINT

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Abstract
This article discusses selected tensile properties of a sealed joint on a real joint. A real joint is a sealed joint that, when tested in laboratory conditions, comes closest to what the real application of sealant looks like in current construction practice. The Aquapanel cement board was selected as the base material for this test. Subsequently, two sealants were selected which, according to the manufacturer's recommendations, are suitable for sealing cement-based materials and were selected also as suitable primers for them. Tests of a real joint were made for these materials, which were subjected to a tensile test on a test device designed for this purpose. This was followed by an evaluation using measurements and visual inspection of the tested joints.

Keywords
Sealant, sealed joint, test sample, adhesion, cohesion

1 INTRODUCTION

The issue of sealing individual materials represents a current topic in the field of construction today. The main function of the sealed joint is to allow a certain range of movement of the substrates, preventing the entry of water, air and other substances into the structure. Furthermore, it provides thermal and sound insulation, possibly also resistance to fire [1], [2].

Sealed joints are exposed to a large number of external influences. Therefore, it is necessary to choose a sealant based on the effects against which it should be resistant. This information is provided by the sealant manufacturer as a recommendation for the sealant use. However, this recommendation does not always correspond to reality and the sealed joint is not always able to maintain its properties and not to degrade even after being exposed to these influences [3], [4], [5], [6], [7], [8].

The research in this article specifically deals with the sealing of a problematic cement-based material, and the adhesion and cohesion of a sealed joint after its exposure to a change in the temperature.

It also deals with the proposed alternative methods of testing sealants, since the existing methods based on the valid European standards are insufficient in many respects. That is why alternative testing methods are proposed, which come closer to sealing in construction practice and introduce the concept of a real joint, which is described in the Methodology chapter. The proposed methodology is intended to simulate the real shape of the applied sealant as accurately as possible so that it comes as close as possible to construction practice and the results of the tests are informative and have a relevant value. Moreover, compared to European standards, the proposed alternative methods take into account shear stress in addition to the tensile stress of the cemented joint.

2 METHODOLOGY

The base material and two sealants were selected for the purposes of the research published in this paper. Aquapanel cement board was chosen as the base material, which is problematic during sealing due to the presence of fine dust particles on the surface of the material, which disrupt the cemented joint.

Furthermore, two sealants were selected, which were chosen primarily for their suitability for sealing the selected cement base material. They were also selected based on their availability to the end customer and price. Based on these criteria, polyurethane sealant Sikaflex 11 FC+ and MS polymer Mapeflex MS45 were selected. Primers for these sealants were selected based on the manufacturer's recommendations, i.e. primers, which partially eliminate the problem of sealing the selected base material. [9], [10], [11].

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The methodology used in this article is based on proposed alternative procedures for testing sealants, which are proposed as a possible addition to testing sealants according to European technical standards. The test published in this paper represents an alternative to the European standard ČSN EN ISO 8339 [12].

The test sample was designed to simulate the caulking of a real joint as best as possible. It consists of two base plates with plan dimensions of 40 × 160 mm and a thickness of 12.5 mm. It also consists of an applied sealant and a mirelon cord with a diameter of 10 mm, which helps with the correct application of the sealant and the creation of the correct cross-section of the sealant. It follows from these dimensions that the width of the sealed joint is 10 mm. The cross-section of the applied sealant is shown in Fig. 1.

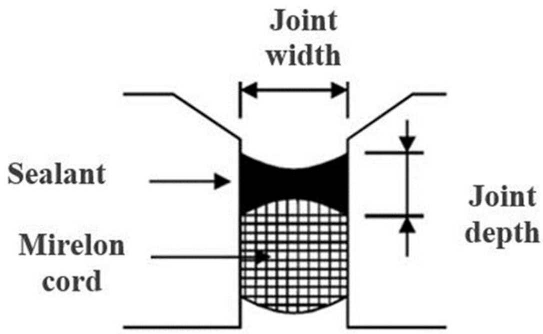

Fig. 1 Recommended solution for a real cemented joint.

Three test samples were produced for the proposed alternative test. The production of the test took place at a maintained temperature of the sealant and the base plates at 23 °C, and the instructions of the sealant manufacturer were followed, which could set the conditions for the use of the base coat, the so-called primer.

An alternative method was proposed both for testing tensile stress, as is also the case with technical standards, and also for shear stress, which is no longer considered by technical standards. Only tensile tests are published in that article.

Prior to the actual testing, it was proposed for the performed alternative test to pre-condition the test according to the prescribed procedure, which is taken from valid technical standards. The test is first left for 28 days at a temperature of 23 °C and relative humidity of 50% to allow the applied sealant to mature properly, and then subjected to the following storage cycles three times:

- 3 days in a drying oven at a temperature of 70 °C,
- 1 day in distilled water at a temperature of 23 °C,
- 2 days in a drying oven at a temperature of 70 °C,
- 1 day in distilled water at a temperature of 23 °C.

Fig. 2 shows the storage of the test in the drying oven and Fig. 3 shows the immersion of the test in water.

Fig. 2 Cycling: storage of test of a real joint in a drying oven.

Fig. 3 Cycling: storage of test of a real joint in water.

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Before the actual testing, the samples were stored for 24 hours at a temperature of 23 °C and a relative humidity of 50%.

The essence of the test was the stretching of the test sample until the failure with the recording of the value of elongation at failure.

In this test, the samples were tested for a temperature of 23 °C and -20 °C. Three tests were carried out for each temperature.

For the 23 °C test, the test samples were placed in the test apparatus and stretched at 23 °C at a rate of 5.5 mm/minute until failure occured. The elongation at the break value was recorded.

For the test at a temperature of -20° C, the test samples were stored for at least four hours at a temperature of -20 °C. Subsequently, they were inserted into the testing device and stretched until the failure at a temperature of -20 °C and a speed of 5.5 mm/minute. The elongation at the break value was recorded. [13].

3 RESULTS

Three test samples were tested for each selected sealant. The test samples were stretched in the testing device until the failure. In the results tables Tab. 1 and Tab. 2, the maximum force at failure, maximum stress at failure and elongation at failure are recorded in millimetres and percentages relative to the original length. Furthermore, the tables of results shows the manner of failure of the test.

Only two types of failure occurred in the tested test samples, namely adhesion failure marked in the results tables with the letters AF and substrate material failure marked in the result tables with the letters SF.

Tab. 1 Test results at the temperature of 23 °C.

Sealant	Test no.	Max. force [N]	Max. tension [MPa]	Elongation at failure [mm]	Elongation at failure [%]	Failure	Failure to occur when stretched by 25% of the original length
Mapeflex MS45	1	165.98	0.10	1.46	12.17	AF	YES
	2	305.11	0.19	2.29	19.08	AF	YES
	3	262.21	0.16	1.59	13.25	AF	YES
Sikaflex 11 FC+	1	154.46	0.10	4,80	40.00	AF	NO
	2	232.17	0.15	6.59	54.92	AF	NO
	3	165.61	0.10	5.59	46.58	AF	NO

Tab. 2 Test results at the temperature of -20 °C.

Sealant	Test no.	Max. force [N]	Max. tension [MPa]	Elongation at failure [mm]	Elongation at failure [%]	Failure	Failure to occur when stretched by 25% of the original length
Mapeflex MS45	1	353.01	0.22	2.25	18.75	AF	YES
	2	459.04	0.29	4.34	36.17	SF	NO
	3	425.61	0.27	3.95	32.92	AF	NO
Sikaflex 11 FC+	1	294.11	0.18	6.49	54.08	SF	NO
	2	277.04	0.17	4.99	41.58	AF	NO
	3	237.98	0.15	5.12	42.67	AF	NO

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4 DISCUSSION

After all test samples were tested, two types of failure occurred in these test samples. The first violation was a violation of adhesion when the sealant was detached from the underlying material. The second violation was a violation of the underlying material. In the test performed at a positive temperature value, both tested sealants only had a breakdown in adhesion. In the test carried out at a negative temperature value, Mapeflex MS45 sealant had a failure of adhesion in two test samples and one had a failure of the underlying material. In the case of Sikaflex FC+ sealant, two test samples also had a violation of adhesion and one test sample had a violation of the underlying material. It is clear from the result tables that when testing the test samples at a negative value of the temperature, a greater force was needed to break the sealant than when testing the test samples at a positive value of temperature. This was caused by the freezing of the sealant joint. This statement was also proven when determining the limit of failure of the test sample when stretched by 25% of the original length. When tested at positive temperature values, Mapeflex MS45 sealant failed in all three tests carried out. On the contrary, the same sealant when tested at a negative temperature value was broken in only one test sample out of three samples tested. Sikaflex 11 FC+ sealant performed very well during testing, as none of the test samples tested were broken either at positive or negative temperatures. At a negative temperature value, a greater tensile force was required for all tested samples than at a positive temperature value. This phenomenon was caused by the freezing of the test sample, which became more solid when exposed to a negative temperature. [14], [15].

5 CONCLUSION

Despite the fact that both sealants were selected on the basis of the manufacturer's recommendations for sealing the selected base material, it is evident from the result table that MS polymer does not comply when exposed to the influence of the temperature changes, even when the primer required by the manufacturer was used, which had the task of improving the adhesion of the sealant and to the underlying material. In contrast, the polyurethane sealant Sikaflex 11 FC+ stood up to its properties and passed this test for all six tests carried out. Therefore, based on the results of this test, only polyurethane sealant can be recommended for sealing the selected cement-based base material. The results obtained by testing according to the proposed alternative procedures are innovative because they approach construction practice. However, only time and more tests can prove that the proposed alternative methods are and will be a good alternative to testing sealants according to valid European standards. However, their great contribution to the construction practice can already be seen.

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