TEST OF ADHESION AND COHESION OF SILICONE SEALANTS ON FACADE CLADDING MATERIALS

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Abstract

The paper describes the testing of the tensile properties of silicone sealants applied to facade cladding materials. The test procedures followed steps defined in applicable technical standards in order to meet their requirements. Furthermore the paper describes the implementation of the tests according to the standards and their application in practice. For the experimental part, industrially produced neutral or universal silicon sealants from three different manufacturers were selected. The researchers also decided to choose silicon sealants from various price categories. The aim of the research was to determine any differences in the resistance of sealants to permanent extension maintained at normal or freezing temperatures. Samples of the following materials were used as facade cladding alternatives: composite aluminium panels, fibre-cement slates, ceramic tiles, fibrecement and compact tiles, metal plates without surface finish, artificial stone panels and thermowood facade panels. It was measured with putty consistency by construction materials. They were always tested in three test samples of each material.

The test results have been evaluated and are displayed in a table that defines appropriate and inappropriate combinations of facade materials and sealants. Only serie of all three test specimen that showed ability to satisfy all requirements had been evaluated as convenient otherwise the test specimens can not be recommended. The conclusion of the tests is that the choice of a suitable sealant is not straightforward and cannot be responsibly carried out without previous experience or measurements. The chosen test method has also revealed that there are significant performance differences between silicon sealants. Likewise, it seems to be a fact that the use of the most expensive sealants does not necessarily lead to the best results.

Key words

Adhesive failure; extension; maintained extension; seal; sealant

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1 INTRODUCTION

Sealants are materials which are runny to doughy in consistency, suitable for filling joints, holes, cracks, depressions and surface irregularities. They can also be used to connect materials, functioning as adhesives. The main task of sealants is the permanent sealing of joints, as described by [1] in more detail. The main issue connected with sealing therefore lies in the need to ensure adequate cohesion between sealed materials and sealant while enabling dilatation movements to occur within the joint without damage to the sealant [2].

Silicones are polymer materials whose basic skeleton is composed from the bonds between silicon and oxygen atoms. Various types of organic substituent can be bonded to a silicon atom, e.g. methyl, vinyl and phenyl groups. It is, according to [3], the silicon content that renders silicone a material whose basic properties include:

- resistance against low and high temperatures, undergoing only small changes in properties with changes in temperature;
- hydrophobic effects;
- resistance against UV radiation, oxidisation from the oxygen in the air, i.e. high weather resistance;
- with regard to other materials silicones are inert, noncorrosive and biologically inert;
- good electrical insulation properties (high dielectric strength over a wide range of frequencies).

Some types resist acids, lyes and weak dissolving agents. Another important property is their good adhesion both on smooth materials, for example glass, and also on porous surfaces – masonry and plaster. They are characterised by thermal resistance over a wide range of temperatures from -50 °C up to +305 °C.

The aim of the research was to determine the degree of adhesion of silicone sealants to normal building materials.

2 LITERATURE REVIEW

Sealants are building materials which are primarily used for the sealing of joints in building structures. According to the Czech standard ČSN EN ISO 6927 [4], a sealant is defined as a material which is shapeless when applied, and which has the capability to seal joints after hardening. The EN ISO 11600 standard [5] divides sealants into two groups: types G and F. Type G – glazing sealant is used for glazing, while type F – building sealants are for use in the joints of buildings and other situations than glazing.

Silicon sealants and adhesives as used in the construction industry were introduced approximately forty years ago. According to the findings which had been already published, many of the silicones applied in the early days are still performing today. Wolf [6] had in his paper from 1999 stated that the material properties of sealants permit them to satisfy important needs in a broad variety of markets. He had also mentioned that the most important properties of silicone sealants for construction are durability and adhesion.

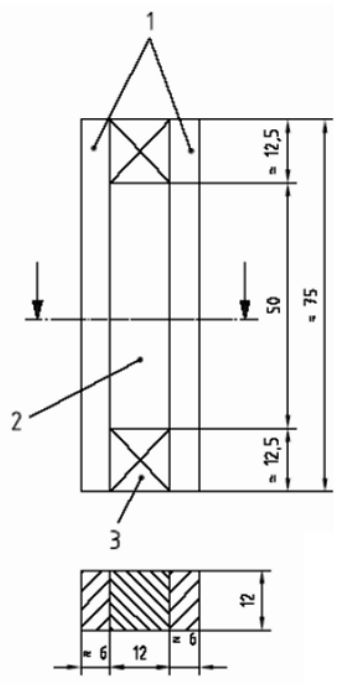
Also in 1999 Chew, from National University of Singapore had published a paper about 'Joint sealant for wall cladding' [7]. He studied the effect of weather changes on the degradation of the sealant joints was studied and discussed in more detail. The author indicates that "the cause of sealant failure on a building facade depend on the types of sealant used and the quality of installation service. Sealant material can fail due to improper curing, aging and weather exposure. Later, his very influential paper about a series of on – site non – destructive tests of silicone sealants was published [8].

It is apparent that researchers tried to conduct a comprehensive literature review with the aim of comparing their own measurements with the results of other authors. However, no reasonable or more similar published works were found on the given topic. Therefore the research findings detailed below should be considered as original.

3 METHODOLOGY

All the requirements which are used for the classification of sealants and references to standardized testing procedures are listed in EN ISO 11600.

As specified in [5], the test procedure for testing the adhesion and cohesion of silicone sealants on various facade materials was also selected. The test sample defined in [9] is shown in Fig. 1; it is identical for all test procedures. Test substrates can have different dimensions than those stated in Fig. 1, but the dimensions of the profile of the sealant and the adhesion surface must be maintained.



Legend
1. Substrate specimen made from anodised aluminium or glass
2. Sealant
3. Spacer

Fig. 1: Test specimen for testing of sealants [9]

To facilitate handling during the execution of subsidiary tests, and due to the need for simplicity in the attachment of the samples in the testing device, a test specimen was designed which was composed of two plates with the dimensions 30x50 mm bonded with a sealant with a transverse profile of 12x12 mm and a length of 50 mm, as shown in Fig. 2 and Fig. 3

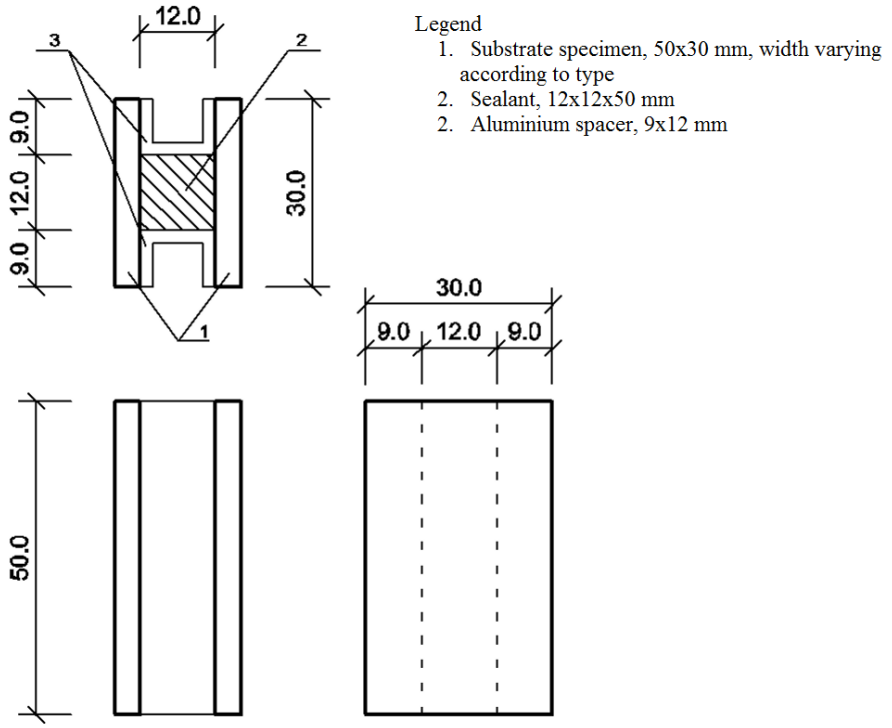


Fig. 2: Test specimen for the practical execution of experiments which fulfil the requirements of the Czech standards group for the testing of sealants [9]

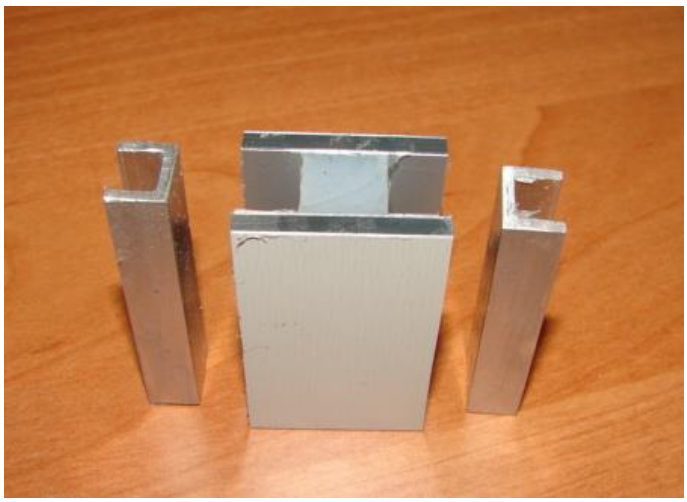


Fig. 3 Example of a test specimen

The substrate specimens are fabricated from plates with the dimensions 30x50 mm and with various thicknesses. They are made from the following materials: composite aluminium panels, fibre cement, ceramics, glass fibre-reinforced concrete and laminate compact boards, steel sheeting without surface finish, artificial stone and facade wood.

Furthermore, industrially produced neutral and universal silicones from three different manufacturers (Tab. 1) were selected in such a way that various price levels were represented.

Tab. 1: An overview of selected sealants and the selected abbreviation system

Sealant	**Manufacturer**		
	Soudal	**Lučební závody**	**SILCO**
Silicone acetate	universal silicone (SO-U)	Lukopren UNI A (LU-U)	universal silicone (SL-U)
Silicone neutral	SILIRUB N (SO-N)	Lukopren UNI N (LU-N)	neutral silicone (SL-N)

In accordance with the relevant standard [9], 3 test specimens were fabricated for each substrate. Before testing, the samples were stored at a temperature of (23±2) °C and a relative humidity of (50±5) % for 28 days.

Execution of tests at a temperature of (23±2) °C

After the specified time, the samples were inserted into a testing machine, where there they were extended by 60% of the value of their original length at a speed of (5.5±0.7) mm/minute at a temperature of (23±2) °C. The extension was maintained in the clamping jaws at a temperature of (23±2) °C for a period of 24 hours.

Execution of tests at a temperature of (-22±2) °C

Before the test, the samples were stored at a temperature of (-22±2) °C. Afterwards, the test specimens were put into the testing machine and extended by 60% of the value of their original length at a temperature of (-22±2) °C and a speed of (5.5±0.7) mm/minute. The extension was maintained at a temperature of (23±2) °C for a period of 24 hours.

Adhesive and cohesive failures were detected and the specimens evaluated. Samples where no sealant failure occurred were marked satisfactory. The results were recorded in a table from which it is obvious which substrates exhibit better cohesion and adhesion with silicone sealants.

4 RESULTS

The results of the measurements were recorded in tables. Tab. 2 records the results during the specimen's extension by 60% of its original length for a period of 24 hours at a temperature of 23°C, while Tab. 3 shows the results obtained during the extension of the specimen by 60% of its original length for a period of 24 hours at a temperature of -20°C. The tables also record whether cohesive or adhesive failure occurred.
As a convenient sample of silicon sealant was evaluated the silicone that satisfied following requirements. As the convenient test sample (or test serie which consists of three test specimens) was evaluated the one that had not showed any violation. This means that when all test samples from one serie had not showed any violation then the tested combination of sealant and facade cladding had been marked pass. Thus the used combination of materials can be recommended. However, when only one of three test samples from one test serie had showed any violation then the selected combination of materials had been marked fail and the test serie had been evaluated as unsatisfactory.

Tab. 2: Results from specimen extension by 60% of original length for a period of 24 hours at a temperature of 23°C

Material of plate / Sealant	Laminate compact boards	CORTEN steel sheet	Fibre cement board	artificial stone	glass concrete	Composite aluminium panels	Wood	Ceramics
SO-U	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
SO-N	FAIL	FAIL	PASS	FAIL	FAIL	FAIL	FAIL	FAIL
LU-U	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	PASS
LU-N	PASS	FAIL	PASS	FAIL	FAIL	FAIL	PASS	FAIL
SL-U	FAIL	FAIL	FAIL	PASS	FAIL	FAIL	FAIL	PASS
SL-N	FAIL	FAIL	FAIL	PASS	FAIL	FAIL	PASS	PASS

Tab. 3: Results from specimen extension by 60% of its original length for a period of 24 hours at a temperature of -20°C

Material of plate / Sealant	Laminate compact boards	CORTEN steel sheet	Fibre cement board	artificial stone	glass concrete	Composite aluminium panels	Wood	Ceramics
SO-U	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
SO-N	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	PASS	PASS
LU-U	FAIL	FAIL	FAIL	PASS	FAIL	FAIL	FAIL	PASS
LU-N	PASS	FAIL	PASS	PASS	FAIL	FAIL	FAIL	FAIL
SL-U	FAIL	FAIL	FAIL	PASS	FAIL	FAIL	FAIL	PASS
SL-N	FAIL	PASS	FAIL	PASS	PASS	FAIL	PASS	FAIL

5 DISCUSSION

After finishing the measurements, which were carried out on the minimum allowed number of samples, it can be said that none of the sealants, even if they are classified as universal, can be used for sealing all building materials. It doesn´t appear to be necessary to carry out a greater amount of measurements in order to gain more precise results as there weren't any significant differences in the results for the individual samples for each sealant.

6 CONCLUSION

The aim of the research is to determine a type of sealant which will have the best cohesion with building material. Commonly available and used building materials and construction sealants were selected. On the basis of tests performed up to now it can be said that no type of sealant is suitable for sealing all building materials.

In tests carried out at a temperature of 23°C, SILIRUB N had the best results – it is a neutral silicone sealant which displayed very good cohesion with fibre cement board and plastic. Lukopren UNI N, another neutral silicone sealant, also performed relatively well – it has very good cohesion with ceramics.

In tests carried out at a temperature of -20°C, SILIRUB N sealants obtained the best evaluation – the product had very good results with wood, ceramics and glass concrete.

In general terms, SILIRUB N can be classified as a sealant which can be used with the widest possible range of building materials.

Sealants on a substrate board made from glass concrete had the worst cohesion properties; only SILIRUB N sealant passed. Elements made from ceramics exhibited the best cohesive properties during the tests carried out at -20°C

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