Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 13 (1988)

Artikel: Sealants: their use, properties and endurance

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DOI: https://doi.org/10.5169/seals-12975

Sealants – their Use, Properties and Endurance

Joints d'étanchéité – applications, propriétés et résistance

Dichtungen – Anwendungen, Eigenschaften, Festigkeit

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SUMMARY
The paper discusses briefly the methods for testing the material properties of sealants used in facade joints, a discussion of existing instructions for use, experiences of seals like found lacks and failures and presents the results of 18 years field experiments in Finland.

RÉSUMÉ
L'article traite des méthodes d'essais de joints d'étanchéité utilisés dans les façades. Il passe en revue les directives actuelles pour leurs applications, les expériences réalisées, les faiblesses et les dommages rencontrés et présente les résultats de dix-huit ans d'essais en Finlande.

ZUSAMMENFASSUNG
Dieser Beitrag diskutiert die Prüfmethoden für Dichtungen in Gebäudefassaden, die Gebrauchsanleitungen, die Erfahrungen und Schadenfälle. Die Ergebnisse von Aussenversuchen während 18 Jahren in Finnland werden beschrieben.

1. INTRODUCTION

The strengthening of joints in facade elements has been widely performed with sealants.

In facade joints sealants have to withstand the cyclic stresses due to movements of elements and degradating effects of weathering factors, especially sun radiation and moisture effects, without failure, for several years preferably as long as the facade surfaces.

In practice it has been found that failures with sealants in joints can occur after a relatively short period, 1...5 years after the sealing work.

Because of failures several questions and claims have been made regarding the serviceability of sealant materials in element joints in Nordic climates.

In order to give some references to questions and claims concerning durability of sealants some background information is given, results of field and laboratory experiments and failure examinations collected since the 1970.

2. PERFORMANCE AND MATERIAL REQUIREMENTS OF SEALANTS

The methods generally used for testing the properties of sealants in Nordic Countries are Nordtest Build test methods from 1976 [1]. At present the revision work is going on. According Finnish standards [2] the sealants, their shapes and dimensional requirements must be confirmed (tables 1, 2 and 3, figure 1). It should be noticed that the elongation properties required in each sealant group (table 2) mean elongation or adhesion loss in 100 mm long joint, sealed between concrete/aluminium supports, after heat ageing of 56 days at +70 ^{o}C and storage in cold water (+2 ^{o}C). The selection of the most suitable sealant dimensions in each case shall be performed according to the evaluated movements of the constructions to be sealed, (e.g. concrete elements), by using the equation 1.

$$d_{min}[mm] = \frac{d\ [mm]}{P\ [\%]} \cdot 100\ [\%] \qquad [1]$$

d_{min} is minimum width of the joint

d is the total movement of the joint width (thermal and moisture movements and drying shrinkage etc.)

P is the maximum allowable movement of the sealants (see table 1)

Table 1. Classification, information on usage and important. properties of sealants.

Sealant group	Group 1 Elastic sealants	Group 2 Elastoplastic sealants	Group 3 Film forming, plastic and oil based sealants
Examples of typical binders	polysufides polyurethanes silicones	butyl rubbers polyacrylates	oils (drying nondrying) artificial resins blendproducts
Dimensions of seals: maximum width minimum width	30 mm 6 mm	25 mm 8 mm	25 mm 10 mm
The greatest allowed movement (elongation/compression) of the joint width, P	25 %	15 %	10 %
Typical use arces	Facade sealants	Joints with small movements and protected against weather	

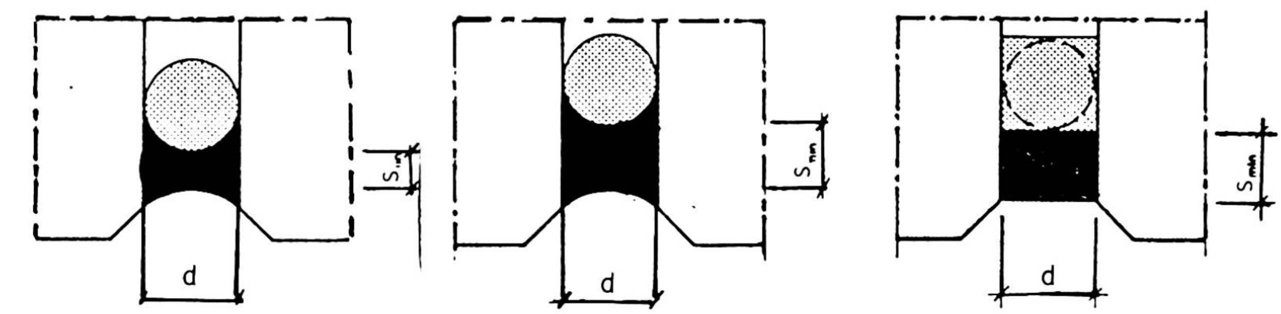
Table 2. Some requirements presented for sealant materials.

Property	Testing method	Sealant group 1	2	3
Elongation with max force, N	NT BUILD 004	≥100 %	≥20 %	≥15 %
Resistance to bases	NT BUILD 011	≥100 %	≥20 %	≥15 %
Shrinkage				
- free	NT BUILD 015	< 20 %	≤20	≤12 %
- restrained	NT BUILD 016	no cracks allowed		
Staining	NT BUILD 014	≤1 mm		
Radiation resistance	NT BUILD 020	no changes in a appearance		

d	Smin
6...12	4... 7
13...20	5... 8
21...30	6... 9

d	Smin
8...12	6...10
13...20	9...12
21...25	11...14

d	Smin
10...12	8...10
13...20	9...12
21...25	11...14



Group 1 sealants Group 2 sealants Group 3 sealants

Figure 1. The shapes of seals made of sealants classified according to groups 1...3.

Table 3. Dimensions of sealants according to sealant group.

Group 1 sealants		Group 2 sealants		Group 3 sealants	
Width, mm d	Thickness, mm S min	Width, mm d	Thickness, mm S min	Width, mm d	Thickness, mm S min
6...12	4...7	8...12	6...10	10...12	8...10
13...20	5...8	13...20	9...12	13...20	9...12
21...30	6...9	21...25	11...14	21...25	11...14

3. FIELD AND LABORATORY EXPERIMENTS

In 1969 field test of eight different sealants were begun (table 4). The test facade, located in Helsinki, (two storeys) consisted of 15 concrete elements, (2400 x 2750 mm), and was directed towards the south, without any protection from sunshine and rain.

Each of the sealants was inserted both into horizontal and vertical joints. The sealing works were performed according to the instructions of the manufacturers of the sealants. Round cellular PE-strips were installed under each sealant.

Table 4. The sealants and joint widths in the field test.

Sealant type	width of vertical joints, mm	width of horizontal joints, mm
1. polysulfide	17	12
2. polyacrylate	16	12
3. polysulfide	20	12
4. polyurethane	18	12
5. oil based product	14	15
6. polysulfide	14	15
7. polysulfide	20	25
8. polysulfide	23	25

The condition of sealants was observed visually up to spring 1987 (18 years) and by hardness measurements up to 1983 (13 years) (table 5). The same sealants, except one polysulfide, were examined in the laboratory. The measured elongation properties are given in table 6.

Table 5. Influences of natural exposure on joints sealed with sealants.

Type of the sealant	Changes in hardness (shore A)		Condition	
	orginal	after 13 years	after 13 years	after 18 years
1. polysulfide	30	45	ADEQUATE [3]	ADEQUATE
2. polyacrylate	30	65...70	vertical joint ADEQUATE horizontal joint GOOD	vertical joint BAD horizontal joint GOOD
3. polysulfide	35...40	45...50	ADEQUATE [2]	BAD
4. polyurethane	45...50	50...65	ADEQUATE	vertical joint ADEQUATE horizontal joint BAD
5. oil based product	40...70	>95	ADEQUATE	BAD
6. polysulfide	30	40	GOOD	vertical joint GOOD horizontal joint BAD [1]
7. polysulfide	40...45	40...45	GOOD	GOOD
8. polysulfide	25...30	15...20	BAD	

1) Level difference of about 15 mm between elements
2) Thickness of the sealant only 1 mm
3) Holes are located in the middle of bubbles

Table 6. Elongation properties of sealants (between Al-concrete substrates)

Sealant type	Elongation at max load after 56 days at +70 ^{0}C	
	test temperature +23 ^{0}C	test temperature -20 ^{0}C
1. polysulfide	200	170
2. polyacrylate blend	~30 (plastic)	<1
3. polysulfide	45	55
4. polyurethane	45	4
5. oil-based sealant	20	2
6. polysulfide	270	200
7. polysulfide	350	550

4. EXPERIENCES ON SEALANT FAILURES

The common failure causes of joints sealed with sealants (due to the) sealants occurring within five years are suumarized in table 7.

Because the sealants used in the example cases were polysulfides the cases should not be generalized to all sealant types. All the cases are under 5 years old.

Table 7. The common failure causes of facade sealants.

Failure type	Cause of the failure
- Cracks in sealant	- Too thin sealant layers (1...2 mm thicknesses)
- Adhesion losses - Adhesion losses or cohesion brakes in element surfaces	- Wet joint surfaces during the sealing (salts adhered to sealant) - Too thick sealants compared to width
- Cracks and adhesion losses	- Too small joint and sealant widths compared to element sizes (for example 6 mm joints between 5 m elements)
- Outswelling of the sealants	- Element movements have concentrated and caused narrowing of joints
- Bubbling and perhaps small holes in the bubbles	- In the installation work the surface of the closed cell bottom list has been broken and cellgases have caused bubbling

5. CONCLUSIONS

On the basis of performed field and laboratory experiments and experiences of failure researches the following conclusions can be made:

- The properties of the sealant type influences greatly the durability of the joint. According to the elongation and aging tests (table 6) the best products in the field could also be predicted. An exception was polyacrylate blend sealant which had a better durability in the field than was expected.

- After 18 years exposure there were several sealants which were in good condition without leakage and other failures.
- According to our knowledge, perhaps the most common failure causes are the wrong dimensions of sealants, because of either careless sealing work or careless element installations.

- Taking account of the knowledge gained and also the fact that the sealant materials have been developed during the period 1970.to.1987, it should be quite possible to achieve service lives of 20 years with sealants installed and selected according instructions.

References

1. Register of Nordtest-methods, Nordtest docgen 017, 1986.
2. Joints in external walls, sealing with sealants RT 80-10100 Rakennustietosäätiö, 1980.