

Dependence between the width of strip overlap and the strength of joints of one-layer bitumen sheets

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Abstract. This paper focuses on the examination of mutual dependence of overlap width of bituminous sheets and the strength characteristics of their mechanically fastened joints. Bituminous sheets with two different widths of overlap and different degree of modification were selected as samples for experimental measurements. They are supposed to be used as single-layer mechanically fastened waterproofing membranes. The aforementioned dependence has not been explicitly documented yet. The aim of this paper is to confirm or to refute a hypothesis that a relationship exists between a different width of overlap of bituminous sheets and the strength of their joints. The formulation of the results was based on the statistical evaluation of laboratory measurement data.

1 Introduction

The use of one-layer mechanically fastened systems is mostly based on meeting the basic requirements and technological regulations specified by manufacturer.

High quality bitumen sheets with the total width of min. 5.0 mm are used for one-layer systems from bitumen sheets. Bitumen coating layer must be of sufficient quality to allow good welding properties and long-term flexibility. The sheets are most commonly reinforced with a combination of PES fleece strengthened with glass fibres laid in one or both directions. The sheet overlaps are usually set to min. 120 mm, although there are also sheets for which manufacturer specifies the overlap to just 100 mm.

The critical joint spot is the presence of fastening element as a spot where force effects caused by wind sucking are captured. Full scale fusion of sufficient width of the joint is a basic requirement to provide waterproofing system ability and to transfer force effects caused by wind sucking.

2 Overlaps of bitumen sheets

The existing standards in force related to waterproofing membranes fail to specify the size of joints. Joints are only specified in ČSN EN 13707+A2. Flexible sheets for waterproofing

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– Reinforced bitumen sheets for roof waterproofing – Definitions and characteristics [2], however, minimum joint length is missing.

Therefore, the minimum overlap width is fully in competence of bitumen sheet manufacturers. The overlap width particularly depends on the application method of the bitumen sheet (roof cladding, substructure, one-layer or multi-layer system), on the presence of a fastening element in the joint, on surface treatment of bitumen sheet, and on joint type – whether longitudinal or transversal overlap is concerned. Regarding longitudinal overlap of one-layer mechanically fastened bitumen sheets, the minimum width is usually set by manufacturers to 120 mm, exceptionally 100 mm. The width in transversal direction (front joint) ranges between 100 mm and 150 mm.

3 Experimental measurement

A pressure chamber was used in which the composition of a roof membrane from a real joint segment of mechanically fastened waterproofing could be subjected to defined stresses. This wind load test is defined in the Approval Guideline for systems of mechanically fastened waterproofing membranes ETAG 006 [6].

Experimental measurements tests were carried out on a standard tensile testing machine. The samples were roof membrane segments, not just the waterproofing membrane. Two metal fastening strips in the arms of the upper grip of the machine held the waterproofing membrane in place. These arms transferred the force of the applied stress to the tested material. A pad, to which the waterproofing membrane was fastened by thermal insulation, was clamped into the lower grip. As the lower grip of the tensile testing machine receded, it applied stress on the joint and subsequently its rupture.

The test samples were prepared according to composition variant S1, i.e. analogically for a roof without thermal insulation with the waterproofing membrane mechanically fastened to OSB board of 22 mm thickness. The fastening element to the hard base was a screw with a metal oval washer. The edge of the pressure washer of the fastening element was located 10 mm from the edge of the lower bitumen sheet. The use of the oval pressure washer was intentional because it provides better pressure on the lower sheet thanks to its larger surface area. As a result, the rupture of the test samples depended on the parameters of the bitumen sheet rather than on the failure of the fastening element.

Three bitumen sheet variants were chosen as the waterproofing membranes:

- 1. Test sample F** - SBS modified bitumen sheet 5.2 mm thick, carrier: PES 180 g/m², reinforced on both sides with glass fibres, flexibility at low temperatures: -25 °C, joint length 100 mm;
- 2. Test sample G** - SBS modified bitumen sheet 5.2 mm thick, carrier: PES 180 g/m², reinforced on both sides with glass fibres, flexibility at low temperatures: -25 °C, joint length 120 mm;
- 3. Test sample A** - SBS modified bitumen sheet 5.0 mm thick, carrier: PES 180 g/m², reinforced longitudinally with glass fibres, flexibility at low temperatures: -20 °C, joint length 100 mm;
- 4. Test sample D** - SBS modified bitumen sheet 5.2 mm thick, carrier: PES 180 g/m² reinforced on both sides with glass fibres, flexibility at low temperatures: -25 °C, joint length 120 mm.



Fig. 1. Testing sample - composition variant S1 [1].



Fig. 2. Testing sample in tensile testing machine during test [1].

4 Evaluation

Approximately 10 samples were used for each testing sample. The resulting force is in the form $\bar{x} \pm \bar{\vartheta}(\bar{x})$, where \bar{x} is the arithmetic average and $\bar{\vartheta}(\bar{x})$ is the probable measurement error. The latter was determined on the basis of the error theory for deviations of arithmetic average using the formula:

$$\bar{\vartheta}(\bar{x}) = \frac{2}{3} \sqrt{\frac{1}{n(n-1)} \sum_{i=1}^n (x_i - \bar{x})^2} \quad (1)$$

5 Results of experimental measurement and discussion

Comparing the measurement results of samples F and G (Fig. 5), there is just a small difference in reached strengths of mechanically fastened joints. Sample F with joint length of 100 mm only showed 5% lower values than sample G (joint 120 mm).

This difference would probably be higher (Fig. 6) for bitumen sheets with lower degree of modification (flexibility at low temperatures -20°C). This comparison is not fully representative, since the parameters of samples A and D differed by carrier type and total sheet width. Nevertheless, the strength of testing sample A (joint 100 mm) was approx. 22% lower than the strength of testing sample D (joint 120 mm).

Detailed results and the comparison of results of all samples are shown in Table 1.



Fig. 3. Unsealed joint near a fastening element and beginning of its deformation – sample G [1].



Fig. 4. Distinct unsealing of joint of testing sample A [1].

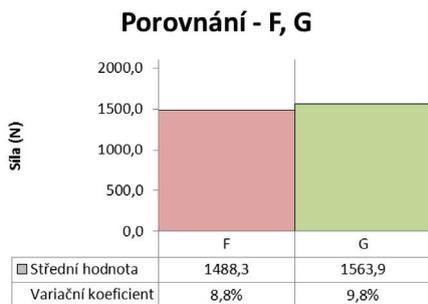


Fig. 5. Comparison of samples F and G (SBS modified bitumen, -25°C) [1].

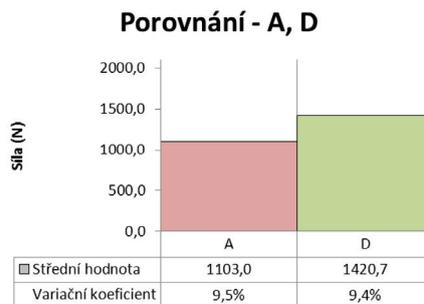


Fig. 6. Comparison of samples A and D (SBS modified bitumen, -20°C) [1].

Table 1. Comparison of testing samples.

Test sample:	F	G	A	D
Bitumen substance:	SBS modified			
Flexibility at low temperatures:	-25 °C		-20 °C	
Sheet thickness:	5.2 mm		5.0 mm	5.2 mm
Carrier:	PES reinforced on both sides, 180 g/m ²		PES reinforced longitudinally, 180 g/m ²	PES reinforced on both sides, 180 g/m ²
Overlap width:	100 mm	120 mm	100 mm	120 mm
The highest tensile strength:	longitudinally: 900 (± 200) N/50mm, transversally: 650 (± 150) N/50mm		longitudinally: 900 (± 200) N/50mm, transversally: 700 (± 150) N/50mm	
Ductility:	longitudinally and transversally: 45 (± 10) %		longitudinally and transversally:	longitudinally and

			50 (± 10) %	transversally: 45 (± 10) %
Mean value:	1 488.3 N	1 563.9 N	1 103.0 N	1 420.7 N
Standard deviation:	131.6 N	153.2 N	104.8 N	134.0 N
Variation coefficient:	8.8%	9.8%	9.5%	9.4%

6 Conclusion

Based on the experiment results, it can be assumed that the length of bitumen sheets with higher degree of modification has no significant effect on the resulting strength of a mechanically fastened joint. Regarding sheets with lower degree of modification, it is assumed that the resulting strength depends on the length much more.

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