Sealing of Window and Door Joints in Timber Frame Buildings and Watertightness

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ABSTRACT

The harsh Norwegian climate requires that buildings to be designed to high standards. Global warming is making the built environment even more vulnerable. Climate change will mean more extreme weather conditions, and buildings will have to withstand greater stresses related to water penetration and air leakages. The sealing methods used in the joints between the wind barrier and the window or door frame result in different properties of air- and watertightness, which influence the building's thermal properties. Some sealing methods highly depend on the performance of the craftsman.

Air- and watertightness of the joints are tested at static air pressure differences over the test section consisting of a window frame with size 1.2 m × 1.2 m mounted in a timber frame section with size 2.4 m × 2.4 m. Several types of wind barriers and sealing methods are tested. The different air barriers tested are asphalt-impregnated porous fiberboard, gypsum board, and spun-bonded polyethylene. The different sealing materials tested are strips of spun-bonded polyethylene clamped with battens, adhesive tape, and sealing compound of acrylic paste. The paper presents the watertightnesses for the different sealing methods. The results will influence on SINTEF's recommendations for sealing methods in joints between the building construction and the window or door frame. (SINTEF Building and Infrastructure is Norway's leading disseminator of research-based knowledge to the construction industry; their building research design guides and other publications provide guidance on specialist building issues.)

INTRODUCTION

Laboratory tests can specify the resistance to water penetration through the wind barrier and the sealing of window and door joints in timber frame constructions. Testing of the resistance to driving rain under static pressure in a test chamber gives the opportunity to quantify and compare how watertight the different wind barrier materials and sealing methods are. The watertightness of the wind barrier is particularly relevant for the building period. The wind barrier's ability to withstand water penetration is also important when choosing wind barrier materials and sealing methods, depending on the weather conditions where the building is situated. The performance of the cladding and the rain shield outside the wind barrier has a great influence on the amount of rain that can drive into the wind barrier. To quantify the wind barrier's watertightness, the tests are performed on test sections without any rain shield.

TEST METHOD

The watertightness was tested in accordance with *EN Standard 1027, Windows and Doors Watertightness Test Method*, method 1A—static pressure. This method is designed to determine the watertightness of completely assembled windows and doors, and is also suitable to determine the watertightness of a wall section. Following the test method, a test section with size 2.4 m × 2.4 m was mounted in a test chamber. Inside the test chamber, a controlled static pressure can be applied across the specimen and a spraying system can apply a continuous, regularly dispersed film of water all over the surface of the test section. The water was sprayed in an angle

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Figure 1 *Nozzles inside the test chamber, spraying water over the test section.*

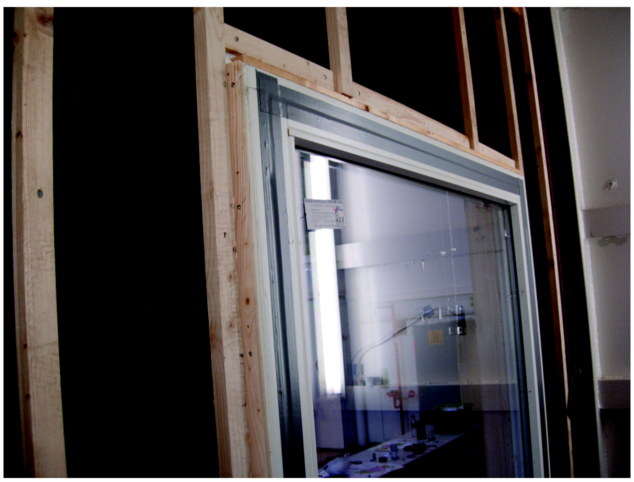

Figure 3 *Test section with wind barrier of asphalt-impregnated fiberboard and window sealed with spun-bonded polyethylene.*

of 114° onto the top of the test section through five nozzles in a rate of approximately 2 L/min per nozzle. The test began with 15 min of spraying water before a static pressure was established across the test section. The watertightness was tested in 10 min on each of the pressures 50 Pa, 100 Pa, 150 Pa, 200 Pa, 250 Pa, 300 Pa, 450 Pa, and 600 Pa. The penetration of water was observed visually during the testing. Location, point in time, and pressure were continuously registered during testing. Figure 1 shows a picture taken inside the test chamber during testing when water was sprayed on the test section.

TEST SECTIONS

The test section consisted of a wind barrier and a window assembled in a timber frame. The timber frame consisted of sills and studs in dimensions 36 mm × 148 mm. The studs were mounted with a center distance of 600 mm. The window was

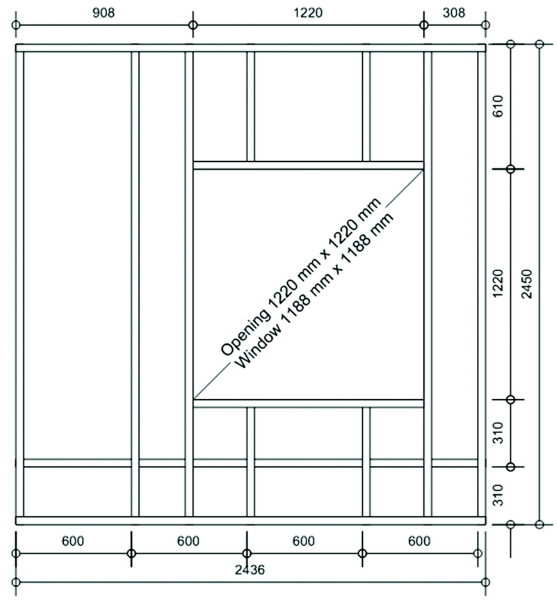

Figure 2 *Schematic of timber frame inside the test chamber.*

assembled in an opening 1220 mm × 1220 mm. The wind barrier was applied with both vertical and horizontal joints. The outside window frame was placed 42 mm out from the wind barrier. The timber frame is shown in Figure 2. Figures 3 to 8 show the various test sections in detail. Table 1 summarizes the test sections' characteristics.

TEST RESULTS

The watertightness of the test sections is presented in column charts. Each column show the highest registered pressure across the test section where no leakages were observed.

Wind Barrier of Asphalt-Impregnated Fiberboard

Four different wall sections with fiberboards were tested in the test chamber. The test results are presented in the Figures 9 and 10.

Wind Barrier of Gypsum Board

Three different wall sections with gypsum boards were tested in the test chamber. The test results are presented in the Figures 11 and 12.

Wind Barrier of Spun-Bonded Polyethylene Flexible Sheets

Two different test sections with spun-bonded polyethylene were tested in the test chamber. The test results are presented in the Figures 13 and 14.

DISCUSSION AND CONCLUSION

The testing gives the opportunity to evaluate the resistance to water penetration through the different wind barrier

Table 1. Overview of Test Sections

No.	Wind Barrier	Vertical Joint	Horizontal Joint	Window Sealing
1	Asphalt-impregnated fiberboard	Battens nailed down to cover the joint	No joint	Strips of spun-bonded polyethylene lapped over the fiberboard on wall. Battens nailed down to window frame.
2	Asphalt-impregnated fiberboard	Battens nailed down to cover the joint	No joint	Sealing compound of acrylic paste.
3	Asphalt-impregnated fiberboard	No batten	Strips of spun-bonded polyethylene. Battens nailed down to cover the joint.	Strips of spun-bonded polyethylene lapped under the fiberboard on wall. Battens nailed down to the window frame.
4	Asphalt-impregnated fiberboard	Battens nailed down to cover the joint	Strips of spun-bonded polyethylene. Battens nailed down to cover the joint.	Adhesive tape adhered down to the fiberboard and into the window frame.
5	Gypsum board	No batten	Plastic list H-profile	Strips of spun-bonded polyethylene lapped over the gypsum board. Battens nailed down to the window frame.
6	Gypsum board	Battens nailed down to cover the joint	Plastic list H-profile	Sealing compound of acrylic paste.
7	Gypsum board	Battens nailed down to cover the joint	Plastic list H-profile	Adhesive tape adhered down to the gypsum board and into the window frame.
8	Spun-bonded polyethylene flexible sheets	100 mm overlap, Battens nailed down to cover the joint	100 mm overlap Battens nailed down to cover the joint	Strips of spun-bonded polyethylene lapped over the wind barrier. Battens nailed down to the window frame.
9	Spun-bonded polyethylene flexible sheets	100 mm overlap Battens nailed down to cover the joint	100 mm overlap Battens nailed down to cover the joint	Adhesive tape adhered down to the wind barrier and into the window frame.

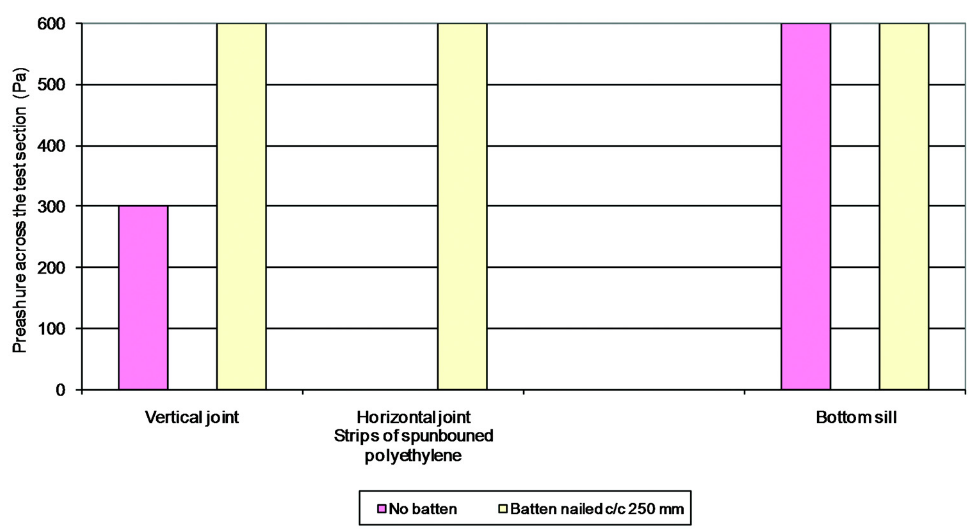

Figure 9 *Watertightness to test section with fiberboard. Watertightness was tested in vertical joint, horizontal joint, and down at bottom sill.*

materials and design of the wind barrier and sealing of window joints. The test results, however, must be considered only as informative. Testing in laboratory is ideal and does not give the variation in materials and workmanship that we can have on the building site. It was not possible to quantify the amount of water in the different leakages. During the test, with increasing water flow, it also was difficult to point out new points of leakages. All leakages were attempted to be registered at the pressure when they first occurred. Very small leakages (e.g., a few drops that clearly decreased), however, were not registered. Even though we will have a rain shield on the finished wall, extreme weather with driving rain may cause water to be forced into the wind barrier and create leaks, as in the tests.

Wind Barrier of Asphalt-Impregnated Fiber Board

The vertical joint with battens nailed down every 250 mm was watertight at 600 Pa. The horizontal joint with strips of spun-bonded polyethylene and battens nailed down every 250 mm was watertight at 600 Pa. The edge beneath the test section with batten nailed down every 250 mm was watertight

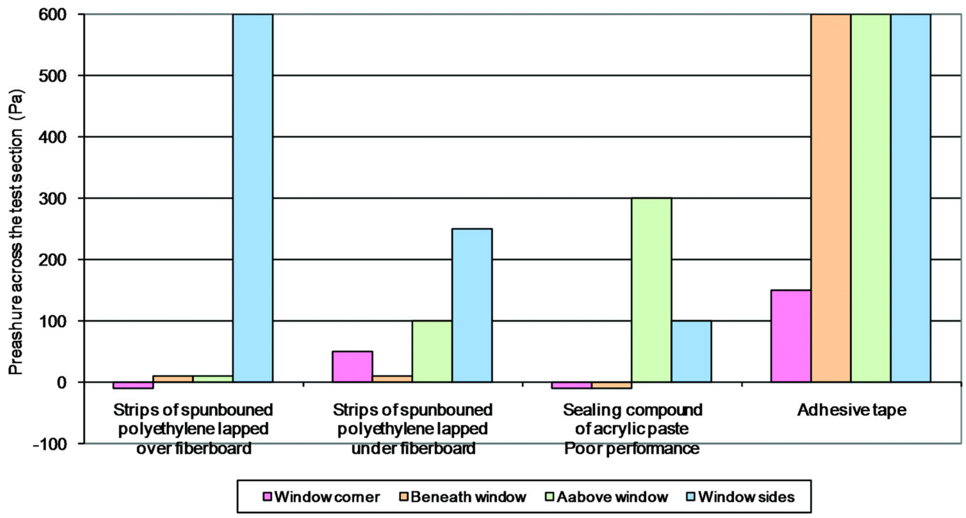

Figure 10 *Watertightness of the different sealing methods on test section with fiberboard. Leakages observed without any pressure across the test section are indicated with a column below from the zero axis. Leakages observed at 50 Pa pressure across the test section are indicated with a column above the zero axis.*

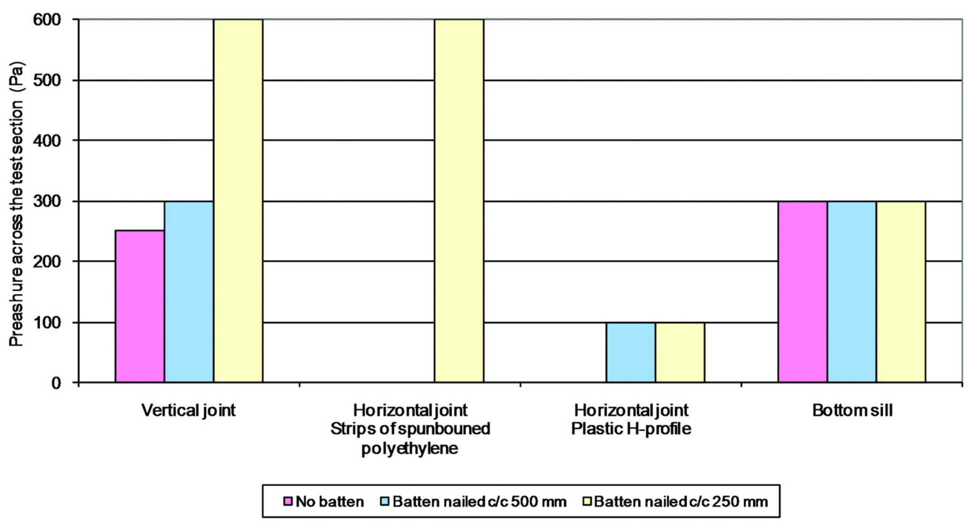

Figure 11 *Watertightness of the test section with gypsum board. Watertightness was tested in vertical joint, horizontal joint, and down at bottom sill.*

Figure 12 *Watertightness of the different sealing methods on test section with gypsum board. Leakages observed without any pressure across the test section are indicated with a column below the zero axis. Leakages observed at 50 Pa pressure across the test section are indicated with a column above the zero axis.*

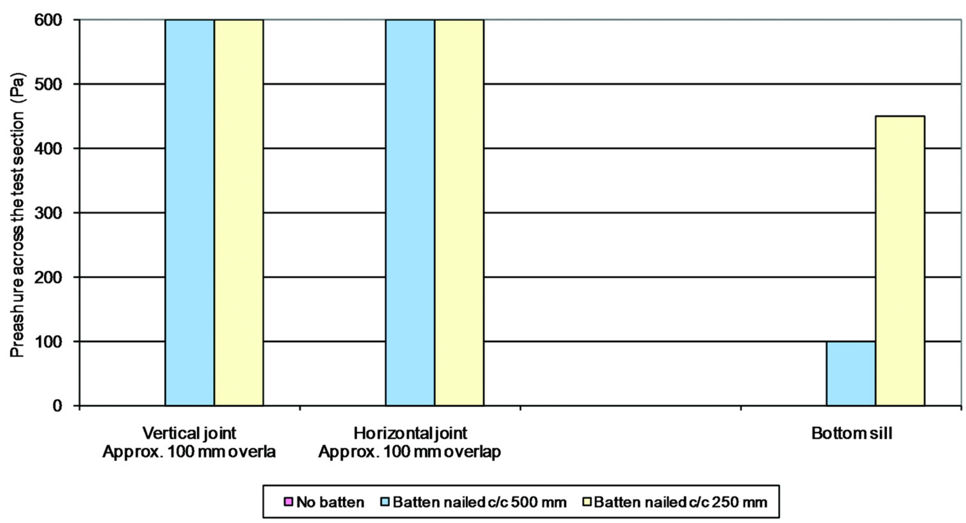

Figure 13 *Watertightness of test section with spun-bonded polyethylene. Watertightness was tested in vertical joint, horizontal joint, and down at bottom sill.*

at 600 Pa. Summarized, the test section with fiber boards and battens nailed down every 250 mm was watertight at 600 Pa.

Wind Barrier of Gypsum Board

The vertical joint with battens nailed down every 250 mm was watertight at 600 Pa. However, leakages were registered without any pressure across the test section where vertical joint ended out in the window and the horizontal joint. The horizontal joint with strips of spun-bonded polyethylene and battens nailed down every 250 mm was watertight at 600 Pa. The horizontal joint with plastic H-profile was watertight at 100 Pa. The edge beneath on the test section with batten nailed down every 250 mm was watertight at 300 Pa. Summarized, the test section with gypsum boards cannot be considered as watertight since leakages were registered without any pressure across the specimen.

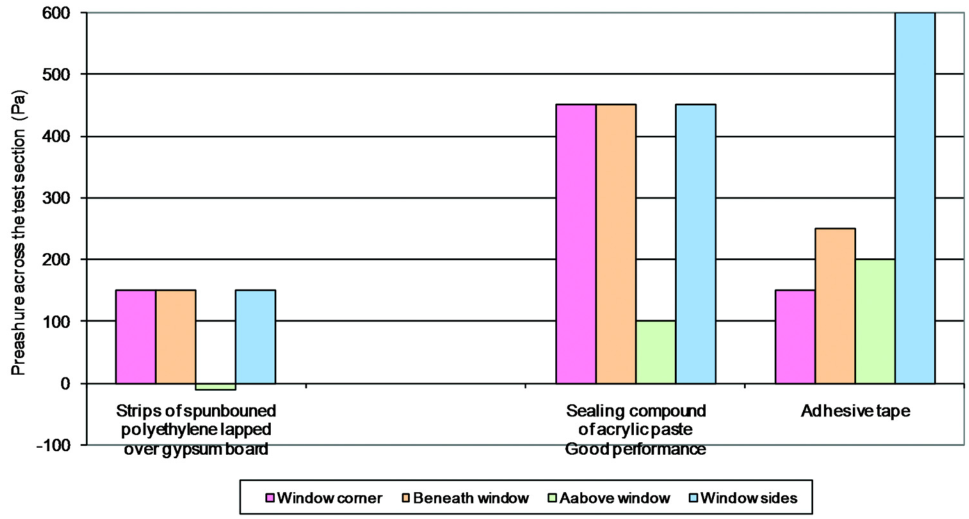

Figure 14 *Watertightness of the different sealing methods on test section with spun-bonded polyethylene. Leakages observed without any pressure across the test section are indicated with a column below the zero axis. Leakages observed at 50 Pa pressure across the test section are indicated with a column above the zero axis.*

Figure 4 *Test section with wind barrier of asphalt-impregnated fiberboard and window sealed with adhesive tape.*

Wind Barrier of Spun-Bonded Polyethylene Flexible Sheets

Both the vertical and the horizontal joints with approximately 100 mm overlap and battens nailed down every 250 mm was watertight at 600 Pa. The edge beneath on the test section with batten nailed down every 250 mm was watertight at 450 Pa. Summarized, the test section with spun-bonded polyethylene flexible sheets and battens nailed down every 250 mm was watertight at 450 Pa.

Figure 5 *Test section with wind barrier of gypsum board; window sealed with spun-bonded polyethylene.*

Sealing of Window Joints with Strips of Spun-Bonded Polyethylene

Sealing of window joints with strips of breather membrane has been common for several decades, and is still recommended in SINTEF design sheets. The testing showed early leakages. The wooden window frame has several grooves, which prevent good tightening when the batten is nailed down to the window frame.

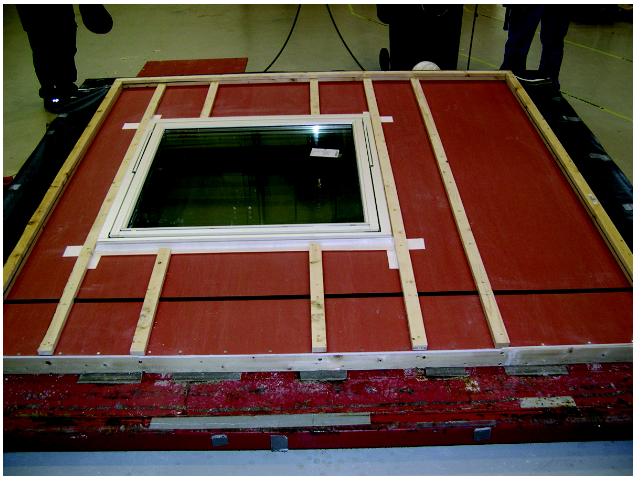

Figure 6 *Test section with wind barrier of gypsum board; window sealed with adhesive tape and horizontal joint performed with plastic H-profile.*

Fiberboard. Strips of spun-bonded polyethylene combined with fiberboard was not watertight with pressure difference across the specimen.

Gypsum Board. Strips of spun-bonded polyethylene combined with gypsum boards were watertight at 150 Pa. Leakages in vertical joint above window gave some leakages without any pressure across the specimen.

Sealing of Window Joints with Sealing Compound

Sealing compound is often used to seal window joints, and is recommended in SINTEF design sheets. Sealing compound of acrylic paste was tested on two different test sections. It is of vital importance that the sealing compound is applied with the best possible workmanship. Provided good application, sealing of window joints with sealing compound is watertight at 100 Pa.

Sealing of Window Joints with Adhesive Tape

Sealing of window joints with adhesive tape has earlier not been recommended by SINTEF. The durability of adhesive tape has up to now not been sufficient documented. Several tape products is now tested for durability and can document lasting adhering properties for many years. The adhesive tape used in these tests can document good long-term adhering. It is of vital importance that the tape is applied with the best possible workmanship. It is difficult to apply the tape with good tightening, particularly around the corners of the window frame. Sealing with tape was tested with wind barrier of both fiberboard, gypsum board and spun-bonded polyethylene. Sealing of window joints with adhesive tape was watertight at 600 Pa along the sides of the window frame and at 150 Pa around the corners.

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Figure 7 *Test section with wind barrier of spun-bonded polyethylene and horizontal joint performed with 100 mm overlap nailed down with batten.*

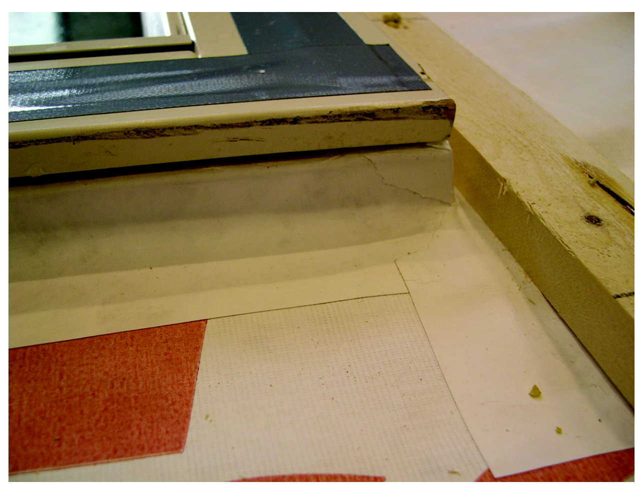

Figure 8 *Test section with wind barrier of spun-bonded polyethylene and window sealed with adhesive tape.*

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