7th International Building Physics Conference

IBPC2018

Proceedings

SYRACUSE, NY, USA

September 23 - 26, 2018

Healthy, Intelligent and Resilient
Buildings and Urban Environments

ibpc2018.org | #ibpc2018

Rain-tightness of door sill sealing

Lars Gullbrekken[1,*], Steinar Grynning[1]

[1] Department of Materials and Structures, SINTEF Building and Infrastructure, Trondheim, Norway

Corresponding email: Lars.gullbrekken@sintef.no

ABSTRACT

The harsh Norwegian climate requires buildings designed according to high standards. The airtightness of the building envelope is crucial to attain an energy efficient building and to avoid moisture problems. A considerable part of building defects registered in the SINTEF Building defects archive are related to leakages through door sills especially in combination with balconies.

The aim of the study has been to examine the rain tightness of the joint below door sills. A laboratory investigation using a driving rain cabined according to EN 1027 has been conducted to provide answers to the matter. In total 14 different test were conducted. Two different sills were included, both a traditional "high" sill and a "lower" handicap-sill. Two different underlays for the sill were included in the investigation. In addition, 3 different heights of the joint-sealing below the sill were chosen (0, 5 and 10 mm). All the tests except two were performed with silicon as joint sealant material.

It was found that the workmanship of the joint-sealing was challenging due to the geometry of the detail. Even if the silicon sealant was carefully applied, voids between the sealant and door sill were found when inspecting closely. When improving the faults, the test showed that the joints was tight. 11 of the 14 tests showed no water leakages at 600 Pa pressure difference. However, leakages were observed at lower pressure differences for the sills with no silicon sealing and for the configurations where there were faults in the silicon sealing.

The laboratory study revealed that the joint below the door sill is vulnerable to small mistakes in the workmanship. Given a carefully application and control of the silicon sealing it is possible to achieve a high water tightness performance. However, improvements to the sealing detail is needed to further increase the robustness of the detail.

KEYWORDS

Laboratory investigation, Driving rain, Door sill

INTRODUCTION

Norway is characterized by an extremely varied climate, the rugged topography and long coastline being one of the main reasons for large local differences over short distances and extreme seasonal variations (O'Brien et al., 2004). The climate puts a great demand on the building envelope of Norwegian buildings. The building envelope may be exposed to severe winds, snow loads, precipitation, freeze/thaw cycles, and rather large temperature fluctuations. The Norwegian report "Climate in Norway 2100" is an updated scientific base for climate adaptation in Norway (Bauer et al., 2015). By assuming a further increase in the greenhouse gas emissions, the climate scenarios show an increase in the yearly precipitation by 10-20 %

depending on the climatic model used. Heavy showers will occur more frequently and rainfall flood become more powerful and occur more often.

Increased precipitation is also affecting the strain from wind-driven rain. Wind-driven rain is one of the most important moisture sources affecting the hygrothermal performance and the durability of building facades (Blocken and Carmeliet, 2012; 2004). Measures to adapt the built environment to the anticipated climate changes were studied by Lisø (2006). Lisø stresses the immediate need for information and research with respect to vulnerably in the built environment and technical solutions. This to prevent or minimize negative climatic impacts on buildings.

The SINTEF Building Research design guidelines recommends a rain tightness performance of the wind barrier of minimum 300 Pa (SINTEF, 2007). Skogstad et al. (2011) performed laboratory testing of the rain tightness of wind barriers and sealing around windows. The tests were performed with a pressure difference ranging from 0-600 Pa. Sealing compound of acrylic was found to be rain tight at 100 Pa pressure difference.

Both the Norwegian planning and building legislation (TEK) and the Equality and Anti-Discrimination Act (Lovdata, 2018) dictates that housings should be available for all people. This entails the need for level door sills which can easily be crossed by wheelchairs. As a result, the height of door sills must not exceed 25 mm. This applies to the height difference between the interior floor and the top of the door sills, as well as the difference in height between outdoor surfaces and the top of the door threshold. Hence, these solutions require level interior and exterior surfaces. This increases the risk for static pressure of water as well as presence of snow and freeze/thaw cycles in front of the sill. A robust solution is proposed in the SINTEF Building Research Design Guidelines which includes a gutter in front of the door to direct the water away from the detail (as seen in Figure 1). However, this solution is costly due to material and time use.

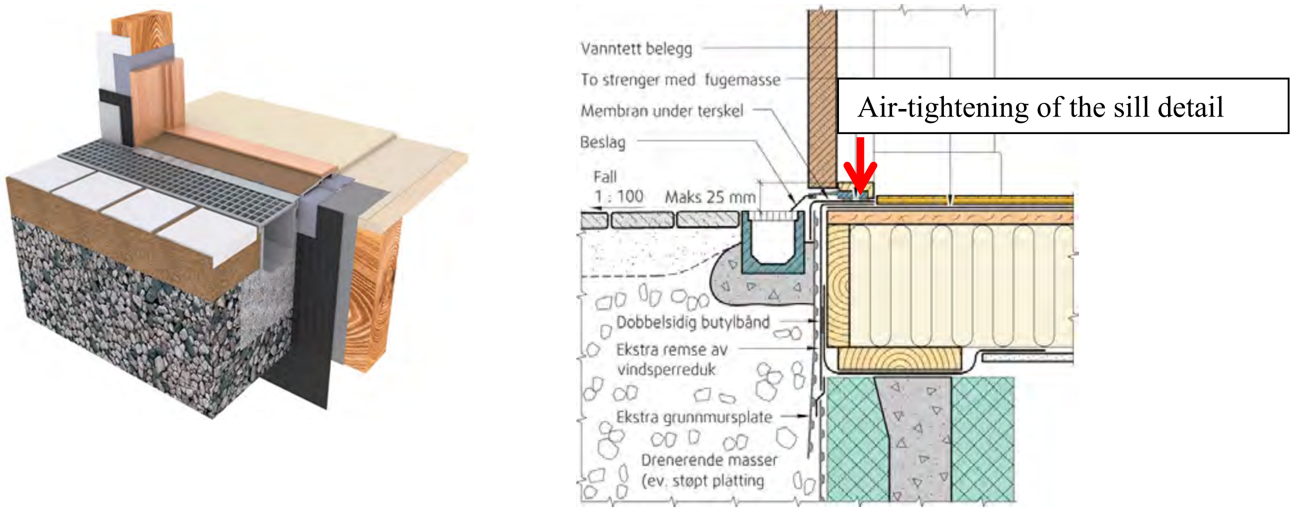

Figure 1. Level door details from the SINTEF Building Research design guidelines 523.731 (SINTEF, 2010).

The purpose of the study has been to examine the rain tightness of the joint below the door sill. A laboratory investigation using a driving rain cabined has been conducted to provide answers to the matter. Tests have been carried out according to EN 1027 (Standard Norge 2016). In total 14 different test sections were tested. Two different sills were included; a traditional "high" sill and a "lower" handicap-sill. Two different underlays (wood and radon-membrane) for the sill were included in the investigation. In addition, 3 different heights of the joint below the sill were tested (0, 5 and 10 mm). All the tests except two were performed with silicon as the joint sealant material. The remaining were sealed with no use of sealant.

METHOD

Test method

The water tightness was tested in accordance with EN 1027 *Windows and doors Water tightness Test method, method 1A – static pressure* (Standard Norge, 2016). The method is designed to determine the water tightness of completely assembled windows and doors. It is also suitable to determine the water tightness of wall sections. Inside the test chamber a controlled static pressure can be applied across the specimen and a nozzle system can apply a continuous regularly dispersed film of water all over the surface of the test section. The water is sprayed by nozzles at an angle of 84° onto the test section at a rate of approximately 2 l/min per nozzle. The test begins with 15 minutes of water application before a static pressure is established over the test section. The water tightness are tested with 5 minute intervals at pressure differences of 50, 100, 150, 200, 250, 300, 450 and 600 Pa. The penetration of water is observed visually during the testing. Location, point in time and pressure is continuously registered during the tests.

Figure 3. Test equipment for testing according to EN 1027. (left) nozzle system. (right) an example of a door mounted in the apparatus.

Design of the specimens

Testing of a worst-case scenario with no exterior flashings and gutters gives conservative results. Hence, test specimens were designed by fixing the door sill to a wood sill or a radon membrane with three different joint heights, see Figure 4, 5 and 6. Six of the specimens were designed with a radon membrane between the door sill and the wood sill. A foam gasket was positioned into the joint as a backing material for the compound sealant. The joint was then sealed with silicon compound exterior to the gasket. The sealing of the test samples were carried out as close to a real-life situation for application as possible. The test specimens were positioned on the floor when applying the silicon compound.

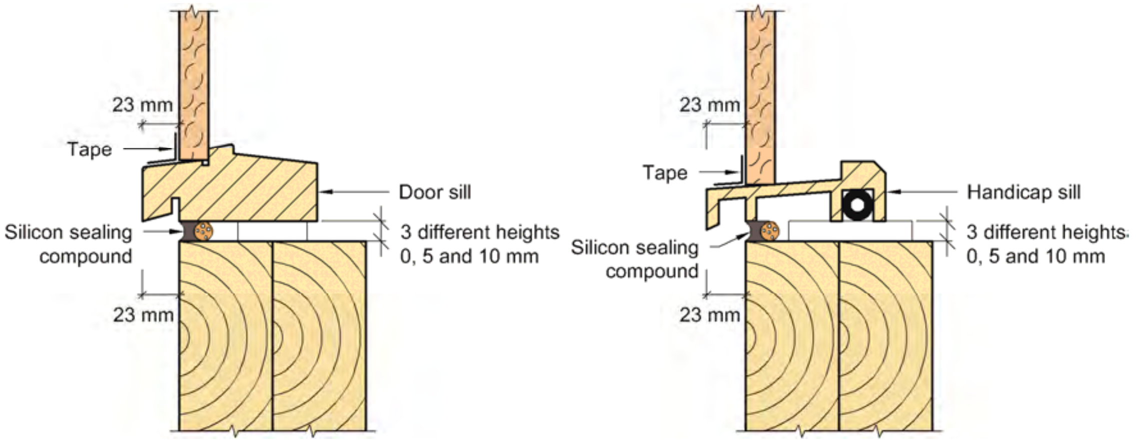

Figure 4. Design of the test specimen.

Figure 5. Standard door sill.

Figure 6. Handicap door sill.

RESULTS

Challenges related to the workmanship of the application of the silicon compound was encountered even in a controlled laboratory environment and when carried out by qualified craftsmen. When applying the sealing compound as carefully as possible (see Figure 7), small faults were found by close inspection, as seen in Figure 8.

Figure 7. Application of silicon compound.

Figure 8. Small defects in the silicon compound was found by closer inspection.

Visual inspections of the specimens were carried out during the tests. The location of leakages occurring at given air pressure differences were registered during tests. It was not practically feasible to register the amounts of the water leakages. Test results are shown in Table 1.

Table 1. Results from the driving rain measurements.

	Without sealing 0 mm	0 mm	5 mm	10 mm
HC without radon	Leakages at 50 Pa	No leakages	No leakages	No leakages
HC with radon		No leakages	No leakages	No leakages
Regular without radon	Leakages at 250 Pa	No leakages	No leakages	Leakages at 0 Pa
Regular with radon		No leakages	No leakages	No leakages

DISCUSSIONS

Based on the performed tests it is possible to evaluate the resistance of water penetration through the door sill structure. Laboratory testing is carried out under controlled conditions and does not represent the variation in building materials and workmanship as it would be on a building site.

The workmanship of the sealing of the joint was challenging due to the geometry of the detail. Even if the silicon sealant was carefully applied, voids between the silicon sealant and the door sill were found when inspecting closely. When improving the faults, the test showed that the joints were surprisingly tight. Most of the tests showed no water leakages at 600 Pa pressure difference. According to the SINTEF Building Research design guidelines this is *high performance*. However, leakages were observed at lower pressure difference for the sills with no silicon sealing and at faults in the silicon sealing. This indicates that the detail is vulnerable and that great care should be taken when applying the silicon sealant. The performance of the sealed joint is depending on the workmanship of the craftsmen. In order to further improve the robustness of the detail there is a need to introduce sealing methods which ensure high performance more independently of workmanship.

The handicap sill with sealing compound was found to be watertight at 600 Pa. Without sealing compound water leakages were registered at 50 Pa pressure difference. High performance was also found for the regular door sill except for the 10 mm joint height without radon membrane where water leakages was observed at 0 Pa pressure difference. By closer inspection it was observed that the water leakage was caused by small imperfections in the sealing compound. Based on the measurement campaign we were not able to reveal any difference between underlay of wood and underlay of radon membrane indicating that the silicon sealant had sufficient adhesion between the door sill and radon membrane.

CONCLUSIONS

A laboratory study was conducted in order to examine the rain tightness of the joint below a door sill. Most of the tests showed no water leakages at 600 Pa pressure difference. Given a careful application and control of the silicon sealing it is possible to achieve high water tightness performance However, the laboratory study revealed that the joint below the door sill is vulnerable to small mistakes in the workmanship. To further improve the robustness of the detail an improved sealing method is needed.

ACKNOWLEDGEMENT

The experiments were carried out as part of the *Tall Timber Facades* project (part of the WoodWisdom 2014-2017 program). The authors also acknowledge the Centre for Research-based Innovation "Klima 2050" for providing necessary funding.

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