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Results from laboratory tests of wind driven rain tightness in more than 100 facades and weather barriers

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SUMMARY:

Over the past five years SP Technical Research Institute of Sweden have, for our clients, made more than one hundred wind driven rain tests in the laboratory of mock-ups of rendered stud walls or ETICS (External thermal insulation composite system) of existing and new designs and other types of facades and weather barriers.

More than 90 % of all tested objects failed and nearly 50 % of all details failed. Connections to windows got the worst results overall, despite windows being the most common details in facades. It is difficult to achieve good results in ETICS or undrained facades and even ventilated facades despite venting create pressure equalization across the façade. The weather barrier would be particularly important for the facades of multi-storey buildings, as leakages are added together downwards. If there are also flaws in the weather barrier there is an increased risk of leakage within the structure. Results from the tests of the weather barriers exposed to rain are similar to conclusions derived for facades. The consequence of leakage through the façade and to the structure has not been included in this study.

One can rarely visually determine whether façade detail solutions are rain tight before the test. It is hardly possible to determine the rain tightness of details only by theoretical assessment of drawings.

1. Introduction

During the last few decades rendered ETICS stud walls have been very popular in Sweden. Unfortunately, the combination of these systems with a wood frame structure has shown itself to be sensitive to moisture, which was revealed in Sweden in 2007 (Samuelson et al. 2007). Experiences from surveys of more than 1000 buildings show that the problem is moisture entering the structure - for example, at joints, poor connections to windows, doors, balconies etc. - wetting the materials inside the stud wall and causing rot and mould growth (Jansson 2011).

In Sweden it is no longer accepted to use ETICS in lightweight structures without improved and proven functionality, which partly led to facade providers need to develop new moisture-proof solutions. Additionally, other facades and weather barriers have got increasing demands for functional accounting.

Over the past five years SP have, for our customers, made more than one hundred wind driven rain tests in the laboratory of mock-ups of rendered stud walls or ETICS of existing and new designs and other types of facades and weather barriers as concrete element, wood panel, metal sandwich panel, weather barriers of fabric, board or slab. The test objects are usually constructed with the desired or common façade details, see FIG 1. The aim of this study is to show the driving rain tightness of facades, weather barriers and connections to joints, windows and balconies etc.



FIG 1. Example of test object, rendered stud wall with façade details.

2. Test objects and method

Various types of facades systems and weather barriers systems have been tested. Objects are divided with regard to function as undrained, drained or ventilated facades, sandwich elements of metal or concrete and second rain barriers (weather barriers) of fabric, board, or slab, see examples of designs in FIG 2 and FIG 3.

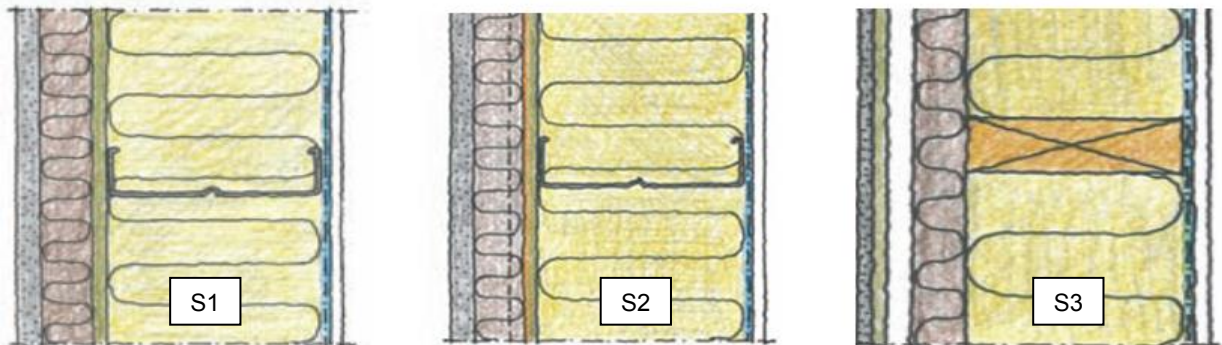


FIG 2. S1=Undrained (ETICS), S2=Drained, S3=Ventilated and drained

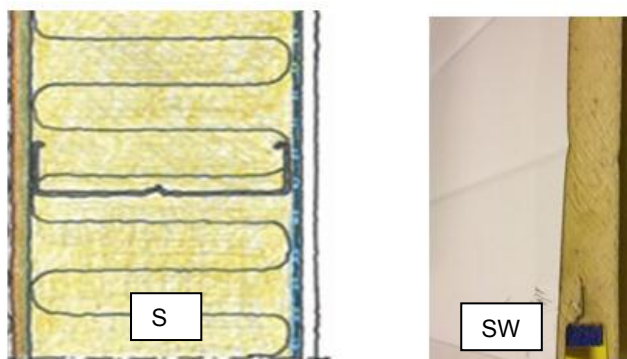


FIG 3. S=Second rain barrier, SW=Sandwich elements of metal or concrete.

The test objects were mainly mounted by the client in a steel test frame with the size of 3x3 meters in SP's laboratory. An airtight barrier of plastic film was attached to the inside of the frame walls. This film was perforated to create an air leakage of 1,6 l/s m² at 50 Pa pressure difference, which represents the maximum allowable air leakage through the climate envelope according to Swedish building regulations 2002 (Boverket 2002). Before the testing started, each façade detail (except the movement joint) was subjected to between 5 - 10 blows (represented by a flat piece of wood hit with a hammer) to simulate the mechanical loading, which they would be subjected to in reality during nailing/construction.

Tests were carried out in accordance to SS-EN 12865 "Determination of the resistance of external wall systems to driving rain under pulsating air pressure" procedure B, with 300 minutes of total test time. The test starts with the object being exposed to 60 minutes simulated rainfall of 1.5 l / (m², min). After that pulsating pressure also starts for 60 minutes for each step 0-150 Pa, 0-300, 0-450 and 0-600 Pa. For objects that are not moisture absorbent method A is used, with a total test time of 60 minutes and the same pulsating pressure steps. When testing weather barrier the pressure difference used is usually up to 300 Pa and sometimes 600 Pa. Leakage of weather barriers of above 300 Pa is not reported in the results below.

Verification was carried out both visually and with moisture indicators which were attached underneath these details, see FIG 4. The moisture indicators were checked after each pressure level. Indicators consisted of absorption paper with thin electrodes for resistance measurement. At the end of the test, the wall was opened in order to investigate any further leakage and to estimate the leakage rate of each leak.



FIG 4. Indicators were placed just below all details behind the façade or exposed surface. The photo was taken after the rain test.

3. Summary of results

Failed = If water leaks through the rain exposed surface into the air gap, drainage gap, thermal insulation or structure. However, many walls may work even if the façade is not rain tight, in those cases the drainage rate, ventilation rate, dry out rate, rain tightness of the weather barrier or second rain barrier must be satisfied and may play an essential roll. The consequence of leakage behind exposed surface and to the structure has not been included in this study.

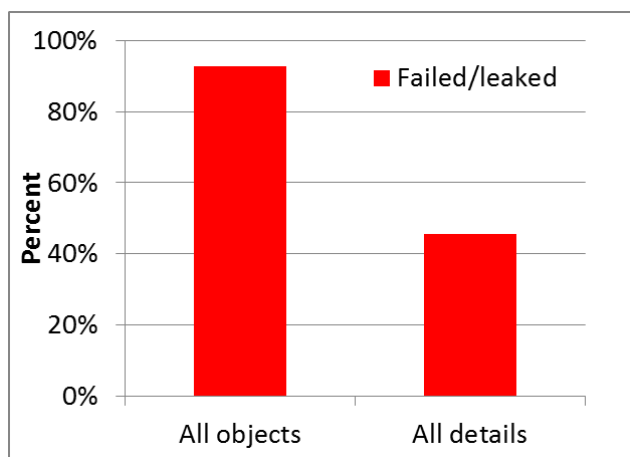


FIG 5. Percentage of objects and details that leaked or failed. 110 objects and 471 details were tested.

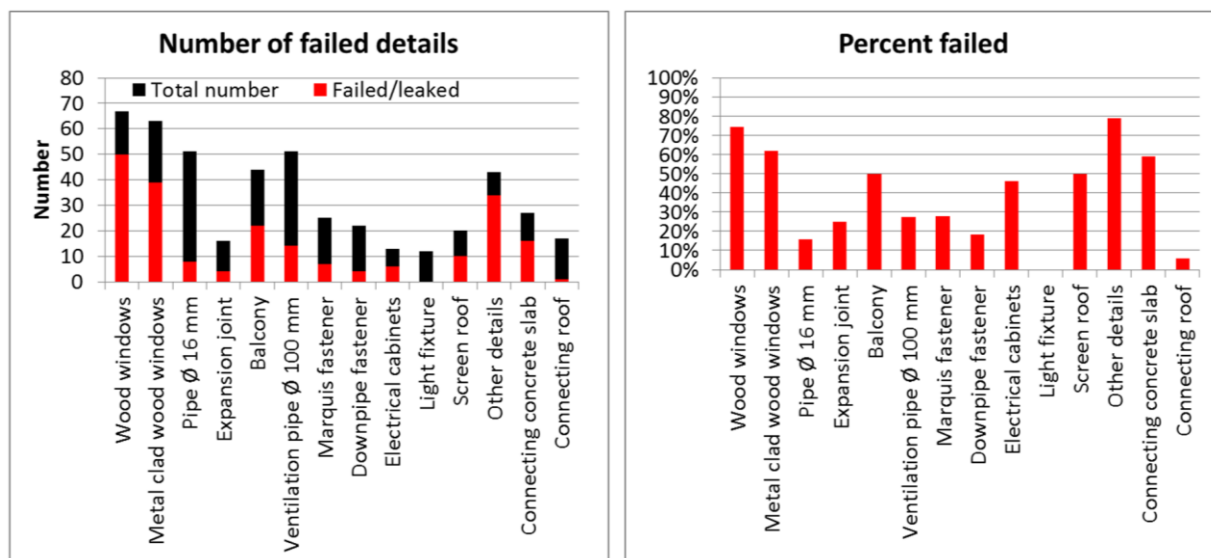


FIG 6. Number of failed details and total number tested (left). Percent of details that failed (right)

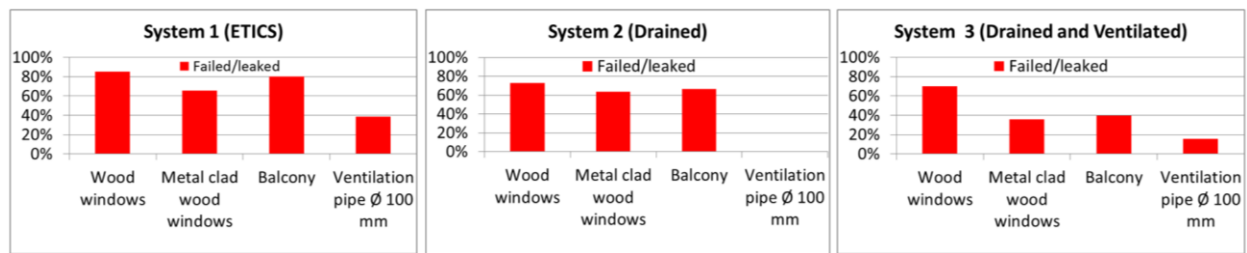


FIG 7. Comparison between system 1, 2 and 3 of failed details of common details.

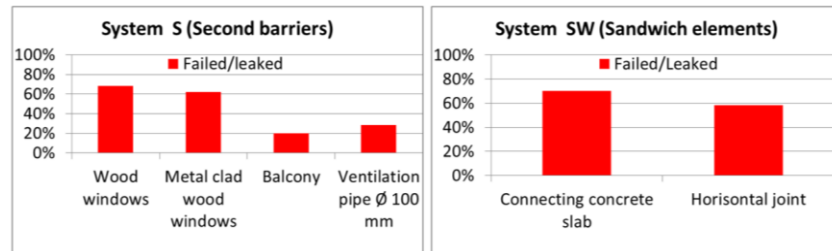


FIG 8. Comparison between system S, SW (and system 1-3, see FIG 7) of failed details of common details.

TABLE 1. Results of estimated leakage rate of failed objects. This result includes only the details that leaked most of each test object.

Description of the leakage rate	Leakage rate of failed objects [%]
1 - One or few drops	20
2 - Continuously dripping	53
3 - Low flow	26
4 - Modest flow	2
5 - Heavy flow	0

4. Conclusions

More than 90 % of all tested objects failed and nearly 50 % of all details failed. Connections to windows got the worst results overall, despite windows being the most common details in facades. It is difficult to achieve good results in ETICS or undrained facades. It is not quite as difficult to achieve good results with ventilated façades that provide almost no pressure difference over the façade cladding, compared to unventilated solutions where there is a pressure difference across the façade. The weather barrier would be particularly important for the facades of multi-storey buildings, as leakages are added together downwards. If there are also flaws in the weather barrier there is an increased risk of leakage within the structure. Results from the tests of the weather barriers exposed to rain are similar to conclusions derived for facades.

One can rarely visually determine whether detail solutions are rain tight before the test. It is hardly possible to determine the rain tightness of details only by theoretical assessment of drawings.

New designs and solutions need to be tested and evaluated. Ideally, there should be robust designs:

- that have at least two barriers against rain (even around details)
- that have good drainage
- without moisture retaining material where water optionally flows

- which can dry fast enough
- with sealing products tested for durability and compatibility (sustain at least 25 years).

5. Acknowledgements

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