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Long term monitoring of repaired external wall assembly

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Abstract

This study discusses on hygrothermal performance of external wall assembly based on long term observation on relative humidity and temperature in layered external wall assembly, when the resistance of water vapor in insulating material is higher than in the main framing of the studied building. In this case the location of the vapor barrier must be examined more closely.
In 1974 completed building the facade of the building was made from concrete and bricks. The external wall assembly was repaired by replacing the thermal insulation and facade brickwork. The original brick-insulation-brick structure was unventilated like those used to be until mid-1980s. The repaired outer layer was constructed with a ventilation gap which satisfies the building codes in force. Old thermal insulation was replaced with aluminum foil backed polyurethane insulation. The aim of the study was to verify that the new structure was performing properly by measuring the circumstances inside the new external wall assembly. The performance of the repaired external wall was monitored by sensors installed in four depths and in five different locations in the building. Each of the sensors measured relative humidity and temperature for two years.
The repaired external wall assembly was observed to be performing correctly. The aluminum foil backed polyurethane insulation functioned as planned as wall assembly's thermal insulation and vapor barrier. Condensation of the indoor air into the structure was not detected during the measurement period. Neither was the outside air's relative humidity condensed outside the vapor barrier during the measurement period. There was no observation of the condensation neither in the ventilation gap, nor in the fire resistant mineral wool layer during the measurement period, in any inside or outside circumstances.

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Keywords: Brick-insulation-brick structure; monitoring; relative humidity; condensation; diffusion

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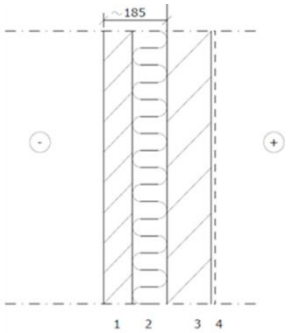
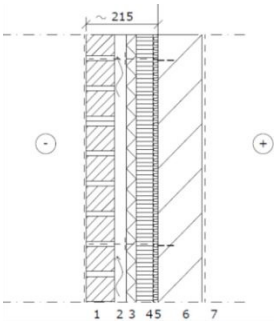
1. Introduction

The study discusses on hygrothermal performance of external wall assembly in listed educational building situated in mid-Finland. The building was completed in 1974 and completely renovated in 2012. This study concentrates on both reparation of the original brick-mineral wool-brick external wall assembly, and monitoring the on the success of the reparation. Structures of wall assemblies are shown in Figs. 1 and 2.



Structures
1 Fair-faced brick 85 mm
2 Mineral wool 100 mm
3 Fair-faced brick 130 mm

Fig. 1 The original external wall assembly



Structures
1 Fair-faced brick 85 mm
2 Ventilation gap 40 mm
3 Wind barrier insulation 30 mm
4 Polyurethane insulation 50 mm
5 Mineral wool mat 10 mm
6 The original fair-faced brick

Fig. 2 The repaired external wall assembly

1.1 Moisture sources of external wall assembly

Common sources of moisture in walls are air leakage in vapor barrier and accidental water leakage. In addition, the following sources were identified critical in this study:

Wind driven rain
The most important moisture source for external wall assembly is wind driven rain. The higher building, the more wind driven rain facades will get [1]. In Finland wind driven rain comes with south-west to south-east winds. Roughly it could be stated that in coastal areas of Finland 60 % of wind driven rain hits to facades while the share in inland is only 40 %. The difference is based on the higher wind speed during rain events in coastal area than inland [2]. The average wind speed during rain event in coastal area is 8 m/s and in inland 4 m/s. The amount of rain in coastal area is approximately 600 mm/a, and in inland app. 450 mm/a. [3]. Together with higher wind speed during rain events, facades in coastal area gets a lot more wet than in inland.

Brick is porous material and its capillary wetting receptivity and receptivity speed are high. Relatively thin brickwork could be totally saturated during rain.

Convection
In well performing ventilated wall structures convection is not normally an issue. But because of bad labor work, ventilation gap might be too narrow and mortar has a contact to inner wall structures. This phenomenon has been detected in several cases. Moisture from wet brickwork could connect to thermal insulation and other parts of wall assembly if mortar is connected to the thermal insulation in some parts of the wall assembly.

However, both wind driven rain and convection should not be an issue after the external wall assembly has been renovated, but they had very important role in degradation of the original one.

Diffusion
Moisture content difference in pore structure of material or in the air tends to stabilize during the time. Moisture tend to move due diffusion to lover moisture content, which means, that the direction of moisture flow will change according to moisture level of studied material. In external wall assembly this means moisture flow from outside to inside during rain events in summer time and from inside to outside during cold season.

In the cavity wall, where the outer layer consists of brickwork, saturated brickwork keeps the relative humidity of air in the ventilation gap relatively high during several hours after rain has been stopped. The air change rate on the ventilation gap depends strongly on windiness and temperature difference between ventilation gap and outdoor air. Usually air change rate is very small