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# Rain Screen Cladding Based on Steel Structures - Thermal and Moisture Physical Behavior of Repaired Wall Structure

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## Summary

The thermal and physical behaviour of a rain screen cladding system with a steel structure was studied with field measurements in a block of flats, whose lightweight aerated concrete facades were repaired with the system. The building was located in central Finland. The results of the field measurements and numerical calculations show that with the system an old external wall structure can be dried out to a level at which further deterioration due to reinforcement corrosion is low under northern European climate conditions. The new, external thermal insulation layer also raised the temperatures of the old wall structure so that further deterioration due to frost is unlikely.

**Keywords:** Thermal and moisture physical behaviour of external walls, facade repair methods

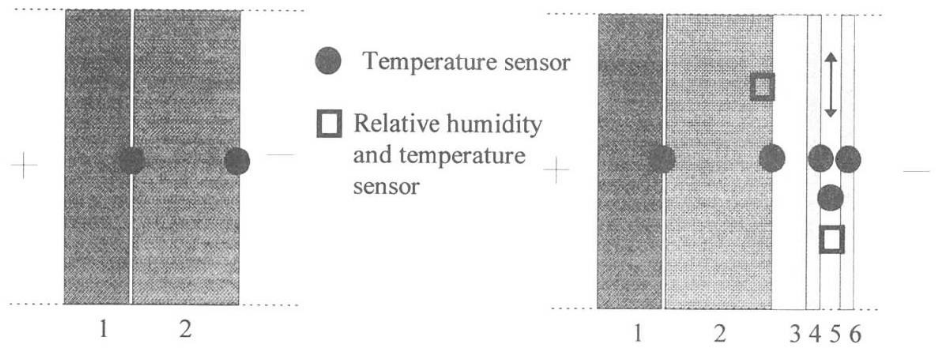
## 1. Field measurements and numerical analysis of facade repair

In the field measurements the thermal and moisture physical behaviour of the rain screen cladding system was studied foe example with temperature and relative humidity sensors placed in the wall structure. The time step in the continuous measurements was 30 minutes. The measurements began in January 1995 approximately one year before the actual repair and have now continued for 2.5 years. The objective of the field measurements was to find out how the cladding system, with its additional external thermal insulation layer and ventilated air gap, improves the thermal and moisture physical behaviour of the external wall structures.

The unrepaired and repaired external wall sections are shown in figure 1. The field measurements include continuous measurements of temperature and air relative humidity of the air, moisture content measurements of samples and local effective heat transfer coefficient measurements with heat flow meters.

In addition to the continuous measurements, the U-value of the unrepaired wall section was measured with heat flow meters combined with room temperature regulation. The moisture content of the lightweight aerated concrete of the old wall structure was measured by taking samples before and after the repair.

The magnitude of the apparent thermal resistance was estimated with transient numerical calculations using the measured outdoor temperature and the temperatures between the inner, load bearing concrete layer and the lightweight aerated concrete layer as boundary conditions. The apparent thermal resistance was defined using iterative calculations. The calculations were made using temperatures in January 1996 and 1997 since the effect of solar heat radiation is lower than at other times of the year.




1. Concrete (gable-end walls) 160mm 3. Thermal insulation layer 70 mm 5. Ventilated air gap
2. Lightweight concrete 300 mm 4. Thermal insulation layer 25 mm 6. Steel cladding

*Figure 1. The unrepaired (a) and repaired (b) test wall sections and the locations of the temperature and air relative humidity sensors in wall sections.*

## 2. Thermal and moisture physical behaviour of repaired facade

The initial moisture content before the repair of the tested facade was, at its highest, 26 $kg \cdot m^{-2}$. The old wall structure started to dry out once the daily mean temperature of the ventilated air gap rose above 0°C. After one year, the additional moisture had dried out and the moisture content of the old lightweight concrete layer corresponded to material exposed to normal climate conditions. The corresponding relative humidities were 40-60 RH%, which indicates that further deterioration due to reinforcement corrosion would be very slow.

The exterior mineral wool thermal insulation layer raised the temperature of the old facade so that the temperature of the lightweight aerated concrete dropped below 0°C for only a few days on the first floor when the outdoor temperature was around -20°C. This indicates that further deterioration of the old facade due to frost is unlikely.

The measured apparent U-values of the facade before repair were 0.42-0.46 $W \cdot m^{-2} \cdot K^{-1}$. These values were lower neighbouring values since the mean moisture content was lower, 5.3 w-%, than in the case of facades exposed to a greater amount of driving rain, the highest measured mean moisture content was 17 w-%. One year after the repair the apparent U-value was estimated to be at a level of 0.18 $W \cdot m^{-2} \cdot K^{-1}$ according to numerical simulations. Taking the simulations into account, the thermal conductivity of the lightweight aerated concrete layer improved from a level of 0.18 $W \cdot m^{-1} \cdot K^{-1}$ to 0.14 $W \cdot m^{-1} \cdot K^{-1}$ due to the drying of the layer. In the numerical simulation the effective thermal resistance of the ventilated air gap was also studied. The effective thermal resistance was found out to be at a level of 0.5 $m^{-2} \cdot K^{-1} \cdot W^{-1}$. This effective thermal resistance is taken into account in the apparent U-value shown above.

The results support the use of the tested type facade repair method as a means of saving energy. In addition, when the structures are carefully designed and the cladding is properly installed, the old external wall structure dries out to a level that considerably extends the service life of the external wall structure.