CASE STUDIES ON EXTERNAL WALL INSULATION SYSTEMS FACED WITH THIN RENDER

JYRI NIEMINEN
VTT Building Technology
P.O.Box 18011
FIN - 02044 VTT

ABSTRACT

An external wall insulation system faced with thin render consists of rigid insulation substrate, light-weight reinforcement net and 6 - 10 mm of render. The performance of these facade systems were studied by measurements of performance properties for various render products, laboratory weather resistance tests for real size wall structures, field measurements in existing buildings for 1 - 3 years periods and field surveys of existing new buildings and renovation projects.

INTRODUCTION

An external wall insulation system faced with thin render (external thermal insulation composite system with rendering) consists of rigid insulation substrate, light-weight glass fibre reinforcement net and 6 - 10 mm of render. The system allows for increased insulation levels and reduced thermal bridging especially in renovation of multi-storied buildings. The thermal transmittance of walls of Finnish apartment houses built in the 1960s and early 1970s varies from 0,5 to 0,35 W/m^2K. The corrosion of reinforcement steel has grown to be a major problem in the concrete facades of many buildings of that era. The additional insulation increases the temperatures of the existing structure which is favorable for the drying of the concrete facades.

There is not much experience on the suitability of the thin render systems for the cold climate of Finland although they are very common systems in Central Europe. The performance of these facade systems were studied by measurement of performance properties for various render products, laboratory weather resistance tests for real size wall structures, field measurements in test buildings for 1 - 3 years periods and field surveys of existing buildings.

PROPERTIES OF THIN RENDER PRODUCTS

The thin render products studied were all cementitious, inorganic materials. The assessment of the fitness for use was carried out by measurement of hygrothermal properties and mechanical resistance and strength properties of three render products, table 1. It can be seen that the material properties do not differ significantly from one product.

Table 1. Properties of three thin render products (Nieminen 1995, 1996). Average of tests for 5 - 10 specimens

Property		R 1	R 2	R 3
Water vapour permeability [kgm/m^{2}sPa] (DIN)		6 $*10^{-12}$	$7*10^{-12}$	$7.5*10^{-12}$
Water absorption by capillary action [h] (UEAtc) 1)		>1	0.8	
Air permeability [m^3/m^{2}sPa]		$1.4*10^{-6}$	$1.4*10^{-6}$	
Bond test		2)	2)	2)
Compressive strength/ Flexural strength	-20°C	6.4/3.0	6.4/2.6	5.3/2.5
[N/mm^2]/ [N/mm^2] (EN)	+20°C		5.1/3.9	4.8/2.5
test temperature	+50°C	5.5/2.5	5.0/3.4	5.1/2.2
Behaviour on impact, test level 10 J (EOTA) 3)		1	1	

1) Time for water penetrating the render layer, render surface immerged in water in the depht of 5 mm

2) Depends on the interlaminar strength of the insulation substrate

3) Hard body impact with a steel ball (1000g) from the height of 1.02 m. Category 1: Superficial damage (no cracking) is considered as showing 'no deterioration'.

PERFORMANCE OF EXTERIOR INSULATION SYSTEMS

Laboratory weather resistance tests

Two laboratory weather resistance tests were carried out for render product R2 (table 2). The test rig and the princible of the test wall is shown in figure 1. The test climate is shown in table 2. The render surface was studied daily for any cracks or other defects. The moisture variations in the timber framed test wall were measured as well as the temperature variations on different locations of the wall.

1. foundation
2. test wall (a, b, c)
3. window
4. roof
5. test rig
6. cold side
7. warm side

Test wall from outside:
- render 6 mm
- rigid rock wool 50 mm
- wood frame + insulation
  - 150 mm (test 1)
  - 250 mm (test 2)
- PE-film vapour barrier
- wood particle board 12 mm

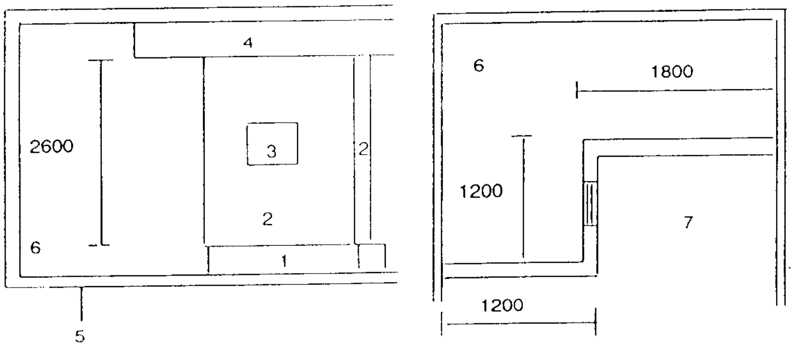

Figure 1. The test rig and the test wall (Nieminen 1995, 1996).

The render surface temperatures varied from -20°C up to +70°C during the test. No cracks or other defcts were found from the render surface. The moisture content of the wooden frame varied from 10% of dry weight to 18% of dry weight. No water penetration into the structure was found.

Table 2. Test climate.

Phase	Duration	Cold chamber climate	Warm chamber climate
1 constant climate	10 days	-20°C	+22°C, 50% rh
2 cyclic changes	50 days	0°C for 4 hours IR-radiation for 1 hour -20°C for 2 hours IR-radiation for 3 hours rain 0.03 l/m^{2}s for 10 minutes drying for 5 hours -20°C for 8 hours	+22°C, 50% rh 50 Pa underpressure
3 constant climate	15 days	-20°C	+22°C, 50% rh 20 Pa overpressure

Test house measurements

The moisture physical behaviour of the facade systems was studied with long term measurements at VTT's test houses in Espoo, Finland. The test building is a one storey detached house with floor area of about 125 m^2. The load bearing wall of the house was built of prefabricated concrete units with a thickness of 80 mm. The external insulation systems studied are shown in table 3.

Table 3. Experimental insulation systems. All insulation materials rigid rock wool.

Wall nr.	Thermal insulation thickness mm	density kg/m^3	surface treatment	Wall orientation	Insulation installation	Render installation
1	110	80	normal binder,	south	3/1990	7/1991
2	110	110	-	south	3/1990	7/1991
3	180	110	special binder	south	3/1990	7/1991
4	180	80	special binder	south	3/1990	7/1991
5	180	80	normal binder	east	5/1990	5/1990
6	180	110	normal binder	east	5/1990	5/1990
7	160 + 20	80 + 250	normal binder 1)	west	5/1990	5/1990
8	160 + 20	80 + 250	normal binder	west	5/1990	5/1990

1) ventilated structure, ventilation grooves on top of 160 mm insulation layer

Small pieces of wood were embedded into the insulation layer for moisture monitoring, figure 2. Moisture variations have been quite the same in all of the structures inspite of the differences in render installation, facade orientation and insulation surface treatment. External mineral wool insulation system alone gives a rather good protection against outdoor weather conditions for the load bearing structure (wall nr. 2). However, the insulation surface needs a surface treatment for a good adhesion between the render and insulation. The treatment can be done either after the insulation installation or before the render installation.

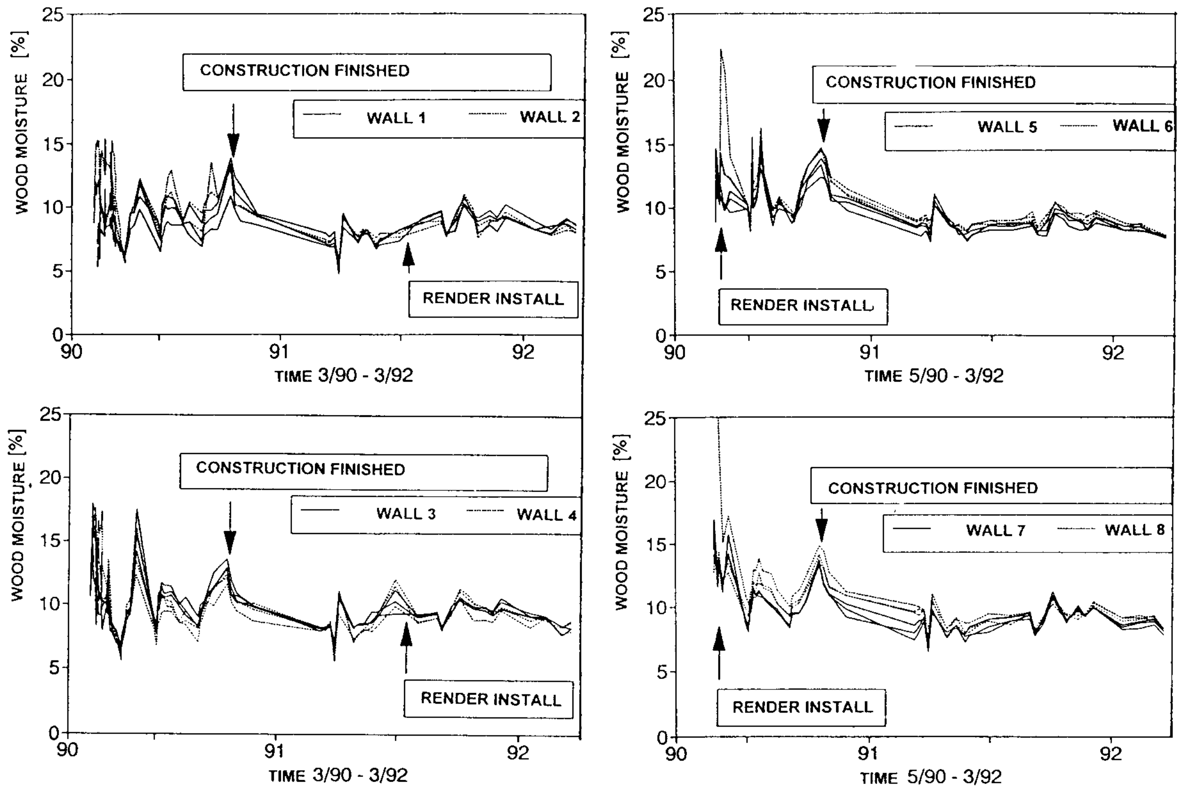

Figure 2. Moisture variations in structures 1 - 8 (Nieminen 1996).

Field measurements

Moisture variations in the external insulation layer were measured from a number of buildings. Small pieces of wood were embedded in the insulation layer for moisture monitoring. Examples of these measurements are shown in figures 3 and 4. A common finding was that the moisture levels maintained on a low level after the possible built-in moisture had dried out.

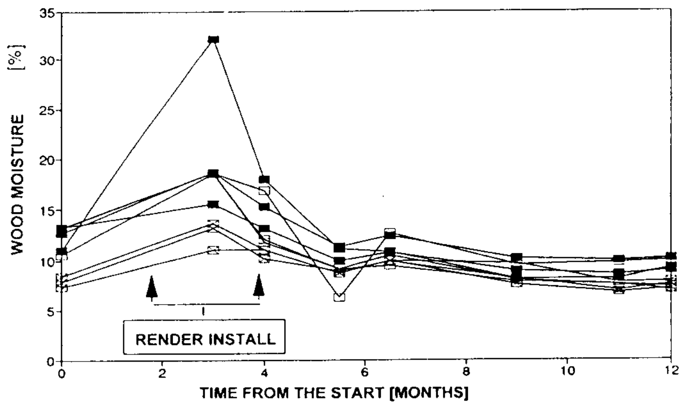

Figure 4. Moisture variations in the insulation layer of a five-storey commercial building. External insulation of 120 mm faced with thin render (Nieminen 1996).

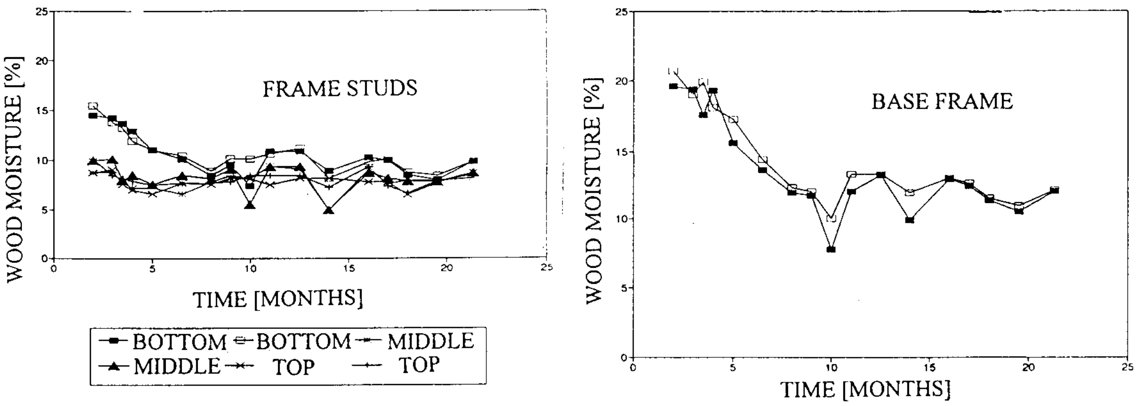

Figure 4. Moisture variations in the insulation layer of a one-storey office building. Wood framed walls insulated with175 mm mineral wool and external insulation of 50 mm faced with thin render (Nieminen 1995).

Field surveys

External insulation composite systems have mainly been used in small houses (1 - 2 storeys) in Finland. A total number of 30 buildings and were checked to find out possible problems in the render surface, table 5.

Table 5. Results from the field surveys.

Building type/ number of cases R = renovation, N = new	Load bearing structure	Findings Type of defect in render surface/ number of cases
Detached or one storied other buildings R 10	Wood	Total number of defect cases 6 Vertical hair cracks 4 Hair crack in window corner 2 Other types of cracks 1
Deatched or one storied other buildings N 12	Wood	Total number of defect cases 7 Vertical hair cracks 5 Hair cracks in window corners 2 Other types of cracks 1
Detached R 1	Brick	Vertical hair cracks Hard body impacts
Row house N 3	Wood	Total number of defect cases 2 Vertical hair cracks
Commercial R 1	Brick	Vertical hair cracks Hair cracks in window corners
Apartment house R 3	Concrete	Total number of defect cases 2 Vertical hair cracks 2 Hard body impacts 1
Industrial R 1	Concrete	Vertical hair cracks Other types of cracks Hard body impacts

The most of the houses were surveyed regularly during a period of 2 - 3 years. A number of hair cracks were found. The common findings from these cracks were for an average case:
- hair crack in the corner of a window
- vertical, almost straight crack on other surface
- typically south or west oriented walls, builtup time at 1 - 2 years of age.
- typically built between 1989 and 1992.

The findings from field investigations did not correlate with the findings from laboratory tests or test house measurements. The cracks in the window corners were caused by insufficient reinforcement of the corners or bad quality of finishing of the corner details. For the other cracks no exact reason could be found, but possible causes of the defects are wrong mixture ratio of the render, too soft substrate (wind caused vibrations) or movements in the load bearing structure (typically wooden frame in the small houses).

CONCLUSIONS

External insulation composite systems with render are a very cost effective facade system for both new buildings and retrofitting especially when a good thermal performance of the wall is required. However, The first realized projects introducing thin render systems were built in the late 1980s in Finland showed rather discouraging results eventhough the results from laboratory tests and preliminary test house studies were quite promising.

The render systems have been further developed to find suitable solutions for cold climate applications. The field surveys were started in 1989 and the final checkings were carried out in 1995. The most of the defect cases were built before 1992. The composition of the early render products have been changed during the years and the new products have performed satisfactorily.

References

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