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INTERNATIONAL BUILDING PHYSICS CONFERENCE
September 18–21, 2000
Eindhoven, The Netherlands

The conference is organized by the Standing Committee of Building Physics Professors at European Universities and the Eindhoven University of Technology, Faculty of Building and Architecture. The subjects of this conference include: building acoustics, lighting, heat, moisture, air, urban physics and the impact of climate on the building envelope.

The conference in Eindhoven will concentrate on the application of building physics to the design and engineering of buildings to identify white spots and bottlenecks. The deadline for papers was November 1999.

On the 18–20 September 2000 there will be two parallel sessions and poster sessions. On Thursday a meeting of the "Standing Committee" will take place and a workshop on education in building physics.

During the conference the results of IEA-annex 24 (Integral building envelope performance assessment) will be presented and the CIB working group 51 will have its meeting. There will also be a meeting of the Task Group on material characterization and benchmarking of hygrothermal properties at the CIB W-40.

For further information contact:

The conference home page: http//www.tue.nl/bwk/bfa/IBPC2000
Congress Office, tel: 00-31-40-2474849 or 2474000
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Report from CMHC: Drying of Stucco-Clad Walls (Vancouver)

INTRODUCTION

Decay of sheathing and framing in wood-frame walls and rusting of steel components in steel-stud-framed walls are becoming more common problems associated with stucco cladding. Larger buildings are more vulnerable. The walls are less sheltered and have a greater variety of penetrations. The problem is worst in coastal climates that have consecutive days of rain at times when drying potential is low. Conventional stucco-clad walls have only incidental spaces for drying and drainage of moisture from behind the stucco. The wrinkles that occur in building paper when stucco application wets the paper shrink and leave gaps connected to the exterior that provide some drainage, unless the edges of the stucco are overzealously sealed. Attempts to keep water out of walls by carefully sealing the exterior surfaces and by introducing heavier sheathing papers can be counterproductive. Heavier paper does not wrinkle as much and retards evaporation of water. Sealed edges retain water and prevent it from draining. At details around penetrations, water often finds a way to get behind both the stucco and the paper. The tighter and less permeable exterior retards drying. Improved detailing and execution at penetrations will undoubtedly reduce the risk of water entering, but will not eliminate it. Providing a drained airspace, vented to the exterior, behind the stucco is another way of reducing the danger of water penetration, one that the City of Vancouver now requires for all stucco-clad buildings outside the scope of Part 9 of the building code. Although this measure was taken to reduce water penetration, it may help drying as well by allowing air circulation behind the stucco. Even if no exterior moisture gets into a wall, plumbing leaks and spills inside the building, however rare, can wet the framing. Walls must be allowed to dry, since even small amounts of water can lead to injurious amounts of rot and rust. Hence the question: Does an air space behind the stucco make any difference to drying of stucco-clad walls?

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RESEARCH PROGRAM

To address this question, researchers constructed seven test specimens, five with wood framing and two with steel framing. All were clad with stucco. All were 1220 mm × 2440 mm in size, with studs at 406 mm centres. One of the wood frame specimens had stucco applied directly, without an air space. All the others had drained and vented air spaces behind the stucco, introduced by various means:

- 19 mm vertical wood strapping at 205 mm centres, with a layer of 30-minute building paper over it to keep stucco out of the cavity
- 9.5 mm Hydroduct without fabric backing on both steel stud and wood stud
- J-Drain (type and size not specified) also without fabric, with a layer of 30-minute building paper over it to keep stucco out of the cavity
- 9.5 mm vertical wood strapping at 205 mm centres, with a layer of 30-minute building paper over it to keep stucco out of the cavity
- 19 mm vertical galvanized sheet metal Z-bars on steel stud

All specimens were constructed with the following layers:

- 12.7 mm Gypsum Board, installed airtight
- 0.25 mm polyethylene film vapour barrier
- 38 × 89 mm wood studs (or 92 mm steel studs) with R-12 glass fibre batt insulation
- 12.5 mm plywood sheathing (on wood studs) or 12.7 mm Dens-Glas Gold gypsum sheathing (on steel studs), installed horizontally with a 6 mm gap between sheets
- 60-minute building paper, shingle lapped
- Drainage cavity (in all cases but one), vented and flashed top and bottom
- 19 mm sand-cement stucco, cured for 28 days

The bottom was flashed with a drip flashing extending from the face of the sheathing to the face of the stucco, with a 12 mm gap between it and the bottom edge of the stucco. At the top, a metal flashing covered the top edge of the stucco, with a 6 mm gap between the back of the flashing and the face of the stucco and with a 12 mm gap above the top edge of the stucco under the flashing.

Each specimen was provided with sensors to measure the moisture content of wood framing and the moisture content of both wood and gypsum sheathing. Sensors were installed in the interior studs at 50 mm and 600 mm above the bottom of the stud space, in the sheathing at the same two levels along the vertical centre of the panel, in the bottom plate at the centre of the panel, and at the centre of one adjoining stud space. Temperature and relative humidity sensors were placed 600 mm above the bottom plate, at the centre of the specimen and midpoint of the stud space. Preliminary tests with additional specimens and more instrumentation had been done to determine what types of sensing to use, and where. Gypsum moisture content readings were not correlated with actual moisture content. The readings are what would be obtained using a wood moisture meter.

Each specimen was also fitted with a means of introducing water into the stud space and with waterproofing at the base of the specimen to prevent leakage.

The completed specimens were sealed to openings in a refrigerated room, with the stucco facing the cold side. After conditioning the specimens, water was introduced into the stud space of each specimen, evenly distributed against the inside of the sheathing at the top, at a rate of 1 litre per day for four days. The amount of water was calculated to be enough to raise the moisture content of all the wood from 10 percent to 20 percent. For steel-framed specimens, half as much water was used over the same time period.

The warm side was kept between 19 deg. C and 25 deg. C, with humidity between 35 percent and 60 percent, while the cold side was between 5 deg. C and 14 deg. C, at 45 percent to 85 percent relative humidity. There was no air pressure difference. The effects of wind and solar heating, which might influence drying of building walls, were absent. Specimens were allowed to reach equilibrium, with no measurable changes of moisture content with time, before water was introduced into the stud space.

After wetting the walls, the test conditions were maintained for five and a half months; moisture data were recorded for 150 days before the experiment was terminated.

RESULTS

After an initial peak between 80 percent and 90 percent, relative humidity of the air in the wall cavity at 600 mm above the bottom plate levelled off to 60 percent or 70 percent in a week (for wood) to a month (for steel); it declined slowly thereafter, never falling back to the initial level prior to introduction of water into the stud space. Drying was very slow, with no significant differences between specimens that had cavities and specimens without them. Introduction of the water had no evident effect on moisture content of studs at the 600 mm level. They remained at about 10 percent moisture content throughout. At 50 mm above the bottom plate, the studs increased in moisture content gradually to about 20 percent in the first 30

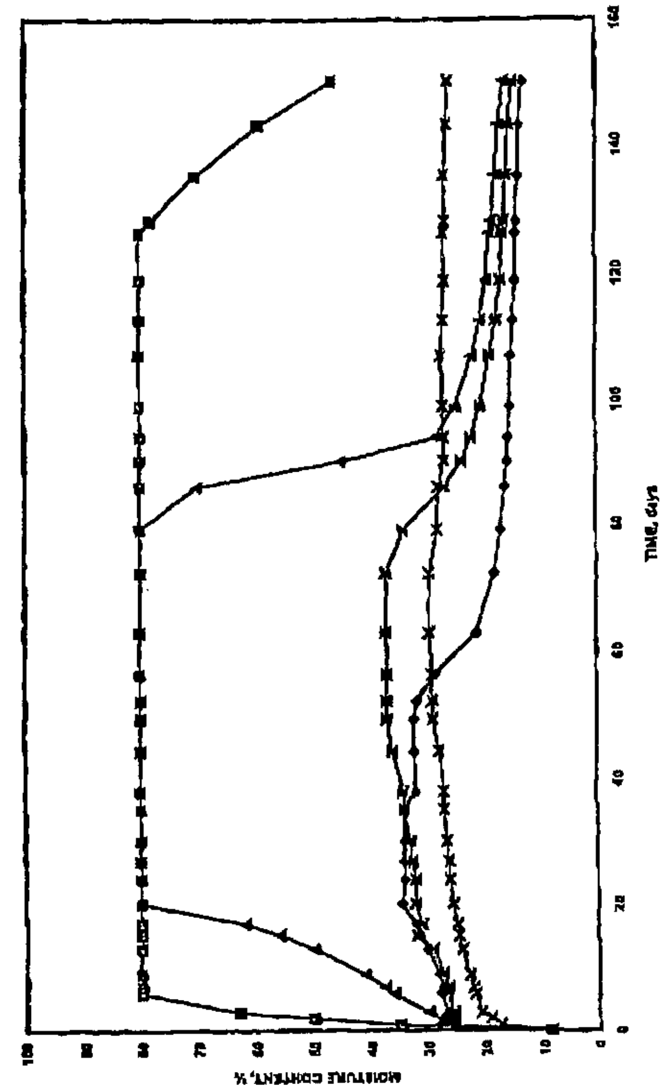

FIGURE 1. Drying of stucco-clad walls.

to 40 days, after which they dried very slowly, never reaching the initial 10 percent. The effect on the sheathing at 600 mm was very similar, except that the peak occurred in fewer than 10 days. The bottom plates showed a variety of responses, as indicated by the plots in Figure 1. The wood sheathing at 50 mm increased rapidly in moisture content to exceed 80 percent in 2 to 25 days, and remained there in all cases for 75 days or more. Two specimens remained above that level at the end of the test; the other three dried to about 65 percent, 30 percent, and 25 percent respectively. The gypsum sheathing increased rapidly in moisture content in the first 10 days, one specimen reaching a reading of 40 percent, the other in excess of 80 percent, and then dried slowly. Both specimens reached about 12 percent—still in excess of the initial 10 percent—at the end of the test, after staying near their respective maximums for about 20 days.

When the walls were removed and opened, the wood framing and sheathing were water-stained at the bottoms of stud cavities and wet enough for rot to be a potential problem. The water that had run down the sheathing and soaked into the wood was not redistributed by diffusion to other parts of the assembly to any significant extent. The bottom plates, the bottom ends of studs, and the sheathing up to at least 50 mm remained wet enough (above 30 percent) to be susceptible to rot, mildew, or rust for the entire test period. The provision of a drained and vented space behind the stucco made no difference.

IMPLICATIONS FOR THE HOUSING INDUSTRY

Walls that have cavities with drainage, venting and appropriate detailing of penetrations are more effective at keeping rainwater out of walls than face-sealed walls without cavities. Once water had entered a wall, however, walls using construction similar to the tested specimens will not dry quickly enough to prevent damage, with or without a cavity. Providing a cavity either makes no difference or only makes a difference with walls that have sheathing and weather barrier materials more permeable to vapour than those tests. Perhaps the result would be different with 19-mm board cladding and 30-minute paper or other more pervious sheathing and sheathing paper. Provision of a cavity will improve things considerably, by reducing rain penetration, but may not solve the problem entirely since walls will still get wet. Some change other than the introduction of the cavity is required to improve drying.

The researchers did not report the vapour permeance of the 60-minute building paper. However, permeance of a common B.C. 60-minute breather paper is 320 ng/Pa·s·m^2, which meets the minimum requirement of CAN/CGSB-51.32-M77 of 170 $nG/Pa{\cdot}s{\cdot}m^2$. How much drying should we have expected? To err on the generous side, assume conditions during the test of 45 percent relative humidity at 5 deg. C in the cold chamber and 75 percent relative humidity at 14 deg. C in the middle of the stud space. Under these conditions, the vapour pressure difference is about 0.80 kPa ($0.75 \cdot 1.598 - 0.45 \cdot 0.8719$). Neglecting the resistance of the other materials, the total amount of water vapour driven through the paper in 150 days would be as follows:

$$3\,(\mathrm{m}^2)\cdot 1.296\cdot 10^7(\mathrm{s})\cdot 0.80\,(\mathrm{kPa})\cdot 320\cdot 10^{-9}(\mathrm{g/Pa\cdot s\cdot m^2}) = 11\,\mathrm{kg}$$

But drying is evidently not uniformly distributed, and the temperature at the back of the sheathing is not 14 deg. C. At the end of the tests, the wood panels weighed between 0.95 and 2.35 kg less than at the beginning, before the water was added.

From this and previous studies, it appears that, in the coastal climate of B.C. in particular, some combination of the following measures is necessary if wall stud spaces are to be adequately protected from moisture:

- improved details at penetrations, including windows, doors, guardrails, and junctures with exterior floors and roofs
- a vented cavity, behind stucco on walls that are exposed to wind-driven rain, flashed and drained to the exterior
- some additional provision for drying moisture out of the framing, if framing is enclosed by polyethylene vapour barrier on one side and by 60-minute building paper on the other
- as an alternate to the last provision, a more vapour permeable substitute for the 60-minute building paper, and perhaps also for the plywood sheathing

Possible measures to promote drying might include:

- insulated sheathing, permeable to moisture unless it also replaces the interior vapour barrier, to raise the temperature in the stud space, and hence increase the drying potential
- to reduce resistance to vapour flow, venting of the stud space with protected vents to provide a path through the building paper and sheathing
- addition of enough insulated sheathing to allow the interior vapour barrier to be replaced with an exterior vapour barrier
- removal of the vapour barrier to allow inward drying if it can be shown that condensation in winter can be managed by other means (such as seasonal storage as moisture contents not harmful to the materials, or drainage to the exterior) and that stored moisture and summer condensation will not wet the back of the drywall enough to cause mildew (in addition to its intended function, a polyethylene vapour barrier protects the drywall from moisture in the stud space in summer and helps to contain spores produced by mold, mildew, or wood-consuming fungi)

- replacement of sheathing and 60-minute paper with more permeable materials
- mechanical ventilation of the stud space with dry air

For other reports see: http://www.cmhc-schl.gc.ca.