Investigation of the Performance of Gypsum Sheathing

Introduction

Gypsum sheathing is sometimes used in brick veneer and exterior insulation finish system (EIFS) walls in high-rise residential buildings. In certain cases, the sheathing has become moldy. In more extreme cases, when additional insulation has been installed in the space between the supporting metal studs, the sheathing has become saturated with water. Significant problems can arise when these conditions lead to structural deterioration.

Historically, the moisture build-up has been attributed to the lowering of the sheathing temperature below the dew point of the indoor air, followed by the migration and condensation of the moisture. Several approaches for resolving these problems have been suggested, including the following:

1. Always maintain the sheathing at a temperature above the dew point temperature of the room air.

2. Keep the moisture content of the sheathing below a level that allows development and growth of mold.

3. Keep the amount of moisture on the gypsum at a level below that required for complete saturation.

4. Protect the gypsum sheathing from the effects of moisture condensation on its inner face by covering the inner face of the gypsum with a layer of a vapour permeable material, such as Tyvek, or by applying polyethylene film over the sheathing to prevent vapour diffusion and water absorption into the sheathing.

In the early 1990s, CMHC initiated a study to investigate this problem further.

Research Program

The study's objectives were:

(i) to establish the limiting moisture content values for gypsum sheathing; and
(ii) to observe the wetting characteristics of protected and unprotected gypsum sheathing under condensing conditions.

The research took place in Calgary. The testing procedure consisted of attaching samples of gypsum wallboard to a panel of exterior

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plywood. The panel was then subjected to various controlled temperature and humidity conditions in a test chamber during three stages of testing. During the first stage, the gypsum samples were left unprotected. During the second stage, coverings of polyethylene with and without insulation were applied to parts of the gypsum. Finally, an exterior acrylic gloss paint was applied to the outside face of the two samples.

Measures of the performance included noting the presence or absence of surface condensation (water droplets) on the interior or exterior surfaces and changes in the weight of the gypsum board that would indicate absorption of moisture.

The computer program, EMPTIED, estimated the thickness of exterior insulation required to keep the sheathing surface above the room dew point temperature, presumably avoiding condensation, both when the stud space was insulated and uninsulated. The limiting leakage areas required to keep the moisture content of the gypsum sheathing below the levels for mold and mildew development and below saturation were also calculated. Using EMPTIED, researchers extrapolated their findings to 15 cities in Canada.

Researchers also reviewed the findings of a U.S. study examining the same problem.

Results

In the Calgary studies, no visible condensation was observed on the unprotected gypsum sheathing even when it was exposed to condensation conditions on the warm side. Also, the gypsum exhibited no measurable increase in moisture content until a less permeable material was applied against its outer, colder surface: in that case, the gypsum board increased in moisture content, but only to a value representing that at equilibrium with 100 per cent relative humidity. When Tyvek or polyethylene was used to protect the inner face of the sheathing, condensation on the surfaces was observed.

With the unprotected gypsum sheathing, observations showed that gypsum sheathing exhibits a water vapour permeance about equal to that of still air or mineral fibre insulation, and the vapour pressure at its surface remains below the saturation vapour pressure at that location.

The study found that covering the inner face of gypsum sheathing with polyethylene prevented condensed moisture from being absorbed by the gypsum sheathing. If the exterior surface was exposed to an air space or to permeable insulation, the exterior surface of the sheathing tended to come to equilibrium with the lower vapour pressures in the colder, exterior regions of the wall and reached relative humidities of less than 100 per cent.

The findings provided some support for the moisture absorption criteria used in the calculations but raised questions regarding the conventional assumption that condensation will occur on all surfaces that fall below the dew point temperature of the air in contact with them. When considered with the analyses and measurements of other researchers, the observations suggest that the processes leading to moisture build-up on components that fall below the predicted dew point temperature might be as follows:

1. When an absorptive surface falls below the dew point temperature, it tends to absorb water vapour until it comes to a moisture content in equilibrium with air at 100 per cent relative humidity.

2. The absorbed moisture migrates by diffusion into the material, and the material increases in moisture content.

3. If the outer surface is exposed to an equally permeable or more permeable component, the moisture will continue to diffuse outward, presumably toward a surface at which a lower vapour pressure is maintained.

4. If evaporation from the outer surface is inhibited by a less permeable material, the moisture content of the material will tend to increase.

5. When the material reaches the "maximum sorption" value, condensation as liquid water could be initiated at the surface and might lead to a further increase in the moisture content of the material up to the "saturation" value.

6. When the condensing surface is below freezing, condensation may occur as frost, even on absorbent surfaces, but will be absorbed and migrate as liquid water when conditions rise above 0°C.

Researchers concluded from their analysis that walls with sheathing paper or with less permeable exterior insulation are more likely to experience moisture accumulation in the gypsum sheathing than walls where the sheathing paper is omitted or where more permeable exterior insulation is employed.

Implication for the Housing Industry

This study helps to explain some observations in practice. Where saturation of gypsum sheathing has occurred in brick veneer walls, sheathing paper has usually been involved. In EIFS walls, the gypsum sheathing is covered with expanded polystyrene (EPS) insulation. In both cases, a material of lower permeance has been applied to the exterior face and a moisture buildup would seem possible. This situation is inherent in EIFS walls, and the elimination of sheathing paper in brick veneer construction might lead to fewer problems.

A number of observations and recommendations emerged from the study:

1. The use of high permeance sheathing paper, such as Tyvek, might serve to diffuse the water vapour in the gypsum, but its non-absorptive characteristics might also induce condensation. These characteristics may be factors in the mold and mildew occurrences experienced on interior gypsum board finishes.

2. If insulation is installed in the stud space of the wall types tested, the temperature of the gypsum sheathing is likely to fall below the indoor dew point temperature in all locations, unless an excessive thickness of exterior insulation is applied. If the stud space is left uninsulated, only modest thicknesses of exterior insulation should be necessary to maintain the sheathing temperature above the room dew point temperature.

3. In all cases, provision must be made for drainage of the condensed liquid to the outside. Failing this, the moisture accumulated in the space will continue to maintain conditions at 100 per cent relative humidity, and the sheathing will not dry out, even when warmer temperatures prevail. This will cause premature failure of the sheathing.

4. Inner surface protection of gypsum sheathing could result in the successful moisture performance of wall systems, even where some air leakage openings or vapour barrier imperfections occur.

5. In situations where the exterior surface of gypsum sheathing is left exposed to the air space behind brick veneer or precast concrete, or where highly permeable fibrous insulation board is applied without adhesives, the gypsum board may not reach serious moisture levels from air leakage or vapour diffusion from the indoors.

Further investigation of the performance of gypsum sheathing under steady state conditions, as well as during exposure to natural weather, would be necessary to validate the moisture absorption processes outlined here or to confirm suggested design approaches. Based on the outcome of such studies, laboratory and field investigation of full-scale panels with different design features could be undertaken.

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A full report on this research project is available from the Canadian Housing Information Centre at the address below.

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