A laboratory facility for research on wind-driven rain intrusion in building envelope assemblies

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Moisture management is critical for durable, energy-efficient buildings. To address the need for research on wind-driven rain intrusion in wall assemblies, the U.S. Forest Products Laboratory is developing a new facility. This paper describes the underlying principle of this facility and its capabilities.

Introduction

Increasing concerns about climate change, energy, and other environmental impacts have stimulated a trend toward “sustainable” or “green” construction. Currently the building sector accounts for 40 percent of total U.S. energy consumption; clearly there is a significant potential for reducing energy consumption in this sector. Buildings with highly-insulated envelopes and extremely low energy demand for space heating and cooling are targeted for widespread adoption in the near future. However, improvements in the energy efficiency of new and existing buildings must be accompanied by attention to moisture management. Increasing the level of insulation, for example, can lower the drying potential of building assemblies. Proper design of buildings is critical for preventing moisture accumulation, which can lead to a host of undesirable consequences, among them the possibility of shortening building service lives.

The importance of durability is underscored by the sheer quantity of wood used in buildings. Construction and repair of buildings account for approximately one-half of all lumber and other wood products (excluding paper) consumed annually in the U.S., and further increases in demand for residential and

non-residential building products are anticipated. The sustainability and health of America's forests depend on efficient use of timber resources.

Reliable strategies for managing moisture in buildings require a quantitative, performance-based approach. Measurements are necessary to quantify moisture sources, the physics of moisture migration and moisture accumulation over time, the properties of building materials as they relate to transfer of heat, air, and moisture, and criteria for acceptable performance, such as avoidance of mold growth, decay, or corrosion. Quantification is integral to a scientific approach; in contrast, many traditional guidelines are based on experience, opinion, or limited technical information. A significant area in need of experimental research is wind-driven rain penetration through wall assemblies. To address this need, the Forest Products Laboratory is developing a new laboratory facility for evaluating wall systems for hygrothermal performance and durability, both for new construction and for retrofit applications.

Materials and methods

The facility, known as the Chamber for Analytic Research on Wall Assemblies exposed to Simulated weather (CARWASh), provides a realistic laboratory simulation of wind-driven rain impinging on a full-scale (approximately 3-m by 3-m) wall assembly. The method of exposure is unique and is representative of the physical phenomena typical in rainstorms. Spray nozzles direct water droplets downward into a moving stream of air, which imparts a horizontal velocity component to the droplets prior to their colliding with the test specimen. In contrast, typical water spray tests rely on water pressure fed to a rack of spray nozzles for control of the impact force. The CARWASh enables precisely-controlled rain simulation up to 150 mm/h at air speeds up to 11 m/s with variable wind direction. The chamber also maintains control of air temperature and humidity as well as the pressure difference across the wall assembly. Infrared radiation can be directed at the specimen to simulate solar warming. On the indoor side, air temperature and humidity are controlled. Tests can be programmed with weather data and set to run for weeks or months at a time.

A data acquisition system records readings from sensors in numerous locations: exterior environmental conditions, including temperature, humidity, wind-driven rain on the wall assembly, wind speed and direction, and radiation on the wall assembly; interior conditions, including temperature and humidity; and conditions within wall assemblies, including moisture content and temperature

in wood framing and sheathing, relative humidity and temperature at select locations, and pressure differentials across components.

The facility will be used in a variety of research areas:

- Investigating wind-driven rain intrusion in walls and drying rates after wetting events
- Investigating the effect of air infiltration and exfiltration on moisture levels in walls
- Providing experimental data for validation of heat, air, and moisture transfer models
- Testing innovative wall assemblies
- Testing window installation details, water management details, and details for enhanced drainage and drying of wall assemblies.

Conclusions

The U.S. Forest Products Laboratory is developing a new laboratory facility for research on wind-driven rain intrusion in wall assemblies. This research will contribute to a quantitative, performance-based approach to moisture management, which is critical for the design of durable, energy-efficient buildings.

Figure 1. Chamber viewed from the exterior.

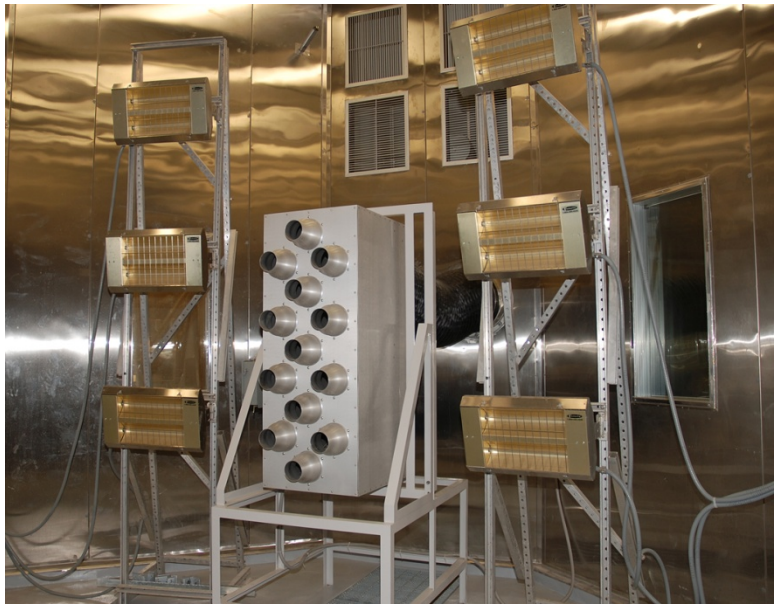

Figure 2. Array of infrared heat lamps and wind nozzle assembly inside the chamber.

Figure 3. One of 16 spray nozzles mounted near the chamber ceiling.

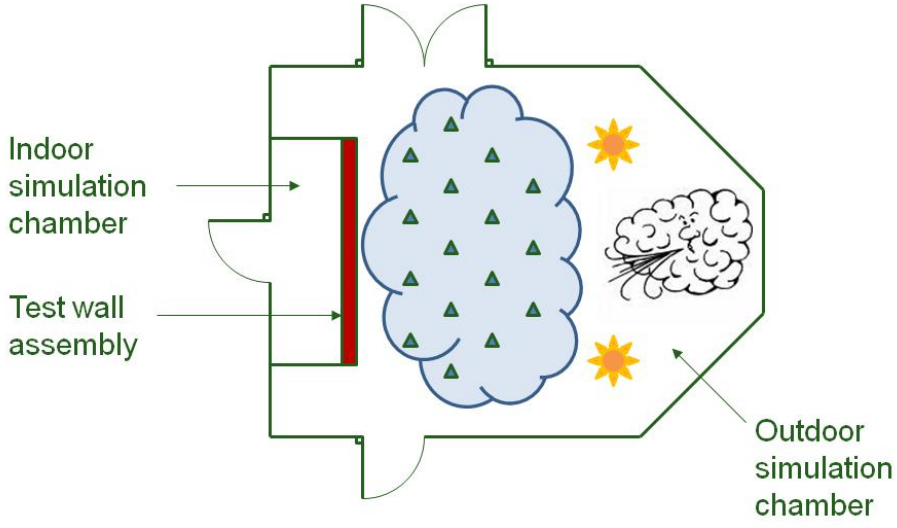

Figure 4. Plan view showing the main components of the facility.

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VTT SYMPOSIUM 263

Keywords: biomaterial, wood, fiber, composite, packaging, passive building

2009 Wood and Fiber Product Seminar

VTT and USDA Joint Activity

September 22–23, 2009

Edited by

Ali Harlin & Minna Vikman

Organised by

VTT

ISBN 978-951-38-7589-3 (soft back ed.)
ISSN 0357–9387 (soft back ed.)

ISBN 978-951-38-7590-9 (URL: http://www.vtt.fi/publications/index.jsp)
ISSN 1455–0873 (URL: http://www.vtt.fi/publications/index.jsp)

JULKAISIJA – UTGIVARE – PUBLISHER

VTT, Vuorimiehentie 5, PL 1000, 02044 VTT
puh. vaihde 020 722 111, faksi 020 722 4374

VTT, Bergsmansvägen 5, PB 1000, 02044 VTT
tel. växel 020 722 111, fax 020 722 4374

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Vuorimiehentie 5, P.O. Box 1000, FI-02044 VTT, Finland
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Edita Prima Oy, Helsinki 2010