Survey of Building Envelope Failures in the Coastal Climate of British Columbia

Introduction

Over the past ten years, significant numbers of low-rise multi-unit wood frame residential buildings in coastal British Columbia have been plagued with envelope performance problems. The problems have included water penetration, damage to cladding systems and rotting and decay of wood components. The City of Vancouver, the National Standing Committee on Small Buildings and other industry groups have responded to the problem in various ways, and stakeholders have established the Building Envelope Research Consortium (BERC) to monitor this issue.

The objective of this 1996 CMHC study was to examine the relationship between the building envelope problems and their potential causes. The findings would be used to help identify key aspects of the design, construction and operations and maintenance processes leading to the problems, and to provide a focus for the efforts to resolve these.

Research Program

The research program followed a series of steps:

- select samples of ”problem” and “control” buildings based on predetermined criteria;
- develop a data collection instrument;
- establish evaluation criteria and standards;
- develop a computerized database to manage the input;
- collect and analyze data; and
- make recommendations.

Problem buildings were defined as those in which a moisture problem within the walls, decks or exterior framing had resulted in damage requiring $10,000 or more to repair; “control” buildings were those which, over a period of at least five years, had not experienced such moisture problems. The actual sample consisted of 37 problem buildings and nine control buildings. The problem buildings incorporated stucco, wood and vinyl wall types. The wall components included various combinations of building paper, OSB, plywood and housewrap.

Cette publication est aussi disponible en français sous le titre : *Enquête sur les défaillances de l’enveloppe des bâtiments construits dans le climat côtier de la Colombie-Britannique*

Results

The table below provides an overview of the extent of the problem in the two samples.

Table 1:
Problems in Study Buildings

	Problem Buildings	Control Buildings	Total
No. of buildings	37	9	46
No. of walls	51	21	72
Problems reported	193	0	193

The sample buildings were to be no more than eight years old. Of the problem buildings, almost 50 % were built between 1988 and 1990; another 16 % built in 1994.

Repair costs were used to indicate the severity and extent of damage to each building. The table below summarizes these findings; multiple attempts at repair are included in the costs, where applicable.

Table 2:
Cost of Repairing Buildings

Cladding	#	Cost/Unit		Std. Deviation
		Mean	Median	
All	37	7,152	3,333	10,918
Stucco	28	8,552	5,100	12,208
Vinyl	5	1,818	1,417	1,148
Wood	8	4,535	4,666	3,178

Overall, the results of the study indicate that the primary source of moisture leading to the performance problems was water entering the building from the exterior, rather than interior sources or construction moisture.

About 90 % of the problems were thought to be related to interface details between wall components or at penetrations. Water enters the wall assembly at details and stays there long enough to initiate rot of wood components.

The problems were thought to originate during design and construction activities (due to poor details on drawings) and not as a result of operations and maintenance or defects in the materials. The stages at which the problems were thought to arise are shown in Table 3.

The data collected in the study indicate that the defects that allowed water to penetrate walls were widespread and appeared on many wall systems. This suggested that it is the quantity of wetting at these defects, combined with the drying characteristics of the wall assembly, that determine whether a wall can accommodate the moisture and provide acceptable performance.

Key differences between problem and control buildings is summarized below:

- The wind exposure of the control buildings was generally lower than that of the problem buildings.
- The absence of overhangs above walls contributes to moisture damage. Roof overhangs were significantly larger on the control buildings than on the problem buildings.

- The control buildings had fewer architectural features and details and more of the details were flashed on the control walls.
- The materials in the wall sections of control walls were less likely to be the most commonly used materials, namely stucco, building paper and OSB. It was not clear whether wall assemblies constructed with OSB or plywood performed better.
- The quality of the design, construction and building materials indicates that certain details were often poorly designed in the control buildings, as well as in the problem buildings. Problems often arise from the individual trade personnel's knowledge and experience, the contractor or designer's diligence in providing clarification and the sensitivity of the assembly performance to a particular detail.

Other key findings included:

- Almost all the problems were associated with details such as windows, decks, walkways, balconies and penetrations on walls. With regard to windows, water seemed to penetrate through the window frame joints and through the interface between the windows and adjacent wall assemblies. With balconies, the problems were related to the installation of waterproof membranes.
- All cladding types experienced performance problems, although the number of problems reported on stucco walls was greater.
- Finally, the study results indicated that in the coastal climate area, face sealed wall assemblies are sensitive to design and construction details, making it difficult to achieve acceptable performance. Rainscreen wall assemblies are thought to offer the best opportunity to achieve acceptable performance. Also needed is significant improvement in the design and construction of interface details and better communication between designers and trade personnel.

The study concluded that greater attention needs to be paid to water management principles (associated with control of moisture entry, drying potential and drainage). It concluded also that local climate conditions need to be taken into account when establishing effective water management strategies in construction.

Implications for the Housing Industry

The study made several recommendations for the housing industry, particularly with reference to design and construction. The recommendations include requirements for the following:

- greater clarity in design strategies;
- improvement in details (e.g., more key details, larger-scale, project-specific information);
- development of guidance documents with respect to the details;
- communication of the design intent through mock-ups;
- establishment of an envelope quality management protocol; and
- training of trade personnel with respect to the construction of envelope materials and systems.

The study also recommended further work in areas unrelated to design and construction, for example:

Table 3:
Problem Sources by Stage

Rating	Design	Construction	Maintenance	Operation
	No. of Problems Contributed			
Acceptable	0	0	0	0
Poor	90	149	13	1
Not Designed	27	na	na	na
Not Maintainable	na	na	6	na
Not Rated	0	0	0	0
Total	117	149	19	1

- effective remedial strategies to address the envelope performance problems;
- the use of rainscreen systems utilizing claddings and other materials that traditionally have not been used in this way;
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- enhancement of the A440 wind performance standard to extend its use for the installed window assembly.
- guidance for building owners regarding exterior wall system maintenance to reduce premature envelope failure.

Project Manager: *Jacques Rousseau/ Don Hazleden*

Research Report: *Survey of Building Envelope Failures in the Coastal Climate of British Columbia, 1998 (English only)*

Research Consultant: *Morrison Hershfield Limited*

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

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