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THE RAINSCREEN WALL:
A COMMISSIONING
PROTOCOL

NOTE: **DISPONIBLE AUSSI EN FRANÇAIS SOUS LE TITRE:**

LE MUR À ÉCRAN PARE-PLUIE : UN PROTOCOLE DE MISE EN SERVICE

The Rainscreen Wall:
a Commissioning Protocol

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Appendix "A"- Forum on the Canada Life Building.

Executive Summary

The rainscreen principle is not new. It was proposed as early as the mid sixties by researchers of the Division of Building Research of the National Research Council of Canada and the basic principles were developed. It has been applied to certain exterior wall types but the performance of rainscreen walls remains largely unknown because of the absence of engineering data. It is only recently that interest has grown in the application of the rainscreen principle because face sealing and the drained cavity approach do not allow for the satisfactory control of moisture in construction cavities from rain or from condensation.

The rainscreen principle is well developed qualitatively but not quantitatively. There are no technical or engineering criteria to assist designers and few established prescriptions for the builder. The actual field performance of the rainscreen with respect to rain control is unknown and the relation to pressure equalization is also unknown. The Canada Mortgage and Housing Corporation (CMHC) recognized the need to undertake further research into the engineering and technology of the rainscreen principle.

This project was commissioned by CMHC and Public Works Government Services Canada (PWGSC) to further advance the application of the rainscreen principle to exterior wall design and construction of both residential and commercial buildings.

This project included three distinct areas of interest. First, the development of a method to monitor the performance of existing rainscreen wall systems and to gain insight into the actual or field pressure equalization performance. This work was also coupled to a laboratory investigation of the wetting and drying of a rainscreen cavity in a metal and glass curtain wall. Secondly, the development of a field performance and design compliance testing procedure. The procedure is termed the Cavity Excitation Method or CEM. It is a field test that does not require elaborate preparations and substantial mockup facilities. Third, the development of performance criteria for the design of rainscreen systems and the development of commissioning guidelines for rainscreen wall system.

This is the third and final report of this project on rainscreen performance research. It examines the design criteria to be applied in rainscreen design and proposes a commissioning protocol for the compliance testing of newly constructed rainscreen wall systems. It also include a summary report on the challenges and successes of applying rainscreen technology to the design and construction of a precast and limestone exterior rainscreen wall.

1.0 Introduction

There are three design approaches to rain penetration control for exterior walls and windows. These are the traditional face seal method, the drained cavity wall approach and the rainscreen principle. The rainscreen principle is the most current approach to long term performance and durability for rain penetration control.

The rainscreen principle comprises several features to include the control of direct rain entry, the provision of capillary breaks and drips to interrupt surface water drainage, the provision of weep holes and internal flashings for drainage , and a vented and pressure equalized cavity. In addition, the wall cavity must be rendered airtight and be compartmentalized from other cavities.

There have been advances in research and development of the rainscreen principle. Most of the current advances were commissioned by the Canada Mortgage and Housing Corporation (CMHC). For example, there is a CMHC research project on rainscreen performance currently in progress at the National Research Council of Canada. This project is examining the effects of dynamic wind loading (sinusoidal loads at various frequencies) and water penetration control. There is also another CMHC project recently completed at Western University in London, Ontario, to study wetting patterns and the strategic locations of compartmentalization for facades. In addition, there are various private contributions of knowledge by manufacturers and a practical interest by architects and engineers for better information on the application and performance of the pressure equalized rainscreen wall or window system.

While the rainscreen principle is sound conceptually and the qualitative attributes have been applied to various wall and window designs, there is little information on the quantitative aspects of its performance. For example, what level of pressure equalization is required to control rain penetration? Is there a difference in rain penetration between a steady wind driven rain and a gusting wind during a rain storm? How much water should be allowed to pass into the cavity or be stored in the cladding materials following a rain storm? How can the design of a rainscreen system be verified for performance and the construction for compliance? It is these and other questions that are explored in this study.

The study was commissioned by CMHC and Public Works Government Services Canada (PWGSC). The study includes three areas of interest. These are;

1) The measuring and monitoring of rainscreen field performance,
2) On site testing, the CEM approach, of the rainscreen system for performance verification and ,
3) Commissioning the design and construction of rainscreen wall and window systems.

This report examines the third area of interest, commissioning the design and construction of rainscreen wall and window systems. It includes a discussion on the performance criteria for use in design and commissioning of the rainscreen wall. It presents a design method using the CMHC "Rain - V2.0" computer program and proposes a commissioning protocol for on site verification of compliance. Further, this report presents a case study which involved a rainscreen design, field performance evaluation and a commissioning procedure for the Canada Life Building in Toronto.

The research findings from the monitoring of rainscreen projects in the field, report no. 1, and the proposed field testing method, the CEM approach, report no. 2, are available from CMHC as separate reports. These are titled "Laboratory Investigation and Field Performance Monitoring of Rainscreen Walls" and "Rainscreen Wall Testing: the Cavity Excitation Method (CEM)" .

2.0 Rainscreen Wall Performance Criteria

The performance of the rainscreen system is defined qualitatively in many publications but for commissioning purposes its performance must be defined quantitatively. In other words, the performance attributes of rain control and pressure equalization must be quantifiable and measurable parameters.

In a rainscreen system, there are numerous parameters that can be measured. The parameters that govern pressure equalization response include;

- volume of cavity
- vent/drainage area
- leakage area through the air barrier and compartment seals
- stiffness (flexibility) of cladding system
- stiffness (flexibility) of air barrier system

By varying any of the above parameter values, the pressure equalization performance of a rainscreen system is easily adjusted to any desired performance. The problem is what pressure equalization performance is required to control rain penetration and to reduce cladding loads for a possible structural benefit.

At the time of this write up, there was no known cladding performance load criteria identified in the literature or any research directed to this question. At the very least, however, the author has determined through laboratory experience and field observations that water penetration control under static conditions of pressure difference can be achieved with as low as 30% steady state equalization. No such anecdotal evidence exists for dynamic performance but it is believed that sinusoidal loading of wind pressure (gusting) would not be as severe for water entry as a static pressure difference.

Also, it is known that the pressure equalization response diminishes with increasing frequency. From previous analyses of this type and to err on the side of adequate performance, the following performance criteria were used to size venting area on claddings, 80% static and 50% dynamic (2 Hz). When combined with a maximum air leakage rate of 0.1 L/s*m^2 @ 75 Pa for the air barrier, the values proposed above may be used as initial performance criteria until better information is obtained from manufacturers, the research community or standard writing bodies. While it is beyond the scope of this project to rigorously explore the values defined above, they provide a point of departure for the engineering and commissioning of any rainscreen system.

3.0 A Commissioning Protocol

If the performance of a rainscreen wall/window system is to be designed and constructed to performance criteria, the normal process of design and construction must be expanded to include engineering and commissioning procedures for the rainscreen system.

1) In the normal course of design, cladding systems are selected during the development of façades. It is during this phase that several key decision must be taken. Will the façades be face sealed or rainscreen. If they are to be rainscreen, will the concept be applied to all elevations or only certain parts. If applied to an entire façade, where are the cavities to be compartmentalized. This aspect of the rainscreen is an integral part of the elements governing performance but it is not studied further in this project. For more information on compartmentalization see the CMHC study on Facade Compartmentalization: a Wind Tunnel Study.

2) Having chosen the rainscreen principle for various parts of the exterior walls, the individual parts must be then be designed. It is also at this time that the performance criteria must be established. These would include the ratio of rain penetration to rain loading (not yet developed) for a given rain storm condition for both steady state and dynamic conditions. The second requirement is to establish the pressure equalization performance required for steady state and dynamic conditions. For demonstration purposes , we have chosen 80% for steady state and 50% for dynamic at a 2 Hz frequency (see discussion above).

3) The designer then proceeds to concept detailing of the exterior walls and windows in the usual manner except that the chosen systems will be subject to performance analysis and design iteration until the performance requirements selected above are attained. The performance analysis may be undertaken with the use of version 2.0 or higher of the CMHC "RAIN" computer program.

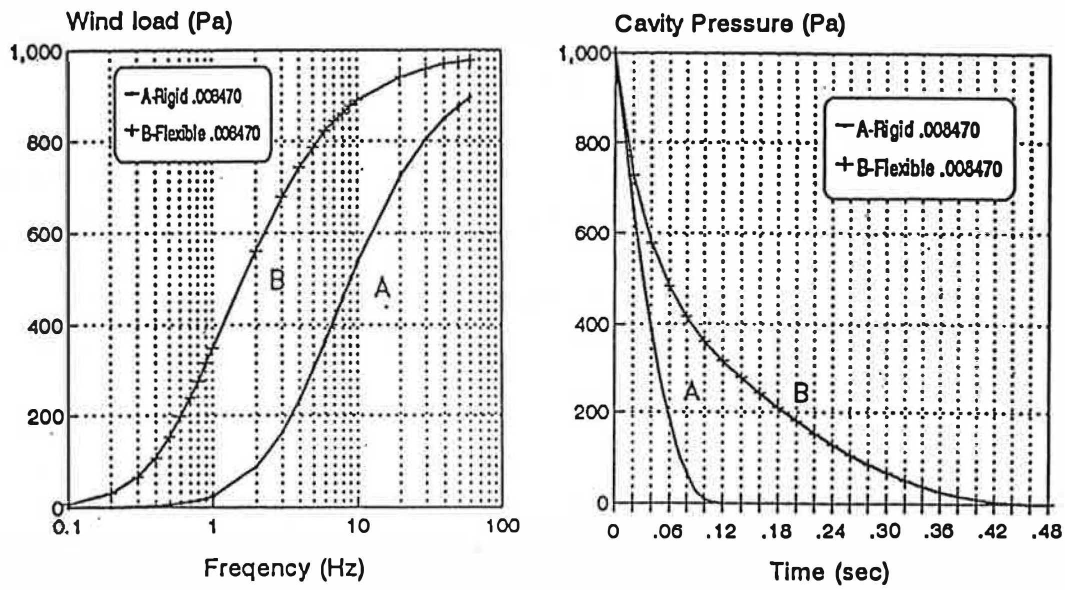
4) For example, consider a brick veneer steel stud exterior wall. The rainscreen cavity is defined as 1 storey (3 m) in height, 6 m long and 0.01 m deep. The air barrier is a membrane over a gypsum substrate and the cavity is partly filled with insulation. It is determined that the air barrier and compartment seals must not leak in excess of 0.1 $L/s{\cdot}m^2$ at 75 Pa or 1.8 L/s total for an equivalent leakage area of no more than 0.00025 m^2. The venting area is provided by the brick vents (0.00078 m^2/vent) or for 10 vents (0.0078 m^2). The brick is considered to be rigid (flexibility=0) and the steel stud which supports the air barrier is attached to the brick veneer and therefore also considered rigid (flexibility=0).

5) Having established initial values for the rainscreen design, determine the steady state equalization and the dynamic performance using version 2.0 of the CMHC "RAIN" computer program. If the initial simulation results indicated a steady state equalization of 80% or more and the dynamic (2 Hz) is better than 50%, the design is then carried to the production of working drawings and the development of the commissioning criteria. If the design fails to meet the criteria established, then the design is revised until both criteria are satisfied. The results of a typical simulation of a brick veneer steel stud rainscreen wall with rigid cavity and its variation with a slightly flexible air barrier system appear below (see Figure 1). Note also the corresponding CEM (decay curve) performance criteria. For a more detailed discussion of the CEM concept see CMHC report no 2, " Field Testing: the Cavity Excitation Method (CEM)".

6) The next step involves validation of the design. Ideally this would be accomplished in a laboratory where a full scale mockup assembly is attached to a pressure chamber. The design of the wall is constructed as per drawings and specifications and tested for steady state and dynamic performance to determine if the performance requirements of the simulation compare adequately with the mockup performance, what quality of construction was required and to determine if the CEM performance criteria comprise reasonable commissioning and compliance test requirements.

7) If the mockup design in the laboratory fails to meet the performance objectives, then the mockup design is progressively revised and tested to determine which construction feature was inadequate or unsuitable. This process is repeated until the design attains feasible constructability with good quality workmanship and materials. On the final iteration, the CEM performance criteria are defined for the field commissioning criteria.

Figure 1 "S" Curve and Decay Curve of Brick Veneer Steel Stud



8) If conditions of timing or budget do not permit this exploration, then the process may be transported to the field as a mockup on site to be part of the construction contract. However, this situation must also include a budget allowance for modest re-design as it is not reasonable for the builder to pay for the uncertainty of design changes. Nevertheless, the design must be validated before the builder accepts responsibility for the eventual commissioning specifications of the rainscreen system.

9) Commissioning the rainscreen system or systems may then proceed in a progressive manner if the project is large and complex or near the completion of construction if adequate site supervision has ensured that the quality of construction required was attained as per laboratory or mockup requirements.

10) The commissioning process would be undertaken as soon as possible so that compliance may be determined. The compliance attributes would be determined by contract but may include;

a) air barrier/compartment seal leakage not exceeding a limit area,
b) the rainscreen vent area total to be not less than the specified limit area,
c) the time decay rate of the prescribed CEM tests are not to exceed the specified criteria or,
d) the deflections of the cladding and air barrier system are not to exceed the specified limits.

11) The commissioning procedure does not include a water test but it would be prudent to undertake a test such as ASTM E543 or its equivalent for the field. This procedure would test for other basic attributes such as direct entry, capillary breaks and gravity control. No water is permitted entry to the inside of the building and excessive water should not be accepted in the rainscreen cavity.

12) If the construction has met the commissioning criteria as per CEM procedure and other test criteria, then a certificate of compliance may be issued by the commissioning agent or architect to the builder.

4.0 A Case Study

The process described above is not as fictitious as might be imagined. It is to the credit of Adason Properties and Mr. David House in particular, that a process approaching the one described above was undertaken for the new Canada Life Building in Toronto.

The Canada Life building is a 14 storey office building, recently completed in which substantial extra expense was incurred to design and validate the air barrier system, the rainscreen compartments and the rainscreen system.

The design development and commissioning sequence was managed by Perreault and Sons Ltd. while the laboratory testing of full scale mockup was undertaken by Trow Engineers Ltd. Additional testing and monitoring was undertaken by Can-Best and Brook Van Dalen Consulting Engineers Ltd.

In view of this unique experience by all those concerned, the Canada Mortgage and Housing Corporation sponsored a post project completion workshop with all those involved, to review the process and to suggest improvements. The workshop minutes were edited and organized by the author and are presented in Appendix "A".

The commissioning of the building envelope or parts of the envelope is a desirable if not necessary next step in the production of higher quality building envelope walls and windows. It is not feasible to apply the concept directly to all performance requirements at this time but it is feasible to commission certain attributes of the rainscreen which would benefit not only the owner but the designer and builder alike. It is this approach and others like it that will provide tangible proof of performance before a project is complete. The conventional method of designing exterior rainscreen walls and windows is based on known principles, but there are no performance criteria on which to determine performance compliance by design or in construction. It is for this reason that builders cannot be expected to construct functional rainscreen walls. This cannot happen until designers have the necessary engineering data.

5.0 Conclusions and Recommendations

The design and construction of the rainscreen system is currently more art than science. There are numerous examples of its application but field evidence seems to indicate that the pressure equalization performance of these examples is considerably less than expected.

The performance criteria for rainscreen wall design must be researched and defined to provide architects and engineers with measurable attributes. At this time, there are no such criteria although the principle is well established. In the absence of a standard or even adequate engineering data, it is proposed that the performance of rainscreens be designed to attain a minimum of 80% pressure equalization at steady state wind pressure and at least 50% under dynamic conditions (2 Hz sinusoidal loading) until further information is provided by the research and or standard writing bodies.

Performance design and commissioning of the rainscreen is viable. The method should be tested on one or two rainscreen systems in a laboratory setting and it should use version 2.0 of the CMHC "RAIN" computer program to determine the steady state as well as dynamic performance of the design. The program will also provide the corresponding CEM test criteria so that these may be validated in the laboratory before incorporating the results into a compliance specifications.

This project was undertaken to explore the overall technical issues relative to performance, design, construction and commissioning of the rainscreen system. To be effective, the performance of a rainscreen must be predictable and the design, construction and commissioning of the rainscreen must be related to its performance. It is believed that the methods explored and developed are feasible, admittedly complex in parts, but with experience and further study should advance our rainscreen design and construction significantly from art to science.

If this work is extended in the future, we recommend that the following project be considered. The performance design and commissioning protocol should be attempted on one or two full scale laboratory wall samples an then on one or two cladding retrofit projects to better understand the constraints, technical and financial as well as performance and durability and to provide experience with commissioning rainscreens for the building envelope.

Quirouette Building Specialists Ltd.

Rick L. Quirouette, B. Arch.
RLQ/nhb

Appendix
"A"

A Forum on the
Canada Life Building

A Forum on Commissioning the Rainscreen Walls of the Canada Life Building in Toronto

submitted to

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A Forum on
Commissioning the Rainscreen Wall of the
Canada Life Building in Toronto

Introduction

On the 7th of January, the Canada Mortgage and Housing Corporation (CMHC) sponsored a forum to review the design and construction of the exterior walls of the Canada Life Building in Toronto. The forum was held at the Adason Life Headquarters, 181 University Avenue, in Toronto and hosted by Mr. David House of Adason Properties.

The purpose of the forum was to discuss the events associated with the upgraded exterior wall design and the construction review process of the Canada Life building in Toronto. Those involved in the process were invited to discuss the problems, frustrations and benefits of commissioning the exterior walls. Also, it was agreed to discuss the reasons for the technological innovations implemented in this project and how best to optimize the process for future buildings.

The meeting was chaired by Pierre-Michel Busque (PMB). He presented an overview of the CMHC objectives with respect to commissioning of building envelopes and rainscreen systems in particular. He explained the ongoing research project and how the Canada Life building experience would be valuable to future research and for applications of this technology.

During the course of the day each person contributed his or her comments regarding the process and provided suggestions to improve it. The forum began at approximately 9:00 AM and was attended by the following persons:

- **David House** of Adason Properties Ltd.
  tel (416) 363-3667, fax (416) 363-7396
- **Tony Colantonio**, B.Arch.
  tel (613) 736-2122, fax (613) 736-2826
- **Thomas Tampold** of Shore, Tilbe, Irwin and Partners
  (416) 971-6060, fax (416) 971-6765
- **Peter J. Cicuto**, P.Eng., of E & M Precast Ltd.
  tel (416) 674-1700, fax (416) 674-7970
- **Tibor Kokai**, Ph.D., P.Eng., of Halsall & Associates Ltd.
  tel (416) 487-5256, fax (416) 487-9766
- **Elie Alkoury**, M.Eng., P.Eng., of CAN-BEST
  tel (905) 791-0344, fax (905) 791-3835

- **Greg A. Hildebrand** of Trow Consulting Engineers
  tel (416) 793-9800, fax (416) 793-0641
- **Sally Thompson**, M.Sc., P.Eng., of Halsall & Associates Ltd.
  tel (416) 487-5256, fax (416) 487-9766
- **Michel Perreault** of Perreault & Sons
  tel (416) 490-1668, fax (416) 490-1101
- **Pierre-Michel Busque** of Canada Mortgage and Housing Corporation, tel (613) 748-4671, fax (613) 748-2402
- **Richard L. Quirouette** of Quirouette Building Specialists
  tel (613) 747-0251, fax (613) 747-0251
- **Antamex** was not present.

David House

David, of Adason Properties, represents the developer. He coordinated and managed the construction of the Canada Life building project. David provided the opening remarks for the meeting and thanked all those attending. His comments and suggestions are summarized as follows.

- Aesthetic of building project is important but so is technical quality of exterior walls and windows.

- Owners and developers must direct team members to explore advanced technology for building envelopes.

- Owners and developers that purchase buildings are frustrated with faulty building envelopes that result in unexpected high repair costs.

- Owners and developers often engage technical specialists. However, there is a wide diversity of opinion among specialists and the results are sometimes contradictory.

- Wall design and construction upgrading not enough. The process must include roof; must include entire envelope.

- The problem with building envelopes is lack of architectural details and those provided do not conform to current technology.

- Finance people will eventually endorse commissioning of the building envelope.

- A building is a laboratory; it provides opportunities for the design and construction team. Owners and developers should provide access to researchers and consultants.

- The cost of engineering the performance of the exterior walls of the Canada Life building was 5.5% of wall cost and 0.9% of building cost.

- Construction mockups are essential, however, would encourage more study of details first and smaller samples/mockup where applicable.

- Team organization very important - early formation a must.

- Improvements to building wall details by trade off not ideal but satisfactory.

- Monitoring to be encouraged for owner and general knowledge.

- Important to find way to integrate HVAC and Envelope Performance. Ex: tight building envelope means third boiler may not be required?

Tony Colantonio, B.Arch.

Tony, as a representative of Public Works Canada (PWC), was invited to share his thoughts and impressions of the process and to offer comments and suggestions.

- PWC has a project delivery system (PDS) that attempts to obtain similar results.

- The PDS is however different in that there is less flexibility for trade offs and changes and no moneys available for development.

- 1968 PWC document specifies, rainscreen principle by NRC, but application guide does not exist.

- PWC is bound by strict accountability, innovation and development are restricted.

- Rainscreen Technology important, PWC supports development by other means.

Thomas Tampold, B.Arch., OAA

Thomas was the architect in charge of the Canada Life building project. The following comments and suggestions were put forward.

- Architecture is an art, aesthetics and function are the most important criteria.

- Performances/durability is a science. If a specialist is required then the owner should retain him.

- Initially we do not trust project contractors, subcontractors and suppliers. Need proof of performance.

- Commissioning of exterior walls was most interesting - it fostered a united construction team and improved trust.

- Performance of wall design features in the laboratory would constitute proof of design and validation of performance.

- Building Science specialists - R2000 fanatics.

- Any third party intervention such as specialist must report to owner, third party is owner.

Peter Cicuto, P.Eng.

Peter was responsible for the coordination of design, production, erection and performance of the architectural precast exterior walls. His comments and suggestions are summarized as follows.

- Architectural precasters manufacture concrete elements -they do not generally have sufficient knowledge or expertise to assess specified performance requirements other than structural and aesthetics.

- Performance specifications are generally meaningless at tender stage. Estimators or quantity surveyors have little or no knowledge of performance criteria nor associated cost impact.

- Prefer prescriptive specifications to performance specifications. We are basically manufacturers with strong structural capabilities not overall wall envelope designers. Performance specs are difficult to estimate and cost. Generally wall performance is only as good as the sub trades that follow. Total wall to be fully addressed and coordinated.

- Lack of details frustrating! Better details would allow us to quantify costs more accurately and to produce better products. To build and design concurrently within a fixed budget and compressed schedule does not work!

- All mock-ups (whether for aesthetics, constructability, performance, material compatibility etc..) to be pre awarded to assess and confirm realistic expectations.

- Supervision of fabrication process should be undertaken by experienced personnel not inexperienced junior.

- Knowing about expectations of quality and performance does not improve chance of getting job, in fact, more often than not, its a hindrance.

- Project management is disastrous if not accompanied by competent technical expertise either internal or external but definitely a team player.

- Repetitious assemblies cost effective. The simpler the better. This point cannot be over stressed.

- Acknowledge and provide reasonable tolerance(s) for production and erection and coordinate with all sub trades that follow.

In summary Peter suggests that team approach is best. Need to discuss expectations more fully, need to study, develop and finalize details fully to avoid prolonged agonies. Would consider broader single source responsibility as way of future.

Tibor Kokai, P.Eng.

Tibor was the structural engineer on the Canada Life building project. He provided the following comments and suggestions.

- Low bidder concept inappropriate to objectives - suggests dropping low and high bidders.

- Engineer retained by architect. Structural design of air barriers and rainscreen is responsibility of architect but would provide services if asked.

- This type of work constitutes an extra and it would require additional compensation.

- Structural engineers are well trained to deal with joint design, i.e. movements from thermal, wind and other loads but must be asked to provide services. Not in usual scope.

Elie Alkoury, M.Eng., P.Eng.

Elie was retained by Adason Properties to assist with developments of rainscreen walls system and the field monitoring in particular. Elie presented the preliminary results of the current pressure equalization monitoring. He provided the following comments and suggestions.

- The following locations were instrumented with pressure taps. They include the outside, the cavity, the inside finish cavity and the inside of the building; 11th floor, panel 89 (10 probes) west elevation panel 94 (6 probes).

- Sampling taken at 200 hz for 10 seconds several times per day.

- Early readings indicate that limestone cladding is pressure equalizing as expected even though observed wind pressures low.

- Sample results provided (see attachments).Curves represent the pressure difference across wall (point 1-in) and two pressure differences (point 2-in, point 3-in) across the air barrier.

- Monitoring in field is simple to set up and simple to undertake.

- CAN-BEST has had similar experience with other buildings.

Greg Hilderbrand, P.Eng.

Greg provided specialized laboratory services at Trow Ltd. with respect to the pressure equalization attributes of the architectural precast panels on the Canada Life building. He provided the following comments and suggestions.

- Architectural precast panel was tested in the laboratory. It was subject to static as well as dynamic testing.

- While attributes of pressure equalization were determined for different frequencies, there is no pass/fail criteria from which to judge performance.

- A distinction should be made between development of design and testing for compliance.

- Experience was valuable as all parties learned about performance.

- Concern about prescription versus performance. Prescriptive too limiting with respect to innovation.

- Not enough known about relation of pressure equalization to water penetration control, structural load sharing, etc.

- What is liability for lab testing? It is shared with owner?

Michel Perreault

Michel was engaged by Adason Properties to develop the exterior wall/window system to higher levels of performance and durability. He provided the following comments and suggestions;

- Quality control of design and construction of exterior walls requires a commitment by the owner/developer to a higher quality performance and to the finances required to attain it.

- Standards of design quality are required for easier implementation. For example, the design of seals for rainscreen compartments varies with the understanding of the designer. It can range from stuffed insulation to sheet metal barriers.

- Role and responsibilities of general contractor or project manager need clarification with respect to architectural detailing changes. How does sequencing affect detailing?

- Provided a brief explanation of rainscreen design. Emphasize need for more complete detailing and detailing review.

- Detailing of architectural and shop drawings requires thorough and prompt review. Procedural method for incorporating changes regarding cost, schedules etc... to be established up front.

- Performance standards for pressure equalization performance of a variety of wall systems must be established to determine minimum requirements for each type.

- Design and construction are normally contracted. Commissioning of the building envelope should also be contracted.

Sally Thompson, P.Eng.

As assistant to Tibor Kokai, Sally provided structural services on the Canada Life building project. She acted as observer during the meeting.

Summary

From the discussions and presentations by the various parties, an overall impression is provided below.

- Development of the science and technology of the envelope and the rainscreen, in particular, is driven by owners, developers and specialists.

- The design, construction, fabricating team can respond positively when requested. When there is an offer of remuneration for their participation and advice, added value is usually obtained but sometimes not.

- Project experience of this type should be published so that other owners and developers can learn of improvements and advances in technology. Specifically what direct benefits are derived.

- The architectural drawings need to be upgraded at the detail level. This could not be over emphasized by all.

- The cost of development and improvement of envelope quality can be as high as 6% of exterior wall costs and 1% of building cost.

- In time, building finance organizations will endorse commissioning of the envelope.

- It is possible to design and build to performance targets, however, it is best attained by successive iteration of design, testing in the laboratory and in the field, the use of prescription specifications with quality supervision. The number of design iterations can be reduced as knowledge is gained of performance and durability of envelope systems and the knowledge is converted to performance engineering principles and commissioning procedures.

From these discussions and the project objectives of CMHC, the following performance engineering and commissioning procedures are presented for improved rain penetration control technology and commissioning of the rainscreen walls.

The control of rain penetration through walls and windows is accomplished by sealing the exterior surface of the building facade, (face seal method), or by applying the principles of rainscreen design (rainscreen method) to various areas and element of the facades. The face seal method is the most common approach and it depends on perfect sealing and regular maintenance every 4 to 7 years. Alternatively, the pressure equalization rainscreen method accepts water penetration past the cladding but diverts it back to the outside. This method is considered superior because, if applied correctly it will virtually eliminates facade maintenance for twenty or more years. It is, however, slightly more expensive and complex to apply.

The Canada Mortgage and Housing Corporation (CMHC) is currently exploring better and more durable rain penetration control methods for residential buildings. Specifically, it is developing various commissioning procedures for the building envelope one of which is to commission the rainscreen wall or window system.

To commission a rainscreen wall or window is to verify its performance before completion of construction. There are several test procedures available and these are discussed further on. Before commissioning can take place, however, the design of the rainscreen wall or window must be validated and this is accomplished through performance engineering and field or laboratory testing. To assist with performance engineering, the Canada Mortgage and Housing Corporation has developed a simple computer program (RAIN) that simulates pressure equalization performance. This program will guide the designer through the pressure equalization performance of any design.

At this time, the performance criteria for pressure equalization of rainscreens has not been established in a rigorous manner but experience with field conditions and laboratory investigations by some consultants report that 80% P.E. at steady state and 50% P.E. under dynamic conditions will provide adequate rain penetration control and is a practical and attainable performance target. These criteria are explained in detail in a CMHC publication on "*A Study of the Rainscreen Concept Applied to Cladding Systems on Wood Frame Walls*".

Further, the performance of any pressure equalized rainscreen system is governed by the type and locations of the compartmentalization. Guidance for the distribution and locations of compartmentalization may be found in NRC publications and the report noted above.

It is from this basis that the design, construction and performance of any rainscreen wall or window may be commissioned. The process suggested is as follows:

(1) Determine the facade areas and windows to be designed as pressure equalized rainscreens,

(2) Locate vertical and horizontal compartments and determine number of rainscreen cavities,

(3) Develop basic design of rainscreen wall or window system to include an air barrier system, compartment seals, cladding systems with vents and drains,

(4) Determine physical attributes of each rainscreen cavity, i.e. volume, vent area, leakage area and stiffness of cladding and air barrier systems (see CMHC report above),

(5) Simulate the performance of each rainscreen cavity using "RAIN" and iterate the design until performance attributes are attained; 80% steady state and 50% dynamic(0-5Hz),

(6) To validate the design, construct a mockup on site or in the laboratory and test its P.E. performance. Validation may also be obtained from previous experience or manufacturer data.

(7) Complete design of envelope and prepare construction documentation,

(8) Prepare tender package and include allowances for design review and development and on site mockup test to validate design or workmanship quality. Establish performance tolerances (± 15% is acceptable). Commission either or both of the following tests :

    (a) Box in test area from outside, pressurize and measure flows and ΔP's. Perform decay rate test and note results. Compare findings with laboratory and simulation results.

(b) Undertake CEM test and note results (this method is under development and should be available after May '94). Compare results with laboratory and simulation results.

(9) Complete testing of the rainscreen wall and window system and report results,

(10) If results fall within margins of tolerance, rainscreen P.E. performance complies with design objectives and workmanship

may be certified as complying with drawings and specifications,

(11) This completes the commissioning of the rainscreen pressure equalization attributes before substantial completion of project.

(12) Post occupancy, the owner may wish to undertake performance monitoring to determine maintenance and durability of the new design. This would be valuable information to the owner as well as the professional community, but it cannot be made part of the original building contract.

The procedure described above and the target performance criteria address only to the pressure equalization performance. Other performance criteria must also be applied to the design to include, control of direct entry of rain, drainage of surface and cavity water, control of water entry by capillary action. These criteria are not commissionable at this time but quality control must be applied to the design of details and to the final assembly for best results.

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