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NORTH AMERICAN FORUM

In Canada the impact of the integrity of the building envelope has for some years been seen as critical to the ultimate performance of the building system. Much focus has been placed on the design and buildability of the envelope and its air barrier system. Recently, however, it has also been recognised that the envelope and its air barrier should be commissioned prior to hand over just as for a great many years now the other key elements impacting the building performance have also been subject to a commissioning process.

The following article by Rick Quirouette of Morrison Hershfield Limited describes commissioning of the air barrier.

COMMISSIONING THE AIR BARRIER

Commissioning an electrical or mechanical, ventilation, heating or cooling system is commonplace in large commercial projects. Commissioning involves testing of the building components and of the system before final acceptance. Commissioning may be defined as the process for verifying that the performance of systems meet the design performance criteria and the operational needs of the building within the limits of the design. Prior to commissioning a system, there are four conditions which must be met. These are:

1. That the performance requirements have been defined with specific quantitative values in a client program brief.
2. That the design claims are certifiable by calculation, testing, or by previous experience.
3. That testing can be carried out during or after assembly to validate the performance requirements and final acceptance.
4. That remedial action can be undertaken if the performance is not up to design requirements.

The concept of applying commissioning procedures to the building envelope is appealing, in view of the numerous performance problems arising with roofs, walls and windows of new building projects. Commissioning of the air barrier system is considered first because it is the principle envelope system upon which most of the other performance requirements usually depend.

The air barrier system has two performance requirements which can be commissioned; these are its structural and its air permeability attributes. Since it is not practical to subject the entire building envelope to an air pressure test at design wind load, it would be undertaken at earlier stages during construction on a sampling area basis. The overall air permeability of the building would also be tested and verified at completion.

However, unlike mechanical and electrical commissioning, there are few if any "rated" air barrier assemblies. Thus, commissioning must begin with pre-commissioning checks, specifically the validation of the design, testing of materials and assemblies during the construction or in the laboratory, prior to the final commissioning test that will certify the system performance.

This paper presents and discusses the key steps to be considered in the pre-commissioning and commissioning of the air barrier system for the building envelope. It is part of a broader study recently undertaken for Public Works Canada entitled "Commissioning of the Building Envelope". I am grateful to PWC for permission to use some of this information in this article.

PWC's study is divided into a series of events and tasks. These include; owner instructions to designers; development of the design brief; pre-commissioning of the air barrier systems design and its details; tendering criteria; construction quality; assurance; and commissioning the air barrier systems.

OWNER'S PROGRAM

The Owner's program suggests that the design team be notified a commissioning program is to be put in place and that various functions of the envelope may have to be commissioned. In this case the air barrier system is to be commissioned.

The program should direct the designer to specify quantitatively the required level of air tightness for the envelope, based on the designer's assessment of the interior and exterior environmental requirements, and the other characteristics of the envelope assembly. For the purposes of this discussion we have assumed that the designer is responsible for setting the acceptable air leakage performance for his design.

The program should also indicate that an independent consultant will be chosen by the Owner, in cooperation with the designers, to follow and eventually commission the air barrier systems. It should also indicate that the designer is to estimate an additional fee for the design process. Similarly an allowance should be included for the builder.

DESIGN BRIEF

The designer, in responding to the owner's program, should acknowledge the commissioning process and the air barrier requirements in particular. In the design brief the designer should indicate what level of air leakage control is to be achieved by the envelope. To set this number, the designer may have to do some research into the effect of various air leakage rates on the envelope and on the operation of the building, and on the air permeability and related structural characteristics of various materials and assemblies. Resource materials available include many IRC and CMHC reports. Technical support may also be obtained from manufacturers and suppliers in the form of product data or testing.

Some assemblies such as windows and curtain wall systems have rated or tested air leakage characteristics. Others are obviously air impermeable, such as built-up roofing and concrete slabs. For both of these groups the critical issue will be their junctions with other assemblies. The air tightness and structural capabilities of the joining materials must be determined.

The design brief should include a list and brief description of the tests that will be carried out, such as the following ASTM tests:

E283: Standard Test Method for Rate of Air Leakage through Exterior Windows Curtain Walls and Doors;
E330: Structural Performance of Exterior Windows, Curtain Walls and Doors by Uniform Static Air Pressure Difference;
E741: Standard Practice for Measuring Air Leakage Rate by the Tracer Dilution Method;
E779: Standard Practice for Measuring Air Leakage by the Fan Pressurisation Method;
E783: Standard Method for Field Measurement of Air Leakage through Installed Exterior Windows and Doors;
E1186: Standard Practices for Air Leakage Site Detection in Building Envelopes.

CSC's Tek-Aid on Air Barriers provides an excellent reference to assist in understanding and addressing building enclosure design, specifications and technology.

The program should also indicate what qualities will be tested to determine the air tightness and structural performance of the air barrier systems. For example quantitative criteria for structural performance and air leakage include:

1) Maximum positive/negative air pressure differences;
2) Flow rates in litres of air per second per square metre of surface area at a given air pressure difference; or:
3) Equivalent leakage area (ELA) calculated on the basis of a pressurisation test.

DESIGN DEVELOPMENT

At this point the general shape of the building will be determined and the various envelope systems chosen, including the air barrier system. The basis for selecting the system or assembly or component should be based on known characteristics for standard items; on custom tests for unproven systems; on the designer's experience; or on acceptable technical analysis.

The air barrier component in each building element (roofs, walls, soffits, etc) should be identified at this stage. Other items that should be addressed at this stage include:

a) How is continuity of the air barrier to be achieved at various junctions; window to wall, wall to floor, wall to roof, wall to foundation in soffits of cantilevered sections, service penetrations, cladding support penetrations or fixtures, between different wall assemblies, or through wall expansion joints?
b) How are wind loads supported and transferred back to the structure?
c) How is differential movement accounted for, including thermal movement, swaying of structure, dead and live load defections, creep?

At this stage, the designer should present the conceptual design of the air barrier system to the owner and make recommendations on how best to validate the general and detailed design of the air barrier system. This may involve laboratory measurements or mock-up testing before completion of the design documents.

The designer would then proceed to develop detail designs of the air barrier system to indicate which details and/or construction techniques are critical to the proper functioning of the air barrier and what sequence of construction must be considered for its assembly. This information will be used by all parties involved in the process to set priorities for construction, site review, inspection, testing and commissioning.

At the end of the detail design stage and before the documents are issued for tender, the designer may be required to certify that the envelope, if built as designed, will meet the air leakage and structural performance criteria of the design brief.

It would be in the designer's responsibility to have any testing of materials, component or assemblies carried out before construction to ensure that the design can perform as specified.

TENDERING STAGE

The tender documents should advise the builder to include an allowance to cover the cost of providing any required mock-up testing and commissioning tests support during the construction of the building. This would include typical window-wall assemblies. Mock-up testing would include the structural and air impermeability characteristics for each type of construction. The builder may waive the pre-commissioning testing but *not* the final commissioning testing if confident that the assembly can be built as designed, and that the design can function without further proof until the final commissioning test. The builder however, will not be responsible for providing the design adequacy.

The successful bidder, in accepting the assignment, must provide a statement to the effect that the air barrier system and associated components can be built as designed and that he will bear the cost of any extra testing and remedial work that may be required to provide the required level of performance, should it be found that a construction deficiency is the cause of the air barrier system failing the commissioning test.

A commissioning schedule for testing should be established.

CONSTRUCTION

Any necessary mock-up testing should be carried out to refine assembly technique and confirm performance. Testing of completed components should take place as early in the construction process as possible. In particular testing of the structural aspects of the various air seals must be done prior to building completion before they are covered over. It should be noted that the structural testing can not be carried out on the whole building as the overall pressurising forces would be too great. Structural testing must be carried out on a sample of the air barrier system and its junctions in particular. The air seals must be proven to withstand the peak wind pressure load as specified by the designer. The results of these tests would be communicated to the contractor, the owner and the designer. A pass allows the construction to proceed without delay. A failure may result in delays until the problem can be solved and successfully retested. The structural testing forms part of the final commissioning report.

COMMISSIONING THE AIR BARRIER SYSTEM

Final testing of the whole building must be carried out to demonstrate that it meets the overall air leakage performance criteria. The fan pressurisation method suggested may use a portable fan or the building's ventilation equipment. Every effort must be made to isolate the building volume from other connected volumes and to ensure that the interior volume is open to the influence of the pressurisation equipment. The pressure differential must be induced and stabilised and the air flow rate through the blower measured. The resulting air flow rate must be within the specified allowable limits or less than or equal to the specified air flow rate.

A successful commissioning test must be followed by certification of performance. The test conditions, procedures and results should be documented in the commissioning report. If the test results are above the acceptable air flow rate, the builder and the designer must be notified and directed to remedy the situation. Further testing may be necessary to determine the reasons for the failure and whatever remedial work is necessary. Also retesting to verify conformity with specifications would be required.

CONCLUSIONS

Commissioning of the envelope and the air barrier in particular is *not* a simple procedure, and requires considerable programming, planning, and testing to determine the quantitative performance attribute of the building envelope. It will of course also add cost to design and construction processes and may require some sorting out of responsibilities between the designer and builder.

Nevertheless, if we are to improve our building envelope performance and durability characteristics, and thus reduce maintenance and repair costs, the development of a commissioning procedure for the envelope and the air barrier system, in particular is imperative for the immediate and near future.

R L Quirouette, B.Arch, Principal, Building Science Services, Morrison Hershfield Ltd, Consulting Engineers, Ottawa. Rick Quirouette is one of Canada's foremost authorities on the building sciences and enclosures. He has authored many articles for Construction Canada, and is a co-author of CSC's Tek-Aid on Air Barriers.

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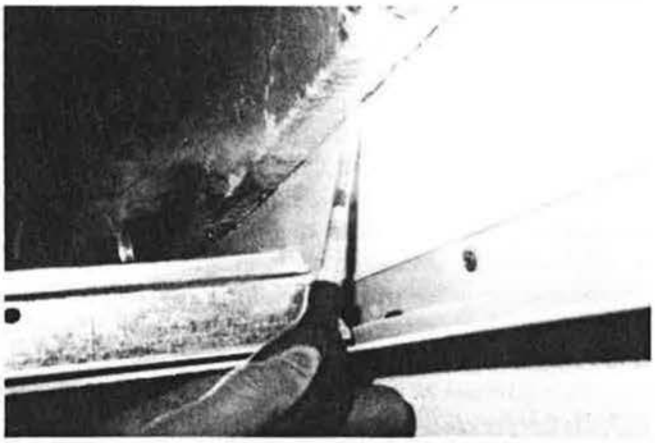
OFFICE BLOCK HAS COMFORT AND SYSTEMS BALANCING PROBLEMS

A brand new prestigious 20,000M^2 office building suffered from the classic symptoms of air leakage, ie comfort problems with areas unable to get up to the desired temperature, excessive air movement across some work stations and an inability to effectively balance the air handling systems.

With these symptoms the blame was as usual focused on some possible deficiency in the mechanical systems but it was finally recognised that the problem might be a leakier than planned envelope.

Building Sciences was commissioned to undertake an Air Leakage Audit on the building envelope which involved two days on site, the majority of the time being spent checking the tightness of a selection of key envelope components and construction details.



Smoke showing air filtration at junction at top of drywall and underside of concrete ring beam.

(Continued of page 3)

CENTRE FOR WINDOW AND CLADDING TECHNOLOGY

Windows and curtain walling often constitute significant elements of the envelopes of most modern buildings. The importance of these key elements was highlighted around two years ago, with the formation of the Centre for Window and Cladding Technology in Bath. Director Dr Stephen Ledbetter describes below the background and aims of the Centre.

The Centre for Window and Cladding Technology is an industry research and information club based at the University of Bath. As its name implies the Centre is concerned with windows and cladding of the facade. The performance of a building envelope depends not only on the performance of individual components but on the interaction of the components, the interfaces and joints between the components and in terms of air infiltration or thermal performance, the aggregate of the components.

The CWCT has been formed to study all aspects of windows and modern cladding methods to improve understanding of the building envelope. The Centre's members are drawn from the whole range of people involved in the procurement, design, manu facture, installation and maintenance of building facades. The Centre's membership of 150 companies is made up as follows:

Sector	Membership (%)	Main Sponsor
Property companies	7	1
Architects	27	
Cladding consultants	2	
Engineers	6	1
Contractors	10	2
Manufacturers	11	2
Installers	2	
Component manufacturers	31	2
Trade Associations	4	2

(Continued on page 2)