Technical guide for cladding system using adhered manufactured concrete stone (installed directly over wood frame backing or over wood strapping)

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Canadian Construction Materials Centre

Technical Guide for

Cladding Systems Using Adhered Manufactured Concrete Stone
(Installed Directly over Wood Frame Backing or Over Wood Strapping)

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N.B. This Technical Guide was prepared under contract by CCMC for the evaluation of a specific product. The technical requirements and performance criteria it contains are not valid for the evaluation of other products unless verified by CCMC under separate contract.

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1.0 Scope

This Technical Guide describes the criteria applicable for the assessment of cladding systems using adhered manufactured concrete stone for the purpose of obtaining a CCMC Evaluation Report. This type of product cannot be assessed solely on the basis of any existing Canadian standard.

Manufactured concrete stone is composed of Portland cement, (lightweight) natural aggregates and mineral oxide pigments. Other additives such as water-repelling agents and air-entraining agents can be added to the mix. The concrete stone is cast in moulds having different shapes and sizes that reflect the surface details of natural stones.
The concrete stone cladding is affixed by mortar adhesion to a metal lath that is in turn attached to a structural wood frame backing. The cladding system may be installed to the wood frame backing by direct application or may be installed in a rain screen approach over wood strapping that would provide a minimum 10 mm clear air space outboard of a commodity-type sheathing membrane.

Note: the installation of concrete stone cladding systems in a rain screen approach by application over wood strapping is intended to create a clear air space that would provide a capillary break and allow for drainage of any water that penetrates the exterior face of the cladding.

The criteria and requirements contained herein were developed to evaluate the performance of exterior cladding systems using adhered manufactured concrete stone with respect to its intended use as an exterior cladding system. This product is evaluated with respect to its equivalency to the intent of the National Building Code of Canada (NBC) 1995, as allowed for in Section 2.5., Equivalents. Equivalency is established with respect to the intent of the new requirements of Section 9.27., Cladding of the NBC 2005. (See Appendix B)

Cladding systems using adhered manufactured concrete stone that fall under the scope of this Technical Guide are considered to be non-loadbearing. Their installation is limited to traditional wood frame houses [wood studs and wood sheathing (OSB, plywood)] falling under the scope of Part 9 of the NBC, whose facades do not exceed 10 m in height above grade.

Note: The evaluation will not cover installations over light steel-frame construction and masonry or concrete backing. The installation over masonry or concrete backing will be limited to chimneys and to the above-grade portions of basement walls. The evaluation of adhered concrete stone cladding systems that are directly applied over the structural wood frame backing will be limited to the climate zones bounded by the geographical areas under consideration. However, there are no geographical restrictions for the evaluation of adhered concrete stone cladding including a clear air space (minimum 10 mm) between the cladding and the sheathing membrane.

A successful evaluation conforming to this Technical Guide will result in a published CCMC evaluation report that is applicable only to products bearing the proper identification of CCMC's evaluation number (see Section 7.3).

2.0 Definitions

Adhered manufactured concrete stone veneer - a veneer system using concrete stone that is secured to and supported by the backing through adhesion.

Backing - wall or surface to which the veneer is secured.

Commodity type sheathing membrane - refers to Code-prescribed and/or a CCMC evaluated sheathing membranes.

Hard body impact - the impact made by a smooth-surfaced steel ball having a mass of 1 kg and a diameter of approximately 62.5 mm.

Note: Hard body impact loads are designed to simulate small dense objects such as hailstones, small rocks, hammer blows and boot kicks being propelled against the cladding.

Large soft impact - the impact made by a spheroconical bag having a mass varying from 4.5 to 50 kg, with a volume composed of a sphere 400 mm in diameter inscribed in a cone, the top of which is located 400 mm from the centre of the sphere

Note: Large soft impact is a dynamic impact that simulates the impact generated by a human body against vertical walls.

Metal support structure - the metal profiles on which the cladding hangs or to which it is attached.

Proponent - manufacturer or submanufacturer of a product or its sole Canadian distributor.

Performance requirements - the actual requirements that a product must meet which closely simulate the pattern of behaviour in its intended use.

Prescriptive requirements - criteria for specific components as well as for the individual material types.

Small soft impact - the impact made by a 4-kg spherical ball that is approximately 100 mm in diameter and has a 1.5-mm envelope made of flexible rubber with a canvas reinforcement.

Note: Small soft impact represents the impact action of an object with a hardness between that of large soft bodies and hard bodies.

Veneer - a non-loadbearing facing attached to and supported by the structural backing.

3.0 Applicable Codes and Standards

3.1 National Building Code of Canada (NBC) 1995

Part 3: Article 3.1.5.5. (Combustible Components for Exterior Walls)
Part 4: Sentence 4.1.8.1.(4)
Part 5: Subsection 5.1.4. (Environmental Separation Requirements) and Section 5.6. (Precipitation)

Part 9: (For cladding systems directly applied to structural wood frame backing), the following sections in Part 9 of the NBC 2005 are applicable:
Subsection 9.20.3. (Mortar),
Article 9.27.2.1. (Minimizing and Preventing Ingress and Damage),
Article 9.27.2.2. (Minimum Protection from Precipitation Ingress),
Article 9.27.2.3. (First and Second Planes of Protection),
Article 9.27.2.4. (Protection of Cladding from Moisture),
Subsection 9.27.3. (Second Plane of Protection),
Articles 9.27.3.7. and 9.27.3.8. (Flashing Materials) and (Flashing Installation)

Subsection 9.27.4. (Caulking) and
Section 9.28. (Stucco).

Part 9: (For cladding systems applied over wood strapping), the following sections in Part 9 are applicable: (See Appendix A 4 for further details)
Subsection 9.20.3. (Mortar),
Subsections 9.27.1. (Application),
Subsection 9.27.2. (Required protection from precipitation),
Subsection 9.27.3. (Second plane of Protection),
Articles 9.27.3.7. and 9.27.3.8. (Flashing Materials) and (Flashing Installation)
Subsection 9.27.4. (Caulking) and
Section 9.28. (Stucco).

3.2 Canadian Standards Association (CSA)

CSA A179-04	Mortar and Grout for Unit Masonry

3.3 American Society for Testing and Materials Limited (ASTM)

ASTM A123/A 123M-02	Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A653/A 653M-04a	Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 666-03	Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM C 129-03	Specification for Nonloadbearing Concrete Masonry Units
ASTM C 140-03	Test Methods of Sampling and Testing Concrete Masonry Units and Related Units
ASTM C 426-99	Test Method for Linear Drying Shrinkage of Concrete Masonry Units
ASTM C482-02	Test Method for Bond Strength of Ceramic Tile to Portland Cement
ASTM C 847-95 (2000)	Specification for Metal Lath
ASTM C 880-98	Standard Test Method for Flexural Strength of Dimension Stone
ASTM C 933-04	Specification for Welded Wire Lath
ASTM C 1032-04	Specification for Woven Wire Plaster Base
ASTM C 1063-03	Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster
ASTM E 96-00	Test Methods for Water Vapor Transmission of Materials
ASTM E 330-02	Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference
ASTM E 331-00	Test Method for Water Penetration of Exterior Windows, Skylights, Doors and Curtain Walls. By Uniform Static Air Pressure Difference

3.4 International Organization for Standardization (ISO)

ISO 7892:1988	Vertical building elements-Impact resistance tests-Impact bodies and general test procedures
ISO 7895:1987	Facades made of components - Tests for resistance to positive and negative static pressure generated by wind

3.5 European Standards

EN 1925:1999	Natural stone test methods. Determination of water absorption coefficient by capillarity.

4.0 General Requirements

4.1 Development of Technical Requirements and Performance Criteria

The requirements and criteria specified in this Technical Guide have been prepared by CCMC evaluation officers in consultation with researchers and experts in construction. For this purpose, CCMC maintains an ongoing relationship with experts from NRC/IRC, other research and testing organizations, and industry.

4.2 Evaluation Process

In evaluating the submitted product, CCMC personnel assess the product, test results, engineering analysis and installation instructions in relation to the technical requirements and performance criteria specified herein. Where this assessment reveals performance levels below those anticipated in this Guide, limitations on the use of the product may result. In-plant quality control procedures are also reviewed to ensure that consistent product quality can be achieved.

4.3 Evaluation Criteria

Adhered manufactured concrete stone cladding is expected to provide the rain and snow penetration control of the wall assembly. The technical requirements described in Section 5.0 pertain to the assessment of performance in the following areas:

- appearance,
- physical and mechanical characteristics,
- rain penetration control
- durability under the action of freeze-thaw,
- stability under the action of wind and seismic loads,
- stability under the action of impact loads, and
- fire protection.

Note: The rain penetration control of directly applied systems was formerly based on a field survey. Presently, the rain penetration control for such systems will also be based as well on laboratory testing methodology that is subject to a separate contract. The rain penetration control of cladding systems, installed over wood strapping that would provide a minimum 10 mm clear airspace, is deemed to provide the level of performance intended by the code without any further testing.

5.0 Technical Requirements

Cladding systems using adhered manufactured concrete stone shall meet the criteria and requirements related to the physical characteristics of the raw materials used in the production of the stone as well as the physical and mechanical characteristics, the structural capacity, the moisture management and durability of the cladding system. The evaluation requirements for the benchmarking of the base materials and system characteristics are expected to be mainly based on laboratory testing and manufacturer's documentation (e.g. material specification, installation manual). The requirements for the assessment of the performance of the system with respect to its intended use (i.e. structural capacity, moisture management, durability) are expected to be based on both laboratory testing and field performance.

Adhered manufactured concrete stone cladding is composed of lightweight concrete stone, mortar for pointing and backing, metal mesh or lath, fasteners, and sheathing membrane attached to a wood stud wall with a wood sheathing board (OSB, plywood). The cladding system may also have extra protection against moisture ingress by incorporating a clear air space that provides a capillary break between the stone cladding and the sheathing membrane. (This is based on application over wood strapping along with the required water management and structural details.)

Adhered manufactured concrete stone cladding must meet the prescriptive as well as the performance requirements listed in this Section.

5.1 Concrete Stone Units

4.1.1 5.1.1 Material and physical requirements

Manufactured stone units shall conform with the requirements of ASTM C 129 (Non-loadbearing concrete masonry units) with the following exceptions:

(1) Section 7 on dimensions and permissible variations is not applicable. Use requirements in Table 1 instead.

(2) The minimum compressive strength shall be 12 MPa.

(3) The additional requirements stated in Table 1 are also applicable.

The tests shall be conducted on actual manufactured concrete stone units or samples cut from these stone units.

Table 1. Physical and Mechanical Properties of Manufactured Concrete Stone

Test	Unit	Requirement	Method
Dimensions			
Length and width	mm	≤ 900	
Thickness	mm	≤ 70	
Area	m^2	≤ 0.26	
Deviation from plane of the back face	mm	≤ 3	Note: This is intended to limit warpage. Local roughness of the surface may exceed this value.
Weight (saturated)	kg/m^2	≤ 75	Weight when air dry and after immersion for 24 hours in water.
Density	kg/m^3	state value	See section 6.5.1.
Moisture properties			
Water absorption (24 hour)	% (by mass)	state value	ASTM C 140, using whole units.
Coefficient of water absorption	$kg/m^2/sec^{½}$	state value	See section 6.5.2.
Vapour permeance (if a water repellant coating or additive is used)	kg/m•s•Pa	state value	ASTM E 96. Use the water method. Test in a controlled atmosphere of 50 ± 2% Relative Humidity at 21 ±1 °C.
Dimensional change			
Drying shrinkage	mm/m	≤ 0.65	ASTM C 426 [Note in test report the dimensions used and age of stone when tested.]
Strength			
Flexural (wet & dry)	MPa	state value	See section 6.5.3.
Compressive	MPa	≥ 12	ASTM C 140. Clause 6.2.4 specifies coupons can be cut with h/t ≥ 2 and l/w ≥ 4. Minimum thickness 30 mm.

5.2 Mortar

4.1.2 *5.2.1 Mortar Properties*

Mortar shall conform to type N or S in CSA A179.

For tests in this Guide requiring the use of mortar, the mortar shall be evaluated according to the property specifications of CSA A179. Determine the aggregate ratio, the water retention, the compressive strength and the air content in accordance with CSA A179. The grading of the sand used in the mortar shall also be determined.

The mortar shall be mixed to a flow suitable for use on site (defined as job-prepared mortar in CSA A179). It is important that the mortar have properties similar to the mortar used on-site. For example, the compressive strengths must be representative of those achieved on-site. The minimum compressive strengths specified in CSA A179 for job-prepared type N and S mortars are 3.5 and 8.5 MPa respectively.

Note: The manufacturer must determine if these minimum strengths are acceptable, and if so, mortar close to these minimums must be used in the test samples specified in this report. The manufacturer should clearly specify in the installation manual the mortar mixes to be used, and evaluate all the mixes.

4.1.3 **5.2.2 *Mortar/Stone Interaction***

5.2.2.1 Shear bond

When tested in accordance with subsection 6.5.4 of this Guide, the adhesion at the interface between the stone units and the mortar backing, and between the mortar backing and the scratch coat, if applicable, shall have a minimum shear strength of 0.35 MPa.

Note: If stone units are available with integral water repellants, these shall also be tested.

5.3 Mesh/Lath and Fasteners

4.1.4 ***5.3.1 Design***

The supports and connectors of the cladding system shall be designed to support the loads (axial, lateral) that will be imposed on them and to transfer these loads to the building structure.

<u>Direct Application</u>
Metal lath shall be attached to the supports (studs) rather than to the sheathing. Fasteners shall be placed every 150 mm o.c. vertically for 400 mm stud spacing, and 100 mm o.c. vertically for 600 mm stud spacing. Nails and staples shall penetrate 25 mm into the wood studs.

<u>Application over Strapping</u>
Metal lath shall be attached to the strapping, which is either directly attached to the studs or to the structural sheathing.
The spacing and fastening requirements shall be established through an engineering analysis that would have been conducted by a professional engineer. The depth of the fasteners penetration into the studs and/or the structural sheathing shall be in conformance with Part 4 of the NBC.

4.1.5 ***5.3.2 Materials***

5.3.2.1 Metal lath

Metal lath shall be in accordance with ASTM standards C 847, C 933 and C 1032. Metal lath used with rain screen claddings incorporating an air space shall have a backing in accordance with ASTM C 847.

5.3.2.2 Fasteners

Nails and staples shall be in accordance with NBC Article 9.28.3.2. Requirements for screws are stated in ASTM C 1063.

5.3.2.3 Strapping

Pressure treated wood strapping shall be used. The dimensions of the strapping shall be designed by a structural engineer.

Note: The strapping depth should be enough to ensure a continuous clear airspace of 10 mm.

4.1.6 5.3.3 Durability

Metal lath shall have a minimum corrosion resistance equivalent to a Z 450 coating (450 g/m^2 on both sides). If stainless steel is used, it shall be the austenitic type.

Fasteners for metal lath shall have a corrosion protection at least equivalent to that of the metal lath. Staples shall be made from austenitic stainless steel.

Aluminum shall not be used.

Note: Metal components are meant to have enough corrosion-resistance to maintain their strength and stiffness over the service life of the cladding (normally > 50 years).

5.4 Other Components

4.1.7 5.4.1 Sheathing membrane

Sheathing membrane used in conjunction with the manufactured concrete stone must be in compliance with the requirements of the NBC Subsection 9.23.17.

4.1.8 5.4.2 Flashing and caulking

Flashing and caulking used in conjunction with the manufactured concrete stone shall be in accordance with NBC Article 9.28.1.5.

5.5 Adhered Manufactured Concrete Stone Wall Performance

4.1.9 5.5.1 Seismic zones

In velocity or acceleration-related seismic zones of 4 or greater, the following limitations apply:

(1) Adhered manufactured concrete stone cladding shall be restricted to one storey in height not exceeding 4.5 m above grade unless an engineering analysis is carried out in conformitance with NBC Part 4.

(2) Nails used for the attachment of the metal lath shall not be allowed. 50 mm staples shall be used to attach the lath in such zones.

(3) The attachment of strapping to the backup wall shall be determined through a structural engineering analysis that would have been prepared by a professional engineer. The engineering analysis shall address all aspects of the strapping and fastening.

4.1.10 5.5.2 Wind load resistance

When tested according to Subsection 6.5.5 of this Guide, the cladding system shall be capable of resisting and transmitting to its points of support the positive and negative forces generated by the design wind loads without any fracture or permanent deterioration of the surfaces resulting from such design loads.

4.1.11 **5.5.3 Movement**

Adhered manufactured concrete stone cladding shall be designed to accommodate inter-storey differential floor movements, and differential movement of supports, including that caused by temperature changes, shrinkage, creep and deflection. An engineering analysis to substantiate conformity to the requirements of this section is required.

5.5.3.1 Out-of-plane movement
The deflection, at a specified load, of the supports to manufactured stone veneer shall be less than the span/360. (as part of wind load resistance test.)

5.5.3.2 In-plane movement
The cladding system shall accommodate not only the inter-storey differential floor movements, but also the overall movement of the structural frame due to load and changes in temperature and moisture (especially shrinkage and compression perpendicular to the grain of the wood). In-plane differential stresses between the veneer and its backing shall be limited by using of movement joints.

Control joints shall be installed to delineate areas not more than 13.4 m^2. The maximum distance between control joints shall be 5 m (in both horizontal and vertical directions). In addition, the maximum length-to-width ratio shall be limited to 2 to 1.

In new housing, horizontal joints may be required at sill plate level at the top of every storey, where significant movement can occur when wet wood is drying out, and for the placement of flashings.

5.5.4 Freeze-thaw resistance
4.1.12

When tested in accordance with Subsection 6.5.5 of this Technical Guide, the adhered manufactured concrete stone panel shall not show any deleterious effect, such as delamination, crazing, spalling and/or cracking.

4.1.13 **5.5.5 Moisture management**

Construction details for managing moisture shall be provided for the veneer system at critical joints, junctions and interfaces. This includes cappings, flashings, weeps and capillary breaks where needed.

Moisture management requirements shall be in accordance with the new provisions in Section 9.27. (Cladding), of the 2005 edition of the National Building Code 2005 (see Appendix B). In geographical areas where a capillary break is required, this shall be by the use of a clear air space. The clear air space shall be provided by installing wood strapping vertically over the sheathing membrane and shall be continuous over the whole height of the air space. The strapping shall be attached at the stud locations. The attachment of strapping at locations other than at the studs would need to be established through an engineering analysis conducted by a structural engineer.

The moisture management of cladding systems using adhered manufactured concrete stone installed over wood strapping that would provide a capillary break between the cladding and the back-up wall assembly in conformance with Article 9.27.2.2 of the NBC 2005 shall be deemed satisfactory without any further testing.

Cladding systems using adhered manufactured concrete stone **directly installed over wood frame backing**, outboard of a commodity type sheathing membrane/wall sheathing shall have their moisture management performance equivalency to the requirements of Section 9.27. of the NBC based on one of the two options:

Option 1: A field performance assessment of existing installations of the system. The field performance assessment must be performed in accordance with the procedure defined in Appendix A.
The field performance assessment procedure defined in Appendix A was developed in the context that it would be performed by an experienced building science consultant. The consultant shall be recognized by CCMC and shall:

- conform to the qualification requirements defined in Appendix A1;
- *act as an independent third party in carrying-on the field assessment procedure and in providing an opinion on the performance of the cladding system; and*
- prepare reports as defined in the field assessment procedure.

The proponent must authorize the consultant to forward an original copy of the reports requested in the field assessment procedure directly to CCMC. The submitted reports will be retained by CCMC. The consultant's reports may be referenced in CCMC's Evaluation Report.

The field performance assessment procedure was written for the assessment of the cladding system of a single proponent. The procedure may be used to undertake a multiple-proponent assessment if it can be demonstrated that the cladding systems of the proponents are so identical that they can be assessed as a generic group. The applicability of a multiple-proponent assessment must be identified by CCMC, and it must be undertaken in accordance with the additional requirements of Appendix A3.

The field assessment shall demonstrate that the cladding system does not allow water penetration past the sheathing membrane of the wall as well as around interfaces with other wall components (e.g., windows, doors) and at the interfaces with other cladding systems and building components (e.g., roof, chimney, balcony). The assessment shall also demonstrate that the cladding system does not allow water penetration at interfaces with service penetrations such as dryer vents, electrical boxes and light fixtures. The materials constituting the cladding system shall show no distress that could lead to premature failure of the system and/or of the wood frame back-up wall assembly. The moisture content of the wall sheathing and of the structural wood elements of the wall assembly shall be less than 19%. It is important that the consultant's reports contain detailed observations with respect to these pass/fail criteria, and corrective solutions in the event they are not meant to help CCMC's evaluation of the moisture management performance of the cladding system.

Option 2: On an experimental and analytical assessment procedure that would be determined through a joint research project between the Institute for Research in Construction's Canadian Construction Materials Centre (CCMC), and Building Envelope and Structure Program (BE&S) and manufacturers.

Note: The water penetration control performance needs to be assessed with respect to the specific sheathing membrane as specified by the manufacturer. The opinion provided on the water penetration control performance that would have been provided based on a specific sheathing membrane can't be extended to cover other sheathing membranes. Other sheathing membranes would be outside the scope of the present work and a separate contract needs to be issued to cover the water penetration control assessment with such alternate sheathing membranes.

4.1.14 *5.5.6 Impact resistance*

When tested in accordance with Subsection 6.5.8 and ISO 7892:1988, "Vertical Building Elements, Impact Resistance Tests, Impact Bodies and General Test Procedures," the cladding system shall be capable of withstanding the applied impact loads specified in the table below without any deterioration in the performance or safety of the system.

Note: The test shall include the assessment of the impact loads on joints.

Table 2. Impact Loads

Impact Body to be Used	Dynamic Mass (kg)	Energy (N.m)	Requirements(3)(4)
For Safety Impact			
Large Soft(1)(2)	50	100	The cladding may be damaged but must not: - allow the impact body to penetrate through; - be dislodged from its fixings; - allow falling debris, capable of injuring people; or - impair the safety of the structure if the cladding has a structural function or is fixed to a structural element.
Hard(1)(2)	1	10	The cladding must fulfil the above requirements but the impact body may pass through the cladding.
For Retention of Performance Impact			
Large Soft(1)(2)	50	34	The cladding system must retain all its functional characteristics and its overall appearance.
Small Soft(1)(2)	3	60	
Hard(1)(2)	1	10	

(1) *See Section 2 for definitions.*

(2) *Large soft bodies are designed to transfer a significant amount of energy to the cladding and to the wall assembly. Small hard bodies are destined to cause localized impact damage without any appreciable transmission of energy to the wall assembly. Small soft bodies are harder than large soft bodies and are destined to induce localized damage as well as to transmit energy to the rest of the assembly.*

(3) *These tests are intended to identify behaviour of the cladding subject on impact. The pass or fail criteria take into account the accessibility of the affected surface and ease of replacement. The test report must explicitly identify aspects such as localized crushing, puncture or breakthrough, localized indentation depth, detailed description of any rupture, and cracking at the surface or at the back of the cladding.*

(4) *For cladding systems that can be repaired or replaced easily, lower impact resistance values may be accepted down to 6 Nm for small soft impact, and 1 Nm for hard impact.*

5.6 Fire Protection

If the manufacturer proposes installations where noncombustibility, flame-spread rating, or smoke development classification are factors, the product must be tested to meet one or more of the following standards:

- CAN/ULC-S101-M89 — Fire Endurance Tests of Building Construction and Materials
- CAN/ULC-S102-M88 — Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies

- CAN4-S114-M80 (R1997) Standard Method of Test for Determination of Non-Combustibility in Building Materials
- CAN/ULC-S134-92 Standard Method of Fire Test of Exterior Wall Assemblies

The determination of the required test is based on the classification of the building in which the product is intended to be installed and its intended application in that building.

6.0 Testing

6.1 General

Testing must be performed at a recognized laboratory as indicated in the covering letter. The proponent must provide copies of this Technical Guide to each laboratory performing tests. The proponent must cover the costs of testing and authorize the testing organization to forward an original copy of the test report for each sample directly to CCMC. The submitted test reports are retained by CCMC and their contents remain confidential.

6.2 Sampling

The proponent must arrange with CCMC to obtain a random selection of samples from the production line or main storage facility for their identification before they are sent to the testing laboratory.

Materials and building sampling for the purpose of the field performance assessment must be in accordance with the requirements of Appendix A.

Samples for the purpose of evaluation must correspond to drawings and to manufacturer's specifications.

The proponent should contact the testing laboratory to obtain information regarding fees and the number of samples required for testing in accordance with this Technical Guide. The proponent must then forward the identified samples directly to the testing laboratory. If several plants manufacture this product, samples from each facility are required.

6.3 Reports from Testing Laboratories

The following information shall be provided by testing laboratories in reports intended for CCMC evaluation purposes:

- detailed information on material sampling (sampling date, method of sampling, sites where sampling was performed and sample reference number);
- the start and end date(s) of test(s);
- detailed specimen preparation methods (if other than specified in the test method, standard or Technical Guide);
- test procedure identification, including:
  - any deviations from the referenced test procedure;
  - reasons for the deviations;
  - additional instrumentation requirements;

- all information mentioned in the reporting section of the referenced standards or standard test methods;

- test results (table format, if appropriate), including:
  - written explanations to account for any discrepancies; and

- a conclusion, including a statement on the product's performance with respect to the overall requirements of the CCMC Technical Guide.

The report should include the statement: "Tested for CCMC Evaluation Purposes."

6.4 Conditioning for Tests

Unless otherwise stated in Section 6 of the Guide, the specimens shall be conditioned in accordance with the specimen's conditioning requirements indicated in the referenced test method.

6.5 Testing Procedures

Note: Any deviation from, or modification to, the testing procedure specified herein must be carried out with the consent of CCMC.

4.1.15 6.5.1 Density of the concrete stone unit

Whole units shall be tested in accordance with ASTM C 140. If the units are porous enough to allow water to escape after removal from water, the volume cannot be determined accurately. In these cases, the unit shall first be weighed in a dry condition, then, coated in a silane-based water repellant to stop absorption of water, allowed to dry, and weighed again. The unit is then weighed under water. The density is determined from the difference between the final weight and the initial dry weight.

4.1.16 6.5.2 Coefficient of water absorption of the concrete stone unit

The water absorption coefficient shall be determined in accordance with EN 1925. The absorption shall be determined with
(1) the back face immersed in water, then
(2) the front face immersed in water.

4.1.17 6.5.3 Flexural tensile strength of the concrete stone unit

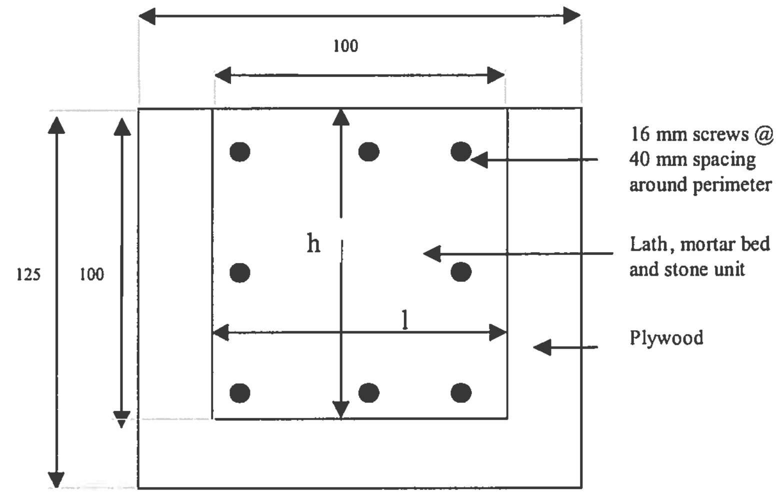
The flexural tensile strength, both in dry and wet conditions, shall be determined in accordance with ASTM C 880. The stone shall be cut to a uniform depth and width.

4.1.18 6.5.4 Shear bond test of the veneer assembly

The shear bond or adhesive strength between the stone unit, the mortar bed and the scratch coat, if used, shall be determined as follows (see Figure 1):

1. The test specimens shall replicate the actual veneer construction as much as possible. Metal lath, and a scratch coat, if used, shall be incorporated.

2. The metal lath shall be attached to 19-mm exterior grade plywood backing with 16 mm screws. The screws shall be spaced around the perimeter at 40-mm intervals. The plywood backing shall have a height of 125 mm and a width of 150 mm.
3. The stone unit shall be cut to have face dimensions of 100 mm x 100 mm (height x width); where the manufactured height is less than 100 mm, use the manufactured height. The top surface of the stone shall be flush with the top of the mortar and plywood. The original back surface of the stone must be in contact with the mortar (a cut surface is not allowed). The bottom of the stone and mortar shall be 25 mm above the bottom of the plywood.
4. Mortar mixes shall have the same mix and properties as the mortar used on site. The mortar mix ingredients, proportions and compressive strength shall be determined. The compressive strength, density and 24-hour water absorption of the concrete stone unit shall also be determined.
5. A minimum of 10 test samples shall be built vertically, similar to actual veneer wall construction, following the manufacturer's installation procedures.
6. Damp cure the specimens for 7 days by enclosing them immediately after construction within a vapour-resistant plastic sheet. After the 7 days, store the specimens for a further 21 days in laboratory air (20 ± 5°C; 30 - 70% RH). Then test the specimens 28 days after construction.
7. Test the specimens by placing them in the jig as shown in Figure 1. A steel angle shall provide support to the bottom of the mortar-embed metal lath (but not to the second coat of mortar if used.) The edges of the plywood of the test specimen are clamped to the steel angle with a minimum of two C-clamps. The load at the top of the specimen shall be applied to the concrete stone unit through a rigid loading plate placed on top of a compressible material such as 6-mm thick felt or 3-mm thick Neoprene of a durometer hardness no greater than 50.
8. The load shall be applied up to one-half the expected maximum load at any convenient rate, after which the controls shall be adjusted so that the remaining load is applied at a uniform rate in not less than 1 min and not more than 2 minutes. The controls shall not be readjusted after this adjustment.
9. The report shall include the following information:
   - identification of the materials tested;
   - mortar mix proportions and compressive strength;
   - stone compressive strength, density and 24-hour water absorption;
   - date each specimen was constructed;
   - construction procedure for the test specimens;
   - dimensions of the test specimen, including thickness of the mortar bedding;
   - maximum load (kg or N) and shear bond strength (MPa) for each specimen;
   - description of the failure mode and location for each specimen;
   - the average shear bond strength of the specimens tested.



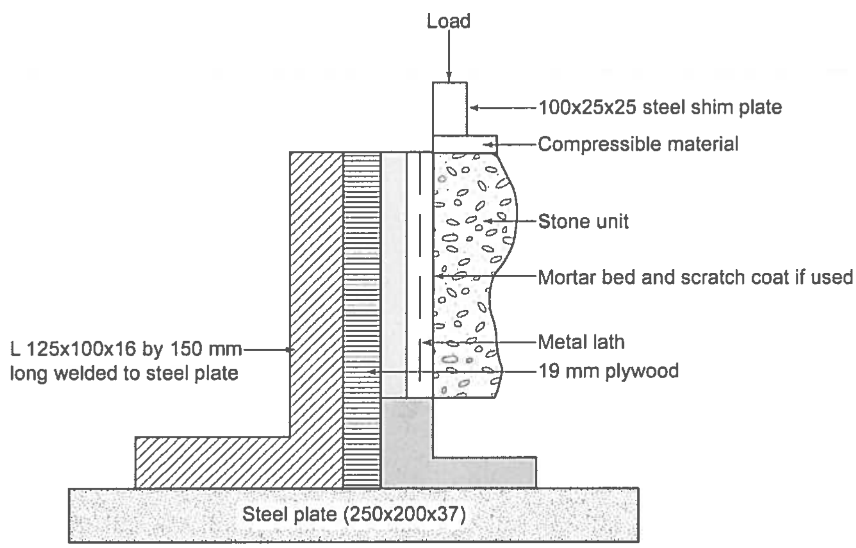


Figure 1. Shear bond test setup

4.1.19 6.5.5 Freeze/thaw resistance test

Test specimens

1. Two test panels (400 mm x 400 mm) shall be built using the same construction materials and procedures as in practice (including exterior grade plywood, sheathing membrane, metal lath, scratch mortar coat, if used, bedding mortar, and concrete stone.)

2. Mortar mixes shall have the same mix and properties as the mortar used on site. The mortar mix ingredients, proportions and compressive strength shall be determined. The compressive strength, density and 24-hour water absorption of the concrete stone unit shall also be determined.

3. The panels shall be built so they fit neatly within an insulated form: 50-mm-thick extruded polystyrene (XEPS, Type 4) shall be attached to the back of the plywood. The top, bottom and sides of the panels shall be enclosed by 25-mm-thick extruded polystyrene (the strips shall be of a uniform depth).
   See Figure 2.

4. Damp cure the panels for 7 days by enclosing them immediately after construction within a vapour-resistant plastic sheet. After the 7 days, store the specimens for a further 21 days in air at 20±5°C and 30-70% relative humidity. During this time, seal the junction between the insulation and the test specimen with a waterproof sealant.

Freeze/thaw test procedure (uni-directional)
Test the panels 28 days after construction
Weigh the test specimens.
Place the test specimen in a vertical position. A continuous water spray shall wet all the surface of the panel for a period of 7 days. The water temperature shall be at 20 ±5°C.
After completion of the water spraying, weigh the specimens again after surface drying with a damp cloth.

Place the freeze/thaw specimens in the freezer unit within 30 min of completion of the water spraying. The freezer unit shall have forced air circulation capable of being regulated to the prescribed freezing condition with the required number of test specimens. The fan shall not blow air directly onto the test specimens. The freezer shall also be equipped with a temperature sensor so the air temperature can be verified.

Freezing phase
Each freezing phase shall last at least eight hours as follows:

- 12 cycles: air temperature from +20±5°C to –20±3°C in 2.5 h ±1.5 h.
- 12 cycles: air temperature from +20±5°C to –5±1°C in 1.75 h ±0.75 h.

Note: At the start of the freeze cycle, the freezer may be at room temperature or already at the required freezing temperature. Domestic freezers have inadequate cooling rates. The small compressors are only designed to keep a temperature at a set point. It may have difficulty in reaching the specified temperature within the required time after insertion of the panels even if the temperature has been set initially at the specified freezing temperature.

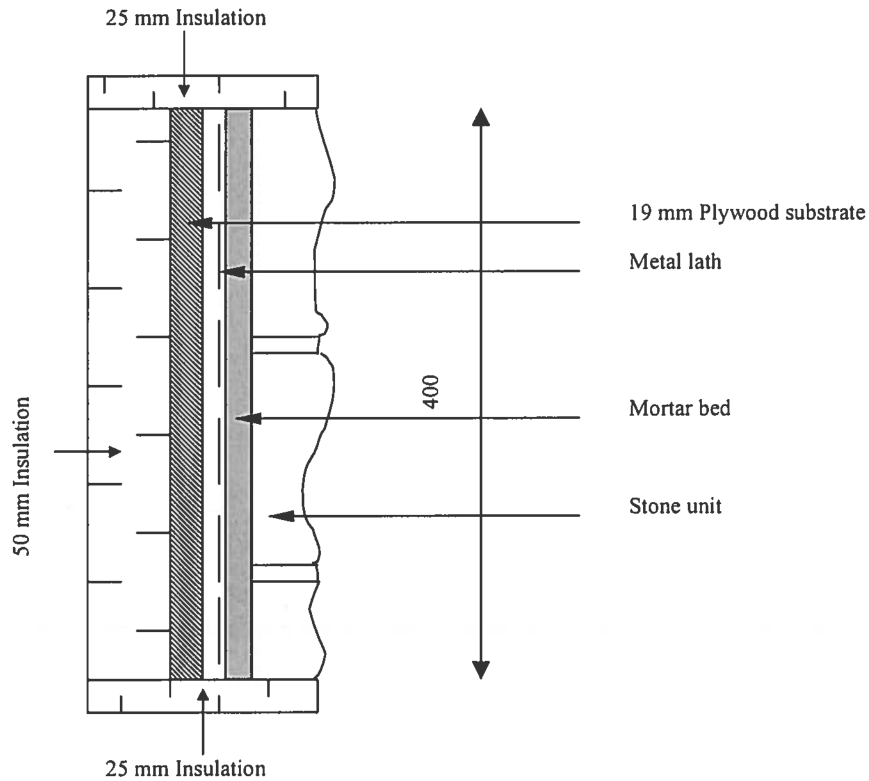


Figure 2. Freeze/thaw test specimen

Thawing phase
At the end of the freezing phase, remove the test specimens from the freezer. Place the test specimens in the vertical position and spray the face continuously with water at 20 ± 5°C for a period of 4 ± 0.5 h (1.9 ± 0.02 litres/min.). Ensure that all the surface is wetted. At the end of the thaw phase, return the panels to the freezer within 30 minutes.

Repeat freezing and thawing phases until the cycles are completed. If the process needs to be interrupted between the freezing and thawing phases, keep the test specimens frozen or, alternatively, enclose in a plastic bag at room temperature to avoid loss of moisture. The plastic bag shall have a thickness between 0.2 mm and 0.3 mm (8 mils and 12 mils). The length and width of the plastic bag shall not exceed the length and width of the specimen by more than 20%.

Assessment
After 12 cycles, inspect visually for surface delamination, cracking and spalling.

After 24 cycles,
(1) weigh the specimens after drying the surface with a damp cloth.
(2) remove the insulation and inspect the surface and sides visually for delamination, cracking and spalling.

Report
The test report shall contain the following information:

- identification of the materials used including insulation;
- date of construction of the test specimens;
- construction procedure for the test specimens;
- description and dimensions of the test specimen including thickness of the mortar bedding;
- mortar mix proportions and compressive strength;
- stone compressive strength, density and 24-hour water absorption;
- date of testing the specimens;
- weight of the test specimens
  – before initial 7 day wetting,
  – after immersion for 7 days,
  – after the Freeze-thaw test is completed.
- description of the condition of the test specimens after 12 cycles and after 24 cycles.

4.1.20 6.5.6 Wind load resistance

The wind load resistance test shall be conducted according to ASTM E 330, Structural Performance of Exterior Windows, Doors Skylights and Curtain Walls, by Uniform Static Air Pressure Difference", Procedure B.
The wall test specimen shall not be less than one storey height. The width of the wall test specimen shall not be less than 3.0 m.
The specimen shall comprise the number of components necessary to accurately represent the supporting structure, the anchorage and all the devices in current use for fixing the elements on the cladding onto the structure and onto adjacent components. The test specimen shall be constructed following the manufacturer's installation procedures, and using materials representative of those on-site.
The size and spacing of the studs should represent the worst-case scenario of the minimum requirements of Table 9.23.10.1. of the NBC 1995. The sheathing board shall have the minimum thickness allowed in the NBC 1995, and as allowed in the manufacturer's installation manual for the cladding system. The sheathing board shall be installed in accordance with Figure 4.

It is recommended to measure the deflections along the horizontal and vertical centre-line at the different location points indicated in Figure 4. However, as a minimum, the deflection at the location points [1, 4, 8 (framing system)], and 6, 18 and 19 (unsupported sheathing edge) shall be reported.

Note: The deflection shall be measured at mid span of intermediate studs relative to their ends, and at mid span of the sheathing relative to the intermediate studs. Measurements for the displacement of the studs and the sheathing shall be taken at all measuring points.

The sample shall be subjected to full-scale positive and negative test loads as described in ISO 7895, "Facades made of components - Tests for resistance to positive and negative static pressure generated by wind."

Note: The testing organization must take the necessary measures to ensure that the pressure loads are transferred to the cladding. Proper sealing of the test specimen is very important as some cladding may allow air flow through the specimen that is in excess of the blower equipment capacity. A single membrane may be installed behind the cladding to prevent air leakage. However, means to stop air leakage shall not restrict any relative movement between specimen components.

The ISO 7895 test protocol specifies three maximum pressure levels for three different modes of wind pressure application: sustained, cyclic and gust loads.

i) Deformation test (sustained pressure)

The facade is submitted to increasing pressure in increasing stages for a minimum period of 10 seconds at each stage, up to the maximum pressure (P_1) required for the test. P_1 shall be taken as the reference velocity pressure for the design of the cladding as per NBC 1995, Sentence 4.1.8.1.(4). This reference velocity pressure is based on a probability of being exceeded in any one year of 1 in 10, and is based on climatic data in conformance with NBC 1995, Article 2.2.1.1. The reference pressure (P_1) and the cyclic (P_2) and gust pressures (P_3) indicated in Table 3 cover applications on buildings that are three storeys high or less, falling under the scope of Part 9 of the NBC 1995.

Proponents wishing to evaluate their cladding systems to wind pressure loads (P_1, P_2 and P_3) that are different (smaller or greater) than the ones indicated in Table 3 must notify the CCMC for approval.

ii) Repeated positive and negative pressure test (cyclic pressure)

The facade shall be submitted to the required number of positive pressure impulses between 0 and the value of P_2 indicated in Table 3.

iii) Safety test (gust wind)

The facade shall be submitted to the maximum required gust pressure (P_3) indicated in Table 3. P_3 shall be reached as quickly as possible, but not in less than 1 s, and held for 3 s. The value of P_3 shall be at least 2.0 times the design value of P_1.

The sample shall be subjected to the maximum positive and negative test loads contained in Table 3 and according to the loading schedule outlined in Figure 1.

Table 3. Maximum Positive and Negative Pressures for Sustained, Cyclic and Gust Loads

For geographical areas where wind design value is:	P_1, P_1' (1) sustained for 1 hr (Pa)	P_2, P_2' (1) 2000 cycles(2) (Pa)	P_3, P_3' (1) gust wind (Pa)
$Q_{10} < 0.40$ kPa	400	530	800
$Q_{10} < 0.60$ kPa	600	800	1200
$Q_{10} < 0.80$ kPa	800	1060	1600

(1) See Figure 3 for references to P_1, P_1', P_2, P_2', P_3, P_3'.

(2) The 2000 cyclic loads can be applied in four stages of 500 cycles or two stages of 1000 cycles reversing from positive to negative pressures.

Deflection Measurements

At the end of the wind loading, deflection measurements shall be taken according to the following criteria:

Maximum deflections shall be recorded at 3.3* times the 1 in 10 hourly wind pressure (Q_{10}), as outlined in Table 4, for both positive and negative pressures. The measurements shall be taken subsequent to the sustained, cyclic and gust wind pressure loading program in Figure 3.

* Note: The design wind load value is based on the Q_{10} value and three factors, namely (Cp) the exposure factor, (Ce) the gust factor, and (Cg) the external pressure coefficient. The 3.3 amplification factor is derived assuming Ce = 1.0, Cg = 2.5 and Cp = 1.3. Thus 1.0 x 2.5 x 1.3 = 3.25 rounded to 3.3. It should be noted that this generalized case for low-rise buildings is applicable to buildings within urban and suburban areas and does not apply to peripheral buildings adjacent to open and exposed areas.

Table 4. Maximum Wind Pressures for Deflection Measurements

For geographical areas where wind design value is:	Record maximum deflection(s) after completion of wind pressure loading at following load(1)
$Q_{10} < 0.40$ kPa	$D_{0.40}$ @ 1320 Pa
$Q_{10} < 0.60$ kPa	$D_{0.60}$ @ 1980 Pa
$Q_{10} < 0.80$ kPa	$D_{0.80}$ @ 2640 Pa

(1) The wind pressure loading shall be maintained for a minimum of 10 s and the maximum deflection, at any point on the specimen, from the supporting member of the cladding system shall be determined for both positive and negative pressures.

Note: The proponent of the system may request that the testing agency measure the deflection of the system at various stages during the wind loading. This additional information may assist the proponent in understanding the system performance during the sustained, cyclic and gust loadings.

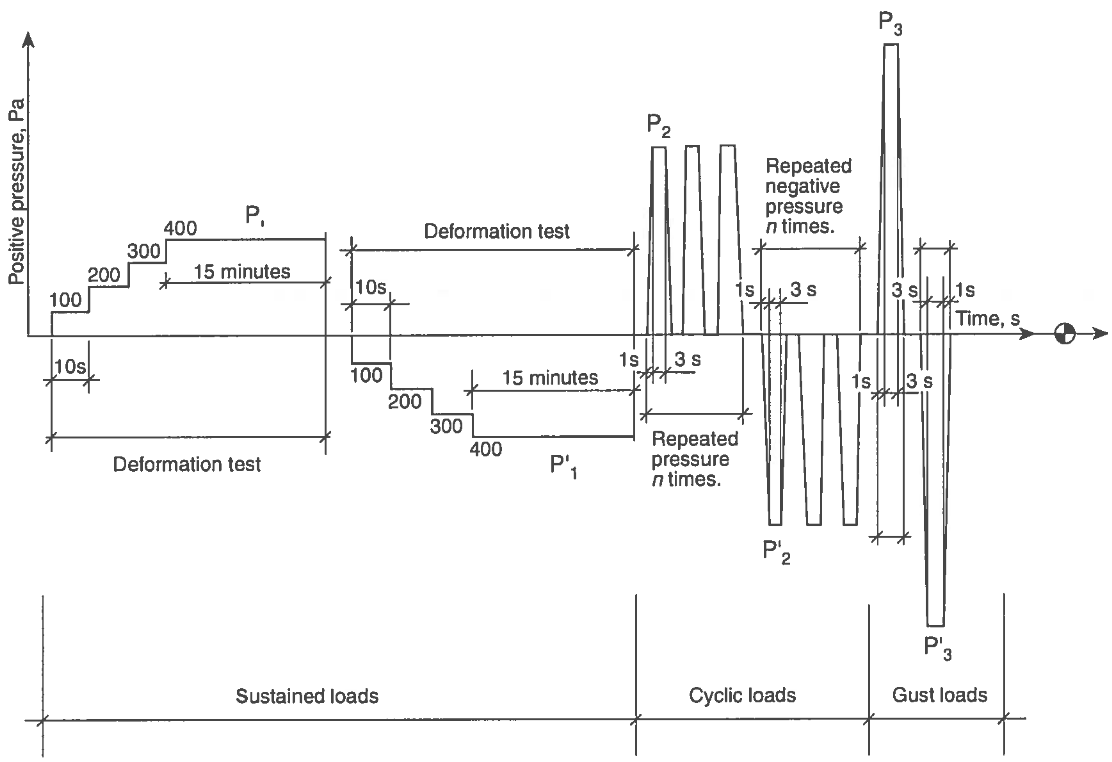


Figure 3. Structural (Wind) Loading Schedule

4.1.21

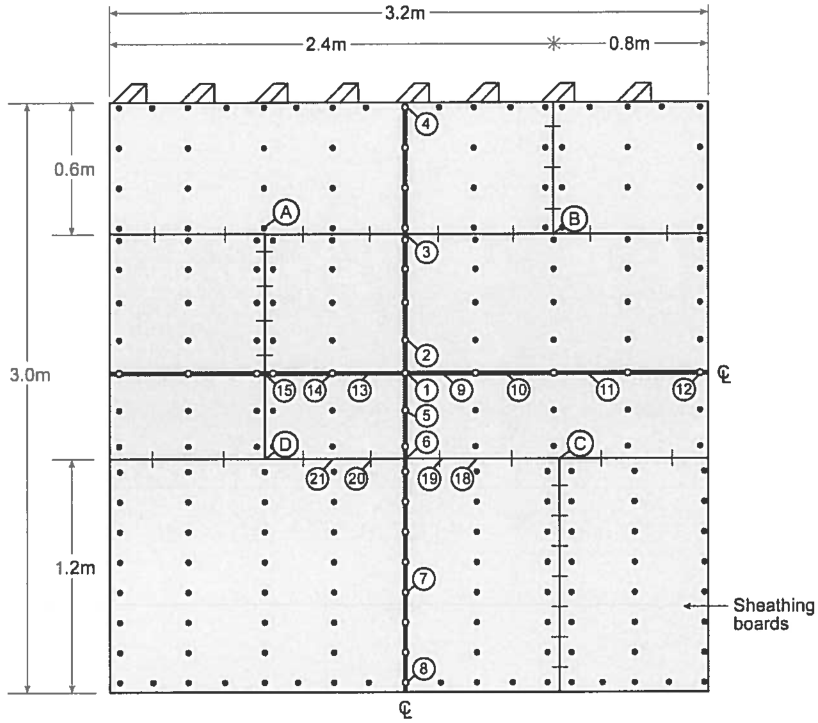


Figure 4. Wind load Test panel (Sheathing pattern and deflection location points)

4.1.22 ***6.5.7 Moisture management - laboratory study***

An experimental and analytical procedure for the assessment of moisture management will be developed through a joint research project between the Institute for Research in Construction's Canadian Construction Materials Centre (CCMC), and Building Envelope and Structure Program (BE&S) and a consortium of manufacturers.

4.1.23 ***6.5.8 Impact resistance***

The test specimen shall undergo a safety impact test and a retention of performance impact test as follows:

- The dimensions and the fixing of the test specimen must simulate the conditions in current use. The test specimen must be in a vertical position and affixed to a sufficiently rigid frame to ensure that any movement or deformation of the frame during impact will be negligible.
- The pendulum movement must always have a radius of not less than 3 m. The strike of the impact body must be normal to the surface of the test specimen.
- For "soft 50 impacts," the most unfavorable point of impact will have to be chosen. For other impacts, the test must be repeated on the most representative points of the test specimen.

7.0 Quality Assurance Program

The proponent must demonstrate that the production process is governed by a quality assurance program, which ensures consistent quality at least to the level represented by the sample being tested and evaluated. CCMC requests that quality control procedures be applied to incoming materials, processes, and finished products.

7.1 Purpose

The purpose of the quality assurance program is to provide guidelines for the control of quality. CCMC must be confident that the submitted samples are representative of the products manufactured at the plant. It remains the proponent's responsibility to ensure that the manufactured products meet or exceed the quality of the samples submitted for testing and evaluation. (See Section 6.0 for information on product testing.)

7.2 Documentation

The proponent shall provide documentation on its quality assurance program, which will be reviewed by an evaluation officer prior to the issuance of an evaluation number. Other documents deemed necessary to demonstrate compliance at the time of application for an evaluation shall be submitted by the proponent upon request.

The documentation must be prepared by the proponent or by a third party, and signed by an authorized officer of the company to confer legitimacy to the document.

The documentation must have provisions that allow for representatives of CCMC or its authorized agents to enter the specified premises for the purpose of inspecting the manufacturing facilities or designating samples for testing.

7.3 Identification

Quality control procedures for finished products must include details on how the product will be identified with the CCMC evaluation number, in the form of "CCMC # XXXXX-R," which shall be both visible and legible. Where permanently identifying a product is not possible, other forms and methods of identification may be allowed pending review and approval by a CCMC evaluation officer.

7.4 Requirements

Quality assurance may be demonstrated by the proponent either through registration by an accredited quality assurance agency that its production process conforms to ISO 9001:2000, "Quality management systems—Requirements" (see Sections 7.5 and 7.6), or by providing a copy of its quality control manual directly to CCMC.

The Quality Control Manual (QCM) shall contain the following information:

- the company's quality control policies;
- provisions for keeping the manual current, e.g., updates and revisions;
- a production flow chart indicating points of quality control, with an explanation of the control at each point, the frequency of controls, and a summary of the production methods;

- production specifications and process tolerances;
- a clear delineation of what constitutes major and minor defects;
- corrective measures for major and minor defects;
- a list of main production equipment;
- a list of manufacturer's specifications and quality control arrangements for raw materials and equipment;
- measuring equipment: type, model, range, accuracy, frequency of calibration, and calibration agency; and,
- a statement by the proponent that CCMC will be notified, in writing, when major deviations have been discovered.

7.5 ISO 9001:2000 Quality Assurance Requirements

Evidence of quality assurance in accordance with ISO 9001:2000, "Quality management systems—Requirements," is demonstrated by the proponent through registration by an accredited quality assurance agency that the facility is under its control. (See Section 7.6 for a list of accredited agencies.)

ISO 9001:2000 specifies the requirements for a quality management system that can be used for internal application by organizations, or for certification, or for contractual purposes. It focuses on the effectiveness of the quality management system in meeting customer requirements.

This edition of ISO 9001 replaces the second edition, ISO 9001:1994, as well as ISO 9002:1994 and ISO 9003:1994. It constitutes a technical revision of these documents. Organizations that have used ISO 9002:1994 and ISO 9003:1994 in the past may use this international standard and exclude certain requirements in accordance with Section 1.2 of ISO 9001.

ISO 9004, "Quality management systems—Guidelines for performance improvements," dated 2000-12-15, and ISO 9001:2000 were developed as a complementary pair of quality management standards. ISO 9004 gives guidance on a wider range of objectives for a quality management system than does ISO 9001, particularly with regards to the continual improvement of an organization's overall performance and efficiency, as well as its effectiveness. ISO 9004 is recommended as a guide for organizations that wish to move beyond the requirements of ISO 9001. However, it is not intended to be used for certification or contractual purposes.

7.6 Accredited Quality Assurance Agencies

The proponent may demonstrate quality assurance by submitting documentation attesting that the production process has been registered as conforming to ISO 9001:2000 by one of the following accredited quality assurance agencies. (The proponent may contact the Standards Council of Canada at (613) 238-3222 to inquire about other accredited agencies.)

Quality Management Institute
90 Burnhamthorpe Road West
Suite 300
Mississauga, Ontario
L5B 3C3
Tel.: (905) 272-3920
(800) 465-3717
Fax: (905) 272-4538

Intertek Testing Services NA Ltd.
Quality Systems Division
1829, 32e avenue
Lachine, Québec
H8T 3J1
Tel.: (514) 631-3100
Fax: (514) 631-1133

Underwriters' Laboratories of Canada
7 Underwriters Road
Toronto, Ontario
M1R 3B4
Tel.: (416) 757-3611
(866) 837-3852
Fax: (416) 757-9540

BNQ Enregistrements de systèmes
CRIQ
333, rue Franquet
Sainte-Foy, Québec
G1P 4C7
Tel.: (418) 652-2296
(888) 267-1476
Fax: (418) 652-2221

SGS International Certification Services Canada Inc.
6275 Northam Drive, Unit 2
Mississauga, Ontario
L4V 1Y8
Tel.: (905) 676-9595
Fax: (905) 676-9362

Canadian General Standards Board
Sales Unit
Place du Portage III, 6B1
11, rue Laurier
Gatineau, Québec
K1A 1G6
Tel.: (819) 956-0425
(800) 665-2472
Fax: (819) 956-5644

8.0 Installation Manual

8.1 Purpose

The proponent or manufacturer shall prepare a well-defined and detailed installation manual that can be used as educational material for installers and users of the product.

8.2 Content

The manual shall address the following areas:

- a detailed description of the cladding system and its components, including their properties and composition;
- preparation requirements for the wood substrates to which the product is to be applied;
- methods of application of the system;
- cold / hot weather construction requirements;
- sequence of assembly operations;
- time and method of curing;
- details regarding installation of the system around windows, doors, penetrations and other openings;
- water management details (including flashings, weeps, capillary breaks);
- details about expansion and/or control joints;
- storage and handling procedures for the cladding product and its components;
- measures to be taken in the event of interruptions in application of the system; and
- temperature and humidity limits for use.

Other points the manufacturer deems pertinent to the installation shall also be included.

9.0 Required Documentation

A typical sample of the product and the following documentation must be submitted to CCMC:

- a detailed description of the product and its various components;
- a copy either of the QCM prepared as outlined in Section 7.0 or of the certificate stating that the manufacturing facility is governed by a registered quality assurance agency;
- a copy of the installation manual provided to installers;
- confirmation that the proponent is an authorized representative of a legally constituted company;

- information demonstrating how reference is to be made to CCMC's evaluation number on the product (see 7.3).

Note: Lack of information or sample will delay the evaluation.

All submitted samples and documentation should be carefully packaged to avoid damage in transit and shipped prepaid, including clearance through Canada Customs, if applicable, to:

Canadian Construction Materials Centre
Institute for Research in Construction
National Research Council Canada
Montreal Road, Building M-24
Ottawa, Ontario
Canada
K1A 0R6

Telephone: (613) 993-6189
Facsimile: (613) 952-0268

Appendix A

Field Performance Assessment Procedure for Cladding Systems Using Adhered Manufactured Concrete Stone

A Scope

The procedure defines the necessary building sampling, measurement and field procedures, and documentation to allow experienced building scientists to develop a professional opinion on the field performance of these systems. The procedure will also help to determine if the cladding system provides a level of performance equivalent to the intent of Section 9.27. of the National Building Code of Canada, while taking into account any provincial or territorial variations to these requirements.

The objectives of the field performance assessment are:

- To identify important factors that affect the moisture performance of the cladding system using adhered manufactured concrete stone.
- To determine the impact of the cladding system is performance on the long-term durability of a wood frame back-up wall.
- To characterize the rain penetration control performance of the cladding system in relation to that provided by rainscreen cladding (as defined by Construction Technology Update No. 9[1]).
- To identify important factors that affect the material and structural integrity of the cladding system and the attachment of the cladding to the back-up wall.
- To develop and document a professional opinion on the long-term performance of proprietary cladding systems using adhered manufactured concrete stone.

B Significance and Use

The results of this field assessment procedure will assist CCMC in evaluating proprietary cladding systems using adhered manufactured concrete stone. The procedure complements laboratory testing and evaluation methods found in the Technical Guide.

The consultant (see Appendix A1) shall serve as an independent third party with respect to implementing the field assessment procedure and providing an opinion on the performance of the cladding system. The consultants shall provide a review of results and conclusions using professional rigour suitable to meet the objectives stated above. CCMC may reference the consultant's report in the Evaluation Report.

C Terminology

For the purposes of this Appendix, the following definitions shall apply:

Consultant – the professional organization retained to undertake the field assessment of the cladding system using adhered manufactured concrete stone and to provide a report that contains an opinion on the long-term performance of the system to CCMC (see Appendix A1).

Contractor – the party retained by the proponent to conduct investigative openings and reconstruction on the sample buildings.

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(1) *Evolution of Wall Design for Controlling Rain Penetration* by G.A. Chown, W.C. Brown and G.F. Poirier. Construction Technology Update No. 9. Institute for Research in Construction, National Research Council Canada. December 1997.

Geographic area – an area that is served by a proponent through a distribution network that includes service representatives and training programs to produce a uniform product throughout the area.

Proponent – the manufacturer or product representative with whom CCMC has contracted for an evaluation of the cladding system.

System – the combination of manufactured concrete stone units, system design details and installation procedures that constitute the product that is represented by the proponent.

D Summary of Procedure

The field performance assessment procedure consists of three tasks, and the required reporting, as follows:

Task 1. Document the cladding system components and materials; document the installation procedures and practices; identify and document potential performance factors.

Task 2. Develop a visual survey methodology; apply the methodology to a survey of a set of buildings using the cladding systems; document the observed field performance of the installed cladding.

Task 3. Select a subset of buildings from the visual survey: some that appear to be performing and some that do not; conduct forensic investigations on these buildings to determine the actual performance of the cladding systems.

This document provides guidelines on the minimum effort expected from the consultant with respect to information gathering, reporting requirements and opinions needed regarding field performance. The consultant should ensure that the objectives stated above are met at all stages of the procedure. As field conditions and construction practices can vary widely, the consultant shall apply professional expertise and judgement in the execution of each of the tasks such that the results will be suitable for CCMC's product evaluation.

The following procedure defines the assessment for a single proponent of a cladding system using adhered manufactured concrete stone. Appendix A3 contains additional requirements for each task for an assessment with more than one proponent. A multiple-proponent assessment can only be undertaken if it can be demonstrated that the cladding systems manufactured by each proponent can be assessed as a generic group.

Task 1. Material Properties and Installation Procedures

1.1 Specified Materials

The consultant shall document the materials used in the cladding system and back-up wall in a manner that facilitates comparison between installations. This documentation shall serve to determine that the materials used in the construction of the cladding system correspond to those tested in other sections of the Technical Guide. The documentation shall also serve to establish that the installations reviewed during the visual and forensic surveys conform to the proponent's system descriptions.

The materials documentation section of the Task 1 report shall include the following as a minimum:

Stone

- cementitious components
- aggregates
- additives
- density
- size and weight of stones
- standard of manufacture

Mortar/Bedding Material

- cementitious components
- sand
- additives
- mix type (or mix proportions)
- water specification

Sheathing

- type
- specification/standard
- minimum thickness

Metal Lath/Mesh

- type of lath (e.g., welded wire, expanded rib lath)
- size, gauge, corrosion protection
- weight (kg/m^2) (lb/ft^2)
- backing paper (if any)
- fasteners (size, spacing, corrosion protection)

Sheathing membrane

- type
- specification (durability/water resistance)

Other items

- water repellant coatings
- sealants
- accessories

1.2 Installation Instructions

The consultant shall document details of the manufacturer's installation instructions to determine whether field installations follow the manufacturer's instructions and to facilitate comparisons between installations.

The manufacturer's installation instructions section of the report shall include the following as a minimum:

- accreditation requirements for installers
- restrictions/limitations on use (building/wall type/geographic or climatic, construction weather conditions)
- acceptance standards for back-up wall (studs, wind bracing, sheathing)
- materials storage procedures
- sheathing membrane application (and related flashing for drainage)
- expansion/contraction control to accommodate frame movement
- lath/mesh application (incl. description, location and spacing of fasteners)
- lath fasteners installed into studs
- details at openings, top of cladding and balconies, including flashing
- junctions with other cladding systems, at foundation, corners and roof
- mortar coat application
  - scratch coat, if used
  - bedding coat
- cutting and placement of stone units
- pointing of joints
- curing procedures
- water-repellant coatings

- maintenance.

1.3 Installation Procedures

The consultant shall document installation procedures during construction. The documentation shall be adequate to establish whether there are differences in trade practices, skill levels or the availability and use of materials between geographic areas. The proponent shall provide the consultant with a minimum of two typical sites per geographic area for which he has requested a product evaluation and where the complete installation process of the cladding system can be observed and recorded.

The consultant shall confirm that materials delivered to the site meet the manufacturer's documented requirements through inspection of labels or testing of the actual materials. The consultant shall record the contents of the labels on materials delivered to the site, e.g., lath, sheathing membrane.

The consultant shall choose one site per geographical area and provide suitable personnel to observe and record, using sketches, photographs and tests as appropriate. The following details shall be recorded as a minimum and compared to detailed specifications for the system.

<u>Materials Delivered to Site</u>

- all materials and specifications from bags and labels
- size of lath mesh/gauges
- fasteners
- storage procedures
- samples of base materials

<u>Installation Records</u>

- crew size and training or licensing
- details of back-up wall and junctions with windows/doors, service penetrations, balconies and foundation
- condition of back-up wall, MC of sheathing and studs
- lay-up of sheathing membrane, flashing and expansion joints in sketch form with photos
- fastening of lath, reinforcement patterns and overlap
- lath fasteners installed into studs

<u>Preparation</u>

- temperature/humidity at site
- equipment for mixing and placement
- mix proportions for scratch coat (if used), mortar bedding coat and mortar/admixtures

- weather during application (temperature and wetness)
- application procedures and thickness of mortar and coats
- cutting and application of concrete stone (in field of wall and at penetrations, corners and junctions with other cladding)
- pointing procedures
- cleaning procedures
- curing (solar, shelter, heating)
- sealants
- water repellant coatings

1.4 Reporting

The report for Task 1 shall include a summary of material properties and where deviations from the proponent's specifications occurred (a discussion on the differences between material properties specified by the proponent and those of the materials used on the installation). The report shall also document the proponent's installation instructions, the installation procedures observed in the field, and the differences between the two.

The consultant shall include in the report a discussion of the effect on system performance of all differences in construction and workmanship observed, and a judgement as to whether factors related to geographical area contributed to the differences.

The consultant shall include in the report an opinion on any aspect of the installation (material variance, trade practice, skill level or availability, etc.) that could adversely affect the water penetration resistance of the system and the durability of the back-up wall. The opinion shall be included in the conclusions of the report.

Task 2. Visual Survey

2.1 Conducting the Visual Survey

The consultant shall conduct a visual survey of field installations of cladding systems using adhered manufactured concrete stone (on buildings selected according to the procedures outlined in this document). The consultant shall provide an overview of the field performance of the cladding system and shall select installations for a detailed forensic investigation.

The consultant will design a survey instrument to direct professional staff conducting the survey. The consultant shall then select and rationalize a sample of buildings to be surveyed with considerable care in order to conduct a uniform and thorough survey. The consultant shall provide CCMC and the proponent with the survey instrument for review and acceptance prior to conducting the survey.

The survey instrument shall include a template that combines text, sketches and photos in a standard format to be used by the consultant for consistency in collection of the survey information. The template must have adequate space to allow for the recording of observations not anticipated during the design of the survey. The professional staff shall apply their judgement during the survey to identify performance factors that are not described in the survey instrument but that may have an impact on the project objectives.

The template shall include the following items, as a minimum:

Local Experience

- discuss local experience with the cladding systems with building officials and document the following:

General Building Information

- street address of building
- building geometry/storeys
- location of cladding system
- area and location covered by system relative to total cladding area
- other cladding systems in place
- spacing between expansion joints
- weather conditions (temp./precip./sun/cloud)
  - current day
  - previous day
  - weekly average (for last three months)

Visual Appearance of Cladding

- structural distress
  - differential movement
  - expansion joints
  - lateral deformation
- moisture distress
  - stains/dampness
  - efflorescence/biological
  - details that may allow water to penetrate the cladding
  - presence of water-repellant coating
- material distress
  - cracking at stone/mortar interface
  - incomplete mortar pointing
  - cracking through base coat (width and uniformity)
  - other cracking
  - loose materials
  - repairs
  - caulking

Note: The visual appearance of cladding shall include chimney installations and potential chimney distress.

Unit Review

- owner's experience with the system
  - leakage
  - required maintenance
  - coatings applied
  - other unusual occurrences
- evidence of water leakage at:
  - interior window head
  - below window
  - floor foundation/sill plate

Unit Review (cont'd)

(use photographs, video scan, etc.)

- age (building and cladding repair)/type/occupancy
- orientation of wall(s) under review
- dimensions of stone
- architectural moulding
- height of starting course above grade or above horizontal elements such as balconies
- size of overhangs
- eavestroughs provided
- plants and trees adjacent to building
- exposure
- ground water drainage and splashing
- where possible
  - polyethylene vs others
  - 2 x 4 or 2 x 6 framing
  - insulation/sheathing
- windows/openings
  - design (frame, sill overhang, drip, barrier at ends)
  - condition
  - joints in sill or other parts
  - window/wall sealant

2.2 Sampling Methodology and Logistics

The consultant shall obtain from the proponent the addresses of buildings and the contacts for all known applications of his product in the geographic areas for which he has requested product evaluation. The consultant shall select a sample of buildings for the visual survey from this group of buildings based on the following criteria:

(i) Geographic Area – a minimum of thirty buildings per area with more than one applicator where feasible.

(ii) Climate Region - The sample selection shall include a majority of buildings in climatic regions with severe climate such as high rain and wind loads or frequent freeze/thaw cycles. The severity of the climate shall be judged according to the climate data in Appendix A2 that includes driving rain indices and number of air frosts.

(iii) Age of buildings in sample – 15% must be 10 years of age or older and 60% must be 5 to 10 years old. No building shall be younger than 3 years or older than 15 years.

(iv) Complexity of Application – The sample buildings must provide examples of application of the cladding system that include windows and service penetrations, changes in wall surface plane, junctions with other cladding types, limited overhangs, balconies and chimneys.

(v) Orientation – The building facades selected for review shall include a majority that are exposed to the prevailing wind-driven rain and/or building runoff while taking into account the climate loads in (ii).

(vi) The final selection of building should identify installations that appear to be trouble-free as well as installations with apparent problems.

(vii) The consultant shall ask the proponent to obtain authority for the visual survey of the sample buildings and an interview to obtain the Unit Review information.

After selecting the samples and before the visual survey commences, the consultant shall provide CCMC and the proponent with the sample list, the General Building Information (see list in **2.1** above), and the rationale for selection.

2.3 Reporting

The report for Task 2 shall contain all information gathered during the visual survey, a discussion of the performance of each cladding system surveyed, as well as conclusions on the overall performance of the proponent's system. It shall also recommend buildings to be included in Task 3 - Detailed Forensic Investigation, as well as additional supporting data that should be collected during the survey.

Task 3 Detailed Forensic Investigation

3.1 Sample Selection and Logistics

The consultant shall conduct a detailed forensic investigation of a selection of buildings in each geographical area for which the proponent has requested a product evaluation:

- To either confirm the opinion on the cladding system's performance that was developed from the visual survey, or to determine the real performance;
- To establish the water penetration control achieved with the cladding system and its impact on the performance of the wall; and

- To determine the general structural adequacy and overall serviceability of the components of the system.

For each separate geographic area:

- A minimum of eight (8) buildings shall be selected from the visual survey buildings for forensic investigation which involves the opening of the wall systems, measurements, and sampling of materials.
- Buildings with apparent problems shall be included in the sample and compared to buildings that appear to be performing well.
- For each building, performance indicators from the visual survey shall be considered with respect to moisture performance, structural adequacy and serviceability.
- The consultant shall provide CCMC and the proponent with a detailed rationale for sample selection before commencing the forensic investigation.

The proponent will arrange for building access, for approval of the opening of the wall systems, and for the provision of guarantees on the adequacy of the reinstatement of the wall components.

The proponent will also ensure that a suitably trained contractor is available to conduct the openings in the wall systems. The consultant will coordinate site visits with the proponent and the contractor, and shall direct the contractor during the opening and closing of the walls.

3.2 Conducting the Forensic Investigation

The forensic investigation shall be conducted through exploratory openings. It is expected that the investigation will focus not only on the field of the wall, but also on critical details such as window openings, service penetrations, balconies, and junctions with other building components. In cases where manufactured stone serves primarily a highlight function, the interfaces with the surrounding systems must be studied. Whole panel removal and replacement may be most economical.

The opening shall be large enough to include all major aspects of the wall. Where necessary, the opening shall be extended to determine the extent of water penetration.

Following is a list of site activities to be carried out and data to be recorded (text, sketches and photos) as a minimum:

Update Visual Sample

- record changes in exterior appearance since visual survey

Testing

- conduct water penetration tests on selected areas of cladding in accordance with ASTM E 1105-90, except that a test chamber and pressure difference across the wall are not required.

Exploratory Openings

- select samples to determine material characteristics
- remove and retain samples of the cladding system including stone, mortar and lath; test stone, mortar and lath according to Task 3.3
- note condition of bond between stone and back-up mortar
- record drainage potential between cladding system and sheathing membrane
- document condition of all elements, including MC, with notations, sketches and photographs
- note type, material, gauge, corrosion protection and condition of lath, including location and extent of corrosion (e.g., area not covered by mortar, within mortar, at fasteners); retain sample
- note type, material, dimensions, corrosion protection and condition of fasteners, including location and extent of corrosion, retain sample
- note flashing/sheathing membrane interfaces
- note sheathing membrane type; retain sample
- remove and retain a sample of the sheathing; record MC
- measure MC of framing
- note condition of insulation (dampness, staining, integrity)
- trace and map moisture damage with additional exploratory openings, as required

3.3 Material Testing

The consultant shall conduct the following tests on the manufactured concrete stone units, the mortar and the metal lath in conformance with Section 6.0 of the Technical Guide. The field sampled materials shall be representative of the ones submitted for the evaluation of the cladding system.

Material and Property Tested	**Test Requirements***
Manufactured Concrete Stone	
– compressive strength	ASTM C 140
– density	ASTM C 140
– 24-h water absorption	ASTM C 140
Mortar (site prepared mixes)	
– analysis of hardened mortar	ASTM C 1324
Metal Lath	
– weight of zinc coating	ASTM A 90/A90M**

* *Refer to the Technical Guide for variations on test procedures.*

** *To be performed on samples of lath which seem to be in good condition to obtain an estimate of the original weight of the zinc coating.*

3.4 Reporting

The consultant shall prepare a report that includes:

3.4.1 Site-Specific Information

Describe the location of the building and the context (building size, orientation and general description of cladding taken from the visual survey). Provide details from the visual survey that led to the selection of this building for the forensic investigation.

3.4.2 Description of Investigation

Describe the investigation that was undertaken, when and by whom. Describe what limitations were placed on the investigation, if any.

3.4.3 Investigation Observations

Describe what was observed at each stage of the investigation pertinent to the objectives of the field study. Describe what measurements were taken.

3.4.4 Analysis and Conclusions

Report the details of the analysis of the information gathered from the field performance assessment to determine compliance with Section 9.27. of the NBC 1995. Based on the observed performance of the cladding, flashing, trim and accessories, record whether the system restricted the entry of rain and snow into the wall assembly in conformance with NBC Article 9.27.2.1.

Water penetration past the sheathing membrane.
The cladding system shall not allow any water past the sheathing membrane. The observations should report any indication of water penetration past the sheathing membrane in the field of the wall as well as around interfaces with wall components and at the interfaces with other cladding systems. If water penetration is observed beyond the sheathing membrane, the consultant shall provide opinions on the cause(s) and associated solutions, e.g., internal window leakage, unrelated roof/wall leakage or leakage at junctions with adjacent systems.

Moisture content of wall sheathing and structural wood members.
The MC of the wall sheathing and of the structural wood members of the wall shall be less than 19%. The consultant should determine the moisture content of the sheathing and of the structural wall. Where the MC is above 19%, the consultant should provide an opinion as to why.

Water penetration at service penetrations.
The cladding system shall not allow any water penetration at service penetrations. The observation should report any indication of water penetration at service penetrations such as dryer vents, electrical boxes and light fixtures. If there is any indication of water penetration, the report shall provide opinions on the cause(s) and associated solutions.

3.4.5 Compliance with Rainscreen Cladding Principles

The report must analyze and draw conclusions as to how the cladding system provides capillary break, drainage and drying as compared with the system principles described in IRC's Construction Technology Update No. 9. If performance problems are observed, the consultant shall attribute them to design, construction or material properties.

3.4.6 Performance of Cladding System

As a conclusion, the consultant shall include a rationalized opinion on the long-term performance of the cladding system using adhered manufactured concrete stone and its ability to meet the intent of Section 9.27 of the NBC 1995, while taking into account any provincial or territorial variations of these requirements. The opinion should be linked to the criteria defined in Task 2.2.

APPENDIX A1

Consultant's Qualifications

The consultant must be approved by CCMC. The consultant team must have the following minimum qualifications:

1. Be composed of professional building consultants (architects, engineers) with demonstrated expertise in heat, air and moisture flows in wood-frame wall systems.
2. Established expertise and experience in assessing equivalent performance levels between cladding systems.
3. Extensive knowledge of cladding system field application procedures and lightweight, wood-frame construction across Canada.
4. Expertise with Canadian Building Codes and their requirements for moisture control in wood-frame housing.
5. Established expertise in building science principles, especially the rainscreen principle for rain penetration control, e.g., CTU No. 9, CTU No. 17, CTU No. 34.
6. The team must include field personnel with experience in conducting field surveys of wood-frame buildings, developing field survey instruments, collecting data and analyzing field results.
7. Demonstrated expertise in how to conduct investigative openings related to cladding over wood-frame walls.
8. Ability to assemble a team with geographic representation of professional personnel across Canada.
9. Professional liability insurance of at least $2 million.

APPENDIX A2
Climate Indices

1. Background

The climate indices contained herein form part of the field performance assessment procedure for the evaluation of cladding systems using adhered manufactured concrete stone. The climate indices and zones were developed to assist the consultant conducting the field survey/investigation in selecting sample buildings for the visual and detailed inspections either for a provincial or national evaluation. The indices and zones are also intended to be used to establish the geographic limitations of applicability of cladding systems using adhered manufactured concrete stone, assuming positive field survey/investigation results.

2. Introduction

It is not currently possible to define a single index to characterize climate for the range of performance characteristics required of a wall cladding. The approach taken here is to define a specific index appropriate for a specific performance characteristic. Three characteristics of wall cladding performance are considered here: moisture response, thermal movement, and freeze-thaw durability. The three corresponding climate indices are shown in Figure A.1.

The three indices chosen to characterize climate in order of importance are:

1. Index 1: Moisture Loading – mean Annual Rainfall (mm);
2. Index 2: Thermal Movement Potential – the Design Range (DR) (°C);
3. Index 3: Freeze-Thaw Durability – a Freezing Index (FI) (mm-cycles/year).

Each index is scaled for easy recognition and increases in severity from zero, being the least severe, to ten and above, being classed as severe.

3. How to Use the Indices

The procedure for using the indices is straightforward. The indices are to be used for, 1) guiding the selection of buildings for a field survey, and 2) aiding in the interpretation of the results of the field survey. The indices were designed to rank climate severity on a scale of one to ten, with ten representing a severe climate load. The normalization scheme does however permit rankings higher than 10. All rankings greater than ten should also be considered severe. To further aid in selecting buildings and interpreting the results, a simple zoning scheme was developed for each index. Threshold values for each index were defined. Each zone represents a collection of locations having a similar climate loading and a similar expected wall response.

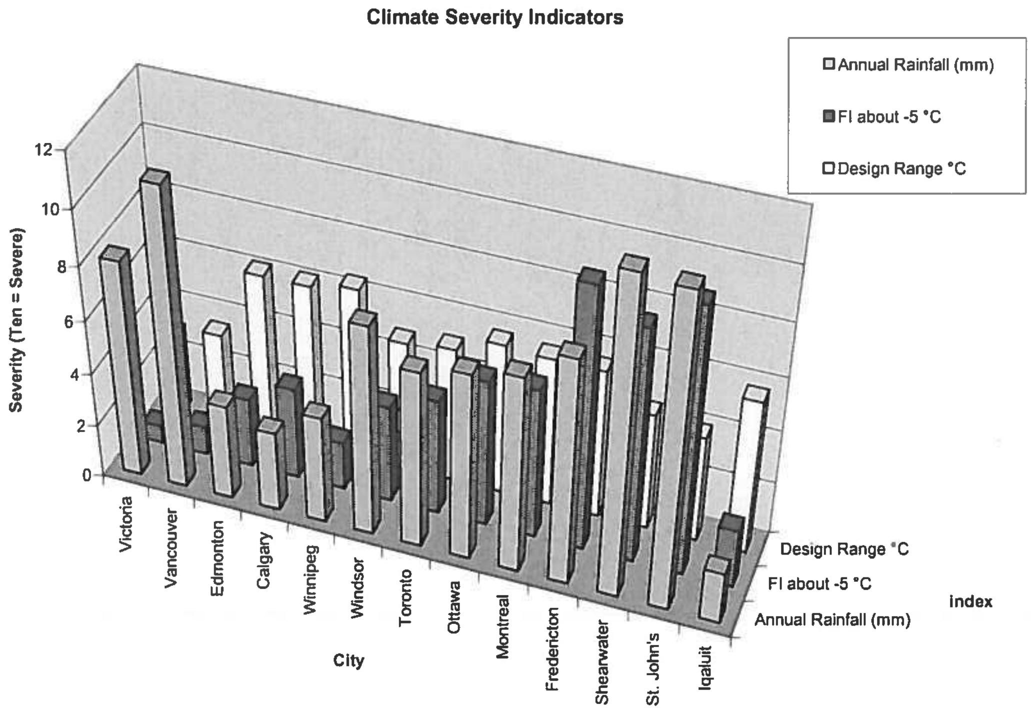

Figure A.1. Climate Severity Indicators. The bar chart shows the three climate severity indices defined for Canada. The indices range from 0 to 10, 10 being severe. The indices are: Mean Annual Rainfall for moisture performance, Freezing Index based on cycles around –5 °C for freeze-thaw durability, and the Design Range based on summer and winter design temperatures.

Selecting Buildings – Given a group of buildings, the buildings to be surveyed/investigated should be selected in locations having higher indices (i.e. more severe climates). One location need not be the most severe of all the indices however. The sample buildings may have to be selected from more than one location or area. For example, if moisture loading is the primary concern, then buildings located in areas with high values on the Moisture Severity Index (Index 1) should be selected. Likewise, if freeze-thaw durability is a concern, then buildings should be selected in areas with high values on the Freezing Index (Index 3). The sample set of buildings culled from the group should include a sufficient number of buildings where the climatic loads are severe to adequately assess the in-situ performance.

Evaluation of the Results – The indices can be used as a guide in the application of the field survey results. For example, if the building stock sampled was mainly in the Prairie Provinces, the following conclusions might be drawn assuming that the cladding in question exhibited no systemic difficulties. Looking at the indices for the Prairie regions, we can see the value on the moisture severity index is around 4 or less which is low in comparison with the other regions of the country (see Figure A.2). Even though the cladding performed well in this climate, it is not possible to speculate on the successful use of the cladding in coastal regions or in central Canada. The same applies for the freeze-thaw durability of the cladding (see Figure A.3). On the other hand, in terms of potential thermal movements, if no systemic problems were recorded in the Prairies then in all likelihood the system would perform well in other regions given the severity of the climate with respect to temperature range (see Figure A.4). Continuing in this vein, the thresholds and zones can be used to determine the limits of use. In terms of moisture loading, a Prairie location would fall into Zone 1. The rule for using the zones is simply stated as *no bumping up*. The limits of applicability with respect to moisture would be all locations included in Zone 1.

A similar restriction might apply for freeze-thaw durability. In the case of thermal movement potential however the system would not be limited to any zone.

4. About the Indices

First, weather conditions may vary markedly within a relatively small geographical area. So, while the published figures give a good indication of the average conditions within a particular region, some caution must be exercised when applying the data to a locality within that region other than that of the weather station itself.

Second, the intent here was to keep everything as simple as possible. For this reason, only three cladding characteristics were selected: moisture performance, thermal movement potential, and freeze-thaw durability. In defining the indices, three basic principles were followed: 1) use commonly available weather information; 2) use the fewest elements possible; and, 3) use a scale from 0 to 10 for rapid recognition. A fourth principle was used insofar as evidence was available; namely that the indices should correlate to experimentally observed data or anecdotal evidence in the field. The indices were based on an examination of thirteen locations, twelve in rough line from west to east, and a far north station to represent severe cold climates. Each index was normalized using a normalizing factor to scale the results.

The moisture severity index (Index 1) is calculated as the mean annual rainfall divided by 100. This produces an index that is directly proportional to the annual rainfall. This means, however, that some locations may have values on the moisture severity index that exceed ten (Tofino, for example, would have a moisture severity index of over 30).

The index for potential thermal movement (Index 2) is calculated as the difference between the 1% January design temperature and the 2.5% July dry-bulb design temperature divided by 10. The design range can therefore be read directly from the index.

The index for freeze-thaw durability is based on a Freezing Index. The index was developed based on a British approach that combines air temperature and moisture data. The approach does not take into consideration the frost resistance of materials. The index was normalized to the maximum value of the Freezing Index in a set of 13 cities for which a detailed climate analysis was carried out.

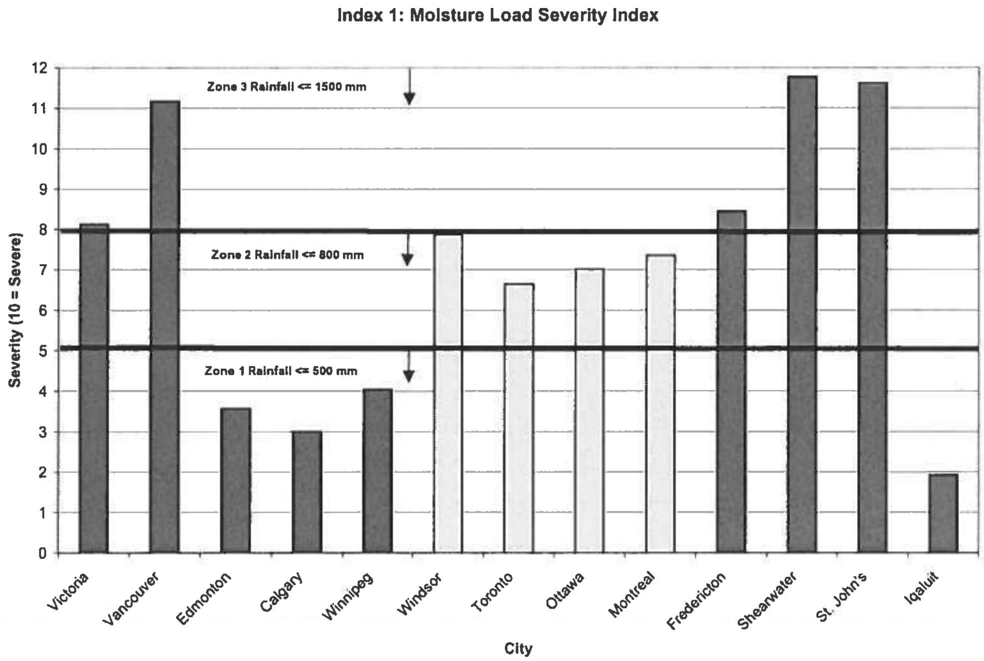

Figure A.2. The bar chart shows the moisture load severity indices defined for Canada. The index ranges from 0 to 10, 10 being severe. The index is based on Mean Annual Rainfall.

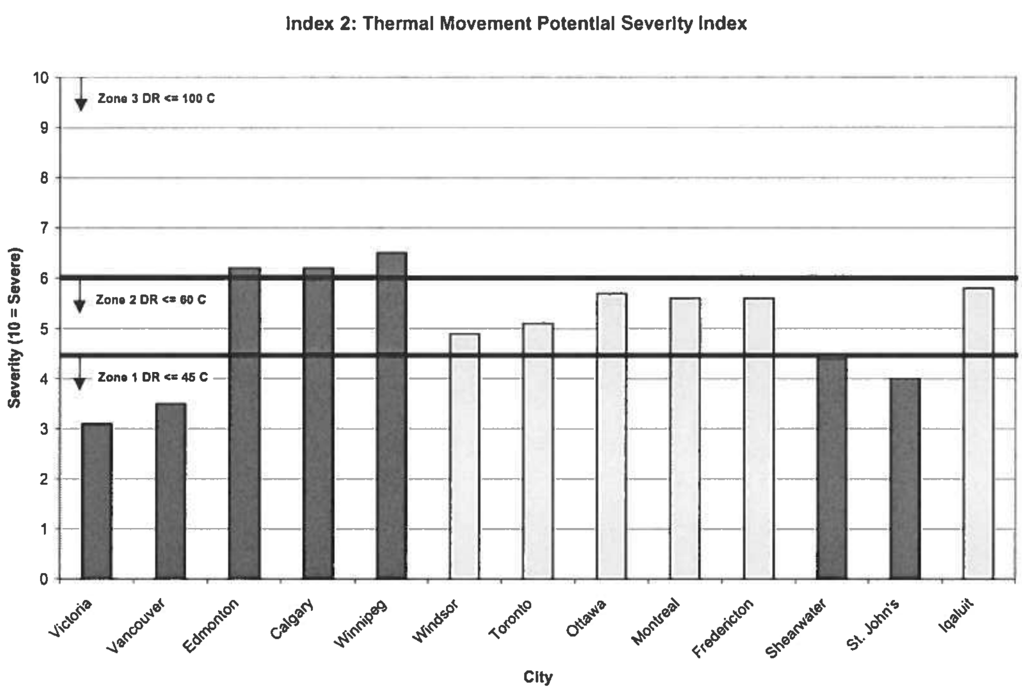

Figure A.3. The bar chart shows the potential for thermal movement for selected locations across the Canada. The index ranges from 0 to 10, 10 being severe. The index is based on the difference between the 1% January and 2.5% July dry-bulb temperatures.

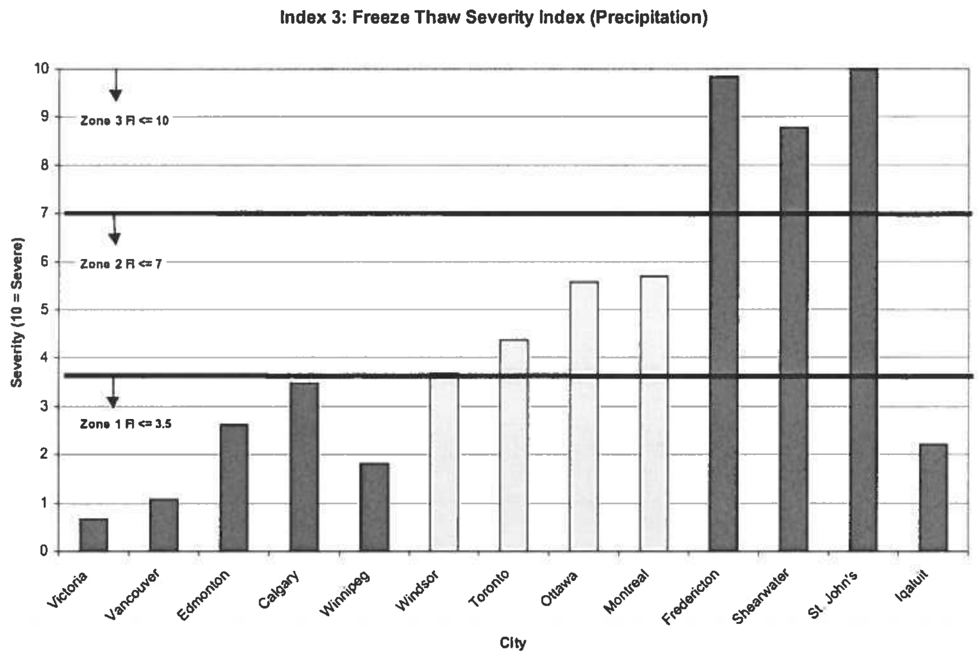

Figure A.4. The bar chart shows a Freeze-Thaw Index for selected locations across the Canada. The index ranges from 0 to 10, 10 being severe. The index is based on the number of monthly freeze-thaw cycles around –5 °C and mean monthly precipitation (mm).

5. Wetting on the Facade

This section gives some details regarding the orientation of wind-driven rain impinging on the facades of buildings. This data provides information on the directional component of wind-driven rain to assist those engaged in field surveys of buildings. The data is intended to help the surveyor focus on specific facades that may experience a greater amount of moisture loading. A few comments regarding the limitations and interpretation of the information are in order.

First, the determination of the directional Driving-Rain Index, and consequently the amount of rain impinging on a facade, requires a considerable amount of basic weather data. Specifically, coincident rainfall intensity, and wind speed and direction are needed. The minimum observational interval required is 1 hour and at least 10 years of recorded data is required. Consequently, analysis for only the 13 locations presented above has been done to date.

Second, the results from weather stations reported here are all located at the local airports. The results may not be representative of areas located away from the airports, especially with regard to wind direction and speed. Local climatic conditions may also produce significant variations in rainfall, especially for West Coast locations.

Finally, a number of assumptions were made in calculating the amount of rainfall. One method from a number of methods was selected. Several assumptions were made regarding terrain, obstructions, facade characteristics, aerodynamic effects, raindrop size and distribution. The assumptions were consistent for all locations to allow for relative comparisons between locations. The loads reported are derived from 30 or more years of weather data and are the average loads expected.

Figures A.5. through A.17. show the amount in litres per square metre per year of wind-driven rain impinging on a facade having a specific orientation. For example, a southeast-facing wall in Victoria would receive an average of 473 litres per square metre of wall in the course a year (see Figure A.5). Table A.1 reports the amounts shown in the rosettes.

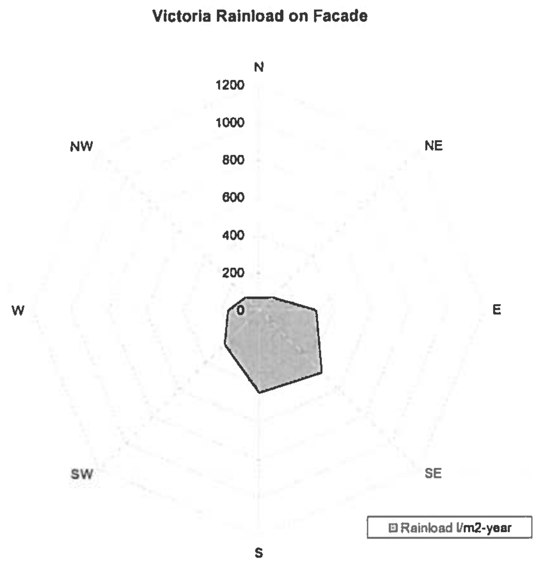

Figure A.5. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Victoria International Airport, BC. East and south facades are likely to experience the most wetting.

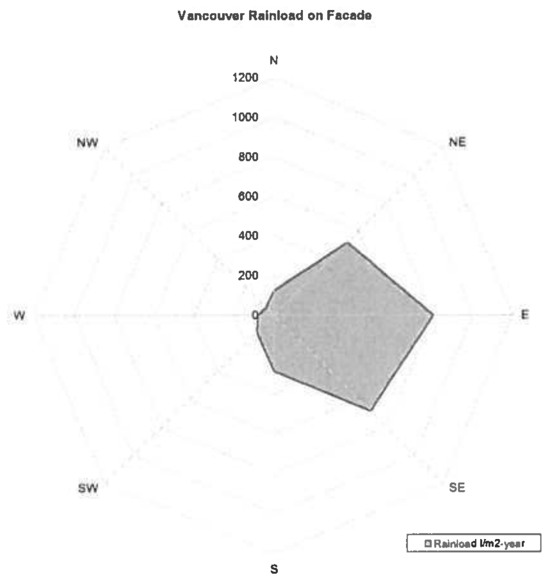

Figure A.6. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Vancouver International Airport, BC. Facades with an eastern orientation are likely to experience the most wetting.

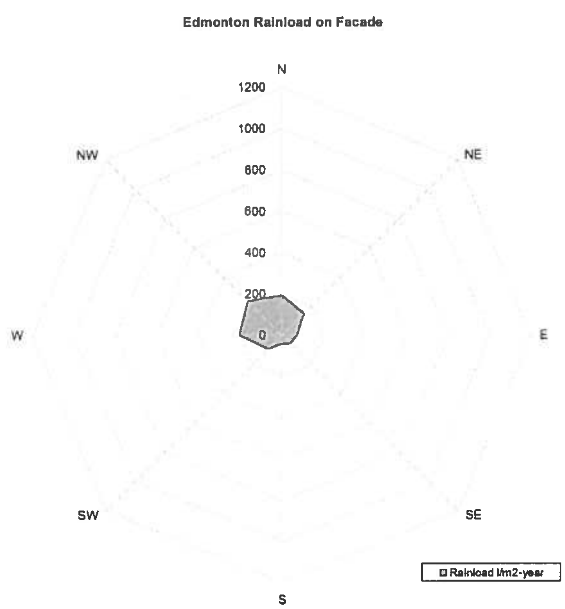

Figure A.7. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Edmonton International Airport, AB. Facades with a northwest orientation are likely to experience the most wetting.

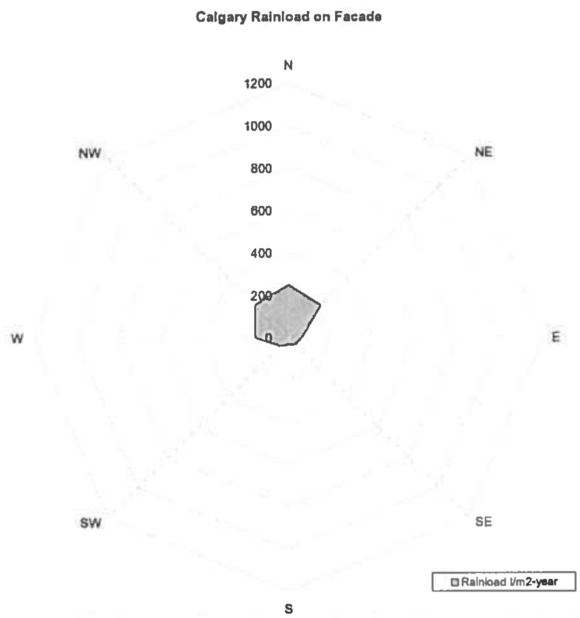

Figure A.8. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Calgary International Airport, AB. Facades with a northwest orientation are likely to experience the most wetting.

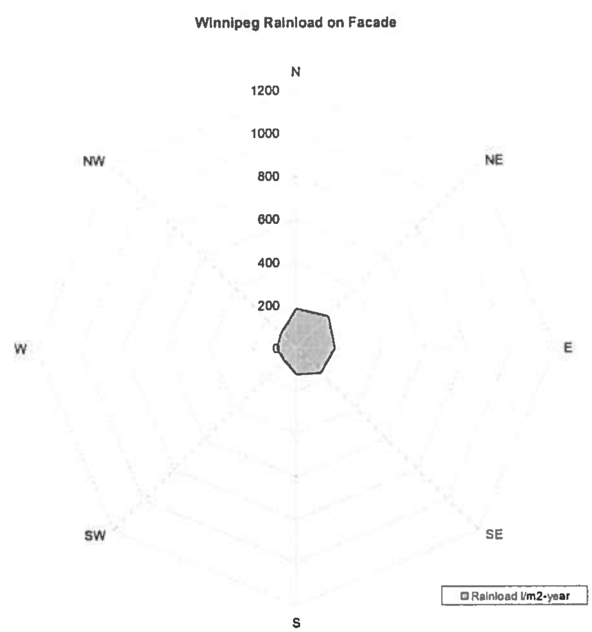

Figure A.9. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Winnipeg International Airport, MB. Facades with a northeast orientation are likely to experience the most wetting.

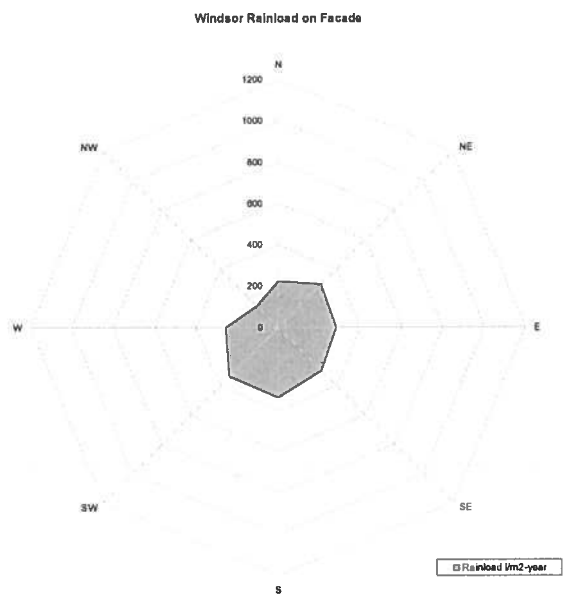

Figure A.10. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Windsor Airport, ON. Facades having a southern or eastern orientation are likely to experience the most wetting.

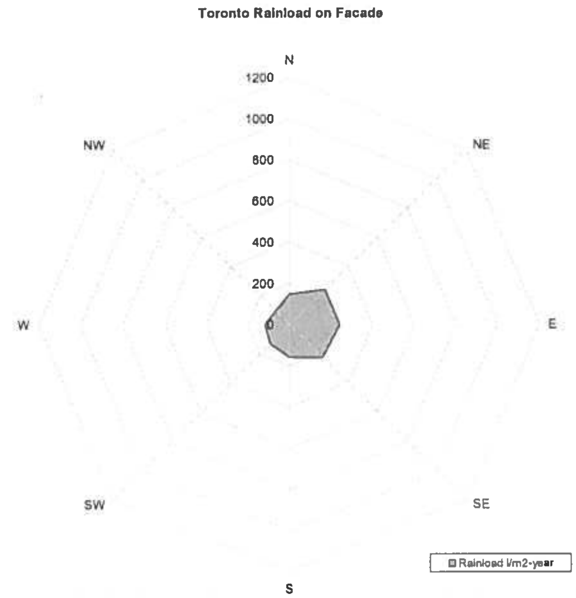

Figure A.11. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Toronto International Airport, ON. Facades with an eastern orientation are likely to experience the most wetting.

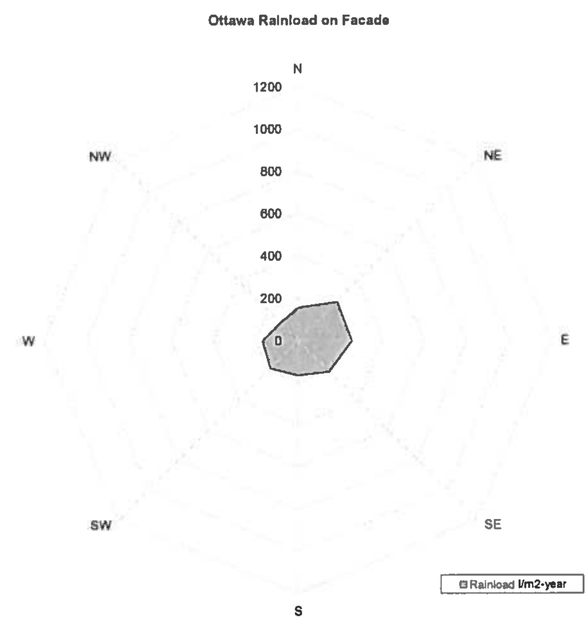

Figure A.12. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Ottawa International Airport, ON. Facades with an eastern orientation are likely to experience the most wetting.

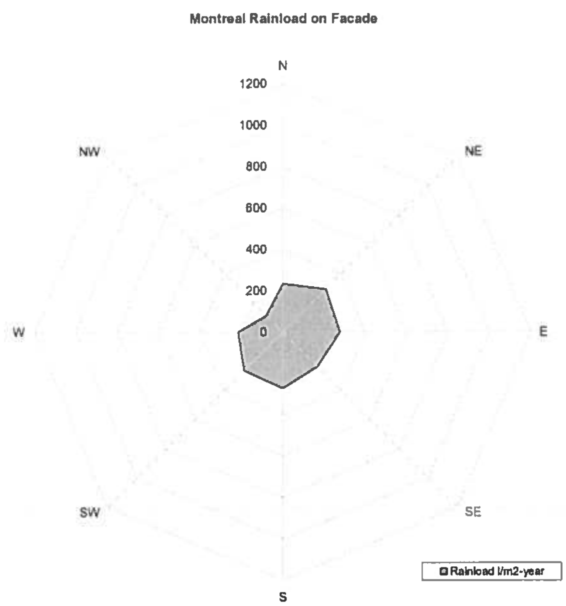

Figure A.13. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Montreal/Dorval International Airport, QE. Facades having a southern or eastern orientation are likely to experience the most wetting.

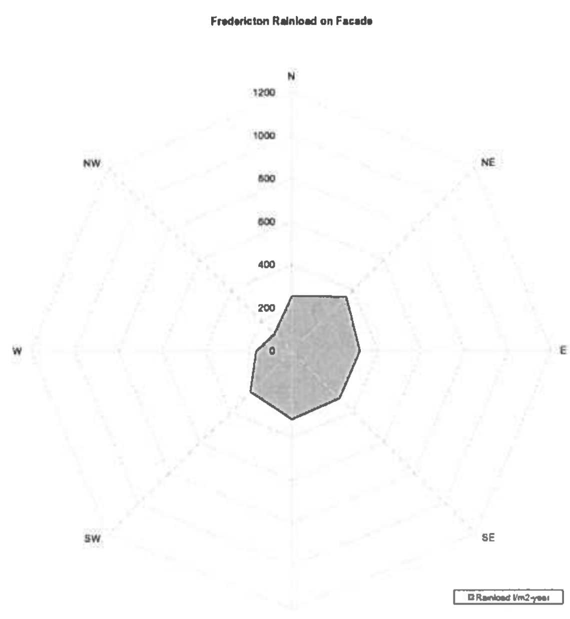

Figure A.14. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Fredericton Airport, NB. Facades having an eastern orientation are likely to experience the most wetting.

Figure A.15. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Shearwater Airport, NS. Facades with a southern or eastern exposure are likely to experience the most wetting.

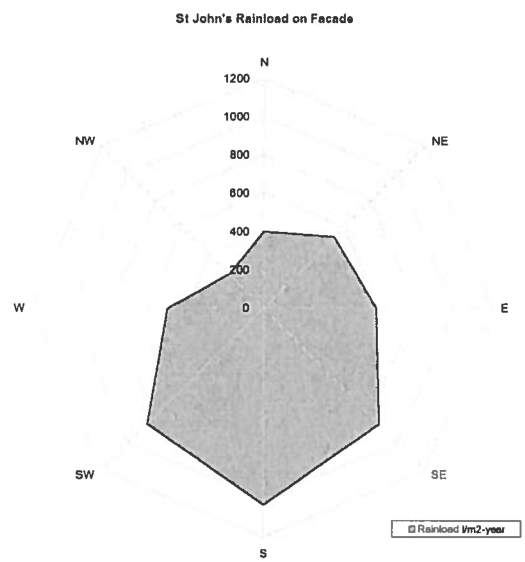

Figure A.16. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is St. John's Airport, NF. Facades having a southern exposure are likely to experience the most wetting.

Figure A.17. The figure shows a rosette plotting the distribution of water impinging on a facade having a specific orientation. The rosette shows the average amount of water that might be expected to strike the facade, in litres per square metre per year. Eight wall orientations are shown. The location is Iqaluit Airport, NU. Facades having an eastern or southern exposure are likely to experience the most wetting.

City	Rain load on Facade (l/m^2-year)							
	N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
Victoria	68	99	305	473	443	260	165	100
Vancouver	125	524	803	688	285	122	79	58
Edmonton	194	150	72	57	43	95	207	234
Calgary	252	219	65	43	32	54	158	223
Winnipeg	187	215	181	165	122	81	90	100
Windsor	224	295	282	297	341	337	255	149
Toronto	149	242	245	227	160	134	119	98
Ottawa	158	261	257	208	166	186	170	119
Montreal	236	295	279	238	274	266	217	114
Fredericton	257	356	315	311	318	267	162	115
Shearwater	240	537	697	742	566	369	165	82
St. John's	401	527	595	863	1033	859	502	255
Iqaluit	64	69	162	219	162	43	52	69

Table A.1. Rain impinging on facades of specific orientations, in litres per square meter of wall surface per year. Note that all the weather stations used for the calculations are located at local airports. Also, specific assumptions have been made regarding terrain, obstructions, and aerodynamic effects.

6. Climate Severity Indices

Tables A.2. to A.14. give the climate severity indices for selected locations in the ten provinces and three territories. The locations were selected based on the availability of climate data and do not necessarily represent a complete list of locations. A star entry means the index was not calculated for that location. A lowercase (a) following a station name indicates an airport station.

Station	Moisture	Thermal	Freezing
Banff	2.8	5.9	*
Calgary Int'l (a)	3.0	6.2	3.5
Cold Lake (a)	3.2	6.6	*
Coronation (a)	2.8	6.3	*
Edmonton Int'l (a)	3.6	6.2	2.6
Edmonton Municipal (a)	3.5	5.7	*
Edmonton Namao (a)	3.4	5.7	*
Edson (a)	4.4	6.5	*
Fort Chipewyan (a)	2.4	7.0	*
Fort McMurray (a)	3.3	6.9	*
Grande Prairie (a)	3.1	6.6	*
High Level (a)	2.0	6.8	*
Jasper	2.8	6.3	*
Lethbridge (a)	2.6	6.4	1.7
Medicine Hat (a)	2.3	6.7	*
Peace River (a)	2.7	6.7	*
Red Deer (a)	3.6	6.4	*
Slave Lake (a)	3.7	6.6	*
Vermilion (a)	3.1	6.7	*

Table A.2. Climate severity indicators for selected locations in Alberta.

Station	Moisture	Thermal	Freezing
Armstrong (a)	5.0	7.0	*
Atikokan	5.8	6.6	*
Big Trout Lake	3.9	6.5	*
Dryden (a)	5.2	6.3	*
Earlton (a)	5.6	6.6	*
Gore Bay (a)	6.0	5.4	*
Hamilton (a)	7.4	5.0	*
Kapuskasing (a)	5.6	6.3	*
Kenora (a)	4.7	6.4	*
Kingston (a)	7.9	5.1	*
London (a)	7.8	5.0	*
Mount Forest	7.1	5.2	*
Muskoka (a)	7.7	5.8	*
North Bay (a)	7.4	5.8	*
Ottawa Int'l (a)	7.0	5.7	5.6
Petawawa (a)	6.1	6.1	*
Peterborough (a)	6.6	5.5	*
Pickle Lake	5.0	6.8	*
Red Lake (a)	4.6	6.4	*
Sarnia (a)	7.1	4.9	*
Sault Ste Marie (a)	6.3	5.7	*
Simcoe	8.0	4.9	*
Sioux Lookout (a)	5.0	6.4	*
Sudbury (a)	6.4	5.9	4.9
Thunder Bay (a)	5.5	6.1	*
Timmins (a)	5.8	6.6	*
Toronto Downsview (a)	6.6	5.3	*
Toronto Island (a)	6.8	5.1	*
Toronto Pearson Int'l (a)	6.6	5.3	4.4
Trenton (a)	7.2	5.2	*
Waterloo Wellington (a)	7.7	5.0	*
Wiarton (a)	7.2	4.8	*
Windsor (a)	7.9	4.9	3.7

Table A.3. Climate severity indicators for selected locations in Ontario.

Station	Moisture	Thermal	Freezing
Abbotsford (a)	14.9	4.0	*
Blue River (a)	6.4	5.4	*
Cape St James	14.9	2.7	*
Castlegar (a)	5.3	5.4	*
Comox (a)	10.9	3.6	*
Cranbrook (a)	2.6	6.2	*
Dawson Creek (a)	3.3	6.6	*
Fort St John (a)	3.0	6.4	*
Hope (a)	17.7	5.0	*
Kamloops (a)	2.0	6.2	*
Kelowna (a)	2.8	5.3	*
Lytton	3.2	5.7	*
Mackenzie (a)	3.5	6.4	*
Nanaimo (a)	10.5	3.5	*
Penticton (a)	2.5	5.1	*
Port Alberni (a)	17.7	3.8	*
Port Hardy (a)	18.0	2.7	*
Prince George (a)	4.2	6.4	*
Prince Rupert (a)	24.1	3.5	*
Princeton (a)	2.2	6.2	*
Quesnel (a)	3.8	6.5	*
Revelstoke (a)	6.1	6.1	*
Sandspit (a)	12.9	2.2	*
Smithers (a)	3.4	5.6	*
Terrace (a)	9.3	4.7	*
Tofino (a)	32.9	2.3	*
Vancouver Int'l (a)	11.2	3.5	1.1
Victoria Gonzales Hts	5.9	3.0	*
Victoria Int'l (a)	8.1	3.1	0.7
Victoria Marine	12.0	3.0	*
Williams Lake (a)	2.7	6.3	*

Table A.4. Climate severity indicators for selected locations in British Columbia.

Station	Moisture	Thermal	Freezing
Broadview	2.9	6.6	*
Cree Lake	3.1	6.8	*
Estevan (a)	3.1	6.6	*
La Ronge (a)	3.6	6.7	*
Moose Jaw (a)	2.6	6.6	*
North Battleford (a)	2.7	6.6	*
Prince Albert (a)	3.0	7.0	*
Regina (a)	2.8	6.7	*
Saskatoon (a)	2.5	6.7	*
Swift Current (a)	2.5	6.6	*
Uranium City (a)	2.2	7.2	*
Wynyard	2.9	6.4	*
Yorkton (a)	3.2	6.6	*

Table A.5. Climate severity indicators for selected locations in Saskatchewan.

Station	Moisture	Thermal	Freezing
Beausejour	4.1	6.3	*
Brandon (a)	3.6	6.6	*
Churchill (a)	2.4	6.5	*
Dauphin (a)	3.7	6.5	*
Flin Flon (a)	3.5	6.7	*
Gillam (a)	3.1	7.0	*
Gypsumville	3.7	6.9	*
Island Lake (a)	3.4	6.4	*
Lynn Lake (a)	3.2	6.9	*
Pilot Mound (aut)	4.0	6.6	*
Portage la Prairie (a)	4.0	6.3	*
The Pas (a)	3.2	6.6	*
Thompson (a)	3.6	7.1	*
Winnipeg Int'l (a)	4.0	6.5	1.8

Table A.6. Climate severity indicators for selected locations in Manitoba.

Station	Moisture	Thermal	Freezing
Bagotville (a)	6.4	6.1	*
Baie Comeau (a)	6.6	5.4	*
Gaspé (a)	9.8	5.0	*
Grindstone Island	6.9	4.6	*
Inukjuak	2.5	5.7	*
Kuujjuaq (a)	2.6	6.5	*
Kuujjuarapik (a)	3.9	6.7	*
Mont Joli (a)	5.7	5.1	*
Montréal/Dorval Int'l (a)	7.4	5.6	5.7
Nitchequon	5.2	6.3	*
Québec (a)	8.8	5.6	*
Roberval (a)	6.0	6.1	*
Rouyn (a)	6.3	6.5	*
Schefferville (a)	4.0	6.4	*
Sept-Iles (a)	7.3	5.6	*
Sherbrooke (a)	8.3	5.9	*
St-Hubert (a)	7.8	5.6	*
Ste-Agathe-des Monts	8.2	5.6	*
Val D'or (a)	6.3	6.5	*

Table A.7. Climate severity indicators for selected locations in Quebec.

Station	Moisture	Thermal	Freezing
Charlo (a)	7.1	5.8	*
Chatham (a)	7.7	5.6	*
Fredericton (a)	8.4	5.6	9.8
Moncton (a)	8.3	5.2	*
Saint John (a)	11.6	4.9	*

Table A.8. Climate severity indicators for selected locations in New Brunswick.

Station	Moisture	Thermal	Freezing
Greenwood (a)	8.7	4.7	*
Halifax Int'l (a)	12.2	4.4	*
Sable Island	12.8	3.9	*
Shearwater (a)	11.8	4.7	8.8
Sydney (a)	11.6	4.5	*
Truro	9.6	5.0	*
Yarmouth (a)	10.8	3.7	*

Table A.9. Climate severity indicators for selected locations in Nova Scotia.

Station	Moisture	Thermal	Freezing
Charlottetown (a)	8.7	4.8	*
Summerside (a)	7.7	4.9	*

Table A.10. Climate severity indicators for selected locations in Prince Edward Island.

Station	Moisture	Thermal	Freezing
Arnold's Cove	10.4	4.3	*
Battle Harbour Lor	4.5	4.4	*
Bonavista	6.5	4.3	*
Burgeo	12.3	4.2	*
Cartwright	4.5	5.2	*
Churchill Falls (a)	4.2	6.4	*
Comfort Cove	6.3	5.0	*
Daniel's Harbour	6.4	4.6	*
Deer Lake (a)	5.9	5.4	*
Gander Int'l (a)	6.3	4.8	*
Goose (a)	4.7	6.0	*
Hopedale (aut)	3.2	5.1	*
Port aux Basques	10.1	3.6	*
St John's (a)	9.9	4.0	10
St Lawrence	11.2	4.0	*
Stephenville (a)	8.0	4.4	*
Wabush Lake (a)	4.0	6.0	*

Table A.11. Climate severity indicators for selected locations in Newfoundland and Labrador.

Station	Moisture	Thermal	Freezing
Burwash (a)	1.9	6.6	*
Mayo (a)	2.0	7.3	*
Teslin (a)	1.9	6.8	*
Watson Lake (a)	2.6	7.4	*
Whitehorse (a)	1.6	6.8	*

Table A.12. Climate severity indicators for selected locations in the Yukon.

Station	Moisture	Thermal	Freezing
Cape Parry (a)	0.7	5.9	*
Fort Reliance	1.7	7.1	*
Fort Simpson (a)	2.1	7.4	*
Fort Smith (a)	2.3	7.3	*
Hay River (a)	1.9	6.9	*
Inuvik (a)	1.2	7.3	*
Mould Bay (a)	0.3	5.7	*
Norman Wells (a)	1.8	7.4	*
Tuktoyaktuk	0.8	6.5	*
Tuktoyaktuk (a)	0.8	6.3	*
Yellowknife (a)	1.5	7.0	*

Table A.13. Climate severity indicators for selected locations in the Northwest Territories.

Station	Moisture	Thermal	Freezing
Alert	0.1	5.8	*
Baker Lake (a)	1.4	6.7	*
Broughton Island	0.4	5.2	*
Byron Bay (a)	0.7	6.7	*
Cambridge Bay (a)	0.7	6.2	*
Cape Dyer (a)	1.0	5.3	*
Cape Hooper	0.5	5.2	*
Chesterfield	0.6	6.1	*
Clinton Point	1.0	6.0	*
Clyde (a)	0.5	5.8	*
Contwoyto Lake	1.3	6.8	*
Coral Harbour (a)	1.5	6.1	*
Eureka	0.3	6.0	*
Gladman Point (a)	0.7	6.8	*
Hall Beach (a)	1.0	6.3	*
Iqaluit (a)	1.9	5.8	2.2
Longstaff Bluff	1.0	6.1	*
Pelly Bay	1.1	6.4	*
Resolute (a)	0.5	5.6	*

Table A.14. Climate severity indicators for selected locations in the Nunavut.

APPENDIX A3

Generic Groups

Multiple-Proponent Assessment Procedures

The field performance assessment procedure defines a process of assessment for a single proponent manufacturing a cladding system using adhered manufactured concrete stone. The procedure maybe used to undertake a multiple-proponent assessment where the proponents claim that their cladding systems are sufficiently identical to be assessed as a generic product. However, the field performance assessment procedure shall include the following requirements:

1 Establishing System Similarity

To establish if the cladding systems can be assessed as a generic product, each cladding system shall undergo all the assessment steps in 'Task 1, Material Properties and Installation Procedures'. The consultant's report shall include a rationalized opinion on how identical the systems are and whether they can be assessed as a generic group.

Together, the consultant and CCMC shall decide as to how identical the systems are and, therefore, how large a sample is required for Task 2 and Task 3. The assessment of the information collected in Task 1 may result in smaller generic group assessment than that proposed by the proponents.

2 Conducting the Visual Survey

Where up to six proponents' systems are judged to be essentially identical, a sample of 30 buildings per geographic area will suffice. If some minor variability in base materials exists, a sample of 45 buildings per geographic area would be required.

Where both base materials and application procedures vary substantially between systems, each system will need to be assessed from a sample of 30 buildings per geographic area.

3 Conducting the Forensic Investigation

Where the systems of multiple proponents (up to six) are deemed identical, 8 buildings per geographic area shall suffice.

If some significant variability in performance of up to six proponents' systems is seen during the visual survey, 12 buildings per geographic area shall be required for the forensic investigation.

Where both base materials and application procedures vary substantially between systems, each system will need to be assessed forensically from a sample of 8 buildings.

Appendix B

Requirements for Cladding Systems Incorporating a Rainscreen with a Capillary Break.

(Based on changes to Part 9 in the 2005 edition of the NBC: Subsection 9.20.3 (Mortar), Subsection 9.27.1 (Application), 9.27.2 (Required protection from precipitation), 9.27.3 (Second plane of protection), 9.27.4 (Caulking), 9.28 (Stucco).

The requirements for cladding systems incorporating a rainscreen with a capillary break are based on changes to Part 9 in the 2005 edition of the NBC: Subsection 9.20.3 (Mortar), Subsection 9.27.1 (Application), 9.27.2 (Required protection from precipitation), 9.27.3 (Second plane of protection), 9.27.4 (Caulking), 9.28 (Stucco)

Exterior walls exposed to precipitation shall be protected against ingress of precipitation with an exterior cladding assembly consisting of a first plane of protection and a second plane of protection where the wall encloses spaces of residential occupancy, or spaces that directly serve spaces of residential occupancy.

A capillary break shall be provided between the first and second plane of protection, in exterior walls exposed to precipitation where
(a) the number of degree-days is less than 3400 and the moisture index is greater than 0.90, or
(b) the number of degree-days is 3400 or more, and the moisture index is greater than 1.00.

A capillary break shall be formed by a clear air space not less than 10 mm in depth between the cladding and the sheathing for the full height and width of the cladding.

The clear air space may be interrupted by
(a) penetrations for windows, doors and services
(b) flashing
(c) furring (strapping) provided the furring does not comprise more than 20% of the furred area.

Where a construction projects over the top of the clear air space, the air space shall not be contiguous with concealed spaces in the projecting construction.

The second plane of protection shall consist of a drainage plane with appropriate inner boundary and flashing to redirect rainwater to the exterior. The protection provided by the second plane shall be maintained at wall penetrations created by the installation of components and services such as windows, doors, ventilation ducts, piping, wiring and electrical outlets, and at the interface with other wall assemblies.