Performance evaluation of proprietary drainage components and sheathing membranes when subjected to climate loads, task 1: wall assembly specifications

Armstrong, Marianne; Di Lenardo, Bruno

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Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads

Task 1 — Wall Assembly Specifications

Marianne Armstrong and Bruno Di Lenardo

30 June, 2015

National Research Council Canada
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Canada

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Roxul Incorporated

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Summary

A benchmark assembly and a series of ten client wall assemblies were developed as part of the project "Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads".

The purpose of this project was to assess the performance of wall drainage components and sheathing membranes (drainage system) in their ability to provide sufficient drainage and drying in Canadian climates with a moisture index (MI) greater than 0.9 and less than 3400 degree-days, or MI greater than 1.0 and degree days ≥ 3400 (primarily coastal areas). In these regions, the 2010 National Building Code requires a capillary break behind all Part 9 claddings. Currently, acceptable solutions* to the NBC capillary break requirement include:

(a) A drained and vented air space not less than 10 mm deep behind the cladding;

(b) An open drainage material, not less than 10 mm thick and with a cross-sectional area that is not less than 80% open, behind the cladding;

(c) A cladding loosely fastened, with an open cross section (i.e. vinyl, aluminum siding)

(d) A masonry cavity wall or masonry veneer constructed according to Section 9.20 (i.e. 25 mm vented air space)

In this project, the performance of proposed alternative solutions for the capillary break was compared through laboratory evaluation and modeling activities to the performance of a wall built to minimum[1] code requirements. The proposed drainage system would be deemed an alternative solution to the capillary break requirement in the National Building Code for use with all code compliant Part 9 claddings provided it exhibits adequate moisture performance as compared to a NBC-compliant benchmark wall assembly.

In This Report — A detailed description is provided of assembly specifications, in which horizontal and vertical cross sections are given for each wall assembly, and includes tables highlighting the differences between the client assemblies and the benchmark wall.

The specifications here-in form the basis for assessing whether the various drainage solutions provided sufficient capability for drainage and drying of wall assemblies in Canadian climates.

* cf. Note 1 in main text

Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 1 – Wall Assembly Specifications

Authored by:

Marianne Armstrong and Bruno Di Lenardo

A Report for the

AIR BARRIER ASSOCIATION OF AMERICA (ABAA)

1600 BOSTON-PROVIDENCE Highway
WAYPOLE, MA 02081
USA

ATT: Mr. Laverne Dalgleish

National Research Council Canada
Ottawa ON K1A 0R6 Canada

30 June, 2015

Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 1 – Wall Assembly Specifications

Final Report Task 1

Marianne Armstrong and Bruno Di Lenardo

1. Background and Introduction

A benchmark assembly and a series of ten client wall assemblies were developed as part of the project "Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads".

The purpose of this project was to assess the performance of wall drainage components and sheathing membranes, that comprise the second plane of protection, in their ability to provide sufficient resistance to the permeation of water at the inner boundary, and drainage and drying of assemblies subjected to Canadian climates with a moisture index (MI) greater than 0.9 and less than 3400degree-days, or MI greater than 1.0 and degree days $\geq$ 3400 (primarily coastal areas). In these regions, the 2010 National Building Code requires a capillary break behind all Part 9 claddings (as described in Table 1). Currently, acceptable solutions to the NBC[1] capillary break requirement include:

(a) A drained and vented air space not less than 10 mm deep behind the cladding;

(b) An open drainage material, not less than 10 mm thick and with a cross-sectional area that is not less than 80% open, behind the cladding;

(c) A cladding loosely fastened, with an open cross section (i.e. vinyl, aluminum siding)

(d) A masonry cavity wall or masonry veneer constructed according to Section 9.20 (i.e. 25 mm vented air space)

In this project, the performance of proposed alternative solutions for the capillary break was compared through laboratory evaluation and modeling activities[2] to the performance of a wall built to minimum code requirements. The proposed drainage the system would be deemed an alternative solution to the capillary break requirement in the National Building Code for use with all code compliant Part 9 claddings provided it exhibits equal or better moisture performance as compared to a NBC-compliant benchmark wall assembly and adequate to ensure low risk of fungal growth on moisture susceptible materials.

[1] The NBC Part 9 prescribed 'acceptable solutions' are the minimum that must be respected for the local jurisdiction and respective geographical area, unless they are inadequate in meeting the performance statement of art. 9.27.2.1. as relates to minimizing and preventing moisture ingress and damage. In these cases, additional measures must be taken to ensure compliance with the NBC and thereby prevent the occurrence of an unacceptable risk for the growth of fungi on moisture-susceptible materials.

[2] A list of Project reports is provided in Appendix 1

Table 1 – 2010 National Building Code requirements for Capillary Breaks in Coastal areas (degree-days < 3400 and MI > 0.9, or degree days ≥ 3400 and MI > 1.0)

Coastal areas (degree-days < 3400 and MI>0.9, or degree days >= 3400 and MI>1.0)			
Sheathing	**Number of Sheathing Membranes**	**Capillary Break**	**Part 9 Claddings**
NO Sheathing	2	10-mm vented air space (80% open) or drainage material (80% open) or Alternative Solution	Lumber siding Wood shingles & shakes Fiber cement shingles and sheets(n/a) Plywood OSB and waferboard Hardboard Metal siding (horizontal or vertical) Vinyl siding (horizontal or vertical) Stucco
OSB/Plywood (Installed but not required)	1		
OSB/Plywood (Required and installed)	2		
OSB/Plywood	1 or, 2	25-mm vented air space	Masonry veneer

2. Terminology

In this document, the term *vented* is used to describe an opening at the base of the cladding, whereas *ventilated* refers to designed openings at the top and base of the cladding. Note that these terms refer only to the design detail of the opening, and do not infer any amount of air circulation or water drainage behind the cladding.

This document describes assemblies in terms of specifications, and does not include as-built conditions. For example – whereas a 10 mm cavity may be specified in the specification, in reality, the process of applying stucco may potentially force stucco or building paper into the cavity, thus resulting in a clear cavity of less than 10 mm. Specific details of as-built assemblies are available for the purpose of estimating the size of the drainage cavity for the respective drainage systems is given in §2.1.2 and §3.2 of the Task 5 report on the "Characterization of Water Entry, Retention and Drainage of Components".[1]

3. Code-Compliant Reference Wall Assembly

The Reference wall assemblies were developed based on minimum*[1] code requirements. Stucco cladding was chosen from among the Part 9 claddings (listed in Table 1), as the "worst case scenario" for water penetration. This selection was based on previous work at NRC on the moisture management for exterior wall systems [[3], [4]] that demonstrated that stucco resulted in the highest moisture load behind the First Plane of protection, due to its absorptive properties, and rain penetration at cracks.

[3] Beaulieu, P. et al. (2002), Final Report from Task 8 of MEWS Project (T8-03) - Hygrothermal Response of Exterior Wall Systems to Climate Loading: Methodology and Interpretation of Results for Stucco, EIFS, Masonry and Siding-Clad Wood-Frame Walls; Research Report, RR-118, NRC Institute for Research in Construction, 2002-11-01; 180 p.

Two alternative code compliant solutions for stucco installation were considered (see Figure 1):

- A solution predominantly practiced on the West Coast, is stucco application on an open welded wire metal lath with heavy paper-backing, designed to maintain a 10 mm clear cavity with 80% open between vertical furring strips;
- A solution predominantly practiced on the East Coast, with expanded metal lath (no paper backing) installed on 19 mm (3/4-in.) pressure-treated wood furring, also with 80% open.

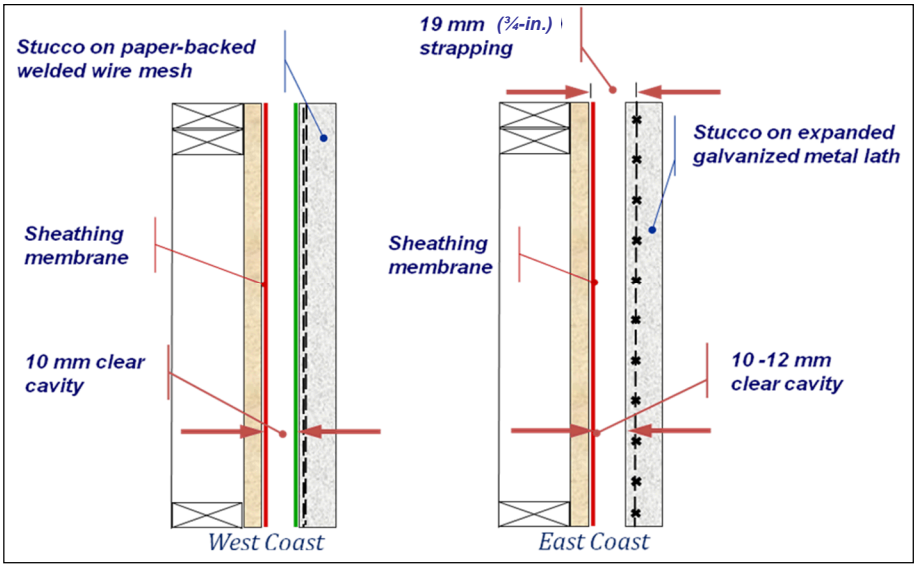

Figure 1 – West and East coast solutions for stucco installation with capillary break

The East Coast solution was selected as a reference assembly, and deemed to be the "worst case scenario" due to the possibility for stucco to pass through the expanded metal lath and into the drainage cavity during placement of stucco onto the lath. Unlike the West Coast solution, this East Coast wall has no layer of building paper behind the expanded metal lath as stucco does not readily pass through expanded-metal lath as compared with open wire mesh. Typically one would install building paper behind metal lath of stucco cladding to reduce the possibility of stucco compromising the capillary break of the drainage cavity of the wall assembly.

The West Coast solution incorporates an open, welded wire metal lath, the size of the openings being ca. 50 mm (2-in.) square and as such, necessarily requires a paper backing to ensure that the capillary break is not compromised in the manner described above. The welded wire metal lath is installed on pressure-treated wooden 10 mm (3/8-in.) furring strips.

The NBC additionally requires the wall to be vented and flashed at the bottom of the wall assembly which for NBC Part 9 buildings may be 3.5 storeys in height. Modeling activities took into account the performance of the full 3.5 storey assembly, including the effect of associated rain and wind loads.

A duct penetration detail is included in the assembly drawings. Experimental work in this project examines and quantifies the potential for water to enter at a deficiency in the sealant around a duct

[4] Beaulieu, P. et al. (2002), Report from Task 8 of MEWS Project - MEWS Methodology for Developing Moisture Management Strategies - Application to Stucco Clad Wood-Frame Walls in North America; Research Report, RR-112, NRC Institute for Research in Construction, 2002-10-01; 13 p.

penetration. This information was then used to determine realistic amounts of water to be introduced in the drainage and drying evaluation of the different assemblies.

Cross sectional views of the selected Reference wall assembly are presented in Figure 2 and Figure 3. Full details of the Reference wall assembly and components are provided in Table 2. The rationale behind the component selection, including relevant NBC requirements, is provided in the final column of the table.

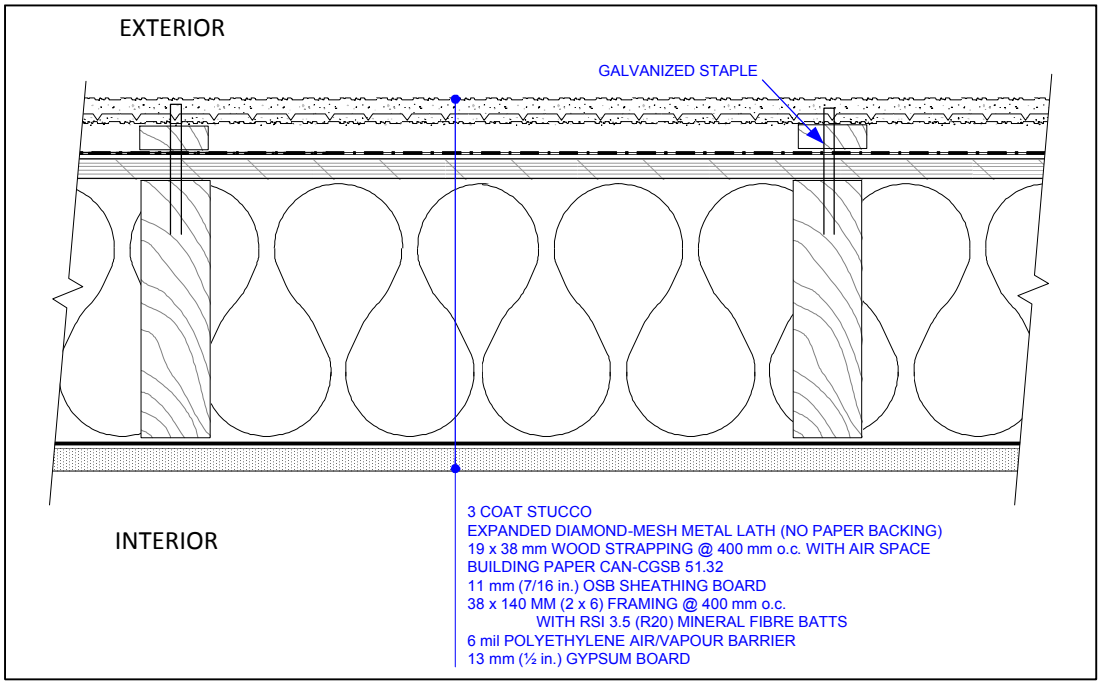

Figure 2 – Code-Compliant Reference wall horizontal cross section

***Specifications for West Coast wall assemblies under the jurisdiction of the HPO* [5, 6]**

Given the number of moisture-related issues that have arisen in wall assemblies over the years in the lower mainland of BC, the HPO and the city of Vancouver, through the Vancouver Building By-Law, have instituted their own prescriptive assembly specifications and good practice that go beyond those requirements for moisture management established for NBC-complaint reference wall assemblies as previously described.

Nominally, a stucco wall system conforming to HPO requirements includes a 10-mm clear cavity behind a semi-rigid asphalt board, with one (1) sheathing membrane, as the designated second plane of protection [5]. In certain instances, the installation of 2 sheathing membranes is considered good practice and this may become the standard practice by HPO.

In addition, should the structural design of the wall system require that shrinkage of the wood be accommodated in the design, then the wall assemblies may require flashing at the rim joist location of every storey [6]. As a consequence, the second plane of the protection would be "ventilated" at each storey.

In addition, the HPO and the "Authority Having Jurisdiction" require an accredited Building Envelope Specialist to review the design for projects.

[5] HPO (2007), Building Envelope Systems; Stucco Siding (Section 2), in: Building Envelope Guide for Houses, Home Protection Office, BC.

[6] HPO (2011), Frame Shrinkage; Rim Joist (Detail 4); in: Building Enclosure Design Guide for Wood Frame Multi-unit Residential Buildings, Home Protection Office, BC.

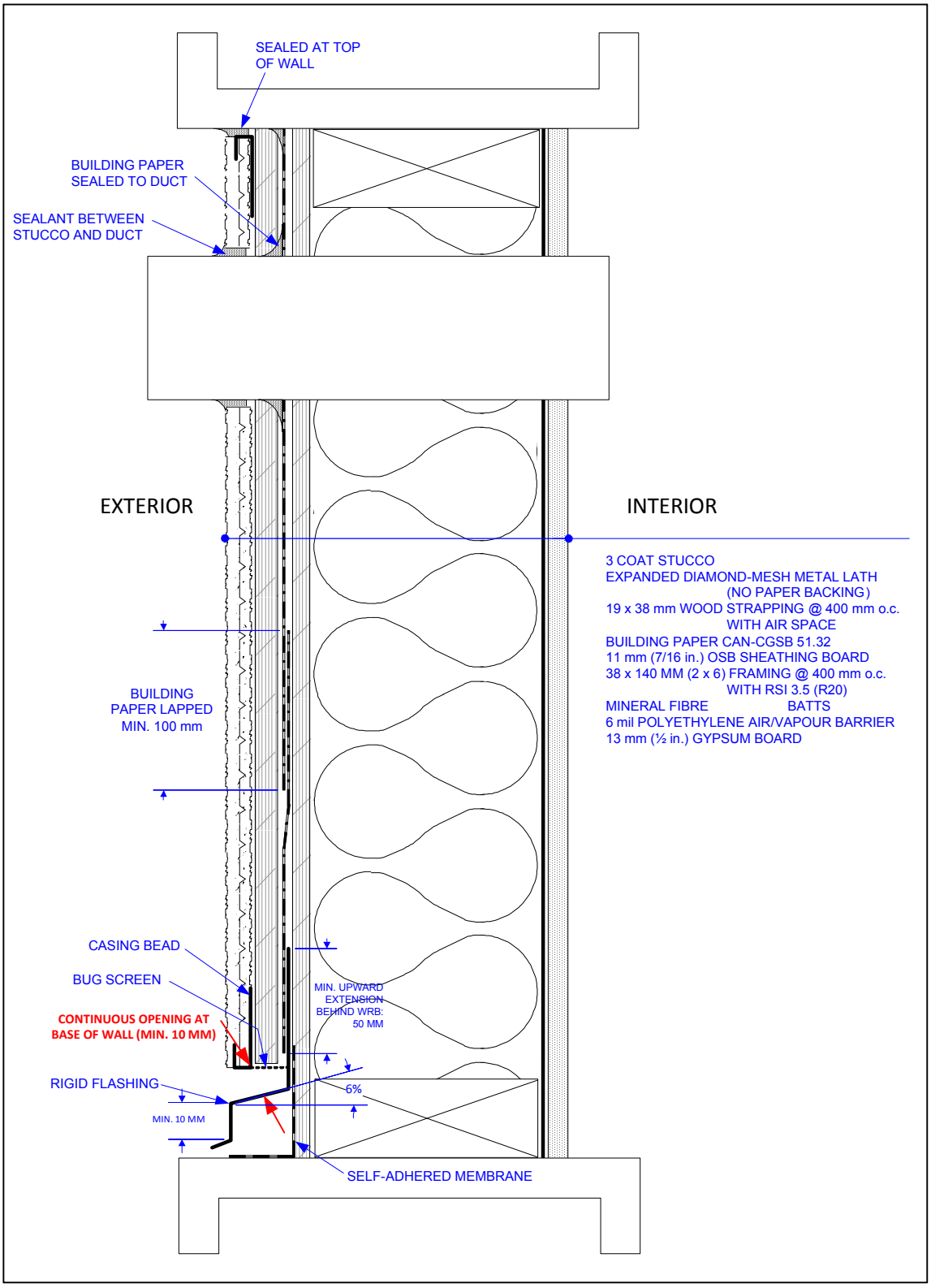

Figure 3 – Code-Compliant Reference wall vertical cross section

Table 2 – Code-Compliant Reference Wall Component Description with Associated Rationale and NBC Requirements

	Item	Description	Thickness	Rationale/Relevant National Building Code Requirements
1	**Interior wall finish**			9.29.
	a) Material	Gypsum Board	12.7 mm	9.29.5.2(1) Conforming to CAN/CSA-A82.27-M
	b) Fastening	Drywall screws 400 mm o.c.		9.29.5.9.(3b)
	c) Paint	Latex paint, Latex primer		Standard practice
2	**Air/vapour barrier**			9.25.3.
	a) Material	Polyethylene	0.15 mm	9.25.3.2.(2) and 9.25.4.2.(4) Complying with CAN/CGSB-51.34-M
	b) Installation	Continuous with all joints sealed with acoustical caulking or lapped >100 mm and clamped		9.25.3.3.(2)
3	**Framing**			
	a) Material	38 x 140 mm (2x6) SPF s-dry wood framing	140 mm	Standard practice
	b) Spacing	Studs @ 400 mm o.c.		9.23.10. and 9.29.5.3.(1)
	c) Plates	Double top plate Single bottom plate		9.23.11.3.(3) 9.23.11.2.(1)
4	**Insulation**			
	a) Material	RSI 3.5 (R20) glass fibre installed to fill stud spaces	140 mm	9.25.2. Complying with CAN/ULC S702
5	**Sheathing**			9.23.16.
	a. Material	CSA O437 OSB O1, or CSA O325 min. 11 mm (7/16 in.), exterior bond	11 mm	9.23.16.2. 9.25.1.2.(3) low-vapour permeance exemption for up to 12.4 mm OSB
	b. Installation	2 mm gap between panels		9.23.16.5.
	c. Fastening	fastened with 51 mm (2"/6d) common or spiral nails - 150 mm o.c. along edges - 300 mm o.c. on int. supports - 3/8 in. from edge		9.23.3.5.
6	**Sheathing Membrane**			9.27.3.
	a) Material	1 x asphalt-impregnated building paper complying with CAN/CGSB-51.32-M	0.2 mm	9.27.3.2.
	b) Installation	Installed (nailed or stapled) horizontally Joints lapped by min. 100mm Shingled (top sheet overlapping bottom sheet)		9.27.3.3.

	Item	Description	Thickness	Rationale/Relevant National Building Code Requirements
7	**Drainage Layer**			9.27.2.2.
	a) Material	19 x 38 mm wood strapping	19 mm	9.27.2.2.
	b) Installation	Fastened to framing @ 400 mm o.c.		9.27.5.3.(3)
8	**Cladding**			
	a) Material	Stucco: Portland/Masonry Cement mix 1:1 with 3.25 parts per part of cementitious material, max. 6% pigment	3 coat: 6 mm 6 mm 3 mm	9.28.2. CAN/CSA-A3001 9.28.5.1. 9.28.5.2.
	b) Lath	Expanded diamond-mesh metal lath, no paper backing		9.28.4.1.
	c) Lath Fastening	Fastened to framing through strapping with corrosion-resistant staples, 1.98 mm thick, 50 mm long (to penetrate min. 25 mm into framing members) 150 mm o.c. vertically 400 mm o.c. horizontally		9.28.3. 9.28.4.6.(2)
	d) Installation	3-coat application: - First coat: min. 6 mm from face of lath - Second coat: min 6 mm - finish coat: Cementitious, min 3 mm 24 hours between application 28 day curing period before testing		9.28.6.

4. Client Wall Assemblies

Client assembly designs were based on consultations between the individual clients and NRC Construction that took place from May 2011 to November 2012. A series of wall test specimens were to built based on these designs in 2013.

This section describes each of the ten client wall assemblies. A list of wall assemblies and their respective characteristic drainage component is provided in Table 3. For each wall assembly, cross sectional diagrams are provided together with a table describing the elements that are different from the benchmark assembly.

The order in which the wall assemblies are presented is random. The order of construction was determined by NRC Construction to facilitate the evaluation process (from those deemed simplest to the most complex assembly). A summary table comparing all assemblies is provided in Section 5.

All client walls featured the same stucco cladding as the benchmark wall. This cladding was chosen as a "worst case scenario". Thus, if the drainage element of the assembly demonstrates the ability to manage the water loads introduced by the stucco cladding, it will be deemed an acceptable drainage solution suitable for use with all code compliant claddings, as listed in Table 1.

Table 3 – List of Wall Assemblies and Respective Characteristic Drainage Component

Designations	Description of Drainage Component	Description of component tested for hygrothermal properties
Code-compliant Reference wall	Air space created by 19 mm plywood strapping; on NBC Code-compliant building paper*	NBC Code-compliant stucco
Client A Wall	Code compliant building paper* / Drainable SBPO** sheathing membrane	Drainable SBPO sheathing membrane
Client B Wall	10 mm air space / Water repellent insulation board (76 mm) / liquid applied membrane	Water repellent insulation board
Client C Wall	Code compliant building paper* / Nylon mesh (10 mm; open matrix) / PP† nonwoven sheathing membrane	Nylon mesh (10 mm; open matrix) bonded to PP nonwoven sheathing membrane
Client D Wall	Code compliant building paper* / Cross woven, micro-perforated polyolefin sheathing membrane with polyolefin coating	Cross woven, micro-perforated polyolefin sheathing membrane with polyolefin coating
Client E Wall	PP† fabric (stucco screen) / Dimpled HDPE‡ (11 mm) membrane / Code compliant building paper*	PP† fabric bonded to dimpled HDPE‡ membrane
Client F Wall	Air space created by 25 mm plywood strapping; on NBC Code-compliant building paper*	Nil (nominal 25 mm air space)
Client G Wall	Non-woven PP† fabric (stucco screen) / PP† mat (10 mm; 3-dimensional extruded PP mono-filament mesh) / Code compliant building paper*	Non-woven PP† fabric (stucco screen) / PP† mat (10 mm; 3-dimensional extruded PP mono-filament mesh)
Client H Wall	Porous PS†† insulation board (52 mm) / liquid applied membrane	Porous PS†† insulation board (52 mm)
Client I Wall	2 ply, corrugated asphalt impregnated paper*; Grade D!! (4.2 mm) / Code compliant building paper*	2 ply, corrugated asphalt impregnated paper* - Grade D!!
Client J Wall	Building paper; Grade D!!; 60 Minute / Air space created by 9.5 mm plywood strapping / 2 layers of Code compliant building paper*	Three coat stucco with paper backed welded-wire mesh lath
Client K Wall	Building paper, Grade D!!; 60 Minute / Air space created by 9.5 mm plywood strapping / 2 layers of Code compliant building paper*	Three coat stucco with paper backed welded wire metal lath

* Conforming to CGSB standard CAN2-51.32-M77; ** SBPO – Spun bonded polyolefin; † PP - polypropylene; ‡ HDPE – high density polyethylene; †† PS – polystyrene; !! Conforming to US Federal Specification UU-B-790a (Type I - Barrier paper; Grade D Water-vapor permeable; Style 2 - Uncreped, not reinforced, saturated)

Client A Wall Assembly Details

The Client A assembly features a thin polymer based drainage membrane that is crimpled, acting both as the drainage medium and as the sheathing membrane. This layer is separated from the stucco cladding by a layer of building paper (i.e. industry standard paper-backed lath meeting CAN-CGSB 51.32). All other elements of the assembly are identical to the benchmark wall. The Client A wall is vented and flashed at the bottom of the wall every 3.5 storeys.

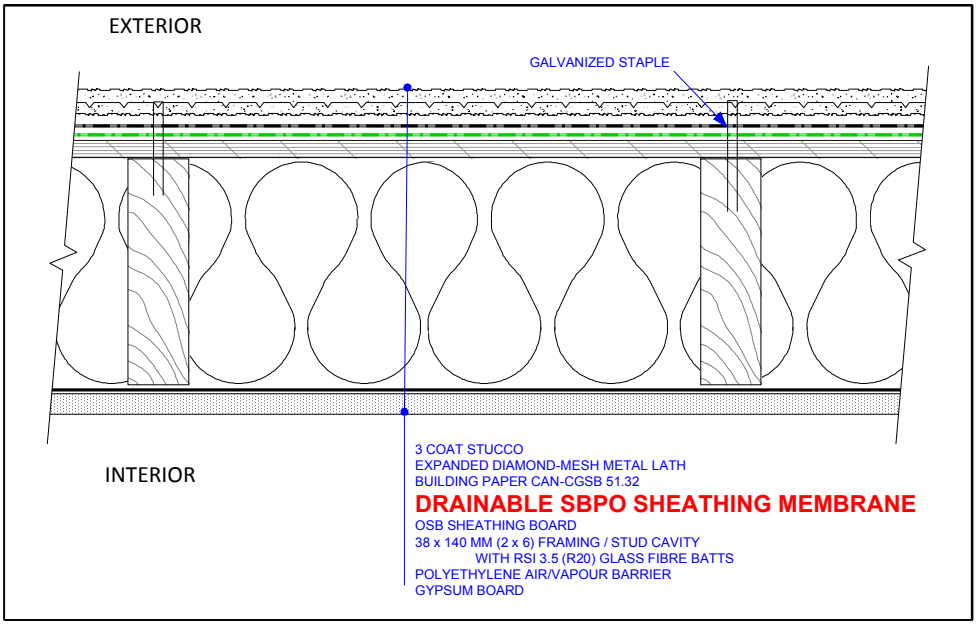

Figure 4 – Client A Wall horizontal cross section

Table 4 – Client A Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Drainage Layer / Sheathing membrane**		
	a) Material	Drainable SBPO sheathing membrane	0.62 mm
	b) Installation	• Install with drainage wrinkles vertical, going up and down • Joints lapped by min. 6 in. Shingled (top sheet overlapping bottom sheet) • Secure to the stud, fasteners should be spaced 6-18 in. on vertical and horizontal stud lines. • Use one or more of proprietary fasteners below for use with the sheathing membrane: • Proprietary cap nails • Proprietary cap screws • Proprietary cap staples • 1.0 inch minimum crown staples • Tape seams with three inch (3”) Proprietary Tape	

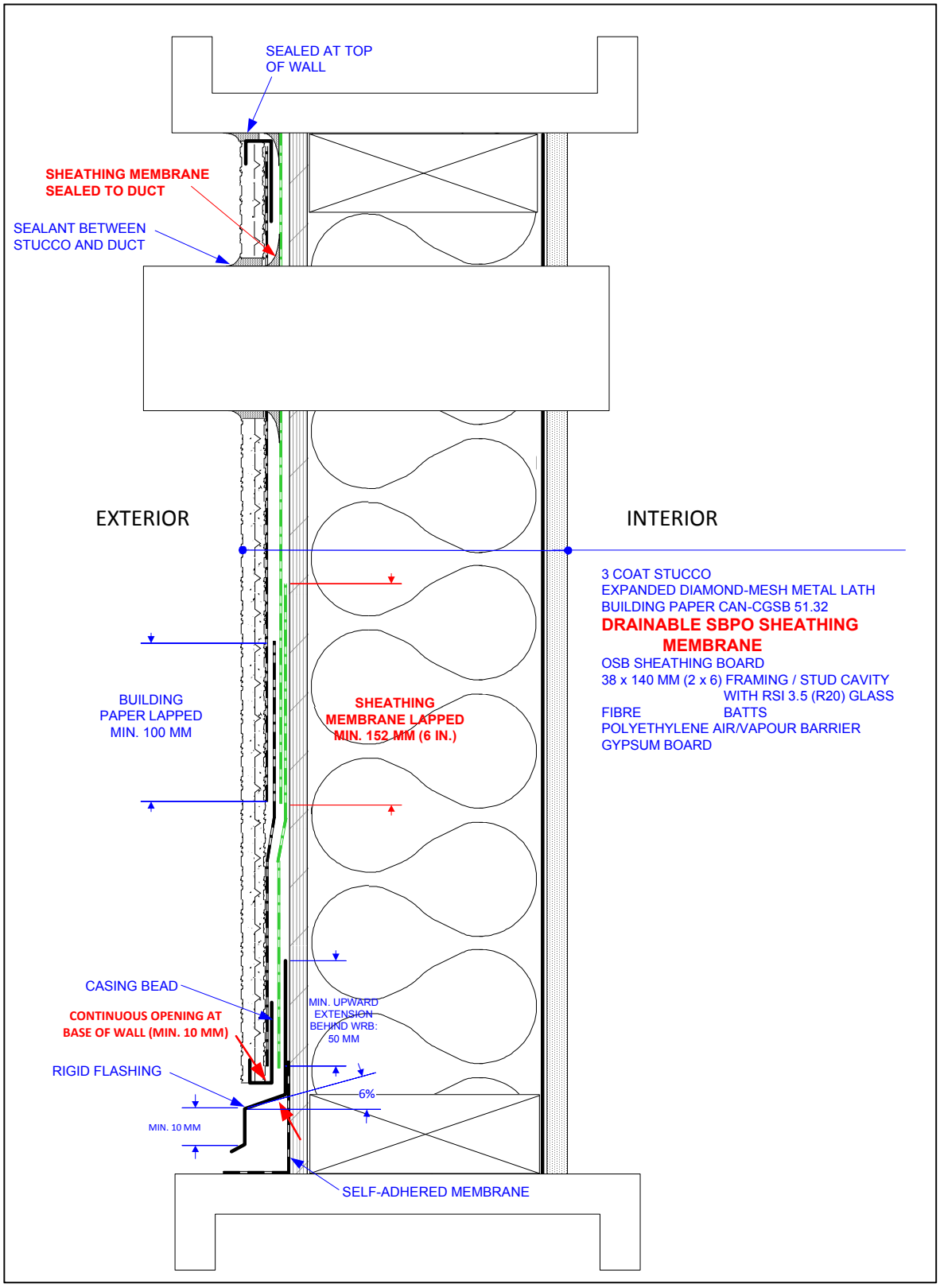

Figure 5 – Client A Wall vertical cross section

Client B Wall Assembly Details

The Client B assembly is the only non-combustible wall assembly in the set of ten client walls. This wall features a number of elements that differentiate it from the benchmark wall, including two proprietary elements: the water repellent insulation board and the liquid applied membrane[7]. Because of the exterior gypsum board and the steel stud framing, the mode of failure for this wall will differ from the residential wood-frame walls. For wood-frame walls with OSB sheathing, the mode of failure is potential mold growth on wood components (due to high moisture content in the OSB and framing). For the commercial assembly, the mode of failure is the potential of corrosion of metal components. The Client B wall is vented and flashed at the bottom of the wall every 3.5 storeys.

In identical fashion to the benchmark wall, the Client B Wall features stucco applied to expanded metal lath (no paper backing) on 19 mm strapping.

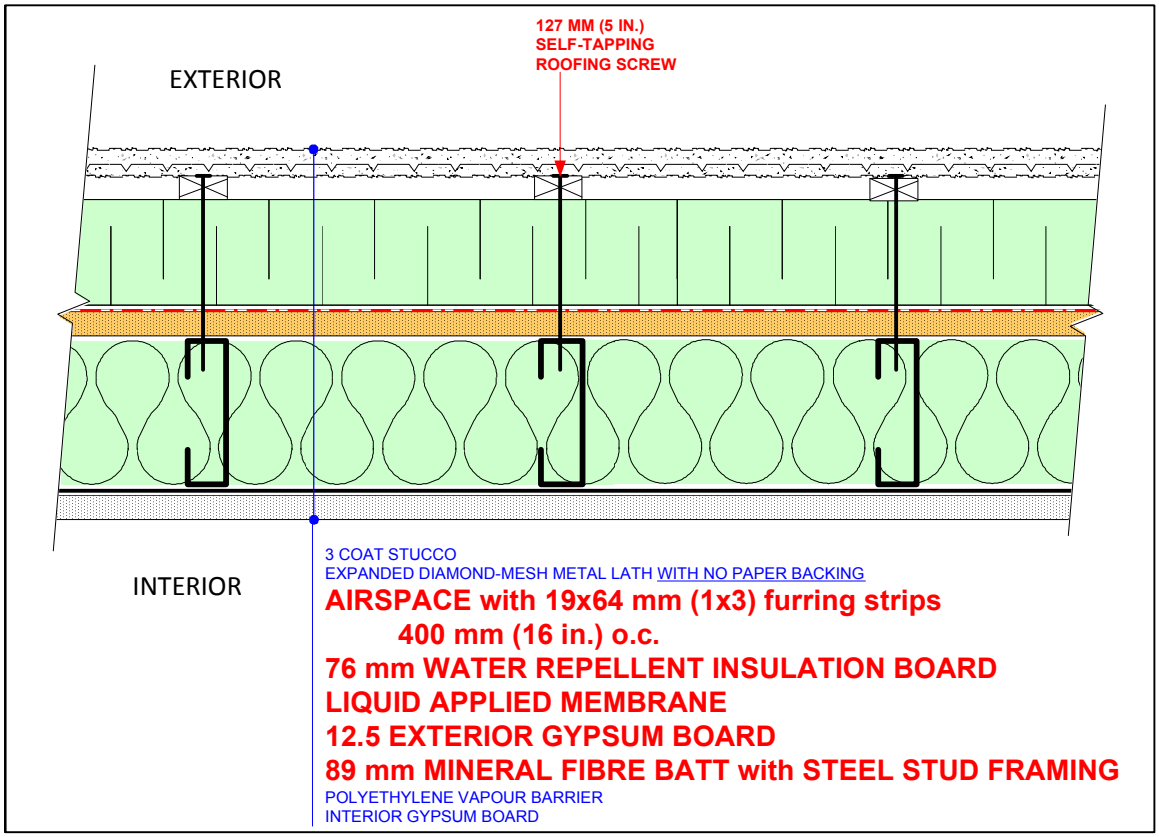

Figure 6 – Client B Wall horizontal cross section

[7] **Note:** if the water vapor permeance of the exterior sheathing with coating is below 60 ng, then the amount of insulation must comply with NBC Table 9.25.5.2. for the respective heating degree days of building location.

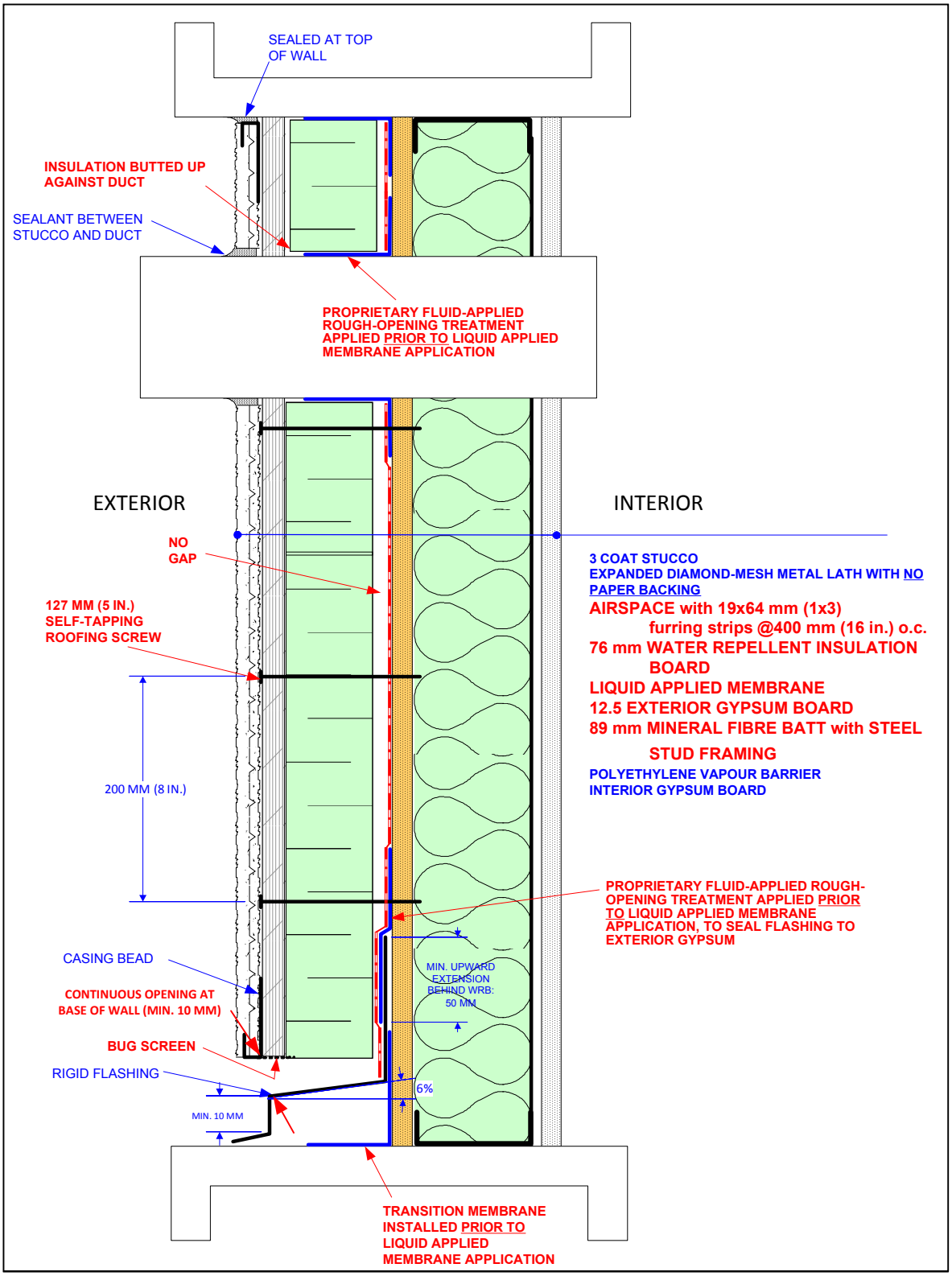

Figure 7 – Client B Wall vertical cross section

Table 5 – Client B Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Framing**		
	a) Material	30 x 91 (gauge 20) steel stud	91 mm
	b) Spacing	Studs @ 400 mm o.c.	
	c) Runners	Top and bottom	
2	**Insulation**		
	a) Material	Mineral wool batt insulation	89 mm
3	**Sheathing**		
	a) Material	Exterior gypsum board	12.7 mm
	b) Installation	2 mm gap between panels	
	c) Fastening	- Fastened with screws spaced 200 mm (8 in.) o.c. at perimeter and 200 mm (8 in.) o.c. along intermediate framing - Fasteners drive to bear tight against and flush with the surface of the sheathing, not countersunk. - Fasteners located a minimum of 3/8 in. from edges and ends of sheathing panels	
4	**Air/Vapour Retarder**		
	a) Material	Liquid applied membrane	0.152 mm
	b) Installation	As per manufacturer specifications	
5	**Rainscreen Insulation**		
	a) Material	Water Repellent Insulation Board	70 mm
	b) Installation	Installed with batts horizontal. Held in place by vertical 19 x 64 mm (1x3) wood furring strips	
	c) Fastening	5 in. self-tapping roofing screws, fastened every 200 mm (8 in.) vertically	
6	**Vapour barrier**		
	a) Material	Polyethylene	0.15 mm
	b) Installation	Not continuous or sealed	

Client C Wall Assembly Details

The Client C assembly features 10 mm, open matrix nylon mesh bonded to a PP nonwoven sheathing membrane. The mesh is separated from the stucco cladding by a layer of building paper (meeting CAN-CGSB 51.32). All other elements of the assembly are identical to the benchmark wall. The Client C wall is vented and flashed at the bottom of the wall every 3.5 storeys.

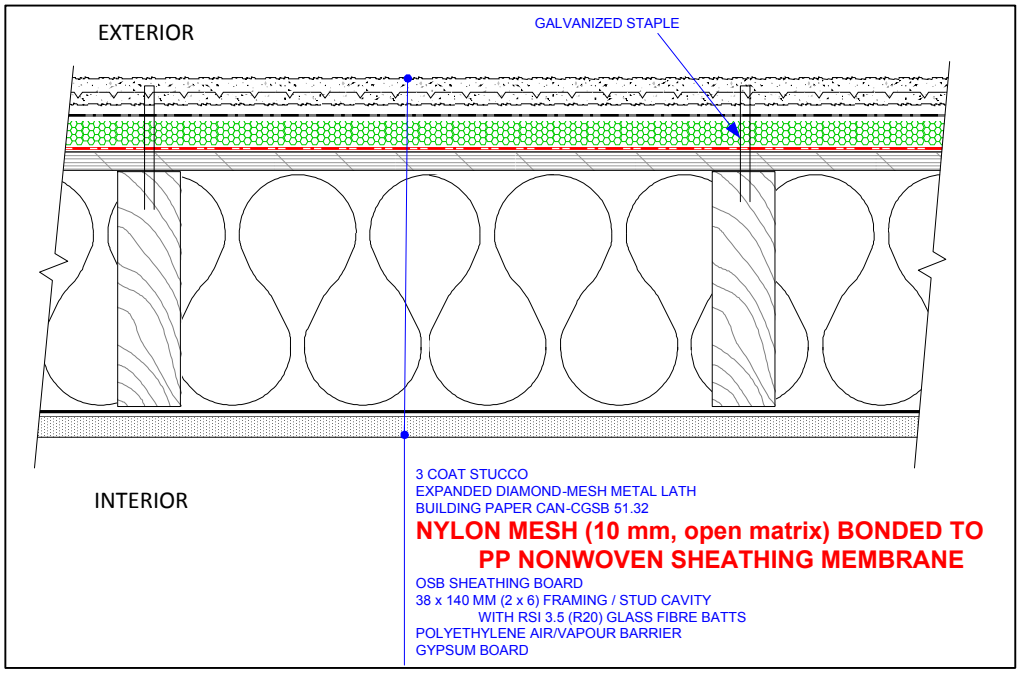

Figure 8 – Client C Wall horizontal cross section

Table 6 – Client C Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Drainage Layer / Sheathing membrane**		
	a) Material	Nylon mesh (nominal 10 mm, open matrix) bonded to PP nonwoven sheathing membrane	10.5 mm
	b) Installation	• Installed horizontally • Nailed or stapled (min. ½ in. staple) every 3 square feet • Sheathing membrane at horizontal joints lapped by min. 100 mm, with matting butted • Shingled (top sheet overlapping bottom sheet) • Vertical joints flashed underneath (by a piece of 12 inch wider WRB or flashing tape)	

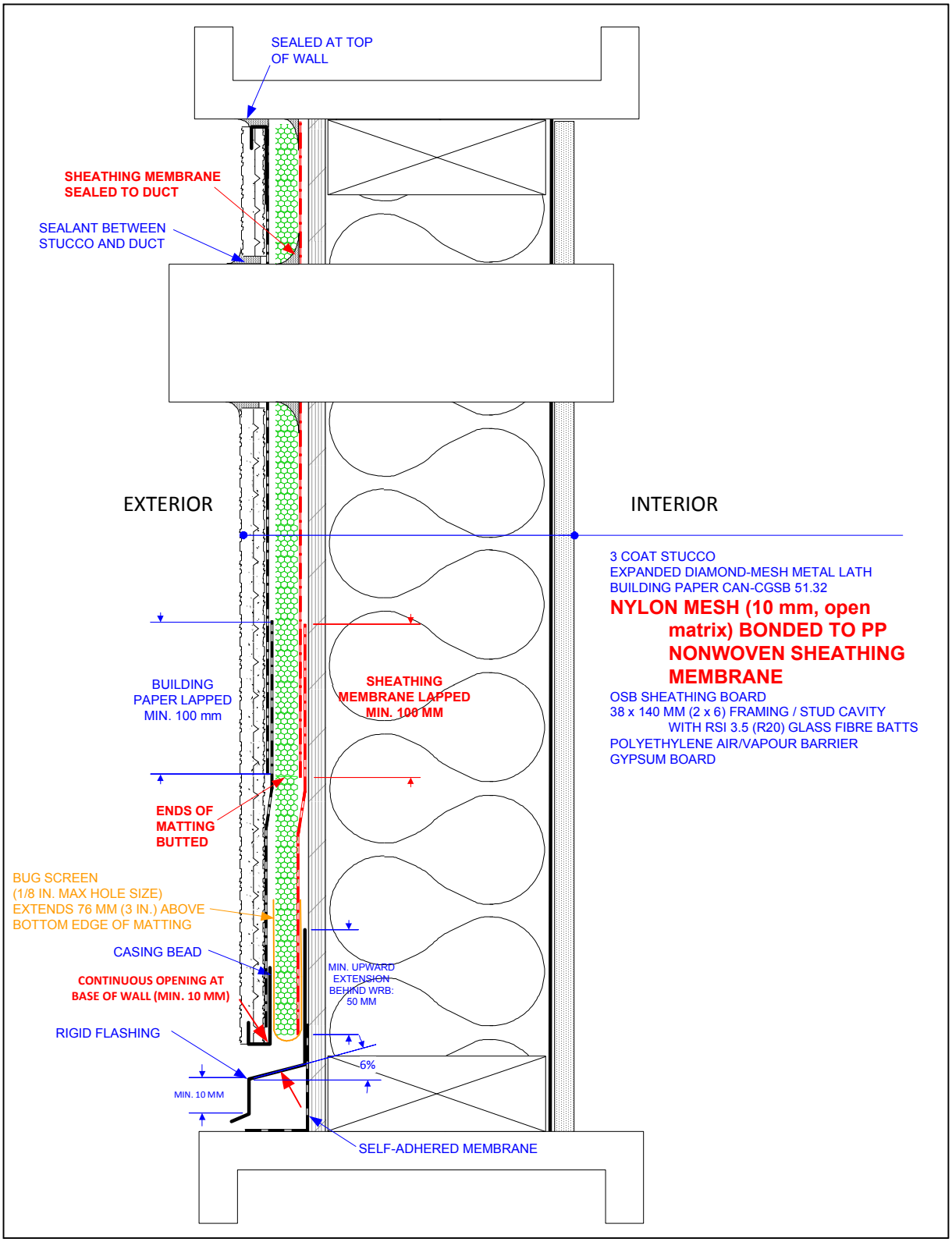

Figure 9 – Client C Wall vertical cross section

Client D Wall Assembly Details

The Client D assembly features a cross woven, micro-perforated polyolefin sheathing membrane with polyolefin coating, acting both as the drainage layer and as the sheathing membrane. The membrane is separated from the stucco cladding by a layer of building paper (meeting CAN-CGSB 51.32) (i.e. paper-backed lath). All other elements of the assembly are identical to the benchmark wall. The Client D wall is vented and flashed at the bottom of the wall every 3.5 storeys.

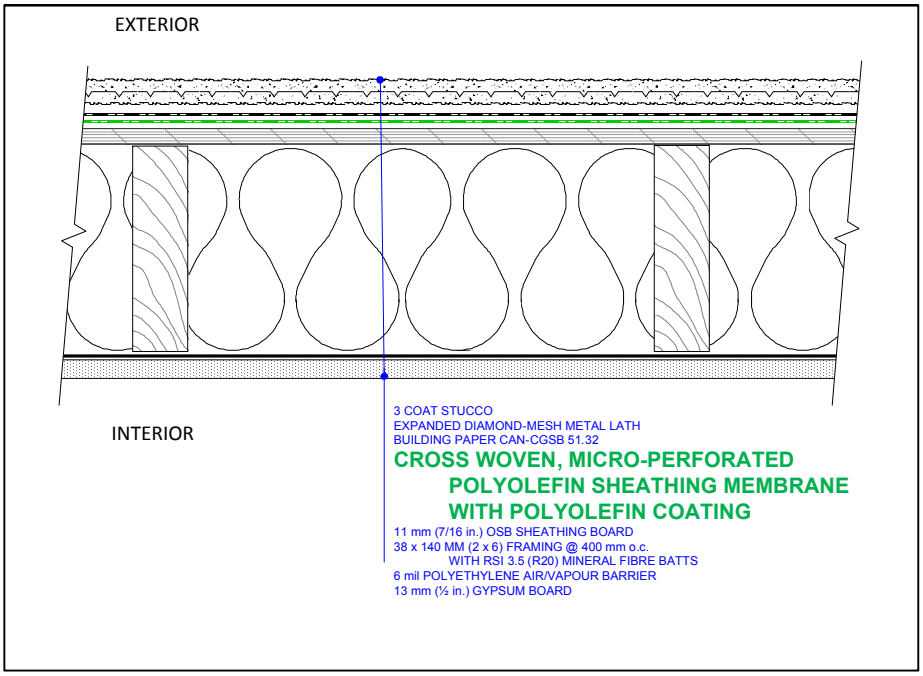

Figure 10 – Client D Wall horizontal cross section

Table 7 – Client D Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Drainage Layer / Sheathing membrane**		
	a) Material	cross woven, micro-perforated polyolefin sheathing membrane with polyolefin coating	0.76 mm (0.03 in.)
	b) Installation	• Installed horizontally, printed side facing out • Fasteners penetrate studs a minimum of 13 mm (1/2 in.), spaced every 406 mm (16 in.) along every other stud location • Vertical and horizontal seams overlapped a minimum of 152 mm (6 in.) vertically, and 50 mm (2 in.) horizontally • Singled (top sheet overlapping bottom sheet) • Seams sealed with proprietary contractor tape	

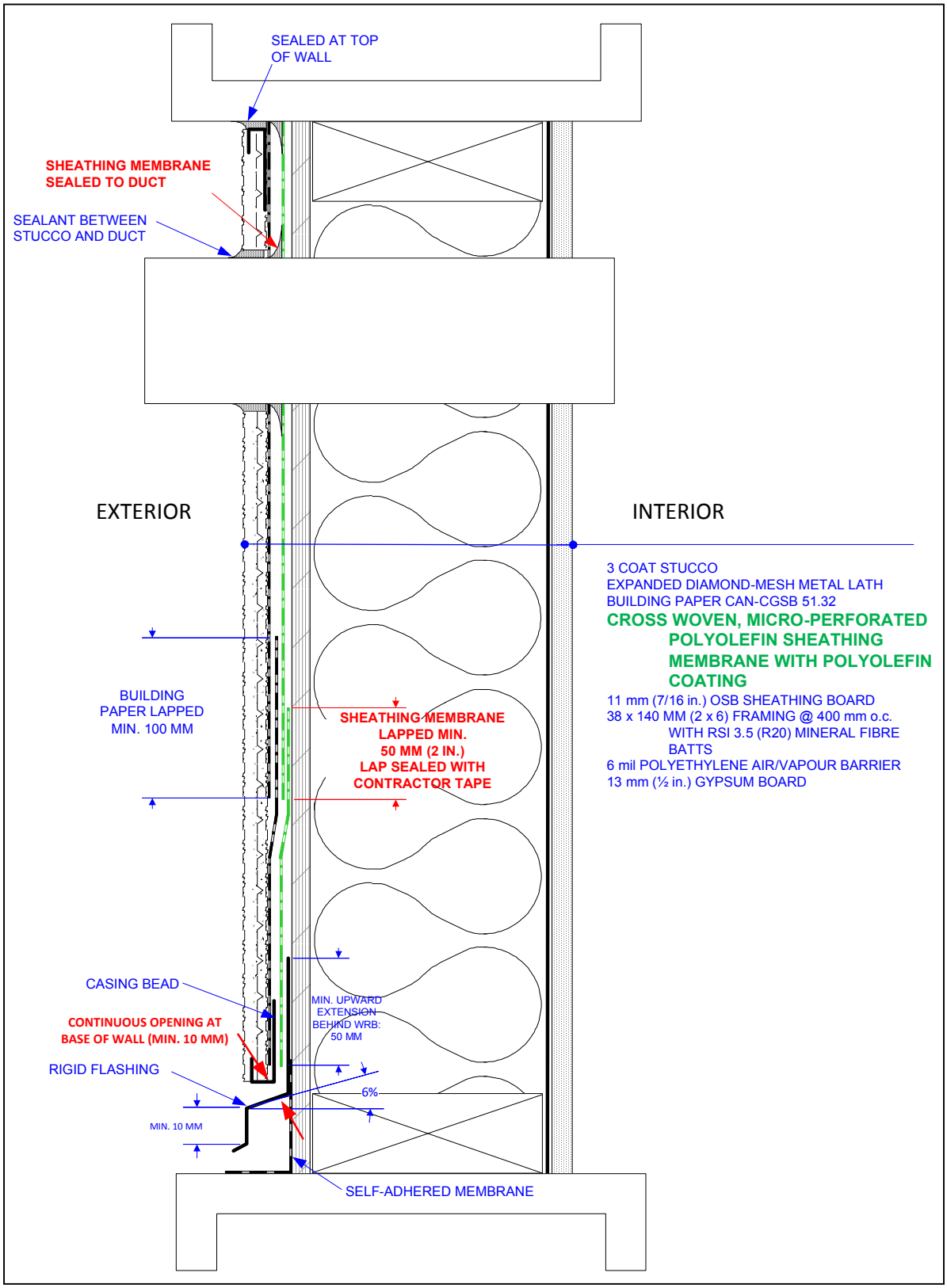

Figure 11 – Client D Wall vertical cross section

Client E Wall Assembly Details

The Client E assembly features a dimpled HDPE membrane that includes a stucco screen (a layer of PP fabric) to help keep stucco out of the drainage layer. This product acts as a drainage medium, and not as a sheathing membrane to protect the wood based sheathing. This dimpled membrane is a low-permeance material and the NBC requires that it be installed outboard of a 10-mm airspace from the exterior sheathing to meet condensation control requirements. The function of the sheathing membrane is performed by a layer of building paper (meeting CAN-CGSB 51.32) on the face of the OSB sheathing board. By using the code minimum required building paper, if adequate performance is demonstrated, the drainage product will be an acceptable solution for use with all code compliant sheathing membranes. All other elements of the assembly are identical to the benchmark wall. The Client E wall has two potential ventilation strategies: Option 1: vented and flashed at the bottom of the wall every 3.5 storeys (as per the benchmark specification), or Option 2: ventilated at the top and bottom of the wall every 2 storeys (as per the manufacturer's installation recommendations).

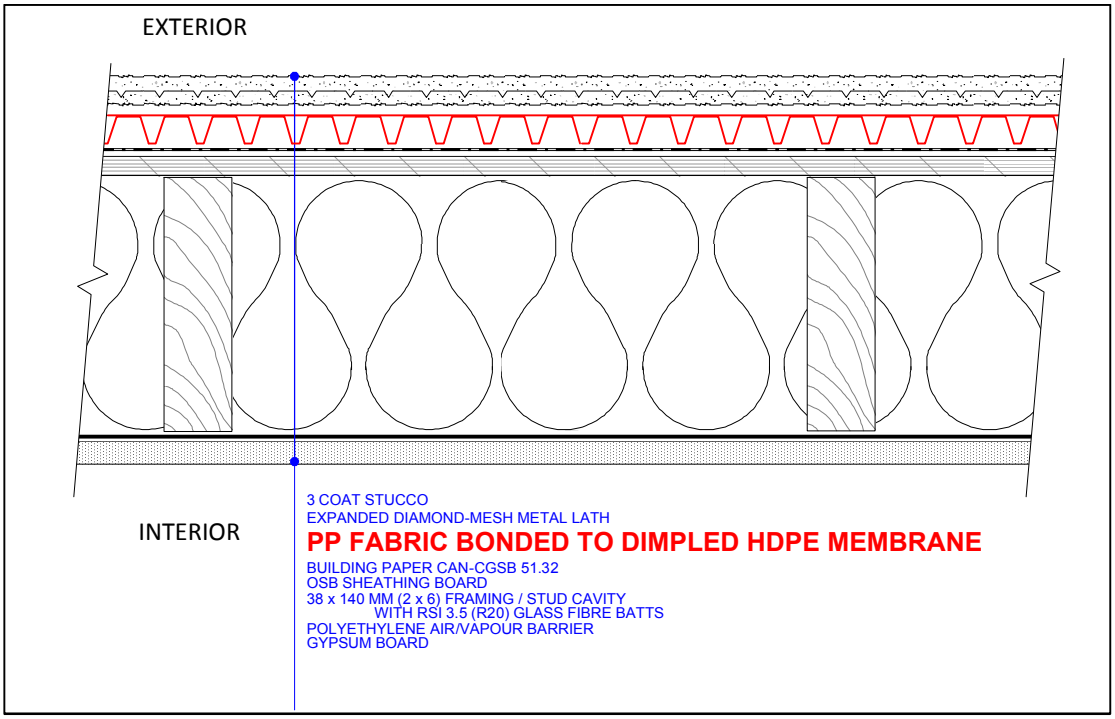

Figure 12 – Client E Wall horizontal cross section

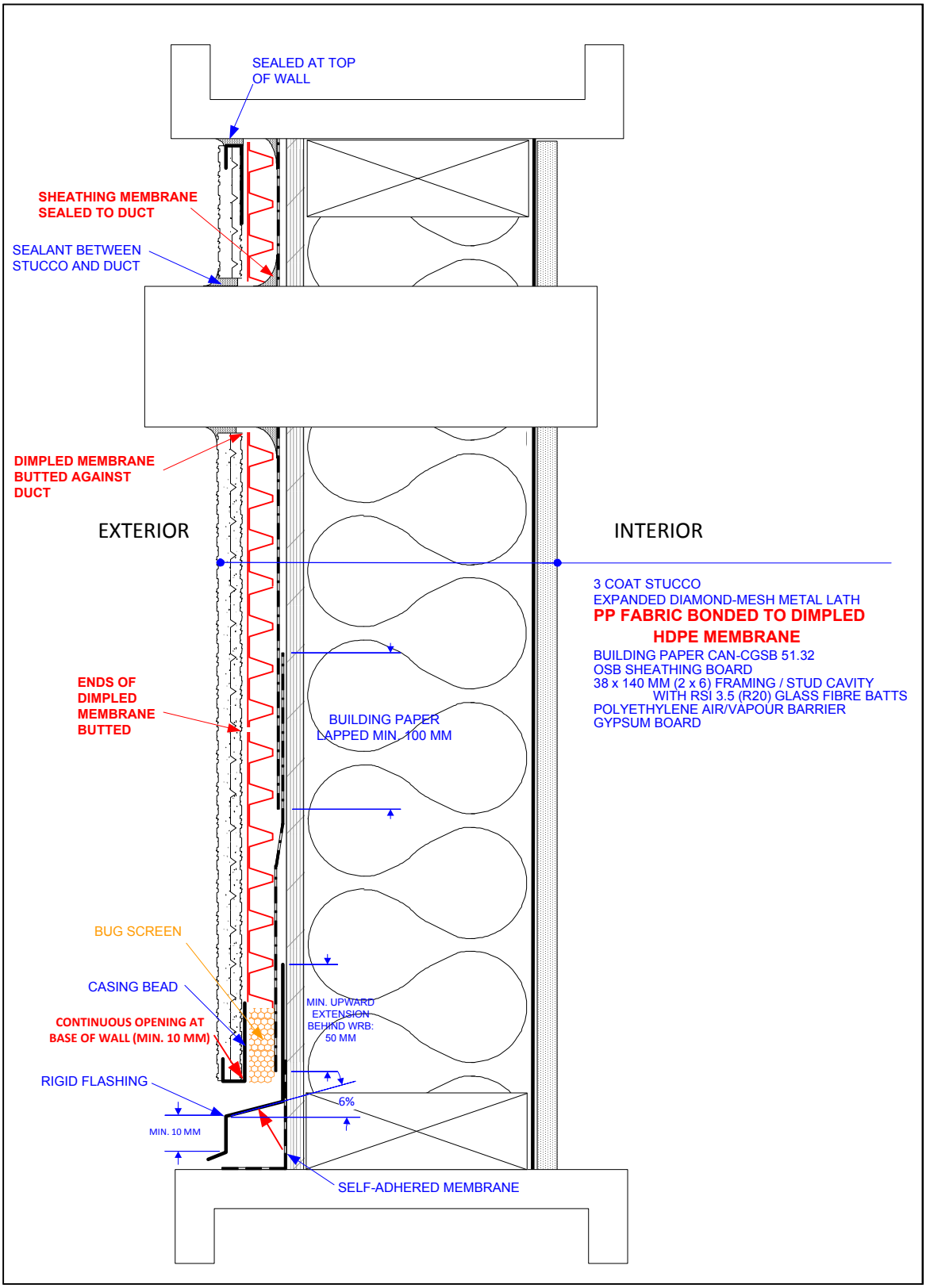

Figure 13 – Client E Wall vertical cross section Option 1 – Vented detail

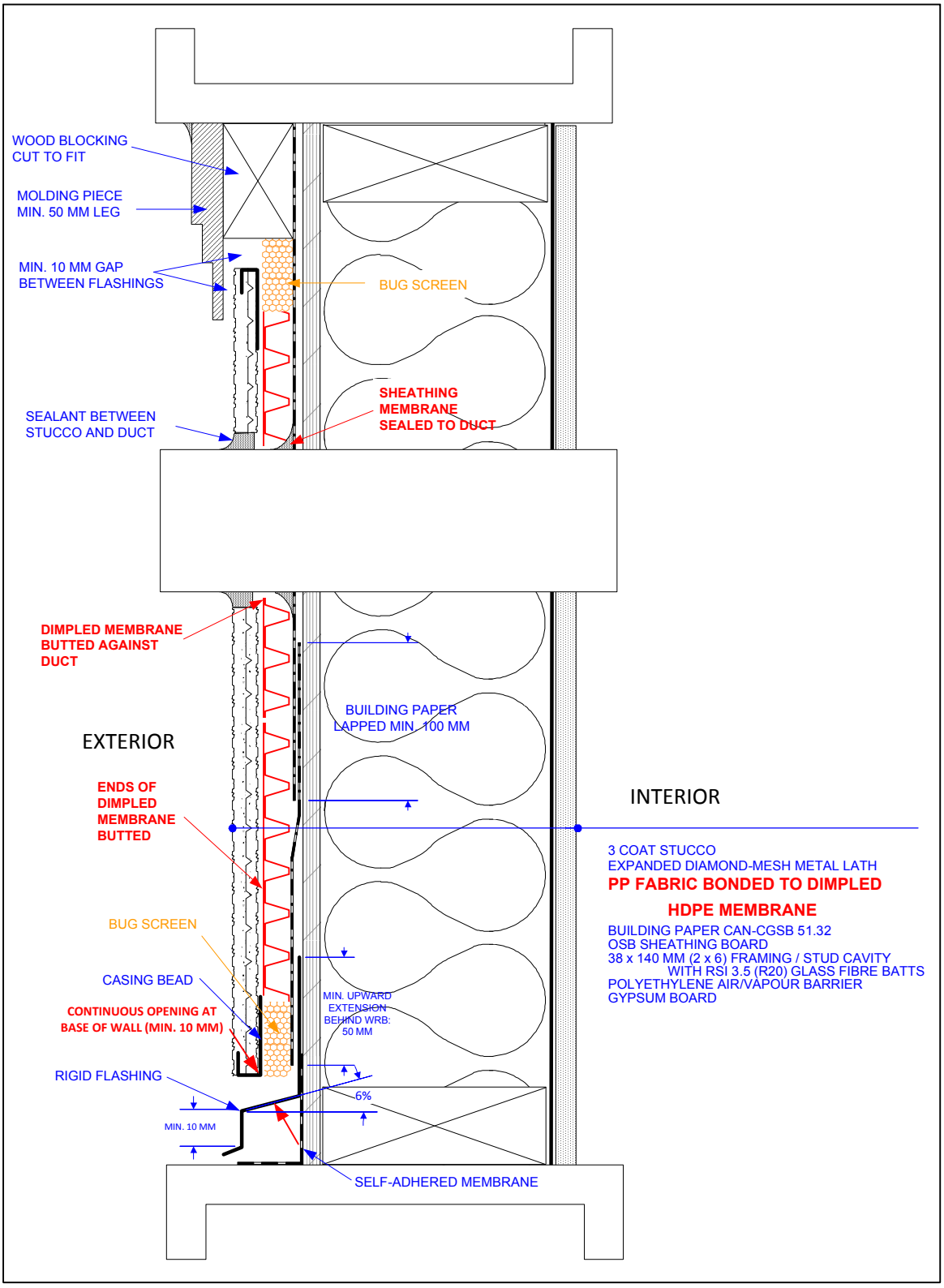

Figure 14 – Client E Wall vertical cross section Option 2 – Ventilated detail

Table 8 – Client E Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Drainage Layer**		
	a) Material	PP fabric bonded to dimpled HDPE membrane	10.6 mm
	b) Installation	Detail at base of wall • Flashing with drip edge installed at bottom of wall, building paper shingle laps over flashing • Bug screen fastened to the flashing, aligned with planned bottom termination of bottom edge of cladding Rainscreen installation • Installed horizontally with the mortar screen facing the exterior • Begin fastening in the middle of the membrane, fasten a maximum of every 600 mm (24 in.) horizontally, fasten to studs wherever possible • Butt ends together, do not overlap or interlock • Fasten end laps every 30 cm (12 in.) vertically, and side laps every 30 cm (12 in.) horizontally • Fasteners: 1-1 ¼ in. corrosion-resistant coil roofing nails	

Client F Wall Assembly Details

The Client F wall is already fully code compliant. The interest in evaluating this wall is to compare the performance of an airspace provided by 25 mm wood strapping to the benchmark stucco performance (with 18 mm strapping). The Client F wall is vented and flashed at the bottom of the wall every 3.5 storeys.

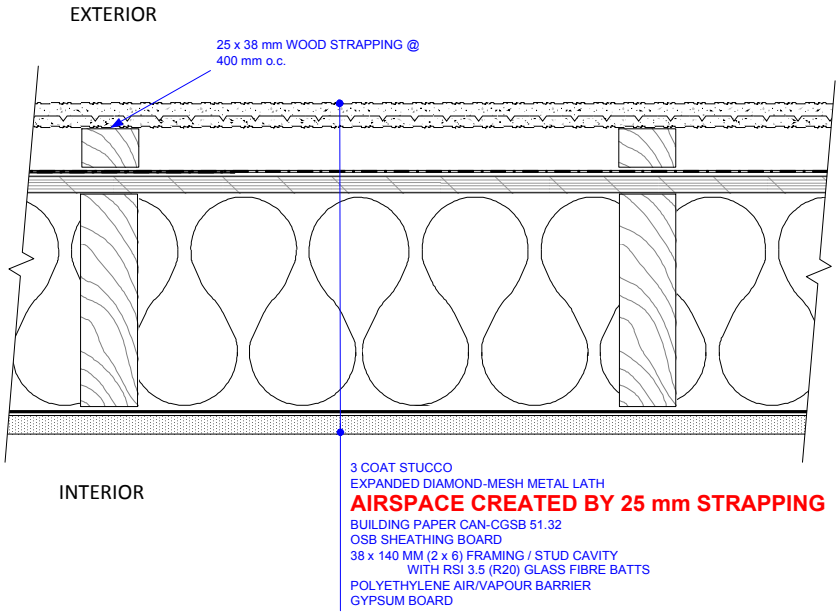

Figure 15 – Client F Wall horizontal cross section

Table 9 – Client F Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Drainage Layer**		
	a) Material	Air space created by 25 x 38 mm wood strapping Since lath not paper backed, stucco expected to protrude through lath and partially fill 25 mm airspace.	Nominal 25 mm
	b) Installation	Fastened to framing @ 400 o.c.	
	c) Venting	Vented at the bottom of the wall	

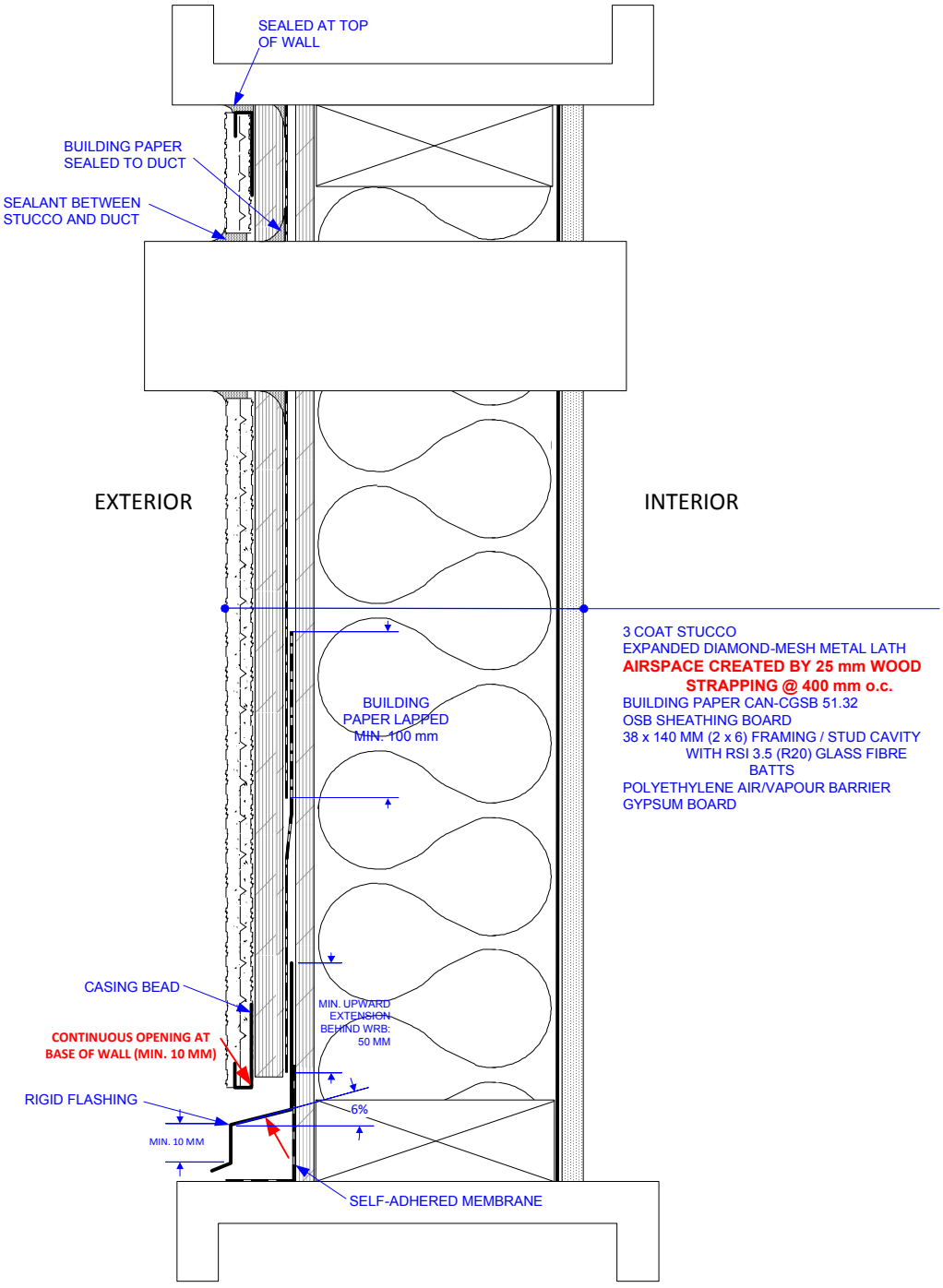

Figure 16 – Client F Wall vertical cross section

Client G Wall Assembly Details

The Client G assembly features a PP mat (10 mm, 3-dimensional extruded PP mono-filament mesh) with a layer of Non-woven PP fabric to help keep stucco out of the rainscreen layer. This product acts as drainage medium, and not a sheathing membrane. The function of the sheathing membrane is performed by a layer of building paper (meeting CAN-CGSB 51.32) on the face of the OSB sheathing board. By using the code minimum required building paper, if adequate performance is demonstrated, the drainage product will be an acceptable solution for use with all code compliant sheathing membranes. All other elements of the assembly are identical to the benchmark wall. The Client G wall is vented and flashed at the bottom of the wall every 3.5 storeys

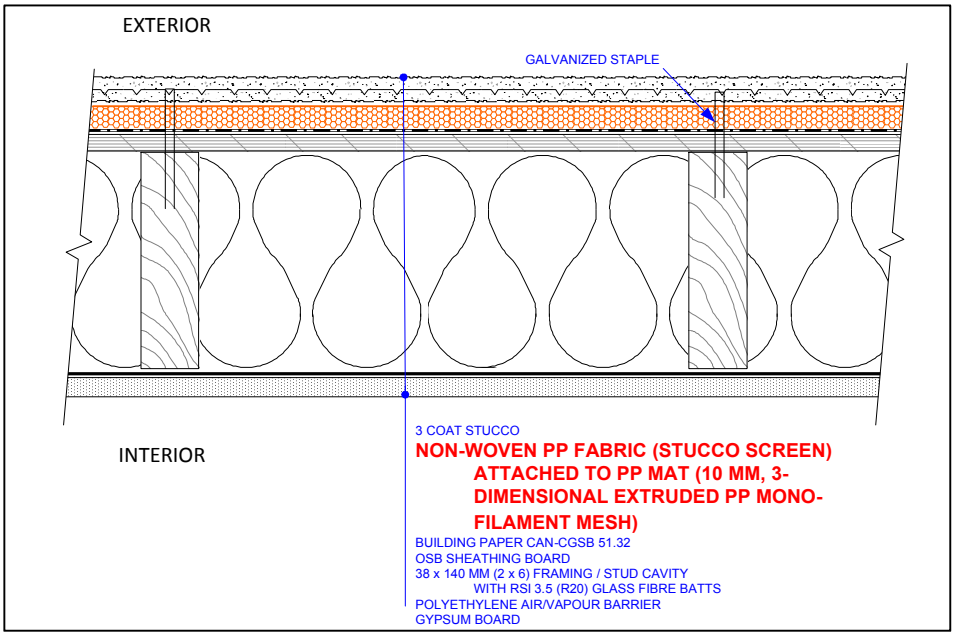

Figure 17 – Client G Wall horizontal cross section

Table 10 – Client G Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Drainage Layer**		
	d) Material	Non-woven PP fabric (stucco screen) attached to PP mat (nominal 10 mm 3-dimensional extruded PP mono-filament mesh)	9.3 mm
	e) Installation	• Install horizontally, fabric side out with entangled core facing the building interior • Mechanically fasten with a cap nail, cap stable or cap screw, one fastener per square foot • Seam adjacent pieces with the selvage edge overlapping the top of the lower piece • Trim around all penetrations, windows and doors	

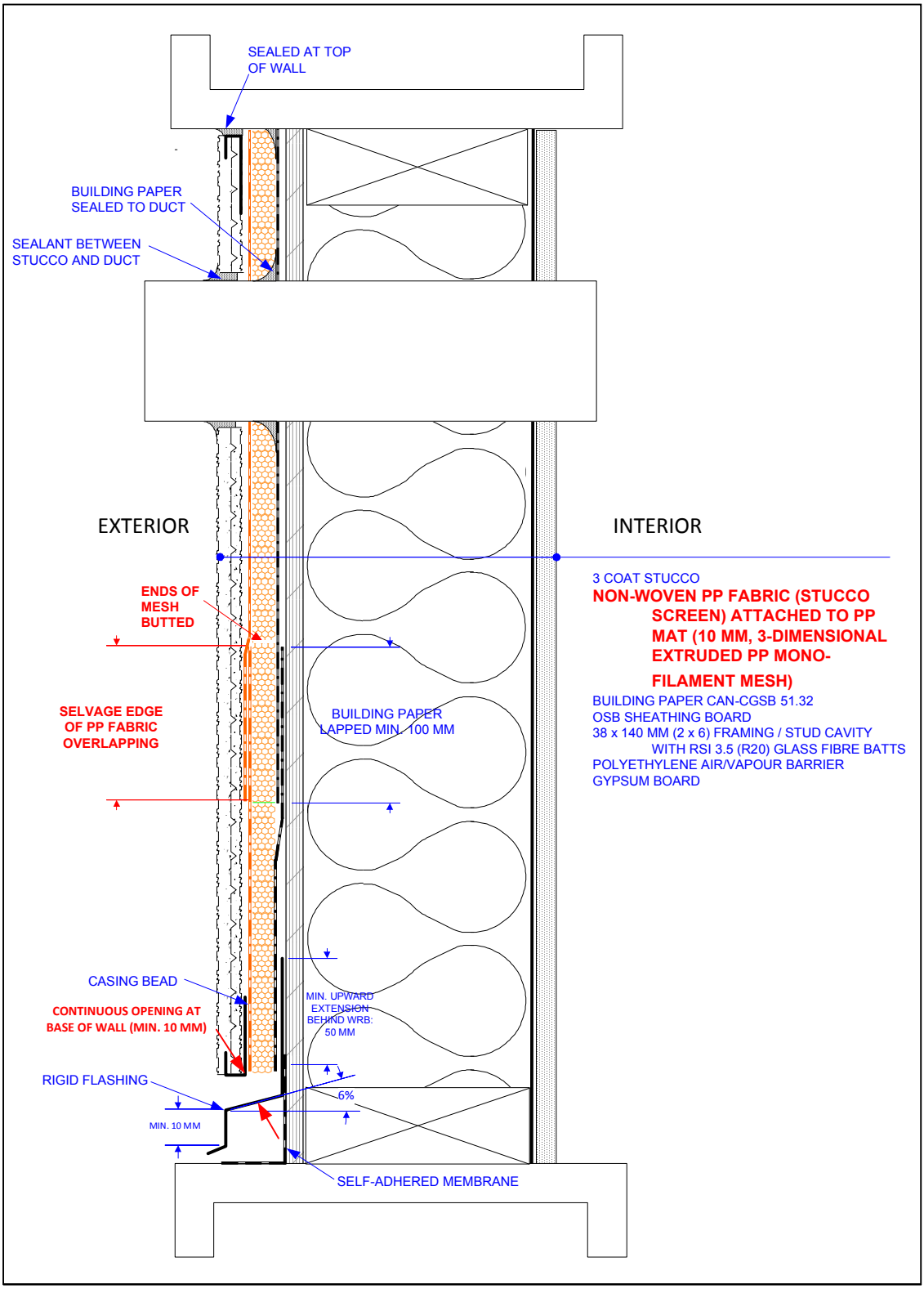

Figure 18 – Client G Wall vertical cross section

Client H Wall Assembly Details

The Client H assembly features a drainable insulation layer adhered to a fluid applied air barrier[8]. These products will be considered a system, linked together. Thus, if adequate performance is demonstrated, the drainable insulation will only be approved for installation in conjunction with the fluid applied air barrier. All other elements of the assembly are identical to the benchmark wall. The Client H wall is vented and flashed at the bottom of the wall every 3.5 storeys.

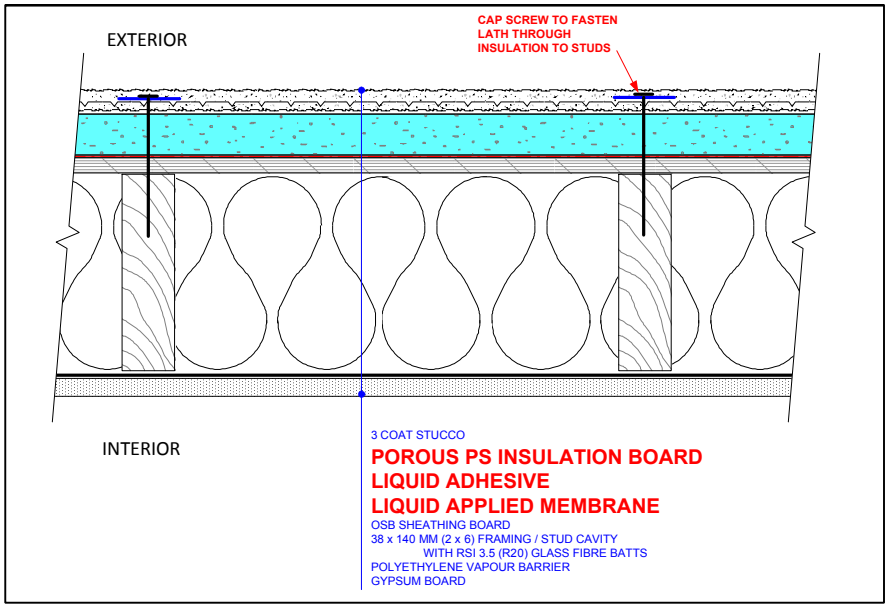

Figure 19 – Client H Wall horizontal cross section

Table 11 – Client H Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Air/Vapour Retarder**		
	a) Material	Liquid applied membrane	0.305 mm
	b) Installation	As per manufacturer's instructions	
2	**Drainable Insulation**		
	a) Material	Porous PS insulation board	51 mm
	b) Installation	Adhered to surface of liquid applied membrane using a uniform layer of proprietary liquid adhesive.	
3	a) Stucco lath - fastening	Cap nails, penetrating a minimum of 19 mm into the framing. Fastened 100 mm o.c. vertically, and 600 o.c. horizontally	
6	**Vapour barrier**		
	a) Material	Polyethylene	0.15 mm
	b) Installation	Not continuous or sealed	

[8] **Note**: If the water vapor permeance of the exterior sheathing with the liquid applied membrane is < 60ng, the required insulation must comply with NBC table 9.25.5.2. for the heating degree days of the building location.

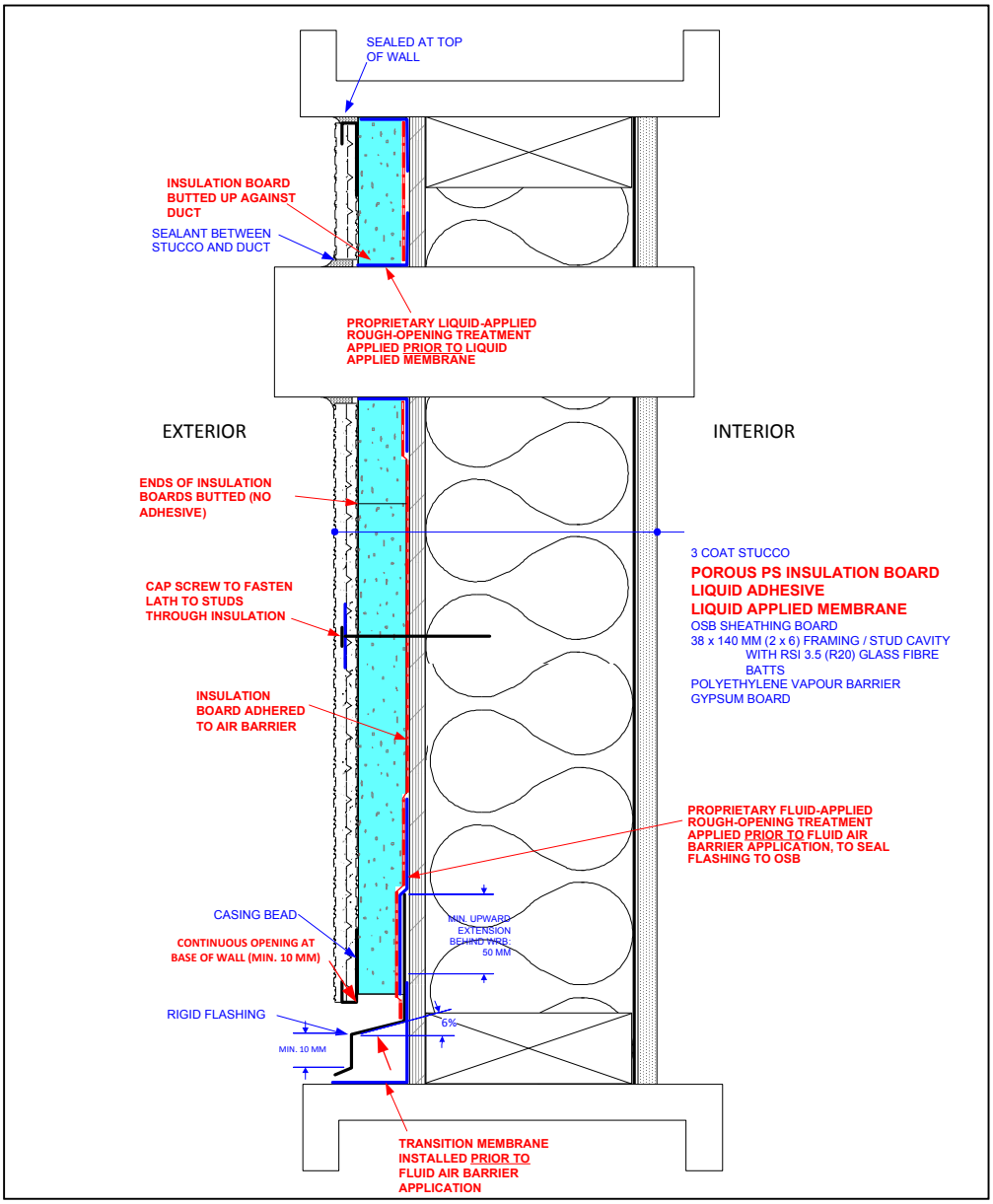

Figure 20 – Client H Wall vertical cross section

Client I Wall Assembly Details

The Client I assembly features a layer of 2-ply corrugated asphalt impregnated paper. This product is intended to act as a drainage medium, and is not intended to perform as the sheathing membrane. A layer of building paper (conforming to CAN-CGSB 51.32) installed on the face of the OSB sheathing board will perform the function of the sheathing membrane. By using the code minimum required building paper, if adequate performance is demonstrated, the drainage product will be an acceptable solution for use with all code compliant sheathing membranes. The drainage layer has a ventilated detail, open at the top and bottom of the wall section. All other elements of the assembly are identical to the benchmark wall. The Client I wall is ventilated at the top and bottom of the wall every storey.

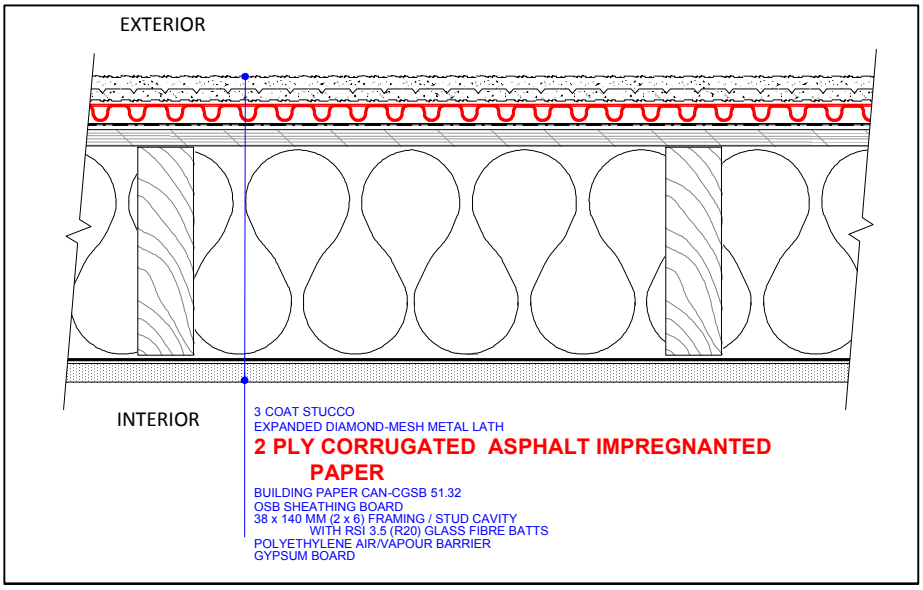

Figure 21 – Client I Wall horizontal cross section

Table 12 – Client I Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Drainage layer**		
	a) Material	2-ply corrugated asphalt impregnated paper, Grade D	3.8 mm
	b) Installation	• Install with corrugations facing inwards • Bottom flap protrudes past the lowest point of the cladding, trimmed off • Flap from upper layer should overlap the lower sheet by 100 mm (4 in.), leaving a 12 mm (1/2 in.) gap between corrugations • Vertical joints taped with construction tape, or covered with a 300 mm (12 in) wide strip of building paper • Horizontal mid wall flashing installed at each floor level	
	c) Fastening	• Fastened with 3/8" or ½" galvanized staples to the wall with a hand stapler	
	d) Venting	• Ventilated – open at both the top and bottom of the wall section	

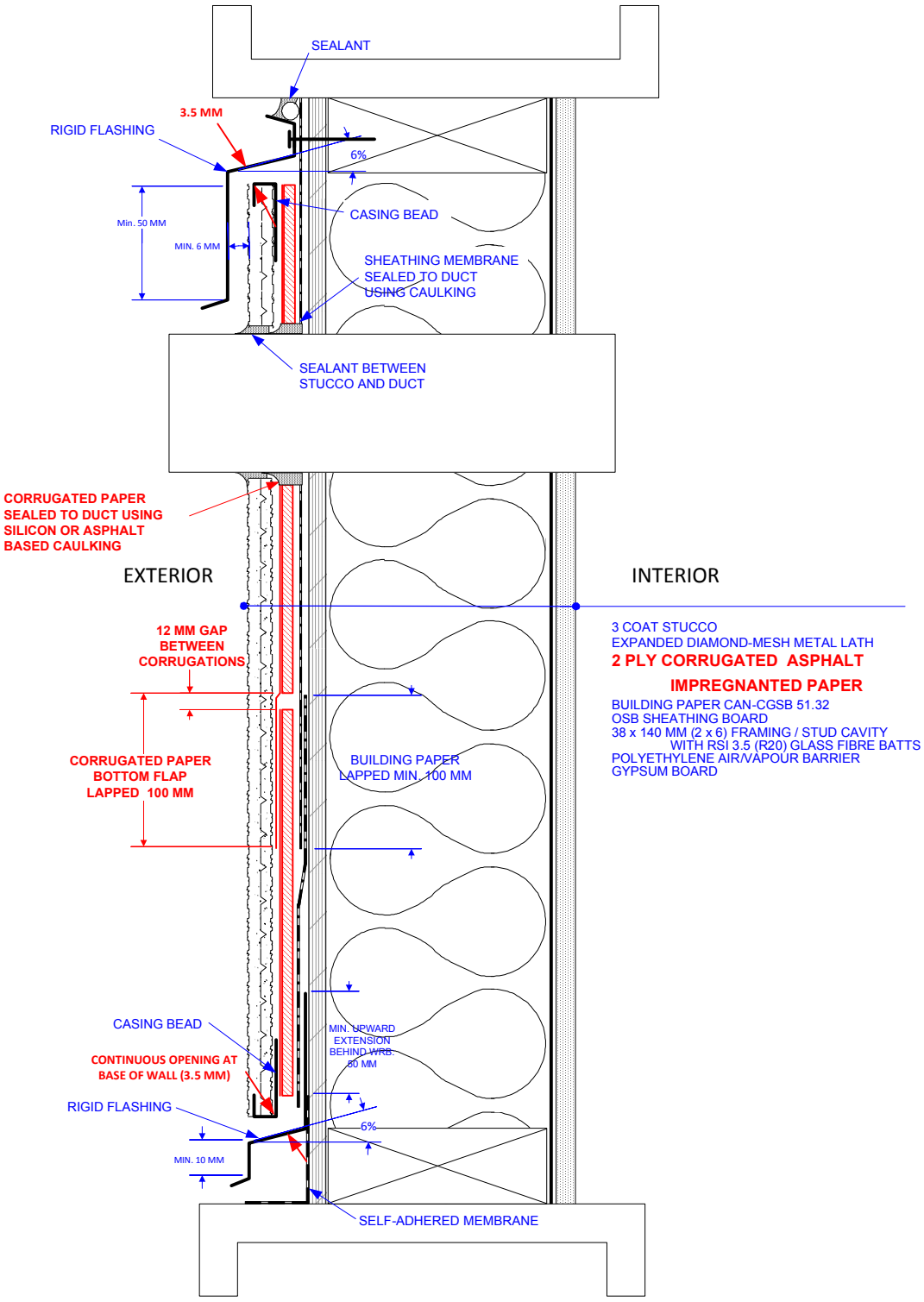

Figure 22 – Client I Wall vertical cross section

Client J Wall Assembly Details

The Client J wall was designed to represent west-coast residential construction. The primary difference between this wall and the benchmark wall is the type of lath – a paper backed welded wire mesh. Unlike the benchmark wall, this configuration is less likely to allow stucco to protrude into the airspace behind the cladding. The Client J wall uses 9.5 mm (3/8 in.) treated plywood strapping. The 9.5 mm gap is specified by BCBC 2012, 9.27.2.2(1)(a), and is less than the 10 mm specified by the National Building Code. The benchmark employed a slightly larger strapping (19 mm [3/4 in.]) to ensure a clear 10 mm airspace, and to accommodate the stucco entering the drainage cavity through the diamond mesh lath. Additionally, the Client J wall has 2 layers of code compliant building paper as a second line of defense. The Client J wall is vented and flashed at the bottom of the wall every 3.5 storeys.

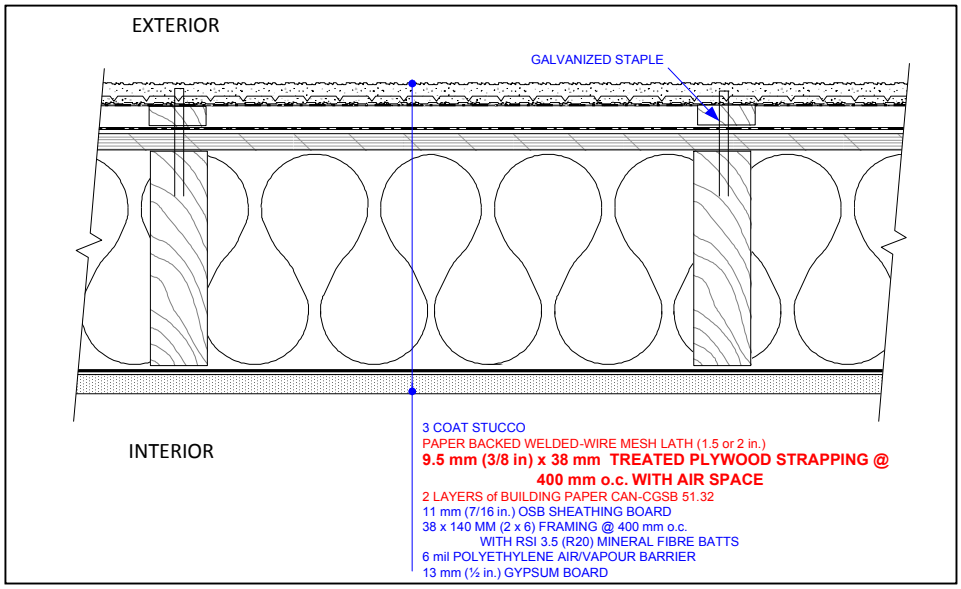

Figure 23 – Client J Wall horizontal cross section

Table 13 – Client J Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Drainage Layer**		
	a) Material	Air space created by **9.5 mm (3/8 in.) plywood** strapping	9.5 mm
	b) Installation	Strapping fastened to framing @ 400 mm o.c.	
2	**Cladding**		
	a) Lath	Paper backed welded-wire mesh lath (1.5 or 2 in.)	
	b) Lath Fastening	Fastened to framing through strapping with corrosion-resistant staples, 1.98 mm thick, 50 mm long (to penetrate min. 25 mm into framing) 100 mm o.c. vertically 400 mm o.c. horizontally	
3	**Sheathing Membrane**		
	c) Material	2 x asphalt-impregnated building paper complying with CAN/CGSB-51.32-M	0.2 mm
	d) Installation	Installed (nailed or stapled) horizontally Joints lapped by min. 100mm Shingled (top sheet overlapping bottom sheet)	

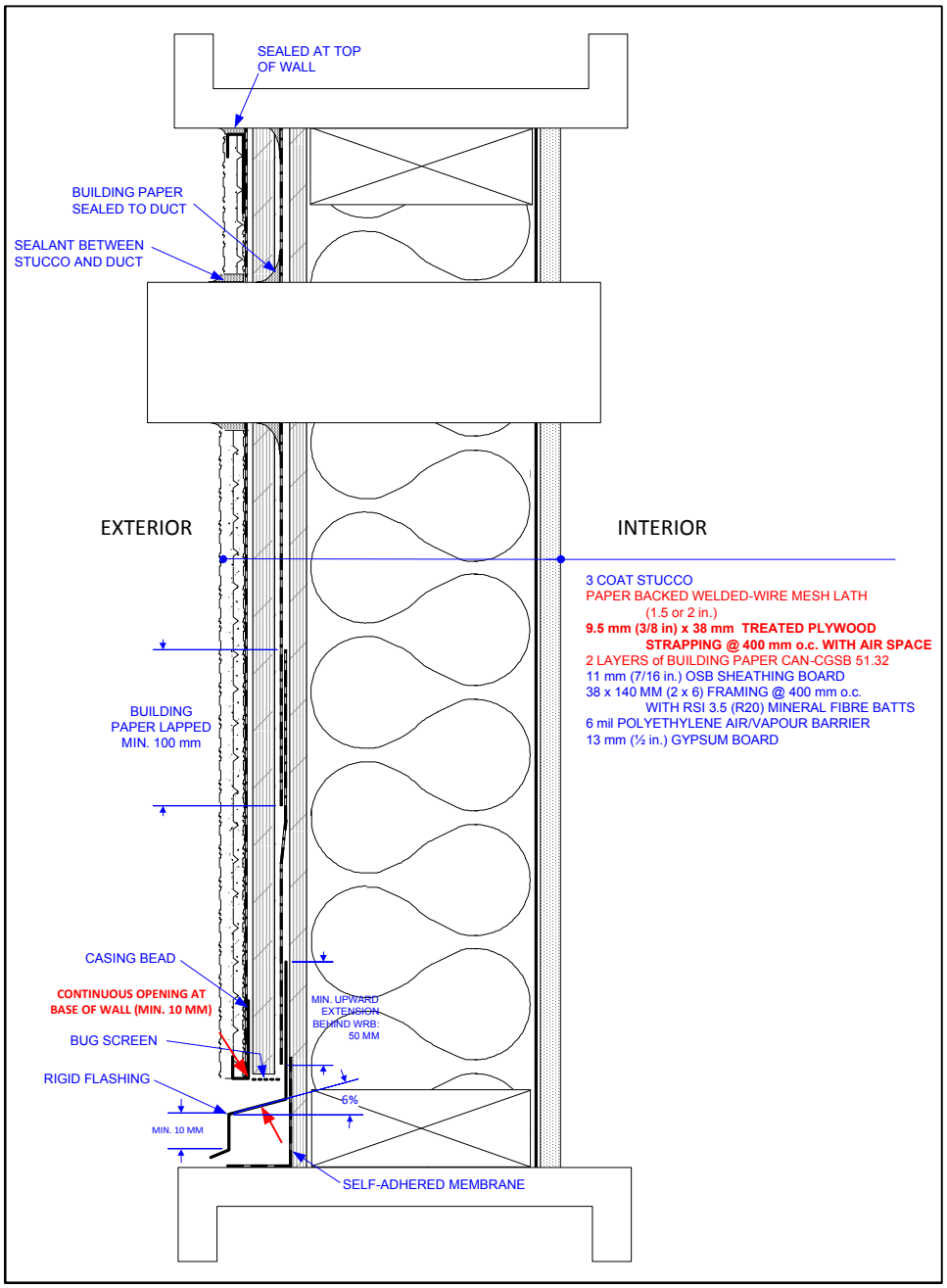

Figure 24 – Client J Wall vertical cross section

Client K Wall Assembly Details

The Client K wall is identical to the Client J wall with the exception of using 19 mm (3/4 in.) strapping in place of 9.5 (3/8 in.) strapping. The Client K wall is vented and flashed at the bottom of the wall every 3.5 storeys.

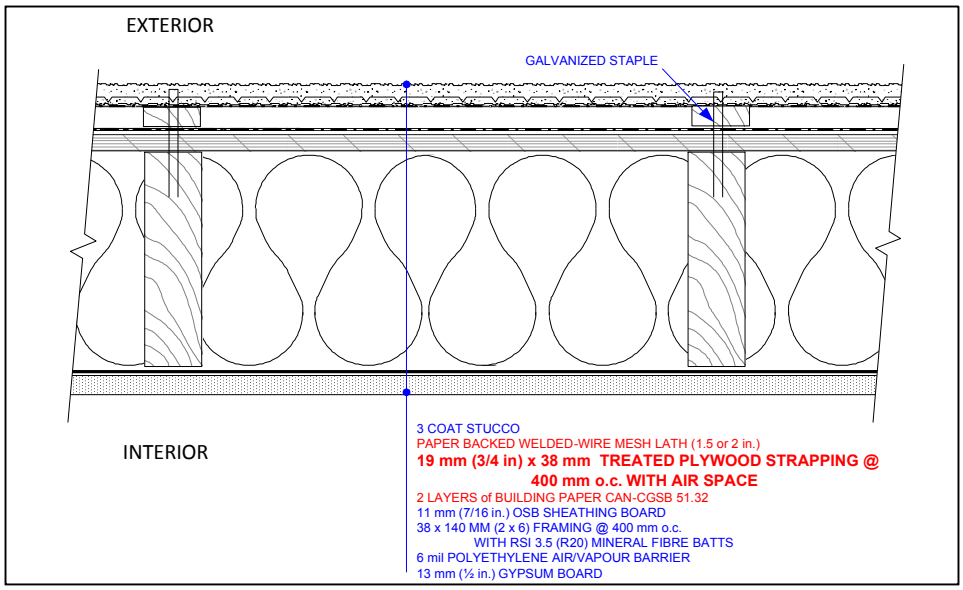

Figure 25 – Client K Wall horizontal cross section

Table 14 – Client K Wall description of components differing from the Benchmark Wall assembly

	Item	Description	Thickness
1	**Drainage Layer**		
	c) Material	Air space created by **19 mm (3/4 in.) plywood** strapping	19 mm
	d) Installation	Strapping fastened to framing @ 400 mm o.c.	
2	**Cladding**		
	c) Lath	Paper backed welded-wire mesh lath (1.5 or 2 in.)	
	d) Lath Fastening	Fastened to framing through strapping with corrosion-resistant staples, 1.98 mm thick, 50 mm long (to penetrate min. 25 mm into framing members) 100 mm o.c. vertically 400 mm o.c. horizontally	
3	**Sheathing Membrane**		
	e) Material	2 x asphalt-impregnated building paper complying with CAN/CGSB-51.32-M77	0.2 mm
	f) Installation	Installed (nailed or stapled) horizontally Joints lapped by min. 100mm Shingled (top sheet overlapping bottom sheet)	

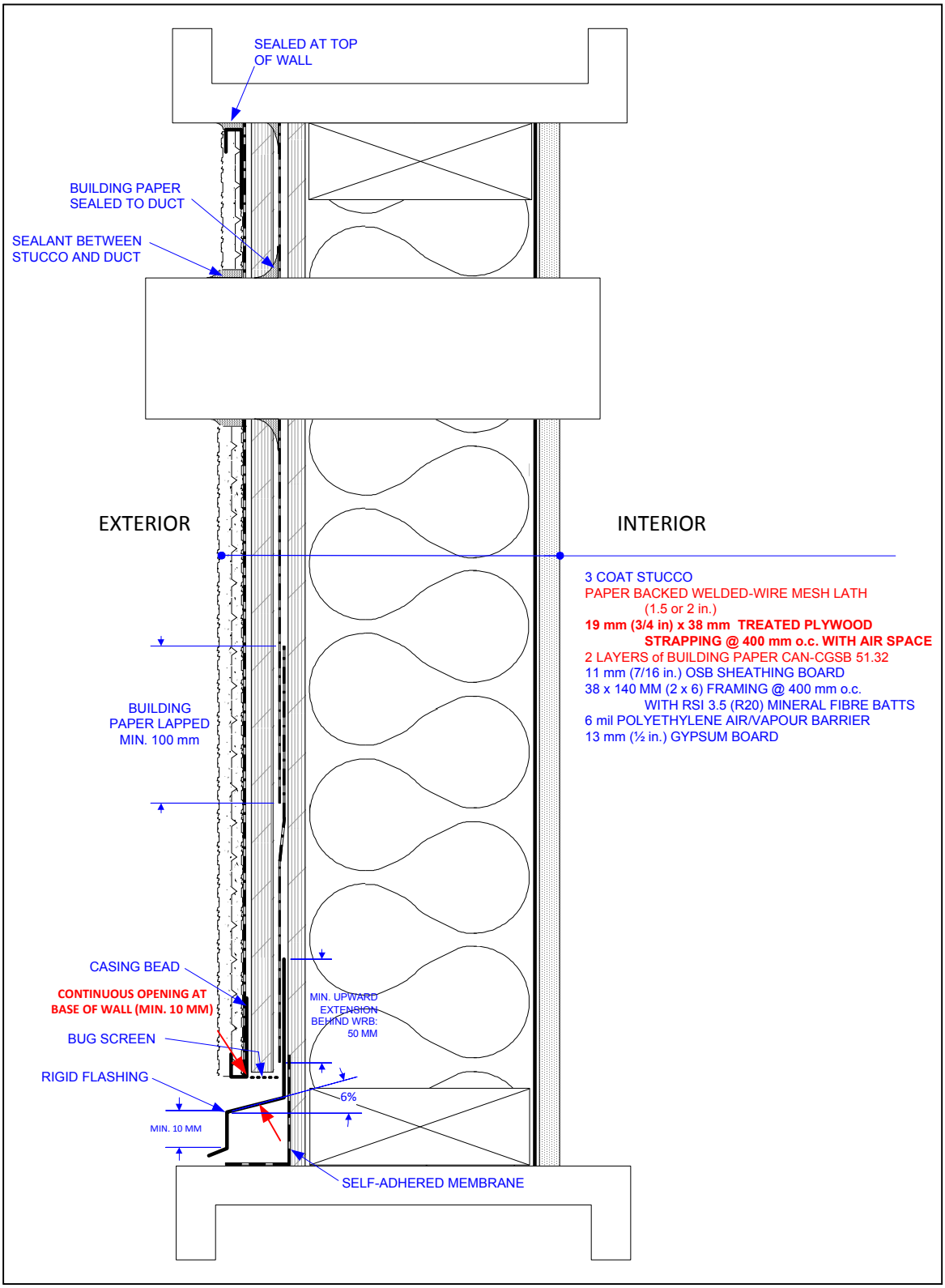

Figure 26 – Client K Wall vertical cross section

5. Summary of Wall Assemblies

A summary of specifications given for each of the proponent's wall assemblies is given in Table 15. The acronym designated "BM" indicates that the component is the same as the benchmark wall assembly. Note that an evaluation of hygrothermal properties was performed for the component highlighted in yellow.

Table 15 – Summary of Benchmark and Client Wall Assembly Elements

Assembly	Cladding	Layer separating cladding from drainage layer	Drainage layer	Sheathing membrane	Sheathing board	Framing	Stud cavity insulatn	Air/Vapour Barrier	Interior finish	Ventilatn Strategy	Notes
Benchmark	3 coat Stucco with expanded diamond-mesh metal lath (no paper backing)	None	Air space created by 19x38 mm wood strapping @ 400 mm o.c.	1 layer of building paper CAN-CGSB 51.32	OSB	28 x 140 mm (2x6) wood stud framing @ 600 mm o.c.	RSI 3.5 (R20) mineral fibre batts	6 mil polyethylene	13 mm (1/2 in.) gypsum board	Vented at the base of the wall every 3.5 storeys	Bug screen at base of wall
Client A	BM	**Building paper CAN-CGSB 51.32**	Drainable SBPO sheathing membrane		BM	BM	BM	BM	BM	BM	
Client B	BM	BM (none)	10mm air space created by 19x64 mm wood strapping @ 400 mm o.c., with 76 mm water repellent **insulation** board	**Fluid applied air barrier**	**12.5 mm Exterior gypsum board**	**Steel stud framing**	**89 mm Mineral fibre batt**	**6 mil polyethylene vapour barrier, not continuous or sealed**	BM	BM	
Client C	BM	**Building paper CAN-CGSB 51.32**	Nylon mesh (10 mm; open matrix) bonded to PP nonwoven sheathing membrane		BM	BM	BM	BM	BM	BM	
Client D	BM	**Building paper CAN-CGSB 51.32**	Cross woven, micro-perforated polyolefin sheathing membrane with polyolefin coating		BM	BM	BM	BM	BM	BM	
Client E	BM	PP fabric bonded to dimpled HDPE membrane		BM	BM	BM	BM	BM	BM	Option 1: BM Option 2: Ventilated top & bottom every 2 storeys	Bug screen at base of wall

Assembly	Cladding	Layer separating cladding from drainage layer	Drainage layer	Sheathing membrane	Sheathing board	Framing	Stud cavity insulatn	Air/Vapour Barrier	Interior finish	Ventilatn Strategy	Notes
Client F	BM	BM (none)	Nominal 25 mm Air space created by 25 x 38 mm wood strapping @ 400 mm o.c.	BM	BM	BM	BM	BM	BM	BM	
Client G	BM	Non-woven PP fabric (stucco screen) / PP mat (10 mm; 3-dimensional extruded PP mono-filament mesh)		BM	BM	BM	BM	BM	BM	BM	
Client H	BM	BM (none)	Porous PS insulation board (52 mm)	**Fluid applied air barrier**	BM	BM	BM	**6 mil polyethylene vapour barrier, not continuous or sealed**	BM	BM	
Client I	BM	BM (none)	2-ply corrugated asphalt impregnanted paper – Grade D	BM	BM	BM	BM	BM	BM	**Ventilated top and bottom every storey**	
Client J	BM	**Building paper CAN-CGSB 51.32**	Air space created by 9.5x38 mm plywood strapping @ 400 mm o.c.	**2 layers of building paper CAN-CGSB 51.32**	BM	BM	BM	BM	BM	BM	Bug screen at base of wall
Client K	BM	**Building paper CAN-CGSB 51.32**	Air space created by 19 mm (3/4 in.) plywood strapping @ 400 mm o.c.	**2 layers of building paper CAN-CGSB 51.32**	BM	BM	BM	BM	BM	BM	Bug screen at base of wall

Appendix 1
List of Project Reports

Report **Reference**

Task 1 M. Armstrong and B. Di Lenardo (2014), Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 1 – Wall Assembly Specifications; Client Report A1-000030.01; National Research Council Canada; Ottawa, ON; 52 pgs.

Task 2 P. Mukhopadhyaya, D. van Reenen and S. Bundalo-Perc (2014), Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 2 – Building Component Hygrothermal Properties Characterization; Client Report A1-000030.02; National Research Council Canada; Ottawa, ON; 58 pgs.

Task 3 H. H. Saber, W. Maref, and G. Ganapathy, (2015) Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 3 –Hygrothermal Model Benchmarking; Client Report A1-000030.04; National Research Council Canada; Ottawa, ON; 63 pgs.

Task 4 W. Maref, H. H. Saber and G. Ganapathy (2015), Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 4 – Characterization of Air Flow within Drainage Cavities; Client Report A1-000030.05; National Research Council Canada; Ottawa, ON; 115 pgs.

Task 5 Steven M. Cornick and Khaled Abdulghani (2013), Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task – Defining Exterior Environmental Loads; Client Report A1-000030.03; National Research Council Canada; Ottawa, ON; 99 pgs.

Task 5 T. Moore and M. Nicholls (2015), Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 5 – Characterization of Water Entry to, Retention and Dissipation from Drainage Components; Client Report A1-000030.06; National Research Council Canada; Ottawa, ON; 43 pgs.

Task 6 H. H. Saber (2015) Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 6 – Hygrothermal Performance of NBC-Compliant Reference Wall for Selected Canadian Locations; Client Report A1-000030.07; National Research Council Canada; Ottawa, ON; 59 pgs.

H. H. Saber (2015) Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 6 – Hygrothermal Performance of Wall Assemblies Incorporating Drainage Components for Selected Canadian Locations; Client Report A1-000030.08; National Research Council Canada; Ottawa, ON; 167 pgs.

H. H. Saber (2015) Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 6 – Hygrothermal Performance of Wall Assemblies Incorporating Drainage Components: Results for wall components having Medium Resistant (MR) Mould Growth Sensitivity Class; Client Report A1-000030.10; National Research Council Canada; Ottawa, ON; 85 p.

Task 7 M. A. Lacasse (2015) Performance Evaluation of Proprietary Drainage Components and Sheathing Membranes when Subjected to Climate Loads – Task 7 – Summary Report on Experimental and Modelling Tasks and Recommendations; Client Report A1-000030.09; National Research Council Canada; Ottawa, ON; 43 pgs.