BC BEC Conference

2011

Building the Enclosure-
Innovation and Transformation

Air Barrier Commissioning of Large Buildings

BC BEC

September 2011

Martin Houston, AIA, LEED AP

Walsh Construction Co.

Outline

- A Brief History of Air Tight Construction (WCC)
  - What were we testing
  - What did we learn
  - Inconsistent units
- Recent Case Studies (Let's get serious):
  - Sitka Apartments
  - Pearl Family Housing
  - University of Washington, Site 33

New Columbia

New Columbia

New Columbia

Pacific Tower

Pacific Tower

Pacific Tower

Sitka Apartments

Sitka Apartments

Salishan

Salishan

Salishan 6

Results from blower doors on 'Salishan 6' new homes:

Type of Unit	Square Footage	Volume	Air Changes at 50 Pascals of pressure
Single family ADA	1840	14,720	ACH 4.6 @ 50 Pa
Duplex (1 party wall)	1295	10,360	ACH 7.4 @ 50 Pa
Triplex End Unit (1 party wall)	970	7765	ACH 5.8 @ 50 Pa
Triplex Middle Unit (2 party walls)	970	7765	ACH 6.7 @ 50 Pa

Homes with party walls did worse than the single family. We could work together on air sealing details to improve these numbers for whatever route you choose to pursue. Tight houses are generally in the 3.0 to 4.0 ACH 50 range. Below that and the project needs to consider heat recovery ventilators to assure fresh air delivery. (O'Brien & Co.)

Salishan 7
SBPP

Photo 15

A layer of Jumbotex D60 building paper over the Tyvek was installed to prevent direct contact with the back of Fiber Cement siding and to improve drainage.
The long term effects of salts and minerals that leach through the back side of Fiber Cement siding is unknown. This is the second reason for adding the paper layer.

Photo 16

The ceiling at the attic is part of the air barrier system for this project. Typically, the drywall contractors come in and do all the drywall work at once.
The ceiling is an "out of sequence" component that has to be scheduled and installed to enable the A.B. testing.

Salishan 7
SBPP

Photo 17

Penetrations through the top plate into the attic must be sealed.
Note the continuous sealant joint at the top plate to GWB ceiling. This is the air seal at this interface, as the top plate needs to bridge the A.B. from ceiling to Tyvek on the exterior wall.

Photo 18

Air seal around the exhaust duct will provide some redundancy as it goes through the rim joist to the exterior side.
It's a redundant measure because the hood is actually sealed to the Tyvek A.B. membrane to provide air seal from the exterior side of the wall.

Salishan 7

SBPP

Results of Building BF2 (Lot 12 / Block 25) Air Barrier Testing

CFM 50	920		@ 50 Pa	
CFM 25	0			
n (flow exponent)	0.65			If one point test (CFM 50), .65 is assumed
Reference pressure	4		Pa	
Reference CFM	178.154304		@ 4 Pa	
ELA	50.5067452		in2	
CFA	2039		ft2	
Average height	8.5		ft	
Volume	17331.5		ft3	Volume may be calculated or entered (entered takes precedence)
ACH50	3.18495225			
SLA	0.00017202		in2	
Code Requirement	0.0003		in2	Base level** July 2010
Code Bonus level 1	0.0002		in2	worth 0.5 points from table 9.1*
Code Bonus level 2	0.00015		in2	worth 1.0 points from table 9.1*
				*table subject to change before July 2010
LEED H level 1	1213.205		CFM50	equiv to 4.2 ACH50
LEED H level 2	722.145833		CFM50	equiv to 3.0 ACH50
Unit Type	EA3.2 (2pts)	EA3.3 (3pts)	Ring Type	SAL7 HISTORY
02 (Lot 13 / Block 25)	1819	1083	A	Initial Reading 3.6ach @ 50
BF1 (Lot 12 / Block 25)	1213	722	A	Initial Reading 3.28 @ 50 (950cfm)
BF2 (Lot 12 / Block 25)	1213	722	A	2nd Reading after insulation 3.18 @ 50 (920cfm)
B	383	228	B	
C	630	375	B	
D	660	393	B	
F	817	486	B	
G	728	434	B	
H	798	475	B	
J	769	458	B	
N	1095	652	A	
O	910	542	B	

Salishan 7

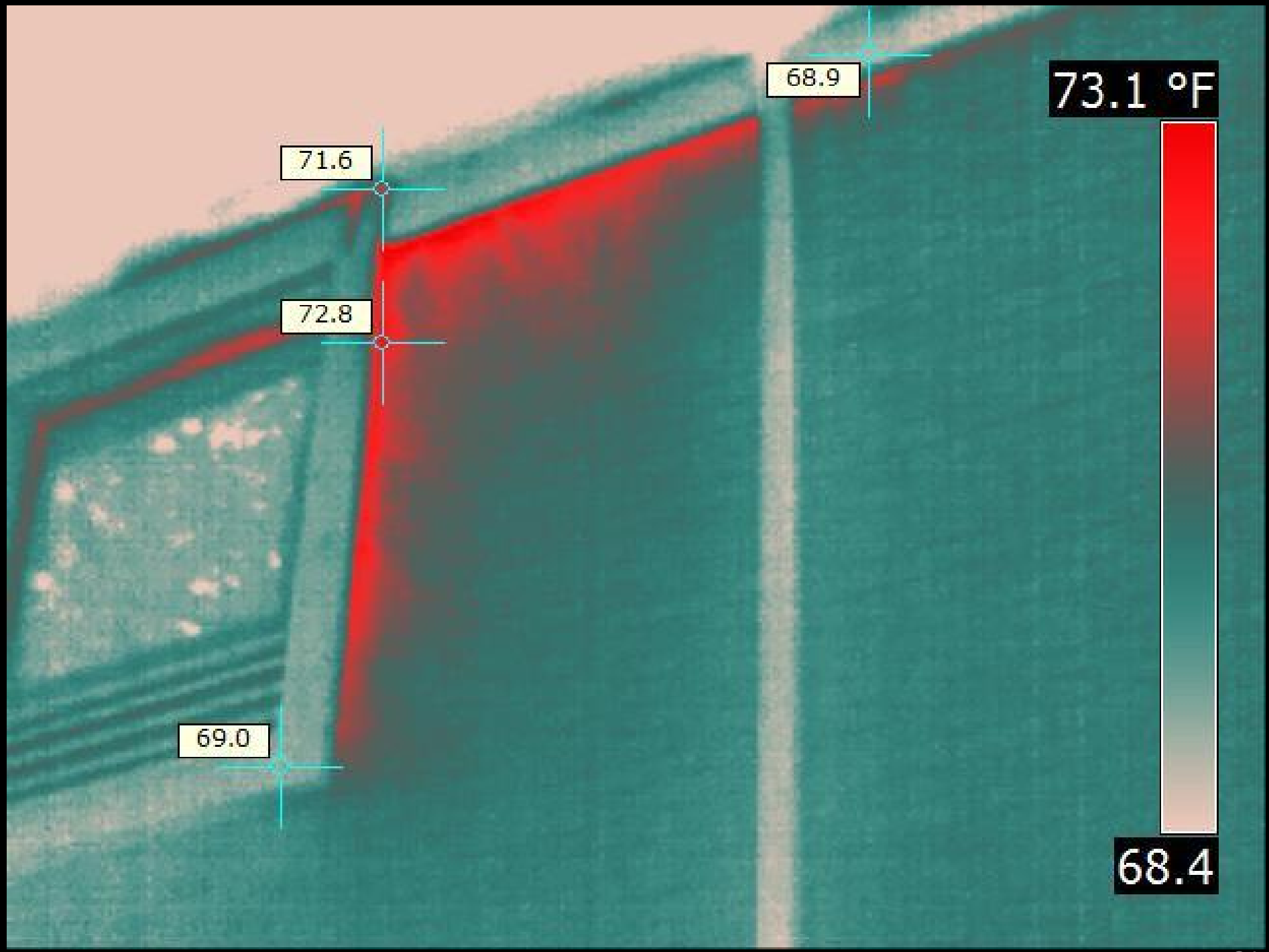
LAM

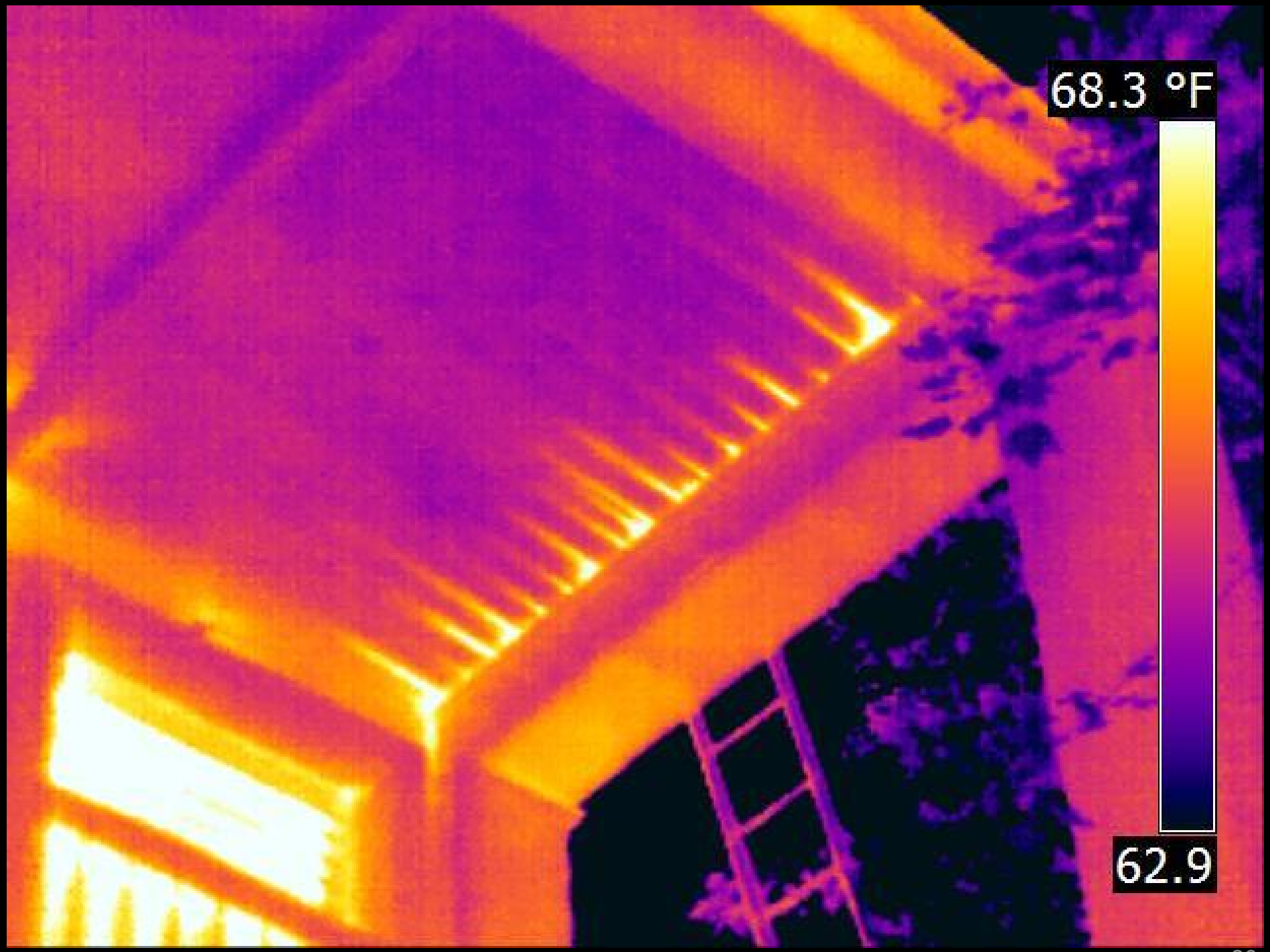
Salishan 7
LAM

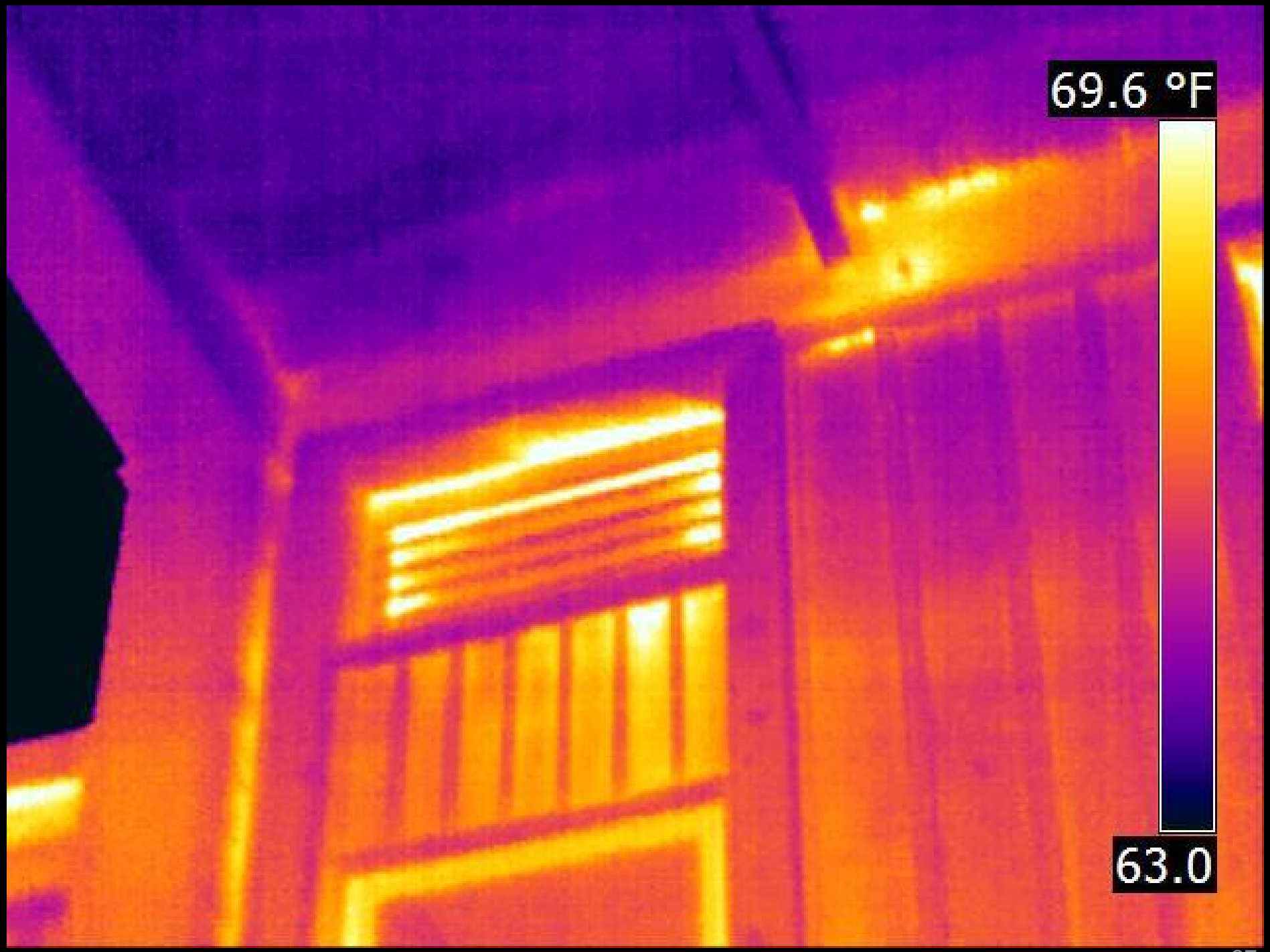
- 1.8 ACH 50
- 33% of air leakage was attributable to windows


JW
JELDWEN


JW
JELDWEN


68.9
73.1 °F
71.6
72.8
69.0
68.4


68.3 °F
62.9


69.6 °F
63.0

Pearl Family Housing

Portland

Image courtesy of Ankrom Moisan

Pearl Family Housing (2009)

- "Son of Sitka": Affordable family housing in Portland's Pearl District
  - 5 story wood frame structure over 1 story concrete frame podium
  - 230,000 SF (including 12000 SF elementary school)
  - 182 units

- Owner/Developer: Turtle Island Development
- Architect: Ankrom Moisan
- Enclosure Consultant: RDH Building Sciences
- MEP Consultant: PAE Consulting Engineers

- Pursuing LEED Gold certification

Image courtesy of Ankrom Moisan

Pearl Family Housing - Comparison of Exterior Wall Assembly Options 9/18/08

PFH Exterior Wall SF 68000

Wall Type	Framing	Cavity Insulation	Exterior Insulation	Whole Wall R-value*	Total Wall Width	Airspace Width	WRB	Air Barrier	Vapor Barrier	Ledger Size	$/sf (Base Wall)	$/sf w/ Siding**	$/sf w/ Brick***	$/sf per R-value Unit (Base Wall)	Comments	PFH - Total Cost (Wall w/ Brick)	Variance from Baseline (Wall 3)
1	2x6 @ 16"o.c.	R-19 FG batt (faced)	None	17.35	1'-2"	2-1/2"	60 min. Grade D paper	None	Kraft paper (facing on batts)	5x5x3/8	5.06	15.71	33.23	0.29	This wall does not have an air barrier. Lack of air barrier is likely to result in significant heat loss that is not reflected in this analysis.	$ 2,259,918.61	$ 8,319.61
2	2x6 @ 24"o.c.	R-19 FG batt (faced)	None	17.86	1'-2"	2-1/2"	60 min. Grade D paper	None	Kraft paper (facing on batts)	5x5x3/8	4.78	15.43	32.63	0.27	This wall does not have an air barrier. Lack of air barrier is likely to result in significant heat loss that is not reflected in this analysis.	$ 2,219,118.61	$ (32,480.39)
3	2x6 @ 24"o.c.	R-21 FG batt (unfaced)	None	17.96	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	Membrain (smart retarder)	5x5x3/8	5.26	15.91	33.11	0.29	Baseline wall assembly for PFH project. A "good" wall: good thermal performance, good drying capacity, good water management capacity. Walls listed below could be considered "better" walls thermally.	$ 2,251,599.00	0
4	2x6 @ 24"o.c.	R-19 cellulose (dense pack)	None	17.86	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	Membrain (smart retarder)	5x5x3/8	6.17	16.82	34.02	0.35	This wall is similar to Wall Type 2 however has dense packed cellulose to achieve a better quality installation with all stud framing cavities filled with insulation material. Cellulose also has some hygric buffer capacity which can help with moisture management.	$ 2,313,479.00	$ 61,880.00
5	2x4 @ 24"o.c.	None	R-10 XPS rigid - 2" (see Note 1)	14.52	1'-1"	1-1/2"	SAM	SAM	SAM	6x6x7/16	6.59	17.54	34.72	0.45	Dryout of construction moisture may be hampered by SAM. Longer schedule and use of enhanced dehumidification for dryout may be required. 2x4 wall may exceed deflection limits for brick veneer? Possible fire rating issue with rigid foam insulation.	$ 2,360,837.60	$ 109,238.60
6	2x4 @ 24"o.c.	R-13 FG batt (unfaced)	R-5 XPS rigid - 1" (see Note 1)	18.94	1'-0"	1-1/2"	Tyvek CW-D	Tyvek CW-D (see Note 2)	None? (see Note 3)	5x5x3/8	5.29	16.09	33.14	0.28	CommercialWrap D provides enhanced drainage behind rigid insulation. This wall may have reduced drying capacity. 2x4 wall may exceed deflection limits for brick veneer? Possible fire rating issue with rigid foam insulation.	$ 2,253,639.00	$ 2,040.00
7	2x6 @ 24"o.c.	R-21 FG batt (unfaced)	R-5 XPS rigid - 1" (see Note 1)	23.58	1'-2"	1-1/2"	Tyvek CW-D	Tyvek CW-D (see Note 2)	None? (see Note 3)	5x5x3/8	6.56	17.36	34.41	0.28	CommercialWrap D provides enhanced drainage behind rigid insulation. This wall may have reduced drying capacity. Possible fire rating issue with rigid foam insulation.	$ 2,339,999.00	$ 88,400.00
8	2x6 @ 24"o.c.	R-23 FG bib	None	18.83	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	Membrain (smart retarder)	5x5x3/8	5.82	16.47	33.67	0.31	This wall is similar to Wall Type 3 however has blown-in fiberglass to achieve a better quality installation with all stud framing cavities filled with insulation material.	$ 2,289,679.00	$ 38,080.00
9	2x6 @ 24"o.c.	R-23 FG bib	R-7.5 XPS rigid - 1-1/2" (see Note 1)	27.35	1'-3"	2"	Tyvek CW-D	Tyvek CW-D (see Note 2)	None? (see Note 3)	6x6x7/16	7.37	18.32	35.50	0.27	Blown-in fiberglass provides improved quality and r-value (vs. batts). CommercialWrap D provides enhanced drainage behind rigid insulation. This wall may have reduced drying capacity.	$ 2,413,779.00	$ 162,180.00
10	2x6 @ 24"o.c.	R-23 FG bib	R-10 XPS rigid - 2" (see Note 1)	30.04	1'-3"	1-1/2"	Tyvek CW-D	Tyvek CW-D (see Note 2)	None? (see Note 3)	6x6x7/16	7.57	18.52	35.70	0.25	Blown-in fiberglass provides improved quality and r-value (vs. batts). CommercialWrap D provides enhanced drainage behind rigid insulation. This wall may have reduced drying capacity.	$ 2,427,379.00	$ 175,780.00
11	2x6 @ 24"o.c.	R-23 polyurethane spray foam (open cell)	None	18.83	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	None? (see Note 3)	5x5x3/8	7.47	18.12	35.32	0.40	Spray foam insulation provides improved quality and r-value (vs. fiberglass). Spray foam insulation also provides additional air barrier. Possible fire rating issue with spray foam insulation.	$ 2,401,879.00	$ 150,280.00
12	2x6 @ 24"o.c.	R-35 polyurethane spray foam (closed cell)	None	22.36	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	None? (see Note 3)	5x5x3/8	10.22	20.87	38.07	0.46	Spray foam insulation provides improved quality and r-value (vs. fiberglass). Spray foam insulation also provides additional air barrier. Possible fire rating issue with spray foam insulation.	$ 2,588,879.00	$ 337,280.00

Notes:

1 Semi-rigid mineral wool insulation (utilizing Roxul CavityRock) can be used in lieu of XPS rigid insulation. Add $1.15/sf to assembly cost (for 2" CavityRock).

2 Sealed sheathing air barrier system (utilizing SAM strips or Dow 795 sealant at DensGlass joints) can be used in lieu of Tyvek air barrier system. Add $1.47/sf to assembly cost.

3 Pending WUFI or other moisture analysis by consultant --------> (Note: Exterior wall designs should avoid placing vapor retarding layers on both sides of wood wall framing).

4 SAM = self-adhering rubberized asphalt membrane, 40 mil (i.e. Soprema, Waterblock 40, or Protectoseal PW-400).

5 Estimated cost of wall options with exterior insulation include allowances for trim/closures at window jambs and heads, wider cap flashings at window sills, and wider veneer anchors.

6 "Base Wall" = framing + sheathing + cavity insulation + exterior insulation (where occurs) + WRB + air barrier (where occurs) + vapor barrier (where occurs).

7 * Whole wall r-values listed for these wall types are based on chart from PAE (dated 9/10/08). These r-values are based on a project-specific framing factor of 22% provided by AMAA.
"Whole wall r-value" includes the thermal performance of not only the "clear wall" area, with insulation and structural elements, but also typical envelope interface details, including wall/wall (corners), wall /roof, wall/floor, wall/door, and wall/window connections.

8 ** "Wall with Siding" = Base wall + fiber-cement lap siding + 1/2" treated plywood furring strips + fasteners + embedded flashings + accessory sealants. Fasteners assumed to be 304 stainless steel.

9 *** "Wall with Brick" = Base wall + support steel (floor line ledgers installation only) + veneer anchors + fasteners + face brick + embedded flashings + accessory sealants. Veneer anchorage, embedded metal flashing, and associated fasteners assumed to be 304 stainless steel.

10 Estimated cost of wall options include two layers of 5/8" Type X DensGlass exterior sheathing. Estimated cost does not include drywall at interior side of wall.

11 1/2" plywood sheathing can be provided in addition to gypsum sheathing where required for lateral force resistance. Add $0.72/sf to assembly cost.

12 For these cost comparison, standard K-D / S-Dry framing material is assumed (not fire-treated or preservative-treated material).

13 Pearl Family Housing exterior wall quantity assumed to be 68,000 sf. This is the "opaque" wall area, exclusive of windows and doors.

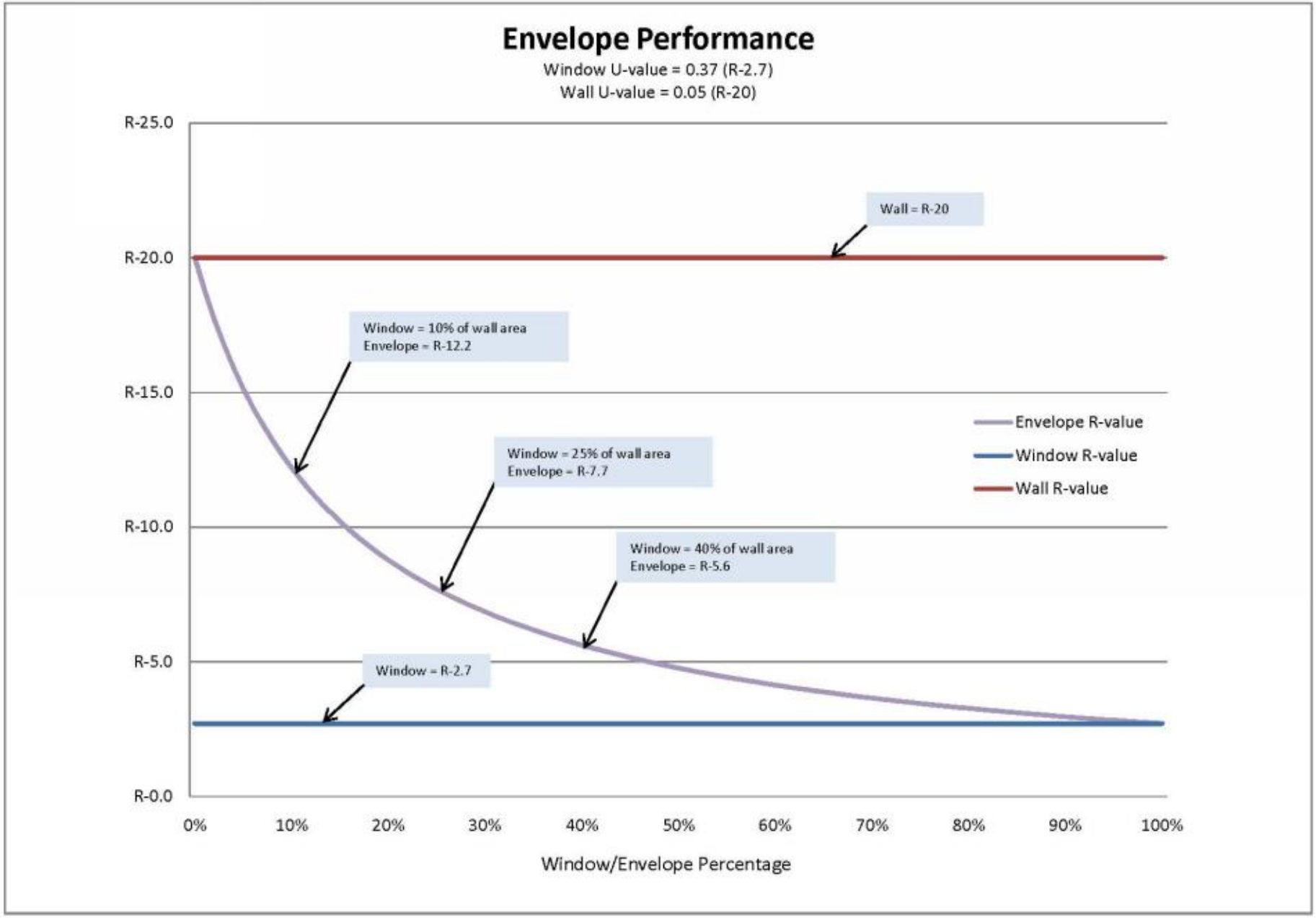
14 Design team will need to research and verify availability of fire ratings / listings for all wall type / assembly options. Use of foam insulation in rated assemblies also needs to be researched and verified.

Pearl Family Housing - Comparison of Exterior Wall Assembly Options 9/18/08

PFH

Wall Type	Framing	Cavity Insulation	Exterior Insulation	Whole Wall R-value*	Total Wall Width	Airspace Width	WRB	Air Barrier	Vapor Barrier	Ledger Size	$/sf (Base Wall)	$/s Sidi
1	2x6 @ 16"o.c.	R-19 FG batt (faced)	None	17.35	1'-2"	2-1/2"	60 min. Grade D paper	None	Kraft paper (facing on batts)	5x5x3/8	5.06	15
2	2x6 @ 24"o.c.	R-19 FG batt (faced)	None	17.86	1'-2"	2-1/2"	60 min. Grade D paper	None	Kraft paper (facing on batts)	5x5x3/8	4.78	15
3	2x6 @ 24"o.c.	R-21 FG batt (unfaced)	None	17.96	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	Membrain (smart retarder)	5x5x3/8	5.26	15
4	2x6 @ 24"o.c.	R-19 cellulose (dense pack)	None	17.86	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	Membrain (smart retarder)	5x5x3/8	6.17	16
5	2x4 @ 24"o.c.	None	R-10 XPS rigid - 2" (see Note 1)	14.52	1'-1"	1-1/2"	SAM	SAM	SAM	6x6x7/16	6.59	17
6	2x4 @ 24"o.c.	R-13 FG batt (unfaced)	R-5 XPS rigid - 1" (see Note 1)	18.94	1'-0"	1-1/2"	Tyvek CW-D	Tyvek CW-D (see Note 2)	None? (see Note 3)	5x5x3/8	5.29	16
7	2x6 @ 24"o.c.	R-21 FG batt (unfaced)	R-5 XPS rigid - 1" (see Note 1)	23.58	1'-2"	1-1/2"	Tyvek CW-D	Tyvek CW-D (see Note 2)	None? (see Note 3)	5x5x3/8	6.56	17
8	2x6 @ 24"o.c.	R-23 FG bib	None	18.83	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	Membrain (smart retarder)	5x5x3/8	5.82	16
9	2x6 @ 24"o.c.	R-23 FG bib	R-7.5 XPS rigid - 1-1/2" (see Note 1)	27.35	1'-3"	2"	Tyvek CW-D	Tyvek CW-D (see Note 2)	None? (see Note 3)	6x6x7/16	7.37	18
10	2x6 @ 24"o.c.	R-23 FG bib	R-10 XPS rigid - 2" (see Note 1)	30.04	1'-3"	1-1/2"	Tyvek CW-D	Tyvek CW-D (see Note 2)	None? (see Note 3)	6x6x7/16	7.57	18
11	2x6 @ 24"o.c.	R-23 polyurethane spray foam (open cell)	None	18.83	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	None? (see Note 3)	5x5x3/8	7.47	18
12	2x6 @ 24"o.c.	R-35 polyurethane spray foam	None	22.36	1'-2"	2-1/2"	Tyvek CW	Tyvek CW (see Note 2)	None? (see Note 3)	5x5x3/8	8.22	20

PAE CONSULTING ENGINEERS, INC.



PAE CONSULTING ENGINEERS, INC.

Summary

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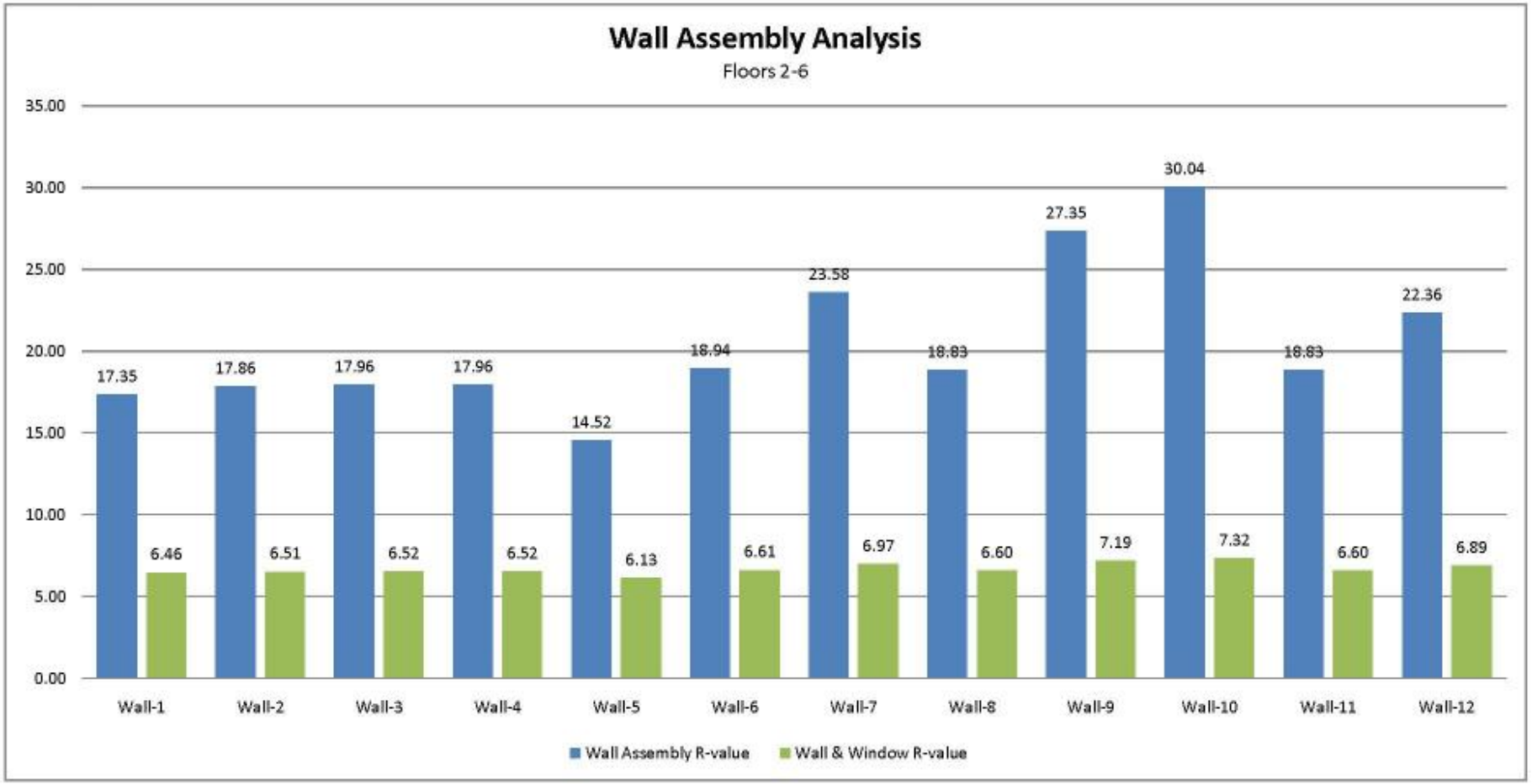
Created By: MAP
Checked By:

Project Number: 08-1081
Date: 9/11/2008



Window U-value:	0.45	
Window Wall Percentage:	24.8%	Includes balcony doors.
Roof R-value:	20	

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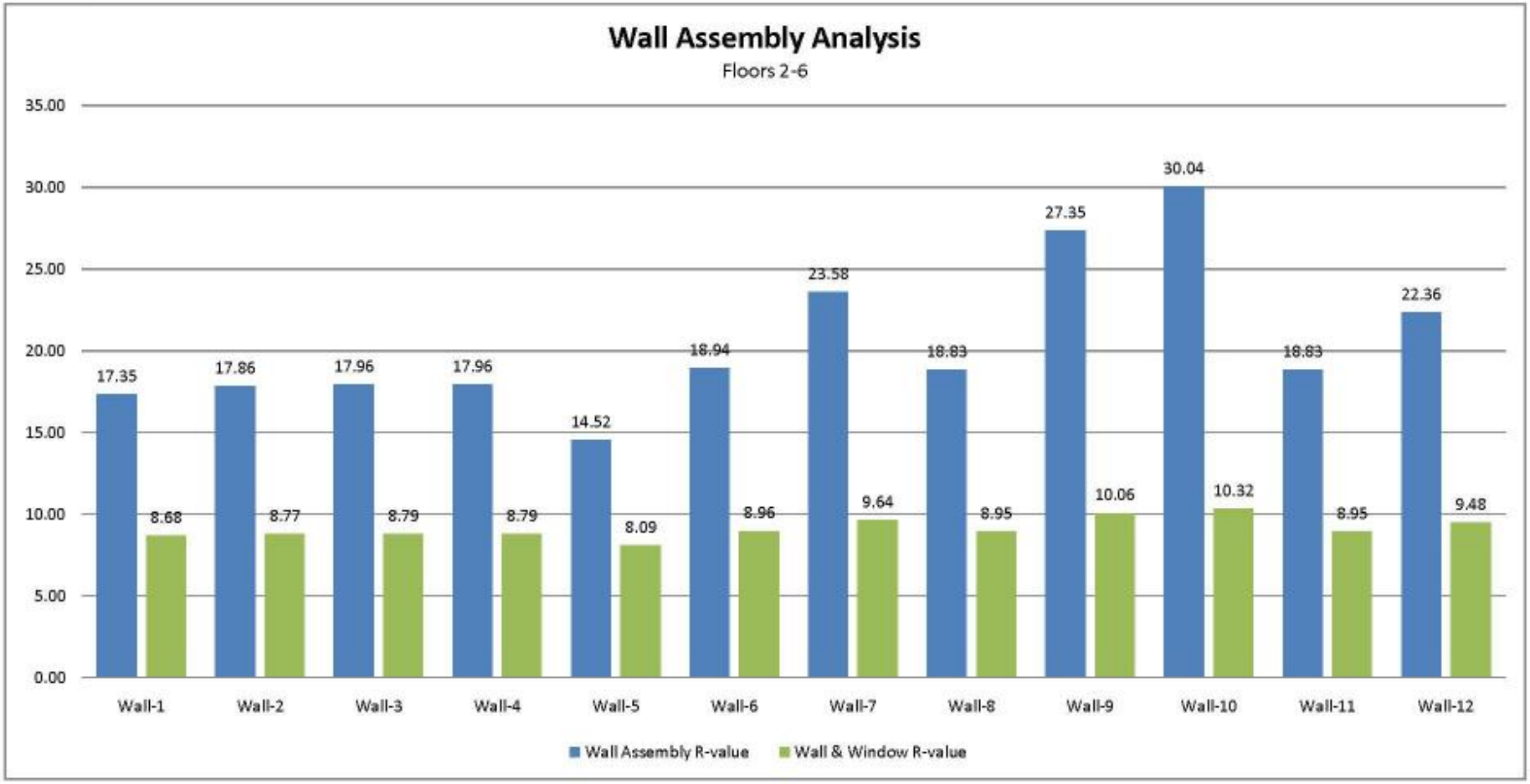
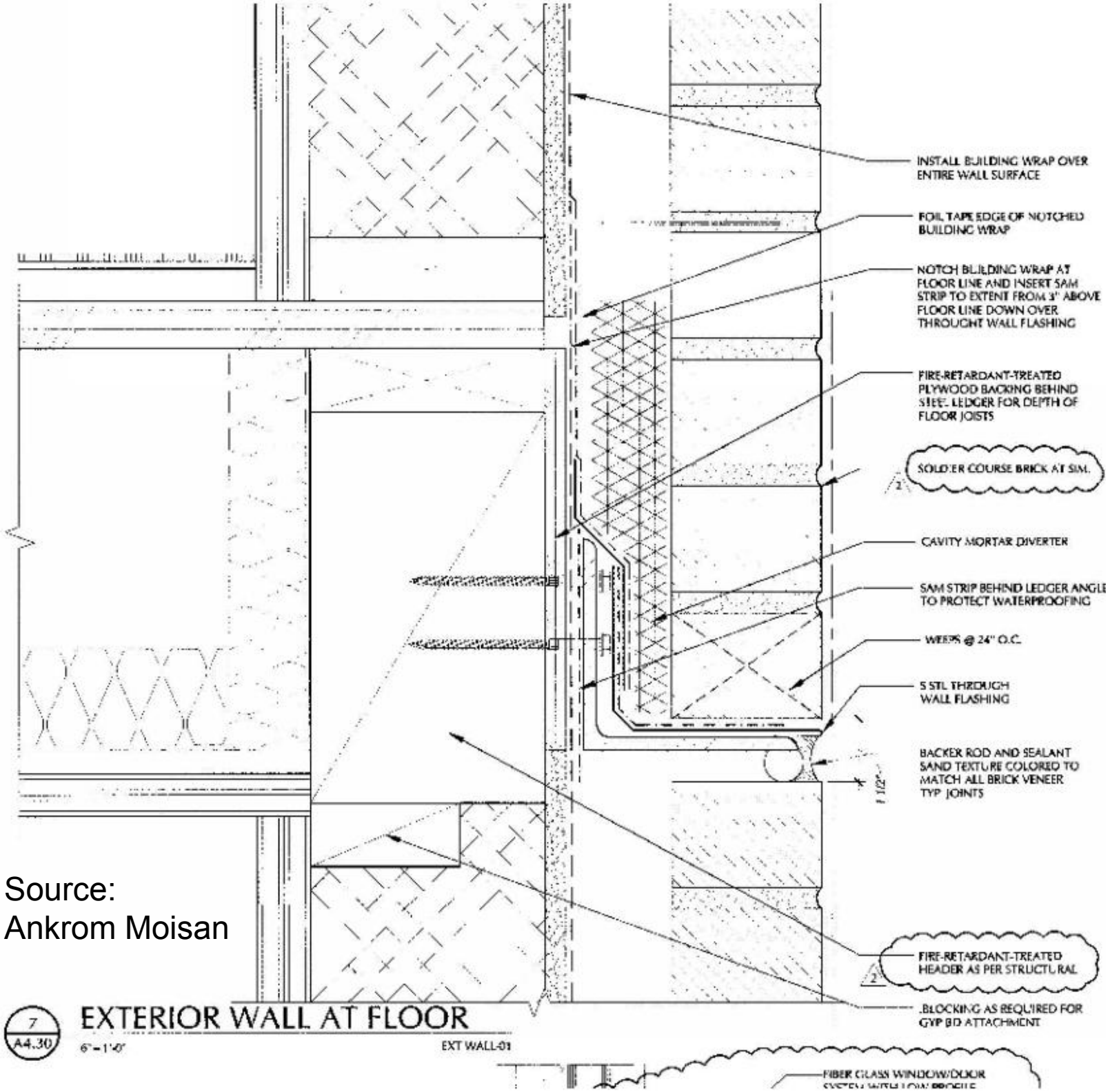


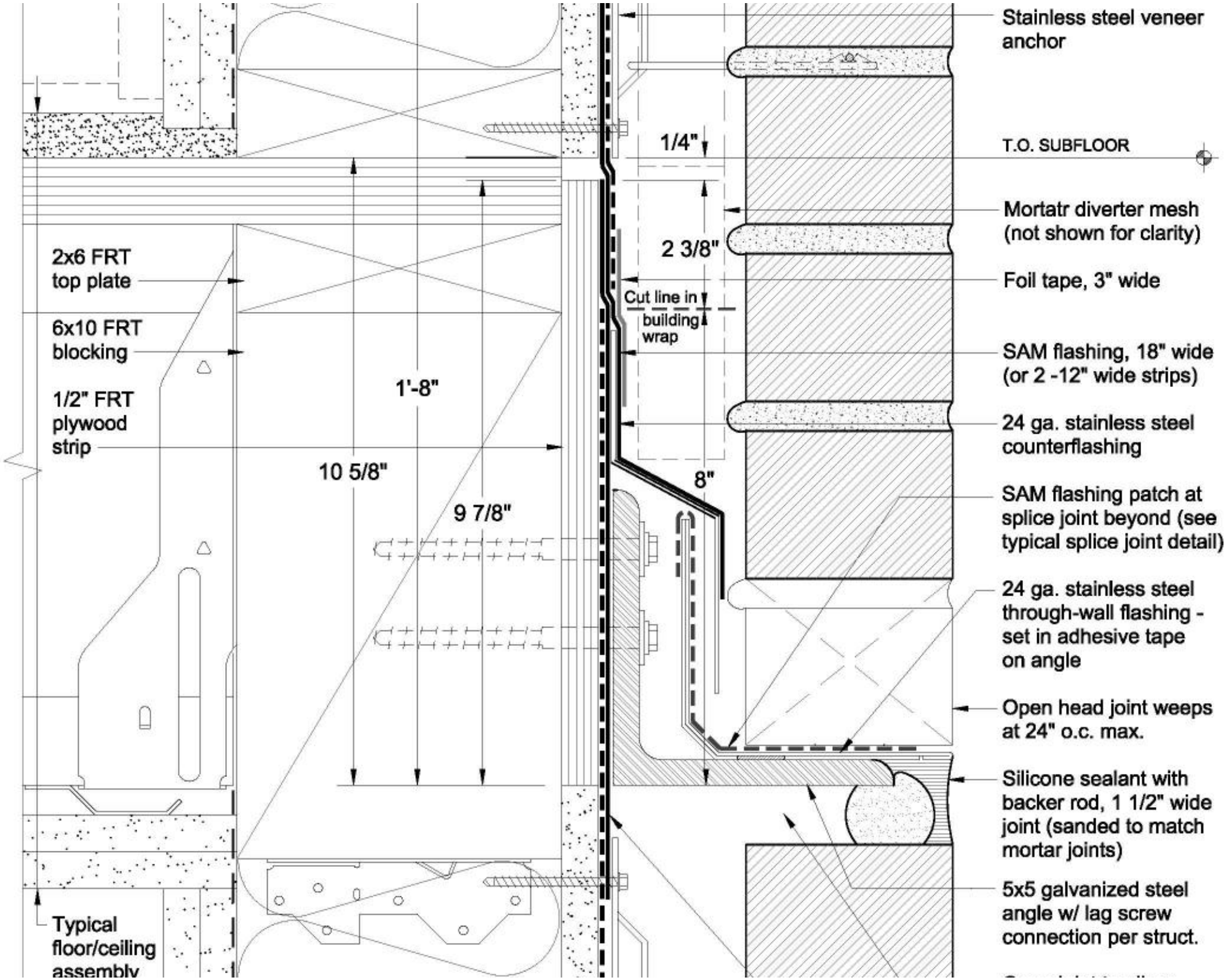
Window U-value:	0.29	
Window Wall Percentage:	24.8%	Includes balcony doors.
Roof R-value:	20	

Exterior Wall SF 68000

f w/ ng**	$/sf w/ Brick***	$/sf per R-value Unit (Base Wall)	Comments	PFH - Total Cost (Wall w/ Brick)	Variance from Baseline (Wall 3)
71	33.23	0.29	This wall does not have an air barrier. Lack of air barrier is likely to result in significant heat loss that is not reflected in this analysis.	$ 2,259,918.61	$ 8,319.61
43	32.63	0.27	This wall does not have an air barrier. Lack of air barrier is likely to result in significant heat loss that is not reflected in this analysis.	$ 2,219,118.61	$ (32,480.39)
91	33.11	0.29	Baseline wall assembly for PFH project. A "good" wall: good thermal performance, good drying capacity, good water management capacity. Walls listed below could be considered "better" walls thermally.	$ 2,251,599.00	0
82	34.02	0.35	This wall is similar to Wall Type 2 however has dense packed cellulose to achieve a better quality installation with all stud framing cavities filled with insulation material. Cellulose also has some hygric buffer capacity which can help with moisture management.	$ 2,313,479.00	$ 61,880.00
54	34.72	0.45	Dryout of construction moisture may be hampered by SAM. Longer schedule and use of enhanced dehumidification for dryout may be required. 2x4 wall may exceed deflection limits for brick veneer? Possible fire rating issue with rigid foam insulation.	$ 2,360,837.60	$ 109,238.60
09	33.14	0.28	CommercialWrap D provides enhanced drainage behind rigid insulation. This wall may have reduced drying capacity. 2x4 wall may exceed deflection limits for brick veneer? Possible fire rating issue with rigid foam insulation.	$ 2,253,639.00	$ 2,040.00
36	34.41	0.28	CommercialWrap D provides enhanced drainage behind rigid insulation. This wall may have reduced drying capacity. Possible fire rating issue with rigid foam insulation.	$ 2,339,999.00	$ 88,400.00
47	33.67	0.31	This wall is similar to Wall Type 3 however has blown-in fiberglass to achieve a better quality installation with all stud framing cavities filled with insulation material.	$ 2,289,679.00	$ 38,080.00
32	35.50	0.27	Blown-in fiberglass provides improved quality and r-value (vs. batts). CommercialWrap D provides enhanced drainage behind rigid insulation. This wall may have reduced drying capacity.	$ 2,413,779.00	$ 162,180.00
52	35.70	0.25	Blown-in fiberglass provides improved quality and r-value (vs. batts). CommercialWrap D provides enhanced drainage behind rigid insulation. This wall may have reduced drying capacity.	$ 2,427,379.00	$ 175,780.00
12	35.32	0.40	Spray foam insulation provides improved quality and r-value (vs. fiberglass). Spray foam insulation also provides additional air barrier. Possible fire rating issue with spray foam insulation.	$ 2,401,879.00	$ 150,280.00



Source:
Ankrom Moisan


Stainless steel veneer anchor
1/4"
T.O. SUBFLOOR
Mortatr diverter mesh (not shown for clarity)
2 3/8"
Foil tape, 3" wide
2x6 FRT top plate
Cut line in building wrap
6x10 FRT blocking
SAM flashing, 18" wide (or 2 -12" wide strips)
1'-8"
1/2" FRT plywood strip
24 ga. stainless steel counterflashing
10 5/8"
8"
9 7/8"
SAM flashing patch at splice joint beyond (see typical splice joint detail)
24 ga. stainless steel through-wall flashing - set in adhesive tape on angle
Open head joint weeps at 24" o.c. max.
Silicone sealant with backer rod, 1 1/2" wide joint (sanded to match mortar joints)
5x5 galvanized steel angle w/ lag screw connection per struct.
Typical floor/ceiling assembly


Tyvek
DUPONT


COMMERCIALWRAP
DUPONT
The miracles of science
DUPONT


FOLD LINE
FF
P/S
+3" into opening
3"
anti flashig
WRAP
The miracles of science
WERNER


Tyvek
COMMERCIALWRAP
DUPONT

Documented Calibration Flow Differential: 0.06 scfm
Differential 0.06 / Ideal 7.36 = 0.08 accuracy - ≥ 1%

Calibration Cross-Check:
Cross checked against 2" orifice plate.
Calibration reading of 28.7 scfm across 2" Plate.
Ideal airflow rate: 28.6 scfm at 75 Pa / 1.60 psf / 0.30 "WC
Documented Calibration Flow Differential: 0.1 scfm
Differential 0.1 / Ideal 28.6 = 0.003 accuracy - ≥ 1%

Flow Rate analysis across entire mock-up:

Measured Airflow: 50.0 scfm
Total square footage of test area: Approximately 850 square feet
50.0 / 850 = **0.06 cfm/ft²**

Note: *Qualitative smoke tests were performed and confirmed that the test chamber seals leaked significantly more than the window product or wall assembly. Due to this fact, the total initial flow rate in test segment #2 was very high. Extraneous airflow was determined by back-masking the window to determine actual product flow rate, and additionally comparative analysis (test 1) for wall performance.*

2. A segmented/compartmentalized test area was assessed along the South elevation:

Total square foot of test area = 85.5 square feet.
Total square foot of window product = 28.75
VPI window measures 57.5" x 72" = 4,130 square inches
4,130 / 144 = 28.75 square feet

Flow Rate #1 Included: Entire area including window product.
Flow Rate Measurement #1: 22.5 scfm

Flow Rate #2 included: Entire area with window MASKED OUT.
Flow Rate Measurement #2: 21.5 scfm

Flow rate attributable to VPI window product: 1.0 scfm
Corrected Flow Rate: 1.0 scfm / 28.5 square feet= **0.04 cfm / ft²**
R, LC, C product classes have allowable rating of 0.30 cfm / ft²

Source: QED Lab

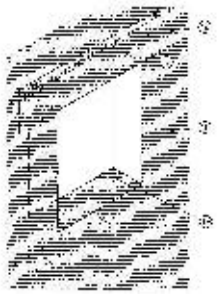
Assembly (mockup) airtightness:
0.06 cfm/sf @ 1.57 psf

WINDOW FLASHING SEQUENCE

SECTION DETAIL VIEW - AXONOMETRIC VIEW

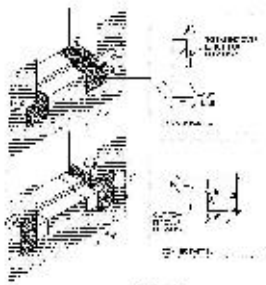
GENERAL NOTES

STEP 1

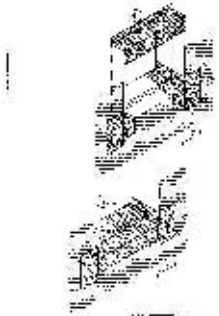


STEP 2

STEP 3



STEP 4



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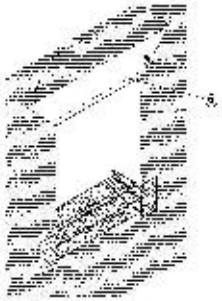

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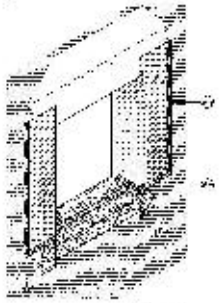

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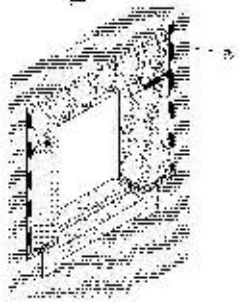

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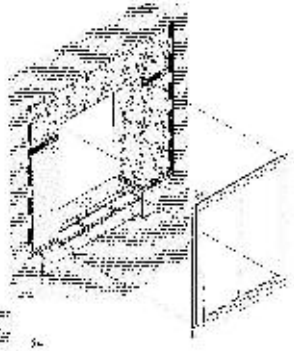

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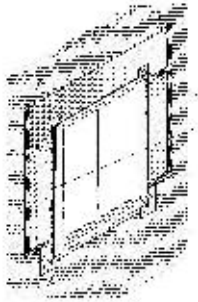
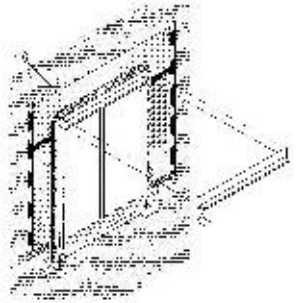
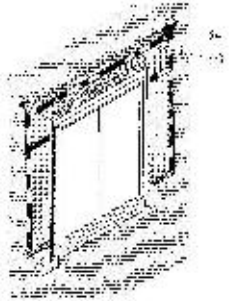


STEP 10



STEP 11



Source:
Ankrom Moisan

ANKROM MOISAN

PEARL FAMILY HOUSING

WINDOW FLASHING SEQUENCE

A4.39

CONSTRUCTION SET

PFH - Airtightness

- PFH energy model based on Sitka airtightness:
  - 0.16 ACH natural
- Air leakage rate for project not specified
- A qualitative air barrier requirement…
  - Based on construction of air barrier system in compliance with project-specific details and specifications


Tyvek
GlasRoc
JLG LIFT
ALL BLACKS


Tyvek
PM
WB
GTS


Tyvek


DUPONT
Tyvek
COMMERCIALWRAP


vek
DUPONT
Protecto Wrap


Tyvek


Tyvek
COMMERCIAL WRAP

PFH

- Infrared Thermography

The Ramona Apartments

Infrared Imaging Report

Air tightness testing and infrared imaging were conducted on Friday, March 4 and Saturday, March 5 at the Ramona Apartments on the corner of NW 14th and Quimby Streets in Portland, Oregon. The tests were conducted as part of a nationwide ASHRAE study to determine air leakage rates for commercial buildings in the United States. On Friday, March 4th, the Ramona was not pressurized, although the heat in the units was raised to 74 degrees to provide a significant temperature differential between the interior and exterior of the building. On Saturday, March 5th, the heat was returned to a setting of 68 degrees F, while negative and positive pressures were induced on the building to measure air leakage rates through the building envelope. This report documents qualitative information documenting areas of air leakage and thermal bridging as seen with an infrared camera.

The camera used for this imaging is a Flir B400 model which is capable of taking infrared, digital and "fusion' images, which combine both digital photographs and infrared images into one image. Examples of fusion images are found on pages 6 and 7 of this report.

Images on the following pages are first described by indicating the date and time the image was taken, the atmospheric temperature and whether or not pressurization was underway at the time of the image. A brief summary on areas for future improvement can be found at the end of this report.

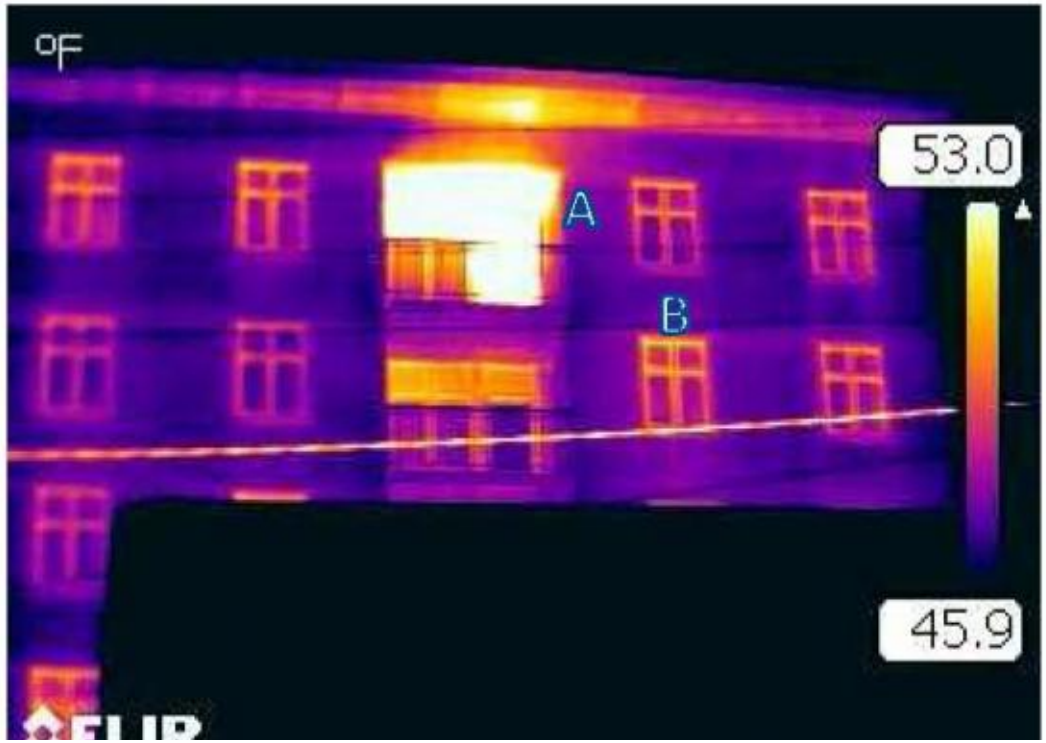
What information does an infrared image convey?

Infrared imaging works by providing a visual representation of the infrared energy emitted by objects. The images allow us to see how heat is distributed. Note on the scale on the right hand side of the image that cooler temperatures are shown as darker while warmer temperatures are lighter. In this particular image, one can see the natural stack effect in the building, as the temperature of the building exterior gets hotter at the upper floors as the heat from each floor continues to rise through the building, resulting in warmer temperatures on the upper floors.

\Infrared imaging can help to highlight areas of air leakage and thermal bridging. It will locate areas that need further study. Infrared imaging does not, however, diagnose the cause of the problem.

Friday, March 4th 4:20 PM 55 degrees F
West Elevation

Thermostats in the units were set to 74F. Visible at the sixth floor deck on the north elevation is the location of one of 10 blower doors installed in the building, seen clearly as a bright area (A). The blower door is turned on and is discharging the heated air from the building, which is clearly heating the window system, the deck soffit and the building overhang. The window head on the fifth floor (B) shows heat transmission through the vinyl frame of the window. This is typical given that the vinyl frame has a lower U value than the glazing or the opaque wall and the vinyl frame acts to conduct the heat to the exterior.

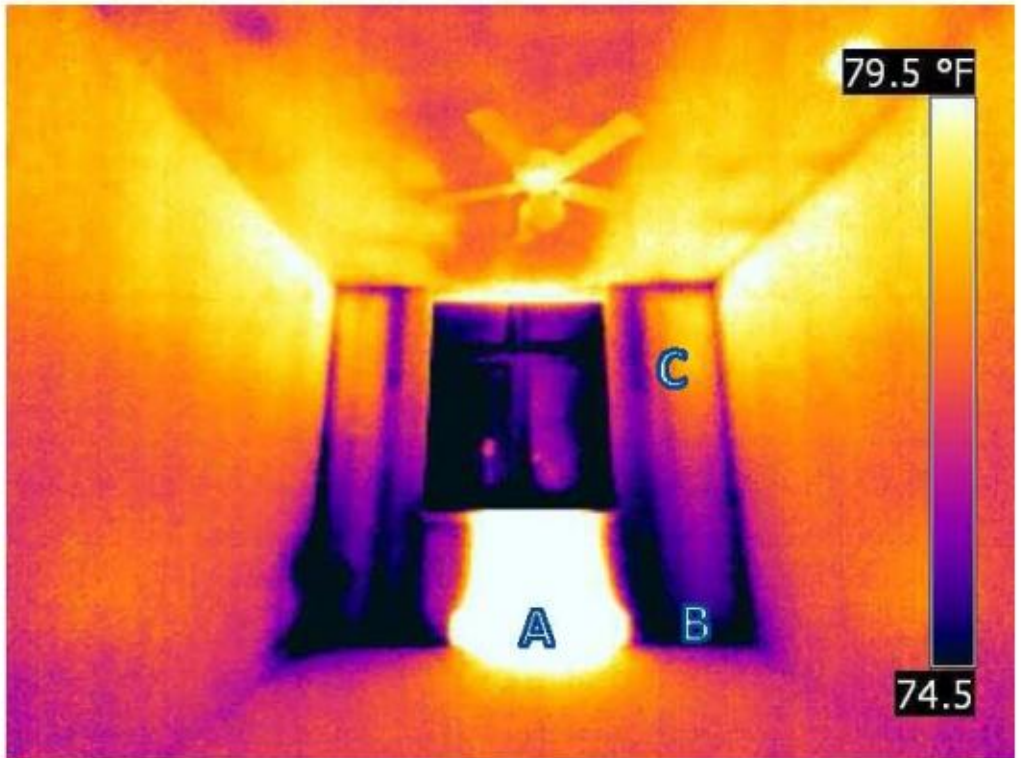


Friday, March 4th 4:20 PM 55 degrees F
South Wall of Courtyard

Air leakage is visible at the roof to wall connection (A). It is not unusual to see air leakage at such intersections, especially at inside and outside building corners, as air barrier construction is difficult where the building geometry is complex. The brick ledger (B), is also visible as a clear thermal bridge, conducting heat through the building frame to the exterior. It is typical for brick ledgers to conduct heat unless thermally isolated from the building frame. Note the heat signature at the outside edge of the soffit (C). The roof-to-wall intersection is the likely source of this warm air leakage.

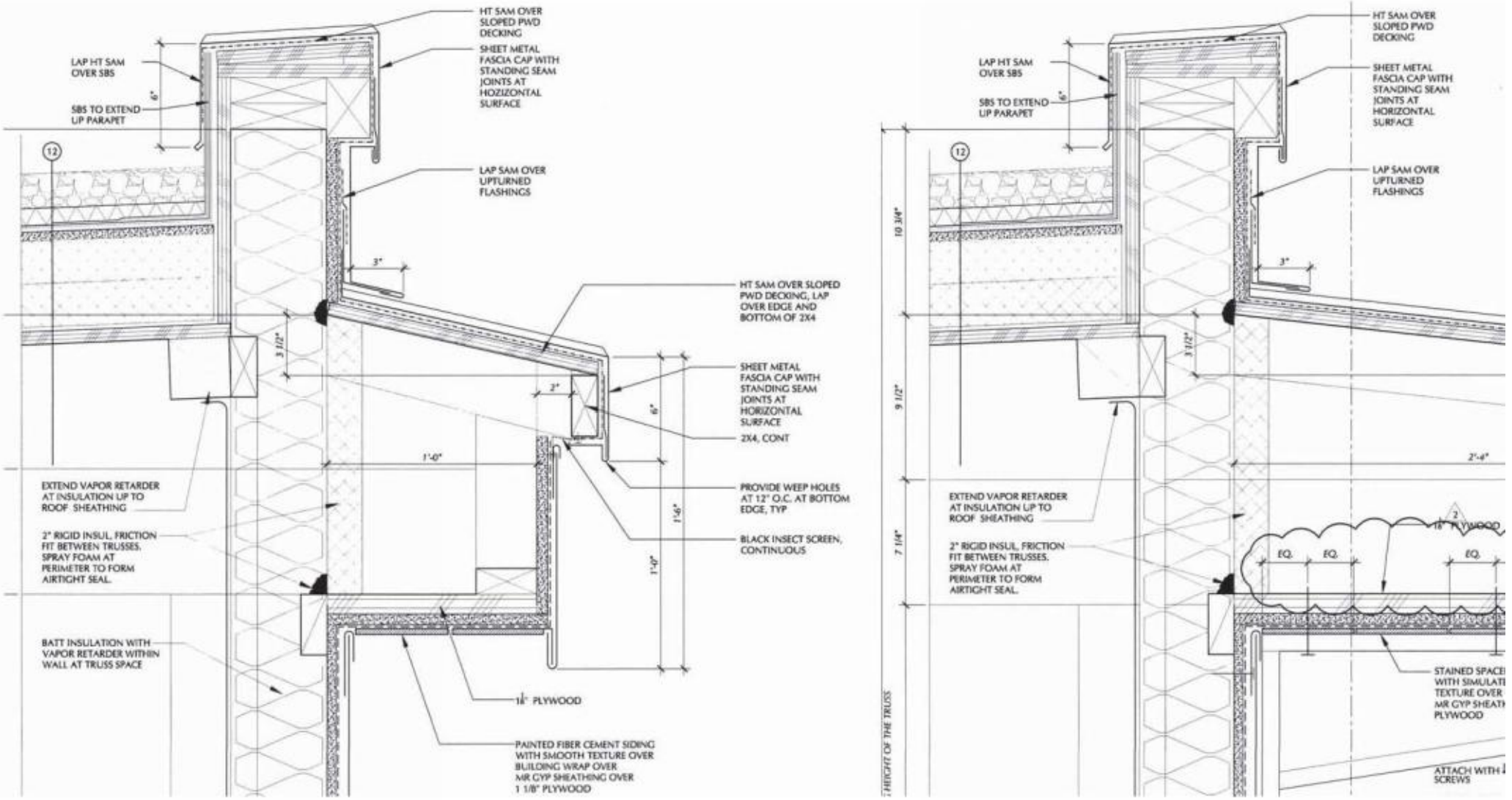
Friday, March 4th 4:20 PM 74 degrees F
Interior Fifth Floor Unit, West Elevation

The baseboard heater (A) is clearly evident as a very bright heat signature below the window with warm air rising up toward the window. Note that convective looping and air stratification likely account for the cool spots at the floor level at the outside corners (B). Dark vertical lines on either side of the window (C) are evidence of the lack of thermal resistance of the large wood timbers that support the exterior sunshades at the west elevation.

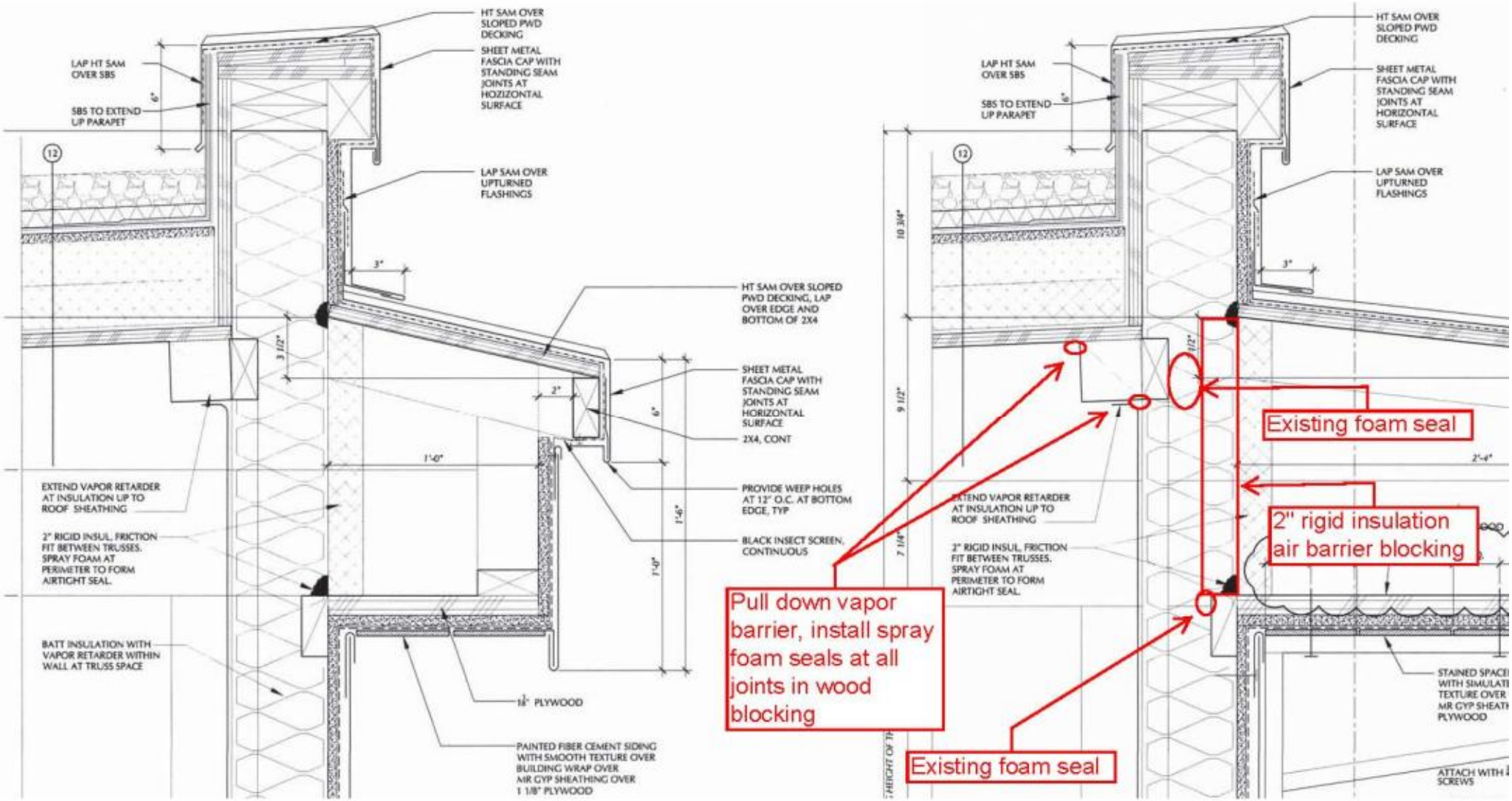



EXIT

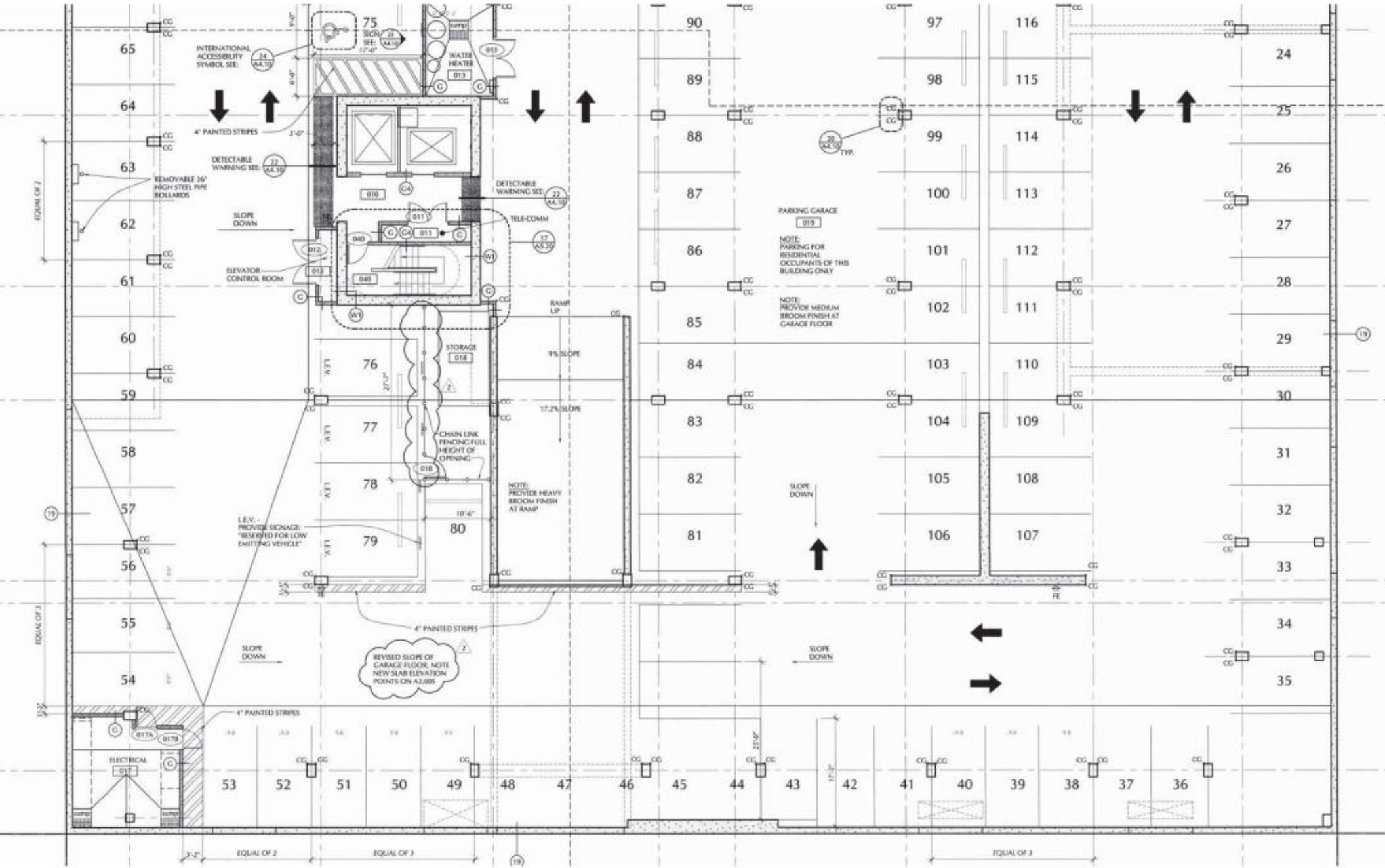

System (whole building)
airtightness:
0.** cfm/sf @ 1.57 psf**



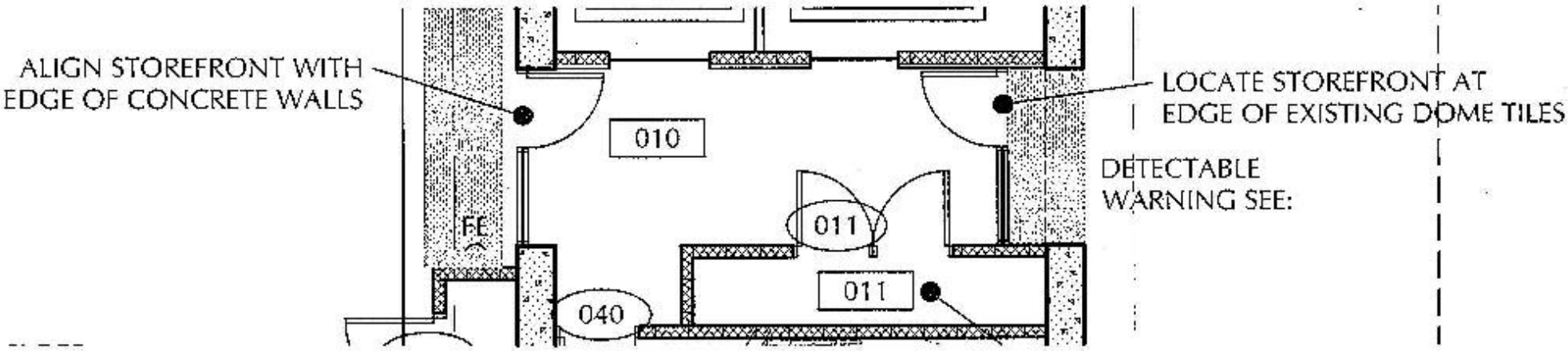
Source: Ankrom Moisan



Source: Ankrom Moisan



Source: Ankrom Moisan



Source: Ankrom Moisan

Conclusions

- Specifications
  - Sitka results
  - Comment on Washington Codes
- Drawings
- Schedule
- Results
  - What if the results aren’t good?