WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

AIVC Conference on air-tightness

Air Tightness Performance of Whole Buildings: Design, Construction and Verification Testing

April 18-19, 2013

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Wiss, Janney, Elstner Associates, Inc.

Whole Buildings Airtightness Verification Testing

- ASHRAE 1478 RP
  - Protocol and Testing
  - Results of Research
- Other Results

ASHRAE 1478 RP

ASHRAE 1478 RP: Measuring Air-Tightness of Mid and High-Rise Non-Residential Buildings

Background

- Lack of scientifically gathered and reported data on modern mid- and highrise non-residential buildings

Objective and Scope

- Measure and report air leakage rates for existing mid- and high-rise buildings
- Develop protocol for testing large buildings
- Analyze results with respect to design and construction parameters
- Complete study in 3 yrs

Key Players ASHRAE 1478 RP

- Wiss, Janney, Elstner, Associates, Inc. Principal Researcher
- Terry Brennan, Camroden Associates
- Gary Nelson and Collin Olson, The Energy Conservatory
- Dave Bohac, Center for Energy and Environment
- Larry Harmon, Air Barrier Solutions
- Jim Cummings and Chuck Withers, FSEC

ASHRAE 1478 RP Participants and Budget

- ASHRAE Research - $150,000
- Wiss Janney Elstner Research - $70,000
- Oak Ridge National Labs / DOE - $50,000
- DuPont Innovations - $30,000
- Energy Conservatory - equipment + expertise, $?
- Air Barrier Solutions - investigations, $?
- Camroden Associates - expertise, $?
- Center for Energy and Environment - $?

ASHRAE 1478 RP: The Plan

- Develop testing protocol
- Select buildings
- Prepare for testing
- Execute testing
- Report findings
- Write paper
- Propose changes to ASHRAE HOF

Current Protocols

- ASTM E779 - US Protocol
- ABAA/US Army Corps of Engineers Protocol
- CAN/CGSB -149.10
- ISO 9972 - International
- BS EN 13829:2001 – British standard
- CIBSE TM-23 Standard

Revised Protocol: Goals

- Address the challenges with testing larger buildings
- Allow reliable comparison of building sample
- Reliably Reproduce Results
- Consider aspects of design or construction

Challenges: Large modern buildings

- Pressure boundary definition
- More penetrations
- Stack and wind effects
- Measuring pressure differences
- Complex geometries
- Uniform air pressure distribution

Test Protocol: Measurements

- Depressurizing and pressurizing airflows
- Pressure differences induced across building enclosure
- Interzonal pressure differences
- Indoor and Outdoor air temperatures
- Wind speed, Gusting, Stack Effect
- Damper Leakage

Protocol Revisions/Considerations

- Blower doors vs mechanical equipment
- Creating a single zone vs sub-set of floors
- Weather Conditions and Stack Effect
- Measuring Building and Roof Pressures
- Contribution of HVAC penetrations
- Mechanical Room Doors
- Interzonal Pressure Differences
- Smoke testing

Test Protocol Equipment


Candidate Building Selection

- 16 Buildings Reported
- Non-residential
- 4 stories or higher
- Sustainability certification (14 of 16)
- Built after the year 2000
- Climate zones 2-7 (All 6 Zones Represented)

Challenges: Candidate building sample

- Owner interest
- Owner costs and responsibilities
- Location and climate zone
- Occupancy / Access
- Willingness to share data
- Timing

What more do we need?

- Pre-Test Preparation
- Logistics
- Test Day Preparation
- Test Execution

	ACTIVITY DESCRIPTION:	Status	Responsible Party
	Master Protocol Draft to WJE	Active	T. Brennan
	Mechanical Drawings from Walsh	Active	WJE, Walsh
	Confirm Area and volume calculations for incorporation into protocol	Active	WJE
	Develop TEC-LOG2 Configuration	Active	WJE, EC
	Updated plans (with color-coded legend) for incorporation into protocol	Active	WJE
	"Working" test participant list with contact information and testing role for incorporation into protocol	Active	WJE, All
	List of MEP penetrations through building enclosure and recommended methods for sealing penetrations for incorporation into protocol	Active	WJE, EC
	Confirm interior door count and coordinate door wedges	Active	WJE, EC
	List of equipment to be used for testing	Active	EC, WJE
	List of potential building enclosure "problem areas" to for incorporation into protocol	Active	WJE
	Development of revised protocol	Active	WJE, T. Brennan
0	Conference Call	Active	All
1	Secure volunteers for testing	Active	TBD
	Ship all equipment and supplies to Portland,	Active	EC, WJE
2	Assignment of volunteers to monitor façade and exit doors	Active	TBD
	Verify all site access and safety requirements. This includes roof top tie-off requirements	Active	WJE, Walsh

Pre-Test Preparation

Collecting information

- Construction documents and building data
  - Building plans and specifications
  - Mechanical schedule
  - Shop Drawings
- Preliminary site visit(s)

Pre-Test Preparation

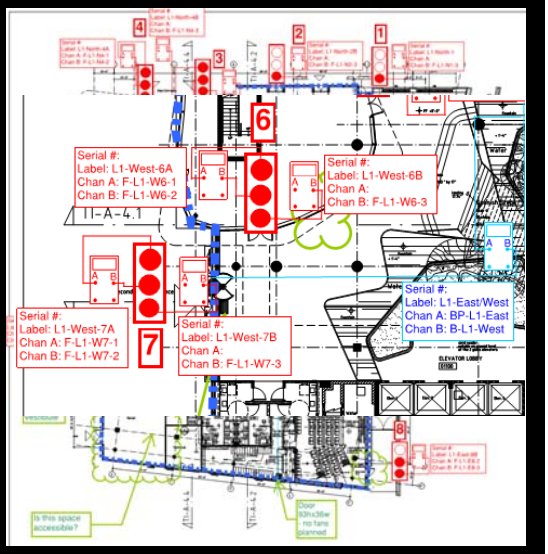
Site Coordination

- Establish dates for testing
- Building personnel (HVAC, Electrical, Security)
- Identify security issues or special conditions
- Identify anticipated occupancy during testing

Pre-Test Preparation

Equipment

- Number of fans
- Distribution and cable/tubing runs
- Establish device mapping for data collection software



Test Day Preparation

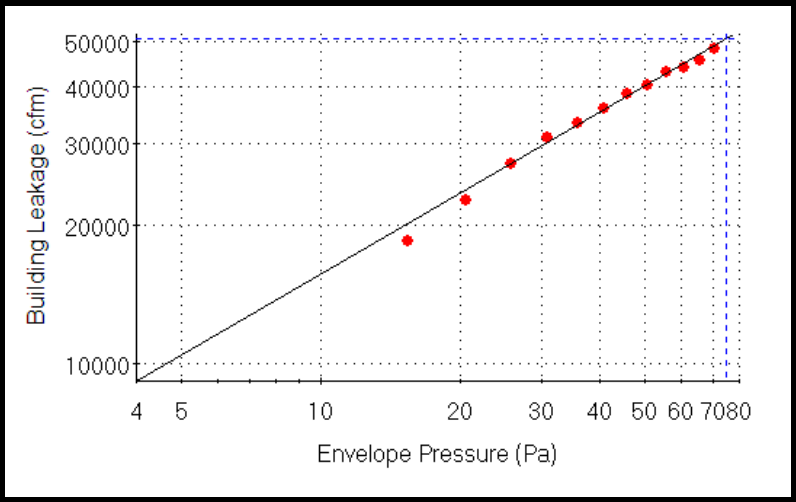
Prepare HVAC System

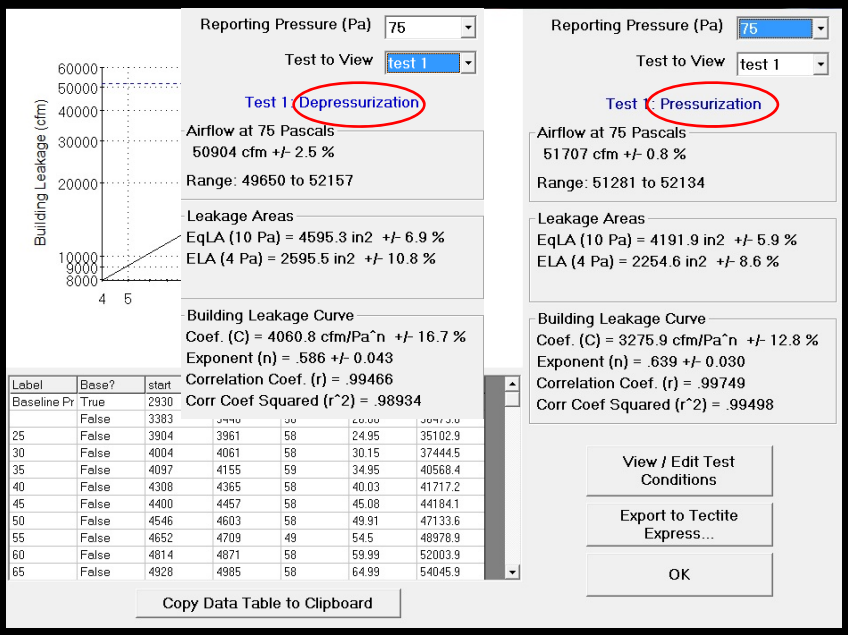
- Open return air dampers (Create single zone)
- Close operable dampers (OA, exhaust, pressure relief)
- Close or mask gravity dampers
- Mask un-dampered exhausts
- Check for combustion equipment

Test Day Preparation

Test Execution

Data Analysis and Calculations





Optional Investigations

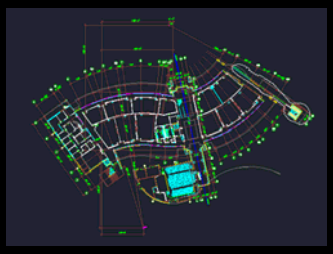
- Penetration Masking
- Leakage Site Detection
  - Smoke
  - Infrared

Reporting and Documentation

- Reporting per ASTM E 779 Section 10
- Building and Systems Description
- Leakage Rates: Total Enclosure / Above Grade Enclosure
- Additional Metrics (ACH50)

Air Barrier System	N None identified Y/N/NA Code required Y Part of Design drawings and specifications N Target airtightness level and pressure test specified
Enclosure Description	*Roofs: Concrete slab with SBS-modified bituminous roofing, a vegetative topping and solar paneling* *Walls: Concrete, steel first floor and wood frame construction. 2.5" airspace and 3.6" brick veneer.* *Fenestration: Most windows are operable outward-opening casement style in the living spaces* *Foundation: One foot think concrete wall*
Architectural features likely to result in significant air leakage	N soffits (rear and front) N complex intersections N vented roof assemblies *Other:* • Loading dock • Open courtyard • Rooftop door weatherstripping • Attic area between finished ceiling and roof • Laundry through-wall equipment
Areas of the building where the air barrier location is uncertain	Y mechanical rooms Y attics Y garages (underground) N crawlspaces Y basements N trenches tunnels

Building 1: Office Building

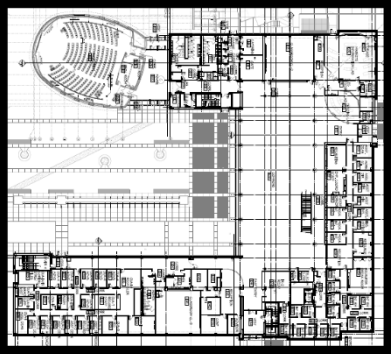


Orlando, FL; Climate Zone 2B

Results

$CFM75_{total}$	CFM75/total A_s	CFM75/above grade As	ELA (in^2)	EqLA (in^2)	C, n
55737	0.41	0.53	3125	5371	5113, 0.6

Building 2: Business Instructional Facility



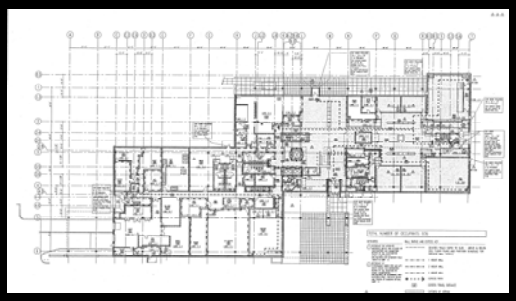
Champaign, IL; Climate Zone 5
LEED Platinum

Results

$CFM75_{total}$	CFM75/total A_s	CFM75/above grade As	ELA (in^2)	EqLA (in^2)	C, n
117077	0.59	0.79	4644	8892	6453, 0.67

Building 3: Corporate HQ

Maple Grove, MN; Climate Zone 6
LEED Platinum

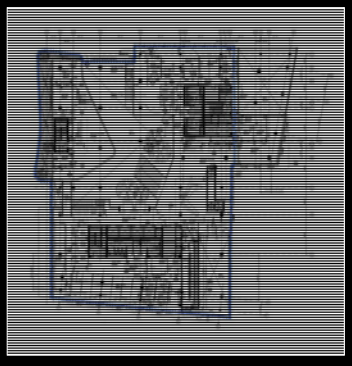


Results

$CFM75_{total}$	CFM75/total A_s	CFM75/above grade As	ELA (in^2)	EqLA (in^2)	C, n
26215	0.14	0.18	1329	2356	2076, 0.59

Building 7: Corporate HQ

Cambridge, MA; Climate Zone 5A
LEED Platinum



Results

$CFM75_{total}$	CFM75/total A_s	CFM75/above grade As	ELA (in^2)	EqLA (in^2)	C, n
52023	0.31	0.39	2369	4345	3514, 0.62

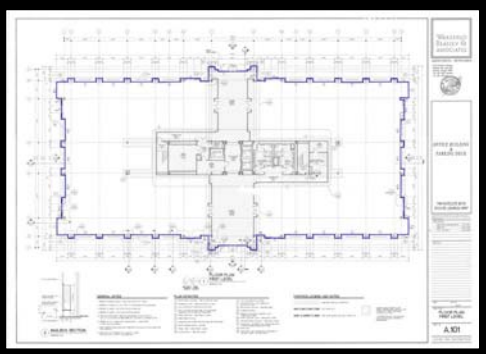
Building 7: Corporate HQ

Results from additional investigation include:

- A 16 Pa pressure difference between the double façade and the building
- Exterior façade was tighter than inner facade

Building 6: Office Building

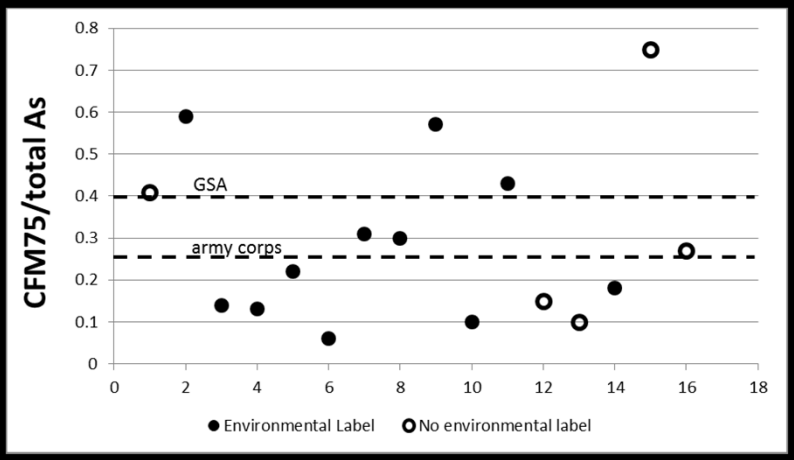
Duluth, GA; Climate Zone 3A
LEED Gold



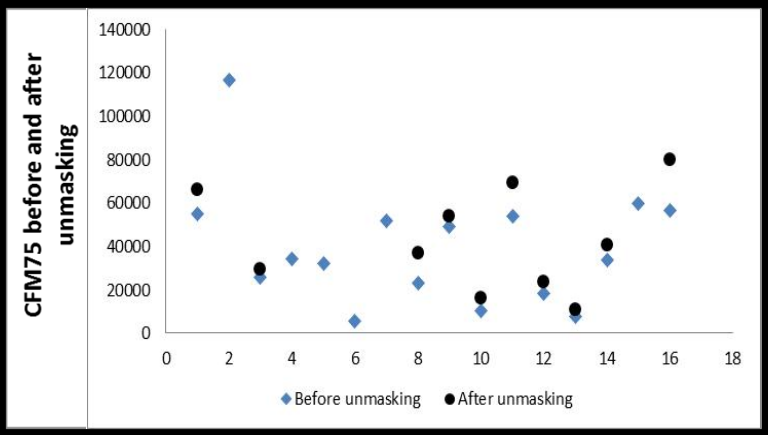
Results

$CFM75_{total}$	CFM75/total A_s	CFM75/above grade As	ELA (in^2)	EqLA (in^2)	C, n
6165	0.06	0.08	329	575	527, 0.57

Results: CFM75/Total As



Results: Increase in Volume Flow at CFM75 due to Unmasking



Common Problems

- Areas that should/may be outside pressure boundary
  - Loading docks
  - Mechanical, electrical, generator rooms
  - Garages
  - Double facades
- Roof to wall intersection
  - Separation of building and vented attics
- Fenestration connection to opaque wall / roof
- Soffits, "wings" and canopies connected to building
- Weatherstripping
- HVAC system leakage
  - Stuck dampers, non-adjusted dampers, leaky dampers
  - Damperless exhausts - kitchen hoods, bathroom exhausts
  - Utility tunnel closures in building sometimes non-existent
  - Utility, chimney and pipe wall and roof penetrations unsealed.

Thank you!

Questions?