Fenestration Air Leakage

A comparison of Field measurements with laboratory tested values

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About this presentation

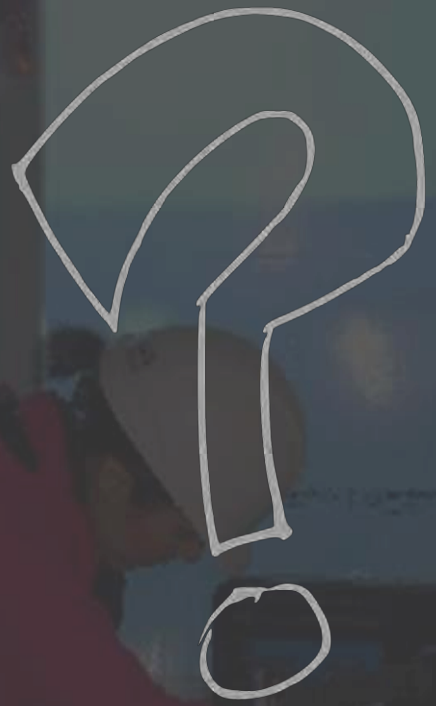
Why – Motivation

How – Test procedure and methods

What – Results

What – Discussions/Comparisons

Motivation of my work



How the laboratory fenestration air leakage measurement compares to the installed product?

Motivation of my work

Study undertaken for Lawrence Berkeley Laboratory

Weidt et al (1979) and Weidt et al (1980)

Compared air leakage characteristics of 192 newly installed windows in residential buildings to the industry, government standards and manufacturer's reports.

Performance capabilities

Today's Concerns

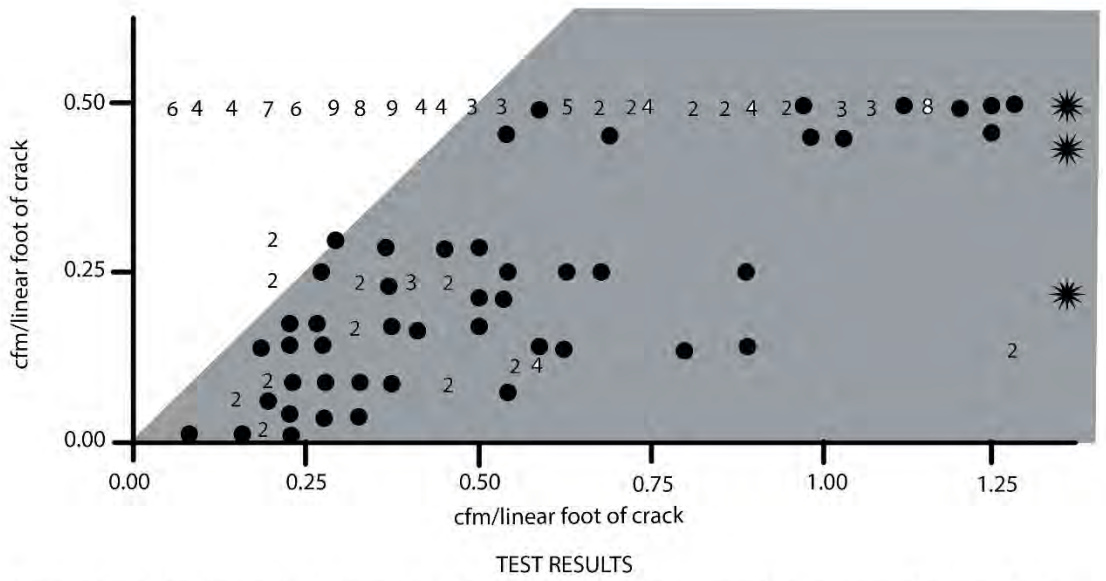
No modern day studies providing similar comparisons

“Designers and builders who specify and purchase windows frequently assume that these laboratory test results are indicative of the window’s field performance capabilities and make their selections accordingly”. Weidt et al. (1980)

Motivation of my work

- Air leakage of newly installed windows can be significantly higher than might be expected from laboratory tests.
- 40% of all windows tested possessed air leakage higher than industry and government standards.
- 60% of the windows tested exceeded the specification of the manufacturers.
- 29% Decline in air leakage characteristics of 25 windows from the time they were manufactured to the time they were installed.
- The study noted some impact of manufacturers and installers on air tightness performance but not as great as the operation type.

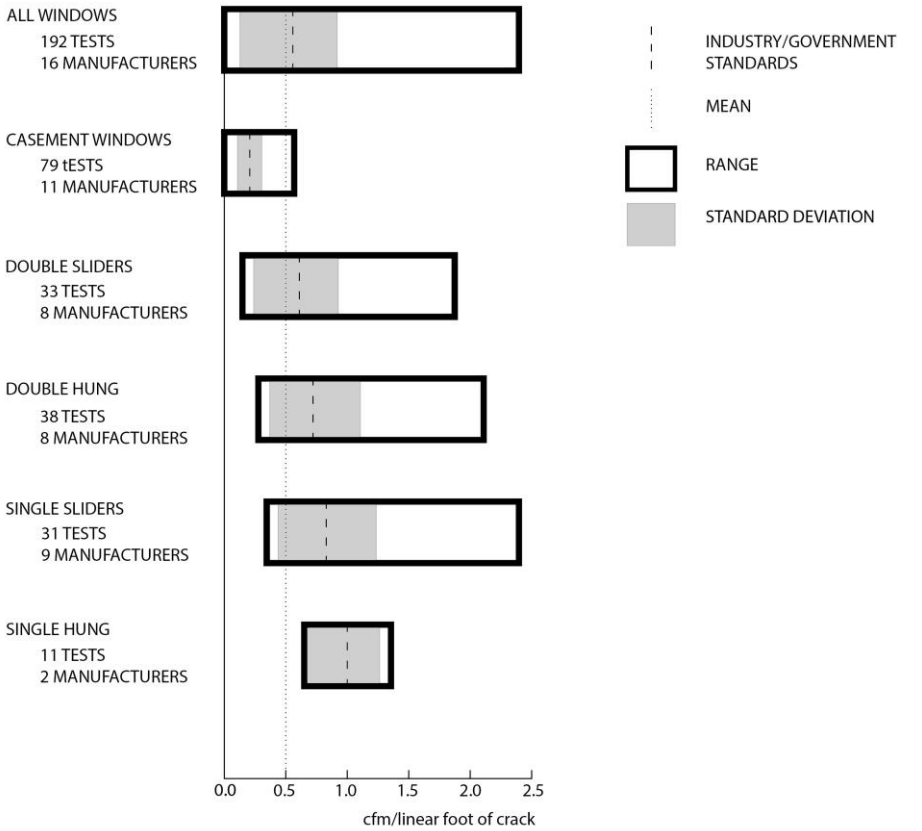
Motivation of my work



TEST RESULTS

Results of each test are plotted relating their field test performance to manufacturer's specifications. Each number indicated that more than one result occurred at a given point. As an example, a point occurring at X=.75, Y=.25 means that the window's manufacturer reported a lab test at .25, the field-measured leakage of the unit was .75. points within the grey area related to windows whose field air leakage were greater than reference. The ✷ designate outliers.

Weidt et al. (1979) – Variation between field and laboratory test results



Weidt et al. (1979) – Variations in field air leakage by window type

Motivation for my work

ASTM E783-02 (2010) Section 5.3

Variations between field measured air leakage and laboratory tested air leakage

The correlation between actual performance of in-service products and the response to these tests has not been established because of insufficient data.

Motivation for my work

AAMA 502 V/S **CSA A440.4.**

Field air leakage testing fenestration standards

Questions that need answering

How does the field tested values compare to laboratory tested values?

Is there a recognizable statistical variation in field tested values?

What is the magnitude of this difference?

Method

- Selection of building
- Reviewing the drawings
- Selection of type of fenestration for use within the study/selection the test samples
- Visual review of test samples

Field air leakage tests

Method-Identifying the study population

- Typically the size of the sample in such a study needs to be determined based on the level of confidence and the confidence interval desired from the expected results.
- It is assumed for this study that the air leakage of the doors would follow a normal distribution.
- There are no previous studies that provide an estimate of the variance to be expected in air leakage rates related to manufacturing and installation considerations.
- A sample size of 30 would be statistically adequate for a study to determine the mean that would be representative of the population with a confidence level of 95% with a standard deviation of 25% of the mean and the margin of error of 10%.

Method

Floor	Number of Type I Patio Doors	
	Total	Tested
Podium	None	None
To 10th	24	0
11th – 15th	11	4
16th -20th	18	2
21st – 25th	26	3
26th – 30th	33	2
31st – 35th	27	2
36th – 40th	41	3
41st – 45th	22	1
46th – 50th	54	7
51st – 55th	33	5
55th and more	21	3
Total	310	32

Distribution of the doors in different floors

Typical test assembly

Wind Maker test equipment

Air flow and Pressure measuring devices

Method - Variable test conditions

Date	Inside Temperature (°C)	Outside Temperature (°C)	Wind Direction/Speed (Km/h)
Nov. 19, 2016	12 to 15	0.585	W – 20 to 26
Dec. 1, 2016	7 to 8	0.503	W – 24 to 38
Dec. 3, 2016	5 to 13	0.199	NW – 11 to 25
Dec. 16, 2016	13	0.714	W – 24 to 31
Dec. 28, 2016	20	0.293	W - 25

Temperature and wind conditions during testing

The results obtained from field tests were tabulated and corrections applied to bring the air leakage measurements to 20° C.

In Accordance with ASTM E783
Calibrated Wind Maker Plus

Method - Test procedure

1. The patio door was examined from the inside and the outside for signs of conditions that may impact air leakage measurements

2. Ambient conditions of temperature and relative humidity were measured. Wind speeds were noted based on local weather reports.

3. A chamber was created on the interior using poly sheets. The fan apparatus was connected to the chamber.

4.The exterior was isolated with poly sheets taped to the frame.

5. The chamber was depressurized and infiltration was measured at 4 different pressure differences: 25, 50, 75 and 100 Pa. Visual observations using smoke pencils and infra-red thermographic camera were made to study paths of air leakage.

6. The exterior poly sheet was removed and the step 5 was repeated.

Results - Air leakage results at 75 Pa

Test Number	Level	Air leakage (L/s)/m²
1	47	0.585
2	46	0.503
3	43	0.199
4	20	0.714
5	17	0.293
6	14	0.515
7	14	0.749

Nov. 19, 2016

Test Number	Level	Air leakage (L/s)/m²
8	64	0.775
9	64	0.521
10	58	0.407
11	54	0.604
12	11	0.654

Dec. 1, 2016

Test Number	Level	Air leakage (L/s)/m²
14	53	0.483
15	53	0.894
17	50	1.112
18	50	0.592
20	35	0.423
21	35	0.604
22	26	0.785
23	26	0.846

Dec. 3, 2016

Test Number1	Level	Air leakage (L/s)/m²
25	36	0.130
26	22	0.526
27	22	0.886
28	22	1.155

Dec. 16, 2016

Test Number	Level	Air leakage (L/s)/m²
31	48	0.904
32	54	0.628

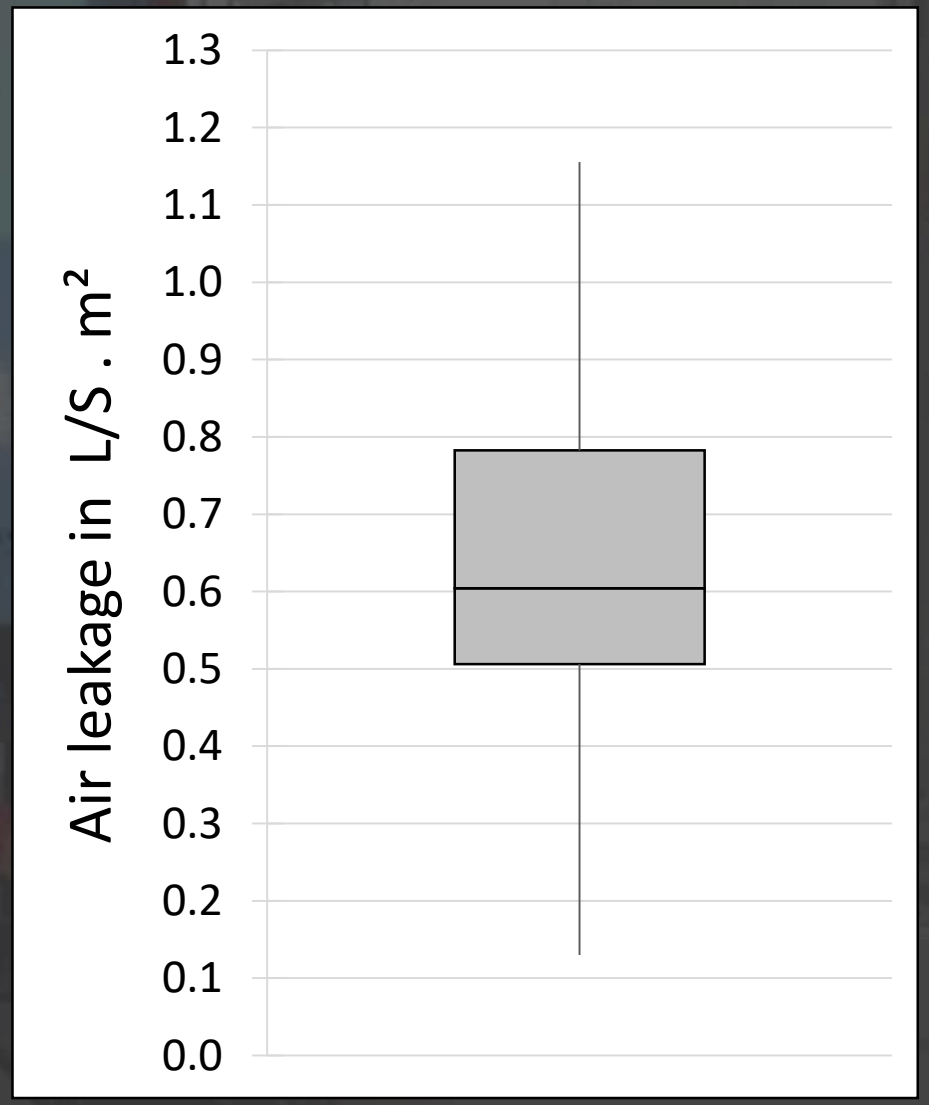
Dec. 28, 2016

The air leakage reported in the laboratory test report was 0.5 l/s/m² at 75Pa pressure difference in infiltration and exfiltration as tested in accordance with ASTM E283.

Results - Distribution at 75 PA

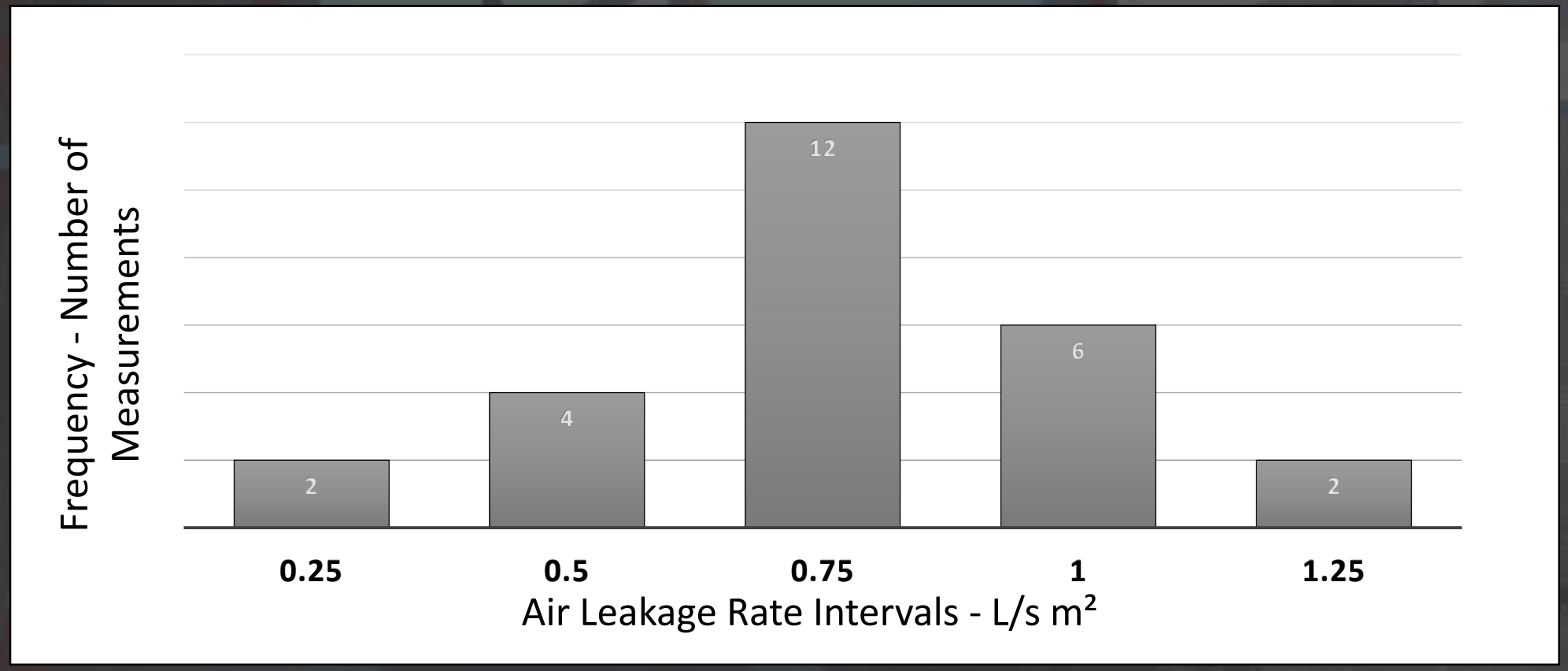
Minimum value 0.13 L/sm²
Maximum value 1.15 L/sm²
Median 0.60 L/sm²
Mean 0.63 L/sm²
Standard deviation 0.24 L/sm²

Interquartile ranges
0.5 – 0.8 L/sm²



Results - The air leakage frequency distribution

Based on a bin interval of 0.25 L/s m²



The distribution follows a normal Gaussian distribution.

Analysis - The air leakage rates

Source	Air leakage (L/s)/m²
Laboratory Tested Value /Used for Certification1	0.500
Mean of Field Tested air leakage rate	0.634
Median of Field Tested air leakage rate	0.604
Minimum of Field Tested air leakage rate	0.130
Maximum of Field Tested air leakage rate	1.155
1.5 x Laboratory Value (AAMA 502 Allowable)	0.750
A440.4-07 Allowable – A1	0.977
A440.4-07 Allowable – A2	0.577
A440.4-07 Allowable – A3	0.350

Air leakage rates for comparative analysis

Analysis - The air leakage testing standards

AAMA 502

V/S

CSA A440.4.

- **When to test ?**
- **How to test ?**
- **How many tests ?**
- **What is an allowable rate?**

Analysis - Discussions

Not clear if the average values should be used or that no field measured value should be greater than the criteria stated in AAMA/CSA Standard ? Or the amount by which the measured values have exceeded the benchmarks is important?

- Comparison of mean to the AAMA allowed value

Among the tested fenestration products:

77% will not meet the laboratory measured test result.

31% will not meet the AAMA 502 criteria based on the laboratory field result.

Highest value of 1.155 L/s m^2 exceeds the AAMA 502 benchmark by 54%

- Comparison of mean to CSA A440.4 allowed value

Similar conclusions can be drawn about the allowable values for A2 and A3 rated doors

Analysis - Discussions

What is lacking:
Setting a practical standpoint
Defining a method of sampling

Conclusions

Thank you

This research was completed as part of Ryerson's master of building science

Read Jones Christoffersen financially supported this presentation

Questions