REAL STORIES FROM REAL BUILDINGS

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Ventilation Conundrum at the YMCA

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Fig. 1.

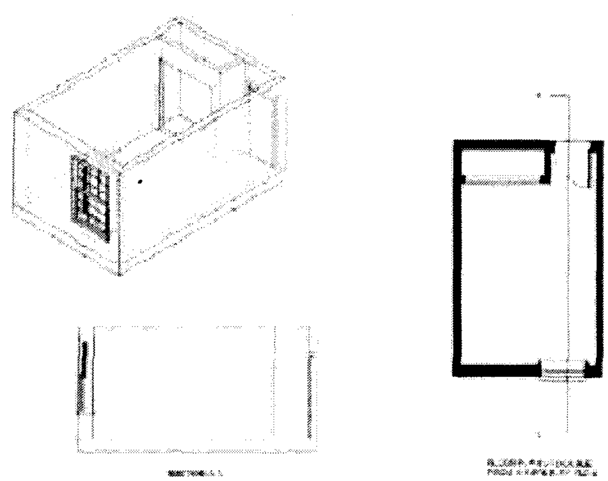


Fig. 2.

Abstract

As part of a Vital Signs case study, the YMCA in Berkeley, California was tested to analyze the benefits of replacing the windows in the residential rooms, which are in a ninety-year old section of the building. The hypothesis was, "By installing new windows in the residence rooms at the Berkeley YMCA, the ventilation rate will fall below the ASHRAE standard." (ASHRAE standard is 30 CFM for hotel rooms). A blower door and CO2 meters were used to test three residential rooms of varying size for air tightness and natural ventilation rate. The results did not prove the hypothesis correct for all of the rooms tested. Two of the three rooms were over-ventilated, resulting in excessive heat loss during the winter. However, it was observed that many residents leave their windows open during the winter, perhaps for thermal control or for air quality reasons. It was observed that the rooms have no mechanical system for ventilation and no vents for cross-breezes. To improve energy efficiency and comfort in the residential rooms, it was concluded that the windows in the residences should be repaired on an individual basis, as whole scale replacement would not be cost effective. Further investigation into systems for providing cross-ventilation is necessary.

Introduction

In February of 2001 as part of a Vital Signs case study, the YMCA in Berkeley, California was looked at for possible investigation. (see Figure 1) During the building tour, Fran Gallati, the Executive Director of the YMCA, mentioned that the YMCA was thinking about installing new windows and new radiators in the residential rooms. The 80 residential rooms house both short and long-term residences and vary in size from 190 ft2 to 230 ft2 with a ceiling height of approximately 9 ft. (see Figure 2) The radiators are steam

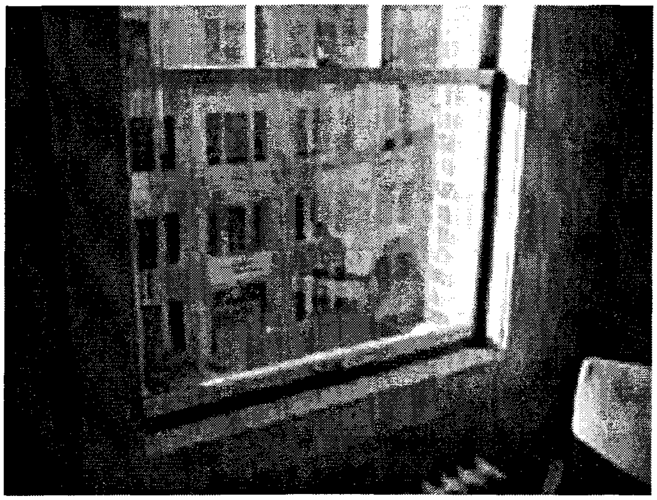


Fig. 3.

driven and have no room controls. We more comfortable.

Hypothesis

By installing new windows in the residence rooms at the Berkeley YMCA, the ventilation rate will fall below the ASHRAE standard.

Inquiry

* How airtight are the rooms?
* What is the current ventilation rate?
* Why do occupants leave the windows open even when the heat is on?
* Do people prefer open windows for ventilation or mechanical ventilation?
* What is the ASHRAE standard for hotel rooms and is it adequate for comfort?
* Would the occupants use room controls if they were installed on the radiators?
* What is an alternative to the transom windows for cross ventilation in the summer?

Ventilation

All of us want fresh air wherever we are, but there is a balance game once we are inside of a building.

Can we have too much fresh air? No, but inside we also want to feel thermally comfortable. The balancing game is the quest for energy efficiency and fresh air. These two are sometimes in conflict as the more outside air that is taken in means the more energy that must be used in order to bring the air up to a hermally comfortable level.

As shown by the equation:

Heating Load = UA Windows + UA walls +UA Ceilings + UA Floors + Air Infiltration Load

Air Infiltration Load:

C x Volume of air (CFM) x [delta]T (°F)= Heat loss (btu/hr)

(Where C = 1.1)

this is a factor that includes density and specific heat of air and a time conversion.

As a result, designers often tried to minimize the amount of air infiltration in order to save energy, which led to sick buildings because they did not have enough ventilation.

In order to combat this problem ASHRAE between 1972 and 1989 made a recommendation that buildings have at least 5 cfm per person. ASHRAE realized that this rate was too low. They have since revised the recommendations. The new ASHRAE Standard for

Room 317 triple room Fan Pressure Ring B installed									
	Room Pressure	Fan Airflow	Correction Factor For 50ACH	Corrected CFM50	Room Volume (Ft^3)	Correlation Factor	ACH50	Seasonal Natural ACH	Natural Ventilation Rate (CFM)
Windows Sealed with Tape	20	460	1.8	825	2052	12.25	24.21	1.98	68
Windows Not Sealed	15	463	2.2	1056	2052	12.25	30.88	2.52	86

Room 314 double room Fan Pressure Ring B installed									
	Room Pressure	Fan Airflow	Correction Factor For 50ACH	Corrected CFM50	Room Volume (Ft^3)	Correlation Factor	ACH50	Seasonal Natural ACH	Natural Ventilation Rate (CFM)
Windows Sealed with Tape	25	435	1.6	686	1683	12.25	24.53	2.00	56
Windows Not Sealed	25	470	1.6	752	1683	12.25	26.81	2.19	61

Room 417 triple room Fan Pressure Ring B installed									
	Room Pressure	Fan Airflow	Correction Factor For 50ACH	Corrected CFM50	Room Volume (Ft^3)	Correlation Factor	ACH50	Seasonal Natural ACH	Natural Ventilation Rate (CFM)
Windows Sealed with Tape	50	260	1	260	2052	12.25	7.60	0.62	21
Windows Not Sealed	25	420	1.1	462	2052	12.25	13.51	1.10	38

hotel bedrooms is 30 cfm/room.

Tests

In order to test how airtight the rooms are and the ventilation rate, two test methods were chosen, a blower door test and a CO2 level test.

Blower Door Test

Testing natural air exchange with blower door

Three rooms were tested with a Minneapolis Model 3 Blower Door. The Test Method chosen is known as ACH50. This method measures the airflow necessary to pressurize the building to 50 Pascals. The seasonal amount of natural air exchange is estimated using the divide by 20 rule or by an estimated correlation factor. One test was done with the window sealed with tape and one was done without sealing. (See Figure 3)

Steps for blower door usage

1. Measure room dimensions to calculate area and volume.
2. Measure ambient temperature inside and out.
3. Turn off all combustion appliances.
4. Verify condition of intentional openings.
5. Decide on configuration of doors to semi-conditioned spaces.
6. Set up Minneapolis blower door.
7. Set gauges to zero.
8. Take measurements.

Correlation Factor

N = C * H * S * L

where:

C = climate factor, a function of annual temperatures and wind

H = height correction factor

S = wind shielding correction factor

L = leakiness correction factor

For the YMCA,

C= 25

H = 0.7

S = 1.0

L = 0.7

So, Correlation Factor, N = 12.25

CO2 Level Test

Spot-checking with CO2 monitor

Testing natural air exchange with CO2 monitor and CO2 Calculator.

Measure the outside CO2 concentration.

Measure indoor CO2 levels 2-3 hours after initial occupancy and determine an average peak value.

In the "Outside CO2 Concentration" box, find the CO2 value closest to your measured inside peak CO2 value by moving the slider.

The black bar in the center window should indicate the approximate cfm-per-person ventilation of the space.

The natural ventilation rate for Room 417

Using the Ventilation Calculator and the values of:

Window Closed

Outside CO2 Level: 485ppm

Inside CO2 Level: 1100ppm

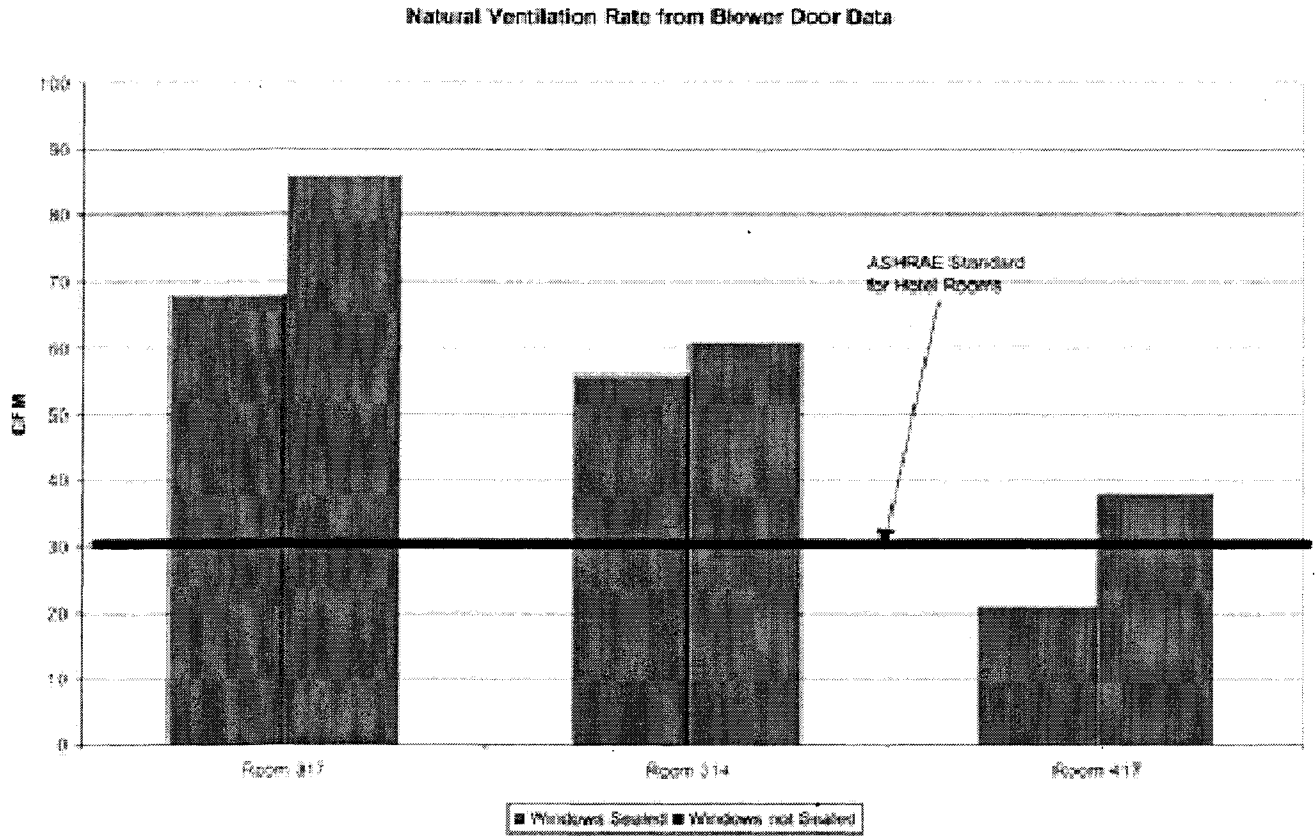
Occupancy: 1 person

The Natural Ventilation Rate = 17 cfm/person or 17cfm/room with the window closed.

Spot-check CO_2 measurements

Room 417 1 occupant 10:00AM 2-17-01

Outside of window:	485ppm	67 °F
3' inside of window (window open 20")	770ppm	68 °F
15' inside of window (window open 20")	770ppm	71 °F
3' inside of window (window closed)	1100ppm	68 °F
15' inside of window (window closed)	1115ppm	72 °F



Using the Ventilation Calculator and the values of:
Window Open
Outside CO2 Level: 485ppm
Inside CO2 Level: 770ppm
Occupancy: 1 person

The Natural Ventilation Rate = is 35 cfm/person or 35cfm/room with the window open.

Long term CO2 measurement
Connect HOBO data logger to CO2 monitor and test room with windows open and windows closed.
The results of the data collected by the blower door test and the CO2 monitor were different by a factor of two. This could be for many reasons, such as outside air speed, pressure difference or the assumptions made when calculating the correlation factor.

ASHRAE Standard

The ASHRAE Standard for hotel bedrooms is 30 cfm/room.
In room 417 the data shows that it was under ventilated in the CO2 test and about right in the blower door test, while the other two rooms seem to be over ventilated.
An under ventilated room is not acceptable during any season, while an over ventilated room is undesirable in the heating season but is desirable in the summer.

Cooling Season

Research has shown that by using natural ventilation it is possible to skew the comfort level, thus reducing the energy load on buildings since no air conditioning is needed at these times. Since the transom windows have been blocked in the rooms, a way should be found in order to keep the air velocity at a high enough rate in order for the occupants comfortable.

Heating Season

During the heating the best method is to control the ventilation rate so not to use excess energy. The two room that were over ventilated, if projected to be the average over ventilation for half of the rooms at the YMCA, would see a savings of:

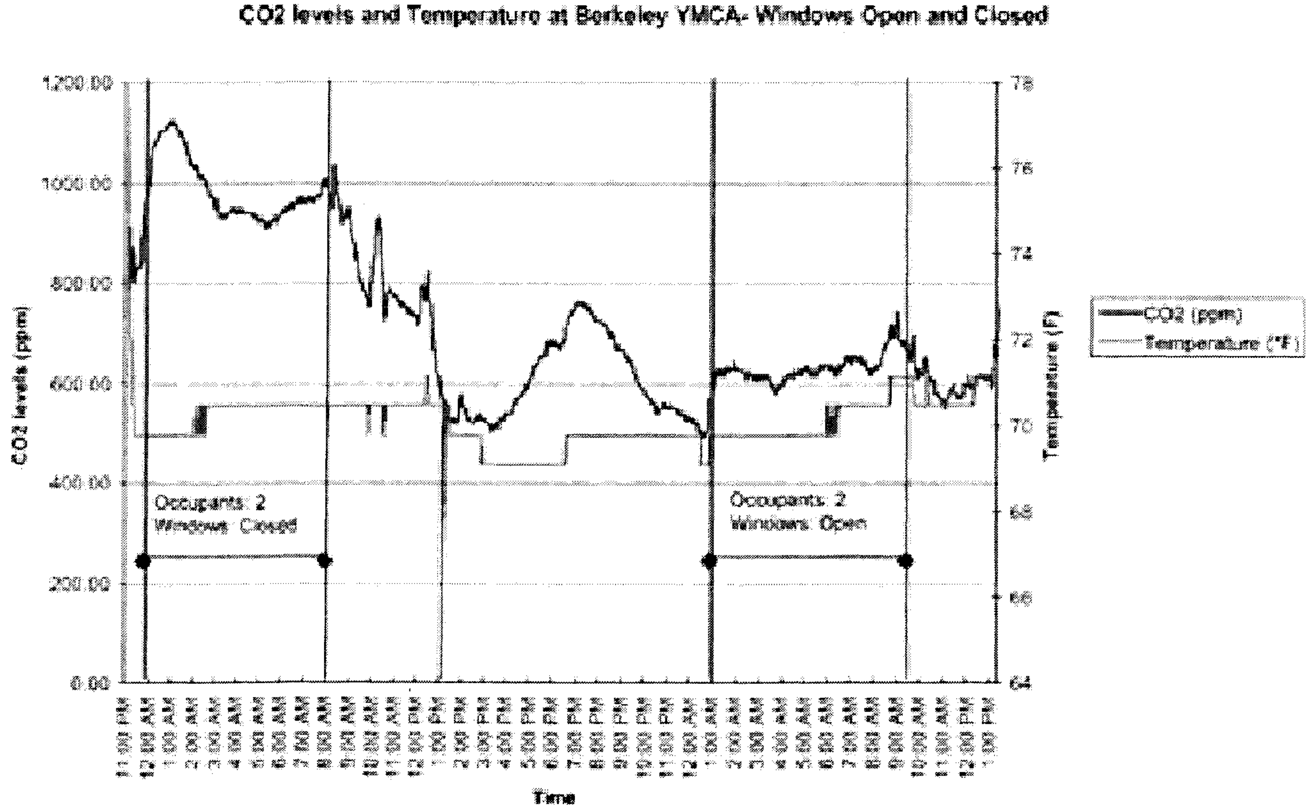
(80 rooms total) / 2 = 40 rooms

Conclusion

The hypothesis was proven for only one of the rooms. The other two rooms were very leaky and taping the windows did not help. The blower door tests are a good way to measure the over all tightness of the rooms, but may not be the best way to show the natural ventilation rate. The natural ventilation rate is dependent on too many variables, which cannot be controlled. For example if there is a strong wind the natural ventilation rate will be higher than at times when the air is still. A modification to the methodology in the blower door test would be to totally block the window by using a large sheet of cardboard that would extend beyond the window trim and that could be sealed with tape directly to the wall.

The CO2 tests are a good measure of the ventilation rate of the room since the ASHRAE standards are based on keeping the CO2 level below 1000 ppm. The problem with this measurement is that at levels near 1000ppm, the room can still feel stuffy and under ventilated. This also is a factor that has many variables the biggest

CO2 levels and Temperature at Berkeley YMCA- Windows Open and Closed



Ventilation Rate needed	Average Over Ventilation	Degree days	Wasted Therms per year	Cost per Therm ($)	Cost of Wasted Energy per Year	Number of Rooms	Total Cost of Wasted Energy
30	51	2980	52.52	$1.28	$67.23	40	$2,689

is individual preference, since the ASHRAE standard is based on what 80% of people find comfortable.

The recommendations that we can make for the YMCA is that each room should be tested individually and the modifications be based on the results of these tests.

Possible Modifications

All modifications should be made to the interior of the building since any exterior renovation would ruin the historic façade.

Winter Heat Loss

Windows should not be replaced but they should be repaired with weather seal and new stops in order to prevent too much heat loss in the wintertime. Weather sealing the windows would result in a savings of $67.00 per year per room. The cost of weather sealing would be less than $100.00 so the pay back period would be less that two years. Replacing the windows would result in a savings of about $17.00 from increased R-value and $67.00 from better air tightness or a total of $84.00 per year per room. The cost of installing a new window would be approximately $1500.00 so the pay back period would be over seventeen years. Repairing the windows is more cost effective than replacing them. The value of the heat loss from all residential rooms due to over ventilation combined was estimated to be about $2,600 per year (based on the price of $1.28 per therm which will most likely rise in the coming years.)

Thermostats should be placed in each room that control the room radiators in order to control the heat usage on warm winter days. If thermostats are not used the user controls on the radiators should be marked and simple instructions on how to use them should be included in each room.

A simple ventilation system could be implemented so that windows would not be opened in order to decrease the "stuffiness" of the rooms. An air-to-air heat exchanger that services all of the rooms would be the most cost effective and would ease the maintenance schedule since only one piece of equipment would have to be serviced.

Summertime Cooling

The transom windows over the doors to the hallway were blocked up at some time because of fire safety **reasons.** In order to cool the rooms using ventilation the upper part of the double hung windows should be made to open. Opening the upper and lower sashes at the same time can help get a cross current flowing in the rooms helping to cool the rooms. Further investigation into this area should be made.

For more information on test methods see the following sites:

Infiltration: Just ACH50 Divided by 20?
Alan Meier
http://hem.dis.anl.gov/eehem/94/940111.html

The use of blower-door data
Max Sherman, Energy Performance of Buildings Group, Environmental Energy Technologies Division, Lawrence Berkeley Laboratory, University of California, Berkeley, California
http://epb1.lbl.gov/blowerdoor/BlowerDoor.html