INDOOR AIR QUALITY ASSESSMENT

Shelburne Town Hall
51 Bridge Street
Shelburne, Massachusetts 01370

Prepared by:
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Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

Based on a request from Terry Purinton, Executive Secretary for the Town of Shelburne, an indoor air quality assessment was done at the Shelburne Town Hall (STH), 51 Bridge Street, Shelburne, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA). Concerns about poor indoor air quality (IAQ) and increases in symptoms suspected of being associated with IAQ prompted this report. A visit was made to this building by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ) on December 5, 2002.

The STH is a two-story, brick clad, wood frame building built in 1875. The second floor contains an auditorium. The first floor contains town offices and the Shelburne Police Department. The building has a dirt floor basement that contains a boiler room. An elevator shaft was retrofitted into the front of the building. Windows in the building are openable.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor.

Results

The STH has a population of approximately 12 employees. The tests were taken under normal operating conditions. Test results appear in Table 1 and are listed in the tables by location that the air sample was taken.

Discussion

Ventilation

It can be seen from the table that carbon dioxide levels were below 800 parts per million parts of air [ppm] in all areas surveyed. These carbon dioxide levels are indicative of adequate fresh air exchange. [Please note, however, that only two people occupied the building during this testing.] Reduced population and open windows can serve to greatly reduce carbon dioxide levels.

No functioning mechanical ventilation systems exist in the building. Each room has a radiator beneath the window that provides heat. The sole source of fresh air is through openable windows. With the lack of supply and exhaust ventilation, pollutants that exist in the interior space can build up and lead to indoor air quality and comfort complaints.

The second floor auditorium contains ceiling-mounted fresh air diffusers connected to a rooftop air handling unit (AHU) (see Picture 1). Town employees report that this unit is used for heating only when the auditorium is occupied.

The town hall was configured in a manner to use cross-ventilation to provide comfort for building occupants. The building is equipped with windows on opposing exterior walls. This design allows for airflow to enter an open window (windward side), pass through the interior and exit the building on the leeward side (opposite the windward side) (see Figure 1). With all windows open, airflow can be maintained in a building regardless of the direction of the wind. This system fails if the windows are closed (see Figure 2). In the case of the STH building, the erection of interior walls to form offices prevents the utilization of cross ventilation when hallway doors are closed. This natural ventilation system was replaced with the installation of window-mounted air conditioners in each office. During summer months, window-mounted air conditioners are used to provide comfort for offices. Each window-mounted air conditioner has minimal capacity to introduce fresh air during operation.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (BOCA, 1993; SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this occurs a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix I.

Temperature readings were within a range of 63° to 72° F in occupied areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 20 to 39 percent, which were below or close to the lower end of the BEHA recommended comfort range in all areas surveyed. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The basement has a dirt floor (see Picture 2). A number of moisture sources exist along the exterior of the building. A major source of water penetration into the basement appears to be water runoff from a peaked roof on a house immediately adjacent to the town hall (see Picture 3). The alleyway between the town hall and house is covered by dirt (see Picture 4). The roof does not have a gutter/downspout system, which results in rainwater collecting on the ground between buildings. No drain appears to exist in the alleyway. Collected water in the alleyway may then penetrate into the basement. Confirming this moisture pathway is the presence of efflorescence along exterior walls of the foundation along the alleyway. Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, the water evaporates, leaving behind white, powdery mineral deposits.

Another possible moisture source is outdoor relative humidity. During the assessment both carbon dioxide and relative humidity in the basement were nearly equal to outdoor measurements, which indicates open pathways for outdoor air into the basement exist.

The basement is used for storage of large amounts of materials on the dirt floor, including carpeting, cardboard and paper products (see Picture 5). If these materials are subjected to high relative humidity conditions without drying for several days, these materials can become colonized by fungi (mold). Some materials were stored in cardboard boxes that were placed on the dirt floor. This method of storage resulted in mold contamination of the boxes and most likely, the stored contents. No means exist for venting the basement to remove water vapor. If water penetrates through the foundation, moisture may accumulate in the basement.

During the spring and summer of 2002, New England experienced a stretch of excessively humid weather during three periods in May, July and August. As an example, outdoor relative humidity at various times ranged from 73 to 100 percent without precipitation from July 4, 2002 through July 12, 2002 (The Weather Underground, 2002). According to the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), if relative humidity exceeds 70 percent, mold growth may occur due to wetting of porous materials (ASHRAE, 1989). If porous materials are not dried within this time frame, mold growth may occur.

Each of these conditions, in combination with high ambient temperatures during the summer, increased relative humidity and possible water sources within the basement, may contribute to moistening of porous materials. In order to explain how mold and associated odors/particulates in the basement can migrate into occupied areas, the following concepts must be understood:

- Heated air (from radiators) will create upward air movement (called the stack effect).
- Cold air moves to hot air, which creates drafts.
- As the heated air rises, negative pressure is created, which draws cold air to the heat source.
- Airflow created by the stack effect, drafts or mechanical ventilation can draw airborne particulates into the air stream (i.e. from the basement).
- Holes on the floor of offices can provide a pathway for air to travel from the basement to the upper floors.

Each of these concepts has an influence on the movement of basement odors or other particulates through holes in the floor. Without an active exhaust ventilation system in the basement, pollutants can accumulate. In order to control possible mold growth, water penetration into the basement area must be minimized/eliminated.

It appears that the roof has experienced water leaks, as demonstrated by the amount of water-damaged insulation within the auditorium (see Picture 6). Insulation paper and ceiling tiles are porous materials that can be prone to mold growth if repeatedly moistened.

Other Concerns

A number of other conditions were noted. While assessing conditions in the basement, a bucket was noted containing several bodies of dead bats (see Picture 7). It appears that bats can access the basement through the elevator shaft. The rooftop opening for the elevator shaft that provides pressure equalization during its operation does not have a bird screen (see Picture 8). Examination of the interior of the building found bird waste accumulation on flat surfaces of the STH and window-mounted air conditioners (see Picture 9). Bird screens were installed on eaves of the peaked roof building next to the STH. Ledges of sealed windows of the STH appear to provide enough purchase for pigeons to land (see Picture 10). While the bird wastes are on the exterior of the building, this air conditioner has the ability to introduce fresh air from outdoors. As air is drawn into the air conditioner, bird waste particulate can be entrained into the air stream and introduced into the interior of the building. Birds and bats in a building raise concerns over diseases that may be caused by exposure to their wastes. These conditions warrant clean up of waste materials and appropriate disinfection. Certain molds (*Histoplasma capsulatum)* are associated with bird/bat waste (CDC, 2001; NIOSH, 1997) and are of concern for immune compromised individuals. Diseases of the respiratory tract may also result from exposure to bird/bat waste. While immune compromised individuals have an increased risk of health impacts following exposure to the materials in bird/bat wastes, these impacts may also occur in healthy individuals exposed to these materials.

The methods to be employed in clean up of a bird/bat waste problem depends on the amount of waste and the types of materials contaminated. The MDPH has been involved in several indoor air investigations where animal waste has accumulated within ventilation ductwork. Accumulation of wastes have required clean up of such buildings by a professional cleaning contractor. In less severe cases, the cleaning of the contaminated material with a solution of sodium hypochlorite has been an effective disinfectant (CDC, 1998). Disinfection of non-porous materials can be readily accomplished with this material. Porous materials contaminated with bat waste should be examined by a professional restoration contractor to determine if the material is salvageable. Where a porous material has been colonized with mold, it is recommended that the material be discarded (ACGIH, 1989).

The building also shows signs of rodent infestation. Mouse droppings were noted behind the refrigerator in the kitchen (see Picture 11). Rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine is known to contain a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms in exposed individuals (e.g., running nose or skin rashes). A three-step approach is necessary to eliminate rodent infestation:

- removal of the rodents;
- cleaning of waste products from the interior of the building; and
- reduction/elimination of pathways/food sources that are attracting rodents.

To eliminate exposure to allergens, rodents must be removed from the building. Please note that removal, even after cleaning, may not provide immediate relief since allergens can exist in the interior for several months after rodents are eliminated (Burge, H.A., 1995). A combination of cleaning, increase in ventilation and filtration can serve to reduce rodent associated allergens once the infestation is eliminated.

Photocopiers exist in one area of the building. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992).

Finally, a vent connecting the furnace to the chimney had a hole (see Picture 12). This breach may result in the release of furnace emissions, particularly carbon monoxide, into the basement. Carbon monoxide is a health hazard and must be vented appropriately outdoors to prevent injury to building occupants.

Conclusions/Recommendations

The conditions observed in the STH raise a number of issues. With water pooling near the foundation of the building, moisture can penetrate into and damage building materials (or stored items) within the crawlspace. The roosting of pigeons, mice, and bats in and around the building provide a number of potential exposure sources to biological pollutants. In addition, the excessive relative humidity during this past summer moistened porous materials, leading to possible mold growth. Since the building does not have mechanical exhaust ventilation, odors, particulates and other materials can build up in the indoor environment and lead to indoor air quality/comfort complaints.

In order to address the conditions listed in this assessment, the recommendations made to improve indoor air quality are divided into **short-term** and **long-term** corrective measures. The short-term recommendations can be implemented as soon as practicable. Long-term solution measures are more complex and will require planning and resources to adequately address overall indoor air quality concerns. In view of the findings at the time of this visit, the following recommendations are made:

Short Term Recommendations:

1) Seal floor penetrations and holes on first floor (e.g. heating pipes) with an appropriate, fire-rated sealing compound to prevent basement air/odors from penetrating into occupied areas.
2) Seal hole in the furnace vent pipe.
3) Render the access door to the auditorium attic crawl space airtight with weather-stripping.
4) Remove bird waste from the exterior of the building a manner consistent with CDC recommendations.
5) Install anti roosting devices on all flat exterior surfaces to prevent bird roosting as was done on select windowsills of the building.
6) Remove bats from basement. Install bird screens on the elevator pressure equalization vent.
7) Do not store porous materials on the dirt floor of the cellar.
8) Examine the feasibility of having a downspout/gutter system installed on the peaked roof building to direct water away from the alleyway.
9) Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek, J. & Brennan, T.; 2001).
10) Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek, J. & Brennan, T.; 2001).
11) For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is

recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).

12) Consideration should be given to removing water-damaged insulation and ceiling tiles within the auditorium.

13) Use IPM to remove pests from the building. Activities that can be used to eliminate pest infestation may include the following activities.

    a) Consult a licensed pesticide applicator on the most appropriate method to end infestation.
    b) Reduction/elimination of pathways/food sources that are attracting pests.
    c) Reduce harborages (plants/cardboard boxes) where pests may reside (MDFA, 1996).

14) Consult a building engineer concerning the most appropriate method to provide active mechanical exhaust ventilation to place the crawlspace under negative pressure. Placing the crawlspace under negative pressure will reverse air penetration into occupied spaces.

15) For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

Long-term Recommendations

1) Consideration should be given to examining the feasibility of installing a mechanical ventilation system to both provide fresh air and exhaust ventilation.

2) A ventilation engineer should be consulted to examine and make recommendations on methods to improve air distribution throughout the building.

3) Examine the feasibility of providing exhaust ventilation for the photocopier.

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http://www.wunderground.com/history/airport/KBAF/2002/7/11/DailyHistory.html
http://www.wunderground.com/history/airport/KBAF/2002/7/12/DailyHistory.html

Figure 1 **Cross Ventilation in a Building Using Open Windows and Transoms**

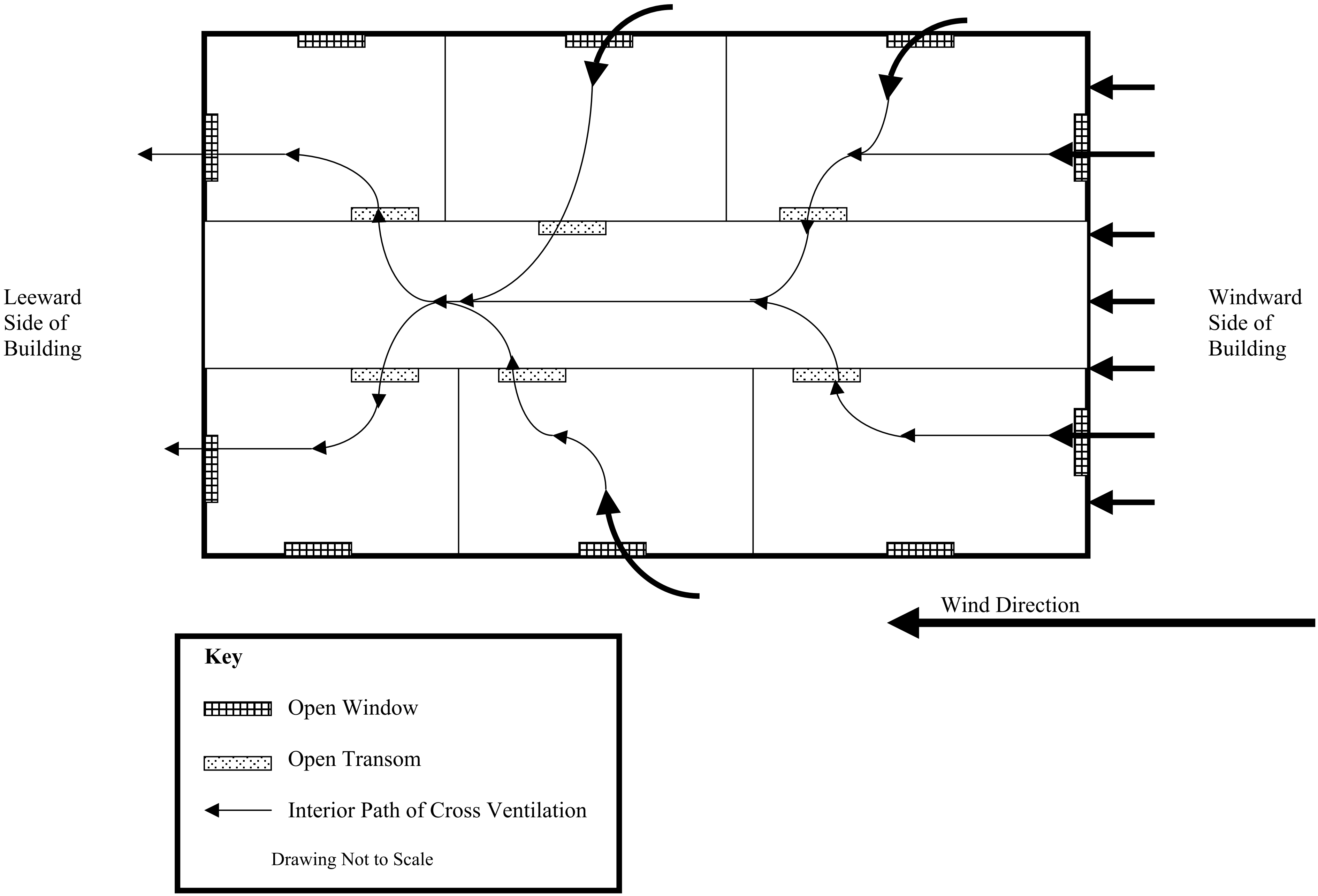
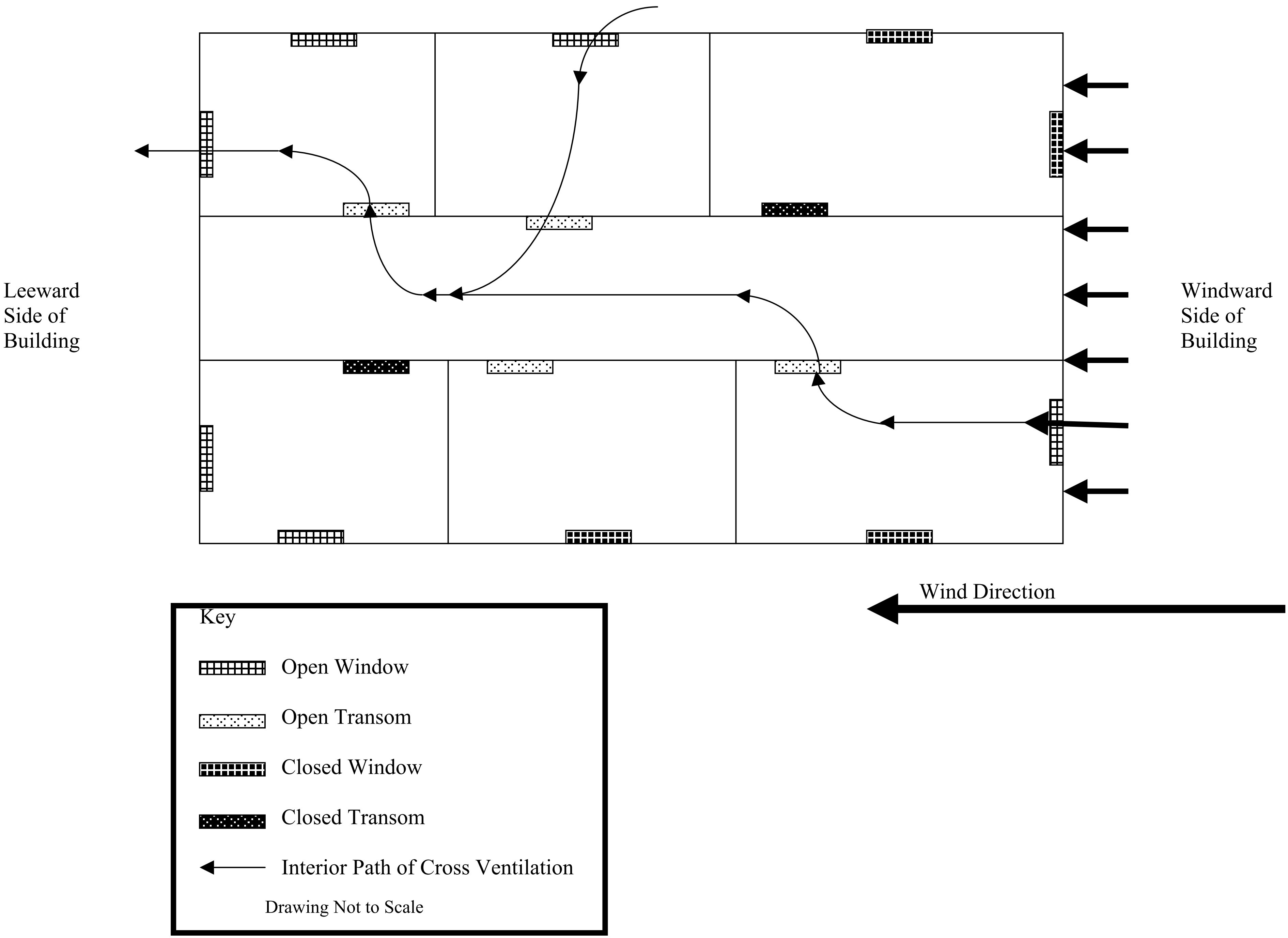


Figure 2 **Inhibition of Cross Ventilation in a Building with Several Windows and Transoms Closed**



Picture 1

AHU for Auditorium

Picture 2

Basement Dirt Floor, Note Efflorescence

Picture 3

Peaked Roof Building Immediately Adjacent to the Town Hall

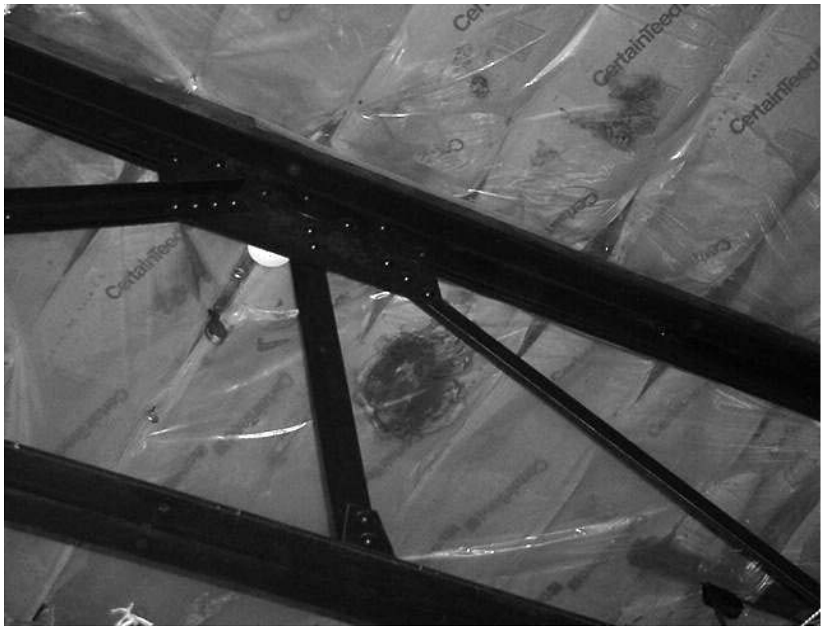
Picture 4

Dirt Floor Alleyway

Picture 5

Materials Stored in Basement, Note Carpeting On Dirt Floor

Picture 6



Water Damaged Insulation Behind Plastic in Ceiling above the Auditorium Stage

Picture 7

Dead Bats in Basement

Picture 8

Elevator Shaft Pressure Equalization Vent, Note Lack of Bird Screen

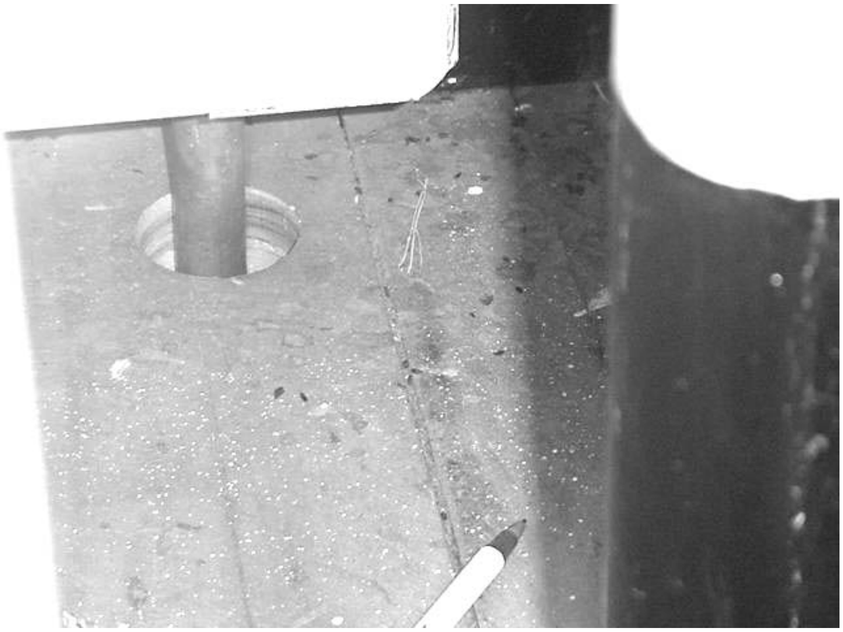
Picture 9

Accumulated Bird Waste in Alleyway

Picture 10

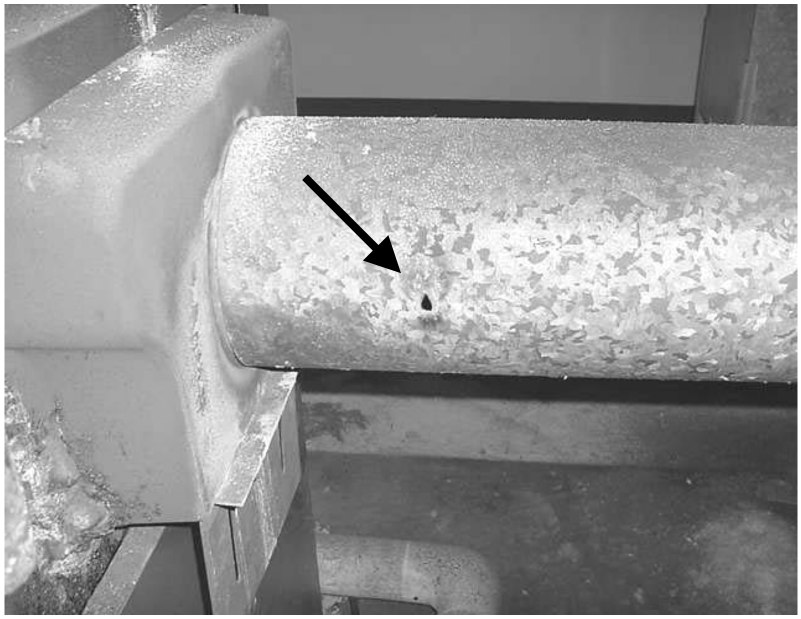
Flat Ledges along Building Exterior

Picture 11



Mouse Droppings in Basement

Picture 12



Hole in Furnace Vent Pipe

TABLE 1

Indoor Air Test Results – Shelburne Town Hall, Shelburne, Massachusetts– December 5, 2002

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Outside (Background)	371	32	57					
Police Chief Office	592	72	29	0	Y	N	N	
Town Office	531	70	22	1	Y	N	N	Closet to elevator, door closed Hole in floor – pipe
Police Dept.	460	70	20	0	Y	N	N	Trash – apple
Meeting Room	437	70	27	0	Y	N	N	Photocopier WD ceiling
Kitchen	466	63	39	0	N	N	N	Mouse dropping, refrigerator WD door, water cooler
Selectman's Meeting Room	524	71	30	1	Y	N	N	
Assessor's Office	385	70	24	0	Y	N	N	
Tax Collector	390	69	25	0	Y	N	N	Hole in floor to basement – Ceiling crack
Auditorium	361	47	26	0	Y	Y	Y	WD insulation
Dirt Floor Basement	327	51	56	0	Y	N	N	

*** ppm = parts per million parts of air**
WD = water damage

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 2

Indoor Air Test Results – Shelburne Town Hall, Shelburne, Massachusetts– December 5, 2002

* ppm = parts per million parts of air
WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%