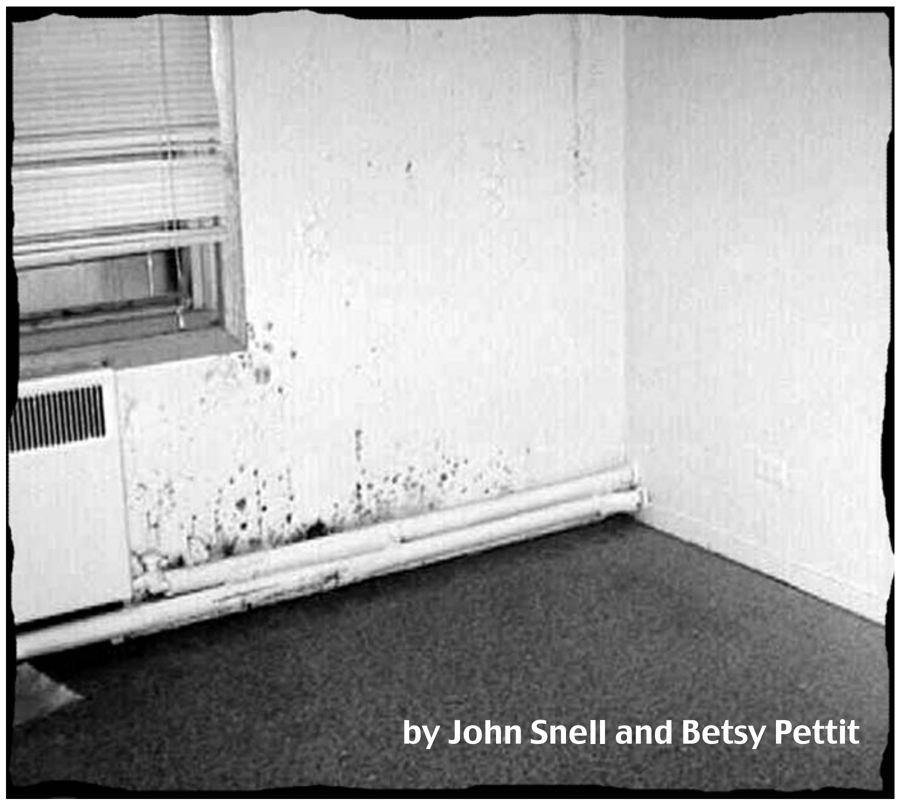
Public Housing Breaks the Mold

Part II: Veterans Era Housing

In Part I, we discussed the particular moisture– and air quality–related problems of midrise housing, and we took a close look at two cases. Here we explore issues unique to Veterans Era Housing and present three cases where moisture problems were successfully addressed.



JOE LSTIBUREK

Housing built for World War II veterans during the 40's, and 50's poses serious technical, institutional, and health-related challenges for housing managers, policy makers, and residents alike. This housing is easy to identify in the poor neighborhoods of old industrial cities such as Chicago, Detroit, Philadelphia, and Boston. The apartments are relatively small (500–900 ft^2 for a two- to four-bedroom unit) and are clustered in multiple buildings in large low-rise developments. The buildings are generally two or three stories high and contain 10 to 30 apartments each. The developments range in size from several hundred to several thousand apartments.

Years of deferred maintenance have created a housing crisis that includes extraordinary deferred capital needs, high utility costs, and unhealthy indoor living conditions. Major capital investments are required to make this housing healthy, safe, and comfortable once again. For example, the Boston Housing Authority owns and manages about 10,000 Veterans Era apartments. The cost to fully upgrade these apartments would be more than $1.5 billion. Solutions, both short-term and long-term, for the moisture problems that we found need to be addressed within the broader context of the major investments required to revive this housing stock.

At the invitation of the individual housing authorities, we studied moisture problems at three Veterans Era housing developments, located in Cleveland, Ohio; Lawrence, Massachusetts; and South Boston, Massachusetts. The moisture-related problems in these developments included mold growth, window condensation and deterioration, leaking pipes, and water infiltration through the building envelope. The Cleveland case study is an example of one of the first mold remediation efforts in public housing. The Lawrence project is an example of a major energy retrofit that exacerbated existing moisture problems. The South Boston development is the focus of a resident-driven health and housing survey and an installed energy retrofit similar to the Lawrence project.

A common theme for all three case studies is our recommendation to add mechanical ventilation in the apartments. While extremely difficult to implement in this housing stock (due to the lack of existing mechanical ventilation and solid masonry walls and ceilings), mechanical ventilation offers an important short-term and long-term solution for moisture problems in Veterans Era apartments. The Cleveland and Lawrence case studies demonstrate that mechanical ventilation can help solve moisture-related problems in Veterans Era housing. The South Boston case study is part of an extensive investigation to determine the direct health benefits of several building upgrades including mechanical ventilation.

Family Housing, Cleveland

The moisture problems in Cleveland's housing included a sensation of dampness in the apartments, window condensation and deterioration, water damage to plaster walls, and mold growth. The apartment buildings are two-story uninsulated masonry structures built just after the end of World War II. The 15 buildings contain 150 apartments, ranging in size from 800 to 900 ft^2. The space conditioning systems are hydronic fin tube radiators connected to a central heating system located in an attached boiler room for each building. No controlled mechanical ventilation, such as exhaust fan systems in the kitchens or bathrooms, was installed.

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Mold growth on exterior walls was one of the most visible symptoms of moisture problems at this Cleveland Housing Authority apartment.

The housing authority had recently installed wood-framed replacement windows in the development, because tenants had complained that the old windows were leaking rainwater. Reduced air leakage through the new windows, however, caused moisture condensation on the windows and mold on the walls and ceilings.

Occupant loading in the relatively small apartments was high, based on visual inspection. Occupant activities also implied high moisture generation in the apartments. Specific examples include hanging up laundry to dry indoors and heavy use of the installed gas stoves for cooking with inadequate kitchen exhaust ventilation (see Table 1). We observed mold growth at exterior corners and condensed water and water stains on window frames. The window stains indicated significant current and past condensation on the window glass.

Investigators concluded that high interior moisture levels, due to inadequate ventilation and to high moisture source strength, caused the sensation of dampness. They also decided that the mold and mildew, window condensation, interior paint damage, and plaster damage were caused by high interior moisture levels combined with cool surfaces.

The recommended solution was to reduce interior vapor pressure and to increase internal air flow.

Reduce interior vapor pressure. Installing controlled mechanical ventilation in each apartment would dilute interior moisture and other pollutants. We recommended installing exhaust-only ventilation to provide approximately 15 CFM per occupant, extracting air from the washrooms and stairwell/hallway areas, and exhausting this air to the exterior via ductwork. Ventilation should operate continuously in order to maintain interior moisture levels between 30% and 45% relative humidity at 72˚F during the winter months.

Increase interior air flow. We recommended undercutting all interior doors $2\frac{1}{2}$ inches (from the top of the floor covering to the underside of the door) to promote air change in the secondary rooms. The continuously operating exhaust fan would then induce the 2-3 Pa pressure differences neces-

Table 1. Potential Apartment Moisture Sources

Moisture Source	Rate
Cooking	.53 gallons/day electric cooker .79 gallons/day gas cooker
Bathing (bath, shower, handwash)	.05 gallons/person/day
Clothes drying (unvented)	.26–.4 gallons/person/day
Indoor plants, heated fish tanks	varies
Humans	.01 gallons/person/hour/asleep .015 gallons/person/hour/awake

Data source: www.branz.org.nz/databases/conference/con 73.pdf

JOHN SNELL

Strategically placed exhaust fans have solved most of the moisture problems at Merrimack Courts apartments in Lawrence, Massachusetts.

sary to ventilate the rooms. Exterior air would enter the rooms and pass into the common areas. When these recommendations were followed, the problems were eliminated.

Family Housing, Lawrence

The moisture problems in the Lawrence Housing Authority (LHA) family housing development were the same as the problems in Cleveland—a sensation of dampness in the apartments, window condensation, water damage to plaster and tile walls, and mold growth. The development, Merrimack Courts Apartments, was completed in 1950. It consists of 297 apartments in 14 buildings. Each building is three stories high and has 15 to 30 apartments, which range in size from 500 to 800 ft^2.

The development was the center of violent riots in 1985 between residents and the state police. In direct response to this violence, LHA—working with city, state, and federal agencies—developed a master plan to renovate the site. The physical renovations (completed in 1989), combined with several related management and resident initiatives, significantly improved the quality of life for residents.

A major component of the renovations was a \$2.7 million energy shared-savings program designed to replace the aging low-pressure steam heating and domestic hot water (DHW) system. Under this program, a nonprofit energy services company (ESCO) replaced the old system with individual high-efficiency forced hot water heating and DHW systems in each building. Before the new heating system was installed, when the outdoor temperature dropped below 20°F, the LHA had to choose between providing residents with heating or providing them with domestic hot water.

Energy savings from the renovation were dramatic—energy consumption dropped by 70%. However, the LHA and the ESCO still had to contend with several thermal comfort and energy-related moisture problems. The ESCO had originally drawn attention to the potential need for mechanical ventilation. The cost submitted by an independent design and build engineering firm was about \$500,000—more than LHA could invest in the development on top of the energy-related development upgrades.

In 1993, LHA hired a building investigator to assess the moisture problems and develop solutions to prevent water damage and related mold growth in the apartments. Test results measured relative humidity in excess of 65% at 70°F during winter months. In addition, test results measured extremely tight building construction (1–2 ACH at 50 Pa). The investigator concluded that high levels of interior-generated moisture caused the problems. Specific sources of moisture included high occupant loading, moisture migration from dirt crawlspaces, condensation on cold water pipes, cold exterior wall surfaces, and back-ups from city storm drains.

The recommended solution was to reduce the interior vapor pressure.

Reduce the interior vapor pressure. We recommended installing a central, continuous-operation ventilation system in each building.

In a follow-up phone conversation with LHA's maintenance director, we confirmed that LHA believes that it has solved most of the moisture problems at Merrimack Courts. However, LHA management was unable to install a central ventilation system due to difficult access in the existing pipe chases. In lieu of the central ventilation system, LHA installed individual bathroom and crawlspace exhaust fans.

The 80 CFM exhaust fans were installed on the bathroom ceilings vented out through the upper sash of the bathroom window. The fans are hard-wired to the bathroom light switch and run whenever the light switch is turned on. In addition, LHA installed fourteen 2,000 CFM (at 1 inch static pressure) exhaust fans, one in each basement crawlspace. The crawlspace fans are hard-wired to

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To reduce moisture levels in Merrimack Courts' moist crawlspace, 2,000 CFM exhaust fans cycle on for two hours, three times a day.

timer switches that cycle the exhaust fans on for two hours, three times per day. In retrospect, LHA should have installed small fans and run them continuously.

In addition to the complaints of chronic dampness, residents complained about the low temperature setpoint specified by the ESCO. Many of them used electric space heaters or turned on their gas stoves to supplement heat from the central heating system. In response to these complaints, LHA increased the maximum temperature setpoint of each apartment's nonelectric zone valve from 70°F to 75°F.

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Residents can drive up indoor humidity levels by drying clothes on baseboard heaters.

Figure 1 indicates the heating energy penalty attributable to LHA's bathroom and crawlspace exhaust fans and higher apartment temperatures. The chart tracks the rolling 12-month average energy consumption per ft^2 per heating degree-day at Merrimack Courts. LHA installed the exhaust fans in February 1997. Shortly after the fans were installed, the chart documents increased annual energy use from 15.5 Btu/ft^2/degree-day to 16.5 Btu/ft^2/degree-day. We estimate that the net heating energy penalty for the exhaust ventilation and the increased apartment temperature is about $34 per apartment per year in gas costs (additional electric costs, if any, are not known).

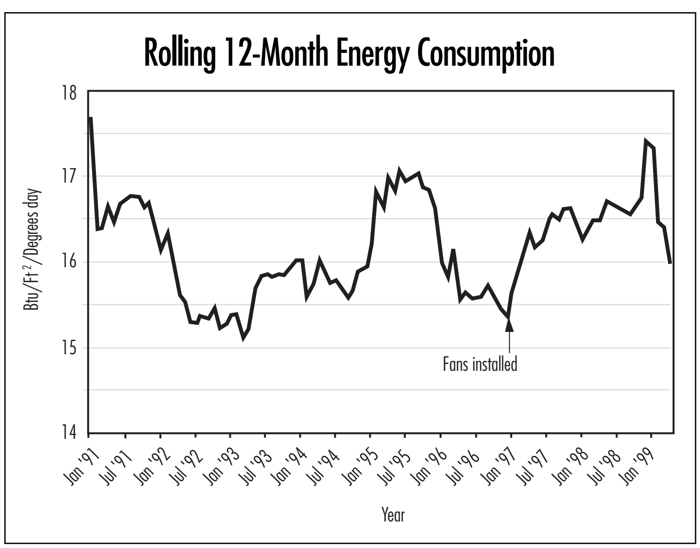

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Figure 1. Merrimack Courts' ventilation fans and higher apartment temperatures increased the annual heating energy costs by $34 per apartment.

Family Housing, Boston

The Boston Housing Authority (BHA) West Broadway Apartments development provides the most in-depth analysis of resident health ramifications associated with moisture and thermal discomfort problems in Veterans Era housing. West Broadway is a state-funded development that was completed in 1949. BHA renovated the development in 1987–1990 at a cost of about $100,000 per apartment. Currently 1,404 residents live in 500 of the 720 apartments (220 apartments are boarded up and unoccupied pending future redevelopment). The entire site covers 16 city blocks in the South Boston section of the city.

A report published in *Planning Practice and Research* in 2000 identified the resident health and building conditions in 50 West Broadway apartments collected by resident surveys in 1998. The report found both high rates of respiratory symptoms and frequent environmental problems. However, the report did not document a direct link between the two. Further study is under way to clarify the potential connection between specific indoor-environment housing conditions at West Broadway and resident health.

None of the findings from this survey was a surprise to the residents or building management, who confront these problems every day. The survey, however, documented the full extent of the building infrastructure and health-related building challenges at West Broadway.

From our perspective the root causes of the moisture-related environmental problems identified at West Broadway included:

- no mechanical ventilation or broken mechanical ventilation;
- minimal insulation;
- 50-year-old piping (near the end of its life expectancy);
- uncontrollable, inefficient central steam heating;
- gas cooking stoves;
- high occupancy loads; and
- limited resources for ongoing maintenance and related repairs.

Our recommended solution is to reduce the interior vapor pressure, increase interior air flow, repair the water leaks, and improve apartment temperature control.

Reduce the interior vapor pressure. We recommended reducing interior moisture generation and increasing the rate of moisture removal. Controlled mechanical ventilation should be installed in each apartment to dilute interior moisture and other pollutants. Exhaust-only ventilation should be installed to provide approximately 15 CFM per occupant. Air from the kitchens, washrooms, and stairwell/hallway areas should be extracted and exhausted to the exterior via a duct. Ventilation should operate continuously in order to maintain interior moisture levels of between 30% and 45% relative humidity at 72˚F during the winter.

Increase interior air flow. We recommended undercutting all interior

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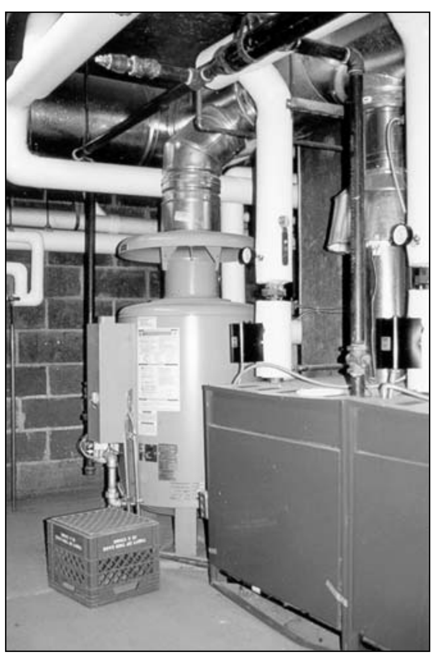
The 50-year-old steam heating distribution system was at the end of its life expectancy.

doors $2\frac{1}{2}$ inches (from the top of the floor covering to the underside of the door) to promote air change in the secondary rooms. The continuously operating exhaust fan would then induce the pressure differences necessary to ventilate the rooms. Exterior air would enter the rooms and pass into the common areas.

Repair water leaks. We recommended replacing the failed underground steam heating distribution system with individual gas-fired, high-efficiency distributed forced hot water heating and DHW systems, one per building. We also recommended installing low-volume toilets and other measures to help pay for the cost of repairing or replacing the leaking potable water and heating system piping with additional water cost savings. Water meters should be read regularly to monitor the consumption at West Broadway. Future water leaks should be identified and repaired quickly.

Improve apartment temperature control. Work should be done to modulate heating system water temperatures in direct proportion to the outdoor temperature (the lower the outdoor air temperature, the higher the heating water temperature). We recommended installing non-electric or low-voltage thermostats in each apartment, in order to allow residents to control the level of comfort in their apartments more efficiently. Modulated heating system water temperatures would also reduce overheating from exposed piping in apartments. Any heating piping should be covered to prevent accidental burns.

BHA completed an energy performance contract project at West Broadway Apartments in December 2000. Measures installed under the contract include individual forced hot water boilers—one per building—and low-volume toilets, showerheads, and aerators. Measures the ESCO did not consider or elected not to install included apartment thermostats, mechanical ventilation, or apartment piping insulation.



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The new boiler and domestic water heater at West Broadway helped to improve apartment temperature control.

The net effect of these upgrades on the health of West Broadway's residents is currently under investigation through a large-scale indoor environment study called the Healthy Public Housing Initiative (HPHI). Preliminary data collected from temperature and humidity data loggers last winter indicate that the environmental conditions in the main living areas fall within acceptable (ASHRAE 55–1992) comfort guidelines. Humidity levels in the bedrooms, however, are significantly higher and are an area of concern to be addressed by the health study.

Over the next three years, HPHI will monitor the indoor environment conditions and resident health in a statistically significant number of apartments to determine the net health benefit of the energy upgrades. In addition, HPHI will recommend, install, and document the benefit of additional energy-related and non-energy-related indoor environment health upgrades.

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Hynes, P. D. Brugge, J Lally. 2000. "Public Health and Physical Environment in Boston Public Housing." *Planning Practice and Research.* 15:31-49.

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