Mold Control in Publicly Funded Housing Developments

Building Science Corporation/Peregrine Group/Bugs, Mold, and Rot III

June 10, 1999

Major health related building problems in public housing can be traced back to MOISTURE.

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Water leakage, condensation, and high relative humidity create environments that are ideal for mold growth.

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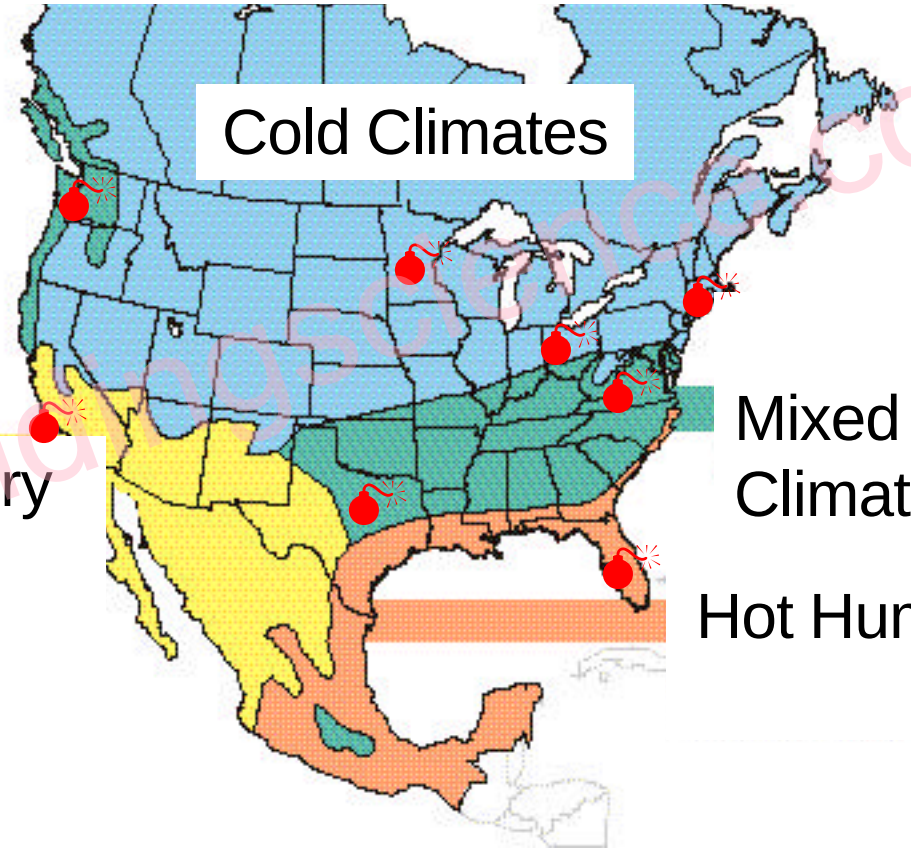
This moisture damage is pervasive throughout the United States.



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This moisture damage can be readily divided into three categories:

- Rain and Ground Water Leakage
- Leaking Pipes
- Condensation

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The solution is to require that housing that is built with public dollars provide the following:

- Control of Rain Water or Ground Water Leakage
- No Leaking Pipes
- Control of Condensation
- Control of Interior Generated Moisture

In existing housing that is redeveloped or renovated this means:

- Fix or replace leaky roofs and windows
- Fix damp basements, crawlspaces or slabs
- Fix or replace water or steam heating and plumbing systems
- Provide mechanical ventilation/air change
- Replace old windows with EnergyStar windows
- Improve building envelope (air tightness and thermal performance)

In new housing this means:

- Provide proper design of roof, wall and foundation assemblies to ensure low maintenance moisture control and air leakage control (BUILDING AMERICA STANDARDS).
- Design plumbing and HVAC systems that can be accessed and maintained. (A maintenance budget for these systems is a must)
- Provide quiet, power efficient continuously operating fans.
- Provide EnergyStar windows

Case Studies

Mold Complaints in Public Housing 1989-1999

Building Science Corporation/Peregrine Group/Bugs, Mold, and Rot III

June 10, 1999

Indian Housing, Maine 1989

- EXISTING CONDITIONS
  - Built in 1973
  - Single story, full basement
  - 1100 square feet
  - 3, 4, or 5 bedrooms and 1 or 2 bathrooms
  - High occupant loading

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Indian Housing, Maine 1989

- NATURE OF COMPLAINT
  - Staining of exterior wall corners in living spaces, presence of condensed moisture on windows and mold

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Indian Housing, Maine 1989

- NATURE OF COMPLAINT
  - Staining of concrete basement walls with moisture and mold

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Indian Housing, Maine 1989

- Additional Considerations
  - In 1980, an additional 6 inches of insulation was added
  - soffit vents were blocked off
  - louvers were installed in each gable to provide passive attic venting
  - original aluminum double-hung single-pane windows were replaced with vinyl double-pane units
  - homes heated by forced-air, atmospherically vented (coupled), oil-fired furnaces, in the basements

Indian Housing, Maine 1989

- Test Results
  - 5 to 9 airchanges per hour at a depressurization pressure of 50 Pascals
  - typical leakage or tightness for houses of this type, age, and location

Indian Housing, Maine 1989

- Conclusions: The problems are a result of:
  - High levels of interior generated moisture
  - Cold building enclosure interior surface temperatures
  - Lack of air change

Indian Housing, Maine 1989

- Recommendations
  - **1. Reduce the interior vapor pressure/moisture**
    - This can be accomplished by:
      - Reducing the rate of moisture generation by venting cooking appliances and clothes dryers.
      - Increasing the rate of moisture removal by installing a controlled ventilation system, based on occupancy, limiting rh to 30 percent at 70^{o} during the winter months.
    - Both of the above strategies are recommended.

Indian Housing, Maine 1989

- Recommendations (con't)
  - **2. Increase the temperature of the cold surfaces.**
    - This can be accomplished by:
      - Adding thermal insulation to the interior surfaces of the perimeter concrete basement walls. Rigid insulation should be installed from the basement floor slab level to the underside of the main floor plywood sub floor.
      - Taping vertical joints in the rigid insulation.
      - Blocking basement window openings with rigid sheet insulation and masonry).
    - All of the above strategies are recommended.

Indian Housing, Maine 1989

- Recommendations (con't)
  - **3. Increase air circulation (increasing heat flowing to a surface)**
    - This can be accomplished by:
      - Cutting vent louvers in all bedroom closet doors, or all the bedroom closet doors should be replaced with louvered doors to promote air circulation and therefore heat flow into closet spaces.
  - **4. Check perimeter attic insulation. Install wind baffles to prevent "wind -washing".**
  - **5. Insulate basement cold water / hot water pipes.**

NOTE:Replacing the original aluminum windows was a positive step in increasing the temperature of cold, potentially condensing surfaces.

Family Housing, Holyoke, Massachusetts 1990

- Existing Conditions
  - 1990 duplex units -two story wood frame structures constructed over cast concrete basement foundations and basement floor slabs.
  - Space conditioning systems are gas fired, high efficiency aerodynamically uncoupled.
  - Exhaust fan systems in the kitchen and bathroom were installed, however they did not extract noticeable quantities of air

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Family Housing, Holyoke, Massachusetts 1990

- Nature of Complaint
  - Sensations of dampness
  - Mold and window condensation,
  - Window deterioration
  - Interior paint and gypsum wall board damage

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Family Housing, Holyoke, Massachusetts 1990

- Test Results
  - 2 to3 air changes per hour at a depressurization pressure of 50 Pascals
  - units are of unusually "tight" construction, a sign of good detailing and good workmanship

Family Housing, Holyoke, Massachusetts 1990

- Conclusions: The problems are a result of:
  - High levels of interior generated moisture due to high occupant loading
  - Lack of air change due to absence of controlled ventilation

Note: Great windows and a well insulated and detailed building envelope still requires air change

Family Housing, Holyoke, Massachusetts 1990

- Recommendations
  - Reduce the interior vapor pressure/moisture by installing a controlled mechanical ventilation system
    - Exhaust fans of 100 to 150 cfm capacity should be installed, extracting air from the washrooms, and basement area.
    - The fans should be operated continuously

Family Housing, Holyoke, Massachusetts 1990

- Cost
  - Installation is approximately $250/unit (this is a retrofit).
  - The operating cost is approximately $100/year for both energy and fan electricity.

Elderly Housing, Winthrop, Massachusetts, 1991

- Existing Conditions
  - Units range from 800 to 1,200 sq. ft.
  - 2 story, vented crawlspace
  - 8 units per building

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Elderly Housing, Winthrop, Massachusetts, 1991

- Nature of Complaint
  - Rotting floor joists
  - Complaints of condensation on windows
  - Mold on interior walls at corners

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Elderly Housing, Winthrop, Massachusetts, 1991

- Test Results
  - Measured Moisture content in floor joists 18 to 28% by weight
  - 2 to 3 air changes per hour at a depressurization pressure of 50 Pascals
  - Typical tightness for units of this type, age and location

Elderly Housing, Winthrop, Massachusetts, 1991

- Conclusions: Problems are a result of:
  - High moisture entry rate due to wet crawlspaces
  - Lack of air change due to absence of controlled ventilation

Elderly Housing, Winthrop, Massachusetts, 1991

- Recommendations
  - Repace rotted framing members
  - Install continuous ground cover in crawl space
  - Install individual exhaust fans in each unit

Elderly Housing, Winthrop, Massachusetts, 1991

- Follow-up
  - Rotted framing members were replace
  - Ground cover was installed
  - Fans were installed
  - No more complaints of rotting floors and mold

Family Housing, Lawrence, Massachusetts 1993

- Existing Conditions
  - 1940's three story walk-up units
  - Units range from 500 to 800 sq. ft.
  - Renovations included new windows and high-efficiency heating

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Family Housing, Lawrence, Massachusetts 1993

- Nature of Complaint
  - Complaints of condensation on windows and mold growth

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Family Housing, Lawrence, Massachusetts 1993

- Test Results
  - Measured rh in excess of 65% @ 70• F during winter months
  - 1 to 2 air changes per hour at a depressurization pressure of 50 Pascals

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Family Housing, Lawrence, Massachusetts 1993

- Conclusions: The problems are a result of:
  - High levels of interior generated moisture due to high occupant loading, dirt crawlspaces, condensation on cold water pipes, cold exterior wall surfaces, and city storm drain backups.
  - Lack of air change

Family Housing, Lawrence, Massachusetts 1993

- Recommendations
  - Install central, continuous operation exhaust fans in each building.

Family Housing, Lawrence, Massachusetts 1993

- Follow-up
  - Owner installed bathroom and crawlspace fans
  - City repaired storm drains
  - Mold and condensation complaints eliminated
  - $34 per apartment per year additional energy cost ($85 per apartment per year if low efficiency heating)

Family Housing, Boston Massachusetts (Roxbury Corners) 1994

- Existing Conditions
  - Individual units ranged from 950 to 1,300 ft2 in floor area over two levels.
  - Steel framed, four story, multi-unit project
  - The space conditioning systems consisted of perimeter hydronic radiators coupled to a gas boiler system

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Family Housing, Boston Massachusetts (Roxbury Corners) 1994

- Nature of Complaint
  - Complaints of mold
    - Lower units at the interior surfaces of exterior walls near basement floor slab locations;
    - Lower units at the interior surfaces of interior walls near basements floor slab locations;
    - Stairwells at interior surfaces near basement floor slab locations

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Family Housing, Boston Massachusetts (Roxbury Corners) 1994

- Test Results
  - 5 to 6 airchanges per hour at a depressurization pressure of 50 Pascals
  - Extremely leaky for multifamily apartment construction of this type, age and location

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Family Housing, Boston Massachusetts (Roxbury Corners) 1994

- Conclusions: The problems are a result of:
  - Summer condensation due to cold surfaces in lower level garden style apartments
    - Warm, humid exterior air "sees" a cooled surface (especially at metal studs)
    - Moisture is deposited at the cooled surface leading to a rise in surface relative humidity and mold
    - Basement level units experience substantial heat loss to the ground at the below grade portions of the perimeter walls and bottom plates of interior walls
    - Warm, humid air enters and is cooled by the concrete foundation assembly
    - The mold growth is occurring as a result of thermal bridging leading to a rise in local surface relative humidity

Family Housing, Boston Massachusetts (Roxbury Corners) 1994

- Recommendations
  - Install thermal breaks under bottom plates of interior and exterior walls
  - Reconstruct the lower units to eliminate the thermal bridging at the exterior walls
  - Strip the damaged gypsum board and place rigid insulation between the metal framing and concrete foundations at perimeter
  - Install individual exhaust fans in each unit

Family Housing, Boston Massachusetts (Roxbury Corners) 1994

- Follow-up
  - Fans were installed, thermal bridging was eliminated, and walls were insulated and sealed
  - No more complaints of mold

Elderly Housing, Holyoke, Massachusetts 1994

- Existing Conditions
  - 1980 7 story apartments
  - Concrete frame structure with block infill walls with stud back-up with gypsum on both sides
  - Space conditioning systems are gas fired centrally located boilers with individual vertical fan coil units

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Elderly Housing, Holyoke, Massachusetts 1994

- Nature of Complaint
  - Water infiltration
  - Mold and window condensation
  - Window deterioration
  - Interior paint and gypsum wall board damage

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Elderly Housing, Holyoke, Massachusetts 1994

- Test Results
  - Water leakage through facade

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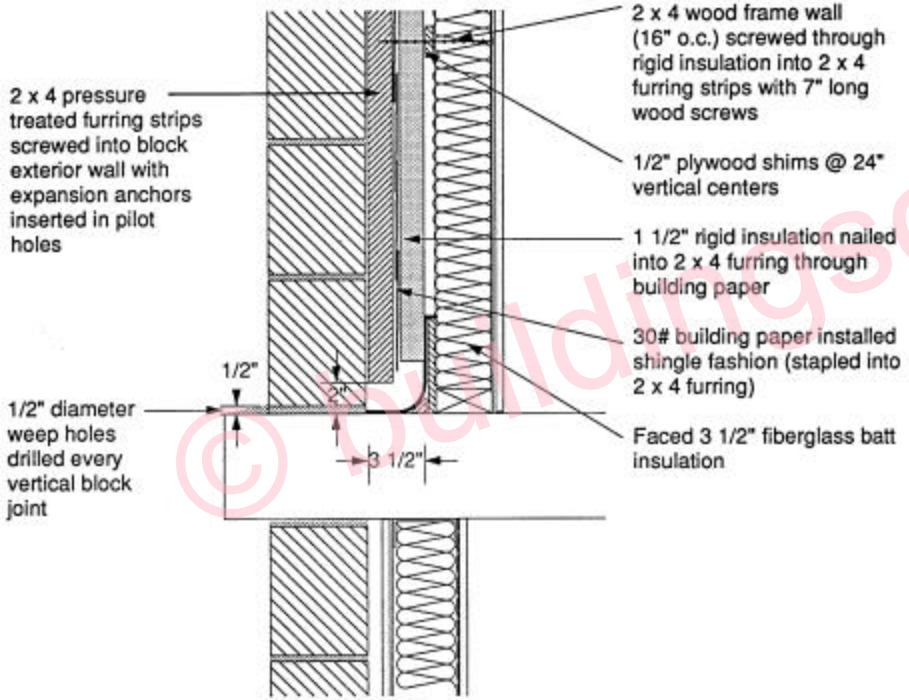
Elderly Housing, Holyoke, Massachusetts 1994

- Conclusions
  - Rain water entry is occurring at the slab edge locations under the fabric flashings
  - Discoloration at the ceiling/exterior wall intersections is due to mold growth as a result of thermal bridging

Elderly Housing, Holyoke, Massachusetts 1994



- Recommendations
  - Create a “water dam” and drainage path at locations where water is entering the building
  - Eliminate the existing thermal bridge affect of the concrete frame

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Indian Housing, Martha's Vineyard, Massachusetts 1997

- Existing Conditions
  - 2 years old single family residences
  - One story wood frame structures constructed predominantly over basement foundations. Portions of some units are constructed over elevated pier foundations.
  - Wall assemblies are 2x6 with plywood sheathing, housewrap and cedar shingles.
  - Roof assemblies are curved, rigid foam insulated stress skin panels with a roofing membrane.

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Indian Housing, Martha's Vineyard, Massachusetts 1997

- Nature of Complaint
  - sensations of dampness
  - mold
  - window condensation and window deterioration
  - interior paint and gypsum wall board damage

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Indian Housing, Martha's Vineyard, Massachusetts 1997

- Existing Conditions (con't)
  - Windows are double glazed, low E wood frame windows
  - Space conditioning systems are propane fired boilers with hot water radiation.
  - Exhaust fan systems in the kitchen and bathrooms are installed.
  - 2, 3 and 4 bedroom -floor areas - 1,200 and 1,500 square feet

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Indian Housing, Martha's Vineyard, Massachusetts 1997

- Test Results
  - 1 to 1.5 air changes per hour at a depressurization pressure of 50 Pascals
  - The units are of unusually "tight" construction, among the tightest units of this size, age and type of occupancy we have tested

Indian Housing, Martha's Vineyard, Massachusetts 1997

- Conclusions: The problems are a result of:
  - Lack of air change

Indian Housing, Martha's Vineyard, Massachusetts 1997

Recommendations

- Reduce the interior vapor pressure/moisture by installing a controlled mechanical ventilation system:
  - Exhaust only ventilation strategy
  - A single exhaust fan of 100 to 150 cfm capacity should be installed in each unit, ducted from each bedroom resulting in air extraction from each bedroom

Family Housing, Cleveland, Ohio 1997

- Existing Conditions
  - Two story uninsulated masonry structures constructed just after the Second World War.
  - Space conditioning systems are hydronic radiators connected to a central heating system not located within units.
  - No controlled mechanical ventilation such as exhaust fan systems in the kitchens or bathrooms were installed.
  - The units had recently (within the past few years) undergone window replacement.

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Family Housing, Cleveland, Ohio 1997

- Nature of complaint
  - Sensations of dampness
  - Mold
  - Window condensation and window deterioration
  - Interior paint and plaster board damage

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Family Housing, Cleveland, Ohio 1997

- Observations and Test Results
  - High occupant loading in relatively small units
  - Occupant lifestyles also inferred high moisture generation (hanging interior laundry, cooking, cleaning, etc.)
  - Mold was observed at exterior corners
  - Condensed water and water stains on window frames indicated significant current and past condensation on the window glass

Family Housing, Cleveland, Ohio 1997

- Conclusions
  - Sensations of dampness occur as a result of high interior moisture levels due to
    - inadequate air change (ventilation) and
    - a high moisture source strength (high occupant loading and lifestyle);
  - The mold and mildew, window condensation, interior paint and plaster board damage occur as a result of
    - high interior moisture levels due to inadequate air change (ventilation) and
    - a high moisture source strength (high occupant loading and lifestyle) combined with cool surfaces

Family Housing, Cleveland, Ohio 1997

Recommendations

- Reduce the interior vapor pressure/moisture by installing controlled mechanical ventilation :
  - Operate ventilation continuously
  - Maintain interior moisture levels between 30 and 45 percent relative humidity at 70 degrees Fahrenheit
  - Exhaust only ventilation fans of 150 cfm capacity should be installed, extracting air from the washrooms and stairwell/hallway areas and exhaust this air to the exterior via a duct
  - To promote air change in the secondary rooms, all interior doors should be undercut 2.5 inches (from top of floor covering to underside of door) or install transfer grills

Family Housing, Boston Massachusetts, 1998 (West Broadway)

Existing Conditions

- State funded development
- Completed in 1939
- Renovated in 1987-1990 at cost of $100,000/unit
- 540 apartments
- 1,510 Residents
- 16 City Blocks

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Conclusions

Conclusions

- In order to insure that publicly funded housing provides healthy environments for its occupants minimum performance standards must be set
- These performance standards must be measurable and achievable

Conclusions

- Long-term solutions will require a collaborative response from housing, public health, and urban planning institutions beginning with systematic surveys of existing conditions

Recommendations

Recommendations

- Standards must be set and tested for compliance in the following categories:
  - Rain water and ground water control
  - Thermal bridge control
    - Foundation wall, crawl space, and slab insulation
    - EnergyStar windows
  - Forced water and steam distribution systems
  - Fresh air supply and distribution

Recommendations

- Develop effective professional and community partnerships
- Set realistic short term and long term priorities
- Leverage multiple funding sources
  - Housing, Health, and Energy
- Consolidate multiple service delivery systems

Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Nature of Complaint
  - Community concern about poor resident health*

***BU/ Tufts Study October, 1998**

***Public Health in Public Housing: A Survey of W. Broadway* Housing for US EPA Region 1**

Professors Pat Hynes and Doug Bruggie

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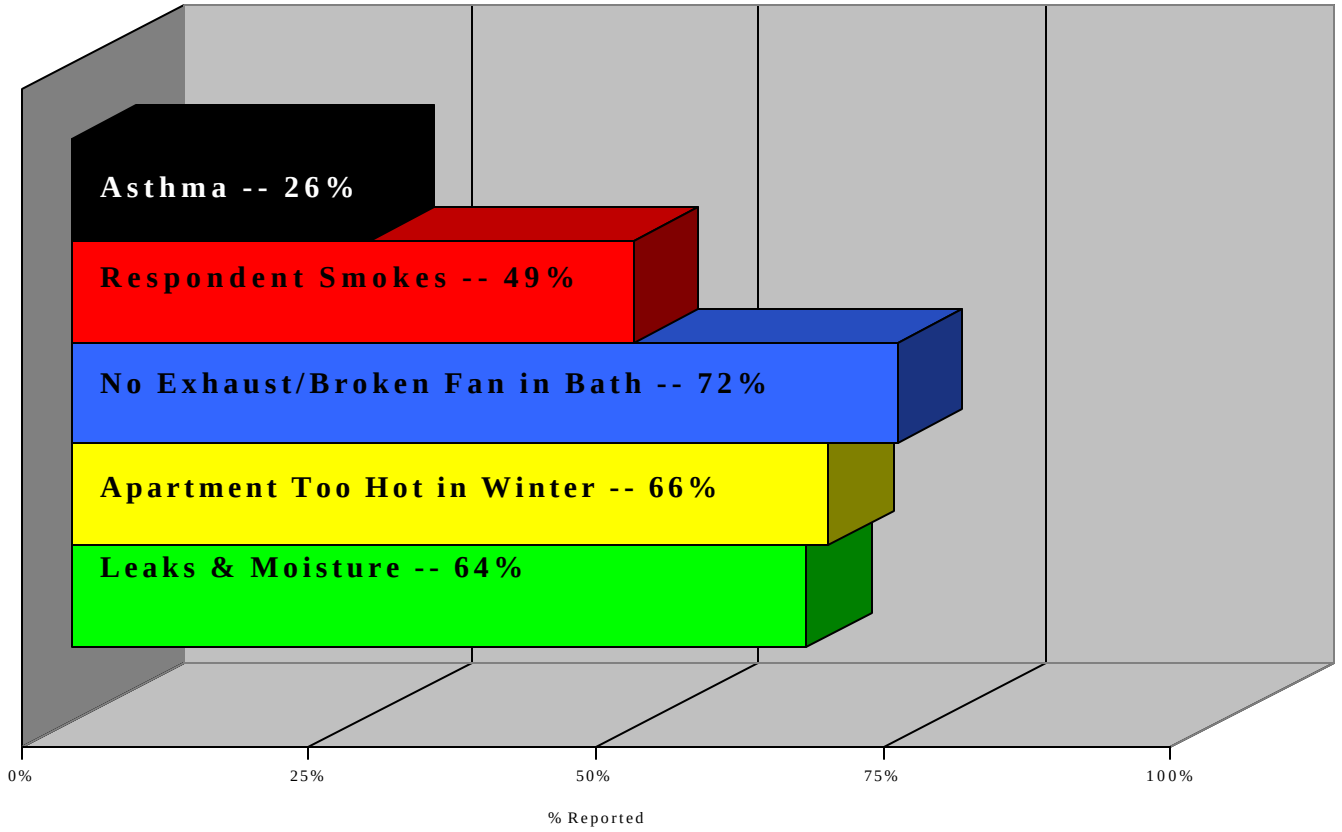
Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Observations and Test Results - Summary



Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Observations and Test Results - Moisture Sources
  - Ceiling water leaks 38%
  - Wall water leaks 17%
  - Toilet, tub, sink leaks 24%
  - Radiator leaks 22%
  - Floor and/or ceiling condensation 17%

Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Observations and Test Results - Other Moisture Variables
  - Mold growth 20%
  - Air is stuffy 58%
  - Leave windows open in winter 82%
  - Use oven to heat apartment 24%

Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Observations and Test Results - Health Problems
  - Reports asthma diagnosis 26%
  - Reports other respiratory 30%
  - Reports allergies 40%
  - Symptoms in last month
    - Headache 56%
    - Coughing 46%
  - Symptom stops outside apartment 40%

Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Observations and Test Results - How are Building Problems Currently Addressed?
  - Residents understand how to submit a work order — 100%
  - Maintenance staff is responsive — 72%
  - Residents make repeated requests for the same problem — 50%

Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Observations and Test Results - Health Costs
  - 20% of pediatric ER is asthma related
    - —$500 - $800 per ER visit
    - —$1,000 - $2,000 per overnight stay
    - —3-1/2 days for average asthma stay
  - Poor environment conditions accelerate cases of severe asthma

Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Recommendations
  - Improve building repair practices
  - BHA needs a housing, public health, and urban planning collaborative to solve these problems
  - BHA should perform systematic surveys of housing and health conditions

Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Conclusion
  - Physical building problems are a significant public health problem at W. Broadway
  - A “clinical” response advising tenants how to improve their health is insufficient to solve the health problems
  - Standard building rehabilitation practices did not guarantee good health conditions at W. Broadway
  - Long-term solutions will require a collaborative response from housing, public health, and urban planning institutions and residents

Family Housing, Boston Massachusetts, 1998 (West Broadway)

- Follow up
  - South Boston Neighborhood Health Center Indoor Air Quality Initiative
  - Boston Medical Center/ NIH Asthma Study
  - EPA Rare Grant - Asthma mitigation
  - BHA Energy Performance Contract
  - BHA Energy Master Plan
  - BHA Health, Energy, and Housing Initiative