

Understanding EPA Document 402-F-13053

“Moisture Control Guidance for Building Design, Construction and Maintenance”

Presented at:



Florida Healthcare Engineering Association
30TH Spring Meeting – May 9, 2014

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Gobbell Hays Partners, Inc.

Architecture • Engineering • Environment • Health • Safety



Introduction: Objectives

- **Review the Science – Moisture Impacts on Buildings**
- **Review the new EPA Moisture Control Guidance Document**
 - **New Construction – Design & Cx**
 - **Operations and Maintenance – Monitoring & Inspecting**



Introduction

“In the 21st century, architecture isn’t truly excellent unless it deeply engages the natural world and promotes health and resilience.”

*William Leddy, FALA; quoted from an Opinion Piece
Repositioning the AIA Institute Honor Awards: There Is No Separation Between Sustainability and Design Excellence*



Part I

Building Envelope Science

Material Properties related to Moisture Transfer

Design and Construction Issues

Means and Methods for Controlling Moisture Intrusion



Capillary Properties of Building Materials

- **Moisture Capacity of Materials is directly related to Capillary Properties of Materials**
 - ▶ **Small Capillary Materials:** Absorb moisture more slowly with higher pressure, but also dry more slowly
 - ▶ **Large Capillary Materials:** Absorb moisture more quickly with lower pressure, but dry more quickly



Capillary Properties of Materials and Permeability of Building Materials

- **Permeability of Materials is directly related to the Capillary Properties of Material**
 - ▶ **Capillary Properties establish Porosity of Materials**
 - ▶ **Porosity allows for movement of moisture through the Materials**



Capillary Properties of Materials and Permeability of Building Materials

- **Moisture movement through Materials is directly related to Moisture Capacity of the Capillaries**
- **High Volume of Moisture movement causes High Capillary Pressure, which tends to begin the breakdown of Materials over time**



Permeability of Building Materials

- **What is the Permeance of Some Standard Building Materials?**

▶ 4” Brick	0.8 Perm
▶ Stucco	1.6 Perm*
▶ 1” of concrete	3.2 Perm
▶ 3/8” Gypsum Board	50.0 Perm
▶ 6 mil. Polyethylene	0.06 Perm
▶ 2 Coats of Exterior Paint	0.9 Perm

***Stucco Permeance Today – Old Stucco can be as high as 18.9 Perm**

Excerpt from “Building Construction Illustrated,” Second Edition, by Francis D.K. Ching



Permeability of Building Materials

- **The Permeance of Some Standard Building Sheathing and Building Wrap Materials**

▶ 3/8” OSB	2.0 Perm
▶ Fiberboard – asphalt impregnated	15.0 Perm
▶ DensGlass	23.0 Perm
▶ XPS rigid insulation	1.0 Perm
▶ No. 15 asphalt saturated felt	6.0 Perm*
▶ Tyvek	58.0 Perm*

***No. 15 asphalt impregnated felt has an Air Permeance of 0.4 Perm while Tyvek is 0.0045 Perm (@ wind pressure 30 mph)**



Design Issues to Control Moisture Infiltration

- **Air Barriers versus Vapor Barriers**
 - ▶ **Air Barrier** – An element that controls the movement of air and/or water across a building envelope system (horizontal and vertical), but may be permeable to moisture vapor.
 - ▶ **Vapor Barrier** – Impermeable to moisture vapor movement.



Design Issues to Control Moisture Infiltration

- **Air Barriers versus Vapor Barriers**
 - ▶ **Air Retarder – An element that effectively resists or slows the rate of airflow across a building envelope system or assembly.**
 - ▶ **Vapor Retarder – Limits the flow of moisture vapor across a building envelope system or assembly.**



Design Issues to Control Moisture Infiltration

- **Traditional Construction Techniques**
 - ▶ **Most all Exterior Building Cladding Materials Allow for Moisture Infiltration!**
 - ▶ **Design Exterior Envelopes to Drain the Moisture that is Allowed into the System.**
 - ▶ **Eliminate potential for moisture collecting in the Building Envelope System.**



Design Issues to Control Moisture Infiltration

- **Traditional Construction Techniques**

- ▶ **Create a Diaphragm**

“Drain Plane – A Plane for Rain to Drain”

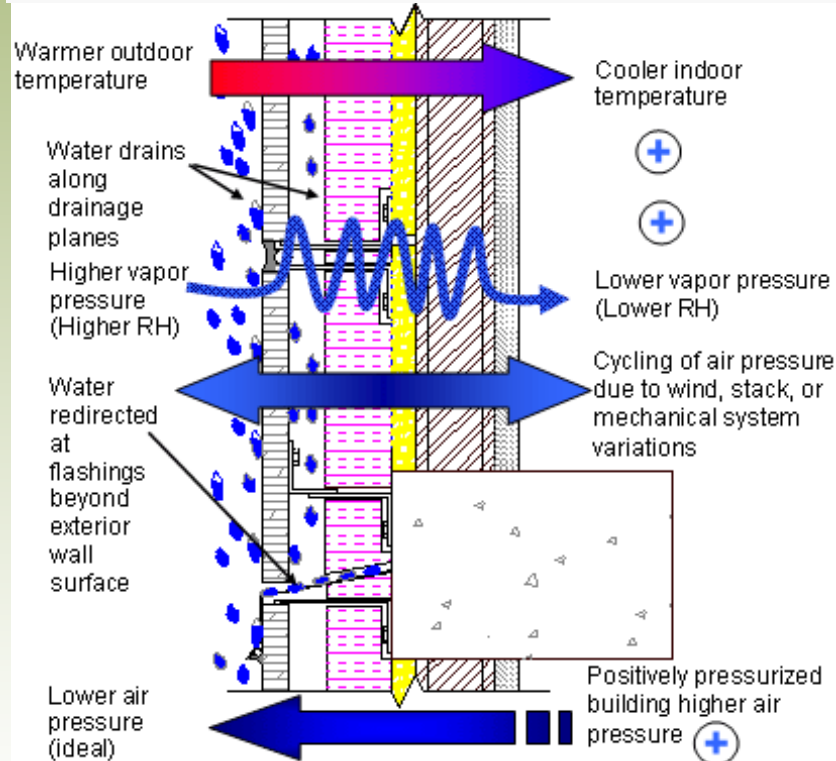
Thomas “Willie” Adams, Envirotest, Inc.

- ▶ **Diaphragm Drained to Daylight**



Design Issues to Control Moisture Infiltration

Moisture Management System



Building Envelope Design Guide - Wall Systems

by Daniel J. Lemieux, AIA and Paul E. Totten, PE

[Wiss, Janney, Elstner Associates, Inc.](http://www.wbdg.org/design/env_wall.php)

http://www.wbdg.org/design/env_wall.php



Construction Means and Methods

- **Appropriate Means, Methods, Techniques, Sequences, and Procedures to Eliminate Moisture Saturation of Building Materials During Construction and beyond.**
- **Standard Specifications are being written to define Limitations for Moisture Saturation of Materials**
- **Important to monitor construction process step-by-step, including third-party review.**



Construction Means and Methods

- **Sequencing of Construction Issues**
 - ▶ **Installing Gypsum Materials Prior to having Building Envelope Dried-in**
 - ▶ **Installing Water Based Materials Against Highly Permeable Materials**
 - ▶ **Installing Materials over Substrates that are not Sufficiently Dry or Conditioned.**



Summary – Part I

- **Prevention of Inappropriate Water and Moisture Vapor Infiltration into Buildings and the Building Materials during Design and Construction is “Step One” to the Prevention of Mold Growth in Building Systems**



Part II

- **EPA Document 402-F-13053 – “Moisture Control Guidance for Building Design, Construction, and Maintenance”**
- **General Guidance for Implementation of Moisture Control Measures**
 - ▶ **New Construction – Design & Cx**
 - ▶ **Operations & Maintenance – Monitoring & Inspecting**



Introduction: What is it?

- **It was developed by the Indoor Environments Division of the EPA**
- **It is a guidance document intended for use by people who work in the design, construction and maintenance of buildings.**



Introduction: What it is not!

- **It's not a code, standard or even a textbook.**
- **It does not deal directly with flooding, just moisture/water intrusion/rainwater.**



Introduction: What is it made of?

- **Chapter 1: Moisture Control Principles**
- **Chapter 2 & 3: Design and Construction**
- **Chapter 4: Operations & Maintenance**
- **Appendix A - G: Provides useful tests, checklists and procedures for specific evaluations.**



Introduction: What is it made of?

- **Following Chapter 1, the remainder of the Document addresses Design, Construction and Operations as it relates to each of the following:**
 - ▶ **Site Drainage**
 - ▶ **Foundations**
 - ▶ **Walls**
 - ▶ **Roof and Ceiling Assemblies**
 - ▶ **Plumbing Systems**
 - ▶ **HVAC Systems**



Chapter 1: Moisture Control in Buildings



- **Un-controlled Moisture results in adverse health conditions and expensive repairs.**
- **Lawrence Berkley Nat'l Lab found that building dampness and mold raise the risk of respiratory illness by 30 to 50%.**
- **Also, 21% of people in the U.S. with Asthma can be attributed to dampness and mold in homes.**



Chapter 1: Moisture Control in Buildings



- **Not only is it unhealthy, its expensive!**
- **The Berkley Lab estimates the annual asthma related medical costs attributable to damp buildings totals approximately \$3.5 Billion. So where's the rest of the money?**
 - ▶ **Absenteeism**
 - ▶ **Reduced Productivity**
 - ▶ **Increased Insurance Risk**
 - ▶ **Repair and Replacement**
 - ▶ **Interruption to Business Operation**



Chapter 1: Moisture Control in Buildings



- **Understanding the air dew-point temperature is critical in determining condensation issues and how to avoid them.**
- **The wall surfaces in this photo have similar near condensation conditions. The mold growth is uniform and evenly distributed rather than a single concentrated area of dampness.**



Chapter 1: Moisture Control in Buildings

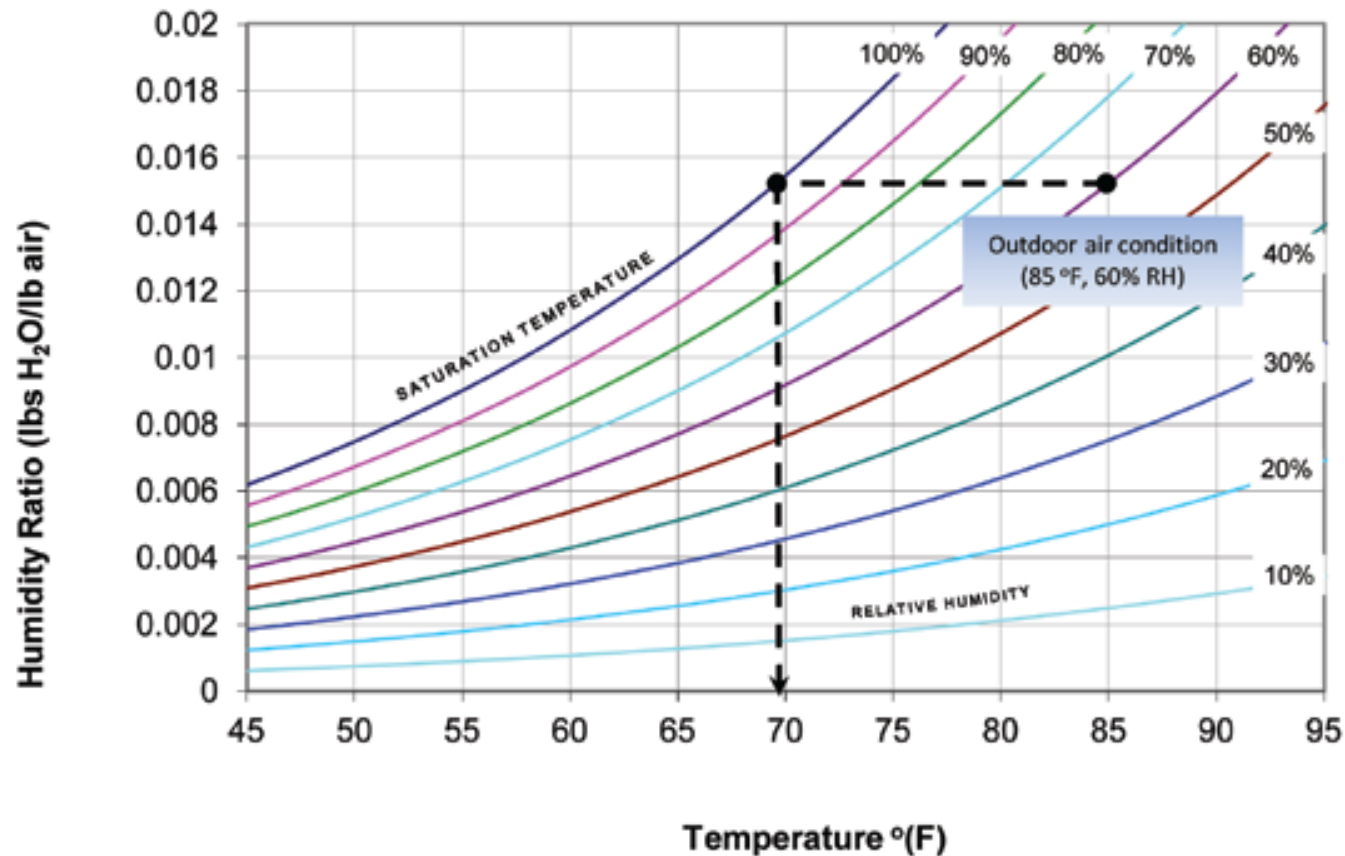


- **The dew point is the temperature of the air at which condensation occurs.**
- **The higher the dew point, the greater the chance for condensation to form.**
- **Very humid air has a high dew point. Condensation can occur on surfaces only a few degrees cooler than the Air.**

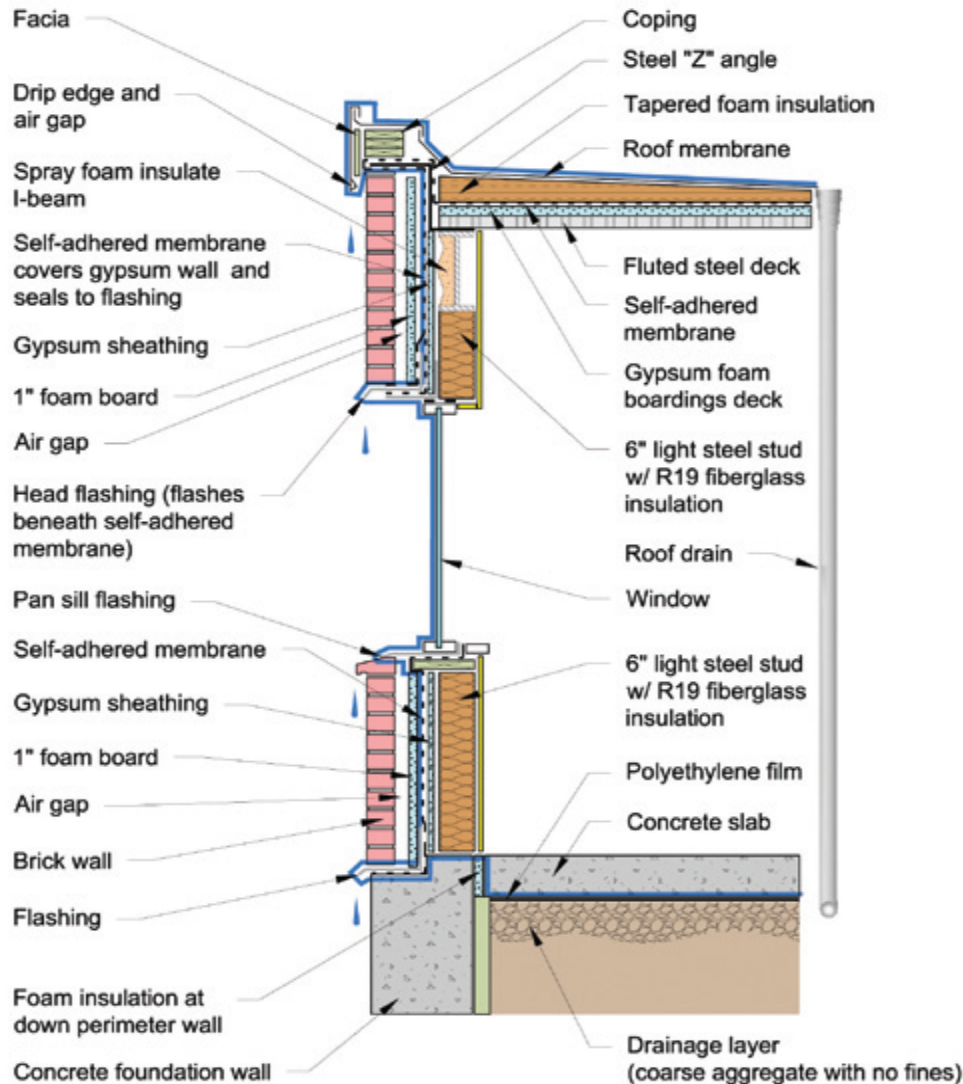


Chapter 1: Moisture Control in Buildings

A Simplified Psychrometric Chart Relates Air Temperature, RH and Dew Point.



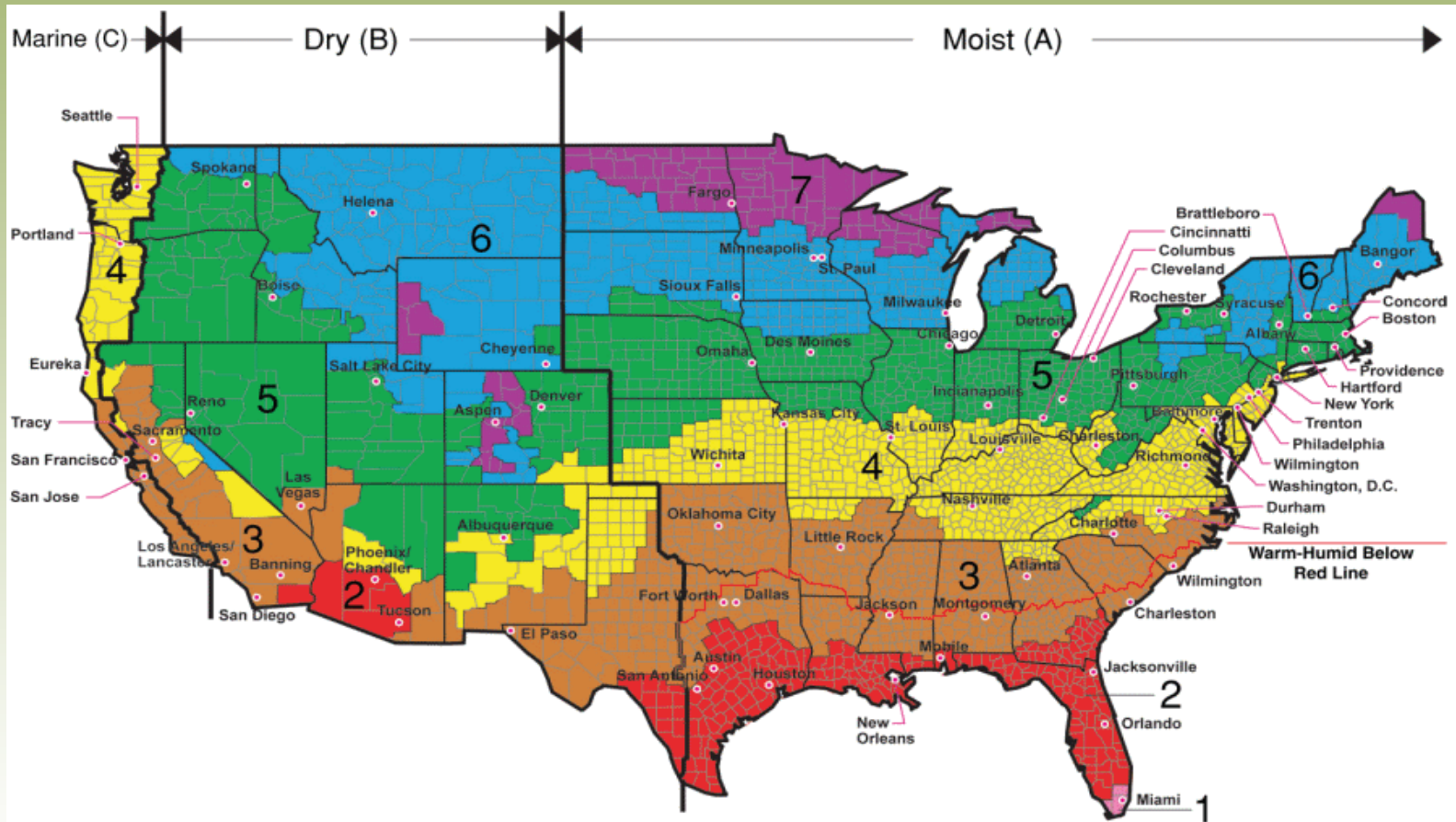
Chapter 1: Tracing Capillary Breaks – Pen Test – Blue Line



- The Blue Line traces the elements of the capillary break in the rainwater control system for a section through a building.
- Known as the “Pen Test.” It is also utilized to trace the continuity of the insulation layer and the air barrier – see Appendix 3.



Chapter 2: Designing for Moisture Control



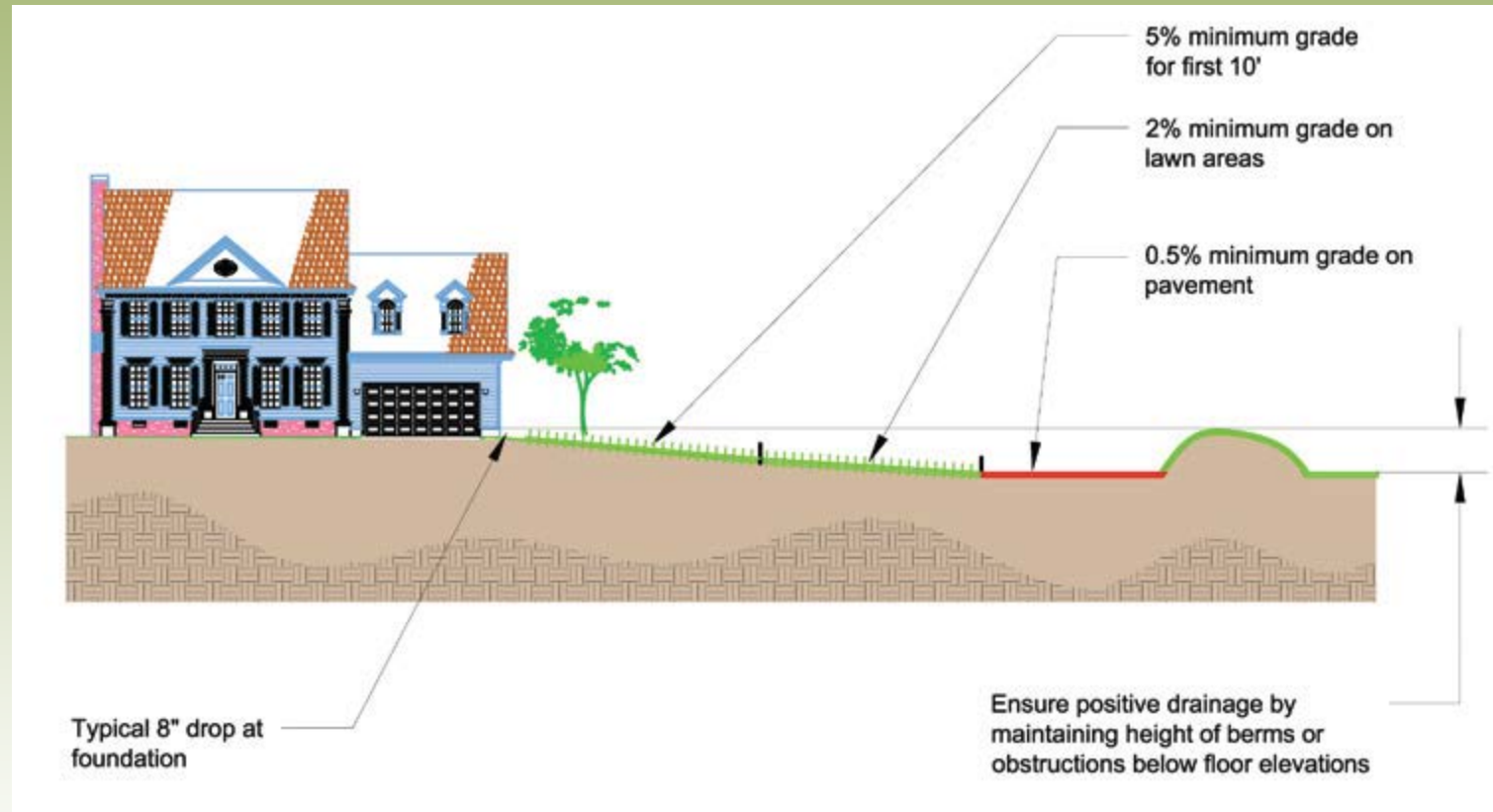
All of Alaska in Zone 7 except for the following Boroughs in Zone 8: Bethel, Dellingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk

Zone 1 includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands

**The International Energy Code Climate Zone Map
Developed by the U.S. Department of Energy**



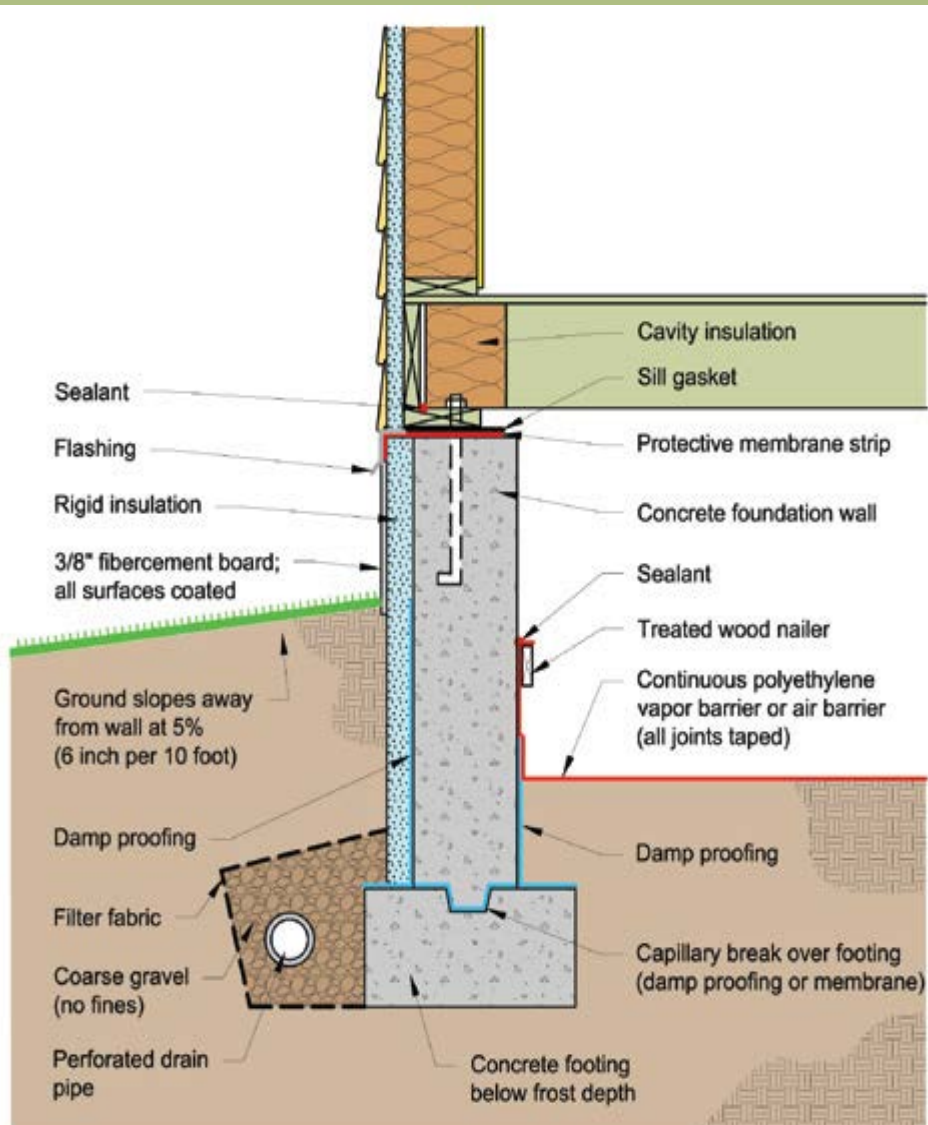
Chapter 2: Designing for Moisture Control



While simplistic, negative drainage is a common deficiency.



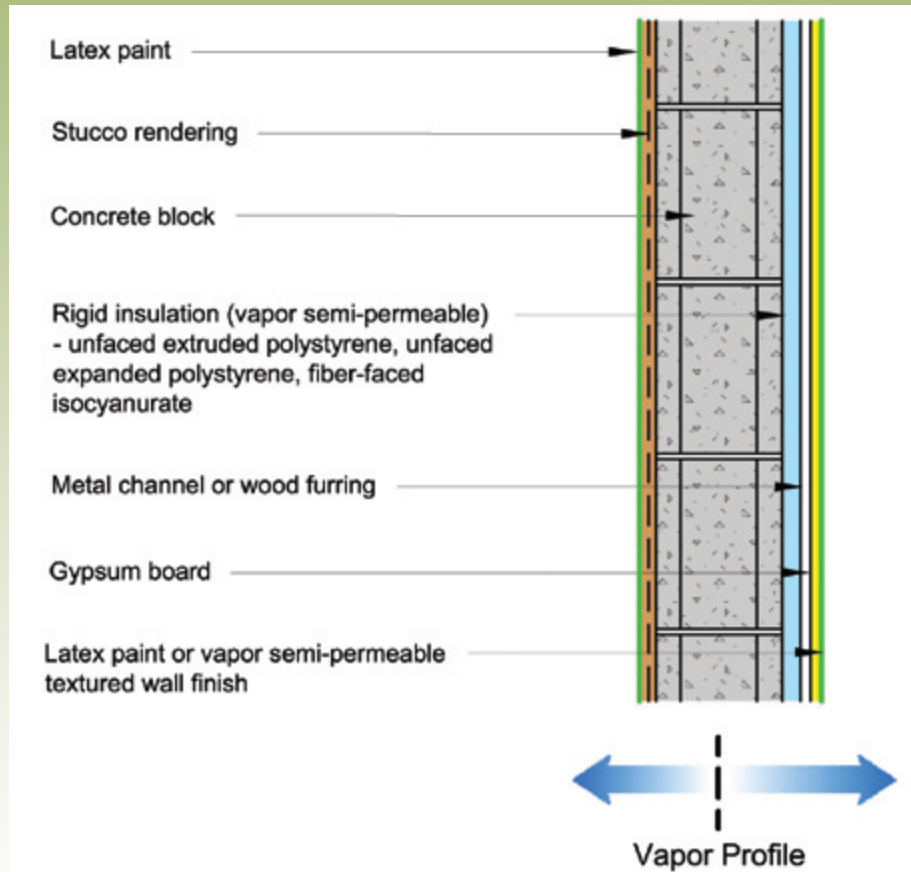
Chapter 2: Designing for Moisture Control



- **Components of an Unvented Crawl Space Foundation.**



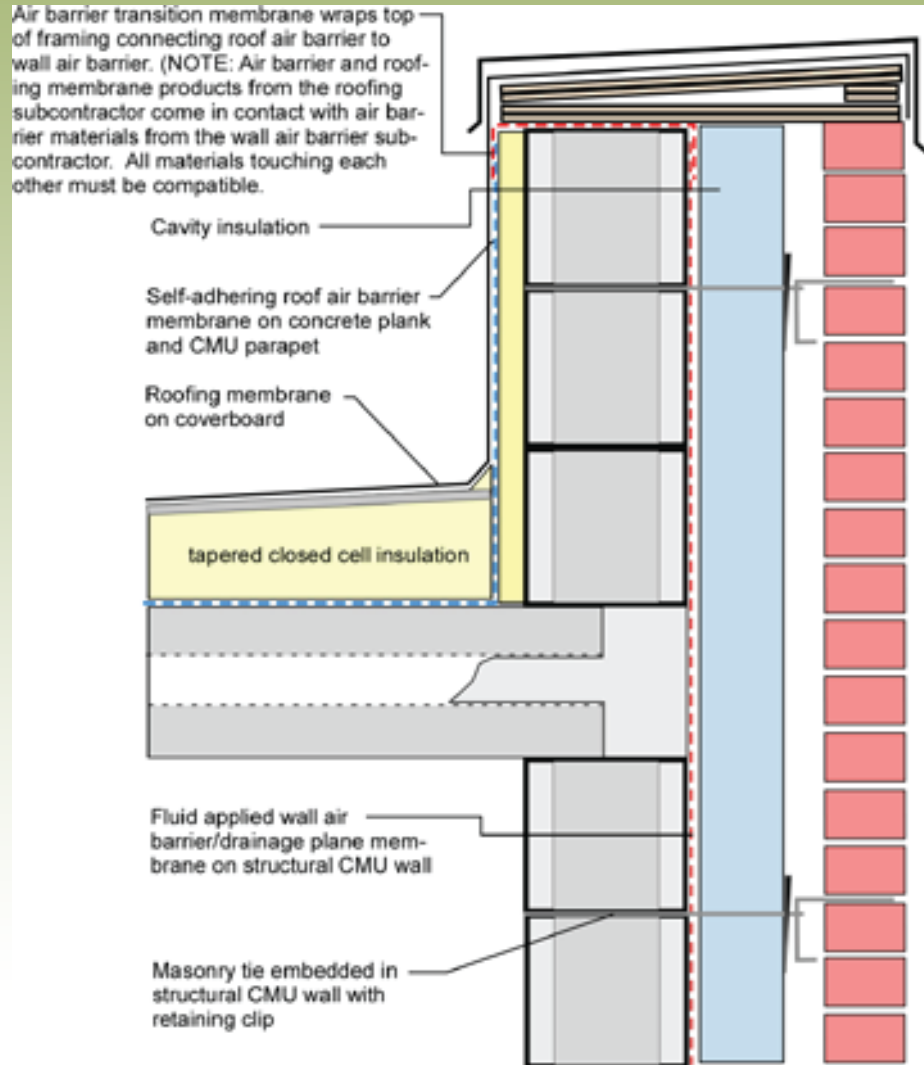
Chapter 2: Designing for Moisture Control



- **Concrete Block with Interior Rigid Insulation and Stucco.**



Chapter 2: Designing for Moisture Control



- **Moisture Control in an Unvented Low-Slope Roof Assembly with Structural CMU Walls.**



Chapter 2: Designing for Moisture Control

- **Plumbing Systems: Three Goals of Design:**
 - ▶ **Design supply, waste and fixtures to prevent leaks and ease in detect leaks and make repairs.**
 - ▶ **Design should address prevention of condensation issues on pipes and fixtures.**
 - ▶ **Select materials to minimize mold growth in areas that are unavoidably wet.**



Chapter 2: Designing for Moisture Control

- **Plumbing Systems: Three Goals of Design:**
 - ▶ **Design supply, waste and fixtures to prevent leaks and ease in detect leaks and make repairs.**
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Chapter 2: Designing for Moisture Control

- **HVAC Systems: 4 goals of design:**
 - ▶ **Keep the indoor air dew point temperature low enough to reduce the risk of condensation and moisture absorption by organic materials.**
 - ▶ **Design against negative pressure conditions by properly addressing all connections on the supply and return sides.**
 - ▶ **Design to control water from coil condensation.**
 - ▶ **Limit indoor humidity loads. Provide for the proper balance of exhaust air with dry makeup air.**



Chapter 3:

Constructing to prevent Moisture Problems:

- **Controlling the uncontrollable: Construction companies have always had to deal with the usual suspects when erecting buildings!**
 - ▶ **Rain – the Weather!**
 - ▶ **Water used in materials that are installed wet.**
 - ▶ **Leaks in temporary or permanently installed plumbing.**
 - ▶ **Poor humidity control following dry in but prior to the HVAC systems being operational.**



Chapter 3:

Constructing to prevent Moisture Problems:

- **Pre-Construction Planning:** Should address each of our six sections:
 - ▶ **Site Drainage**
 - ▶ **Foundations**
 - ▶ **Walls**
 - ▶ **Roof and Ceiling Assemblies**
 - ▶ **Plumbing Systems**
 - ▶ **HVAC Systems**
- **When constructing, keep it dry! If you see a design problem – Get it Resolved! Address, O & M issues that will change due to the “as built construction.”**



Chapter 3:

Constructing to prevent Moisture Problems:

- **Pre-Construction Planning: Consists of the two following goals:**
 - ▶ **Develop a Moisture Control Plan to be used during Construction.**
 - ▶ **Review the Moisture Control Plan details with the Design Team, Construction Management, and Subcontractors.**



Chapter 3:

Constructing to prevent Moisture Problems:

- **Three Guidance Items for Developing the Moisture Control Plan**
 - ▶ **The owner and design team will determine the level of concern for moisture control.**
 - ▶ **Make the construction schedule, sequencing of work and delivery of materials to meet the objectives of the Plan.**
 - ▶ **Identify the those responsible for each part of the plan.**



Chapter 3:

Constructing to prevent Moisture Problems:

- **Three Guidance Items for Reviewing the Moisture Control Plan**
 - ▶ **Address rainwater and subsurface water control, seasonal conditions and changes, commissioning & testing.**
 - ▶ **Make sure that any changes are reflected in the contract documents, shop drawings and submittals.**
 - ▶ **Schedule required inspections & testing while moisture control details are exposed.**



Chapter 4: Operating and Maintaining Moisture-Controlled Environments:

“The people who keep buildings working—the HVAC mechanics, carpenters, plumbers, electricians, engineers, custodians and managers—inherit the good points and the bad points of the design and construction.”



Chapter 4: Operating and Maintaining Moisture-Controlled Environments:

- **Site Drainage Maintenance: GOALS**
 - ▶ **Facility maintenance and preventative maintenance plans include site drainage.**
 - ▶ **All runoff from parking lots, sidewalks, etc. is diverted to a designed, designated drainage system.**
 - ▶ **Future site development or building modifications, additions do not interfere with existing site drainage conditions.**



Chapter 4: Operating and Maintaining Moisture-Controlled Environments:

- **Foundation Maintenance: GOALS**
 - ▶ **Foundation drainage systems divert water away from structures.**
 - ▶ **Do you even have a foundation drainage system???**



Chapter 4: Operating and Maintaining Moisture-Controlled Environments:

- **Wall Maintenance: GOALS**
 - ▶ **Create and operate verification and inspection systems to detect potential moisture problems before harm is done**
 - ▶ **Effectively maintain walls to prevent moisture problems, as intended by the design.**



Chapter 4: Operating and Maintaining Moisture-Controlled Environments:

- **Roof & Ceiling Maintenance: GOALS**
 - ▶ **Facility maintenance and preventative maintenance plans include moisture control issues for roof and ceiling assemblies.**
 - ▶ **Moisture does not penetrate roof or ceilings or collect in exterior elements, except as intended by design.**



Chapter 4: Operating and Maintaining Moisture-Controlled Environments:

- **Plumbing Maintenance: GOAL**
 - ▶ **Plumbing systems are inspected and maintained to prevent flooding and condensation.**
- **HVAC Maintenance: GOAL**
 - ▶ **Facility maintenance and preventative maintenance plans include moisture control in HVAC Systems.**



The Appendices:

Appendix A: “The Pen Test”

Appendix B: Roof Inspection Checklist

Appendix C: Testing Moisture During Construction

Appendix D: Air Pressure Mapping

Appendix E: HVAC Inspection Checklist

Appendix F: Site Drainage & Maintenance

Appendix G: Dampness and Mold Evaluation Glossary



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