ANSWER SHEET

First Name: _____ Last Name: _____ Date: _____

Address: _____ City: _____ State: _____ ZIP: _____

Phone: _____ Email: _____

Florida CILB License #: _____

** See instructions on the cover page to submit your exams and pay for your course.

Florida Building Code 6th Edition: Advanced Course Final Exam *Questions on pages 3-4*

1. Ⓐ Ⓑ Ⓒ Ⓓ	6. Ⓐ Ⓑ Ⓒ Ⓓ	11. Ⓐ Ⓑ Ⓒ Ⓓ	16. Ⓐ Ⓑ Ⓒ Ⓓ	21. Ⓐ Ⓑ Ⓒ Ⓓ
2. Ⓐ Ⓑ Ⓒ Ⓓ	7. Ⓐ Ⓑ Ⓒ Ⓓ	12. Ⓐ Ⓑ Ⓒ Ⓓ	17. Ⓐ Ⓑ Ⓒ Ⓓ	22. Ⓐ Ⓑ Ⓒ Ⓓ
3. Ⓐ Ⓑ Ⓒ Ⓓ	8. Ⓐ Ⓑ Ⓒ Ⓓ	13. Ⓐ Ⓑ Ⓒ Ⓓ	18. Ⓐ Ⓑ Ⓒ Ⓓ	23. Ⓐ Ⓑ Ⓒ Ⓓ
4. Ⓐ Ⓑ	9. Ⓐ Ⓑ Ⓒ Ⓓ	14. Ⓐ Ⓑ Ⓒ Ⓓ	19. Ⓐ Ⓑ Ⓒ Ⓓ	24. Ⓐ Ⓑ Ⓒ Ⓓ
5. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ	15. Ⓐ Ⓑ Ⓒ Ⓓ	20. Ⓐ Ⓑ Ⓒ Ⓓ	25. Ⓐ Ⓑ Ⓒ Ⓓ

5 Hour Specialty Course Final Exam

Questions on pages 24-28

Part One: Workplace Safety

1. Ⓐ Ⓑ Ⓒ Ⓓ	3. Ⓐ Ⓑ Ⓒ Ⓓ	5. Ⓐ Ⓑ Ⓒ Ⓓ	7. Ⓐ Ⓑ Ⓒ Ⓓ	9. Ⓐ Ⓑ Ⓒ Ⓓ
2. Ⓐ Ⓑ Ⓒ Ⓓ	4. Ⓐ Ⓑ Ⓒ Ⓓ	6. Ⓐ Ⓑ Ⓒ Ⓓ	8. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ

Part Two: Workers' Compensation

1. Ⓐ Ⓑ Ⓒ Ⓓ	3. Ⓐ Ⓑ Ⓒ Ⓓ	5. Ⓐ Ⓑ Ⓒ Ⓓ	7. Ⓐ Ⓑ Ⓒ Ⓓ	9. Ⓐ Ⓑ Ⓒ Ⓓ
2. Ⓐ Ⓑ Ⓒ Ⓓ	4. Ⓐ Ⓑ Ⓒ Ⓓ	6. Ⓐ Ⓑ Ⓒ Ⓓ	8. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ

Part Three: Laws & Rules

1. Ⓐ Ⓑ Ⓒ Ⓓ	3. Ⓐ Ⓑ Ⓒ Ⓓ	5. Ⓐ Ⓑ	7. Ⓐ Ⓑ Ⓒ Ⓓ	9. Ⓐ Ⓑ Ⓒ Ⓓ
2. Ⓐ Ⓑ Ⓒ Ⓓ	4. Ⓐ Ⓑ Ⓒ Ⓓ	6. Ⓐ Ⓑ Ⓒ Ⓓ	8. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ Ⓒ Ⓓ

Part Four: Business Practices

1. Ⓐ Ⓑ Ⓒ Ⓓ	3. Ⓐ Ⓑ Ⓒ Ⓓ	5. Ⓐ Ⓑ Ⓒ Ⓓ	7. Ⓐ Ⓑ Ⓒ Ⓓ	9. Ⓐ Ⓑ Ⓒ Ⓓ
2. Ⓐ Ⓑ	4. Ⓐ Ⓑ Ⓒ Ⓓ	6. Ⓐ Ⓑ	8. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ Ⓒ Ⓓ

Part Five: Wind Mitigation

1. Ⓐ Ⓑ Ⓒ Ⓓ	3. Ⓐ Ⓑ Ⓒ Ⓓ	5. Ⓐ Ⓑ	7. Ⓐ Ⓑ Ⓒ Ⓓ	9. Ⓐ Ⓑ
2. Ⓐ Ⓑ Ⓒ Ⓓ	4. Ⓐ Ⓑ Ⓒ Ⓓ	6. Ⓐ Ⓑ Ⓒ Ⓓ	8. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ Ⓒ Ⓓ

Durability by Design: A Guide for Residential Builders and Designers Final Exam *Questions on pages 53-55*

1. Ⓐ Ⓑ Ⓒ Ⓓ	9. Ⓐ Ⓑ Ⓒ Ⓓ	17. Ⓐ Ⓑ Ⓒ Ⓓ	25. Ⓐ Ⓑ Ⓒ Ⓓ	33. Ⓐ Ⓑ Ⓒ Ⓓ
2. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ Ⓒ Ⓓ	18. Ⓐ Ⓑ Ⓒ Ⓓ	26. Ⓐ Ⓑ Ⓒ Ⓓ	34. Ⓐ Ⓑ Ⓒ Ⓓ
3. Ⓐ Ⓑ Ⓒ Ⓓ	11. Ⓐ Ⓑ Ⓒ Ⓓ	19. Ⓐ Ⓑ Ⓒ Ⓓ	27. Ⓐ Ⓑ Ⓒ Ⓓ	35. Ⓐ Ⓑ Ⓒ Ⓓ
4. Ⓐ Ⓑ Ⓒ Ⓓ	12. Ⓐ Ⓑ Ⓒ Ⓓ	20. Ⓐ Ⓑ Ⓒ Ⓓ	28. Ⓐ Ⓑ Ⓒ Ⓓ	36. Ⓐ Ⓑ Ⓒ Ⓓ
5. Ⓐ Ⓑ Ⓒ Ⓓ	13. Ⓐ Ⓑ Ⓒ Ⓓ	21. Ⓐ Ⓑ Ⓒ Ⓓ	29. Ⓐ Ⓑ Ⓒ Ⓓ	37. Ⓐ Ⓑ Ⓒ Ⓓ
6. Ⓐ Ⓑ Ⓒ Ⓓ	14. Ⓐ Ⓑ Ⓒ Ⓓ	22. Ⓐ Ⓑ Ⓒ Ⓓ	30. Ⓐ Ⓑ Ⓒ Ⓓ	38. Ⓐ Ⓑ Ⓒ Ⓓ
7. Ⓐ Ⓑ Ⓒ Ⓓ	15. Ⓐ Ⓑ Ⓒ Ⓓ	23. Ⓐ Ⓑ Ⓒ Ⓓ	31. Ⓐ Ⓑ Ⓒ Ⓓ	39. Ⓐ Ⓑ Ⓒ Ⓓ
8. Ⓐ Ⓑ Ⓒ Ⓓ	16. Ⓐ Ⓑ Ⓒ Ⓓ	24. Ⓐ Ⓑ Ⓒ Ⓓ	32. Ⓐ Ⓑ Ⓒ Ⓓ	40. Ⓐ Ⓑ Ⓒ Ⓓ

Review of Structural Materials for Home Building: 1900 to 2000 Final Exam *Questions on pages 103-104*

1. Ⓐ Ⓑ	7. Ⓐ Ⓑ Ⓒ Ⓓ	13. Ⓐ Ⓑ Ⓒ Ⓓ	19. Ⓐ Ⓑ Ⓒ Ⓓ	25. Ⓐ Ⓑ Ⓒ Ⓓ
2. Ⓐ Ⓑ Ⓒ Ⓓ	8. Ⓐ Ⓑ Ⓒ Ⓓ	14. Ⓐ Ⓑ	20. Ⓐ Ⓑ Ⓒ Ⓓ	26. Ⓐ Ⓑ Ⓒ Ⓓ
3. Ⓐ Ⓑ Ⓒ Ⓓ	9. Ⓐ Ⓑ Ⓒ Ⓓ	15. Ⓐ Ⓑ Ⓒ Ⓓ	21. Ⓐ Ⓑ	27. Ⓐ Ⓑ Ⓒ Ⓓ
4. Ⓐ Ⓑ Ⓒ Ⓓ	10. Ⓐ Ⓑ Ⓒ Ⓓ	16. Ⓐ Ⓑ Ⓒ Ⓓ	22. Ⓐ Ⓑ Ⓒ Ⓓ	28. Ⓐ Ⓑ Ⓒ Ⓓ
5. Ⓐ Ⓑ Ⓒ Ⓓ	11. Ⓐ Ⓑ Ⓒ Ⓓ	17. Ⓐ Ⓑ Ⓒ Ⓓ	23. Ⓐ Ⓑ Ⓒ Ⓓ	29. Ⓐ Ⓑ Ⓒ Ⓓ
6. Ⓐ Ⓑ Ⓒ Ⓓ	12. Ⓐ Ⓑ	18. Ⓐ Ⓑ Ⓒ Ⓓ	24. Ⓐ Ⓑ Ⓒ Ⓓ	30. Ⓐ Ⓑ Ⓒ Ⓓ

VERY IMPORTANT

YOU MUST SIGN BELOW IN ORDER TO RECEIVE CREDIT FOR THE COURSE

By signing below, I hereby certify that I have spent the required time to study this course material and that I have personally completed each module/session of instruction, including the exam.

Signature_____

Florida Building Code 6th Edition: Advanced Course Final Exam

1. **The Florida Building Code 6th Edition replaces the Florida Building Code 5th Edition as of _____.**
   a. 01/31/2018
   b. 12/31/2016
   c. 12/31/2017
   d. 6/30/2018

2. **The Florida Building Code 6th Edition is based off of which of the following?**
   a. 2012 International Building Code
   b. 2015 International Building Code
   c. OSHA Construction Safety
   d. None of the above

3. **To determine the height and area of a building, the allowable value is based on which of the following variables?**
   a. Occupancy classification of the building
   b. Type of construction of the building
   c. Whether or not the building is sprinklered and if it is sprinklered, the type of sprinkler system provided
   d. All of the above

4. **True or false? Basements need not be included in the total allowable floor area of a building provided the total area of such basements does not exceed the area permitted for a one-story above grade plane building.**
   a. True
   b. False

5. **The allowable area of a single-occupancy building with no more than one story above grade plane shall be determined in accordance with Equation 5-1. Which of the following is Equation 5-1?**
   a. Fh = qh(GCr)Af(1b)(N)
   b. F = qzGCfAf(1b)(N)(29.4-1)
   c. Fv = qh(GCr)Ar(1b)(N)
   d. A_a = At + (NS x If)

6. ***Fire walls* designed and constructed in accordance with _____ shall be deemed to comply with section 706.2 Structural Stability.**
   a. NFPA 221
   b. NFPA 13
   c. FM Global
   d. Section 903.4.1

7. **An automatic sprinkler system must be installed in a building when the roof is used for which of the following?**
   a. Group A-2 assembly occupancy with an occupant load exceeding 100.
   b. Group A occupancies where the occupant load exceeds 300.
   c. Group B occupancies where the occupant load exceeds 500.
   d. Both A and B are correct

8. **Provisions for limited area sprinkler systems have been revised to reduce the number of sprinklers that may be supplied from a building plumbing system to ____ in a single fire area.**
   a. five
   b. six
   c. seven
   d. eight

9. **Which of the following areas classified by NFPA 13 shall be permitted to be protected by limited area sprinkler systems?**
   a. Light Hazard areas
   b. Ordinary Hazard Group I areas
   c. Ordinary Hazard Group II areas
   d. Both A and B are correct

10. **True or false? Automatic water mist systems are considered equivalent to automatic sprinkler systems.**
    a. True
    b. False

11. **Where a secondary water supply is required for an automatic sprinkler system, an automatic water mist system shall be provided with _____.**
    a. an approved secondary water supply.
    b. an optional secondary water supply.
    c. supervision and alarms.
    d. floor control valves.

12. **Permanent ladders shall be permitted to provide access to which of the following areas?**
    a. Spaces frequented only by personnel for maintenance, repair or monitoring of equipment
    b. Elevated levels in Group U not open to the general public
    c. Nonoccupiable spaces accessed only by catwalks, crawl spaces, freight elevators or very narrow passageways
    d. All of the above

13. **The new exception regarding the use of synthetic underlayments requires them to have a minimum tear strength of ____ lbs in accordance with ASTM D 1970 or ASTM D 4533.**
    a. 10
    b. 15
    c. 20
    d. 25

14. **The attachment of underlayments requires the use of metal cap nails where the ultimate design wind speed, V_{ult}, equals or exceeds _____ mph.**
    a. 125
    b. 150
    c. 100
    d. 75

15. **The exception for using wood structural panels for opening protection in wind-borne debris regions has been revised based on new research. The maximum span has been reduced from 8 feet to ____ inches.**
    a. 30
    b. 72
    c. 44
    d. 96

16. **Storage sheds that are not designed for human habitation and that have a floor area of ____ square feet or less are not required to comply with the mandatory windborne debris impact standards of this code.**
    a. 67
    b. 30
    c. 720
    d. 50

17. **The design wind force for other structures (chimneys, tanks, similar structures, open signs, lattice frameworks and trussed towers) whether ground or roof mounted, shall be determined by which of the following equations?**
    a. Fh = qh(GCr)Af(1b)(N)
    b. F = qzGCfAf(1b)(N)(29.4-1)
    c. Fv = qh(GCr)Ar(1b)(N)
    d. A_a = At + (NS x If)

18. **Many Florida communities and property owners can attest that designing and constructing buildings to account for flood loads and conditions significantly reduces damage. FEMA reports that structures built to NFIP criteria experience _____% less damage through reduced frequency and severity of losses.**
    a. 80
    b. 75
    c. 70
    d. 50

19. **Chapter 16 of the *FBC, Building* requires designers to develop _____, which involves determining flood conditions (flood depth, velocity, scour/erosion, and wave/debris impact).**
    a. flood maps
    b. flood zones
    c. flood provisions
    d. flood loads

20. **Zones V, VE, V1-30, and VO are flood hazard areas identified as which of the following?**
    a. The inland extent of 1.5-foot waves.
    b. Areas subject to flooding by the 500-year flood.
    c. Areas found along open coastlines where, during the base flood, waves are expected to be 3 feet and higher.
    d. Areas along rivers and streams, in isolated areas where floodwaters accumulate without draining to a waterway.

21. **Flood depth can be determined by which of the following?**
    a. By subtracting the ground elevation from the base flood elevation (BFE) shown on the FIRM
    b. By using standard methods for estimating open-channel flow velocities
    c. It can be estimated with the use of the Flood Insurance Study's floodway data table.
    d. All of the above

22. **Many Florida communities adopt requirements for additional elevation above the minimum in the FBC, ranging from ____ to ____ feet above the BFE. This added factor of safety is called "freeboard." Buildings that are higher than the BFE sustain less damage and owners pay lower Federal flood insurance premiums**
    a. 1 to 3 feet
    b. 2 to 4 feet
    c. 3 to 5 feet
    d. 4 to 6 feet

23. **According to *Table 504.3 Allowable Building Height in Feet Above Grade Plane*, a building with the following specifications can be how many feet above grade plane?**
- **Occupancy classification: I-4**
- **Construction type: Type II- A**
- **Sprinkler system: Building is equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1**
    a. 85
    b. 65
    c. UL
    d. 180

24. **According to *Table 504.4: Allowable Number of Stories Above Grade Plane*, a building with the following specifications can be how many stories above grade plane?**
- **Occupancy classification: A-3**
- **Construction type: Type III-B**
- **Sprinkler system: Building is not equipped throughout with an automatic sprinkler system**
    a. UL
    b. 4
    c. 3
    d. 2

25. **According to *Table 506.2 Allowable Area Factor (At = NS, S1, S13R, or SM, as applicable) in Square Feet*, a building with the following specifications can have an area of how many square feet?**
- **Occupancy classification: F-1**
- **Construction type: Type V-B**
- **Sprinkler system: Building is two stories above grade plane and equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1**
    a. 8,500
    b. 34,000
    c. 25,500
    d. NP

Florida Building Code 6th Edition: Advanced Course

Course Introduction

PDH Academy's 2 CE hour *Florida Building Code 6th Edition: Advanced Course* discusses many highlights and changes from the previous Florida Building Code 5th Edition. It is important to note that the Florida Building Code 5th Edition was based off of the 2012 International Building Code while the Florida Building Code 6th Edition is based off of the 2015 International Building Code. The Florida Building Code 6th Edition is scheduled to replace the Florida Building Code 5th Edition as of 12/31/2017.

This course focuses on the following subjects:

- Building Height & Building Area Modifications
- Structural Stability (Fire Walls)
- Assembly Occupancies on Roofs
- Limited Area Sprinkler Systems
- Automatic Water Mist Systems
- Ladders
- Underlayment
- Protection of Openings
- Rooftop Equipment (HVHZ)
- Flood Resistant Construction

The *Florida Building Code 6th Edition: Advanced Course* is provided in accordance with the requirements of the Florida Department of Business and Professional Regulation (DBPR) for the required Advanced Florida Building Code Module.

This course is designed to cover some of the most significant changes from the 5th Edition to the 6th Edition of the Code. However, this course does not cover every change between the codes. Building professionals will have their own areas of expertise making it essential that every architect, engineer, and contractor carefully study the code sections most affecting their professional practice.

***Disclaimer**: This course is intended to give the reader information current at the time of publication. This course is not a substitute for professional advice and should not be used for guidance or decisions related to a specific design or construction project. This course is not intended to reflect the opinion of any of the entities, agencies, or organizations identified in the materials.*

Chapter 5: General Building Heights and Areas

Building Height & Building Area Modifications

The allowable area and height provisions of the code have been rewritten and reorganized to be more user friendly and provide technical consistency. While the provisions have been completely overhauled, the result is essentially an editorial change.

Table 503 from the 5th Edition (2014) *Florida Building Code, Building* (FBCB), that represented unmodified base allowable area and height data, has been separated into three specific tables and placed in context at the appropriate technical sections for the design or review process.

Table 504.3, "Allowable Building Height in Feet Above Grade Plane", Table 504.4, "Allowable Number of Stories Above Grade Plane" and Table 506.2, "Allowable Area Factor", now provide the allowable value based on the three (3) required variables to determine the height and area of a building:

1. Occupancy classification of the building
2. Type of construction of the building, and
3. Whether or not the building is sprinklered and if it is sprinklered, the type of sprinkler system provided.

Section 504: Building Height and Number of Stories

504.1 General. The height, in feet, and the number of stories of a building shall be determined based on the type of construction, occupancy classification and whether there is an *automatic sprinkler system* installed throughout the building.

> **Exception:** The *building height* of one-*story* aircraft hangars, aircraft paint hangars and buildings used for the manufacturing of aircraft shall not be limited where the building is provided with an *automatic sprinkler system* or *automatic fire-extinguishing system* in accordance with Chapter 9 and is entirely surrounded by public ways or yards not less in width than one and one-half times the *building height*.

504.1.1 Unlimited area buildings. The height of unlimited area buildings shall be designed in accordance with Section 507.

504.1.2 Special Provisions. The special provisions of Section 510 permit the use of special conditions that are exempt from, or modify, the specific requirements of this chapter regarding the allowable heights of buildings based on the occupancy classification and type of construction, provided the special condition complies with the provisions specified in Section 510.

504.2 Mixed occupancy. In a building containing mixed occupancies in accordance with Section 508, no individual occupancy shall exceed the height and number of story limits specified in this section for the applicable occupancies.

504.3 Height in feet. The maximum height, in feet, of a building shall not exceed the limits specified in Table 504.3.

> **Exception:** Towers, spires, steeples, and other roof structures shall be constructed of materials consistent with the required type of construction of the building except where other construction is permitted by Section 1510.2.5. Such structures shall not be used for habitation or storage. The structures shall be unlimited in height where of noncombustible materials and shall not extend more than 20 feet (6096mm) above the allowable building height where of combustible materials (see Chapter 15 for additional requirements).

504.4 Number of stories. The maximum number of stories of a building shall not exceed the limits specified in Table 504.4.

TABLE 504.3[a]
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		Type I		Type II		Type III		Type IV	Type V	
		A	B	A	B	A	B	HT	A	B
A, B, E, F, M, S, U	NS[b]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
H-1, H-2, H-3, H-5	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S									
H-4	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 1, I-3	NS[d, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 2, I-2	NS[d, f, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85						
I-4	NS[d, g]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
R	NS[d, h]	UL	160	65	55	65	55	65	50	40
	S13R	60	60	60	60	60	60	60	60	60
	S	UL	180	85	75	85	75	85	70	60

For SI: 1 foot = 304.8 mm.

Note: UL = Unlimited; NS = Buildings not equipped throughout with an automatic sprinkler system; S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1; S13R = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.2.

a. See Chapters 4 and 5 for specific exceptions to the allowable height in this chapter.

b. See Section 903.2 for the minimum thresholds for protection by an automatic sprinkler system for specific occupancies.

c. New Group H occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.5.

d. The NS value is only for use in evaluation of existing building height in accordance with the *Florida Building Code, Existing Building.*

e. New Group I-1 and I-3 occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.6. For new Group I-1 occupancies Condition 1, see Exception 1 of Section 903.2.6.

f. New and existing Group I-2 occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.6 and the *Florida Fire Prevention Code.*

g. For new Group I-4 occupancies see Exceptions 2 and 3 of Section 903.2.6.

h. New Group R occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.8.

Table 504.3: Allowable Building Height in Feet Above Grade Plane

TABLE 504.4[a,b] ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE										
OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		Type I		Type II		Type III		Type IV	Type V	
		A	B	A	B	A	B	HT	A	B
A-1	NS	UL	5	3	2	3	2	3	2	1
	S	UL	6	4	3	4	3	4	3	2
A-2	NS	UL	11	3	2	3	2	3	2	1
	S	UL	12	4	3	4	3	4	3	2
A-3	NS	UL	11	3	2	3	2	3	2	1
	S	UL	12	4	3	4	3	4	3	2
A-4	NS	UL	11	3	2	3	2	3	2	1
	S	UL	12	4	3	4	3	4	3	2
A-5	NS	UL	UL	UL	UL	UL	UL	UL	UL	UL
	S	UL	UL	UL	UL	UL	UL	UL	UL	UL
B	NS	UL	11	5	3	5	3	5	3	2
	S	UL	12	6	4	6	4	6	4	3
E	NS	UL	5	3	2	3	2	3	1	1
	S	UL	6	4	3	4	3	4	2	2
F-1	NS	UL	11	4	2	3	2	4	2	1
	S	UL	12	5	3	4	3	5	3	2
F-2	NS	UL	11	5	3	4	3	5	3	2
	S	UL	12	6	4	5	4	6	4	3
H-1	NS[c, d]	1	1	1	1	1	1	1	1	NP
	S									
H-2	NS[c, d]	UL	3	2	1	2	1	2	1	1
	S									
H-3	NS[c, d]	UL	6	4	2	4	2	4	2	1
	S									
H-4	NS[c, d]	UL	7	5	3	5	3	5	3	2
	S	UL	8	6	4	6	4	6	4	3
H-5	NS[c, d]	4	4	3	3	3	3	3	3	2
	S									
I-1 Condition 1	NS[d, e]	UL	9	4	3	4	3	4	3	2
	S	UL	10	5	4	5	4	5	4	3
I-1 Condition 2	NS[d, e]	UL	9	4	3	4	3	4	3	2
	S	UL	10	5						
I-2	NS[d, f]	UL	4	2	1	1	NP	1	1	NP
	S	UL	5	3						
I-3	NS[d, e]	UL	4	2	1	2	1	2	2	1
	S	UL	5	3	2	3	2	3	3	2
I-4	NS[d, g]	UL	5	3	2	3	2	3	1	1
	S	UL	6	4	3	4	3	4	2	2
M	NS	UL	11	4	2	4	2	4	3	1
	S	UL	12	5	3	5	3	5	4	2
R-1	NS[d, h]	UL	11	4	4	4	4	4	3	2
	S13R	4	4						4	3
	S	UL	12	5	5	5	5	5	4	3
R-2	NS[d, h]	UL	11	4	4	4	4	4	3	2
	S13R	4	4	4					4	3
	S	UL	12	5	5	5	5	5	4	3
R-3	NS[d, h]	UL	11	4	4	4	4	4	3	3
	S13R	4	4						4	4
	S	UL	12	5	5	5	5	5	4	4
R-4	NS[d, h]	UL	11	4	4	4	4	4	3	2
	S13R	4	4						4	3
	S	UL	12	5	5	5	5	5	4	3

Table 504.4: Allowable Number of Stories Above Grade Plane

S-1	NS	UL	11	4	2	3	2	4	3	1
	S	UL	12	5	3	4	3	5	4	2
S-2	NS	UL	11	5	3	4	3	4	4	2
	S	UL	12	6	4	5	4	5	5	3
U	NS	UL	5	4	2	3	2	4	2	1
	S	UL	6	5	3	4	3	5	3	2

Note: UL = Unlimited; NP = Not permitted; NS = Buildings not equipped throughout with an automatic sprinkler system; S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1; S13R = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.2.

a. See Chapters 4 and 5 for specific exceptions to the allowable height in this chapter.

b. See Section 903.2 for the minimum thresholds for protection by an automatic sprinkler system for specific occupancies.

c. New Group H occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.5.

d. The NS value is only for use in evaluation of existing building height in accordance with the *Florida Building Code, Existing Building.*

e. New Group I-1 and I-3 occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.6. For new Group I-1 occupancies, Condition 1, see Exception 1 of Section 903.2.6.

f. New and existing Group I-2 occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.6 and the *Florida Fire Prevention Code.*

g. For new Group I-4 occupancies, see Exceptions 2 and 3 of Section 903.2.6.

h. New Group R occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.8.

Table 504.4: Allowable Number of Stories Above Grade Plane *(Continued)*

Section 506: Building Area

506.1 General. The floor area of a building shall be determined based on the type of construction, occupancy classification, whether there is an automatic sprinkler system installed throughout the building and the amount of building frontage on public way or open space.

506.1.1 Unlimited area buildings. Unlimited area buildings shall be designed in accordance with Section 507.

506.1.2 Special Provisions. The special provisions of Section 510 permit the use of special conditions that are exempt from, or modify, the specific requirements of this chapter regarding the allowable areas of buildings based on the occupancy classification and type of construction, provided the special condition complies with the provisions specified in Section 510.

506.1.3 Basements. Basements need not be included in the total allowable floor area of a building provided the total area of such basements does not exceed the area permitted for a one-story above grade plane building.

506.2 Allowable area determination. The allowable area of a building shall be determined in accordance with the applicable provisions of Section 506.2.1 through 506.2.4 and Section 506.3.

506.2.1 Single-occupancy, one-story buildings. The allowable area of a single-occupancy building with no more than one story above grade plane shall be determined in accordance with **Equation 5-1:**

$A_a = A_t + (NS \times I_f)$ **(Equation 5-1)**

where:

A_a = Allowable area (square feet)

A_t = Tabular allowable area factor (NS, S1, or S13R value, as applicable) in accordance with Table 506.2.

NS = Tabular allowable area factor in accordance with Table 506.2 for nonsprinklered building (regardless of whether the building is sprinklered).

I_f = Area factor increase due to frontage (percent) as calculated in accordance with Section 506.3.

506.2.2 Mixed-occupancy, one-story buildings. The allowable area of a mixed-occupancy building with no more than one story above grade plane shall be determined in accordance with the applicable provisions of Section 508.1 based on Equation 5-1 for each applicable occupancy.

TABLE 506.2 [a,b]
ALLOWABLE AREA FACTOR ((A_t = NS, S1, S13R, or SM, as applicable) IN SQUARE FEET

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		Type I		Type II		Type III		Type IV	Type V	
		A	B	A	B	A	B	HT	A	B
A-1	NS	UL	UL	15,500	8,500	14,000	8,500	15,000	11,500	5,500
	S1	UL	UL	62,000	34,000	56,000	34,000	60,000	46,000	22,000
	SM	UL	UL	46,500	25,500	42,000	25,500	45,000	34,500	16,500
A-2	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
A-3	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
A-4	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
A-5	NS	UL	UL	UL	UL	UL	UL	UL	UL	UL
	S1									
	SM									
B	NS	UL	UL	37,500	23,000	28,500	19,000	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	108,000	54,000	27,000
E	NS	UL	UL	26,500	14,500	23,500	14,500	25,500	18,500	9,500
	S1	UL	UL	106,000	58,000	94,000	58,000	102,000	74,000	38,000
	SM	UL	UL	79,500	43,500	70,500	43,500	76,500	55,500	28,500
F-1	NS	UL	UL	25,000	15,500	19,000	12,000	33,500	14,000	8,500
	S1	UL	UL	100,000	62,000	76,000	48,000	134,000	56,000	34,000
	SM	UL	UL	75,000	46,500	57,000	36,000	100,500	42,000	25,500
F-2	NS	UL	UL	37,500	23,000	28,500	18,000	50,500	21,000	13,000
	S1	UL	UL	150,000	92,000	114,000	72,000	202,000	84,000	52,000
	SM	UL	UL	112,500	69,000	85,500	54,000	151,500	63,000	39,000
H-1	NS[c]	21,000	16,500	11,000	7,000	9,500	7,000	10,500	7,500	NP
	S1									
H-2	NS[c]	21,000	16,500	11,000	7,000	9,500	7,000	10,500	7,500	3,000
	S1									
	SM									
H-3	NS[c]	UL	60,000	26,500	14,000	17,500	13,000	25,500	10,000	5,000
	S1									
	SM									
H-4	NS[c, d]	UL	UL	37,500	17,500	28,500	17,500	36,000	18,000	6,500
	S1	UL	UL	150,000	70,000	114,000	70,000	144,000	72,000	26,000
	SM	UL	UL	112,500	52,500	85,500	52,500	108,000	54,000	19,500
H-5	NS[c, d]	UL	UL	37,500	23,000	28,500	19,000	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	108,000	54,000	27,000
I-1	NS[d, e]	UL	55,000	19,000	10,000	16,500	10,000	18,000	10,500	4,500
	S1	UL	220,000	76,000	40,000	66,000	40,000	72,000	42,000	18,000
	SM	UL	165,000	57,000	30,000	49,500	30,000	54,000	31,500	13,500
I-2	NS[d, f]	UL	UL	15,000	11,000	12,000	NP	12,000	9,500	NP
	S1	UL	UL	60,000	44,000	48,000	NP	48,000	38,000	NP
	SM	UL	UL	45,000	33,000	36,000	NP	36,000	28,500	NP
I-3	NS[d, e]	UL	UL	15,000	10,000	10,500	7,500	12,000	7,500	5,000
	S1	UL	UL	45,000	40,000	42,000	30,000	48,000	30,000	20,000
	SM	UL	UL	45,000	30,000	31,500	22,500	36,000	22,500	15,000
I-4	NS[d, g]	UL	60,500	26,500	13,000	23,500	13,000	25,500	18,500	9,000
	S1	UL	121,000	106,000	52,000	94,000	52,000	102,000	74,000	36,000
	SM	UL	181,500	79,500	39,000	70,500	39,000	76,500	55,500	27,000
M	NS	UL	UL	21,500	12,500	18,500	12,500	20,500	14,000	9,000
	S1	UL	UL	86,000	50,000	74,000	50,000	82,000	56,000	36,000
	SM	UL	UL	64,500	37,500	55,500	37,500	61,500	42,000	27,000
R-1	NS[d, h]	UL	UL	24,000	16,000	24,000	16,000	20,500	12,000	7,000
	S13R									
	S1	UL	UL	96,000	64,000	96,000	64,000	82,000	48,000	28,000
	SM	UL	UL	72,000	48,000	72,000	48,000	61,500	36,000	21,000

R-2	NS[d, h]	UL	UL	24,000	16,000	24,000	16,000	20,500	12,000	7,000
	S13R									
	S1	UL	UL	96,000	64,000	96,000	64,000	82,000	48,000	28,000
	SM	UL	UL	72,000	48,000	72,000	48,000	61,500	36,000	21,000
R-3	NS[d, h]	UL	UL	UL	UL	UL	UL	UL	UL	UL
	S13R									
	S1									
	SM									
R-4	NS[d, h]	UL	UL	24,000	16,000	24,000	16,000	20,500	12,000	7,000
	S13R									
	S1	UL	UL	96,000	64,000	96,000	64,000	82,000	48,000	28,000
	SM	UL	UL	72,000	48,000	72,000	48,000	61,500	36,000	21,000
S-1	NS	UL	48,000	26,000	17,500	26,000	17,500	25,500	14,000	9,000
	S1	UL	192,000	104,000	70,000	104,000	70,000	102,000	56,000	36,000
	SM	UL	144,000	78,000	52,500	78,000	52,500	76,500	42,000	27,000
S-2	NS	UL	79,000	39,000	26,000	39,000	26,000	38,500	21,000	13,500
	S1	UL	316,000	156,000	104,000	156,000	104,000	154,000	84,000	54,000
	SM	UL	237,000	117,000	78,000	117,000	78,000	115,500	63,000	40,500
U	NS	UL	35,500	19,000	8,500	14,000	8,500	18,000	9,000	5,500
	S1	UL	142,000	76,000	34,000	56,000	34,000	72,000	36,000	22,000
	SM	UL	106,500	57,000	25,500	42,000	25,500	54,000	27,000	16,500

Note: UL = Unlimited; NP = Not permitted;

For SI: 1 square foot = 0.0929 m^2

NS = Buildings not equipped throughout with an automatic sprinkler systems; S1 = Buildings a maximum of one story above grade plane equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1; SM = Buildings two or more stories above grade plane equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1; S13R = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.2.

a. See Chapters 4 and 5 for specific exceptions to the allowable height in this chapter.

b. See Section 903.2 for the minimum thresholds for protection by an automatic sprinkler system for specific occupancies.

c. New Group H occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.5.

d. The NS value is only for use in evaluation of existing building area in accordance with the *Florida Building Code, Existing Building.*

e. New Group I-1 and I-3 occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.6. For new Group I-1 occupancies, Condition 1, see Exception 1 of Section 903.2.6.

f. New and existing Group I-2 occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.6 and the *Florida Fire Prevention Code.*

g. New Group I-4 occupancies see Exceptions 2 and 3 of Section 903.2.6.

h. New Group R occupancies are required to be protected by an automatic sprinkler system in accordance with Section 903.2.8.

Table 506.2 Allowable Area Factor (At = NS, S1, S13R, or SM, as applicable) in Square Feet

Chapter 7: Fire and Smoke Protection Features

Structural Stability (Fire Walls)

The requirement that the fire wall have sufficient structural stability such that it will remain in place for the duration of time indicated by the required fire-resistance rating has been deleted.

706.2 Structural stability. *Fire walls* shall be designed and constructed to allow collapse of the structure on either side without collapse of the wall under fire conditions. *Fire walls* designed and constructed in accordance with NFPA 221 shall be deemed to comply with this section.

Chapter 9: Fire Protection Systems

Assembly Occupancies on Roofs

This is a new section requiring an automatic sprinkler system to be installed in a building when the roof is used for a Group A-2 assembly occupancy with an occupant load exceeding 100, as well as for other Group A occupancies where the occupant load exceeds 300.

[F] 903.2.1.6 Assembly occupancies on roofs. Where an occupied roof has an assembly occupancy with an *occupant load* exceeding 100 for Group A-2 and 300 for other Group A occupancies, all floors between the occupied roof and the *level of exit discharge* shall be equipped with an *automatic sprinkler system* in accordance with Section 903.3.1.1 or 903.3.1.2.

Exception: Open parking garages of Type I or Type II construction.

Limited Area Sprinkler Systems

Provisions for limited area sprinkler systems have been revised to reduce the number of sprinklers that may be supplied from a building plumbing system to six in a single fire area to eliminate the potential for multiple limited area sprinkler systems and combined water supply demands necessary to control a single fire event. Also revised to limit the six sprinklers to a discharge density of Light Hazard or Ordinary Hazard Group I. The basis for these values provides coordination with longstanding requirements in NFPA 101, Life Safety Code, Section 9.7.1.2, which limits the number and discharge density of automatic sprinklers supplied from a plumbing system.

[F] 903.3.8 Limited area sprinkler systems. Limited area sprinkler systems shall be in accordance with the standards listed in Section 903.3.1 expect as provided in Sections 903.3.8.1 through 903.3.8.5.

903.3.8.1 Number of sprinklers. Limited area sprinkler systems shall not exceed six sprinklers in any single *fire area*.

903.3.8.2 Occupancy hazard classification. Only areas classified by NFPA 13 as Light Hazard or Ordinary Hazard Group 1 shall be permitted to be protected by limited area sprinkler systems.

903.3.8.3 Piping arrangement. Where a limited area sprinkler system is installed in a building with an automatic wet standpipe system, sprinklers shall be supplied by the standpipe system. Where a limited area sprinkler system is installed in a building without an automatic wet standpipe system, water shall be permitted to be supplied by the plumbing system provided that the plumbing system is capable of simultaneously supplying domestic and sprinkler demands.

903.3.8.4 Supervision. Control valves shall not be installed between the water supply and sprinklers unless the valves are of an *approved* indicating type that are supervised or secured in the open position.

903.3.8.5 Calculations. Hydraulic calculations in accordance with NFPA 13 shall be provided to demonstrate that the available water flow and pressure are adequate to supply all sprinklers installed in any single *fire area* with discharge densities corresponding to the hazard classification.

Automatic Water Mist Systems

This is a new section providing requirements for automatic water mist systems. While water mist systems can serve as an alternative, in some applications, to automatic fire sprinkler systems, no exceptions, reductions, or "trade-offs" for water mist systems are granted or permitted as automatic water mist systems are not considered equivalent to automatic sprinkler systems. Automatic water mist systems have been approved by FM Global for occupancies similar to Light Hazard (as defined by NFPA 13) and by UL for occupancies similar to Ordinary Hazard Group I (as defined by NFPA 13).

[F] 904.11 Automatic water mist systems. *Automatic water mist systems* shall be permitted in applications that are consistent with the applicable listing or approvals and shall comply with Sections 904.11.1 through 904.11.3.

[F] 904.11.1 Design and installation requirements. *Automatic water mist systems* shall be designed and installed in accordance with Sections 904.11.1.1 through 904.11.1.4.

[F] 904.11.1.1 General. *Automatic water mist systems* shall be designed and installed in accordance with NFPA 750 and the manufacturer's instructions.

[F] 904.11.1.2 Actuation. *Automatic water mist systems* shall be automatically actuated.

[F] 904.11.1.3 Water supply protection. Connections to a potable water supply shall be protected against backflow in accordance with the *Florida Building Code, Plumbing*.

[F] 904.11.1.4 Secondary water supply. Where a secondary water supply is required for an *automatic sprinkler system*, an *automatic water mist system* shall be provided with an *approved* secondary water supply.

[F] 904.11.2 Water mist system supervision and alarms. Supervision and alarms shall be provided as required for automatic sprinkler systems in accordance with Section 903.4.

[F] 904.11.2.1 Monitoring. Monitoring shall be provided as required for *automatic sprinkler systems* in accordance with Section 903.4.1.

[F] 904.11.2.2 Alarms. Alarms shall be provided as required for *automatic sprinkler systems* in accordance with Section 903.4.2.

[F] 904.11.2.3 Floor control valves. Floor control valves shall be provided as required for *automatic sprinkler systems* in accordance with Section 903.4.3.

[F] 904.11.3 Testing and maintenance. *Automatic water mist systems* shall be tested and maintained in accordance with the *Florida Fire Prevention Code*.

Chapter 10: Means of Egress

Ladders

This is a new section addressing means of egress requirements for spaces such as catwalks above ceilings, mechanical equipment areas, service pits etc. that are occasionally accessed or that are accessed by able bodied trained personnel. Specific areas have been identified where the use of ladders is permitted.

1011.16 Ladders. Permanent ladders shall not serve as a part of the *means of egress* from occupied spaces within a building. Permanent ladders shall be permitted to provide access to the following areas:

1. Spaces frequented only by personnel for maintenance, repair or monitoring of equipment.
2. Nonoccupiable spaces accessed only by catwalks, crawl spaces, freight elevators or very narrow passageways.
3. Raised areas used primarily for purposes of security, life safety or fire safety including, but not limited to, observation galleries, prison guard towers, fire towers or lifeguard stands.
4. Elevated levels in Group U not open to the general public.
5. Nonoccupied roofs that are not required to have *stairway* access in accordance with Section 1011.12.1.
6. Ladders shall be constructed in accordance with Section 306.5 of the *Florida Building Code, Mechanical*.

Chapter 15: Roof Assemblies and Rooftop Structures

Underlayment

There is a new section for underlayment. Underlayment requirements for all roof coverings have been consolidated into a single location in Section R905.1.1. This section requires underlayment to comply with, be applied, and be attached in accordance with New Table 1507.1.1.

There is also a new exception regarding the use of synthetic underlayments which requires them to be an approved alternate to ASTM D 226 Type II and a minimum tear strength of 20 lbs in accordance with ASTM D 1970 or ASTM D 4533. Attachment is required according to the method in Table 1507.1.1 for the applicable roof covering and slope. Metal cap nails are required where V_{ult} equals or exceeds 150 mph.

The required type, installation, and fastening of underlayments for roof coverings have been consolidated into new Table 1507.1.1. Underlayment complying with ASTM D 226 Type II or ASTM D 4869 Type IV (ASTM D 6757 for some roof coverings) is now required for all roof coverings where the roof slope is 4:12 and greater.

1507.1 Scope. Roof coverings shall be applied in accordance with the applicable provisions of this section and the manufacturer's installation instructions.

1507.1.1 Underlayment. Unless otherwise noted, underlayment for asphalt shingles, metal roof panels, metal roof shingles, mineral surfaced roll roofing, slate shingles, wood shingles, and wood shakes shall conform to the applicable standards listed in this chapter. Underlayment materials required to comply with ASTM D226, D1970, D4869 and D6757 shall bear a label indicating compliance to the standard designation and, if applicable, type classification indicated in Table 1507.1.1. Underlayment shall be applied and attached in accordance with Table 1507.1.1.

Exception: A reinforced synthetic underlayment that is approved as an alternative to underlayment complying with ASTM D226 Type II and having a minimum tear strength per ASTM D1970 or ASTM D4533 of 20 pounds (9.1kg) shall be permitted. This underlayment shall be installed and attached in accordance with the underlayment attachment methods of Table 1507.1.1 for the applicable roof covering and slope, except metal cap nails shall be required where the ultimate design wind speed, V_{ult} equals or exceeds 150 mph.

TABLE 1507.1.1 UNDERLAYMENT TABLE				
Roof Covering Section	**Roof Slope 2:12 and Less Than 4:12 Underlayment**	**Underlayment Attachment[a]**	**Roof Slope 4:12 and Greater Underlayment**	**Underlayment Attachment[a]**
Asphalt shingles 1507.2	ASTM D226 Type I or II ASTM D4869 Type II, III or IV ASTM D6757	1	ASTM D226 Type II ASTM D4869 Type IV ASTM D6757	2
	ASTM D1970	3	ASTM D1970	3
Concrete and Clay Tile 1507.3	See Section 1507.3.3			
Metal roof panels 1507.4	ASTM D226 Type I or II ASTM D4869 Type II, III or IV ASTM D6757	1	ASTM D226 Type II ASTM D4869 Type IV ASTM D6757	2
	ASTM D1970	3	ASTM D1970	3
Metal roof shingles roofing 1507.5	ASTM D226 Type I or II ASTM D4869 Type II, III or IV ASTM D6757	1	ASTM D226 Type II ASTM D4869 Type IV ASTM D6757	2
	ASTM D1970	3	ASTM D1970	3
Mineral-surfaced roll roofing 1507.6	ASTM D226 Type I or II ASTM D4869 Type II, III or IV ASTM D6757	1	ASTM D226 Type II ASTM D4869 Type IV ASTM D6757	2
	ASTM D1970	3	ASTM D1970	3
Slate shingles 15.7.7	ASTM D226 Type I or II ASTM D4869 Type II, III or IV ASTM D6757	1	ASTM D226 Type II ASTM D4869 Type IV ASTM D6757	2
	ASTM D1970	3	ASTM D1970	3
Wood shingles 1507.8	ASTM D226 Type I or II ASTM D4869 Type II, III or IV	1	ASTM D226 Type II ASTM D4869 Type IV	2
Wood shakes 1507.9		Limited to roof slopes 4:12 and Greater	ASTM D226 Type II ASTM D4869 Type IV	2
Photovoltaic Shingles 1507.17	ASTM D226 Type I or II ASTM D4869 Type II, III or IV ASTM D6757	1	ASTM D226 Type II ASTM D4869 Type IV ASTM D6757	2
	ASTM D1970	3	ASTM D1970	3

[a]Underlayment Attachment

1. Roof slopes from two units vertical in 12 units horizontal (17-persent slope), and less than four units vertical in 12 units horizontal (33-percent slope). Apply a 19-inch (483 mm) strip of underlayment felt parallel to and starting at the eaves, fastened sufficiently to hold in place. Starting at the eave, apply 36-inch-wide (914 mm) sheets of underlayment, overlapping successive sheets 19 inches (483 mm), end laps shall be 6 inches and shall be offset by 6 feet. The underlayment shall be attached to a nailable deck with corrosion-resistant fasteners with one row centered in the field of the sheet with a maximum fastener spacing of 12 inches (305 mm) o.c., and one row at the end and side laps fastened 6 inches (152 mm) o.c. Underlayment shall be attached using metal or plastic cap nails with a nominal cap diameter of not less than 1 inch. Metal caps shall have a thickness of not less than 32-gage

sheet metal. Power-driven metal caps shall have a minimum thickness of 0.010 inch. Minimum thickness of the outside edge of plastic caps shall be 0.035 inch. The cap nail shank shall be not less than 0.083 inch for ring shank cap nails and 0.091 inch for smooth shank cap nails. Cap nail shank shall have a length sufficient to penetrate through the roof sheathing or not less than ¾ inch into the roof sheathing.
2. Roof slopes of four units vertical in 12 units horizontal (33-percent slope) or greater. Underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 4 inches (51 mm), end laps shall be 6 inches and shall be offset by 6 feet. The underlayment shall be attached to a nailable deck with two staggered rows in the field of the sheet with a maximum fastener spacing of 12 inches (305 mm) o.c., and one row at the end and side laps fastened 6 inches (152 mm) o.c. Underlayment shall be attached using metal or plastic cap nails with a nominal cap diameter of not less than 1 inch. Metal caps shall have a thickness of not less than 32-gage sheet metal. Power-driven metal caps shall have a minimum thickness of 0.010 inch. Minimum thickness of the outside edge of plastic caps shall be 0.035 inch. The cap nail shank shall be not less than 0.083 inch for ring shank cap nails and 0.091 inch for smooth shank cap nails. Cap nail shank shall have a length sufficient to penetrate through the roof sheathing or not less than ¾ inch into the roof sheathing.
3. Roof slopes from two units vertical in 12 units horizontal (17-percent slope), and greater. The entire roof deck shall be covered with an approved self-adhering polymer modified bitumen underlayment complying with ASTM D1970(2015a) installed in accordance with both the underlayment manufacturer's and roof covering manufacturer's installation instructions for the deck material, roof ventilation configuration and climate exposure for the roof covering to be installed.
Exception: A minimum 4-inch wide (102 mm) strip of shelf-adhering polymer-modified bitumen membrane complying with ASTM D 1970(2015a), installed in accordance with the manufacturer's instructions for the deck material, shall be applied over all joints in the roof decking. An approved underlayment in accordance with Table 1507.1.1 for the applicable roof covering shall be applied over the entire roof over the 4-inch-wide (102 mm) membrane strips.

Table 1507.1.1 Underlayment Table

Chapter 16: Structural Design

Protection of Openings

The exception for using wood structural panels for opening protection in wind-borne debris regions has been revised based on new research. The maximum span has been reduced from 8 feet to 44 inches. New prescriptive attachment methods are provided for wood, masonry, and concrete construction. The prescriptive fastening table has been deleted.

1609.1.2 Protection of openings. In *wind-borne debris regions*, glazed openings in buildings shall be impact resistant or protected with an impact-resistant covering meeting the requirements of ANSI/DASMA 115 (for garage doors and rolling doors) or TAS 201, 202 and 203, AAMA 506, ASTM E1996 and ASTM E1886 referenced herein, or an approved impact-resistant standard as follows:

1. Glazed openings located within 30 feet (9144 mm) of grade shall meet the requirements of the large missile test of ASTM E1996.
2. Glazed openings located more than 30 feet (9144 mm) above grade shall meet the provisions of the small missile test of ASTM E1996.
3. Storage sheds that are not designed for human habitation and that have a floor area of 720 square feet (67 m2) or less are not required to comply with the mandatory windborne debris impact standards of this code.
4. Openings in sunrooms, balconies, or enclosed porches constructed under existing roofs or decks are not required to be protected provided the spaces are separated from the building interior by a wall and all openings in the separating wall are protected in accordance with Section 1609.1.2 above. Such spaces shall be permitted to be designed as either partially enclosed or enclosed structures.

Exceptions:

1. Wood structural panels with a minimum thickness of 7/16 inch (11.1 mm) and maximum span between lines of fasteners of 44 inches (1118 mm) shall be permitted for opening protection in Group R-3 or R-4 occupancy buildings with a mean roof height of 33 feet (10,058 mm) or less where V_{ult} is 180 mph (80 m/s) or less. Panels shall be precut to overlap the wall such that they extend a minimum of 2 inches (50.8 mm) beyond the lines of fasteners and are attached to the framing surrounding the opening containing the product with the glazed opening. Panels shall be predrilled as required for the attachment method and secured with corrosion-resistant attachment hardware permanently installed on the building.
   a. Attachments shall be designed to resist the components and cladding loads determined in accordance with the provisions of ASCE 7, with corrosion-resistant attachment hardware

provided and anchors permanently installed on the building.

b. As an alternative, panels shall be fastened at 16 inches (406.4 mm) on center along the edges of the opposing long sides of the panel.

i. For wood frame construction, fasteners shall be located on the wall such that they are embedded into the wall framing members, nominally a minimum of 1 inch (25.4 mm) from the edge of the opening and 2 inches (50.8 mm) inward from the panel edge. Permanently installed anchors used for building with wood frame wall construction shall have the threaded portion that will be embedded into the wall framing based on 1/4 inch (6.35 mm) lagscrews and shall be long enough to penetrate through the exterior wall covering with sufficient embedment length to provide an allowable minimum 300 pounds ASD design withdrawal capacity.

ii. For concrete or masonry wall construction, fasteners shall be located on the wall a minimum of 1 ½ inches (37.9 mm) from the edge of the opening and 2 inches (50.8 mm) inward of the panel edge. Permanently installed anchors in concrete or masonry wall construction shall have an allowable minimum 300 pounds ASD design withdrawal capacity and an allowable minimum 525 pounds ASD design shear capacity with a 1 ½ inch edge distance. Hex nuts, washered wing-nuts, or bolts used to attach the wood structural panels to the anchors shall be minimum 1/4 inch (6.4 mm) hardware and shall be installed with or have integral washers with a minimum 1-inch (25 mm) outside diameter.

iii. Vibration-resistant alternative attachments designed to resist the component and cladding loads determined in accordance with provisions of ASCE 7 shall be permitted.

2. Glazing in *Risk Category* I buildings, including greenhouses that are occupied for growing plants on a production or research basis, without public access shall be permitted to be unprotected.

3. Glazing in *Risk Category* II, III or IV buildings located over 60 feet (18,288 mm) above the ground and over 30 feet (9144 mm) above aggregate surface roofs located within 1,500 feet (458 m) of the building shall be permitted to be unprotected.

Rooftop Equipment (HVHZ)

This section has been revised to modify the rooftop equipment loading requirements in ASCE 7- 10 to permit the use of Section 29.5.1 in ASCE 7-10 for rooftop equipment loads on buildings of all heights. (Consistent with ASCE 7-16.)

1620.6 Rooftop equipment and structures. Sections 29.5 and 29.5.1 of ASCE 7 shall be modified as follows:

29.5 Design wind loads: other structures

The design wind force for other structures (chimneys, tanks, similar structures, open signs, lattice frameworks and trussed towers) whether ground or roof mounted, shall be determined by the following equation:

F = qzGCfAf(1b)(N)(29.4-1)

where:

qz = velocity pressure evaluated at height z as defined in Section 29.3, of the centroid of area Af;

G = gust-effect factor from Section 26.9;

Cf = force coefficients from Figures 29.5-1 through 29.5-3; and

Af = projected area normal to the wind except where Cf is specified for the actual surface area, in square feet (m^2).

29.5.1 Rooftop structures and equipment for buildings.

The lateral force, Fh for rooftop structures and equipment shall be determined as specified below.

Fh = qh(GCr)Af(1b)(N)

where:

GCr = 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh);

qh = velocity pressure evaluated at mean roof height of the building; and

Af = vertical projected area of the rooftop structure or equipment on a plane normal to the direction of wind, in square feet (m^2).

The vertical uplift force, Fv, on rooftop structures and equipment shall be determined from Equation (29.5-3).

Fv = qh(GCr)Ar(1b)(N)

where:

(GCr) = 1.5 for rooftop structures and equipment with Ar less than (0.1BL). (GCr) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of

Ar is increased from (0.1BL) to (BL);

qh = velocity pressure evaluated at the mean roof height of the building; and

Ar = horizontal projected area of rooftop structure or equipment, in square feet (m^2).

Exception: Exposed mechanical equipment or appliances fastened to a roof or installed on the ground in compliance with the code using rated stands, platforms, curbs, slabs, walls, or other means are deemed to comply with the wind-resistance requirements of the 2007 Florida Building Code, as amended. Further support or enclosure of such mechanical equipment or appliances is not required by a state or local official having authority to enforce the Florida Building Code.

Flood Resistant Construction

Overview

Hurricanes and other storms that result in flooding have caused billions of dollars in damage across all parts of Florida. Local jurisdictions throughout the state recognize, plan for and manage development in flood hazard areas. To participate in the National Flood Insurance Program (NFIP), communities agree to regulate all development in flood hazard areas mapped by the Federal Emergency Management Agency (FEMA).

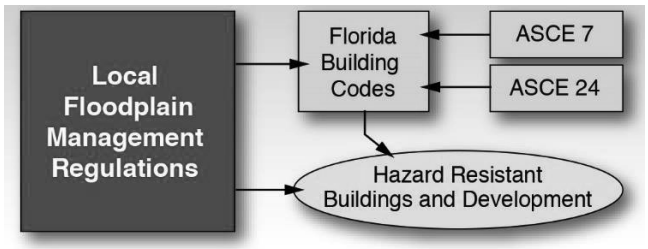
Once an owner or developer makes a decision to construct, add to or substantially improve a building in a flood hazard area, certain requirements intended to minimize future flood damage must be satisfied. Flood provisions for buildings are in the Florida Building Code (FBC), making it easier for design professionals and builders to address the requirements along with other applicable load and design requirements.

The flood provisions of the FBC achieve two broad objectives:

1. As with the rest of the code, the flood provisions help fulfill the purpose of safeguarding public health, safety, and general welfare. Many Florida communities and property owners can attest that designing and constructing buildings to account for flood loads and conditions significantly reduce damage. FEMA reports that structures built to NFIP criteria experience 80% less damage through reduced frequency and severity of losses. Buildings that sustain less damage are more quickly reoccupied, facilitating recovery.
2. The flood provisions fulfill some of the requirements necessary for communities that participate in the NFIP. FEMA states the flood provisions of the International Code Series®, which is the foundation of the FBC, meet or exceed the NFIP requirements for buildings and structures. However, NFIP communities are responsible for regulating all development, including activities that are not within the scope of the codes.

This is accomplished by the adoption of local floodplain management regulations (see graphic). Relying on the model ordinance developed by the Florida Division of Emergency Management (DEM) and approved by FEMA, nearly all Florida communities have adopted local regulations explicitly written to rely on the FBC to satisfy the NFIP requirements for buildings.

Degree of Safety Warning. The degree of flood protection afforded by the flood provisions in the FBC is considered reasonable for regulatory purposes and is based on scientific and engineering considerations. Larger floods can and will occur, flooding land outside of mapped flood hazard areas.



Florida Statute s. 553.73(5) was amended in 2010 to allow communities to adopt local administrative amendments to implement the flood provisions of the FBC and local technical amendments to adopt flood provisions that are more stringent than the FBC (also called "higher standards"). Under most circumstances, local amendments will not sunset when the state adopts a new edition of the code. Model language for some higher standards is available on the DEM webpage.

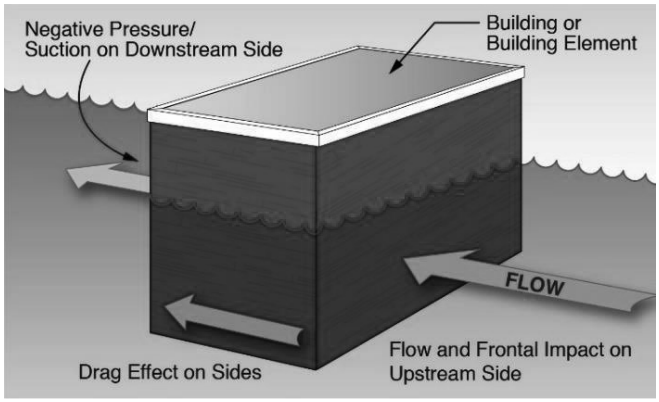
Flood Resistant Construction

The NFIP – and the FBC – requires communities to ensure that new buildings and structures in flood hazard areas are designed and constructed to resist the effects of flood hazards and flood loads. The same requirements apply to existing buildings if proposed work is determined to constitute substantial improvement or repair of substantial damage (both terms are defined in the FBC).

Chapter 16 of the *FBC, Building* requires designers to develop flood loads, which involves determining flood conditions (flood depth, velocity, scour/erosion, and wave/debris impact). Flood loads and load combinations are described in Chapter 5 of ASCE 7, *Minimum Design Loads for Buildings and Other Structures*. Section R322 of the FBC, Residential requires dwellings to be designed and constructed in accordance with specific provisions.

Although hydrostatic load, a function of water depth, is the most obvious load and the easiest to compute, other loads may be more important in final designs. Flood conditions necessary to compute hydrodynamic loads are more difficult to determine (see graphic) and may require consultation with civil or hydraulic engineers. The FBC, Residential requires a design professional to prepare designs for homes in coastal high-hazard areas and Coastal A Zones, but not in other flood zones (see next section for descriptions of flood zones). Designers and builders are cautioned to evaluate whether any flood conditions (such as velocities or waves) may warrant a closer look at flood loads.

Other aspects of flood-resistant construction found in the FBC include the use of flood damage-resistant materials, requirements for enclosures below elevated buildings, and the location of electrical, plumbing, heating, ventilation, and air-conditioning (HVAC) equipment, swimming pools, and tanks.



Flood Hazard Areas and Flood Conditions

Flood Insurance Rate Maps (FIRMs) prepared by FEMA are the most common flood hazard maps adopted by Florida communities. Designers and builders should check with individual communities to determine whether a locally-prepared map is used for regulatory purposes. FIRMs identify flood hazard areas associated with the base flood (the 1%-annual-chance or "100-year" flood). Some FIRMs also identify areas subject to flooding by the less frequent 500-year flood.

FIRMs identify flood hazard areas based on characteristics of flooding:

- Zone A, AE, A1–30, AO, and AH. These zones include flood hazard areas along rivers and streams, in isolated areas where floodwaters accumulate without draining to a waterway and in coastal areas inland of Zone V and along many shorelines. Floodways are designated along some rivers and streams.

  Coastal A Zone. Revised FIRMs for coastal communities may have a Limit of Moderate Wave Action (LiMWA) delivered. The area between the LiMWA and the Zone V boundary or the shore is designated the "Coastal A Zone."

- Zone V, VE, V1–30, and VO. These zones identify coastal high-hazard areas found along open coastlines where, during the base flood, waves are expected to be 3 feet and higher.
- Limit of Moderate Wave Action. When shown, the LiMWA identifies the inland extent of 1.5-foot waves and the area between the LiMWA and the Zone V boundary or shoreline is designated as Coastal A Zone.
- Zone X (shaded) identifies areas subject to flooding by the 500-year flood and Zone X (unshaded) identifies land areas that are outside of the 100- and 500-year flood hazard areas.

Some site-specific flood conditions can be determined using FIRMs and associated Flood Insurance Studies, while others can be estimated using the best available information:

- Flood depth, used to compute lateral and vertical hydrostatic loads, is determined by subtracting the ground elevation from the base flood elevation (BFE) shown on the FIRM. Lateral hydrostatic loads need not be considered for enclosures below elevated buildings that have flood openings to allow floodwater to flow in and out automatically. Vertical (buoyant) hydrostatic loads are calculated for elements below the BFE and may be important when soils are saturated.
- Flood velocity, used to compute hydrodynamic load, may be estimated in riverine areas if the Flood Insurance Study has a floodway data table or by using standard methods for estimating open-channel flow velocities (see FEMA's *Recommended Procedures for Flood Velocity Data Development*. In coastal areas there is more uncertainty in estimating flood velocity, which is speed of the mass movement of floodwater, not breaking waves (e.g., as a storm surge moves onshore or recedes). A number of FEMA references include a graph showing velocity as a function of stillwater flood depth (see FEMA P-55, *Coastal Construction Manual*).
- Debris in moving water can impart a considerable impact load when it collides with buildings. Whether debris is likely to be present, and the types and sizes of debris, cannot be determined from flood maps and studies. ASCE 7 Chapter 5 commentary provides guidance for consideration of debris impact loads.
- Wave loads, important in coastal areas, depend largely on wave height. Wave height is a function of stillwater flood depth and may be approximated using information in Flood

Insurance Studies. The magnitude of wave loads can be 10 times or more than wind forces. ASCE 7 Chapter 5 commentary provides guidance on determining wave loads.

- Erosion and scour may affect the stability of foundations and the loss of supporting soils should be considered because it affects flood loads. Refer to FEMA P-55 for guidance on the effects of erosion and scour.
- Duration of flooding, although not a direct contribution to flood loads, is a condition that warrants consideration. Long-duration flooding is more likely to delay reoccupancy and is a factor in whether dry floodproofing measures can be used for nonresidential buildings (not allowed in Zone V). Also, long-duration flooding is likely to cause nonstructural damage even if flood damage-resistant materials are used.

If BFEs are not shown on the flood hazard map, the FBC gives the building official the authority to require the permit applicant to obtain and use data from another source or to determine the design flood elevation (DFE) using accepted engineering practices. Many communities provide applicants with BFE or flood depth information, and some communities may allow the use of approximation methods, such as interpolating the special flood hazard area boundary based on topographic mapping.

FBC, Building- Chapter 1 Administration

Chapter 1 establishes the applicability of the code and describes how the code is to be applied and enforced. This chapter includes flood provisions in a number of sections:

- Hunting "camps" are exempt from the FBC unless certain conditions apply, including location in the "100-year floodplain" (Sec. 102.2).
- Site plans should show flood hazard areas, floodways, and DFEs (Sec. 107.2.5).

BFE and DFE. The codes use the term DFE, which is the same as the BFE unless the community adopts a map showing a more extensive flood hazard area than the SFHA with flood elevations higher than the BFE. Some communities adopt additional maps to show areas prone to flooding outside of the SFHA.

- The minimum plan review criteria include flood hazard areas, flood zones, DFE, lowest floor elevations, enclosures and flood damage-resistant materials (Sec. 107.3.5).
- The authority to issue permits on the basis of affidavits (Sec. 105.1 and Sec. 107.6.1) does not extend to the flood load and flood resistant requirements of the FBC to preserve the NFIP requirement that local officials review and approve permits.
- As part of required inspections, submission of certifications (prepared by a Florida licensed professional surveyor) of the lowest floor elevation are required upon placement of the lowest floor and prior to further vertical construction. Final ("as-built") certifications must be submitted as part of the final inspection (Sec. 110.3).
- Certificates of occupancy are to include a statement that the elevation certificate has been provided and is retained in the community's records (Sec. 111.2).

Also see flood provisions in Sec. 102.2.5 (certain exemptions that may be adopted by enforcement districts), Sec. 102.7 (relocation of manufactured buildings), and Sec. 117.1 (variances in flood hazard areas, which refers to local floodplain management regulations).

FBC, Building

New Flood Requirements in the 6th Ed. FBC. For easy identification in the following descriptions, underlining identifies the flood requirements that are new to the 6th Edition FBC.

Most, but not all, flood provisions in the FBC, Building are found in Sec. 1612, Flood Loads (see Table 1612.1 for a listing of all flood provisions in the FBC). The following highlight key provisions:

- In Sec. 1612.3, flood hazard areas are established by local floodplain management ordinances, which adopt flood hazard maps and supporting data. FEMA Flood Insurance Studies and Flood Insurance Rate Maps (FIRMs) are specified. Some Florida communities adopt locally prepared studies and maps.
- Detailed specifications for flood-resistant design are not included in the code. Rather, Sec. 1612.4 refers to ASCE 24, Flood Resistant Design and Construction, for specific requirements. A number of requirements in ASCE 24 are based on the Flood Design Class that is assigned in Sec. 1603.1.7 (see ASCE 24 for Flood Design Classes, which are similar to risk categories).

Special Detailed Requirements Based on Use and Occupancy. Special detailed requirements (Chapter 4) based on use and occupancy include flood provisions in Sec. 449 (hospitals), Sec. 450 (nursing homes), Sec. 453 (educational facilities), and Sec. 454 (pools).

Notice of Local Higher Standards (Freeboard). Many Florida communities adopt requirements for additional elevation above the minimum in the FBC, ranging from 2 to 4 feet above the BFE. This added factor of safety is called "freeboard." Buildings that are

higher than the BFE sustain less damage and owners pay lower Federal flood insurance premiums (see graphic).

- Elevation requirements depend on flood zone. See the summary of elevation requirements in Highlights of ASCE 24-14 prepared by FEMA. Elevation requirements above the BFE start at +1 foot (Flood Design Class 2) and go up to +2 feet or the 500-year flood elevation, whichever is higher (Flood Design Class 4).
- Coastal A Zones, if designated, are treated as Zone V, although backfilled stemwalls are permitted if foundation designs account for scour.
- Specific requirements for enclosures below elevated buildings are based on flood zone. All enclosure walls must have flood openings, including walls intended to breakaway under wave loads. Enclosures are limited to uses for parking, storage and building access.
- The use of dry floodproofing (only nonresidential occupancies in Zone A) is limited depending on flood velocities and adequate warning time to implement measures that require human intervention. A Florida amendment to ASCE 24 permits dry floodproofing in Coastal A Zones provided designs account for wave loads and potential erosion and scour.
- Utility equipment and machinery that serve buildings are required to be elevated or meet a specific performance expectation. Similar requirements are found in the *FBC, Mechanical; FBC, Plumbing; and FBC, Fuel Gas*.

- Sec. 1612.5 requires submission of elevation certification (also see Sec. 110.3, Inspections) and, if pertinent to specific buildings, design documentation for dry floodproofing, engineered openings, foundation and anchorage, and breakaway walls. Design documentation must be prepared and sealed by registered design professionals.
- Sec. 1804.4 includes requirements for grading and fill. Where allowed in flood hazard areas, fill shall be placed, compacted, and sloped to be stable under flood conditions.
- Sec. 3109 includes requirements for buildings seaward of the Coastal Construction Control Line (CCCL). Areas seaward of the CCCL that are also mapped as flood hazard areas are subject to the more restrictive of the flood requirements. This section is revised in the 6th Edition FBC to minimize differences with Sec. 1612 and ASCE 24.
- Buildings in "high-velocity hurricane zones" (Broward and Miami-Dade counties) are required to comply with the specific provisions for those zones and also the requirements of Sec. 1612, if located in flood hazard areas (Sec. 1601.1).

BASF CCCL Fact Sheet. Visit www.buildingasaferflorida.org to download a fact sheet summary of the revised CCCL requirements.

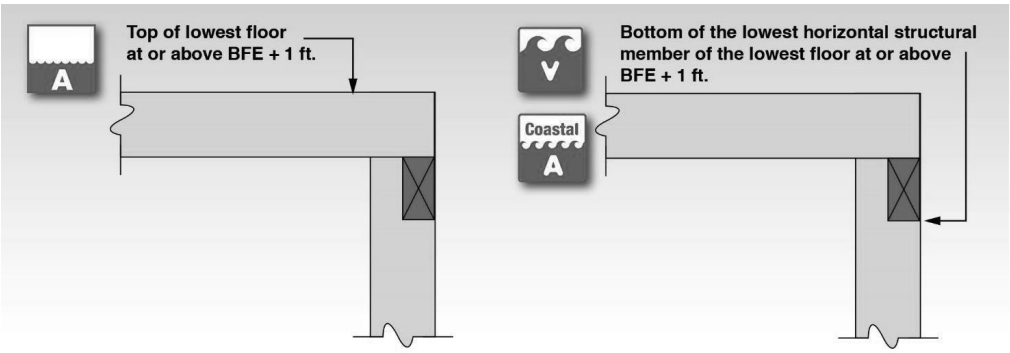
FBC, Residential

Most, but not all, flood provisions in the FBC, Residential are found in Sec. R322, *Flood-Resistant Construction* (see FBC, Building Table 1612.1 for a listing of all flood provisions in the *FBC, Residential*). Unlike the FBC, Building, which refers to ASCE 24, the *FBC, Residential* includes detailed requirements. Dwellings seaward of the CCCL must be in accordance with Sec. 3109 of the *FBC, Building*. The following highlight key provisions:

- New in the 6th Edition, areas subject to wave heights between 1 ½ and 3 feet are delineated (by Limit of Moderate Wave Action) or otherwise designated by the community are Coastal A Zones (CAZ). If CAZs are designated, dwellings in CAZs must comply with the requirements for Zone V in Sec. R322.3.
- In Table R301.2(1), communities adopt local floodplain management ordinances to specify the date of entry into the NFIP and the title and date of the current Flood Insurance Study and FIRMs.
- Sec. R309.3 requires garages to be elevated or, if below the BFE and used solely for parking, access or storage, meet the requirements of Sec. 322 (for enclosed areas below the BFE).
- Sec. R322.1 includes general provisions that apply to dwellings in all flood hazard areas (including Zone A, Zone V, and Coastal A Zones):
  - Dwellings proposed in identified floodways are required to be designed and constructed according to ASCE 24. This requirement recognizes that flooding is deeper and usually flows faster in floodways, which include the channel and adjacent lands that should be reserved to convey floodwaters. Obstructing flow in floodways can cause increases in flood depths, which may cause increased damage on adjacent properties.
  - Sec. R322.1.1 permits use of ASCE 24 in all flood hazard areas as an alternative to the requirements of Sec. R322.
  - In areas commonly referred to as "approximate Zone A" where FIRMs do not specify BFEs, the building official may require use of data available from another source or may require the applicant to determine flood elevations using accepted engineering practices. Keeping

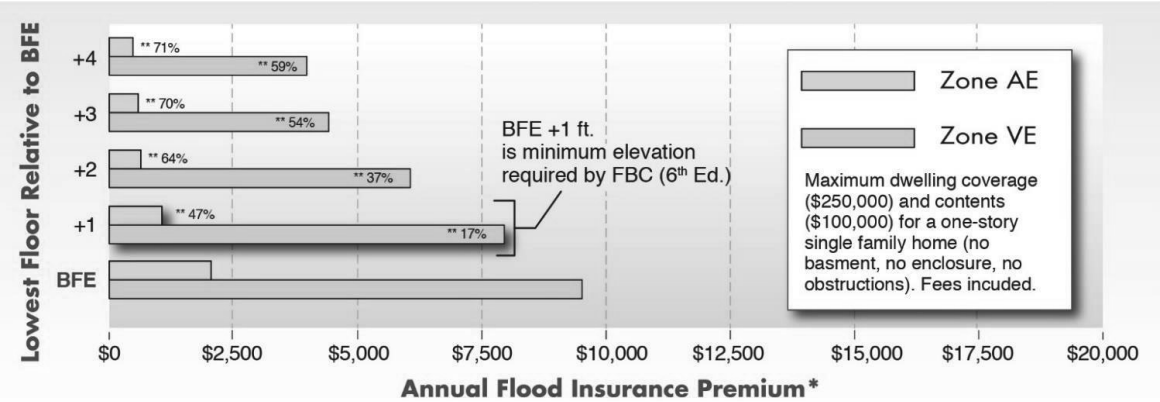
a record of elevations used previously is a good practice so that future permit decisions can be based on the same data.

- The lowest floor is defined as the floor of the lowest enclosed area, but does not include unfinished enclosures below elevated dwellings that comply with the code (see graphic below).
- Unfinished enclosures under elevated buildings are permitted if used only for parking, building access or limited storage (or crawlspace). Building officials should ensure that plans specify enclosed areas are only for those uses. An owner who subsequently modifies an enclosure in any way that alters compliance with these requirements may be subject to higher Federal flood insurance premiums.
- Utility equipment and machinery that serve buildings must be elevated or meet a specific performance expectation that generally cannot be met by typical installations.
- Use of flood damage-resistant materials is required below the elevations required in R322.2 (Zone A) and R322.3 (Zone V and Coastal A Zone). These materials are capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage. FEMA Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements*, is referenced for materials and installation methods.
- Dwellings seaward of the CCCL that are also in mapped flood hazard areas must comply with the more restrictive of Sec. 3109 of the *FBC, Building* and Sec. R322.
- Minimum elevation requirements call for the lowest floor (see graphic left, previous page), including basement, to be at or above the BFE plus 1 foot or DFE, whichever is higher. The additional elevation, called "freeboard," is required in all flood hazard areas. (see graphic below) Basements and all areas that are below grade on all sides are not permitted.
- The area below elevated dwellings may be enclosed by foundation walls or framed walls. To minimize damage due to hydrostatic loads, flood openings are required (see FEMA Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures*). Flood openings may be prescriptive (providing 1 square inch of net open area for each square foot of enclosed area) or engineered (requires design certification). Measurement of net open area must account for the presence of louvers, blades, screens, and faceplates.
- Tanks may be installed underground or on-grade (if anchored to resist flood loads) or elevated on platforms.



- Sec. R322.2 includes specific requirements that apply in flood hazard areas commonly referred to as "Zone A." (except in Coastal A Zones, which are subject to Sec. R322.3). The Zone A requirements include:

Enclosures and Flood Insurance. Federal flood insurance is more expensive if Zone V buildings have enclosures below the BFE, even if the walls are compliant breakaway walls. Insurance is even more expensive if enclosures are larger than 300 square feet.



* Unofficial estimates using 2014 rates; use only for comparison purposes
** Savings over at-BFE premium

- Sec. R322.3 includes specific requirements that apply in coastal high-hazard areas, commonly referred to as "Zone V," and Coastal A Zones:
  - Minimum elevation requirements call for the bottom of the lowest horizontal structural member of the lowest floor (see graphic previous page, right) to be elevated to or above the BFE plus 1 foot or DFE, whichever is higher. The additional elevation, called "freeboard," is required in all flood hazard areas. (see graphic below)
  - Foundations are limited to pilings or columns because they present the least obstruction to the passage of waves. In CAZ, backfilled stemwalls are permitted if foundations have deep footings to account for scour. Foundation designs are required to be certified by a registered design professional.
  - The area under elevated homes must be free of obstruction (see FEMA Technical Bulletin 5, *Free-of-Obstruction Requirements*). The area may be enclosed with insect screening or open lattice or, if enclosed by walls, the walls must be designed to break away under flood loads without causing damage to the foundation or elevated building. FEMA Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls Below Elevated Coastal Buildings*, includes prescriptive requirements for breakaway walls. The code specifies that utility components are not permitted to be mounted on or penetrate breakaway walls because post-flood investigations have determined that walls with such components do not break away cleanly. Flood openings are required in breakaway walls to minimize wall failure under relatively shallow flooding.
  - An exterior door is required in the doorway at the top of stairways that provide access to dwellings and that are enclosed by breakaway walls.
  - Tanks may be installed underground (if anchored to resist flood loads) or elevated on platforms.
- Dwellings in flood hazard areas in "high-velocity hurricane zones" (Broward and Miami-Dade counties) are required to comply with the specific provisions for those zones and also the requirements of Sec. R322 (also see Sec. R301.1 and Sec. R401.1).
- In Zone A, above-ground pools, on-ground pools and in-ground pools that involve placement of fill are allowed without any special requirements unless located in a floodway, in which case documentation must be provided to evaluate the effects of the encroachment on flood elevations. Pools in Zone V are required to conform to the requirements of ASCE 24, which preclude obstructing flow that causes damage to other buildings. For consistency, Chapter 41, Swimming Pools, cross-references to Sec. R322.
- Chapters with specifications for mechanical systems, HVAC systems, duct construction, combustion air, boilers and water heaters, special piping and storage systems, fuel gas, plumbing, plumbing fixtures, sanitary drainage and vent systems all include flood provisions. In general, the pertinent sections refer to Sec. R322.1.6.

FBC, Existing Building

A fundamental premise of the FBC, Existing Building is that work on an existing building does not lessen the compliance or conformance of the structure. It is important to keep this in mind when considering projects that repair, alter, add to, or otherwise improve buildings in flood hazard areas that were originally built to comply with flood-resistant requirements. For example, the open area under buildings required to be elevated on pilings is permitted to be enclosed by walls only if the walls comply with the flood-resistant construction requirements and if the use of the resulting enclosure is limited only to parking, building access or storage.

The first step when considering work on an existing building in a flood hazard area is to determine whether the proposed work constitutes "substantial improvement" (SI) or repair of "substantial damage" (SD). If a proposal is determined to be SI/SD, then the existing building is required to be brought into compliance with the requirements for new construction found in Sec. 1612 of the FBC, Building or R322 of the FBC, Residential, as applicable.

The SI/SD determination is made by comparing the cost of all of the proposed work to the market value of the building (excluding land) before the work is undertaken. If a proposal is to repair a damaged building, the market value is the value of the building before the damage occurred. When the cost equals or exceeds 50% of the market value, the work is determined to be substantial improvement or repair of substantial damage. In 2010, FEMA published FEMA P-758, Substantial Improvement/Substantial Damage Desk Reference, to summarize extensive guidance, include sample letters and an informative sample packet for applicants, designers and builders (Appendix D). Communities should establish procedures for consistent handling of applications to do work on existing buildings.

Notice of Local Amendments (Cumulative SI). Some Florida communities enforce "cumulative" SI over a specified period of time (e.g., 1, 5 or 10 years or life of the building). These communities keep records and evaluate whether each subsequent proposal to improve or repair a building will trigger the SI requirement to bring the building into compliance with the requirements for new construction.

The flood provisions of the FBC, Existing Building are found in several chapters (see Table 1612.1 for a listing of all flood provisions in the FBC, Existing Building):

- Repairs. Chapter 6 has a general requirement that requires compliance when the repair of a building in a flood hazard area constitutes substantial improvement (Sec. 601.3). Sec. 606.2.4 also specifies that buildings that have sustained substantial damage shall be brought into compliance. Compliance refers to the requirements for new construction in Sec. 1612 of the FBC, Building or Sec. R322 of the FBC, Residential, as applicable.

Reconstruction is New Construction. Reconstruction of a building that is demolished or so significantly damaged that it cannot be repaired is new construction, even if the old foundation can be reused.

- Alterations – Levels 1, 2, and 3. Chapter 7, Alterations – Level 1, has a general requirement that requires compliance when alterations constitute substantial improvement (Sec. 701.3). Because the requirements for alterations are cumulative, the requirement in Chapter 7 also applies to Level 2 alterations (Chapter 8) and Level 3 alterations (Chapter 9).
- Additions. Handling additions is complicated by the fact that some circumstances prompt compliance of the addition as well as the base building. Sec. 1103.5 distinguishes between horizontal additions that are structurally connected and those that are not structurally connected. It also specifies that if vertical additions or foundation work are determined to constitute substantial improvement, then base buildings must be brought into compliance. New or replacement foundations must comply, without requiring SI/SD determinations. DEM's guidance listed in Resources is based on FEMA P-758.
- Historic Buildings. The key to proper enforcement of the flood provisions is whether a historic building meets the exception in Sec. 1201.3. The FBC, Existing Building defines "historic buildings," however, the definition is not entirely consistent with the definition used by the NFIP. The NFIP allows historic buildings in flood hazard areas to be improved and repaired without bringing them into compliance provided the buildings are qualified. Importantly, any proposed work must not preclude such buildings from continued listing as historic. FEMA guidance suggests building officials require applicants to obtain evidence of continued designation from the appropriate authority or a qualified historic resources professional.
- Relocated or Moved Buildings. Sec. 1302.6 specifies that buildings relocated or moved into flood hazard areas are required to comply with the flood provisions of Sec.1612 or R322, as applicable (no determination of substantial improvement). This means new foundations must meet the elevation and other requirements based on the flood zone of the new location.
- Prescriptive Compliance. The sections that articulate the prescriptive compliance method

for additions, alterations, and repairs and each specify that if the work constitutes SI/SD, then the existing building must be brought into compliance with the requirements for new construction (Chapter 4). Similarly, the performance compliance method includes the same requirement (Chapter 14).

FBC, Mechanical, Plumbing, Fuel, Gas

Each of the mechanical, plumbing and fuel gas codes includes similar provisions requiring equipment and systems to be located at or above the elevation specified in Sec. 1612.4 (thus matching the elevation of the building) or to meet a specific performance expectation that generally cannot be met by typical installations. See Table 1612.1 for a listing of all flood provisions in these codes. Of particular note:

- Each code specifies that systems and equipment shall not be mounted on or penetrate walls intended to break away under flood loads (applies in Zone V and Coastal A Zones).
- *FBC, Mechanical* requires ducts to be located above the elevation specified in Sec. 1612.4 or designed and constructed to prevent water from entering or accumulating and to resist flood loads.

Local Floodplain Management Regulations

Florida communities adopt local floodplain management regulations to regulate development activities in identified flood hazard areas. The regulations (typically called "ordinances"), in conjunction with the *Florida Building Code*, meet or exceed the minimum requirements of the NFIP. Development other than buildings includes subdivision of land; filling, grading, and other site improvements and utility installations; placement, installation, or replacement of manufactured homes and manufactured buildings; installation or replacement of tanks; placement of recreational vehicles; installation of swimming pools; and any other development. Importantly, to fulfill the NFIP requirements, floodplain management ordinances also regulate structures, and facilities that are exempt from the *Florida Building Code*.

Local floodplain management regulations are administered in conjunction with the *Florida Building Code*. Key features include:

- Adoption of Flood Insurance Studies and FIRMs to establish flood hazard areas (flood zones).
- Designation of the Floodplain Administrator; in many communities, the Building Official is designated the Floodplain Administrator, while in others the position is assigned to a different office.
- Duties of the Floodplain Administrator, including review of applications for development other than buildings, inspection of permitted development and flood hazard areas, maintenance of records.
- Details of the process for making substantial damage and substantial improvement determinations.
- Specifications for determining flood elevations in areas without BFEs on FIRMs.
- Procedures, limitations, and conditions for evaluating requests for variances, including variances from the flood provisions of the Florida Building Code.
- Requirements for the following:
  - Subdivisions, including manufactured home parks and subdivisions
  - Site improvements and utilities (sanitary sewage facilities and water supply facilities)
  - Placement of fill
  - Manufactured homes, recreational vehicles (including park trailers)
  - Tanks (above-ground and underground)
- Limitations on development in floodways, including fill, fences, retaining walls, roads and watercourses, in addition to buildings and structures. Applications must be accompanied by analyses to determine proposed activities do not increase flood levels.
- General requirements for any development not specifically addressed, including:
  - Anchoring to prevent flotation, collapse or lateral movement resulting from flood loads
  - Use of flood damage-resistant materials
  - Mechanical, plumbing and electrical systems elevated or protected

Assistance from DEM. DEM is designated by the Governor to be the link between Florida communities and the NFIP. Changes to floodplain management ordinances should be reviewed by DEM prior to adoption. Contact the State Floodplain Management Office for guidance.

Part One: Workplace Safety
Final Exam

1. **Which of the following measures should be taken when working with hand and/or power tools?**
   a. Workers should be provided with the appropriate personal protective equipment
   b. Workers should be trained in the proper use of all tools
   c. All electrical connections must be suitable for the type of working conditions
   d. All of the above

2. **When should a hazardous situation be reported?**
   a. Within 2-3 days
   b. Immediately
   c. At the beginning of the month
   d. During staff meetings

3. **What do the greatest hazards from hand tools result from?**
   a. Misuse
   b. Improper maintenance
   c. Both a and b
   d. None of the above

4. **Spark-resistant tools made of non-ferrous materials can be used in which of the following conditions?**
   a. Around flammable gases
   b. Around highly volatile liquids
   c. Around explosive substances
   d. All of the above

5. **What should all power tools be fitted with?**
   a. Guards
   b. Safety switches
   c. Batteries
   d. Both a and b

6. **A reciprocating saw must be equipped with which of the following?**
   a. A positive "on-off" control switch
   b. A "lock-on" control
   c. A constant-pressure switch or control that shuts off the power when pressure is released
   d. None of the above

7. **What are some of the most serious hazards associated with electric tools?**
   a. Electrical burns and shocks
   b. Severed limbs
   c. Paralysis from falls
   d. There are no risks when using electric tools

8. **When tapped, a stable and undamaged wheel will make what kind of sound?**
   a. A cracked or dead sound
   b. A clear metallic tone or "ring"
   c. A soft humming sound
   d. A loud bang

9. **What are pneumatic tools powered with?**
   a. Compressed air
   b. Liquid fuel
   c. Electricity
   d. Pressurized water

10. **True or false? A liquid fueled tool should always be "on" when refilling with gasoline.**
    a. True
    b. False

Part Two: Workers' Compensation Final Exam

1. **Your employer is required by law to report your injury to the insurance company within _____ days of when you report your accident or injury.**
   a. 7
   b. 15
   c. 20
   d. 30

2. **If you are injured at work and unable to work for more than _____ days, you should receive money to partly replace what you were not able to earn after your accident.**
   a. 5
   b. 8
   c. 7
   d. 10

3. **If you are injured at work and your injury is critical, you may receive _____% of your regular wages for up to 6 months after the accident.**
   a. 66 2/3%
   b. 80%
   c. 75%
   d. 100%

4. **Who must authorize the doctor that treats an injured worker?**
   a. The employer
   b. The insurance company
   c. The injured worker
   d. The Florida Division of Insurance

5. **Once your doctor says you are at Maximum Medical Improvement, you are as good as he or she expects you to get. If you receive a(n) _____ rating, you will receive money based on that rating.**
   a. partially impaired
   b. minimally impaired
   c. permanent impairment
   d. restricted

6. **Which of the following posters must be displayed in a conspicuous place by the employer in the workplace?**
   a. "Broken Leg" Poster
   b. "Anti-Fraud Notice" Poster
   c. "Broken Arm" Poster
   d. Both B and C

7. **As an employer, which of the following should be done if restricted work is available for an injured employee?**
   a. Discuss a starting time and date
   b. Discuss the pay based on new job duties
   c. Report the restricted work to the adjuster
   d. All of the above

8. **Employers may have to pay a penalty of _____ for being over 28 days late in filing an injury report with the insurance company which causes the First Report of Injury to be filed late with the Division.**
   a. $200
   b. $500
   c. $300
   d. $400

9. **Who may elect to exempt themselves from the workers' compensation coverage requirements?**
   a. Corporate officers
   b. Sole proprietors
   c. Partners
   d. All of the above

10. **True or false? An out-of-state employer engaged in work in Florida must immediately notify their insurance carrier that it has employees working in Florida.**
    a. True
    b. False

Part Three: Laws & Rules
Final Exam

1. **A certificate holder who desires to continue as a certificate holder must renew the certificate every _____ years.**
   a. 1
   b. 2
   c. 3
   d. 4

2. **A certificate holder must provide proof of having completed at least _____ hours of continuing education during each biennium.**
   a. 14
   b. 50
   c. 2
   d. 12

3. **Which of the following must be obtained before a license is renewed?**
   a. Workers' compensation insurance
   b. Public liability insurance
   c. Property damage insurance
   d. All of the above

4. **In determining financial stability, the board can set minimum requirements for net worth, cash, and bonding for Division I certificate holders of no more than $_____.**
   a. $14,000
   b. $10,000
   c. $20,000
   d. $50,000

5. **True or false? An inactive licensee my engage in contracting as long as it is by referral only.**
   a. True
   b. False

6. **If a delinquent licensee does not renew his or her license before the end of the current license period, what will happen to his or her license?**
   a. It becomes inactive
   b. It becomes disengaged
   c. It becomes void
   d. It is automatically re-activated

7. **A license renewal notification will be sent to an active or inactive certificate holder _____ days prior to the end of a licensure cycle.**
   a. 60
   b. 90
   c. 120
   d. 30

8. **Which of the following are included in the definition of an "energy, water, and wastewater efficiency and conservation measure"?**
   a. Insulation of the facility structure and systems within the facility.
   b. Automatic energy control systems.
   c. Energy storage systems, such as fuel cells and thermal storage.
   d. All of the above

9. **A guaranteed energy, water, and wastewater performance savings contract must include a written guarantee stating that annual cost savings will _____ the amortized cost of energy, water, and wastewater efficiency and conservation measures.**
   a. meet
   b. exceed
   c. fall below
   d. Both a and b

10. **Who is liable for a shortfall found in the annual reconciliation of the guaranteed cost savings of an energy, water, and wastewater efficiency and conservation measure?**
    a. The agency
    b. The state legislature
    c. The financing institution
    d. The contractor

Part Four: Business Practices
Final Exam

1. **Under the Federal Trade Commission Act, advertising must _____:**
   a. be truthful
   b. be non-deceptive
   c. have evidence to back up a claim
   d. all of the above

2. **True or false? All advertising laws are implemented through the Federal Trade Commission Act. States do not have their own laws governing advertisements.**
   a. True
   b. False

3. **According to the FTC, an ad is deceptive if it contains a statement - or omits information – that does which of the following?**
   a. Provides material examples of the product
   b. Provides evidence that backs up the ad's claims
   c. Misleads consumers acting reasonably under the circumstances
   d. Directly injures the consumer

4. **According to the Federal Trade Commission Act, an ad or business practice is unfair if it _____:**
   a. causes or is likely to cause substantial consumer injury which a consumer could not reasonably avoid
   b. is not outweighed by the benefit to consumers
   c. Both a and b
   d. None of the above

5. **Which of the following does the FTC do when reviewing an ad?**
   a. The FTC focuses on specific words rather than the ad in context
   b. The FTC looks at only "implied" claims
   c. The FTC does not take evidence into consideration
   d. The FTC looks at what the ad does not say

6. **True or false? Letters from satisfied customers cannot be used to substantiate a claim in an advertisement.**
   a. True
   b. False

7. **Which of the following are penalties that can be imposed against a business that runs a false or deceptive advertisement?**
   a. Cease and desist orders
   b. Monetary remedies
   c. Corrective advertising
   d. All of the above

8. **Which of the following is true regarding bait and switch advertising?**
   a. It is illegal to advertise a product with no intention of selling that item, but instead plan to sell a consumer something else.
   b. It is legal to advertise a product with no intention of selling that item and instead plan to sell a consumer something else as long as the advertised item is also sold.
   c. It is legal to advertise a product with no intention of selling that item and plan to sell a consumer something else as long as that item is less expensive than the advertised item.
   d. All of the above

9. **Is it legal for a company to compare its product to another company's product in an ad?**
   a. This is legal as long as the product is unnamed
   b. This is legal as long as it is truthful
   c. This is legal as long as the other company is anonymous
   d. This is illegal

10. **Which of the following disclaimers are considered ineffective?**
    a. A fine-print disclosure at the bottom of a print ad
    b. A brief video superscript in a television ad
    c. A disclaimer that is easily missed on a website
    d. All of the above

Part Five: Wind Mitigation Final Exam

1. **What causes the primary damage to homes from hurricanes?**
   a. Wind
   b. Water intrusion
   c. Lightning
   d. Both a and b

2. **FEMA conducted a study that estimated the value of all mitigation activities funded between mid-1993 through mid-2007. The study concluded a value of $_____ was saved in response and recovery for every $1 spent on mitigation.**
   a. $2
   b. $3
   c. $4
   d. $5

3. **When is it easiest to perform a roof tie-down?**
   a. New construction
   b. Re-roofing
   c. Major remodeling
   d. All of the above

4. **When anchoring the roof to the foundation, a double wrap connector would be a continuous connector in the shape of a modified ____ to fit the framing.**
   a. L
   b. U
   c. W
   d. J

5. **True or false? Porches that are connected to the house or that share a common roof should be mitigated and have their attachments strengthened.**
   a. True
   b. False

6. **When reinforcing gable ends, horizontal beams should be at least _____ feet and long enough to connect to at least three attic floor framing boards and extend 2 1/2 feet past the third board.**
   a. five
   b. six
   c. seven
   d. eight

7. **What is the most common type of covering for glazed openings such as windows?**
   a. Panel shutters
   b. Impact-resistant glass
   c. Plywood boards
   d. Wood beams

8. **The bolt lock of a door should be _____ long to extend far enough into the frame to hold the door in a closed position.**
   a. 2 inches
   b. 2 1/2 inches
   c. 1 inch
   d. 1/2 inch

9. **True or false? French doors are secure at their connection point and do not need to be shuttered.**
   a. True
   b. False

10. **Who is qualified to perform an inspection and sign a uniform mitigation verification form?**
    a. A certified building code inspector
    b. A licensed building contractor
    c. A licensed architect
    d. All of the above

Part One: Workplace Safety

Hand and Power Tool Safety

From OSHA: The Occupational and Health Administration

1. What is the Purpose of Hand and Power Tool Safety?

This section of your course is designed to present workers with the basic safety procedures and safeguards associated with hand and portable power tools. The following sections identify various types of hand and power tools and their potential hazards. They also identify ways to prevent worker injury through proper use of the tools and through the use of appropriate personal protective equipment.

Please note: Material in this course is based on the standards of the Occupational Safety and Health Administration (OSHA). This course should not be considered as a substitute for the full safety and health standards for general industry, or for the construction industry. These texts are available at www.osha.gov.

2. The Danger of Hand and Portable Power Tools

Tools are such a common part of our lives that it is difficult to remember that they may pose hazards. A serious incident can occur before steps are taken to identify and avoid, or eliminate tool-related hazards. The following measures should always be taken:

- Workers who use hand and power tools must be provided with the appropriate personal protective equipment.
- All electrical connections for these tools must be suitable for the type of tool and the working conditions (wet, dusty, flammable vapors).
- When a temporary power source is used for construction, a ground-fault circuit interrupter should be used.
- Workers should be trained in the proper use of all tools.
- Workers should be able to recognize the hazards associated with the different types of tools and the safety precautions necessary.

Here are five basic safety rules that can help prevent hazards associated with the use of hand and power tools:

1. Keep all tools in good condition with regular maintenance.
2. Use the right tool for the job.
3. Examine each tool for damage before use and do not use damaged tools.
4. Operate tools according to the manufacturers' instructions.
5. Provide and use properly the right personal protective equipment.

Employees and employers should work together to establish safe working procedures. If a hazardous situation is encountered, it should be brought to the attention of the proper individual for hazard abatement immediately.

3. The Hazards of Hand Tools

What are hand tools? Hand tools are tools that are powered manually. Hand tools include anything from axes to wrenches. The greatest hazards posed by hand tools result from misuse and improper maintenance. Some examples of misuse include the following:

- If a chisel is used as a screwdriver, the tip of the chisel may break and fly off, hitting the user or other workers.
- If a wooden handle on a tool, such as a hammer or an axe, is loose, splintered, or cracked, the head of the tool may fly off and strike the user or other workers.
- If the jaws of a wrench are sprung, the wrench might slip.
- If impact tools such as chisels, wedges, or drift pins have mushroomed heads, the heads might shatter on impact, sending sharp fragments flying toward the user or other workers.

The employer is responsible for the safe condition of tools and equipment used by employees. Employers shall not issue or permit the use of unsafe hand tools. Employees should be trained in the proper use and handling of tools and equipment.

When using saw blades, knives, or other tools, workers should direct the tools away from aisle areas and away from others working in close proximity. Knives and scissors must be sharp; dull tools can cause more hazards than sharp ones. Cracked saw blades must be removed from service.

Wrenches must not be used when jaws are sprung to the point that slippage occurs. Impact tools such as drift pins, wedges, and chisels must be kept free of mushroomed heads. The wooden handles of tools must not be splintered.

Iron or steel hand tools may produce sparks that can be an ignition source around flammable substances. Where this hazard exists, spark-resistant tools made of non-ferrous materials should be used where flammable gases, highly volatile liquids, and other explosive substances are stored or used.

Appropriate personal protective equipment such as safety goggles and gloves must be worn to protect against hazards that may be encountered while using

hand tools. Workplace floors shall be kept as clean and dry as possible to prevent accidental slips with or around dangerous hand tools.

4. The Dangers of Power Tools

The types of power tools are determined by their power source: electric, pneumatic, liquid fuel, hydraulic, and powder-actuated. Power tools must be fitted with guards and safety switches; they are extremely hazardous when used improperly. To prevent hazards associated with the use of power tools, workers should observe the following general precautions:

- Never carry a tool by the cord or hose.
- Never yank the cord or the hose to disconnect it from the receptacle.
- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not using them, before servicing and cleaning them, and when changing accessories such as blades, bits, and cutters.
- Keep all people not involved with the work at a safe distance from the work area.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. Do not hold fingers on the switch button while carrying a plugged-in tool.
- Maintain tools with care; keep them sharp and clean for best performance.
- Follow instructions in the user's manual for lubricating and changing accessories.
- Be sure to keep good footing and maintain good balance when operating power tools.
- Wear proper apparel for the task. Loose clothing, ties, or jewelry can become caught in moving parts.
- Remove all damaged portable electric tools from use and tag them: "Do Not Use."

5. Guards

The exposed moving parts of power tools need to be safe- guarded. Belts, gears, shafts, pulleys, sprockets, spindles, drums, flywheels, chains, or other reciprocating, rotating, or moving parts of equipment must be guarded. Machine guards, as appropriate, must be provided to protect the operator and others from the following:

- Point of operation.
- In-running nip points.
- Rotating parts.
- Flying chips and sparks.

Safety guards must never be removed when a tool is being used. Portable circular saws having a blade greater than 2 inches in diameter must be equipped at all times with guards. An upper guard must cover the entire blade of the saw. A retractable lower guard must cover the teeth of the saw, except where it makes contact with the work material. The lower guard must automatically return to the covering position when the tool is withdrawn from the work material.

6. Operating Controls and Switches

The following hand-held power tools must be equipped with a constant-pressure switch or control that shuts off the power when pressure is released:

- Drills
- Tappers
- fastener drivers;
- horizontal, vertical, and angle grinders with wheels more than 2 inches in diameter
- disc sanders with discs greater than 2 inches
- belt sanders
- reciprocating saws
- saber saws, scroll saws, and jigsaws with blade shanks greater than 1/4-inch wide
- other similar tools

These tools also may be equipped with a "lock-on" control, if it allows the worker to also shut off the control in a single motion using the same finger or fingers. The following hand-held power tools must be equipped with either a positive "on-off" control switch, a constant pressure switch, or a "lock-on" control:

- disc sanders with discs 2 inches or less in diameter
- grinders with wheels 2 inches or less in diameter
- platen sanders, routers, planers, laminate trimmers, nibblers, shears, and scroll saws
- jigsaws, saber and scroll saws with blade shanks a nominal 1/4-inch or less in diameter

It is recommended that the constant-pressure control switch be regarded as the preferred device. Other hand-held power tools such as circular saws having a blade diameter greater than 2 inches, chain saws, and percussion tools with no means of holding accessories securely must be equipped with a constant-pressure switch.

7. Electric Tools

Employees using electric tools must be aware of several dangers.Among the most serious hazards are electrical burns and shocks. Electrical shocks, which can lead to injuries such as heart failure and burns, are among the major hazards associated with electric-powered tools. Under certain conditions, even a small amount of electric current can result in fibrillation of the heart and death. An electric shock also can cause the user to

fall off a ladder or other elevated work surface and be injured due to the fall.

To protect the user from shock and burns, electric tools must have a three-wire cord with a ground and be plugged into a grounded receptacle, be double insulated, or be powered by a low-voltage isolation transformer. Three-wire cords contain two current-carrying conductors and a grounding conductor. Any time an adapter is used to accommodate a two-hole receptacle, the adapter wire must be attached to a known ground. The third prong must never be removed from the plug.

Double-insulated tools are available that provide protection against electrical shock without third-wire grounding. On double- insulated tools, an internal layer of protective insulation completely isolates the external housing of the tool.

The following general practices should be followed when using electric tools:

- Operate electric tools within their design limitations.
- Use gloves and appropriate safety footwear when using electric tools.
- Store electric tools in a dry place when not in use.
- Do not use electric tools in damp or wet locations unless they are approved for that purpose.
- Keep work areas well lighted when operating electric tools.
- Ensure that cords from electric tools do not present a tripping hazard.

In the construction industry, workers who use electric tools must be protected by ground-fault circuit interrupters or an assured equipment-grounding conductor program.

8. Portable Abrasive Wheel Tools

Portable abrasive grinding, cutting, polishing, and wire buffing wheels create special safety problems because they may throw off flying fragments. Abrasive wheel tools must be equipped with guards that:

- cover the spindle end, nut, and flange projections
- maintain proper alignment with the wheel
- do not exceed the strength of the fastenings

Before an abrasive wheel is mounted, it must be inspected closely for damage and should be sound, or ring, tested to ensure that it is free from cracks or defects. To be tested, wheels should be tapped gently with a light, non-metallic instrument. If the wheels sound cracked or dead, they must not be used because they could fly apart in operation. A stable and undamaged wheel, when tapped, will give a clear metallic tone or “ring.”

To prevent an abrasive wheel from cracking, it must fit freely on the spindle. The spindle nut must be tightened enough to hold the wheel in place without distorting the flange. Always follow the manufacturer’s recommendations. Take care to ensure that the spindle speed of the machine will not exceed the maximum operating speed marked on the wheel.

An abrasive wheel may disintegrate or explode during start-up. Allow the tool to come up to operating speed prior to grinding or cutting. The employee should never stand in the plane of rotation of the wheel as it accelerates to full operating speed. Portable grinding tools need to be equipped with safety guards to protect workers not only from the moving wheel surface, but also from flying fragments in case of wheel breakage. When using a powered grinder:

- Always use eye or face protection.
- Turn off the power when not in use.
- Never clamp a hand-held grinder in a vise.

9. Pneumatic Tools

Pneumatic tools are powered by compressed air and include:

- chippers
- drills
- hammers
- sanders

There are several dangers associated with the use of pneumatic tools. First and foremost is the danger of getting hit by one of the tool’s attachments or by some kind of fastener the worker is using with the tool.

Pneumatic tools must be checked to see that the tools are fastened securely to the air hose to prevent them from becoming disconnected. A short wire or positive locking device attaching the air hose to the tool must also be used and will serve as an added safeguard. If an air hose is more than 1/2-inch in diameter, a safety excess flow valve must be installed at the source of the air supply to reduce pressure in case of hose failure. In general, the same precautions should be taken with an air hose that are recommended for electric cords, because the hose is subject to the same kind of damage or accidental striking, and because it also presents tripping hazards.

When using pneumatic tools, a safety clip or retainer must be installed to prevent attachments such as chisels on a chipping hammer from being ejected during tool operation. Pneumatic tools that shoot nails, rivets, staples, or similar fasteners and operate at pressures more than 100 pounds per square inch, must be equipped with a special device to keep fasteners from being ejected, unless the muzzle is pressed against the work surface.

Airless spray guns that atomize paints and fluids at pressures of 1,000 pounds or more per square inch, must be equipped with automatic or visible manual safety devices that will prevent pulling the trigger until the safety device is manually released.

Eye protection is required, and head and face protection is recommended for employees working with pneumatic tools.

Screens must also be set up to protect nearby workers from being struck by flying fragments around chippers, riveting guns, staplers, or air drills. Compressed air guns should never be pointed toward anyone. Workers should never "dead-end" them against themselves or anyone else. A chip guard must be used when compressed air is used for cleaning.

Use of heavy jackhammers can cause fatigue and strains. Heavy rubber grips reduce these effects by providing a secure handhold. Workers operating a jackhammer must wear safety glasses and safety shoes that protect them against injury if the jackhammer slips or falls. A face shield also should be used. Noise is another hazard associated with pneumatic tools. Working with noisy tools such as jackhammers requires proper, effective use of appropriate hearing protection.

10. Liquid Fuel Tools

Fuel-powered tools are usually operated with gasoline. The most serious hazard associated with the use of fuel-powered tools comes from fuel vapors that can burn or explode and also give off dangerous exhaust fumes. The worker must be careful to handle, transport, and store gas or fuel only in approved flammable liquid containers, according to proper procedures for flammable liquids.

Before refilling a fuel-powered tool tank, the user must shut down the engine and allow it to cool to prevent accidental ignition of hazardous vapors. When a fuel-powered tool is used inside a closed area, effective ventilation and/or proper respirators such as atmosphere-supplying respirators must be utilized to avoid breathing carbon monoxide. Fire extinguishers must also be available in the area.

11. Power-Actuated Tools

Powder-actuated tools operate like a loaded gun and must be treated with extreme caution. In fact, they are so dangerous that they must be operated only by specially trained workers. When using powder-actuated tools, a worker must wear suitable ear, eye, and face protection. The user must select a powder level—high or low velocity—that is appropriate for the powder-actuated tool and necessary to do the work without excessive force. The muzzle end of the tool must have a protective shield or guard centered perpendicular to and concentric with the barrel to confine any fragments or particles that are projected when the tool is fired. A tool containing a high-velocity load must be designed not to fire unless it has this kind of safety device.

To prevent the tool from firing accidentally, two separate motions are required for firing. The first motion is to bring the tool into the firing position, and the second motion is to pull the trigger. The tool must not be able to operate until it is pressed against the work surface with a force of at least 5 pounds greater than the total weight of the tool.

Safety precautions that must be followed when using powder- actuated tools include the following:

- Do not use a tool in an explosive or flammable atmosphere.
- Inspect the tool before using it to determine that it is clean, that all moving parts operate freely, and that the barrel is free from obstructions and has the proper shield, guard, and attachments recommended by the manufacturer.
- Do not load the tool unless it is to be used immediately.
- Do not leave a loaded tool unattended, especially where it would be available to unauthorized persons.
- Keep hands clear of the barrel end.
- Never point the tool at anyone.

When using powder-actuated tools to apply fasteners, several additional procedures must be followed:

- Do not fire fasteners into material that would allow the fasteners to pass through to the other side.
- Do not drive fasteners into very hard or brittle material that might chip or splatter or make the fasteners ricochet.
- Always use an alignment guide when shooting fasteners into existing holes.
- When using a high-velocity tool, do not drive fasteners more than 3 inches from an unsupported edge or corner of material such as brick or concrete.
- When using a high velocity tool, do not place fasteners in steel any closer than 1/2-inch from an unsupported corner edge unless a special guard, fixture, or jig is used.

12. Hydraulic Power Tools

The fluid used in hydraulic power tools must be an approved fire-resistant fluid and must retain its operating characteristics at the most extreme temperatures to which it will be exposed. The exception to fire-resistant fluid involves all hydraulic fluids used for the insulated sections of derrick trucks, aerial lifts, and hydraulic tools that are used on or around energized lines. This hydraulic fluid shall be of the insulating type. The manufacturer's recommended

safe operating pressure for hoses, valves, pipes, filters, and other fittings must not be exceeded.

All jacks—including lever and ratchet jacks, screw jacks, and hydraulic jacks—must have a stop indicator, and the stop limit must not be exceeded. Also, the manufacturer's load limit must be permanently marked in a prominent place on the jack, and the load limit must not be exceeded. A jack should never be used to support a lifted load. Once the load has been lifted, it must immediately be blocked up. Put a block under the base of the jack when the foundation is not firm, and place a block between the jack cap and load if the cap might slip.

To set up a jack, make certain of the following:

- The base of the jack rests on a firm, level surface;
- The jack is correctly centered;
- The jack head bears against a level surface; and
- The lift force is applied evenly.

Proper maintenance of jacks is essential for safety. All jacks must be lubricated regularly. In addition, each jack must be inspected according to the following schedule:

(1) for jacks used continuously or intermittently at one site—inspected at least once every 6 months,

(2) for jacks sent out of the shop for special work—inspected when sent out and inspected when returned, and

(3) for jacks subjected to abnormal loads or shock—inspected before use and immediately thereafter.

Part Two: Workers' Compensation

The Florida Workers' Compensation System Guide

The Workers' Compensation System Guide is intended to give all parties a general overview and summary of the Workers' Compensation System. It is not intended to supersede or take the place of the Florida Workers' Compensation law (Chapter 440, Florida Statutes) or Florida Workers' Compensation Case Law. Its purpose is to assist all stakeholders in their roles and responsibilities. It provides general information and references that may assist with resolving issues and answering questions.

PART ONE: EMPLOYEE INFORMATION

Injured Worker Duties

If you have an accident or are injured on the job you must:

- Tell your employer you have been injured, as soon as possible. The law requires that you report the accident or your knowledge of a job-related injury within 30 days of your knowledge of the accident or injury, or within 30 days of a doctor determining you are suffering from a work-related injury.
- When you do so, you must ask your employer what doctor you can see. You must see a doctor authorized by your employer or the insurance company.
- Your employer may tell you to call the insurance company handling your claim; the name and phone number should be on the "Broken Arm" poster that should be posted at your workplace.
- If it is an emergency and your employer is not available to tell you where to go for treatment, go to the nearest emergency room and let your employer know as soon as possible what has happened.

Your employer is required by law to report your injury to the insurance company within 7 days of when you report your accident or injury. If they do not do this, and they do not give you a phone number for the insurance company to call, you can call the workers' compensation (WC) hotline for assistance at 1-800-342-1741.

- After you or your employer report the injury to the insurance company, many companies will have an insurance claim adjuster call you within 24 hours to explain your rights and obligations.
  - If you receive a message and a number to call, you should call as soon as possible to find out what you need to do to get medical treatment.
- Within 3-5 business days after you or your employer report the accident, you should receive an informational brochure explaining your rights and obligations, and a Notification Letter explaining the services provided by the Employee Assistance Office of the Division of Workers' Compensation. These forms may be part of a packet which may include some or all of the following:
  - A copy of your accident report or "First Report of Injury or Illness," which you should read to make sure it is correct;
  - A fraud statement, which you must read, sign and return as soon as possible, or benefits may be temporarily withheld until you do so;
  - A release of medical records for you to sign and return; and
  - Medical mileage reimbursement forms that you should fill out, after seeking medical treatment, and send to your claims adjuster for reimbursement.

If you do not receive a call or the information packet from the insurance company, you can call the WC hotline for assistance at 1-800-342-1741.

When you see the doctor

- Give the doctor a full description of the accident or how you were injured.
- Answer all questions the doctor might have about any past or current medical conditions or injuries.
- Discuss with the doctor if the injury is related to work or not.
- If related to work, find out if you can work or not.

If you are released to work but can't return to your same job, you should get instructions from the doctor on what work you can and cannot do. Keep and attend all appointments with your doctor, or benefits may be suspended.

After seeing the doctor

- Speak with your employer as soon as you leave the doctor. Tell your employer how much your job means to you, and explain to them what work the doctor said you can and cannot do.
- If you are admitted to a hospital, call or have someone call your employer for you to explain what happened and where you are.
- Give your employer the doctor's note as soon as possible.
- Ask your employer if they have work for you to return to that does not require you to do things the doctor said you cannot do yet.
- If yes, ask when you should report for work.
- If not, make sure your employer has a way to contact you if appropriate work becomes available.
- Contact the insurance company and let them know what the doctor said about your injuries, work status, and whether your employer has work available within your physical restrictions.
- You should continue to stay in contact with your employer and the insurance company throughout your treatment and recovery.

Benefits you may receive

Money you may be entitled to:

- Indemnity Benefits: If you are unable to work for more than 7 days, you should receive money to partly replace what you were not able to earn after your accident.

  Note: Your weekly benefit can never exceed the maximum compensation rate for the year in which your accident or illness occurred. For a table of the maximum compensation rates visit www.myfloridacfo.com/Division/WC/Insurer/ bma_rates.htm

- Temporary total disability: If your doctor says you cannot work at all:
  - You should receive money equaling about 66 2/3% of your regular wages at the time you were hurt. Your benefit is paid to you beginning with the 8th day you lose time from work.
  - The first 7 days lost from work is only paid if you lose more than 21 days from work.
  - If your injury is critical, you may receive 80% of your regular wages for up to 6 months after the accident.
  - You can receive up to a total of 104 weeks of temporary total disability and/or temporary partial disability benefits. **Please see note regarding Supreme Court decisions.
- Temporary partial disability: If you can return to work, but you cannot earn the same wages you earned at the time you were hurt:
  - You will receive money equaling 80% of the difference between 80% of what you earned before your injury and what you are able to earn after your injury.
  - You can receive up to a total of 104 weeks of temporary total disability and/or temporary partial disability.

  Example:

Your average weekly wage: $320 (Earnings before injury) x .80	= $256
Your weekly earning after injury:	- $150
Your actual lost wage:	$106
$106 x .80 =	$84.80

Weekly temp. partial disability benefit: $84.80

- Impairment benefits: Once your doctor says you are at Maximum Medical Improvement, you are as good as he or she expects you to get. At this point your doctor should evaluate you for:
  - Possible permanent work restrictions and,
  - A permanent impairment rating. If you receive a permanent impairment rating, you will receive money based on that rating.

Medical treatment:

Your employer is responsible for providing medical treatment.

- Do not delay in getting a doctor's appointment from your employer or insurance company.
- Do not go on your own to your private doctor for treatment. The insurance company must authorize the doctor who is to treat you.

- If you do not get a doctor's name from the insurance company, you should contact your adjuster and ask for a doctor.

Reemployment Services assistance you may receive:

If you are unable to return to your job because of permanent work restrictions resulting from your on-the-job injury, you may obtain information or assistance from the Bureau of Employee Assistance and Ombudsman Office/Reemployment Services section at the following website, by phone or by e-mail:

- http://www.myfloridacfo.com/Division/WC/Employee/reemployment.htm
- Telephone: (800) 342-1741 - option 4
- Email: wcres@myfloridacfo.com

For assistance on how any of the above benefits are calculated, call the WC hotline at 1-800-342-1741.

If you have a dispute with your insurance company

- First, try to talk about the problem with your adjuster or their supervisor.
- If you still need assistance, contact the WC hotline at 1-800-342-1741.
- If the insurance company still will not agree to pay the benefits that you believe you are entitled to, you can file a Petition for Benefits with the Office of the Judges of Compensation Claims.
  - You may wish to hire an attorney to represent you in this action.
  - See Appendix A, a flow chart of the dispute process.

For assistance on how to fill out and file a Petition for Benefits, call the WC hotline at 1-800-342-1741.

Employee workers' compensation criminal violations

The following are criminal violations of s. 440.105, F.S., that constitute a felony of the first, second or third degree depending on the monetary value of the fraud as provided in s. 775.082, s. 775.083, or s. 775.084, F.S.:

- Filing a false claim of on-the-job injuries or exaggerating injuries.
- An injured worker or any party making a claim of an on-the-job injury will be required to provide his or her personal signature attesting that he or she has reviewed, understands, and acknowledges the following statement: "Any person who, knowingly and with intent to injure, defraud, or deceive any employer or employee, insurance company, or self-insured program, files a statement of claim containing any false or misleading information commits insurance fraud, punishable as provided in s. 817.234."
- If the injured worker or party refuses to sign the document, benefits or payments shall be suspended until such signature is obtained.

How to get more information and help with your claim

Division of Workers' Compensation Employee Assistance and Ombudsman Office:

- The Employee Assistance and Ombudsman Office (EAO) will assist you at no cost with questions or concerns you may have about your workers' compensation claim.
- EAO works on your behalf to resolve issues with your workers' compensation claim. Issues that cannot be resolved informally may require the filing of a Petition for Benefits.
- EAO offices are located around the state to assist you.
  - http://www.myfloridacfo.com/Division/WC/Employee/default.htm
  - http://www.myfloridacfo.com/Division/WC/Employee/eao_offices.htm
  - Phone (toll free): 1-800-342-1741

The Division of Workers' Compensation Website: www.myfloridacfo.com/Division/WC/

- For additional information click on "Information and FAQs" on the left side of the Division's homepage.

PART TWO: EMPLOYER INFORMATION

Employer Duties

If you see an accident on the job or someone reports one:

- Contact your insurance company right away.
- Stay in contact with your employee and the adjuster until the injured worker is back on the job.

If the employee is released to work with restrictions:

- Get the doctor's list of restrictions from the injured worker or directly from the doctor's office, and
- Meet with the injured worker to see if work is available that he/she can do.
- If restricted work is available:
  - Discuss with the injured worker:
    - Starting time and date,
    - What you can pay him/her based on new job duties, and
    - Report the restricted work to the adjuster.

- Inform the adjuster:
  - When the injured worker is scheduled to return to restricted work.
  - If the injured worker will not be earning what he/she earned before:
    - Send the adjuster wage information on a weekly or bi-weekly basis to determine if temporary partial benefits are due.
  - If the injured worker is unable to, due to restrictions, continue working, or
  - If you can't give him/her restricted work any longer, or
  - If the doctor releases him/her to regular work

Employer Requirements

Posting Requirement:

The "Broken Arm Poster" and the "Anti-Fraud Notice" should be posted in a conspicuous place and should identify the name of the insurance company providing coverage and where to call to report an accident or injury. Contact your insurance company to obtain the poster and the notice.

Recording Requirement:

Record all workplace injuries and retain the records for at least 2.5 years.

Reporting Requirement:

- Report all job-related injuries to the insurance company within 7 days of discovery.
- Provide a copy of the injury report to the injured worker (Form DFS-F2-DWC-1).
- Report required wage information to the insurance company within 14 days of learning of an injury that will require the employee to miss work for more than 7 days or that results in a permanent impairment.
- If requesting the employee's authorization for release of social security benefit information, give the Form DFS-F2-DWC-14 to the employee, submit the Request for Social Security Disability Benefit Information to the Social Security Administration office nearest to the employee's address, and send a copy of the completed form to the Division within 14 days of the request (Form DFS-F2-DWC-14).

Penalties for late filing of a claim that was due to the employer's failure to timely notify the insurer

If the First Report of Injury (DFS-F2-DWC-1) is filed late with the Division, due to the late reporting of the accident by the employer to the insurance company, the employer may be penalized for the late filing, according to the following schedule:

- $100 for 1 through 7 days of untimely filing.
- $200 for 8 through 14 days of untimely filing.
- $300 for 15 through 21 days of untimely filing.
- $400 for 22 through 28 days of untimely filing.
- $500 for over 28 days of untimely filing.

In addition to the above administrative penalty paid to the Division, the employer may be liable for penalties and interest on the late payment of compensation, due to the late filing.

Penalties and interest for late payment of compensation paid directly to the injured worker along with indemnity payment that was late

1. If any installment of compensation for death or dependency benefits, or compensation for disability benefits payable without an award is not paid within 7 days after it becomes due, there shall be added to such unpaid installment a penalty of an amount equal to 20 percent of the unpaid installment, which shall be paid at the same time as, and in addition to, such installment of compensation.

2. If any installment of compensation is not paid when it becomes due, the employer, insurance company or servicing agent shall pay interest at the rate of 12 percent per year from the date the installment becomes due until it is paid, whether such installment is payable without an order or under the terms of an order. The interest payment shall be the greater of the amount of interest due or $5.

If you as an employer receive a notice from the Division about a late filing with a filing penalty due to the Division and penalties and interest due to the injured worker, you send the filing penalty payment to the Division and the penalty & interest payment, on the late indemnity payments, directly to the injured worker.

Workers' Compensation Coverage / Compliance Requirements for the Employer

Chapter 440, F.S., establishes workers' compensation coverage requirements for employers.

1. Construction Industry: An employer in the construction industry who employs one or more part- or full-time employees must obtain workers' compensation coverage. Sole proprietors, partners, and corporate officers are considered employees. Members of a limited liability company are considered corporate officers. Corporate officers may elect to exempt themselves from the coverage requirements of Chapter 440.

A construction industry contractor, who sub-contracts all or part of their work, must obtain proof of workers' compensation coverage or a Certificate of Election to be Exempt from all sub-contractors, prior to work being done. If the sub-contractor is not covered or exempt, for purposes of workers' compensation coverage, the

sub-contractor's employees shall become the statutory employees of the contractor. The contractor will be responsible to pay any workers' compensation benefits to the sub-contractor and its employees.

2. Non-Construction Industry: An employer in the non-construction industry, who employs four or more part- or full-time employees, must obtain workers' compensation coverage. Corporate officers are considered employees, unless they elect to exempt themselves from the coverage requirements of Chapter 440. Sole proprietors and partners in the non-construction industry are not considered to be employees unless they elect to be employees. Members of a limited liability company will be considered as corporate officers and employees, unless they elect to exempt themselves from the coverage requirements of Chapter 440.

3. Agricultural Industry: Agricultural employers with six or more regular employees and/or 12 or more seasonal employees, who work for more than 30 days, must obtain workers' compensation liability coverage for those employees.

4. Out-of-State Employers: An out-of-state employer engaged in work in Florida must immediately notify their insurance carrier that it has employees working in Florida. A company that has employees working in Florida must have a Florida workers' compensation insurance policy or an endorsement must be added to the out-of-state policy that lists Florida in Section 3.A. of the policy. A contractor working in Florida who contracts with an out-of-state subcontractor must obtain proof of a Florida workers' compensation policy or an endorsement to the out-of-state employer's policy that lists Florida in Section 3.A. of the policy, on the declaration page. Otherwise, the Florida contractor's policy must include the out-of-state subcontractor and their employees per Chapter 440.10 (1) (g), Florida Statutes.

Extraterritorial Reciprocity: Out-of-state employers whose home jurisdiction has in its statute an "extraterritorial reciprocity" clause allowing temporary employees from another jurisdiction (including Florida) to work under the "home state's" workers' compensation policy is permitted to work in Florida using the workers' compensation policy from their "home state", as long as the work is temporary in nature. Temporary is defined as no more than 10 consecutive days with a maximum of 25 total days in a calendar year. [For a list of the current jurisdictions who have an extraterritorial reciprocity statute, contact the Division of Workers' Compensation at 850.413.1609].

Obtaining Required Coverage

1. Coverage Options: Contact a Florida-licensed insurance agent to obtain a workers' compensation policy. If the employer has applied for and been rejected by two non-affiliated workers' compensation insurers in the voluntary market, within the last sixty (60) days, they may contact the Florida Workers' Compensation Joint Underwriting Association (FWCJUA) at (941) 378-7400 or go to their website at www.fwcjua.com. The employer may also consider leasing employees from a Professional Employer Organization or PEO. In this circumstance, the PEO becomes the employer and provides workers' compensation coverage to each employee who is paid by the leasing PEO.

2. Accurate Employer Job Classification and Payroll: Since workers' compensation premiums are based on the information provided by the employer, it is important that accurate information such as what type of work is being performed (i.e. interior trim carpentry, roofing, restaurant, clerical, etc.) and estimated payroll for each job classification code is reported to the insurance company. If any changes occur in the job duties or services performed or the employer's payroll amount during the policy term, the employer must notify its insurance company.

3. Professional Employer Organization or Employee Leasing Company: If an employer enters into an employee leasing agreement with a licensed employee leasing company, the agreement entails workers' compensation coverage only for employees listed with the employee leasing company. The client company is responsible for workers' compensation coverage for all non-leased employees. The payroll for all employees must be paid through the leasing company. Any changes in job duties or status of an employee must be reported to the leasing company promptly.

4. Individual Self Insurers: Pursuant to Chapter 440.38, F.S., an employer may become individually self-insured and secure the payment of workers' compensation by providing proof of financial strength necessary to ensure timely payments of current and future claims. Authorization and regulation of individual self-insurers is through the Division.

5. Commercial Self-Insurance Funds: Pursuant to Chapter 624.462, F.S., a group of persons may form a commercial self-insurance fund for purposes of pooling and spreading liabilities for any commercial and/or casualty insurance. Authorization and regulation of commercial self-insurance funds is through the Office of Insurance Regulation.

Part Three: Laws & Rules

This section of your course is designed to refresh your knowledge on the laws and rules that govern the Florida construction industry. These regulations can be found in Title XXXII Regulation of Professions and Occupations, Chapter 489 of the 2017 Florida Statutes. These statutes have been put in place by the Florida Legislature for the benefit of the health, safety, and welfare of the general public. After reading this section of your course, you will have reviewed the requirements for maintaining an active license, the requirements for inactive and delinquent license status, and lastly the regulations on guaranteed energy, water, and wastewater performance savings contracting.

Part One: Maintaining an Active License

Licenses must be renewed every 2 years.

- Each certificate holder or registrant who desires to continue as a certificate holder or registrant shall renew the certificate or registration every 2 years. The department shall mail each certificate holder and registrant an application for renewal.

At least 14 hours of continuing education are required to renew a license. The board requires that specific courses be taken such as workers' compensation, business practices, workplace safety, wind mitigation, and laws and rules.

- Each certificate holder or registrant shall provide proof, in a form established by rule of the board, that the certificate holder or registrant has completed at least 14 classroom hours of at least 50 minutes each of continuing education courses during each biennium since the issuance or renewal of the certificate or registration.
  - The board shall establish by rule that a portion of the required 14 hours must deal with the subject of workers' compensation, business practices, workplace safety, and, for applicable licensure categories, wind mitigation methodologies, and 1 hour of which must deal with laws and rules.
  - The board shall prescribe by rule the continuing education, if any, which is required during the first biennium of initial licensure. A person who has been licensed for less than an entire biennium must not be required to complete the full 14 hours of continuing education.
  - In addition, the board may approve specialized continuing education courses on compliance with the wind resistance provisions for one and two family dwellings contained in the Florida Building Code and any alternate methodologies for providing such wind resistance which have been approved for use by the Florida Building Commission. Division I certificate holders or registrants who demonstrate proficiency upon completion of such specialized courses may certify plans and specifications for one and two family dwellings to be in compliance with the code or alternate methodologies, as appropriate, except for dwellings located in floodways or coastal hazard areas as defined in ss. 60.3D and E of the National Flood Insurance Program.
  - The board shall require, by rule adopted pursuant to ss. 120.536(1) and 120.54, a specified number of hours in specialized or advanced module courses, approved by the Florida Building Commission, on any portion of the Florida Building Code, adopted pursuant to part IV of chapter 553, relating to the contractor's respective discipline.

The board will renew the license upon receipt of the renewal application and fee.

- The certificate holder or registrant shall complete, sign, and forward the renewal application to the department, together with the appropriate fee. Upon receipt of the application and fee, the department shall renew the certificate or registration.

Workers' compensation insurance, public liability insurance, and property damage insurance must be obtained before a license is renewed.

- As a prerequisite to the initial issuance or the renewal of a certificate or registration, the applicant shall submit an affidavit on a form provided by the board attesting to the fact that the applicant has obtained workers' compensation insurance as required by chapter 440, public liability insurance, and property damage insurance for the safety and welfare of the public, in amounts determined by rule of the board. The board shall by rule establish a procedure to verify the accuracy of such affidavits based upon a random sample method.

If a licensee requests a change of status, they must submit proof of financial responsibility. A credit report from a nationally recognized credit agency serves as this proof.

- A certificate holder or registrant shall, upon requesting a change of status, submit to the board a credit report from a nationally recognized credit agency that reflects the financial responsibility of the applicant or certificate holder or registrant. The credit report required for the initial applicant shall be considered the minimum evidence necessary to satisfy the board that he or she is financially responsible to be certified, has the necessary credit and business reputation to engage in contracting in the state, and has the minimum financial stability necessary to avoid the problem of financial mismanagement or misconduct. The board shall, by rule, adopt guidelines for determination of financial stability, which may include minimum requirements for net worth, cash, and bonding

for Division I certificate holders of no more than $20,000 and for Division II certificate holders of no more than $10,000. Fifty percent of the financial requirements may be met by completing a 14-hour financial responsibility course approved by the board.

Part Two: Inactive and Delinquent Status

If a license is not active, the licensee may not engage in contracting.

- A certificate holder or registrant may not engage in contracting unless the certificate holder or registrant has an active status certificate or registration. A certificate holder or registrant who engages in contracting without an active status certificate or registration is subject to disciplinary action as provided in ss. 455.227 and 489.129.

An active or inactive license status can be chosen at the time of license renewal.

- A certificate holder or registrant may not engage in contracting unless the certificate holder or registrant has an active status certificate or registration. A certificate holder or registrant who engages in contracting without an active status certificate or registration is subject to disciplinary action as provided in ss. 455.227 and 489.129.

An inactive license can be returned to active status at any time as long as the board's requirements are met. These include paying the necessary fees and completing continuing education.

- An inactive status certificate holder or registrant may change to active status at any time, if the certificate holder or registrant meets all requirements for active status, pays any additional licensure fees necessary to equal those imposed on an active status certificate holder or registrant, pays any applicable late fees, and meets all continuing education requirements prescribed by the board.

If a licensee fails to renew their license they will become delinquent. If the delinquent licensee fails to renew their license before the next licensure cycle then they must complete an initial licensure application.

- A certificate holder or registrant shall apply with a completed application, as determined by board rule, to renew an active or inactive status certificate or registration before the certificate or registration expires. Failure of a certificate holder or registrant to so apply shall cause the certificate or registration to become a delinquent certificate or registration. Further, any delinquent certificate holder or registrant who fails to apply to renew licensure on either active or inactive status before expiration of the current licensure cycle must reapply in the same manner as an applicant for initial certification or registration.

A delinquent licensee must renew their license before the end of the current license period or their license will become void.

- A delinquent status certificate holder or registrant must apply with a completed application, as determined by board rule, for active or inactive status during the current licensure cycle. Failure by a delinquent status certificate holder or registrant to become active or inactive before the expiration of the current licensure cycle renders the certificate or registration void, and any subsequent licensure shall be subject to all procedures and requirements imposed on an applicant for initial licensure.

An inactive licensee is not required to complete more than one renewal cycle of continuing education.

- The board may not require an inactive certificate holder or registrant to complete more than one renewal cycle of continuing education for reactivating a certificate or registration.

The board can impose discipline on a licensee no matter the status of their license.

- The status or any change in status of a certificate holder or registrant shall not alter in any way the board's right to impose discipline or to enforce discipline previously imposed on a certificate holder or registrant for acts or omissions committed by the certificate holder or registrant while holding a certificate or registration.

The board will forward a license renewal notification or a notice of pending cancellation 60 days prior to the end of a licensure cycle.

- At least 60 days prior to the end of a licensure cycle, the department shall forward:
  - A licensure renewal notification to an active or inactive certificate holder or registrant at the certificate holder's or registrant's address of record.
  - A notice of pending cancellation of licensure to a delinquent status certificate holder or registrant at the certificate holder's or registrant's address of record.

Part Three: Regulations on Guaranteed Energy, Water, and Wastewater Performance Savings Contracting

The state legislature encourages state agencies to invest in energy, water, and wastewater efficiency/conservation measures. It is the opinion of the legislature that this will minimize energy and water consumption and maximize energy, water, and wastewater savings.

- The Legislature finds that investment in energy, water, and wastewater efficiency and conservation measures in agency facilities can reduce the amount of energy and water consumed and wastewater

produced and produce immediate and long-term savings. It is the policy of this state to encourage each agency to invest in energy, water, and wastewater efficiency and conservation measures to minimize energy and water consumption and wastewater production and maximize energy, water, and wastewater savings. It is further the policy of this state to encourage agencies to reinvest any savings resulting from energy, water, and wastewater efficiency and conservation measures in additional energy, water, and wastewater efficiency and conservation measures.

The state legislature defines the following terms for clarification: "Agency," "Energy, water, and wastewater efficiency and conservation measure," "Energy, water, or wastewater cost savings," "Guaranteed energy, water, and wastewater performance savings contract," "Guaranteed energy, water, and wastewater performance savings contractor", and "Investment grade energy audit".

- "Agency" means the state, a municipality, a political subdivision, a county school district, or an institution of higher education, including all state universities, colleges, and technical colleges.
- "Energy, water, and wastewater efficiency and conservation measure" means a training program incidental to the contract, facility alteration, or equipment purchase to be used in a building retrofit, addition, or renovation or in new construction which reduces energy or water consumption, wastewater production, or energy-related operating costs and includes, but is not limited to, any of the following:
  - Installing or modifying any of the following:
    - Insulation of the facility structure and systems within the facility.
    - Window and door systems that reduce energy consumption or operating costs, such as storm windows and doors, caulking or weatherstripping, multiglazed windows and doors, heat-absorbing or heat-reflective glazed and coated window and door systems, additional glazing, and reductions in glass area.
    - Automatic energy control systems.
    - Energy recovery systems.
    - Cogeneration systems that produce steam or forms of energy such as heat, as well as electricity, for use primarily within a facility or complex of facilities.
    - Renewable energy systems.
    - Devices that reduce water consumption or sewer charges.
    - Energy storage systems, such as fuel cells and thermal storage.
    - Energy-generating technologies.
    - Automated, electronic, or remotely controlled technologies, systems, or measures that reduce utility or operating costs.
    - Software-based systems that reduce facility management or other facility operating costs.
    - Energy information and control systems that monitor consumption, redirect systems to optimal energy sources, and manage energy-using equipment.
  - Installing, replacing, or modifying any of the following:
    - Heating, ventilating, or air-conditioning systems.
    - Lighting fixtures.
  - Implementing a program to reduce energy costs through rate adjustments, load shifting to reduce peak demand, demand response programs, changes to more favorable rate schedules, or auditing utility billing and metering.
  - An improvement that reduces solid waste and associated removal costs.
  - Meter replacement, installation, or modification; installation of an automated meter reading system; or other construction, modification, installation, or remodeling of water, electric, gas, fuel, communication, or other supplied utility system.
  - Any other energy conservation measure that reduces British thermal units (Btu), kilowatts (kW), or kilowatt hours (kWh); that reduces fuel or water consumption in the building or waste water production; or that reduces operating costs or provides long-term cost reductions.
  - Any other repair, replacement, or upgrade of existing equipment that produces measurable savings, or any other construction, modification, installation, or remodeling that is approved by an agency and that is within the legislative authority granted the agency, such as an energy conservation measure.
  - Any other measure not otherwise defined in this chapter which is designed to reduce utility consumption, reduce wastewater costs, enhance revenue, avoid capital costs, or achieve similar efficiency gains at an agency or other governmental unit.
- "Energy, water, or wastewater cost savings" means a measured reduction in the cost of fuel, energy or water consumption, or wastewater production; stipulated operation and maintenance savings; improvements in supplied utility systems, including, without limitation, revenue enhancements or reduction in net operating

costs resulting from increased meter accuracy or performance; and identified capital savings, created from the implementation of one or more energy, water, or wastewater efficiency or conservation measures when compared with an established baseline for the previous cost of fuel, energy or water consumption, wastewater production, stipulated operation and maintenance, meter accuracy or performance, and identified capital costs.

- "Guaranteed energy, water, and wastewater performance savings contract" means a contract for the evaluation, recommendation, and implementation of energy, water, or wastewater efficiency or conservation measures, which, at a minimum, shall include:
  - The design and installation of equipment to implement one or more of such measures and, if applicable, operation and maintenance of such measures.
  - The amount of any actual annual savings that meet or exceed total annual contract payments made by the agency for the contract and may include allowable cost avoidance if determined appropriate by the Chief Financial Officer.
  - The finance charges incurred by the agency over the life of the contract.
- "Guaranteed energy, water, and wastewater performance savings contractor" means a person or business that is licensed under chapter 471, chapter 481, or this chapter and is experienced in the analysis, design, implementation, or installation of energy, water, and wastewater efficiency and conservation measures through energy performance contracts.
- "Investment grade energy audit" means a detailed energy, water, and wastewater audit, along with an accompanying analysis of proposed energy, water, and wastewater conservation measures, and their costs, savings, and benefits prior to entry into an energy savings contract.

In order to begin work on an energy, water, or wastewater efficiency/conservation measures, the contractor must prepare a report that estimates the project's cost savings. Payment to the contractor is contingent upon the cost savings being equal to or greater than the total projected costs of the energy conservation measures.

- Before design and installation of energy, water, or wastewater efficiency and conservation measures, the agency must obtain from a guaranteed energy, water, and wastewater performance savings contractor a report that summarizes the costs associated with the energy, water, or wastewater efficiency and conservation measures or energy-related operational cost-saving measures and provides an estimate of the amount of the cost savings. The agency and the guaranteed energy, water, and wastewater performance savings contractor may enter into a separate agreement to pay for costs associated with the preparation and delivery of the report; however, payment to the contractor shall be contingent upon the report's projection of energy, water, and wastewater cost savings being equal to or greater than the total projected costs of the design and installation of the report's energy conservation measures.

The contract for work must include a written guarantee stating that the annual cost savings will meet or exceed the amortized cost of the energy, water, and/or wastewater efficiency and/or conservation measures.

- A guaranteed energy, water, and wastewater performance savings contract must include a written guarantee that may include, but is not limited to the form of, a letter of credit, insurance policy, or corporate guarantee by the guaranteed energy, water, and wastewater performance savings contractor that annual cost savings will meet or exceed the amortized cost of energy, water, and wastewater efficiency and conservation measures.

The contractor is required to provide a 100% public construction bond for their faithful performance in completing the project.

- The guaranteed energy, water, and wastewater performance savings contract must require that the guaranteed energy, water, and wastewater performance savings contractor to whom the contract is awarded provide a 100-percent public construction bond to the agency for its faithful performance, as required by s. 255.05.

The contract for work can contain a provision stating any annual cost savings that exceed the amount guarantee in the contract.

- The guaranteed energy, water, and wastewater performance savings contract may contain a provision allocating to the parties to the contract annual cost savings that exceed the amount of the cost savings guaranteed in the contract.

The contract must require the contractor to provide an annual reconciliation of the guaranteed cost savings. If the reconciliation shows a shortfall in savings, then the contractor is liable for the shortfall. If the reconciliation shows an excess in savings, those savings cannot be used to cover any future shortages.

- The guaranteed energy, water, and wastewater performance savings contract must require the guaranteed energy, water, and wastewater performance savings contractor to provide to the agency an annual reconciliation of the

guaranteed energy or associated cost savings. If the reconciliation reveals a shortfall in annual energy or associated cost savings, the guaranteed energy, water, and wastewater performance savings contractor is liable for such shortfall. If the reconciliation reveals an excess in annual cost savings, the excess savings may be allocated, but may not be used to cover potential energy or associated cost savings shortages in subsequent contract years.

An alteration to the facility that is required in order to properly implement the conservation measures may be included as part of the contract.

- A facility alteration that includes expenditures that are required to properly implement other energy conservation measures may be included as part of a performance contract. In such case, notwithstanding any provision of law, the installation of these additional measures may be supervised by the performance savings contractor.

Part Four: Business Practices

Advertising FAQs: A Guide for Businesses

From the Federal Trade Commission: Protecting America's Consumers

The Federal Trade Commission (FTC) released this FAQ to help business owners better understand and comply with truth-in-advertising standards. These FAQs also address other issues that can arise from advertising a business' products and services. This part of your course is designed to emphasize the importance of complying with rules that regulate advertising as well as provide resources if additional assistance is needed to meet the FTC's standards.

Part 1: Truth-In-Advertising Standards

What truth-in-advertising rules apply to advertisers?

Under the Federal Trade Commission Act:

- Advertising must be truthful and non-deceptive;
- Advertisers must have evidence to back up their claims; and
- Advertisements cannot be unfair.

Additional laws apply to ads for specialized products like consumer leases, credit, 900 telephone numbers, and products sold through mail order or telephone sales. And every state has consumer protection laws that govern ads running in that state.

What makes an advertisement deceptive?

According to the FTC's Deception Policy Statement, an ad is deceptive if it contains a statement - or omits information - that:

- Is likely to mislead consumers acting reasonably under the circumstances; and
- Is "material" - that is, important to a consumer's decision to buy or use the product.

What makes an advertisement unfair?

According to the Federal Trade Commission Act and the FTC's Unfairness Policy Statement, an ad or business practice is unfair if:

- it causes or is likely to cause substantial consumer injury which a consumer could not reasonably avoid; and
- it is not outweighed by the benefit to consumers.

How does the FTC determine if an ad is deceptive?

A typical inquiry follows these steps:

- The FTC looks at the ad from the point of view of the "reasonable consumer" - the typical person looking at the ad. Rather than focusing on certain words, the FTC looks at the ad in context - words, phrases, and pictures - to determine what it conveys to consumers.
- The FTC looks at both "express" and "implied" claims. An express claim is literally made in the ad. For example, "ABC Mouthwash prevents colds" is an express claim that the product will prevent colds. An implied claim is one made indirectly or by inference. "ABC Mouthwash kills the germs that cause colds" contains an implied claim that the product will prevent colds. Although the ad doesn't literally say that the product prevents colds, it would be reasonable for a consumer to conclude from the statement "kills the germs that cause colds" that the product will prevent colds. Under the law, advertisers must have proof to back up express and implied claims that consumers take from an ad.
- The FTC looks at what the ad does not say - that is, if the failure to include information leaves consumers with a misimpression about the product. For example, if a company advertised a collection of books, the ad would be deceptive if it did not disclose that consumers actually would receive abridged versions of the books.
- The FTC looks at whether the claim would be "material" - that is, important to a consumer's decision to buy or use the product. Examples of material claims are representations about a product's performance, features, safety, price, or effectiveness.

- The FTC looks at whether the advertiser has sufficient evidence to support the claims in the ad. The law requires that advertisers have proof before the ad runs.

What kind of evidence must a company have to support the claims in its ads?

Before a company runs an ad, it has to have a "reasonable basis" for the claims. A "reasonable basis" means objective evidence that supports the claim. The kind of evidence depends on the claim. At a minimum, an advertiser must have the level of evidence that it says it has. For example, the statement "Two out of three doctors recommend ABC Pain Reliever" must be supported by a reliable survey to that effect. If the ad isn't specific, the FTC looks at several factors to determine what level of proof is necessary, including what experts in the field think is needed to support the claim. In most cases, ads that make health or safety claims must be supported by "competent and reliable scientific evidence" - tests, studies, or other scientific evidence that has been evaluated by people qualified to review it. In addition, any tests or studies must be conducted using methods that experts in the field accept as accurate.

Are letters from satisfied customers sufficient to substantiate a claim?

No. Statements from satisfied customers usually are not sufficient to support a health or safety claim or any other claim that requires objective evaluation.

My company offers a money-back guarantee. Very few people have ever asked for their money back. Must we still have proof to support our advertising claims?

Yes. Offering a money-back guarantee is not a substitute for substantiation. Advertisers still must have proof to support their claims.

What penalties can be imposed against a company that runs a false or deceptive ad?

The penalties depend on the nature of the violation. The remedies that the FTC or the courts have imposed include:

- Cease and desist orders. These legally-binding orders require companies to stop running the deceptive ad or engaging in the deceptive practice, to have substantiation for claims in future ads, to report periodically to FTC staff about the substantiation they have for claims in new ads, and to pay a fine of $40,654 per day per ad if the company violates the law in the future.
- Civil penalties, consumer redress and other monetary remedies. Civil penalties range from thousands of dollars to millions of dollars, depending on the nature of the violation. Sometimes advertisers have been ordered to give full or partial refunds to all consumers who bought the product.
- Corrective advertising, disclosures and other informational remedies. Advertisers have been required to take out new ads to correct the misinformation conveyed in the original ad, notify purchasers about deceptive claims in ads, include specific disclosures in future ads, or provide other information to consumers.

Will the FTC review my company's ads before they run to make sure that we've complied with the law?

FTC staff cannot clear your ads in advance. However, there is guidance to help you comply with the law. Information about advertising particular kinds of products (for example, foods, dietary supplements, or "environmentally friendly" merchandise), advertising credit, and guidelines for advertising on the Internet is available at www.ftc.gov. For more general information on advertising policies, call the FTC's Division of Advertising Practices at 202-326-3090.

What can my company do if a competitor is running an ad that I think is deceptive?

You can:

- Explore your legal options under federal and state statutes that protect businesses from unfair competition. For example, the Lanham Act gives companies the right to sue their competitors for making deceptive claims in ads.
- File a complaint with the National Advertising Division (NAD) of the Council of Better Business Bureaus, if your competitor's ad is running nationally or regionally. The NAD is a private, self-regulatory group affiliated with the BBB. It investigates allegations of deceptive advertising and gives advertisers a mechanism for resolving disputes voluntarily.
- Call your local BBB or file an online complaint with the Better Business Bureau if the ad is local. Many BBBs have procedures for resolving disputes between businesses.
- Contact the radio station, television station, or publication where the ad ran. Let them know that they're running an ad you think may be deceptive.
- Contact your state Attorney General's Office or your city, county, or state Office of Consumer Affairs. To get their phone numbers, check your telephone directory.
- Contact the FTC. By mail: Federal Trade Commission, Consumer Response Center, 600 Pennsylvania Avenue, NW, Washington, DC 20580; by telephone: toll-free 1-877-FTC-HELP.

Part 2: Other Advertising Issues

1. Bait and Switch

How does the FTC define "bait and switch" advertising?

It's illegal to advertise a product when the company has no intention of selling that item, but instead plans to sell a consumer something else, usually at a higher price. For more information, ask the FTC for its Guides Against Bait Advertising.

2. Comparative Advertising

Is it legal for a company to compare its product to another company's product in an ad? Comparative advertising is legal as long as it is truthful. For more information, ask the FTC for the Comparative Advertising Policy Statement.

3. Disclosures and Disclaimers

Does FTC law specify how disclaimers or disclosures must appear in ads?

Some laws and regulations enforced by the FTC, such as the 900 Number Rule, the Truth in Lending Act, and the Consumer Leasing Act, have specific requirements that apply to advertising, including that certain information must be "clearly and conspicuously" disclosed. For more information, ask the FTC for the publications Complying with the 900 Number Rule and Advertising Consumer Leases.

How prominent does a disclaimer or disclosure have to be in other kinds of ads?

When the disclosure of qualifying information is necessary to prevent an ad from being deceptive, the information should be presented clearly and conspicuously so that consumers can actually notice and understand it. A fine-print disclosure at the bottom of a print ad, a disclaimer buried in a body of text unrelated to the claim being qualified, a brief video superscript in a television ad, or a disclaimer that is easily missed on a website are not likely to be effective. Nor can advertisers use fine print to contradict other statements in an ad or to clear up misimpressions that the ad would leave otherwise. For example, if an ad for a diet product claims "Lose 10 pounds in one week without dieting," the fine-print statement "Diet and exercise required" is insufficient to remedy the deceptive claim in the ad. To ensure that disclosures are effective, advertisers should use clear and unambiguous language, place any qualifying information close to the claim being qualified, and avoid using small type or any distracting elements that could undercut the disclosure. Although there is no hard-and-fast rule about the size of type in a print ad or the length of time a disclosure must appear on TV, the FTC often has taken action when a disclaimer or disclosure is too small, flashes across the screen too quickly, is buried in other information, or is otherwise hard for consumers to understand. Most importantly, if you are concerned that a disclaimer or disclosure may be necessary to clarify a claim, evaluate your ad copy and substantiation carefully to ensure that you are not misleading consumers.

What about disclaimers and disclosures online?

Regardless of whether you advertise on TV or radio, in print ads, through direct mail or online, the law is the same: disclaimers and disclosures must be "clear and conspicuous." Dot Com Disclosures offers special guidance for online advertisers regarding 'Net specific issues such as banner ads, pop-up windows, scrolling, hyperlinks, etc.

4. Endorsements and Testimonials

Are there any rules on how endorsements may be used in ads?

The FTC's Guides Concerning the Use of Testimonials and Endorsements offer practical advice on endorsements by consumers, celebrities, and experts. All endorsements must reflect the honest experience or opinion of the endorser. Endorsements may not contain representations that would be deceptive, or could not be substantiated, if the advertiser made them directly.

- Endorsements by consumers must reflect the typical experience of consumers who use the product, not the experience of just a few satisfied customers. If an endorsement doesn't reflect users' typical experience, the ad must clearly disclose either what consumers can expect their results to be or the limited applicability of the endorser's experience. Saying "Not all consumers will get these results" or "Your results may vary" is not enough.
- Endorsements by celebrities must reflect the celebrity's honest experience or opinion. If the endorsement represents that the celebrity uses the product, that celebrity actually must use the product. Once a celebrity (or expert) has endorsed a product, the advertiser has an obligation to make sure the endorsement continues to reflect the endorser's opinion.
- To give an expert endorsement, a person must have sufficient qualifications to be considered an expert in the field. But just being an expert isn't enough. Expert endorsements must be supported by an actual evaluation, examination, or testing of the product that other experts in the field normally would conduct to support the conclusions in the endorsement.
- Advertisers also must disclose any material connection between a person endorsing a product and the company selling the product. A "material connection" is defined as a relationship that might affect the weight or credibility of

the endorsement. For example, if an endorser is an employee or relative of the advertiser, that fact must be disclosed because it is relevant to how much weight a consumer would give to the endorsement. Similarly, an advertiser must disclose if a consumer has been paid for giving an endorsement.

5. Energy Savings Claims

Are there rules for making energy savings claims in ads?

The FTC's Appliance Labeling Rule and the R-Value Rule address energy savings claims for appliances, lighting products, and insulation. For example, under these rules, energy efficiency claims in ads must be based on specific standardized tests.

6. Environmental Advertising

Are there rules for using environmental claims like "recycled" or "ozone-friendly"?

The FTC's Guides for the Use of Environmental Claims cover how words like biodegradable, recyclable, and environmentally friendly can be used in ads. In addition, some states have laws governing environmental claims. Check with the Attorney General's office of the state(s) where you plan to advertise. If you make environmental claims or use environmental symbols on your direct mail advertising, ask the FTC for Making Environmental Marketing Claims on Mail.

7. "Free" Claims and Rebate Offers

When can a company advertise something as "free"?

When a "free" offer is tied to the purchase of another product, the price of the purchased product should not be increased from its regular price. For more information, ask the FTC for the Guides Concerning Use of the Word "Free" and Other Representations and the Guides Against Deceptive Pricing. In addition, if you're advertising a product as "free" or offering it at a low cost in conjunction with the purchase of another item, the ad should clearly and conspicuously disclose the terms and conditions of the offer. Disclose the most important information - like the terms affecting the cost of the offer - near the advertised price. For more information, ask the FTC for Big Print. Little Print. What's the Deal? You also may want to check with the Attorney General's office in the state(s) where you plan to advertise. In addition, the Better Business Bureau has voluntary standards for when something can be advertised as "free."

What are the rules on advertising rebates to consumers?

Ads that include rebate promotions should prominently state the before-rebate cost, as well as the amount of the rebate. Only then will consumers know their actual out-of-pocket cost and have the information they need to comparison shop. Rebate promotions also should clearly disclose any additional terms and conditions that consumers need to know, including the key terms of any purchase requirements, additional fees, and when consumers can expect to receive their rebate. The FTC's brochure Big Print. Little Print. What's the Deal? outlines other factors advertisers should bear in mind when making rebate promotions.

8. Guarantees

When a company advertises that products are sold with a guarantee or warranty, what information about the terms and conditions must be included in the ads?

If an ad mentions that a product comes with a guarantee or warranty, the ad should clearly disclose how consumers can get the details. Any conditions or limits on the guarantee or warranty (such as a time limit or a requirement that the consumer return the product) also must be clearly disclosed in the ad. Finally, the law requires companies to make copies of any warranties available to consumers before the sale. This applies to retail sales, sales by phone or mail, and online transactions. For more information, ask the FTC for the Guides for the Advertising of Warranties and Guarantees.

9. Internet Advertising

Is advertising on the Internet subject to the same laws as other advertising?

Yes. Ad claims on the Internet must be truthful and substantiated. Ask the FTC for a copy of Advertising and Marketing on the Internet: The Rules of the Road for more information. Dot Com Disclosures offers special guidance for online advertisers regarding how to make sure that any disclaimers and disclosures in online ads are clear and conspicuous. It addresses 'Net specific issues such as banner ads, pop-up windows, scrolling, hyperlinks, etc. Internet marketers also should be aware that the FTC's Mail or Telephone Order Merchandise Rule ("Mail Order Rule") applies to online transactions. For specific guidance on complying with the Mail Order Rule online, ask the FTC for a copy of Selling on the Internet: Prompt Delivery Rules, as well as A Business Guide to the Federal Trade Commission's Mail or Telephone Order Merchandise Rule.

What do I need to know about consumer privacy online?

Advertisers should be aware of the privacy issues raised by Internet marketing. For more information about recent FTC Reports to Congress on consumer privacy on the Internet, visit the FTC's website (www.ftc.gov). Basically, the FTC strongly encourages companies to implement four fair information practices: giving consumers notice of a website's information practices;

offering consumers choice as to how their personally identifying information is used; providing consumers with access to the information collected about them; and ensuring the security of the information collected. In addition, companies need to know about the Children's Online Privacy Protection Act and the rule that implements it. The law requires websites to obtain verifiable parental consent before collecting, using, or disclosing personal information from children, including their names, home addresses, email addresses, or hobbies. For more information, ask the FTC for How to Comply with the Children's Online Privacy Protection Rule.

10. Pricing

Are there any standards governing the advertising of prices?

The same standards for truthfulness apply when companies make claims about price comparisons, "sale" prices, and the like. For more information, ask the FTC for the Guides Against Deceptive Pricing. Since many pricing issues involve local practices, you also may want to contact the Attorney General's office in the state(s) where you plan to advertise.

What responsibility does a company have to make sure that prices are accurate?

In many jurisdictions, companies are legally required to charge no more than the advertised or shelf price for a product, so good pricing practices are important for both customer satisfaction and a company's bottom line. For tips on accurate pricing practices in advertising and in retail stores, ask the FTC for Good Pricing Practices? SCAN DO.

For More Information

The FTC works for the consumer to prevent fraudulent, deceptive, and unfair business practices in the marketplace and to provide information to help consumers spot, stop, and avoid them. To file a complaint or to get free information on consumer issues, visit ftc.gov or call toll-free, 1-877-FTC-HELP (1-877-382-4357); TTY: 1-866-653-4261. The FTC enters consumer complaints into the Consumer Sentinel Network, a secure online database and investigative tool used by hundreds of civil and criminal law enforcement agencies in the U.S. and abroad.

Part Five: Wind Mitigation

The 2017 Florida statutes state that *"the effects of recent hurricanes on the state have demonstrated the effectiveness of the Florida Building Code in reducing property damage to buildings constructed in accordance with its requirements, and have also exposed a vulnerability of some construction undertaken prior to implementation of the Florida Building Code."*

The purpose of wind mitigation is to prevent or lessen damage caused by high winds during storms; hurricanes in particular. This section of your course will review the importance of implementing building standards outlined in the Florida Building Code for effective wind mitigation.

What is Wind Mitigation?

Mitigation is defined as the lessening of the force or intensity of something unpleasant. Wind mitigation specifically targets the structural and nonstructural aspects that prevent or lessen damage caused by high winds that occur with storms. In Florida, the primary concern is the wind damage caused by hurricanes. Hurricane season begins June 1 and ends November 30. That means for five of twelve months of every year, Floridians are at risk for exposure to high winds. It is also not unusual to have a hurricane or tropical storm outside of hurricane season.

But what is wind mitigation? What actions or changes constitutes mitigating a home?

The primary damages from hurricanes are wind and water intrusion (Summary Report on Building Performance 2004 Hurricane Season). Water, as rain directed by varying wind directions, enters homes through gable ends, soffit vents and poorly sealed windows and doors. Once rain enters homes mildew can develop within days. Like water, wind causes damage by entering the home through poorly sealed openings. Wind damages homes by increasing pressure and causing uplift forces on the roof.

Why Mitigate?

Studies say…

1. FEMA's Federal Insurance and Mitigation Administration participated in a study that estimated the value of all mitigation activities funded between mid-1993 through mid-2007. This study included mitigation of floods, hurricanes and earthquakes. The study concluded a value of $4 was saved in response and recovery for every $1 spent on mitigation.
2. The Florida Department of Finance states that 15% - 70% of insurance premiums could be attributed to wind-damage risk.

Safety

Too often people wonder why damage occurred after a disaster. Wind mitigation is meant to avoid a hazard by reducing the amount of damage to a home, reducing the amount of debris that may result in damage to other homes and speed cleanup efforts. The steps to mitigating a home that follow in this manual are research-based activities that will help minimize the damage to a home.

The arm bands of hurricanes often spawn tornados or

generate gusts of wind so strong that objects, trees and other debris can cause extensive damage regardless of mitigation efforts.

Recovery

Community recovery from a disaster doesn't take one or two years. It can take five years before a community recovers jobs, housing and revenue lost from a disaster.

Imagine you have evacuated to a shelter and then come home - from here let's imagine two different scenarios.

1. Scenario A - A large piece of the roof to your home is missing, there is significant water damage to three rooms of your house and four windows are shattered. Clearly this is not a safe environment and mold will grow within days.
2. Scenario B - There is minimal damage to your roof due to a tree leaning on your home. There is minor water damage in your living room and is manageable by placing a tarp on your roof. You are back in your home after one night in a shelter.

Which scenario would you prefer?

Economic

Florida Statute 627.711 requires insurance companies to notify homeowners of premium discounts for hurricane loss mitigation and establishes a uniform mitigation verification inspection form. If a home has undergone a wind inspection then the owners are potentially eligible for insurance discounts or credits.

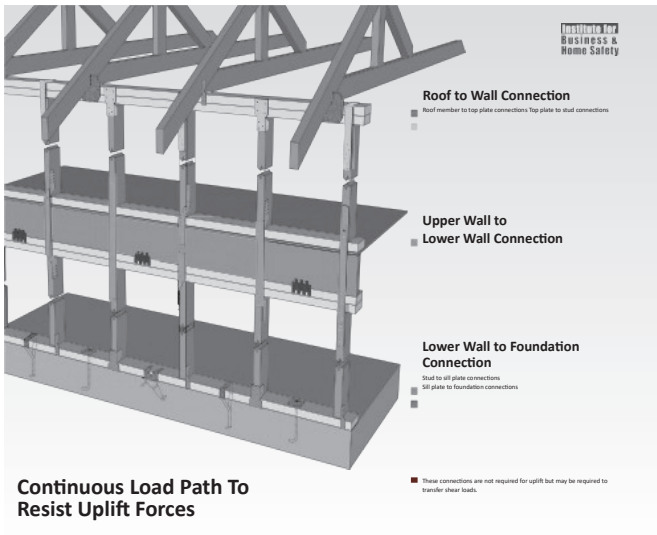
Beyond insurance savings - the value of a home increases and there are cost savings when a disaster occurs. These savings are dependent on many different variables and cannot be predicted.

Types of Mitigation

1. Anchoring, Roof-to-Wall: Reinforce foundation-to-wall, floor-floor (multistory homes) and wall-to-roof connections to establish a continuous load path. A continuous load path allows the home to resist high-wind forces as a unit. Weak links in a load path are generally where damage occurs.
2. Gable Ends: Gables that are taller than 4 feet will benefit from reinforcing the framing and bracing the top and bottom of the gable. Generally, a licensed professional engineer is best to design a gable end bracing system appropriate for the specific location and home construction.
3. Window Openings: There are many options for window openings. Shatterproof glass windows are expensive, but eliminate the need to shutter before a storm. Clear, lightweight, cloth, electric and roll-down shutters exist to assist persons with varying disabilities.
4. Doorways: Doors, including garage doors, are best replaced with a hurricane-rated door. For existing garage doors additional bracing can be applied. Hurricane- rated garage doors are heavier and often in a storm power is lost, so electric openers won't work.

Anchoring, Roof-to-Foundation

A continuous load path is the function of a house as a whole rather than the components of a foundation, walls and a roof. Anchoring the walls to the foundation (the first floor to the second floor and the walls to the roof) establishes a connection of roof to foundation. With anchoring in place, a home can resist the various forces that exist when winds push on the roof and walls, and penetrate the home.

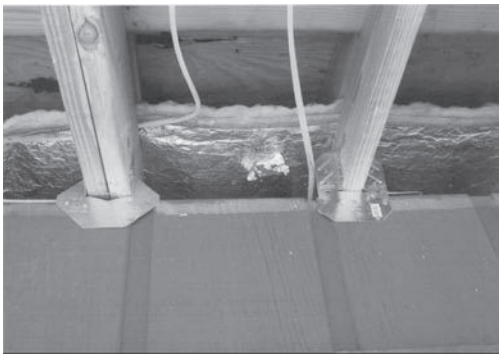


A roof tie-down, like roofing, is easiest done with new construction, re-roofing or major remodeling. On existing homes this generally encompasses the removal of the soffit to expose where the rafters meet the wall framing. Most homes have a standard connection on one side of the beams. For high-wind resistance, metal connectors are bolted to both sides where the rafter and the wall frame meet.

A double wrap connector is a continuous connector in the shape of a modified U to fit the framing. Many varieties of connectors are manufactured to meet the wide variety of connections that could exist between the rafters and the walls. Every connection, every joint must be secured. Local building departments generally require permits which will leave the soffits uncovered until a post-inspection of work is completed. Work closely with local building departments to minimize this exposure time.

Upper wall to lower wall connections exist with a multistory home. This connection is not required for single story homes. The connector/hurricane strapping for the upper wall to lower wall connection is a solid steel connector that requires the removal of siding on existing homes.

Wall to foundation connectors and reinforcements generally require the removal of siding on existing homes. Block and brick walls require steel rod supports to be added. Like roof to wall connections, every joint should be secured.



Porches that are connected to the house or that share a common roof should be mitigated and have their attachments strengthened. Enclosed porches should be shuttered as well to minimize uplift forces. Reinforce wood porch frames much as the roof-to- wall and wall-to-foundation for the home. A variety of connectors and strappings are made to support frames at the base and roof joints.

Aluminum porches and screen frames (often found around pool decks) are not designed to withstand hurricane force winds. As most aluminum porches are attached to the boards at the eaves of homes, the best mitigation is to ensure the board is well- reinforced to the roof structure to ensure the board continues connection to the home if the aluminum frame is damaged.

Gable Ends

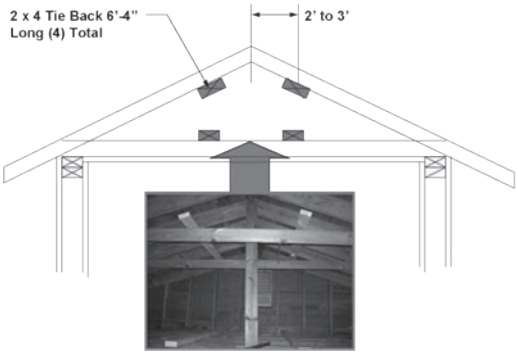
Gable ends respond to pressure within the house by bowing in and out. This action loosens the connections to the wall and roof. When reinforcing the roof-to-wall connections at the gable ends, also make sure to reinforce the connections at the base of the gable end to the wall below.

Mitigating gable ends includes two primary activities.

1. Reinforcing the connections to the roof and the wall below.
2. Place four horizontal beams two to three feet from the point of the gable end.

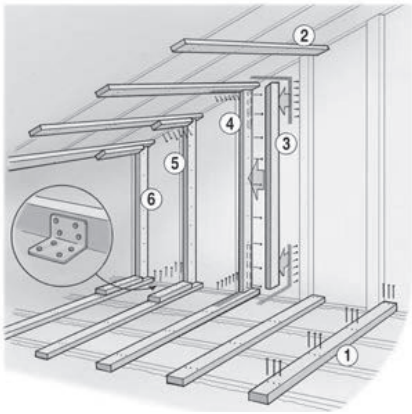
Horizontal beams should be at least six feet and long enough to connect to at least three attic floor framing boards and extend 2 1/2 feet past the third board. If there is a gap in connecting the horizontal beam to the gable wall, which is more common in block homes, use a wood shim to close the gap. The reinforcement of horizontal beams against the gable minimizes the bowing that occurs as pressure within the house varies during a storm.

In the picture below, the added horizontal frames are painted white so the mitigation is clear. When installing the horizontal beams, it may be best to install the lower beams first to extend the walking surface in the attic. Make sure you do not pinch wires between the boards as this may result in a fire hazard.



In some cases, an engineer may recommend multiple vertical beams attached to an existing stud and connecting to the horizontal beam. This creates a U-shape against the gable end wall.

Connect the beam with an L-shape strap and reinforce with a block of wood at the joint to further compress the connection. The top of the retrofit stud should be cut square and does not have to match the pitch of the roof. Further secure the retrofit stud by applying construction adhesive along the sheathing (wall of the gable end).



Glazed Openings

Glazed openings refer to any opening that has a glazed surface. This includes windows, glass doors and glass block. Panel shutters are the most common type of covering for glazed openings and are available in a

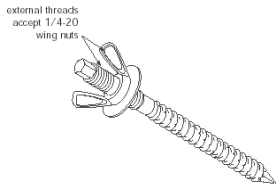
wide variety of materials and mounting options. Panel shutters are mounted either by tracks or by small metal posts. Either option is a permanent feature to the home. For many, the appearance of tracks or posts on the side of their home is not aesthetically pleasing. Most recognize it is a valuable safety feature for high wind prone areas.

For those bothered by the appearance of tracks or posts, another option for windows and glazed surfaces within doors is to buy windows and doors with impact-resistant glass. These are more expensive and are not shatter proof. Replacement of impact resistant glass can be expensive. Replacement of cracked surfaces is a necessity in securing a home for high-wind storms.

While having impact-resistant glass windows prevents the need to shutter before a storm, impact- resistant glass windows are heavier, may be difficult to open for daily use and enjoyment, and do not prevent debris from entering a home if fractured. So the recommended mitigation is to shutter your home. Panels come in steel, lightweight aluminum, plexi-glass and cloth. In addition, shutters can be permanent fixtures and have a traditional appearance (good for registered historical homes and structures), be accordion, or be automated and roll down and lock with the click of a button.

Water can intrude around shutters and cause damage to frames both inside and outside the home. Make sure you inspect all openings before and after a storm to ensure water has not penetrated the walls of the home. If water penetrates the home and is left untreated, mold and mildew will grow quickly.

The picture above shows tracks installed above and below the opening. Before a storm arrives, the resident will slide and secure the panels into the tracks. The tracks are permanent installations.



The pictures above show the post installed around a window that will be used to anchor the panel shutter. These posts are permanent installations and shutters are fastened with a wing- nut.

A quick, effective and easy shutter is a plywood board. There are various clips and braces that can be added to hold plywood in place. Plywood is cheap and it is easy to customize the size to fit any window. While thick plywood is an effective shutter, insurance companies are not required to provide discounts for plywood shutters.

Before installing shutters, inspect the framing around the windows and doors to ensure the framing is in good condition. If necessary, replace or reinforce framing and apply weathering strips or caulk to create a good seal around the windows and doors.

Areas around doorways that have decorative glass and/or glazed surfaces should be shuttered. The picture above demonstrates a decorative feature that required shuttering of the entire area. Even though the glazed area is small, the decorative features weaken the wall and its ability to withstand high winds.

Doorways

Wind resistant doors are generally heavy, solid doors. The most obvious feature of wind resistant doors is that it opens out. Wind resistant doors also have at least three (and generally four) mounting brackets with screws that are 2 1/2 to 3 inches long. This will ensure the door is connected to the door frame as well as the wall framing behind the door frame.

When replacing a door, ensure the framing is solid and if necessary replace and reinforce the framing. It is important to ensure the door is installed to manufacturer's specifications.

The hinges strengthen only one side of the door. On the other side is a bolt lock that should also be secure. The bolt lock should be 1" long to extend far enough into the frame to hold the door in a closed position.

French doors or double doors should be shuttered. French doors often fail at their connection point because the center beam is not designed to sustain the force of high winds. Garage doors should be shuttered, replaced with a wind rated door or in some cases they can be reinforced by adding a bracing bar behind each panel. In addition, any glazed surface panels should

be replaced with solid panels before the storm. Wind rated garage doors are generally solid doors with extra bracing. The added weight of a solid door requires reinforced tracks and a stronger garage door opener.

Often during a hurricane, power is lost for a period of time. If there is a major storm, power may be out for days. Make sure the garage door opener has a manual release. Also, given the added weight of a wind rated garage door, the garage door should not be the primary exit. It may be difficult to open the door after a storm.

Insurance premium discounts

The Florida Statutes prescribe standards for insurance premium discounts for hurricane loss mitigation. This same statute also prescribes a uniform mitigation verification inspection form. Read the statute below:

Statute 627.711 Notice of premium discounts for hurricane loss mitigation; uniform mitigation verification inspection form.—

1. Insurers must notify their policy holders that premium discounts/credits/rate differentials/reduction in deductibles are available for properties where the construction reduces the amount of loss in a windstorm. There is a prescribed form that describes what policyholders can do to reduce their windstorm premiums:

(1) Using a form prescribed by the Office of Insurance Regulation, the insurer shall clearly notify the applicant or policyholder of any personal lines residential property insurance policy, at the time of the issuance of the policy and at each renewal, of the availability and the range of each premium discount, credit, other rate differential, or reduction in deductibles, and combinations of discounts, credits, rate differentials, or reductions in deductibles, for properties on which fixtures or construction techniques demonstrated to reduce the amount of loss in a windstorm can be or have been installed or implemented. The prescribed form shall describe generally what actions the policyholders may be able to take to reduce their windstorm premium. The prescribed form and a list of such ranges approved by the office for each insurer licensed in the state and providing such discounts, credits, other rate differentials, or reductions in deductibles for properties described in this subsection shall be available for electronic viewing and download from the Department of Financial Services' or the Office of Insurance Regulation's Internet website. The Financial Services Commission may adopt rules to implement this subsection.

Homes built prior to the 2001 building code

Description of Feature	Estimated* Premium Discount Percent	Estimated* Annual Premium ($) is **Reduced** by:
Roof Covering (i.e., shingles or tiles) • Meets the Florida Building Code. • Reinforced Concrete Roof Deck. (If this feature is installed on your home you most likely will not qualify for any other discount.)		
How Your Roof is Attached • Using a 2" nail spaced at 6" from the edge of the plywood and 12" in the field of the plywood. • Using a 2 1/2" nail spaced at 6" from the edge of the plywood and 12" in the field of the plywood. • Using a 2 1/2" nail spaced at 6" from the edge of the plywood and 6" in the field of the plywood.		

Roof-to-Wall Connection • Using "Toe Nails" – defined as three nails driven at an angle through the rafter and into the top roof. • Using Clips - defined as pieces of metal that are nailed into the side of the rafter/truss and into the side of the top plate or wall stud. • Using Single Wraps – a single strap that is attached to the side and/or bottom of the top plate and are nailed to the rafter/truss. • Using Double Wraps - straps are attached to the side and/or bottom of the top plate and are nailed to the rafter/truss.		
Roof Shape • Hip Roof – defined as your roof sloping down to meet all your outside walls (like a pyramid). • Other.		
Secondary Water Resistance (SWR) • SWR – defined as a layer of protection between the shingles and the plywood underneath that protects the building if the shingles blow off. • No SWR.		
Shutters • None. • Intermediate Type —shutters that are strong enough to meet half the old Miami-Dade building code standards. • Hurricane Protection Type -- shutters that are strong enough to meet the current Miami-Dade building code standards.		

* Estimate is based on information currently on file and the actual amount may vary.

Homes built under the 2001 building code or later

Description of Feature	Estimated* Premium Discount Percent	Estimated* Annual Premium ($) is **Reduced** by:
Homes built under the 2001 Florida Building Code or later edition (also including the 1994 South Florida Building Code for homes in Miami-Dade and Broward Counties) are eligible for a minimum 68% discount on the hurricane-wind portion of your premium. You may be eligible for greater discount if other mitigation features are installed on your home.		
Shutters • None. • Intermediate Type —shutters that are strong enough to meet half the old Miami-Dade building code standards. • Hurricane Protection Type -- shutters that are strong enough to meet the current Miami-Dade building code standards.		
Roof Shape • Hip Roof – defined as your roof sloping down to meet all your outside walls (like a pyramid). • Other.		

* Estimate is based on information currently on file and the actual amount may vary.

2. There is a "uniform mitigation verification inspection form" that must be used by policyholders when submitting proof of mitigation to apply for policy discounts. The form must be signed by an authorized mitigation inspector (see list below).

(2)(a) The Financial Services Commission shall develop by rule a uniform mitigation verification inspection form that shall be used by all insurers when submitted by policyholders for the purpose of factoring discounts for wind insurance. In developing the form, the commission shall seek input from insurance, construction, and building code representatives. Further, the commission shall provide guidance as to the length of time the inspection results are valid. An insurer shall accept as valid a uniform mitigation verification form signed by the following authorized mitigation inspectors:

1. A home inspector licensed under s. 468.8314 who has completed at least 3 hours of hurricane mitigation training approved by the Construction Industry Licensing Board which includes hurricane mitigation techniques and compliance with the uniform mitigation verification form and completion of a proficiency exam;

2. A building code inspector certified under s. 468.607;

3. A general, building, or residential contractor licensed under s. 489.111;

4. A professional engineer licensed under s. 471.015;

5. A professional architect licensed under s. 481.213; or

6. Any other individual or entity recognized by the insurer as possessing the necessary qualifications to properly complete a uniform mitigation verification form.

(b) An insurer may, but is not required to, accept a form from any other person possessing qualifications and experience acceptable to the insurer.

3. The person who signs the mitigation verification form must personally inspect the structure unless they are qualified to have a direct employee complete the inspection.

(3) A person who is authorized to sign a mitigation verification form must inspect the structures referenced by the form personally, not through employees or other persons, and must certify or attest to personal inspection of the structures referenced by the form. However, licensees under s. 471.015 or s. 489.111 may authorize a direct employee, who is not an independent contractor, and who possesses the requisite skill, knowledge and experience, to conduct a mitigation verification inspection. Insurers shall have the right to request and obtain information from the authorized mitigation inspector under s. 471.015 or s. 489.111, regarding any authorized employee's qualifications prior to accepting a mitigation verification form performed by an employee that is not licensed under s. 471.015 or s. 489.111.

4. The authorized inspectors cannot commit misconduct that will cause financial harm to a customer or an insurer, or that will jeopardize the customer's health and safety. Examples of misconduct can be found below.

(4) An authorized mitigation inspector that signs a uniform mitigation form, and a direct employee authorized to conduct mitigation verification inspections under subsection (3), may not commit misconduct in performing hurricane mitigation inspections or in completing a uniform mitigation form that causes financial harm to a customer or their insurer; or that jeopardizes a customer's health and safety. Misconduct occurs when an authorized mitigation inspector signs a uniform mitigation verification form that:

(a) Falsely indicates that he or she personally inspected the structures referenced by the form;

(b) Falsely indicates the existence of a feature which entitles an insured to a mitigation discount which the inspector knows does not exist or did not personally inspect;

(c) Contains erroneous information due to the gross negligence of the inspector; or

(d) Contains a pattern of demonstrably false information regarding the existence of mitigation features that could give an insured a false evaluation of the ability of the structure to withstand major damage from a hurricane endangering the safety of the insured's life and property.

Wind Mitigation Summary

Wind mitigation is an initiative that should be taken to keep residents of Florida more secure in their homes during storms, protect their properties, and lower their insurance premiums. For more information on retrofitting existing buildings to comply with wind mitigation standards, see Chapter 17 of the 6th Edition of the Florida Building Code, Existing Building.

Durability by Design: A Guide for Residential Builders and Designers Final Exam

1. **Building and designing a durable home requires which of the following:**
   a. A building scientist
   b. A durability specialist
   c. Rocket science
   d. Commitment

2. **With regards to 2.2 *What is Durability*, a house is expected to last for:**
   a. Well over 100 years
   b. 100 to 150 years
   c. 75 years or more
   d. 50 years

3. **Building codes specify the minimum durability of various materials based on which of the following criteria:**
   a. Regional climate
   b. Local geology
   c. Biological conditions
   d. All of the above

4. **Temperature causes materials to _____and_____.**
   a. Expand, contract
   b. Dry, wither
   c. Weaken, fade
   d. Dehydrate, shrink

5. **Many *factors influence durability*, including moisture, sunlight, temperature and:**
   a. Economic conditions
   b. Molecular bonding
   c. Birds
   d. Chemicals

6. **What is the typical, annual, out-of-pocket maintenance and repair expenditure for a home?**
   a. $100-$200
   b. $300-$600
   c. $500-$800
   d. $1,000-$1,500

7. **A rule of thumb regarding *Ground and Surface Water* is:**
   a. Do not build below-ground space below highest seasonal water table level
   b. Provide one sump pit for every 400 square feet of below grade space
   c. Be sure all foundation walls are water-proofed with a petroleum based mastic.
   d. All basement floors should be "floating" to accommodate the water table

8. **Foundation options generally include which of the following:**
   a. Basement
   b. Slab-on-grade
   c. Crawl pace
   d. All of the above

9. **A rule of thumb regarding *Rain and Water Vapor* is:**
   a. Use only synthetic underlayments at all roof penetrations
   b. Avoid depending on caulk as a primary barrier to moisture penetration
   c. Only masonry walls can be considered completely waterproof
   d. Use only professional grades of polyurethane sealants

10. **As per Table 4.1, the recommended minimum rake overhang width for a two story wood-frame building with a climate index of 21 to 40 is:**
    a. 12 inches
    b. 18 inches
    c. 24 inches
    d. 16 inches

11. **As per Table 4.2, a roof pitch of 9:12 to 11:12 has a factor of:**
    a. 1
    b. 1.05
    c. 1.1
    d. 1.2

12. **It may be advisable to use an air space between siding and a drainage plane if a house is:**
    a. At a high altitude
    b. Near a large body of water
    c. In a particularly severe climate
    d. In an isolated location

13. **What does the acronym HDD stand for?**
    a. Heat Delimited Dynamic
    b. Heat Degree Days
    c. Heat Determiner Divergent
    d. Heat Date Degree

14. **_____ is perhaps one of the disappearing crafts in the world of modern construction and modern materials that seem to suggest simple installation, "no-worry" performance, and low maintenance.**
    a. Splintering
    b. Flashing
    c. Curating
    d. Multislacking

15. **Plastic vent louvers commonly used on gable ends must contain _____.**
    a. Cap filters
    b. Weep holes
    c. UV inhibitors
    d. Felt paper

16. **When building an unventilated crawlspace, the exterior grading must have a minimum slope of ___percent.**
    a. 4
    b. 6
    c. 8
    d. 10

17. **As per Table 4.8, if a house is in a hot/humid climate, a crawlspace is:**
    a. Required
    b. Optional
    c. Recommended
    d. Not recommended

18. **Sunlight is made up of visible light and nonvisible radiation such ultraviolet (UV) and:**
    a. Microwave (MW)
    b. Gamma (GM)
    c. X-ray (XR)
    d. Infrared (IR)

19. **UV protective glazing is a relatively expensive treatment and should only be used for _____facing windows.**
    a. North
    b. East
    c. South
    d. West

20. **Concrete, clay tile roofing, Portland cement stucco, and _____are naturally resistant to UV radiation.**
    a. Deciduous wood
    b. Felt paper
    c. Aluminum roofing
    d. Brick siding

21. **Insects known to damage wooden materials in homes and in other structures include termites, carpenter ants, wood-boring beetles and:**
    a. Cicadas
    b. Locusts
    c. Millipedes
    d. Carpenter bees

22. **What is the most common form of termite control used by the building community?**
    a. Termite baits
    b. Treated wood products
    c. Soil treatments
    d. Bait termiticides

23. **As per Figure 6.1, how many regions of termite probability (hazard) are there in the United States?**
    a. 4
    b. 5
    c. 6
    d. 7

24. **Which of the following is a termite-resistant material?**
    a. Plastic
    b. Wood
    c. Thin metal
    d. Concrete

25. **Termites can gain hidden access through cracks as small as ____inch wide.**
    a. 1/16
    b. 1/32
    c. 1/48
    d. 1/64

26. **Using lumber treated with termite-resistant materials can add as much as _____to the price of a typical home.**
    a. $1,000
    b. $2,000
    c. $3,000
    d. $4,000

27. **Wood decay will be rapid when the temperature is in the range of ___to___ °F.**
    a. 50, 65
    b. 60, 75
    c. 70, 85
    d. 80, 95

28. **Which of the following will prevent wood decay:**
    a. Protect (or separate) wood from moisture
    b. Use naturally decay-resistant wood
    c. Use preservative treated wood
    d. All of the above

29. **In most normal outdoor exposures, wood will come to an equilibrium moisture content of less than ___ percent.**
    a. 10
    b. 20
    c. 30
    d. 40

30. **In constantly damp locations or in conditions of extremely high humidity, the moisture content will increase up to the saturation moisture content of wood to approximately ___ percent.**
    a. 30
    b. 35
    c. 40
    d. 45

31. **With regards to performance problems of exterior wood finishes, "alligatoring" is synonymous to:**
    a. Peeling
    b. Blistering
    c. Checking
    d. Cracking

32. **As per Table 7.2, for a marine application, the recommended preservative retention level is ___.**
    a. 0.25
    b. 0.4
    c. 0.6
    d. 2.5

33. **As per Table 7.3, a stainless steel nail has a service life of ___years.**
    a. 50+
    b. 60+
    c. 70+
    d. 80+

34. As per Table 8.1 – Hurricane-Damage Statistics, the frequency of moderate to severe damage to roof sheathing from Hurricane Opal was:

a. 64%
b. 2%
c. 18%
d. 87%

35. To improve the durability of homes in areas prone to frequent high winds, moderate sloped roofs of ____ to_____ should be installed to minimize wind uplift.

a. 2:12, 4:12
b. 4:12, 6:12
c. 6:12, 8:12
d. 8:12, 10:12

36. Which of the following would benefit from wear-resistant surfacing (tile, hardwood, vinyl, etc.) due to its high traffic:

a. Kitchens
b. Bedrooms
c. Stairways
d. Basements

37. To avoid cracks, visible seams, and nail pops, sufficiently dry lumber with a maximum moisture content of ___% should be installed.

a. 6
b. 8
c. 10
d. 12

38. With regards to *HVAC* systems, the issues primarily relate to comfort, and in a few cases:

a. Potential moisture problems
b. Potential dryness issues
c. Cracked heat exchangers
d. Leaking evaporator coils

39. A problem that commonly occurs with horizontal siding is _____ at rim joists as a consequence of shrinkage of the large dimension lumber.

a. Splitting
b. Cracking
c. Buckling
d. Expanding

40. Examples of problems that result from site conditions that can be noticed very quickly include: warping of wood products, staining or mold growth and:

a Slight bumps in the floor at cut edges
b Wear of floor coverings
c Weakening of some materials
d Shrinking sheathing

CHAPTER 1 | INTRODUCTION

1.1 General

Of all the issues that must be considered when building a home, durability has perhaps the broadest impact on long-term performance, the most complex set of physical interactions, and the largest potential economic consequence. Fortunately, many of the best practices intended to improve durability require little more than good judgment and a basic knowledge of the factors that affect building durability.

A fundamental element of this discussion is the very meaning of durability. For this guide, durability may be defined as the ability of a material, product, or building to maintain its *intended function* for its *intended life-expectancy* with *intended levels of maintenance* in *intended conditions of use*.[1] Obviously this definition may take on different meanings for different groups (e.g., builders, homeowners, manufacturers), implying that communication and education are key aspects that affect durability.

Addressing durability is not a pursuit of extremes, but rather a pursuit of cost-effectiveness in terms of initial and long-term (i.e., maintenance, replacement) costs. Trying to make a home too durable can add so much to the cost of a new home that it may deny access to the basic need of decent shelter in the present time. Erring in the other direction can result in an equally disastrous future in terms of homeowner complaints, unsafe or unhealthy living conditions, and excessive maintenance and repair costs.

The above comparison assumes that there is a direct trade-off between durability and affordability of homes. While the saying, "you get what you pay for," is generally true, there are many design and construction practices that have minimal construction cost impacts, and significant durability benefits. The benefits may be measured in terms of maintenance, repair, general function of the home and its component parts over time, enhanced business reputation, and customer satisfaction. Moreover, many such practices are well-known and need not be re-invented, but only communicated to the builder, designer, and consumer.

This guide strives to reinforce "tried and true" practices that add to the durability of homes, shed some light on areas of confusion, and identify important trade-offs between cost and durability that should be carefully considered by the designer, builder, and homeowner.

[1] For a standardized definition of durability, refer to ASTM E632-82 (1996) *Standard Practice for Developing Accelerated Tests to Aid Prediction of the Service Life of Building Components and Materials,* American Society of Testing and Materials, West Conshohocken, PA (www.astm.org)

The guide focuses on practical solutions in key areas that are known to create significant and reoccurring durability problems. The guide also identifies timeless design concepts and principles that, once understood, can be applied to a variety of conditions and applications in modern housing design, construction, and maintenance. Finally, an attempt is made to draw attention to innovative materials and techniques that hold promise for improved durability in houses of the future.

1.2 Durability Requires Commitment

Building and designing a durable home does not require a building scientist or durability specialist, but it does require commitment. Achieving durable construction not only includes the basics—material selection, verification of manufacturer warranties, and passing minimum code-required inspections—but it also involves a reasonable consideration of key details in the production of a home and understanding of the interactions between different materials and trades. Furthermore, durability also requires the appropriate *use and installation* of specified materials and, equally

WHY IS DURABILITY IMPORTANT?

- *Avoidance of short-term durability or performance problems (i.e., callbacks) is important to the builder's and designer's reputation and business profitability.*
- *The long-term condition of a home is important to retaining its investment value as well as its continued function as a safe, healthy, and aesthetic living environment.*
- *Poor durability adds to the operating and maintenance cost of home ownership.*
- *Failure to meet reasonable expectations for durability increases liability exposure.*
- *People don't like maintenance (i.e., high durability and low maintenance are important sales and purchasing factors).*
- *New products designed without adequately considering durability can prematurely fail, leading to both customer dissatisfaction and manufacturer losses.*

DURABILITY CHECKLISTS

To assist in using this guide and in applying selected recommended practices, a durability checklist is provided in Appendix A. It lists various actions or considerations that should occur during the course of designing and constructing a house. Also included are action items appropriate for homeowners. Feel free to use and modify the checklist to suit your needs and level of interest.

important, the functional integration of various materials and products such that the house performs as intended. In tandem, durability design criteria should incorporate concepts such as ease-of-repair or replacement where appropriate.

Building a durable home is relatively simple if the right information and guidance is available. In fact, including durability as a design criterion (though often subjective in nature) can add marketable features to homes at very little additional cost or design effort. Some features may already be incorporated into existing designs while others can be added through a simple modification of plans and specifications.

Admittedly, although some aspects of designing for durability are rather straight forward such as the building code requirement of keeping untreated wood from contacting the ground—other tasks may involve somewhat greater effort. Achieving cost-effective and durable construction requires a reasonable commitment in the planning, design, and construction of houses.

1.3 Overview

This guide is arranged in the most practical and user-friendly way possible. However, there are many interrelated topics, which make any arrangement of information on durability somewhat challenging. To the degree possible, redundancy in content is minimized and interrelated topics or discussions are appropriately cross-referenced so that the reader can seek the depth of information needed with relative ease. A glossary is provided at the end of this guide to aid in the proper understanding of this writing.

The chapters of this guide are organized mainly by the factors that affect durability, i.e., ground and surface water, rain and water vapor, sunlight, etc. Within each chapter, the first section is always directed toward a general understanding of the concepts and issues related to the specific topic(s) of the section. An effort has been made to include geographically-based data and other technical information that allows the reader to quickly determine the relevance of a particular durability issue to local conditions or requirements.

Chapter 2 introduces the topic of durability and presents some important over-arching concepts and issues that create a foundation of understanding upon which the remainder of the guide builds. Chapter 3 addresses concerns related to ground and surface water, primarily affecting site and foundation design. Chapter 4 addresses rain and water vapor and their effect on the above-ground structure. Combined, Chapters 3 and 4 cover some of the most prevalent housing durability issues related to water—the most formidable durability factor known to man. Chapter 5 deals with sunlight and methods to mitigate the effects of ultraviolet (UV) radiation on building materials. In Chapter 6, methods to prevent insect infestation and damage are presented. Chapter 7 addresses the issue of wood decay and corrosion of metal fasteners, both associated with the effects of moisture. Practices to improve the durability of homes that are subject to natural hazards, such as hurricanes and earthquakes, are presented in Chapter 8. Finally, Chapter 9 covers several miscellaneous and "serviceability" issues related to durability, including items such as wear-and-tear, nuisances, plumbing/ mechanical/electrical systems, and exterior appurtenances.

CHAPTER 2 | CONCEPTS OF DURABILITY

2.1 General

In this chapter, some fundamental concepts of durability related to the design of residential buildings are addressed. This background information is intended to establish a baseline of understanding and to introduce concepts and information important to developing a balanced perspective regarding durability.

Before discussing the concept of durability, some discussion on unrealistic notions surrounding the topic of durability is in order. Despite the best efforts of the most knowledgeable and capable people, unforeseen problems will continue to occur in homes (e.g., premature failures of building products, components, and systems). This undesirable outcome is often a consequence of taking calculated risks in moving toward more resource efficient, affordable, functional, and appealing homes. Further, it is impractical to think that the durability of all building components and systems can be exactly designed and crafted such that they all last just as long as intended. In fact, the service life of building materials and products varies substantially (see Appendix B—Estimated Life-Expectancy of Building Materials and Products). Thus, it can be expected that some components of a home will require some vigilant attention along the way (i.e., maintenance, repair, and eventual replacement of "worn-out" components).

Note that many changes have occurred in home building over the past several decades that will likely affect the durability of houses in the short and long term—some good and some bad. Examples of material changes include the increased use of engineered wood products, adhesives, and plastics, among many others. At the same time, housing designs have tended to grow in complexity and size, thereby increasing exposure to the elements and vulnerability. Also, newer materials and technologies have changed both the susceptibility and exposures of building materials in modern homes. New homes are also increasingly complex to operate and maintain. In short, there are more durability issues to deal with and more material choices than ever before.

2.2 What is Durability?

Durability is the ability of a material, product, or building to maintain its *intended function* for its *intended life-expectancy* with *intended levels of maintenance in intended conditions of use*. However, we all know that the road to success is not just paved with good intentions. Ultimately, what is built must work as expected, or as nearly so as practicable.

What is a reasonable expectation or goal for durability? It depends.

It depends on how much it costs. It depends on the expectations of the end user and the long term investment value of the product. It depends on the local climate. It also depends on expected norms when the end user is not intimately involved with or knowledgeable of various design decisions and their implications. It also depends, of course, on the material itself.

For example, a house is expected (at least in theory) to last for 75 years or more with normal maintenance and replacement of various components (see Appendix B – Estimated Life-Expectancy of Building Materials and Products). But then again, what one person considers normal maintenance may be perceived differently by another. Durability is, therefore, an exercise in the management of expectations as well as an application of technology. For this reason, some builders and designers make significant efforts to inform their clients and trade contractors about reasonable expectations for the durability, performance, maintenance, and operation of a home. Some references to help in this matter include:

- *Caring For Your Home: A Guide to Maintaining Your Investment* (NAHB/Home Builder Press, 1998);
- *Your New Home and How to Take Care of It* (NAHB/Home Builder Press, 2001); and
- *A Builder's Guide to Marketable, Affordable, Durable, Entry-Level Homes to Last* (HUD, 1999).

2.3 Building Codes and Durability

Numerous requirements found in building codes imply a minimum level of durability performance or expectation. Building codes specify the minimum type and nature of various materials, including certain installation requirements that may vary according to local or regional climatic, geologic, or biologic conditions.

Despite the extensive framework of requirements found in building codes, there are still gaps in the details or in the reliability of the information for any specific application or local condition. In some instances, the requirements are clear, e.g., "a metal connector with minimum G60 galvanic coating shall be used" and in other cases the guidance is quite vague, e.g., "use corrosion resistant fasteners." Likewise, standardized durability tests for materials are rarely calibrated to performance in actual conditions of use.

Further, building codes and standards are often driven by various opinions and data or experiences expressed in the code development process. Sometimes the evidence is contradictory or incomplete. Nonetheless, it is legally required that a builder and designer adhere to code prescribed requirements related to durability and, when deemed appropriate, seek approval of alternate means and methods of design or construction that are at least equivalent to that required or implied by the locally approved building code.

The major U.S. model building codes currently available are listed in the sidebar to the right. However, the reader should be informed that earlier versions may be in use locally since these codes do not become law until they are legislatively adopted at the local level. In addition, these national model codes are often amended to address local issues and concerns.

2.4 Factors Influencing Durability

The manner in which materials and buildings degrade over time depends on their physical makeup, how they were installed, and the environmental conditions to which they are subjected. It is for this reason that environmental conditions, such as humidity and temperature, are carefully controlled in museums to mitigate the process of degradation. Even then, artifacts still require periodic care and maintenance.

Houses, depending on where they are located with respect to geology and climate, are more or less subjected to various types of durability "factors." Each of the "factors" listed below, which can be managed but not externally controlled, is addressed in this guide:

- Moisture
- Sunlight (UV radiation)
- Temperature
- Chemicals
- Insects
- Fungi
- Natural Hazards
- Wear and Tear

In essence, a house is part of an environmental cycle as depicted in Figure 2.1 and is subject to the same powerful forces of nature that create and then erode mountains, cause organic matter to decompose, and change the face of the earth.

Over the course of time, the greatest concerns (and impacts) regarding durability are those processes that occur constantly over the life of a home. Most notable of these factors is moisture. Moisture comes in many forms (i.e., rain, snow, ice, vapor) and is linked to

other durability factors. For instance, moisture must be present in sufficient quantity to promote corrosion (e.g., chemical degradation), insect habitation (e.g., subterranean termites), and rot (e.g., wood decomposition). By controlling exposure to moisture, many other durability problems are also solved. Other problems, such as mold and indoor air quality, are also related to moisture. It is for this reason that there is a major emphasis on moisture in this guide. In fact, the effects of moisture on building durability have been associated with enormous economic impact in the United States for wood construction alone.

The UV radiation from sunlight also has a tremendous impact on the exterior finishes of homes. For example, sunlight causes coatings to chalk-up or fade in color, plastics to degrade, wood to weather, and asphalt roof shingles to become brittle. Sunlight can also fade carpets, drapes, and furnishings inside homes. In relation to moisture, sunlight can heat surfaces and drive moisture into or out of materials and buildings; intermittent sunlight can also cause temperature cycling.

Temperature causes materials to expand and contract. Temperature cycling, particularly in the presence of water, can cause some materials to weaken or fatigue. Thermal expansion and contraction can also cause materials to buckle and warp and, therefore, become less effective in their intended function (e.g., buckling of improperly installed siding which may allow increased rain water penetration). When temperature cycles above and below the freezing temperature of water, even more damaging effects can occur to materials with high moisture content.

Chemical reactions, most often occurring in the presence of water, are responsible for a variety of durability problems and can dramatically accelerate otherwise normal rates of degradation. For example, a galvanic reaction between dissimilar metals can cause one metal to degrade relatively rapidly. This effect is evidenced by more rapid corrosion of galvanized fasteners in preservative-treated wood (i.e., chromated copper arsenate or CCA) relative to untreated wood. Another example is the pitting of copper piping due to the presence of certain salts and minerals in water or soil.

Certain *insects* are particularly fond of wood and, in fact, depend on wood for food. In the presence of wood-consuming insects such as termites and carpenter ants, an unprotected wood-frame home is nothing more than a free food source.

Natural hazards form a special class of durability concerns that are generally associated with localized climatic or geologic conditions. These conditions are generally considered from a life-safety perspective, but they are considered here in the broader sense of durability. For example, a life-safety provision in a building code may require that an extreme wind or earthquake event be considered in the structural design of a home. However, durability impacts may be realized in even moderate or mild natural events. Even a mild hurricane can cause significant water penetration and salt deposition resulting in immediate (e.g., flooding) and long-term (corrosion, mold growth) damage. Natural hazards that affect durability include hurricanes, earthquakes, floods, wildfires, hail, snow, thunderstorms, and tornadoes.

Wear and tear is simply the result of abrasion, physical damage, staining and other symptoms of continued use. Homeowner habits and lifestyles are particularly important for this durability factor.

In summary, all houses are under attack by a mighty and unstoppable foe, namely the forces of nature, along with kids, pets, and other "use conditions." Recognizing this issue is not intended to signal retreat or resignation, but rather to draw attention to the need for action.

Of course, actions must be practical in that the benefits of improved durability should be reasonably balanced with the costs and efforts of doing so. Appropriate actions to consider include selecting high quality material, using appropriate design detailing, following proper installation procedures, and performing judicious maintenance.

The concept of durability as a function of material quality is illustrated in Figure 2.2. Note the different levels of maintenance required to retain acceptable function of the three hypothetical materials in Figure 2.2. In many cases, however, installation quality may actually be more important than material quality. In other cases design decisions can have a profound effect on making poor quality materials or installations perform satisfactorily. Proper maintenance and repair are critical factors in some instances. Usually, all of these factors are important considerations.

TABLE 2.1 - TOP FIVE HOMEOWNER WARRANTY CLAIMS

Based on Frequency of Claim	Based on Cost of Claim
Gypsum wall board finish	Foundation wall
Foundation wall	Garage slab
Window/door/skylight	Ceramic tiles
Trim and moldings	Septic drain field
Window/door/skylight frames	Window/door/skylight & other

Source: *Defect Prevention Research Project for Part 9 Houses,* Ontario Home Warranty Program, Canada Mortgage Housing Corporation, Ottawa, Ontario, Canada, November 1994.

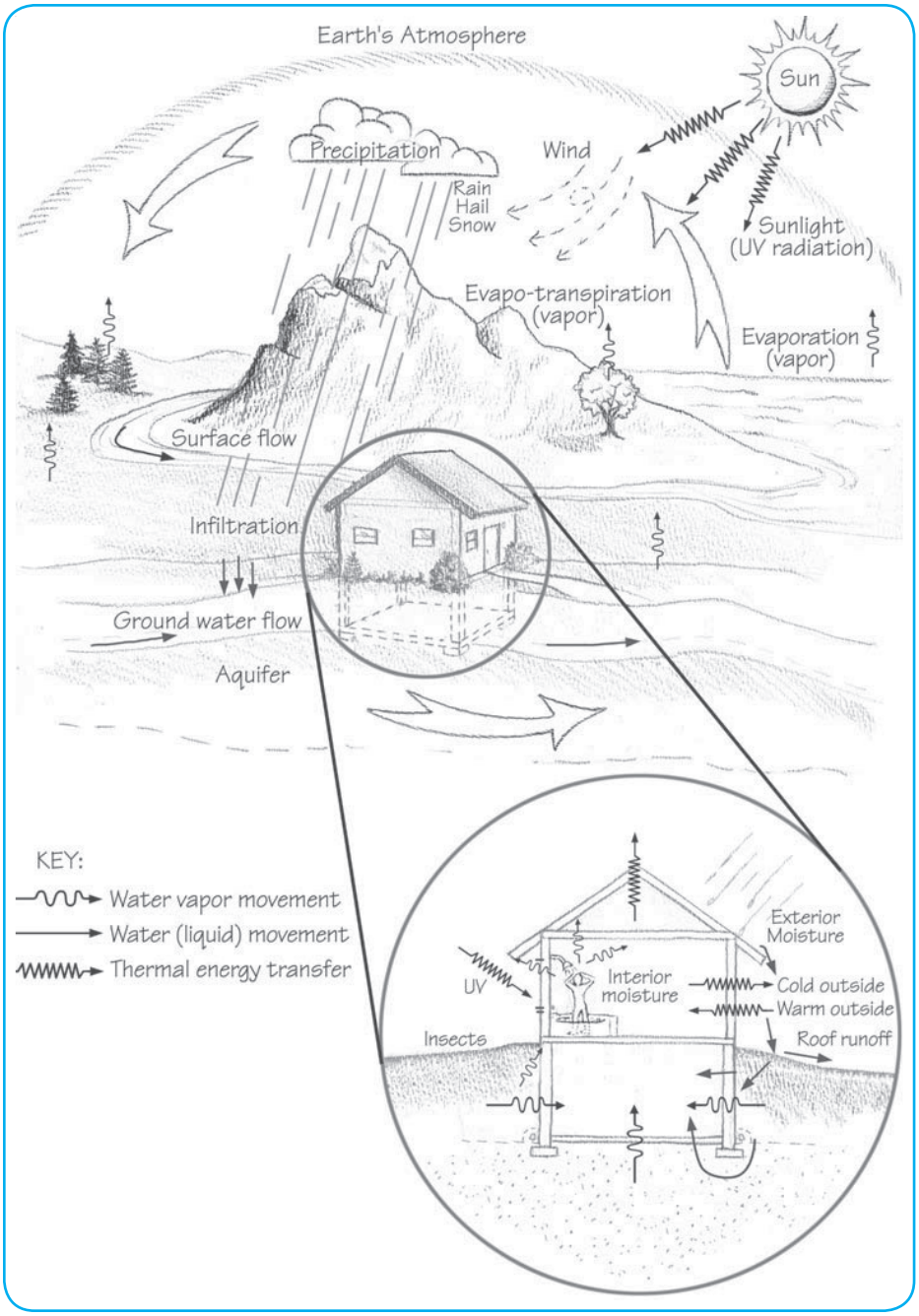


Figure 2.1 - The House and the "Duralogic Cycle"

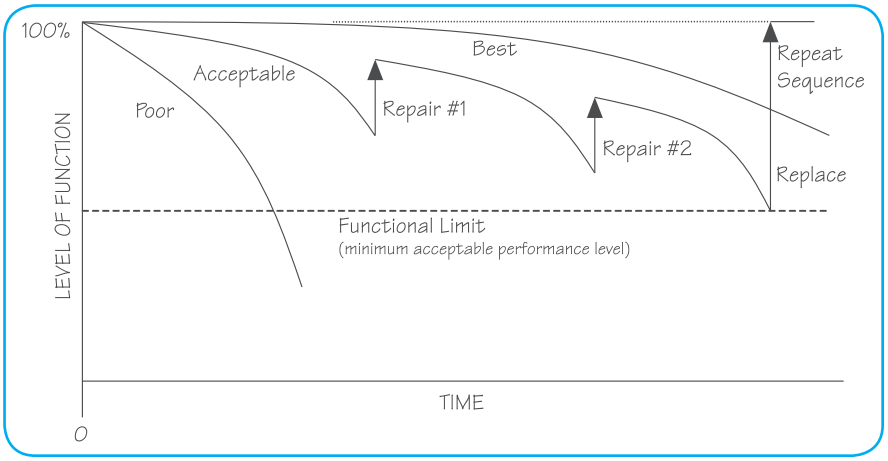


Figure 2.2 - Loss of Function vs. Time for Three Hypothetical Materials or Products of Different Quality Levels (poor, acceptable, and best)

Enough said on the concepts, theory, and philosophy of designing for durability. The next section reviews some of the most common durability or performance issues experienced in modern homes, many of which are addressed in the remaining parts of this guide.

2.5 Common Durability Issues

The type and frequency of durability related problems and general performance problems experienced in modern homes can be gathered from various information sources, such as trade organizations, industry surveys, warranty claims, popular literature, and others. These problems may be related to design, materials, methods, maintenance, or a combination of these factors. For this reason, this guide focuses primarily on design issues, but also has significant content on installation, materials selection, and maintenance topics as well.

The following summaries, including Tables 2.1 and 2.2, illustrate some commonly reported durability issues:

Problem Areas in New Construction

- Paints/Caulks/Finishes
- Flooring
- Windows and Skylights
- Doors
- Foundations and Basements
- Siding and Trim
- Structural Sheathing
- Wallboard
- Foundation Insulation and Waterproofing
- Framing

Source: Survey of builders conducted by NAHB Research Center, Upper Marlboro, MD, January 1992.

Most Frequent House Problems

- Improper Surface Grading/Drainage
- Improper Electrical Wiring
- Roof Damage
- Heating System
- Poor Overall Maintenance
- Structurally-Related Problems
- Plumbing
- Exteriors
- Poor Ventilation

Source: *ASHI NEWS Press Release,* American Society of Home Inspectors, Des Plaines, IL, 2000.

TABLE 2.2 - MAJOR EXPENDITURES FOR REPAIRS, MAINTENANCE, AND REPLACEMENTS TO OWNER OCCUPIED HOMES (1998)

Category	1998 Value ($ Millions)
Roofing	8,740
Painting and Papering	8,641
HVAC	5,872
Windows and Doors	5,769
Plumbing	3,368
Siding	1,853
Driveways and walkways	1,138
Flooring	826
Electrical	493
Others (including materials on hand)	10,814
TOTAL	47,514

Source: U.S. Department of Housing and Urban Development.

WHAT'S THE COST OF MAINTENANCE?

Most people don't consider long-term repair and maintenance costs as an issue in making a home purchase. However, a typical annual, out-of-pocket (i.e., not including do-it-yourself tasks) maintenance and repair expenditure is about $300 to $600. (Source: NAHB Housing Economics, Nov 1997. Based on data from 1995 American Housing Survey). This amount may actually reflect a tendency to defer maintenance. *Items like replacing appliances or HVAC equipment will create even greater costs as a house becomes older.*

Home Builder and Housing Consumer Product Problems

1. Foundations and basements—Leaks, construction cost is higher than the perceived value, difficult to insulate;
2. Paints, caulks, finishes—Caulk shrinkage, premature discoloration and fading, peeling and blistering, mildew growth, imperfections of surface, poor coverage;
3. Windows and skylights—Air and water leakage, glass fogs and frosts;
4. Doors—Warping, poor weather stripping, checking and splitting of panels, swelling;
5. Finish flooring—Seams visible, damages easily, inconsistent color, coming up at edges, poor adhesion;
6. Structural sheathing—Excessive swelling, delamination of sheets;
7. Roofing—Leaks, does not seal properly, wind damage, inconsistent coloration;
8. Siding and trim—Siding buckles, nails bleed, algae grows on it, paint peels, seams are noticeable, moisture induced swelling;
9. Wallboard, interior coverings—Nail pops, finish shows seams and/or nail heads;
10. Framing—Warped/twisted lumber, checking/splitting, too many large knots;
11. HVAC Equipment—Wrong sizing, insufficient warm air.

Source: *Product Failure Early Warning Program,* prepared for NAHB by the NAHB Research Center, Inc., Upper Marlboro, MD, 1996.

All of these summaries of housing durability issues point to the previously mentioned problem areas of installation and material quality, design, and proper maintenance. And while these performance problems are not necessarily related to any specific building product, it's worth mentioning that builders are generally averse to a certain class of products—those that are "too new." Major product and installation failures that have resulted in class action lawsuits in the United States have given builders and designers some reason to think twice about specifying new products. Past examples include:

- Exterior Insulated Finish Systems (EIFS);
- Fire-Retardant Treated (FRT) Plywood Roof Sheathing;
- Certain Composite Sidings and Roofing Products; and
- Polybutylene Water Piping.

It should be noted, however, that many of these problems have been resolved by subsequent product improvements. For example, EIFS systems are now almost exclusively used with a "drainage plane" system such that any moisture that enters the wall can escape without harm.

In other cases, products such as polybutylene piping have been entirely removed from the market. Although costly examples, these experiences demonstrate the risk and complexity in the development and application of new materials and methods of home construction.

From a recent pilot study[2] of homes of two different age groups (1970's and 1990's), some important trends and observations regarding durability of housing in one locality (Anne Arundel County, MD) have been identified:

1. The size of roof overhangs decreased between the 1970s and 1990s.
2. Use of vinyl siding and window frames have increased dramatically.
3. When present, signs of poor site grading (i.e., surface depressions next to house) were associated with an increased tendency for foundation cracks.
4. The occurence of wood rot (predominantly associated with exterior trim) in newer and older homes was 22 percent and 31 percent, respectively.
5. Masonry foundations tended to evidence cracks more frequently than concrete foundations.

CHAPTER 3 | GROUND AND SURFACE WATER

3.1 General

Nearly all building sites have some potential to experience problems with ground moisture, particularly when the water table is high or drainage is poor. Poor site drainage and difficult site conditions, such as "loose- soils or fills, can contribute to eventual building settlement, foundation wall cracking, and aggravated moisture problems. Years ago, it was generally much easier to select a suitable building location on a larger site or to seek alternate sites that provide better drainage and bearing support characteristics. However, such a luxury is not easily afforded in today's market. Thus, this section gives recommendations that recognize the need to be resourceful with the land that is available.

The objective of a foundation is to separate the building materials and the indoor environment from the earth while also providing adequate structural support. The following rules of thumb and recommended practices of Section 3.2 should serve to minimize the potential for durability and performance problems related to foundations (refer to Section 2.5, Common Durability Issues).

[2] *Assessing Housing Durability: A Pilot Study*, U.S. Department of Housing and Urban Development, Washington, D.C., November 2001

3.2 Recommended Practices

3.2.1 Recommendation #1: Preliminary Site Investigation

The following actions may help to identify potential site problems that can be accounted for in planning and design. An illustration of a typical bore-hole used to explore subsurface conditions is shown in Figure 3.1.

- Survey the surface conditions and local plant species for signs of seasonal or constant high ground water levels.
- Consider the lay of the land and surface water flow onto and off of the site to ensure that proper surface water drainage can be achieved around the building site.
- Check soil maps from USDA's Natural Resources Conservation Service or use a hand auger to bore one or more test holes at the proposed building location; and determine general soil type/characteristics and ascertain the water table level (be sure to factor in any seasonal or recent climate conditions such as the amount of precipitation over the previous month or so) (see Figure 3.1). At least one hole should be at the building location and extend at least a couple of feet below the proposed footing elevation. If deeper subsurface problems are expected (as by local experience), then a geotechnical engineer may need to use special drilling equipment to explore deeper below grade to ensure that adequate support and stability exists.
- If possible, test the soil for bearing capacity at the depth and location of proposed footings. A simple hand-held penetrometer (e.g., a standardized metal rod and drop weight) used in accordance with the manufacturer's instructions serves this purpose.

RULES OF THUMB

- Most damp foundations are caused by improper surface drainage.
- Wet site—"waterproof" basement walls per code and use a sump pump; damp/dry site—"moistureproof" basement walls.
- Do not build below-ground space below highest seasonal water table level.
- Using only typical construction practices, as many as 1 out of 3 basements experience some form of water problem within the first two years.
- When in doubt, seek advice from a qualified geotechnical engineer.
- Moisture entering a house through the foundation will contribute to potential moisture problems in the above-ground portions of the building, even the attic through added water vapor loading.

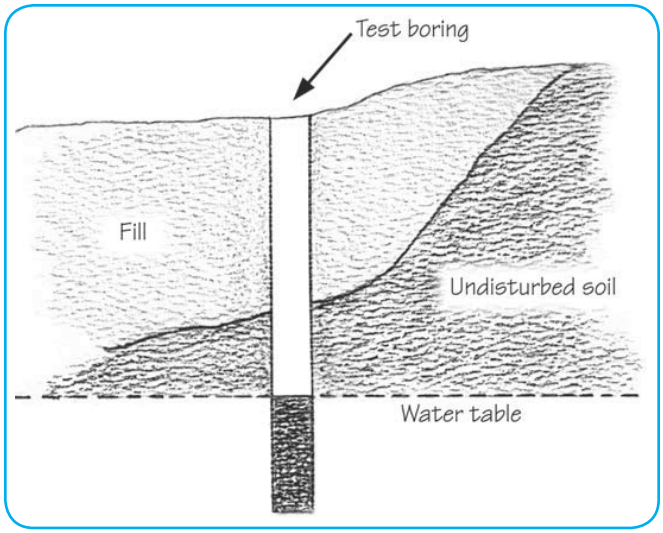


Figure 3.1 - Bore Hole Used for Preliminary Site Investigation

- If fill or questionable soil conditions are suspected (as on a steep slope), the services of a design professional and knowledgeable foundation contractor may be needed to appropriately prepare the site (e.g., compaction) or design a suitable foundation system.
- Do not use basement foundations on sites with high ground water table.
- Avoid silt, heavy clay, or expansive clay backfill, particularly for basement walls. Granular soils are preferable.
- Use minimum 3,000 psi concrete in slabs and foundation walls with welded wire fabric in slabs and light reinforcement (#3 rebar) in foundation walls to control cracking, improve concrete resistance to moisture and weathering, and improve concrete finishing.

3.2.2 Recommendation #2: Site Grading and Surface Water Drainage

Site grading plans should consider the existing natural water flow and change the water flow to direct water away from the building foundation, particularly if the building is located down-slope from a hill or similar land formation that may produce significant rainfall runoff. Use of grassy swales is a common and cost-effective practice when the potential water volume is not large, wetting is not constant, and the swale is not sloped steeply enough to produce high water velocities (see Figure 3.2). The range of acceptable swale slope depends on many factors, but slope should not be less than about 1% to prevent ponding, nor more than about 15% unless rip-rap (4 to 8 inch stone) is used to line the swale with a filter cloth underlay. The grading immediately adjacent to the building should be sloped a minimum of about 4% (or 1/2 inch in 12 inches) for at least 6 feet outward from a building foundation or as far as practical. If concrete flatwork (i.e., patio slabs, driveways, and walks) are adjacent to the building, they should be sloped not less than 2% (about 1/4 inch

in 12 inches) away from the building. Backfill should be tamped firmly to prevent excessive settlement or the grade should be adjusted to allow for future backfill settlement. In addition, gutters and gutter drains should be used to further remove roof run-off from the foundation area (See Section 4.2.2).

3.2.3 Recommendation #3: Foundation Construction

Foundation options generally include basement, slab-on-grade, crawl space, or a mix of these foundation types (e.g., split level construction). One thing is common in all foundation construction: ground moisture will find its way "in" unless appropriate measures are taken. An important measure to include is a ground vapor barrier under all basement, slab-on-grade, or crawl space construction. This will eliminate (or suitably minimize) a large potential water vapor source to a house that can result in or aggravate above-ground moisture vapor problems (see Chapter 4). The ground vapor barrier should be placed directly below and immediately prior to pouring the concrete slab to avoid damage during construction. Second, some method of removing ground water from around the foundation is recommended in all but the driest and most well-drained site conditions.

Typical basement construction practice and optional enhancements (i.e., polyethylene sheeting) for particularly wet sites are illustrated in Figure 3.3. However, "water proofing" is not meant to resist water from flooding or a high water table. It should be noted that concrete has a considerably lower vapor permeability (i.e., can stop water vapor better) than masonry. However, available data seems to suggest no significant difference between concrete and masonry relative to the potential for basement water problems in actual practice.

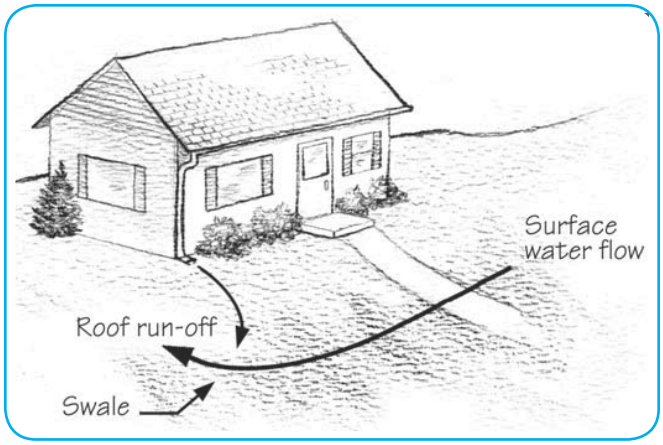


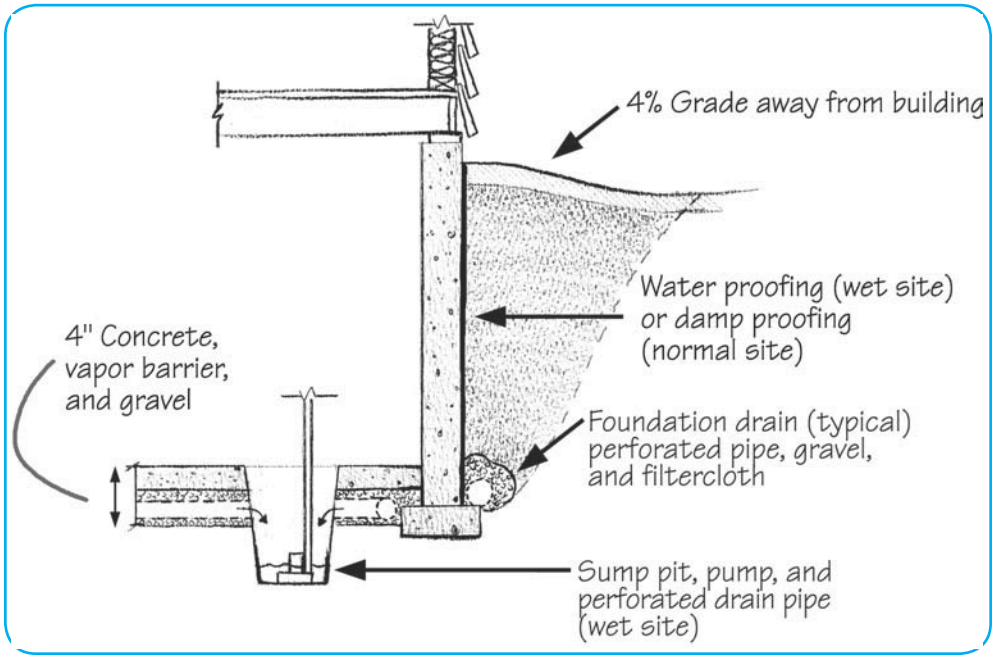
Figure 3.2 - Site Grading and Surface Drainage

For slab-on-grade and crawlspace foundations, moisture protection usually involves placing the building on a slight "mound" relative to the surrounding site. The use of a gravel layer under the slab or on the crawlspace floor is considered optional for mounded foundations, however, a vapor barrier should always be used. If the site is properly graded, a perimeter drain system is unnecessary in mounded foundation systems.

3.2.4 Recommendation #4: Frost Protection

Foundations are conventionally protected from frost (i.e., heave), by placing footings below a locally prescribed frost depth. An alternative in northern climates is the Frost Protected Shallow Foundation technology which offers the benefits of frost protection, energy efficiency, warmer slab edge temperatures (reduced condensation potential and improved comfort), and material savings. This technology uses the heat generated within a building

Figure 3.3 - Basement Construction and Optional Enhancements for Wet Site Conditions



and stored in the ground to raise the frost depth around the structure, allowing for reduced-depth footings. A typical frost protected shallow foundation detail is shown in Figure 3.4. The technology and concept can be used to protect a variety of foundation types and site structures from frost heave. Refer to *Design Guide for Frost-Protected Shallow Foundations* (NAHB Research Center, 1996) for additional design and construction guidance.

It should be noted that current building codes prohibit the use of foundation insulation in areas with "heavy" termite infestation probability (i.e., southeastern United States). The foam can create a "hidden pathway" for termite access to wood building materials. Refer to Chapter 6 for methods to deter termite infestation.

CHAPTER 4 | RAIN AND WATER VAPOR

4.1 General

The most common and disastrous durability problems are frequently related to bulk moisture or rain penetrating a building's exterior envelope without any opportunity to drain or dry out rapidly. If rain penetration occurs repetitively and continues undetected or uncorrected, it can cause wood framing to rot, mold to grow, and steel to corrode. In fact, particularly bad cases of this type of problem have resulted in severely rotted wood frame homes within the period of a couple of years. However, most rain penetration problems can be isolated to inadequate detailing around windows and door openings and similar penetrations through the building envelope.

The objective of designing a weather barrier system is pure and simple—keep rain water away from vulnerable structural materials and interior finishes. Keeping these components dry will maintain a building's structural integrity and help prevent moisture-related problems like mold. Within this guide, "weather barrier" is a general term for a combination of materials used as a system that protects the building from external sources of moisture.

Important related issues are water vapor diffusion and drying potential. These issues are considered in tandem since they are practically inseparable design issues, creating the need to have an integrated design approach (i.e., one that adequately considers all factors and their potential impact on durability).

Some of the information presented in this chapter is generic in nature and will apply to most house designs (e.g., overhangs), while other recommendations are geared more towards specific configurations like vinyl or wood siding installed over wood sheathing. The Rules of Thumb listed in the sidebar to the right and the recommendations in this chapter should help to address the durability and performance issues related to liquid moisture (rain), perhaps the most significant durability factor.

4.2 Recommended Practices

Building walls are subject to water penetration and repeated wetting depending on their exposure, the climate, and the integrity of the siding system. While you can't change the climate in which you build, it is possible to improve the shielding of walls and to design walls that are appropriate for "imperfect" (i.e., leaky) siding systems.

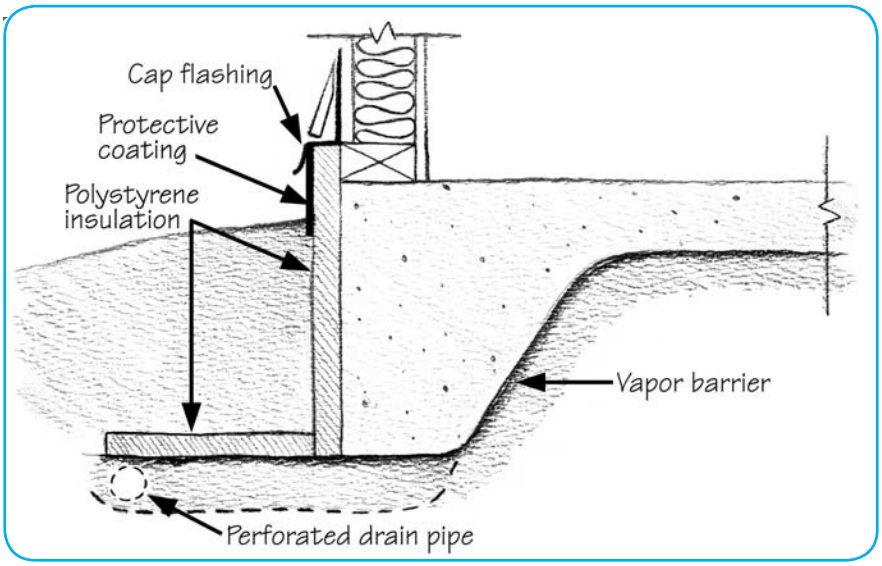


Figure 3.4 - Typical Frost-Protected Shallow Foundation with Perimeter Drain

4.2.1 Recommendation #1: Roof Overhangs

Figure 4.1 illustrates the frequency of building walls having moisture penetration problems in a particularly moist, cool climate (British Columbia) as a function of roof overhang length. The shielding effect of roof overhangs is illustrated in Figure 4.2. Note that a roof overhang's impact will depend on the climate (Figure 4.3) and type of construction protected. The potential for wind-driven rain should also be considered. The climate index map of Figure 4.3 does not directly account for wind-driven rain, a condition that varies with local climate or site exposure. Some important considerations regarding roof overhangs include:

- Roof overhangs protect exterior walls and foundations from excessive wetting by rain water—the culprit in many moisture problems in residential buildings.
- Just as the safety factor is important to providing for a reasonable structural design that accounts for foreseen events and unexpected extremes, so is the roof overhang to those interested in durable wood-frame building construction.
- The width of roof overhang to use depends on a variety of factors, including construction cost, wall type below, amount of windows and doors exposed, and the height of the wall. Recommended overhang widths are provided in Table 4.1 for typical conditions.

RULES OF THUMB

- Liquid *water or rain obeys the following rules with respect to movement:*
  - Gravity—*water runs downhill*
  - Capillary—*water is attracted into small cracks due to capillary action or surface tension*
  - Wind—*wind can drive rain into places it would not otherwise go and create building interior and exterior pressure differentials that move it uphill, breaking the first rule (gravity)*
- NO wall or roof covering is perfectly waterproof, especially considering that there will be wall openings, roof penetrations, and other materials that compromise even the "waterproof" materials—particularly in view of the effects of time.
- Avoid depending on caulk as a primary barrier to moisture penetration (i.e., use flashing).

- Greater flexibility in architectural design with respect to the use (or non-use) of overhangs for rain water protection is afforded in more arid climate conditions; in other areas there are significant durability trade-offs (see Figure 4.1).
- In moist climates with significant rainfall, liberal use of overhangs is recommended.

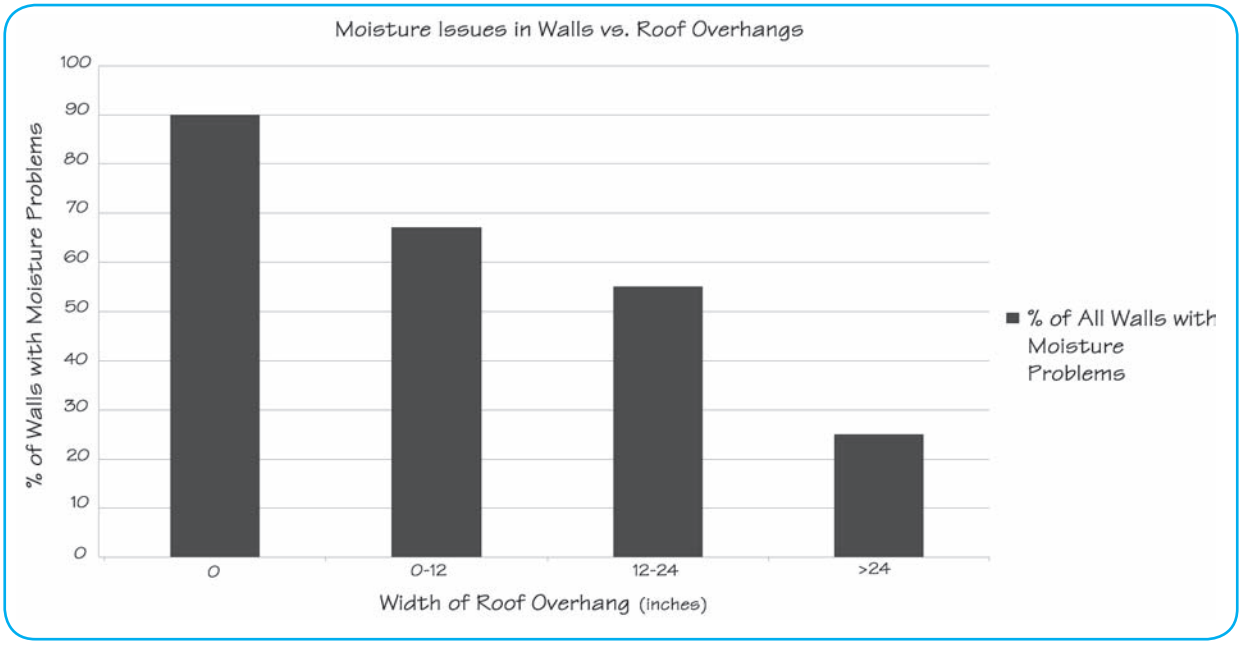


Figure 4.1 - Frequency of Moisture Problems in Walls of Selected Buildings in a Moist, Cool Climate
(Climate Index of approximately 70 based on Figure 4.3)

Source: Morrison Hershfield Limited, *Survey of Building Envelope Failures in the Coastal Climate of British Columbia,* Canada Mortgage and Housing Corporation, Burnaby, BC, Canada, 1996. Figure is based on a selection of 46 buildings of up to eight years old, three to four stories, wood-frame, with various wall claddings. Fifty percent of walls with problems used direct-applied stucco cladding over building paper and oriented strand board (OSB) wood panels.

- Roof overhangs also provide durability and energy benefits in terms of solar radiation (see Section 5.2).

In Table 4.1, the recommended overhang widths are given with the assumptions that: all walls have a properly constructed weather barrier, roofs are adequately guttered, and normal maintenance of exterior will occur. For overhangs protecting more than two-story walls with exposed windows and doors, larger overhangs should be considered. Rake (gable end) overhangs also deserve special consideration because more costly "outrigger" framing methods will be required for overhangs exceeding about 12 inches in width and the appearance may not be acceptable to some home buyers. Also, for sites subject to frequent wind-driven rain, larger overhangs and drainage plane techniques that include an air space behind the siding should be considered (see Section 4.2.3). For non decay-resistant wood sidings and trim (as for windows and door casings), greater overhangs and porch roofs are recommended.

4.2.2 Recommendation #2: Roof Gutters and Down-spouts

Properly designed roof gutters reduce the amount and frequency of roof run-off water that wets above-grade walls or the foundation. A list of recommendations and a rule-of-thumb design approach are presented below to help in the proper use of gutters. Figure 4.4 illustrates a typical gutter installation and components.

TABLE 4.1 - RECOMMENDED MINIMUM ROOF OVERHANG WIDTHS FOR ONE-AND TWO-STORY WOOD FRAME BUILDINGS[1]

Climate Index (Figure 4.3)	Eave Overhang (Inches)	Rake Overhang (Inches)
Less than 20	N/A	N/A
21 to 40	12	12
41 to 70	18	12
More than 70	24 or more	12 or more

Source: Modification of *Prevention and Control of Decay in Homes* by Arthur F. Verrall and Terry L. Amburgey, prepared for the U.S. Department of Agriculture and U.S. Department of Housing and Urban Development, Washington, DC, 1978.

1 Table based on typical 2-story home with vinyl or similar lap siding. Larger overhangs should be considered for taller buildings or wall systems susceptible to water penetration and rot.

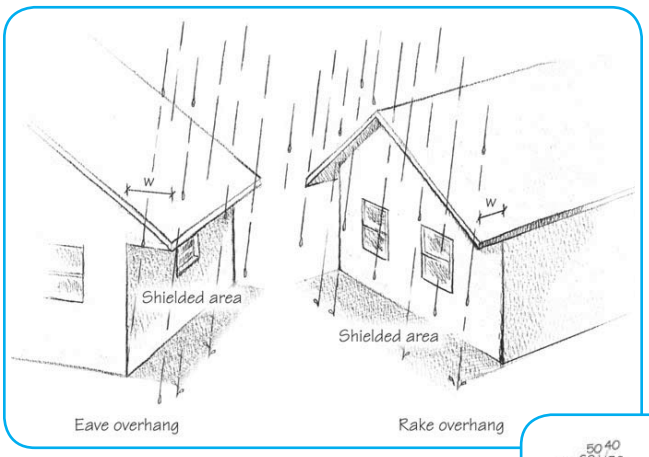


Figure 4.2 - Roof Overhangs

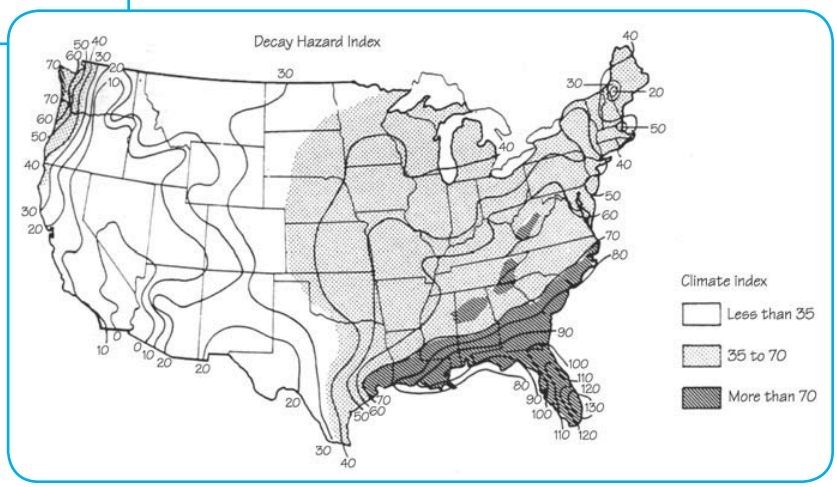


Figure 4.3 - Climate Index Map Based on Wood Decay Potential

Prepared by the U.S. Weather Bureau.

Source: Theodore C. Scheffer, "A climate index for estimating potential for decay in wood structures above ground," *Forest Products Journal,* Vol. 21, No. 13, October 1971.

Site specific indices may be determined using the following formula, where T is the monthly mean temperature (°F), D is the mean number of days in the month with 0.01 inch or more of precipitation, and Σ is the summation of products (T-35)(D-3) for respective months of the year.

$$\text{Climate Index} = \frac{\sum_{Jan.}^{Dec.} \left[(T - 35)(D - 3)\right]}{30}$$

NOTE: Roof overhangs also provide protection from sunlight; refer to Chapter 5 for advice on using overhangs to minimize the impact of UV radiation. Roof overhangs in hurricane-prone locales may require additional anchorage of the roof.

- Downspouts that discharge to the surface should do so at least two feet outward from the building. Splash blocks or plastic corrugated pipe are recommended to prevent erosion and to give further extension of discharge water away from the foundation, particularly for downspouts located at inside corners of buildings.
- Downspouts that discharge water below grade should do so into non-perforated corrugated or smooth plastic pipe. The pipe should be run underground to a suitable outfall. Do not connect the gutter drain pipe to the perforated foundation drain pipe, this practice will soak the foundation.
- Gutters and downspouts should be resistant to corrosion and abrasion from flowing water; material choices include aluminum (most popular), vinyl or plastic, copper, and coated metal (baked enamel or galvanized).
- Use a gutter splash shield at inside corners (i.e., valleys) where fast moving water in a roof valley may "overshoot" the gutter.
- Gutters, downspouts, and splash blocks must be cleaned and properly maintained by the homeowner.

Sizing of Gutters and Downspouts

Generally, a standard 5-inch deep gutter and 2-inch by 3-inch downspouts are adequate for most homes in most climate conditions in the United States. However, the following simplified sizing method may help to avoid problems when unique situations are encountered. An example is provided on page 21.

Step 1: Determine the horizontal projected roof area to be served by the gutter and multiply by the roof pitch factor from Table 4.2.

Step 2: Estimate the design rainfall intensity (see map in Figure 4.5).

Step 3: Divide selected gutter capacity (Table 4.3) by the rainfall intensity estimated in Step 2 to determine the maximum roof area served.

Step 4: Size downspouts and space along gutter in accordance with factored roof area calculated in Step 1 for the selected gutter size and type. As a rule of thumb, one square inch of down-spout cross section can serve 100 square feet of roof area (i.e., 2"x3" downspout for 600 ft^2; 3"x4" downspout for 1,200 ft^2).

(***Source:*** "All About Gutters" by Andy Engel, *Fine Homebuilding*, August/September 1999).

TABLE 4.2 - ROOF PITCH FACTORS

Roof Pitch	Factor
Flat to 3:12	1
4:12 to 5:12	1.05
6:12 to 8:12	1.1
9:12 to 11:12	1.2
12:12	1.3

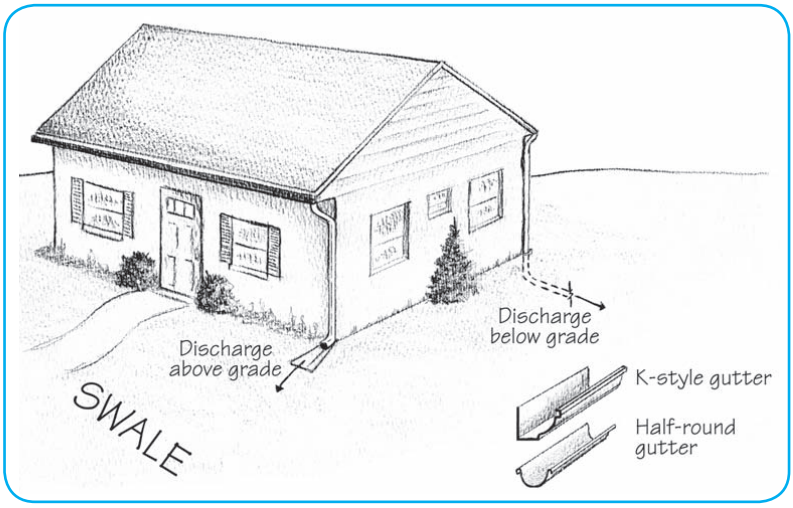


Figure 4.4 - Roof Gutters and Discharge Methods

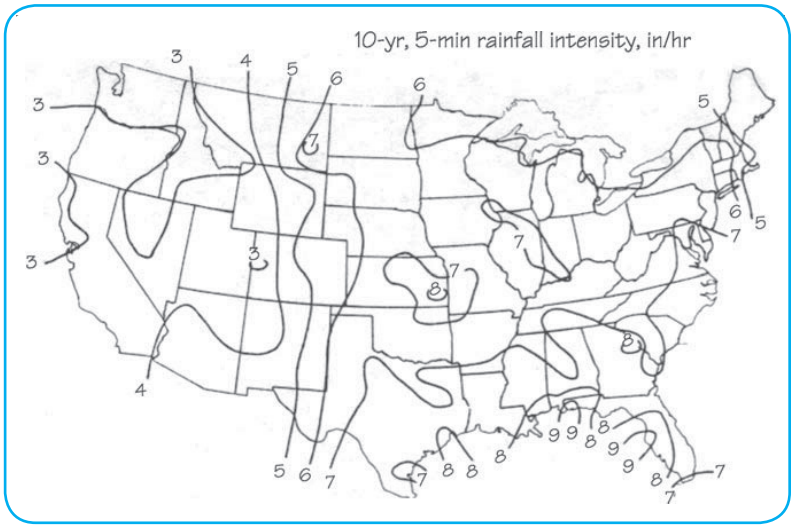


Figure 4.5 - Rainfall Intensity Map of the United States

TABLE 4.3 - GUTTER CAPACITY (ROOF AREA SERVED IN SQUARE FEET) BASED ON 1 IN/HR RAINFALL INTENSITY[1]

Gutter Shape	Gutter Size	
	5-inch depth	6-inch depth
K-style	5,520 ft^2	7,960 ft^2
Half-round	2,500 ft^2	3,840 ft^2

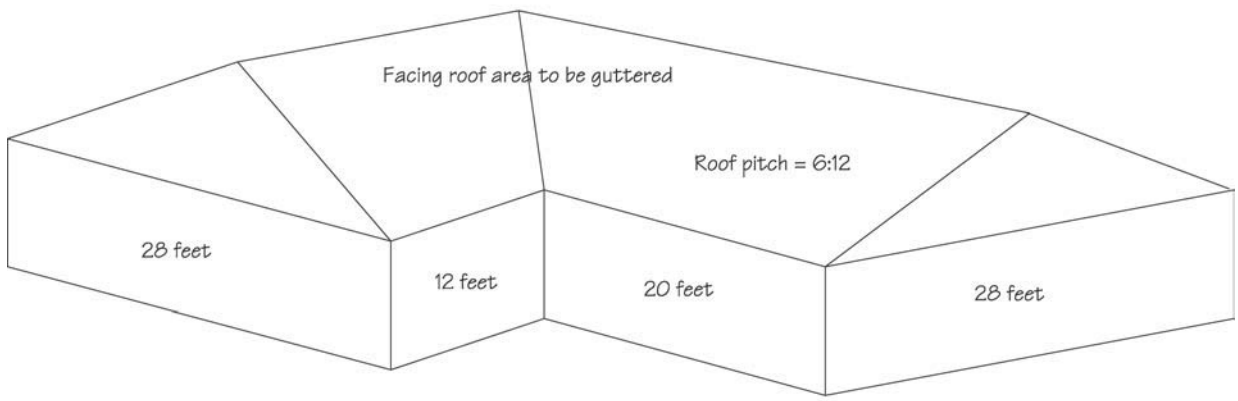
Note:

1 Values based on a nearly level gutter. Increasing gutter to a slope of 1/16 inch per foot, multiply values by 1.1 or by 1.3 for 1/8 inch per foot slope.

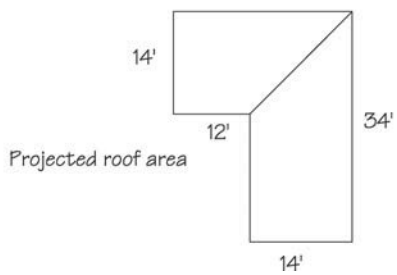
DRAINAGE, VAPOR, AND AIR

Drainage planes do just what their name implies—they drain away liquid water that gets past siding or exterior cladding. But that's not all they do. Drainage planes made from building paper or housewrap can affect how water vapor passes (or tries to pass) through a wall. Table 4.4 gives recommendations on this. Drainage planes like housewrap may also serve as air barriers, a boundary around the house that reduces air infiltration. Even if housewrap is only used as an air barrier to cut down air infiltration, it's crucial to understand that it will also collect and channel liquid water that gets past the wall's cladding—like it or not. Housewrap Recommendations (page 26) gives guidance on this issue.

GUTTER DESIGN EXAMPLE



Building site is in Savanna, GA



Step 1

Horizontal projected roof area = (14" x 12") + (14" x 34") = 644 ft^2

Factored area = (1.1)(644 ft^2) = 708 ft^2

Step 2

From fainfall intensity map, Figure 4.5, the estimated rainfall intensity is 7 in/hr.

Step 3

Select a K-style gutter with a 5-inch-depth and a 5,520 ft^2 in/hr rating from Table 4.3.

*Divide by rainfall intensity as follows: (5.520 ft^2 * in/hr) / (7 in/hr) = 788 ft^2 > 708 ft^2 OK*

Therefore, the gutter is capable of serving this area.

Step 4

A single 2" x 3" downspout is not large enough (i.e., 600 ft^2 < 708 ft^2). Therefore, use one 3" x 4" downspout (at one of the outside corners) or two 2" x 3" downspouts (one at each outside corner). Be sure the gutter is sloped evenly from near its midpoint toward each downspout so that a nearly equal roof area is served by each.

4.2.3 Recommendation #3: Weather Barrier Construction

Weather barrier is a broad term for a combination of materials including siding, roofing, flashing, sheathing, finishes, drainage plane, and vapor retarders that, as a system, exhibit water retarding and vapor retarding characteristics and may also possess thermal insulation and air infiltration barrier characteristics.

Drainage Planes

The primary goal in protecting a building wall is to shield the wall from bulk moisture through the use of overhangs, gutters, siding, and opening protection (i.e., flashing or overhangs). As a second line of defense, a drainage plane provides a way out to drain any moisture that penetrates the wall's primary line of defenses (i.e., rain water that gets behind cladding). In less severe climates (low climate index—see Figure 4.3) or when a wall is otherwise protected from rain, the use of a specially detailed barrier may have little durability benefit. However, for wall systems that are not extremely well-protected from bulk moisture, that are in wind-driven rain climates, or that are sensitive to wetting, the use of a secondary drainage plane should be employed.

Figure 4.6 shows a typical wall system with siding. It's safe to assume that all types of wall coverings (siding, brick, masonry) are imperfect and will leak at some point—some more than others. Therefore, it is important to consider the use of a drainage plane behind the siding material. In some climates, like arid regions with infrequent rain events, a drainage plane may be unnecessary or of very little use. Rain water that does penetrate wood-framed wall systems in these regions can take advantage of wood's capacity to temporarily store moisture, and the wall can dry out via air movement and vapor diffusion once arid outdoor conditions resume (see below for more about Drying Potential).

It may be advisable to use an air space between siding and a drainage plane if:

- A house is in a particularly severe climate (frequent rainfall or wind-driven rain) such as coastal regions subject to hurricanes; and
- Moisture-sensitive siding materials (e.g., wood) are used.

This air space (e.g., use of furring in Figure 4.6), in conjunction with vents (and general air leaks) that allow air to move behind the exterior siding or cladding, provides pressure equalization and creates a capillary break between the back of the siding and the drainage plane. These features will help to reduce the amount of rain water that penetrates behind the exterior cladding and promote better drying potential for the siding and the inner wall. However, creating this space using furring strips applied on top of the drainage plane material must account for the effect on details for flashing and finishing around wall openings such as windows and doors.

Depending on the wall design approach and the climate, a drainage plane needs to exhibit certain characteristics for allowing or retarding the transmission of water vapor, while still rejecting the passage of liquid water like rain. Table 4.4 provides guidance in selecting appropriate wall drainage plane characteristics for various climates. The table considers both how well certain materials reject *liquid* water and how readily they allow water *vapor* to pass through

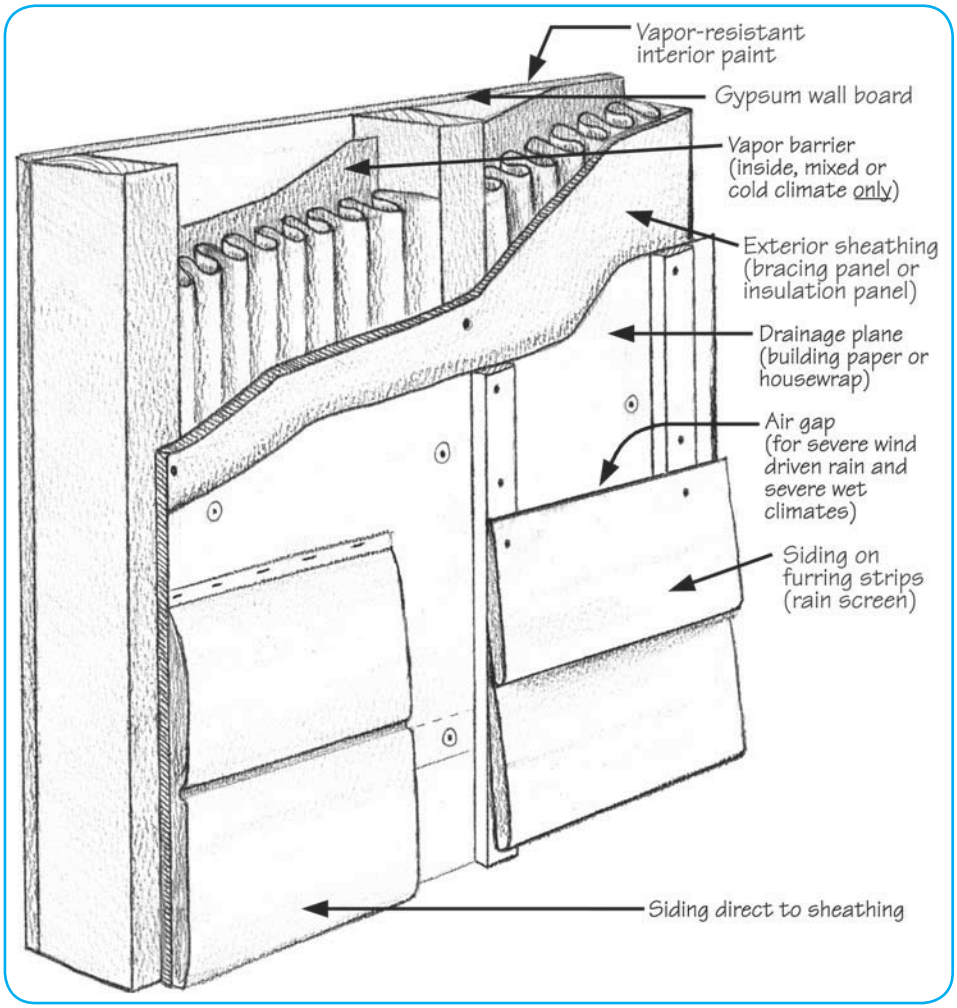


Figure 4.6 - Weather Barrier Construction

them. This is an important issue that affects the drying potential of walls.

The properties of materials that can be used for drainage planes are found in Table 4.5. In all applications, any material used as a drainage plane should have high resistance to liquid water penetration.

Vapor Retarders

While it's obvious that the drainage plane of a wall must be located on the outer face of a wall or just behind the siding, it is just as important to remember one rule of thumb related to moisture vapor transport in walls. Namely, any vapor retarder must be located on the warm-in-winter side of the wall (i.e., inside) in all climates except hot/humid climate where it should be placed on the warm-in-summer side of the wall (i.e., outside) if one is used at all.

Water vapor in the air is transported by vapor diffusion and bulk air movement. Vapor retarders are intended to restrict the transmission of water vapor via diffusion. A common application of a vapor retarder would be the use of a polyethylene sheet or kraft paper between drywall and framing of exterior walls in cold climates. However, bulk air movement (i.e., air leakage containing water vapor) is far more significant in terms of the amount of water vapor that can be transmitted, moving roughly 10 to 100 times more moisture than diffusion. This being said, the vapor retarder can still play an important role in controlling the movement of water vapor in walls, particularly in very cold climates.

TABLE 4.4 - RECOMMENDED DRAINAGE PLANE CHARACTERISTICS FOR EXTERIOR WALLS IN VARIOUS CLIMATE CONDITIONS

Climate Condition[1]	Drainage Plane Characteristic		Recommended Product Type
	Liquid Water Resistance	Water Vapor Permeability (low = little vapor passes; high = vapor passes easily)	
Hot & Humid Climate Index >70 HDD < 2,500	High	Moderate to Low[2]	15# tarred felt
Mixed High Climate Index >20 2,500 < HDD < 6,000	High	High to Moderate	15# tarred felt or housewrap
Cold HDD > 6,000	High	High[3]	15# tarred felt or housewrap
Dry Climate Index < 20	N/A	N/A[4]	optional

Notes:

1 HDD refers to Heating Degree Days relative to 65°F (see Figure 4.7). See Figure 4.3 for Climate Index.

2 HOT/HUMID CLIMATE CONCERNS: The drying potential of hot/humid climates is through the interior wall, and the layer of lowest vapor permeability (i.e., vapor retarder) must be located to the outside of the wall. If a drainage plane material is used with a low permeability (i.e., polyethylene sheet or foam panel insulation) then it is imperative that a high permeability is achieved on the inside face of the wall (which may affect interior finish selection such as paint type and limit use of materials such as wall paper—see Table 4.5 below). In addition, it becomes more important in hot/humid climates to carefully size HVAC systems so that they operate without "short cycling." Again, moisture entry to the building and condensation potential can be significantly reduced by use of a foundation/ground vapor barrier (Chapter 3).

3 COLD CLIMATE ALTERNATIVES AND CONCERNS: In this case, energy efficiency can be a conflicting objective to the table's recommendation. For instance, interest in energy efficiency (or code mandated minimum R-values) often leads builders in cold climates to place an impervious layer of insulation (i.e., polystyrene or foil-faced polyisocyanurate) on the outer surface of the wall. These materials generally have a low permeability to water vapor (see Table 4.5). Since vapor barriers are often required on interior (warm-in-winter side) of walls in cold climates, this can create a situation where a wall has low drying potential. Therefore, this approach should be used with caution in areas that are cold but are also subject to substantial rainfall which may penetrate an improperly installed weather barrier or one that fails to maintain its resistance to liquid water penetration over time. In addition, it becomes critical to seal key leakage areas judiciously to prevent leakage of moist, warm indoor air into the wall cavity where it may condense. Condensation in the wall cavity can also be prevented by controlling indoor air humidity. At a minimum, interior moisture sources should be addressed by using bathroom and kitchen exhaust fans to remove the significant moisture that is produced in these areas of the building. Finally, moisture entering the building/walls from the ground should be minimized by the use of foundation and ground vapor barriers (see Chapter 3).

4 No drainage plane is required for durability purposes in a dry climate, although care should be taken to seal major air-leakage points for sake of keeping infiltration air out of wall assemblies.

Table 4.6 provides guidance on appropriate locations and characteristics of vapor retarders for various climates. When using a vapor retarder, it must be installed on the correct side of the wall or ceiling. Otherwise, condensation will form and cause sudden or eventual damage. Also, some older codes established minimum perm ratios for the inner and outer faces of a wall (e.g., a minimum outer face to inner face perm ratio of 5:1 in cold climates to facilitate drying to the outside). Design rules like this one point out that many materials can and will affect vapor diffusion even if they are not classified as vapor retarders. This point, and the fact that air movement can also move large amounts of water vapor, are equally important to designing a wall to handle water vapor.

PLUG UP THE LEAKS

In all cases, major air leakage points through the building envelope should be sealed to limit the flow of air, heat, and moisture. Places to air seal include areas around door and window frames, attic hatches, kneewalls, HVAC chases, and electrical and plumbing penetrations into attics.

Building Paper vs. Housewrap

The question "should I use building paper or housewrap" is often asked. And for certain climates in Table 4.4, the question remains. This leads to a discussion of the two product categories and their relative performance characteristics.

TABLE 4.5 - DRAINAGE PLANE AND VAPOR RETARDER MATERIAL PROPERTIES[1,2]

Material	Weight or Thickness	Permeance, Perms[3] *(vapor retarder = 1 perm or less)*			Liquid Water Loss[5]
		Dry-cup Method	Wet-cup Method	Other	
15# asphalt felt	14 lb/100 sf	1.0	5.6	—	30%
15# tar felt	14 lb/100 sf	4.0	18.2[4]	—	—
Building wraps (6 brands)	—	5.0 - 200.0	5.0 - 200.0	—	0 to 80%
Blanket Insul., asphalt coated paper	6.2 lb/100 sf	0.4	0.6 - 4.2	—	—
6 mil polyethylene	0.006 in	0.06	—	—	—
Aluminum foil	0.001 in	0.0	—	—	—
Gypsum board	3/8 in	—	50.0	—	—
Plywood (interior glue)	1/4 in	—	1.9	—	—
Block	8 in	—	2.4	—	—
Brick	4 in	—	0.8	—	—
Concrete	4 in	—	0.8	—	—
Polystyrene, expanded board	1 in	2.0 - 5.8		—	—
Polystyrene, extruded board	1 in	1.2		—	—
Vapor retarder paint	0.0031 in	—	0.5	—	—
Primer sealer paint	0.0012 in	—	6.3	—	—
Exterior acrylic house and trim paint	0.0017 in	—	5.5	—	—

Notes:

1 These values only relate to performance in standardized and constant test conditions and do not necessarily represent actual behavior under actual conditions of use. Leakage as a result of discontinuities and other conditions experienced in construction of buildings may easily alter, by a factor of 2 or more, the overall or localized performance of a vapor retarder in comparison of these standardized values. Therefore, these values can be used for indexing purposes only.

2 Differences in perm ratings between dry-cup, wet-cup, and other test methods are substantial and any cross comparison should be made on the bases of similar test methods and conditions. Manufacturer data should be consulted when available.

3 Usually tested according to ASTM E 96.

4 Value can vary to more than 60 perm in 95% relative humidity test conditions.

5 Tested using AATCC 127 test method modified to a 3.5 inch head for 2-hour duration (University of Massachusetts, Building Materials and Wood Technology, Paul Fisette, as reported on www.umass.edu/bmatwt/weather_barriers.html, October 1999).

6 Of six brands tested, R-Wrap and Tyvek received the best possible rating of 0 water loss (liquid water transmission). However, when these products were subjected to soapy water and a cedar extractives water solution, the loss rates increased slightly.

Any discussion of this sort should be prefaced by recognizing that *neither* product will work effectively if not installed correctly—and could even do serious harm to a building's durability if used incorrectly.

Housewrap products are sometimes viewed solely as air barriers—a product that will reduce air infiltration and do nothing else. Wrong. As discussed in Table 4.4, housewrap products also block liquid water that gets past siding, making this type of product useful for a drainage plane.

And in fact, housewraps will act to collect and channel liquid water whether the installer intends for them to do so or not. This can lead to trouble if housewrap is installed in a manner (e.g., not lapped correctly, drains water behind windows) that doesn't allow for channeling water out of a wall system. So the lesson is: housewraps are not just air barrier products, they can— and should be—used as drainage planes as well. Their vapor diffusion characteristics aren't sufficient to allow quick drying should misinstallation result in bulk water penetration.

In addition to air barrier and drainage plane functions, housewraps are designed to allow water vapor to diffuse through them. Housewraps should not be considered as vapor retarders. Research conducted by the University of Massachusetts (www.umass.edu/bmatwt/weather_barriers.html) examined 6 brands of housewrap and found permeability levels ranging from 5 to 200 perms. This research also stated that the housewraps appeared to have their ability to reject liquid water degraded somewhat by the use of soapy water (from power washing) and, to a lesser degree, water laden with a cedar extractive.

On the other hand, 15# felt paper has a lower perm rating (~ 4 perms at low relative humidity) than housewrap products, enhancing its ability to limit vapor transmission through the wall (in either direction). This characteristic is a benefit in hot and

TABLE 4.6 - RECOMMENDED VAPOR RETARDER CHARACTERISTICS FOR BUILDING EXTERIORS OR INTERIORS IN VARIOUS CLIMATE CONDITIONS

Climate Condition[1]	Location of Vapor Retarders	Water Vapor Permeability[2] (low = little vapor passes high = vapor passes easily)	Recommended Product Type[2]
Hot and Humid HDD < 2,500	Outer side of wall	Low to moderate (see Table 4.4, Drainage Plane)[3]	15# tarred felt
	Foundation (slab, crawl, or basement)	Low	6 mil polyethylene plastic sheet on ground
	Attic & Cathedral Roof	High	None
Mixed 2,500 < HDD < 6,000	Inner side of wall	Moderate (2,500 HDD) to Low (6,000 HDD)	Kraft paper on batts or vapor retarder paint on interior
	Foundation (slab, crawl, or basement)	Low	6 mil polyethylene plastic sheet on ground
	Attic & Cathedral Roof (ceiling side)[4]	High (2,500 HDD) to Moderate (6,000 HDD)	None to Kraft paper on batts (6,000 HDD)
Cold HDD > 6,000	Inner side of wall	Low	3 mil polyethylene or vapor retarder paint on interior
	Foundation (slab, crawl, or basement)	Low	6 mil polyethylene on ground
	Attic & Cathedral Roof (ceiling side)[4]	Moderate (6,000 HDD) to Low (9,000 HDD)	Kraft paper on batts to 3 mil polyethylene or vapor retarder paint on interior

Notes:

1 HDD refers to Heating Degree Days relative to 65°F (see Figure 4.7).

2 These recommendations are based on both the material properties (perms) and how they are used. A product that is not applied continuously over a surface (e.g., kraft faced batts in a ceiling) will allow more vapor to pass than a continuous layer.

3 Because it is equally important to ensure that the interior surface of a wall has a high permeability finish, select paint with high permeability and avoid finishes such as vinyl wall paper that will act as a vapor barrier. Prevention and Control of Decay in Homes, USDA/HUD, 1978, recommends that "In warm climates, walls and ceilings without vapor barriers are safer."

4 Attic vapor barriers for hip and gable roofs, if used in mixed and cold climates, should be placed on the warm-in-winter side of the attic insulation. The same applies to cathedral ceilings.

humid regions and in designs where some resistance to vapor movement from outside to inside is desired (e.g. behind brick veneer or unsealed wood siding). While building paper is not usually viewed as an air barrier product, it can still be used in conjunction with other measures (e.g. caulk and foam sealants) to produce a wall system with reduced air infiltration.

So both products can shed liquid water. Housewrap tends to be more vapor permeable than building paper (check the perm rating for specific brands though), allowing water vapor to diffuse more easily; but neither product would be considered a vapor retarder even though both slow the movement of vapor to some degree. Housewrap can be used as an air barrier, whereas building paper would likely be used in tandem with other air sealing measures. These differences, as well as price, should be the basis for a choice when a decision needs to be made. But once more, keep in mind that *neither* type of product will perform the way it's supposed to if it's not properly installed and integrated with flashing of windows and doors (see Section 4.2.4 on flashing and housewrap installation).

Housewrap Recommendations

Housewraps are relatively new materials that serve a dual role as a secondary "weather resistant" barrier and an air barrier. However, this dual role of building materials has been known for some time for materials such as building paper or "tar paper" (USDHEW, 1931). Even lath and plaster has been classified as an effective air barrier—a finding that also stands for its modern day counterpart, gypsum wallboard. Of course, an air barrier is not a substitute for proper sealing of penetrations in the building envelope around windows, doors, utilities, and other leakage points.

Therefore, as with the application of building paper, housewraps should be viewed and installed with the main goal of serving as a secondary weather-resistant barrier (i.e. drainage plane). Like tar paper, the edges of housewrap should be lapped to provide a drainage pathway for water out of the wall. It is only necessary to tape lapped edges if some improvement in air-barrier performance is desired. However, building wraps are not all created equal in terms of their "breathability" and this additional sealing can affect the drying time of the wall system should it become inadvertently wetted by condensation or, more importantly, rain water (See Table 4.5). At wall penetrations, the housewrap should be properly detailed or flashed (See Section 4.2.4). In some cases, housewraps are installed after window and door installation (Figure 4.13), and manufacturer-recommended tapes must be used to seal the joints. While this practice is not uncommon, a preferred method is to install the building wrap prior to window and door installation and to additionally flash window and door heads as shown in Figure 4.12.

Drying Potential

Drying potential, the ability of a wall system to dry out after it is wetted, is important because it can compensate for conditions when water gets where it's not supposed to be. High drying potential will allow walls that are moist to dry out in a reasonable amount of time and limit the consequences. An ideal wall would be one that doesn't let any moisture in from interior vapor, exterior vapor, rain, snow, or ice. This would require a hermetically-sealed wall, which is not practical in residential construction. If this design approach of a "perfect" sealed wall is pursued and water does get into the wall, it will be trapped there and the results can be disastrous. Therefore, it is imperative to make less than ideal materials work satisfactorily through careful design, careful construction, and an expectation that water will get into walls. Appropriate solutions will depend on climate conditions, the building use conditions, and common sense.

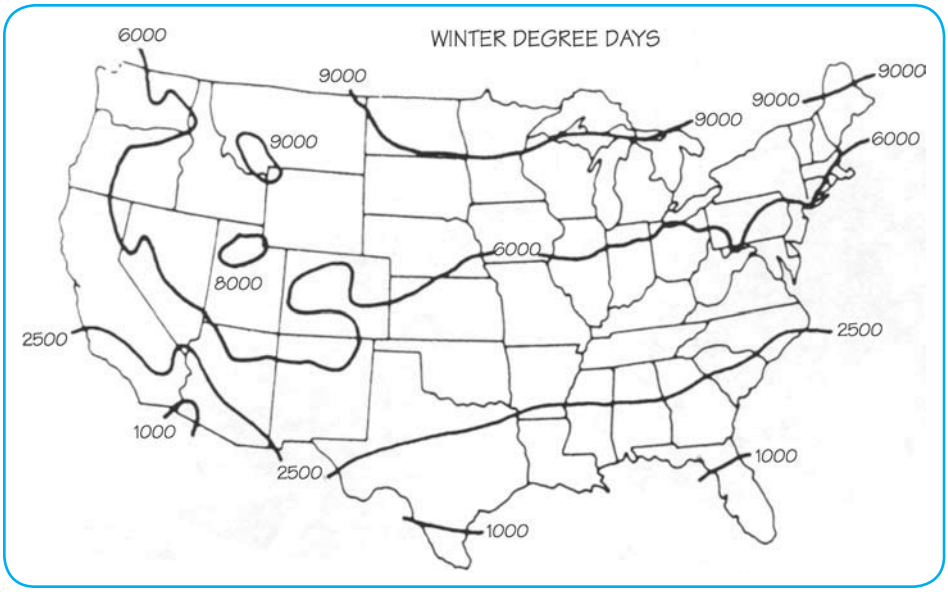


Figure 4.7 - Heating Degree Day (HDD) Map of the United States (65°F basis)

An ideal wall material acts as a storage medium, safely absorbing excess moisture and expelling it when the relative humidity decreases during periods of drying. Heavy masonry walls do this. To some degree, natural wood materials also exhibit this characteristic and create a beneficial "buffering effect" to counter periods where moisture would otherwise accumulate to unacceptable levels. This effect is part and parcel of the "breathing building" design approach and it serves as a safety factor against moisture problems, just like a roof overhang.

Materials such as concrete, masonry, and brick also exhibit a moisture storage or buffering capacity as do many contents of a home. This creates a lag effect that should be considered in building design and operation. For example, moisture levels in building materials tend to increase during warm summer months. As the weather cools in the fall, a moisture surplus exists because the expulsion of excess moisture lags in comparison to the rate of change in season temperatures.

Bear in mind that most building moisture problems are related to exterior moisture or rain. Moisture vapor and condensation is usually only a problem in extremely cold climates (upper Midwest and Alaska) or in extremely hot and humid climates, particularly when significant moisture sources exist within a home. For instance, a small house in a cold climate with high internal moisture loads (people, bathing, cooking), little natural or mechanical ventilation, and the lack of a suitable interior vapor retarder (i.e., between drywall and external wall framing) will likely experience moisture problems.

RULES OF THUMB AND TIPS

- *Flashing is necessary for proper drainage plane performance in walls and for roofing systems.*
- *Most leakage problems are related to improper or insufficient flashing details or the absence of flashing.*
- *All openings in exterior walls and roof penetrations must be flashed.*
- *Caulks and sealants are generally not a suitable substitute for flashing.*
- *Water runs downhill, so make sure flashing is appropriately layered with other flashings or the drainage plane material (i.e., tar, felt, or housewrap).*
- *Water can be forced uphill by wind, so make sure that flashings have recommended width overlap.*
- *Sometimes capillary action will draw water into joints between stepped flashing that is not sufficiently lapped or that is placed on a low-pitch roof—take extra precaution in these situations.*
- *Avoid joint details that trap moisture and are hard to flash.*
- *Treat end joints of exterior wood trim, railings, posts, etc. prior to painting; paint end joint prior to assembly of joints; if pre-treating, be sure the preservative treatment is approved for use with the type of paint or stain being used.*
- *Minimize roof penetrations by use of ventless plumbing techniques, such as air admittance valves, side wall vents, and direct vented appliances (check with local code authority for approval).*
- *Use large roof overhangs and porches, particularly above walls with numerous penetrations or complex window details.*

BASIC FLASHING MATERIALS AND TOOLS

- *Flashing stock (coated aluminum, copper, lead, rubber, etc.)*
- *15# felt paper*
- *Bituminous adhesive tape*
- *Utility knife*
- *Aviator snips or shears*
- *Metal brake (for accurate bending of custom metal flashing)*

4.2.4 Recommendation #4: Proper Flashing

Flashing is perhaps one of the disappearing crafts in the world of modern construction and modern materials that seem to suggest simple installation, "no-worry" performance, and low maintenance. An emphasis on quick installations often comes at the expense of flashing.

Good flashing installations take time. But it's time well invested. So, if flashing is to be installed, it is best to invest the effort to make sure it's done right. In Figures 4.8 - 4.16 some typical but important flashing details are provided as models for correct installation techniques.

4.2.5 Recommendation #5: Sealants and Caulking

In general, do not depend on sealants and caulking for long-term service. Using normal quality caulks and sealants with typical surface preparation, combined with shrinkage and swelling of building components, usually results in failure of a water tight seal within 2 to 3 years or less, particularly on southern exterior exposures. Nonetheless, there will be joints and seams that will benefit from appropriate use and maintenance of caulks and sealants. Optimally, joints in exterior wood trim or framing should be simple enough not to trap water and allow quick drying.

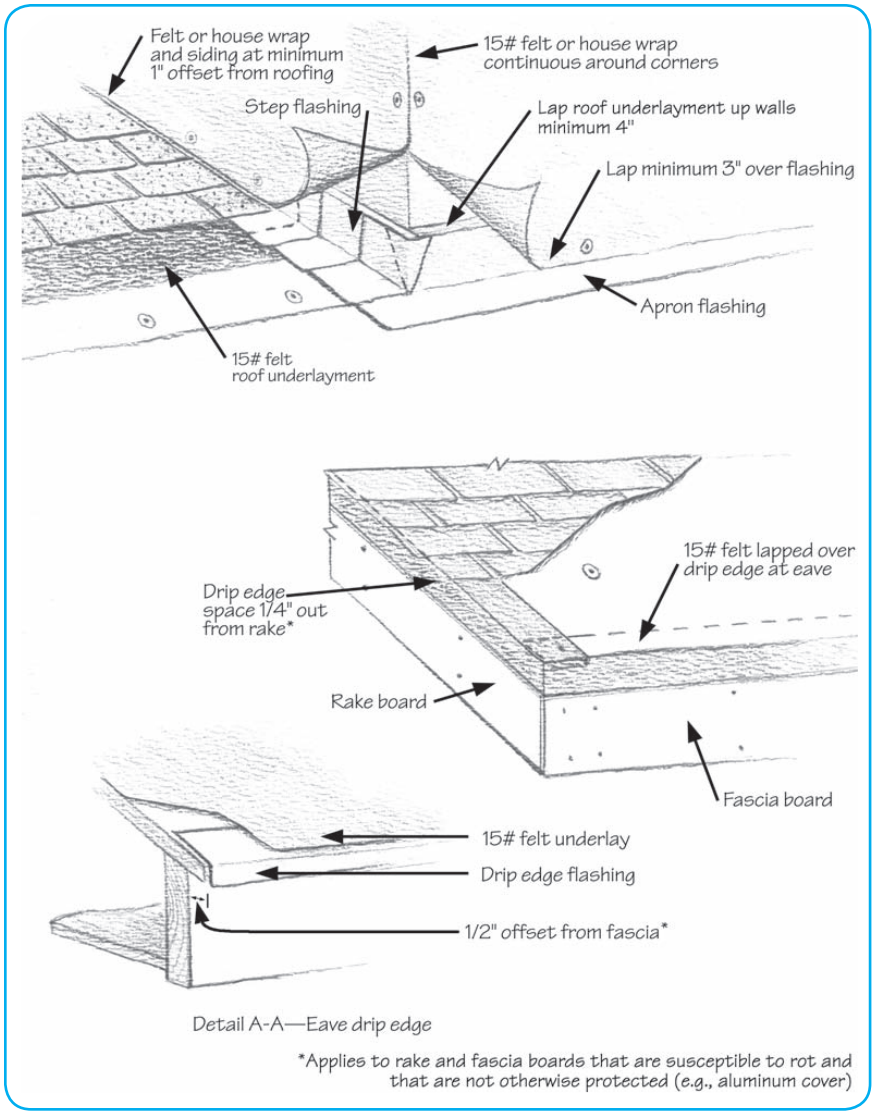


Figure 4.8a - Basic Roof Flashing Illustrations

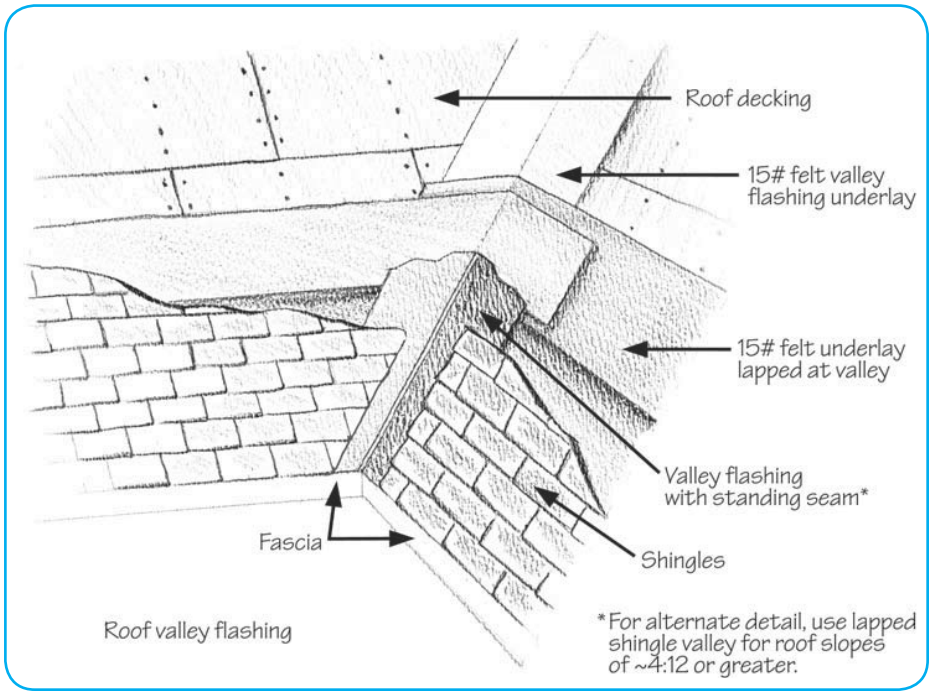
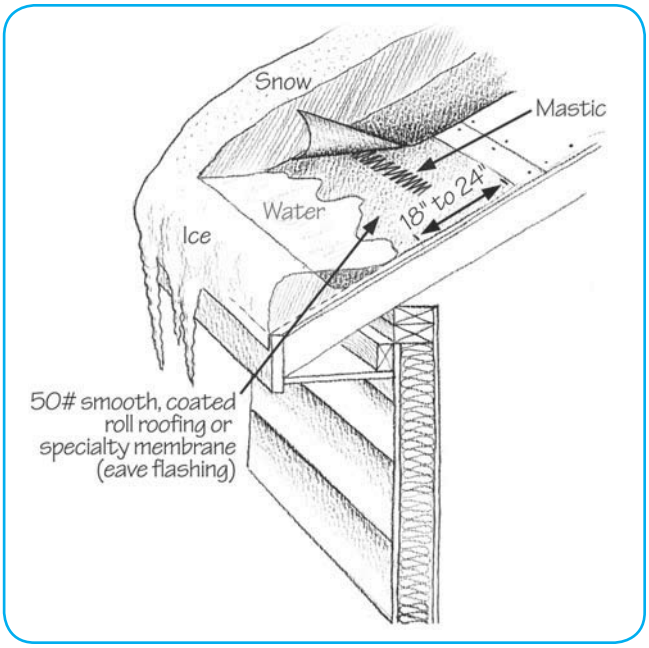


Figure 4.8b - Basic Roof Flashing Illustrations

Figure 4.9 - Eave Flashing for Preventing Ice Dams

Notes:

- Extend eave flashing 18 to 24 inches inside the plane of the exterior wall.
- Overhang eave flashing 1/4-inch beyond drip edge flashing.
- Apply mastic continuously to joints in eave flashing.
- If joints in the eave flashing are not avoidable, locate them over the soffit rather than the interior area of the building.
- While eave flashing is generally recommended for areas with an average January temperature less than 25°F, ice dams can be prevented by (1) adequate sealing of ceilings and tops of interior and exterior walls to prevent warm indoor air from leaking into the attic space, (2) adequate attic/roof insulation (usually local code requirements are sufficient) all the way out to the plane of the exterior walls and (3) proper ventilation through the eave and attic space.



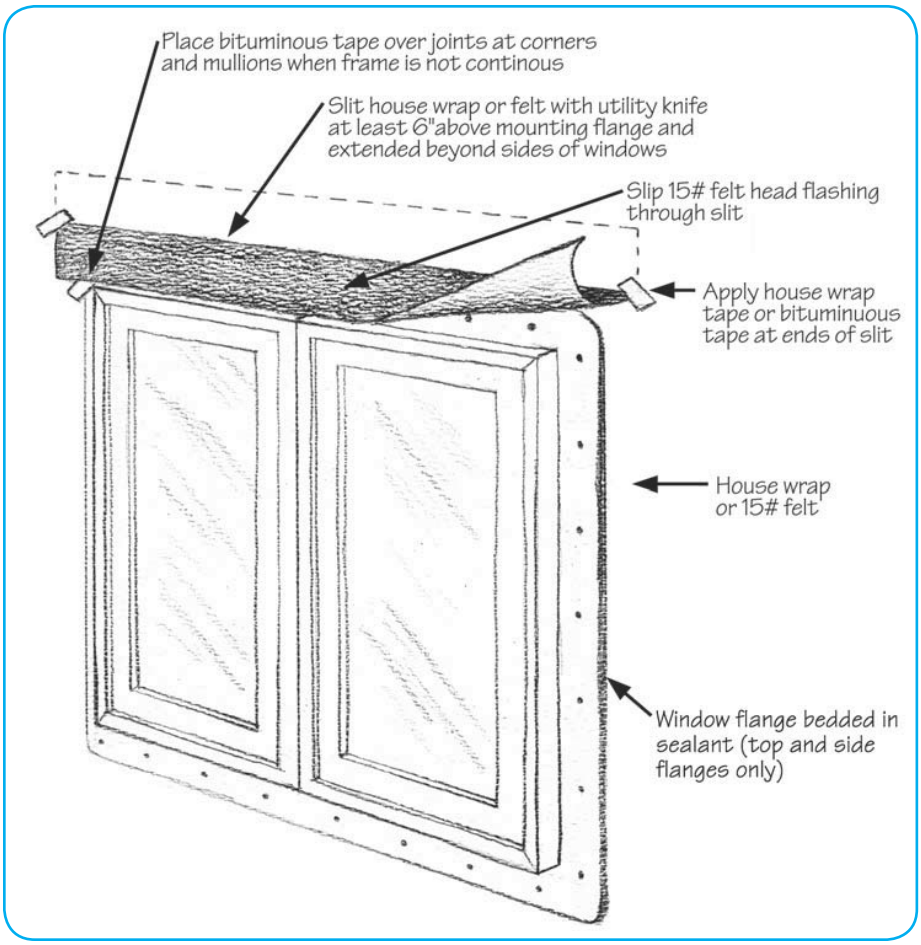
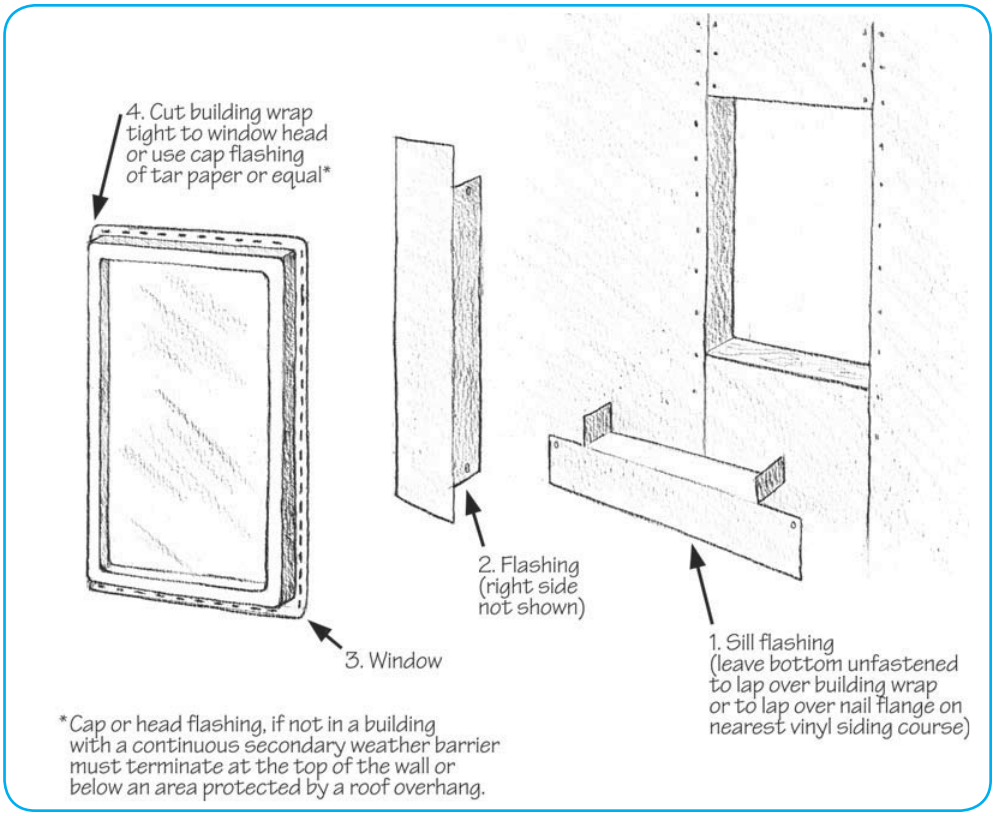


Figure 4.10 - Window Flashing Illustration ***(building wrap installed prior to window; typical nail flange installation)***

Figure 4.11 - Window Sill and Jamb Flashing Detail ***(building wrap installed after window)***



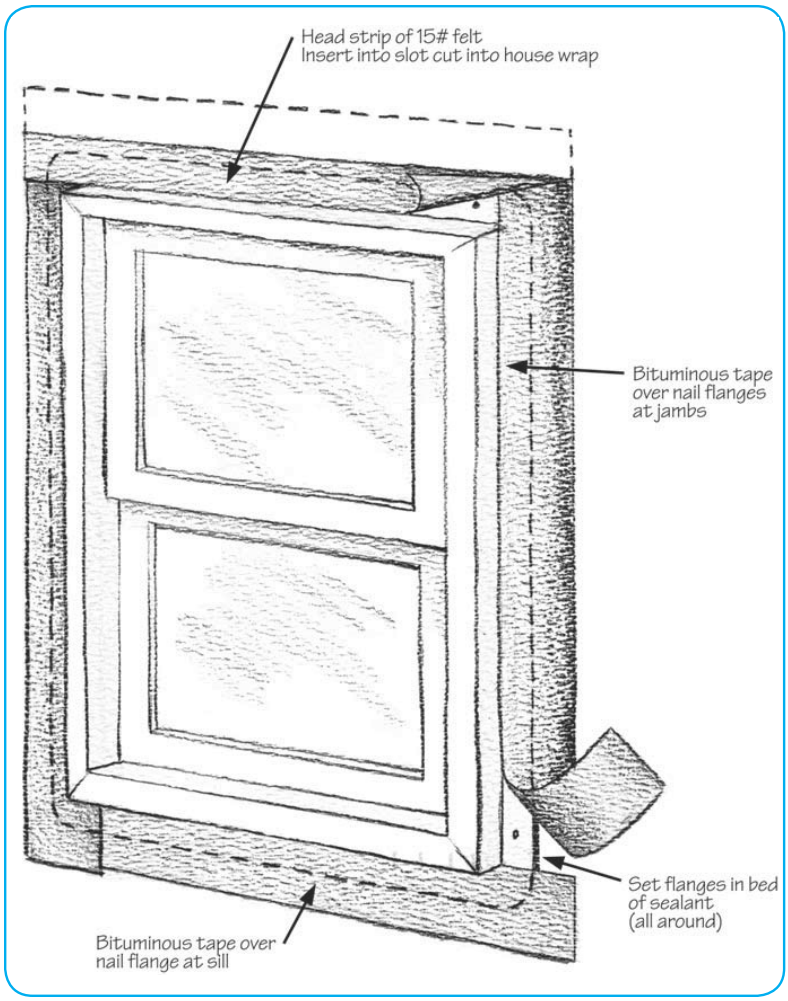


Figure 4.12 - Window Flashing for Severe Weather ***(areas subject to frequent wind-driven rain)***

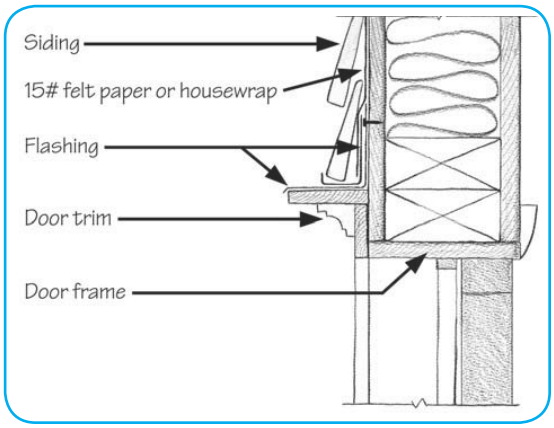


Figure 4.13 - Door and Head Trim Flashing Detail

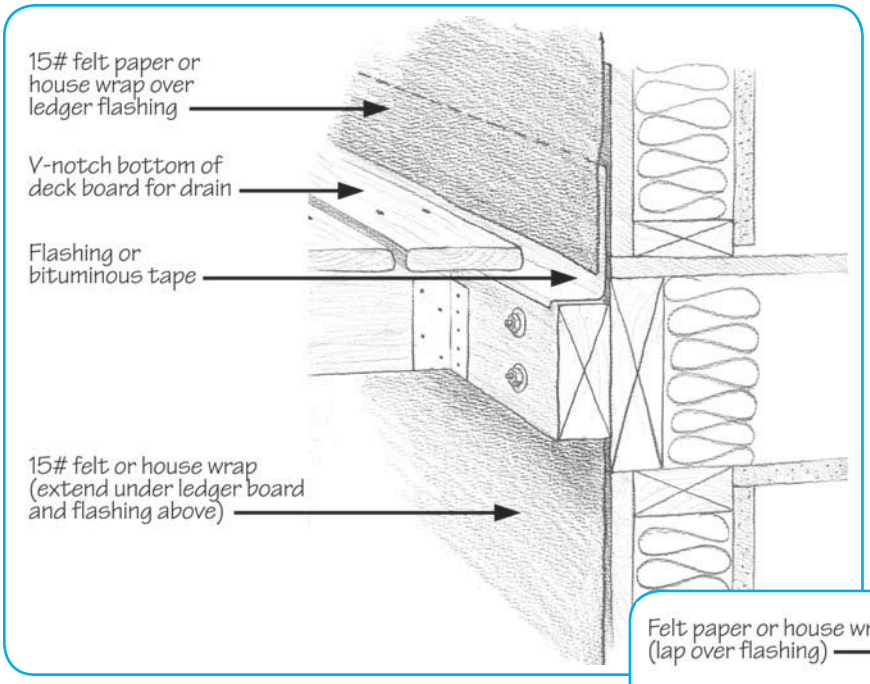


Figure 4.14 - Deck Ledger Flashing Detail

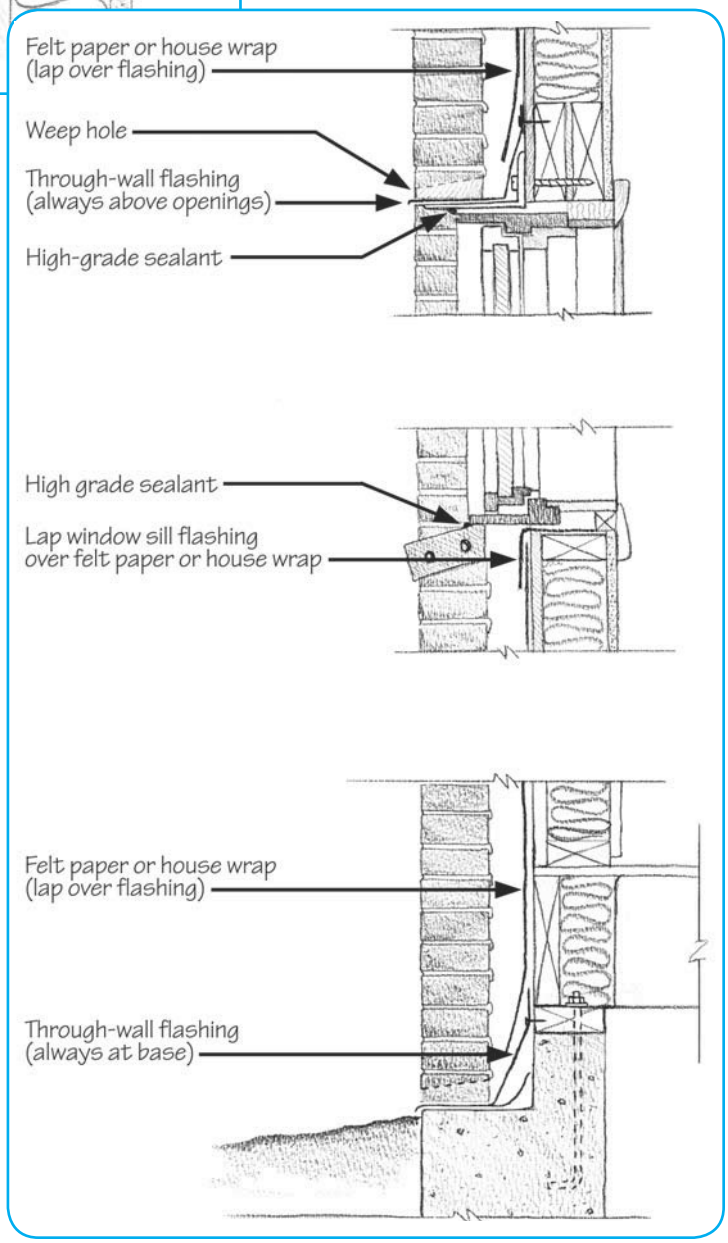


Figure 4.15 - Typical Brick Veneer Flashing Details

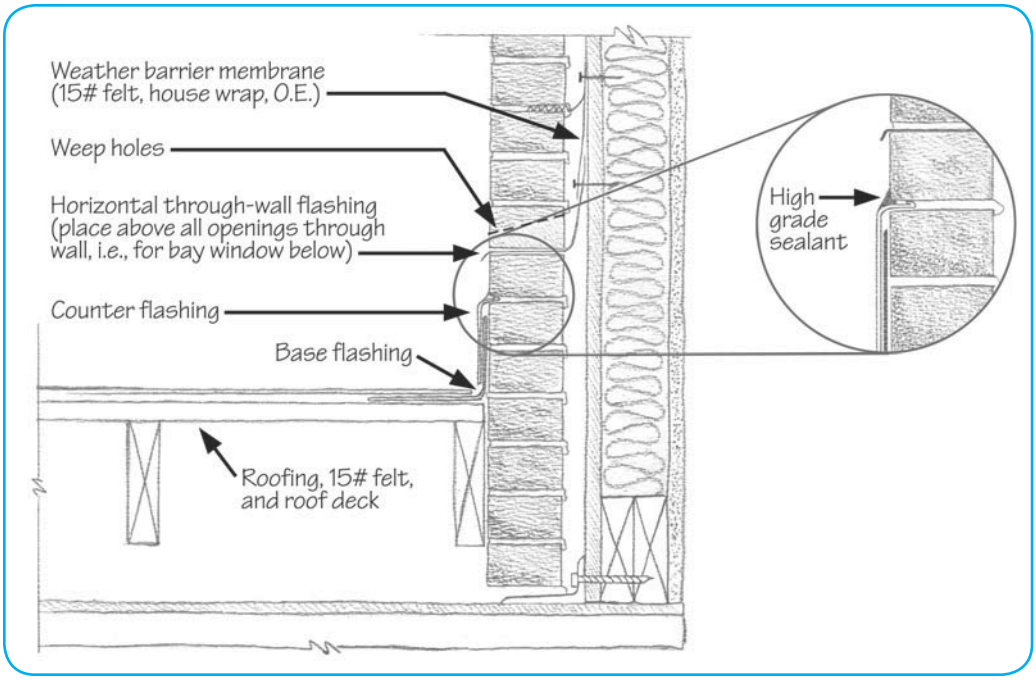


Figure 4.16 - Brick Veneer Flashing at Roof Intersections

With reasonable adherence to manufacturer instructions (particularly with respect to surface preparation and conditions during installation), high quality caulks and sealants can be made to endure for a reasonable time (i.e., up to 5 years or considerably more when not severely exposed). Some recommendations regarding selection of quality caulks and sealants are provided in Table 4.7. In addition, caulks and sealants should be stored in a warm environment and should not be stored for more than a couple of years before use. Finally, the need for homeowner maintenance and replacement of caulking must be strongly emphasized.

4.2.6 Recommendation #6: Roof and Crawl Spaces To Ventilate or Not to Ventilate

The use of ventilation has been a topic of confusion for some time. Until recently there has been little convincing research to confirm traditional practices or to suggest better ones. To aid in decisions regarding roof and crawlspace ventilation, recommendations are provided in Table 4.8 based on the best information available on the topic. Prior to use, the reader should consult local building code requirements and roofing manufacturer warranties to identify potential conflicts.

Roofs vents (when required) must be installed in accordance with the local building code or accepted practice. Plastic vent louvers commonly used on gable ends must contain UV inhibitors. Vents must be adequately screened to prevent vermin or insect entry. In addition, ridge vents (if used) should be installed and attached to the roof in accordance with manufacturer recommendations—numerous incidents of improper installation have resulted in damage during wind events or rain/snow entry to the roof. Vent area ratios, such as 1 square foot of vent opening for every 300 square feet of attic area refer to the net vent area, not gross area; so the sizing of vents must account for obstructions to vents from louvers and screens. The roof ventilation recommendations in Table 4.8 are based primarily on durability concerns. These recommendations are further based on the assumption that the following good practices have been employed:

- All bath and kitchen exhaust fans exhaust moist indoor air directly to outdoors.
- Indoor relative humidity is kept within reasonable limits (i.e., 40-60%) and significant point sources of moisture (e.g. hot tubs) are controlled with ventilation.
- Ceiling vapor barriers are used in accordance with Table 4.6.
- Proper attic insulation levels are installed for the given climate and location.

While non-vented roof assemblies are a viable alternative (especially in hot/humid climates), performance data on such designs over time is still lacking. Further, the required detailing that goes along with such a design (e.g., insulation detailing, controlling surface temperatures in the assembly to prevent condensation) may be less forgiving than a traditional ventilation approach in terms of durability. If a non-vented design is employed, some critical items to consider include:

- Local building department approval;
- Implications for roofing material warranty;
- All major air leakage points between the living space and the attic (wire penetrations, recessed light cans, plumbing lines, HVAC boots and chases, attic hatches) have been sealed to limit air leakage; and
- Perimeter wall insulation detailing to satisfy local fire and insect design requirements.

TABLE 4.7 - CAULK CHARACTERISTICS AND APPLICATION RECOMMENDATIONS[1]

Caulk	Life (Yrs)	Best Uses	Adhesion	Shrink-free	Primer Use[2]	Joint Type	Tack-free (hrs)	Cure (days)	Clean-up with[3]	Paint	Available Colors
Oil-base	1 - 7	not desirable	fair-good	poor	porous surfaces	non-moving to 14″ w, 3/4″ d	2 - 24	to 365	paint thinner	must	white, natural, gray
Acrylic-latex	2 - 10	indoors, protected, or painted	excellent, except metal	fair	porous surfaces for best results	non-moving to 1/4″ w	1/4 - 1/2	3	water	best	white, black, gray, bronze
Butyl rubber	7 - 10	narrow openings in wood, metal, glass, masonry	very good	fair	none needed	non-moving up to 1/4″ x 1/4″	1/2 - 1 1/2	7	paint thinner, naphtha	best	white, clear, gray, black, brown, redwood, beige, bronze, sandstone
Polysulfide rubber	20+	anywhere	excellent	excellent	special primer on all but metal	all up to 1/2″ x 1/2″	24 - 72	7	TCE, toluene, MEK	if desired	white, black, gray, limestone bronze
Silicone rubber	20+	outdoor metal, heat ducts, shallow joints	good, excellent with primer	excellent	porous surfaces	all from 1/4″ d	2 - 5	2 - 5	paint thinner, naphtha, toluol, xylol	read label	brown, white black, clear, gray
Urethane	20+	anywhere	excellent	excellent	none needed	all to 1/4″ x 1/2″	4 - 14	4 - 14	MEK, acetone lacquer, thinner	if desired	white, gray, black, limestone, bronze; special colors
Weatherstrip/ caulking cord	to 20	temporary draft sealing and hole plugging	none	excellent	none needed	non-moving	—	none	not sticky	no	clear, gray

Source: *Structures and Environment Handbook,* Eleventh Edition (Midwest Plan Service, 1983)

Notes:

1 Based on advancement in caulk formulation and materials, this table may be in need of revision and may not include newer materials.

2 “Porous” includes wood, wood products, concrete, and brick.

3 MEK = methyl-ethyl-ketone, TCE = trichloroethylene.

For crawlspaces, a non-ventilated crawlspace design can be employed in all of the climate regions shown in Table 4.8. A non-ventilated crawlspace offers benefits in terms of both moisture control and energy performance. Ventilated crawlspaces, especially in humid and mixed regions, often introduce moist outdoor air into a cooler crawlspace environment. The result is condensation and the resulting problems like mold and degradation of building materials. In terms of energy, an unventilated crawlspace also provides an area for HVAC equipment and ducts that doesn't present the temperature swings (and energy penalties) found in ventilated crawlspaces.

There's more to it than just taking out the vents however. The following steps must also be followed when building a unventilated crawlspace:

- Careful attention to exterior grading (4% slope *minimum*);
- Air sealing between outdoors and the crawlspace area to prevent humid air from getting into the crawlspace;
- Insulating at the crawlspace perimeter walls—not the floor;
- 6 mil polyethylene groundcover in crawlspace with joints lapped; and
- Damp-proof foundation wall.

TABLE 4.8 - ROOF AND CRAWL SPACE VENTILATION RECOMMENDATIONS

Climate[3]	Attic[1,5]	Cathedral Roof[4]	Crawl Space[2]
Hot/Humid	Yes	Yes	No
Mixed	Yes	Yes	Not Preferred
Cold	Yes	Yes	Optional
Arid (dry)	Yes	Yes	Optional

Notes:

1 All roof ventilation recommendations are based on the ceiling being sealed at all major air leakage points (i.e., chases, electric and mechanical penetrations, etc.) and bath and kitchen vent ducts adequately routed to expel air out-of-doors. In some climates (see Table 4.6), a ceiling vapor retarder (i.e., vapor retarder paint, polyethylene sheet, or asphalt coated paper) is required in addition to adequate attic/roof insulation.

2 All recommendations are based on properly graded sites and the use of a continuous ground vapor retarder applied to the foundation area.

3 Climates are defined as in Table 4.4.

4 Cathedral roof ventilation must be continuous along soffit/eave and ridge.

5 Net attic vent area should be 1/300 of attic area and vents shall be continuous along soffit/eave and also located at the ridge and/or gable ends.

CHAPTER 5 | SUNLIGHT

5.1 General

Sunlight is made up of visible light and non-visible radiation such as ultraviolet (UV) and infrared (IR). Depending on the color and surface characteristics of an object, various wavelengths of solar radiation may be absorbed, reflected, and emitted (i.e., "released"). The more light absorbed and the less heat capacity (i.e., thermal mass), the greater the object's ability to be heated by sunlight. For example, a dark driveway becomes much hotter on a sunny day than a light colored concrete sidewalk. Thus, the sun produces two significant effects that attack materials and shorten their life-expectancy:

(1) chemical reaction (i.e., breakdown) from ultraviolet radiation and heat

(2) physical reaction (i.e., expansion and contraction) from daily temperature cycles caused by objects absorbing and emitting heat gained from sunlight.

The chemical and physical reactions caused by sunlight can cause colors to fade and materials to become brittle, warp, or crack. Deterioration can happen relatively quickly (a year or less) or over longer periods of time depending on the characteristics of a material and its chemical composition. In some cases, materials like plastics that are vulnerable to UV degradation can be made resistant by adding UV inhibitors to the chemical formulation.

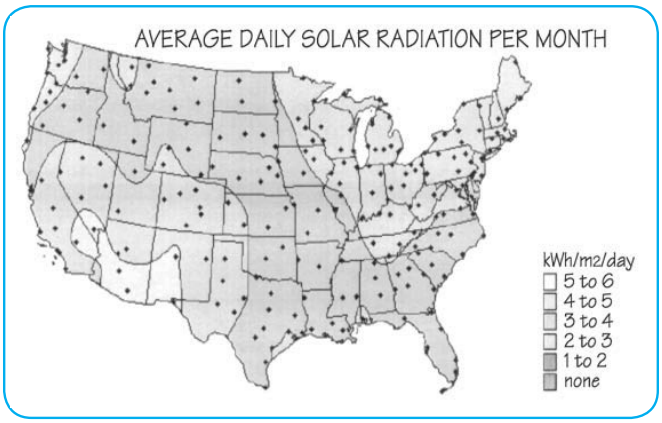


Figure 5.1 - Solar Radiation Map of the United States

Source: National Renewable Energy Laboratory

A prime example is vinyl siding. As an alternative approach, materials can be protected from sunlight by matter of design (e.g., providing shading or using reflective coatings).

UV light from the sun is not all bad. For example, it is UV light that causes a chemical reaction on special paper that forms the blue lines on blue prints. However, most everyone has witnessed or experienced the painful effects of UV radiation on skin, which causes sunburn. Consider that the exterior of a house is like its skin. Therefore, the proper selection of materials determines to what degree the building exterior will be able to withstand the damaging effects of UV radiation. The amount of solar radiation also varies by geography (see Figure 5.1); the number of cloudless days affects the dose of UV radiation over the lifetime of a product.

The following section presents a few measures that can help to counter the effects of solar radiation on building materials and systems. For homes, some of the primary problems associated with solar radiation are color fading, premature asphalt roof shingle failure, and vinyl siding warping. Excessive exposure to sunlight will also cause caulk joints to fail quickly. In addition, when shining through windows, sunlight can cause interior colors to fade.

5.2 Recommended Practices

5.2.1 Recommendation #1: Overhangs

As with rain on the building envelope, properly sized roof overhangs can minimize the exposure to solar radiation and, hence, minimize radiation-related problems. The width of a roof overhang that will protect walls from excessive solar exposure in the summer while allowing heat gain through windows from winter sunshine depends on where the building is located with respect to the equator. The sun is higher overhead in the summer than in the winter. In addition, for any day of the year, at higher latitudes the sun is lower in the sky than at lower latitudes. Therefore, buildings situated farther south receive greater protection from the summer sun by roof overhangs, as shown in Figure 5.2.

The solar angle factors of Table 5.1 can be used to help determine overhang width to achieve the desired shading effect on south-facing surfaces. An example calculation shows how the solar angle factor is used.

TABLE 5.1 - SOLARANGLE FACTORS[1]

Date	Latitude (degrees North)			
	24	32	40	48
To prevent winter shading:				
Dec 21	1.5	2.0	3.0	5.4
Jan 21 and Nov 21	1.2	1.7	2.4	3.8
Feb 21 and Oct 21	0.8	1.0	1.4	1.9
Mar 21 and Sept 21	0.4	0.6	0.8	1.1
To produce summer shading:				
April 21 and Aug 21	0.2	0.4	0.5	0.7
May 21 and July 21	0.1	0.2	0.4	0.5
June 21	0.0	0.1	0.3	0.5

Source: *Structures and Environment Handbook*, Eleventh Edition, Midwest Plan Service, Iowa State University, Ames, Iowa, 1983.

1 Factors apply for times between 9:00 am and 3:00 pm for winter shading and at noon for summer shading. Direct south facing orientation is assumed.

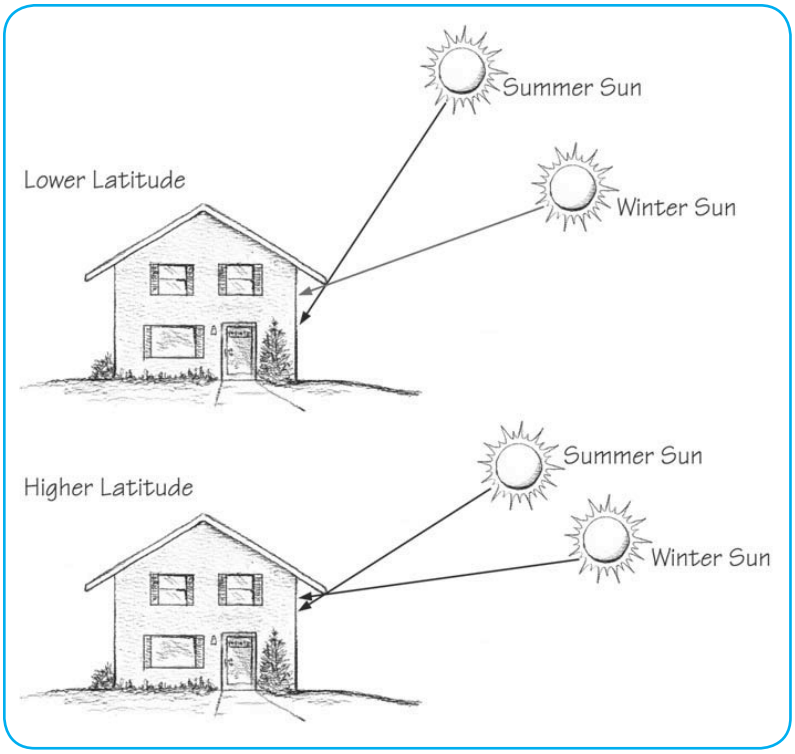


Figure 5.2 - Effect of Building Latitude on Effectiveness of Overhangs

5.2.2 Recommendation # 2: Light Colored Exterior Finishes

As a second line of defense against damage from solar radiation, light colored materials and finishes can be selected. White is excellent and aluminum, reflective-type coatings are even better. Light colors can also reduce summertime cooling load and should reduce energy bills especially in cooling dominated climates by lowering the solar heat gain into a building. If properly accounted for in cooling load calculations, lighter colored roofing may allow for the use of smaller capacity air conditioning units. In addition, light colored roof shingles reduce shingle temperature and, therefore, increase shingle life. The effect of building exterior color on solar heat gain is illustrated in Figure 5.3. It is very important, however, to keep light colored finishes like roofs relatively clean to take full advantage of their reflectivity.

5.2.3 Recommendation #3: UV Protective Glazing

Windows that receive direct sunlight and that are not treated to block UV radiation will allow sunlight to enter and fade susceptible materials such as furniture coverings, carpeting, and drapes. One solution is to specify interior materials that have UV inhibitors or that are not susceptible to UV radiation. Another solution is to specify colors that will not show fading. However, if these options are not desired or considered sufficient, there are glazing options for windows and doors that block UV radiation. These relatively expensive treatments need only be specified for south-facing windows.

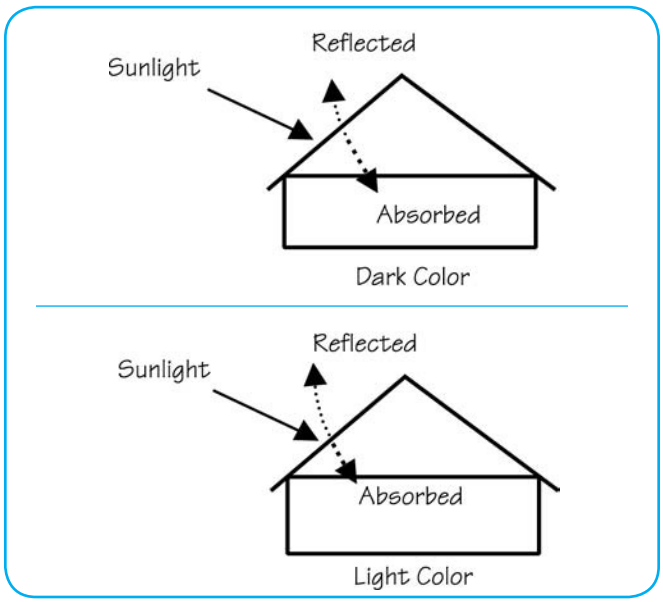


Figure 5.3 - Effect of Surface Coloration on Solar Heat Gain

EXAMPLE: DETERMINE ROOF OVERHANG WIDTH TO PROTECT WALL AGAINST SUMMER SUN

Find the overhang length (OL) to shade 6 feet of wall below the roof overhang for June through July. Building is located at latitude of 32 degrees North (consult Atlas for latitude). It is desired to provide shade for 6 feet of wall below the overhang at mid-day (i.e., to bottom edge of windows).

Solar Angle Factor (SAF) = 0.2 (for July 21) from Table 5.1

Wall distance below overhang to shade (WD) = 6 feet

OL = SAF x WD = (0.2)(6 feet) = 1.2 feet

Use a 16-inch (1.33 feet) overhang which will provide roughly 6 feet 8 inches of shading below the overhang.

Determine degree of shading in the winter (using Feb 21) as follows:

WD = OL/SAF = 1.33 feet / 1.0 = 1.33 feet or 16 inches.

The selected overhang width will provide no more than about 16 inches of shading to the wall during the main winter months of November through February. However, some shading to the top few inches of windows will occur in the early and late winter months when maximum solar heat gain may be desirable. But, in this case, the overhang width should not be decreased in the interest of maintaining weather protection of the wall.

5.2.4 Recommendation #4: UV Resistant Materials

Some materials are naturally UV-resistant, while others require the addition of UV inhibitors in the make-up of the material. For example, concrete or clay tile roofing and Portland Cement stucco or brick siding are naturally resistant to UV radiation and are also resistant to temperature effects compared to other exterior building materials. On the other hand, plastics are prone to "dry rot" (embrittlement from excessive UV exposure) unless UV inhibitors are provided. Plastics are also prone to significant expansion and contraction from temperature swings.

Be sure that UV inhibitors are used in materials that require protection. Many low budget components, such as some plastic gable end vents, may also lack UV resistance. All other factors being equal, choose the material with the best UV resistance if exposure to the sun is a concern.

5.2.4 Recommendation #5: Landscaping for Shading

Trees planted near a home along the southern exposure provide shading when most needed during the day (see Figure 5.4). Also, deciduous trees, such as maple or oak, should be used so that winter sun can reach the building. With appropriate planning, trees can also serve as a wind break to minimize the effects of wind-driven rain. Trees should be planted far enough away from a house to prevent possible damage from limbs or roots, as well as clogging gutters. Bear in mind that the greatest amount of solar radiation is generally received between 9 am and 3 pm. However, shading of only the late day sun (i.e., after 3 pm) is often a preferred and more practical solution for many sites.

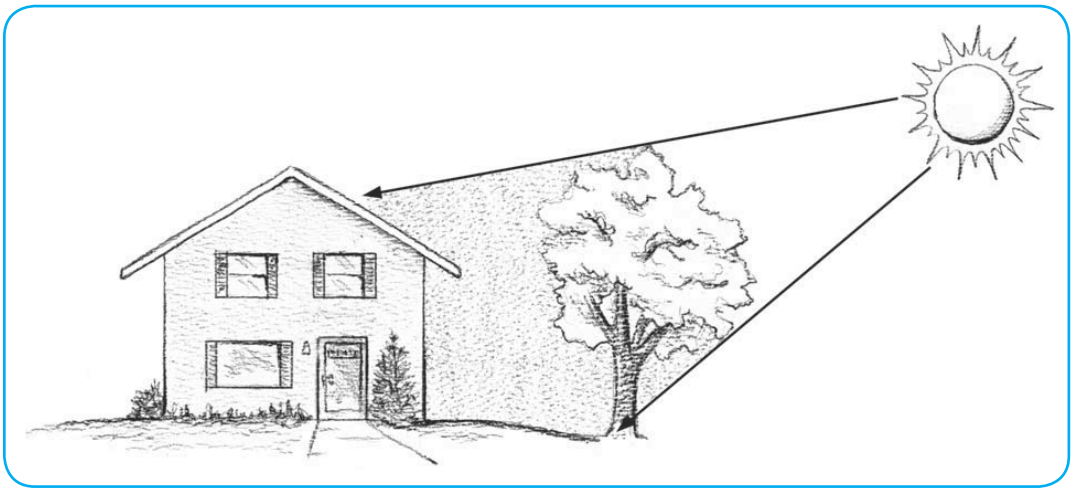


Figure 5.4 - Illustration of Solarscaping

EXAMPLE: DETERMINE LOCATION OF SHADE TREE TO PROTECT AGAINST SUMMER SUN

Use the following equation and the solar angle factors (SAF) of Table 5.1 to determine the appropriate location of a maple tree (mature height of ~60') southward of a building wall (8' height) that is to be shaded during summer months. The building latitude is 40° North (refer to atlas for site latitude).

$$d = SAF \times h_o \left(h_o - h_s\right)$$

where:

d = distance between object obstructing the sun at highest point and item to be shaded
h_o = height of the object obstructing the sun
h_s = height of object to be shaded
SAF = solar angle factor (from Table 5.1)

The following values are given:

SAF = 0.4 from Table 5.1 at 40°N latitude for May 21 or July 21
h_o = 60 feet
h_s = 8 feet

Substituting in the equation above,

$$d = (0.4)(60 \text{ ft} - 8 \text{ ft}) = 20.8 \text{ ft}$$

Therefore, the center of the maple tree should be located about 21 feet southward from the wall or windows to be shaded. Note that the shading at the first day of summer (June 21) will be slightly less due to the higher solar angle than assumed above. In addition, the tree should not overhang the building at its mature age. Thus, a distance smaller than about 20 feet is not recommended and the distance should be increased for trees that are larger at maturity.

CHAPTER 6 | INSECTS

6.1 General

Insects are not just nuisances, some are also a serious threat to building durability. The following types of insects are known to damage wooden materials in homes and in other structures:

- Termites,
- Carpenter Ants,
- Wood-boring Beetles, and
- Carpenter Bees.

While all of the above insects can pose a threat to wood-framed homes, termites are the most prevalent and damaging insect. Therefore, most of this chapter addresses issues and practices related to the control and prevention of termite infestation. Some of the practices for repelling termites, such as eliminating hidden areas that termites can travel through undetected, are also relevant to carpenter ants. Carpenter ants and wood-boring beetles, like termites, can be treated chemically with insecticides. Carpenter bees can be deterred by plugging entrance holes that commonly occur on wood siding and soffits.

There are about 56 species of termites in the United States that can be placed into two groups: subterranean (ground inhabiting) and non-subterranean (wood inhabiting). Subterranean termites are the most common and are responsible for most termite damage to wood structures. Therefore, this chapter focuses on subterranean termites. If non-subterranean termites are present, special measures may be necessary to eliminate them. Fortunately, non-subterranean termites live in much smaller colonies and are much slower acting than subterranean termites.

One variety of the subterranean termite group is the Formosan termite—an Asian termite introduced to the United States following WWII. The Formosan termite is different from the native subterranean termite in that it has a much greater colony size and thus damages wood at a much faster rate. Estimates state that a colony of Formosan termites will consume nearly 1,000 pounds of wood per year, whereas other termite varieties will only eat a few pounds annually. Formosan termites are also more likely to survive in a building with minimal ground contact, even though they require a constant source of water like other subterranean termites. Formosan termites are expanding in range, and are currently found in the Gulf Coast states and southern states along the Atlantic coast.

A termite hazard or probability map, shown in Figure 6.1, is frequently used by building code authorities, designers, and builders to determine when certain termite prevention or control methods should be used. Some building codes may vary in delineation of the termite probability zones based on local conditions. The termite hazard map generally corresponds to the geographic limits of reported termite damage as shown in Figure 6.2. The inclusion and degree of termite control and prevention used in a building depends on the risk of termite infestation as defined in Figures 6.1 and 6.2, as well as local experience.

In summary, termites like to eat wood and they don't care if it's in your home. In areas subject to termite infestation, at least one of the practices listed in Section 6.2 should be used.

6.2 Recommended Practices

There are basically three techniques for controlling or preventing termite damage:

- Chemical soil treatment or baits,
- Termite shields, and
- Use of termite resistant building materials.

6.2.1 Recommendation #1: Chemical Treatment

Types

Chemical treatments for termite control come in a variety of forms. Generally, chemical treatments for termites include soil termiticides, termite baits, and treated wood products. This section will only discuss soil and bait termiticides.

Chemical soil treatments are designed to form a protective barrier around a structure to prevent termites from contacting or penetrating the building.

Soil treatments are the most common form of termite control used by the building community. Commercially, there exist about a dozen soil treatments that, by various biological means, kill termites or repel them. Termiticides are generally preferred over repellents.

Termite baits are encapsulated termiticides designed to lure insects to the bait, be eaten, and then killed. The poisons are designed to act slowly so as to not repel the insect and to facilitate the consumption and transport of the poison to the nest. Other termites ingest the termiticide from the insects that feed directly on the baits through secretions emitted by the original feeders.

Application

Chemical soil treatments are generally applied to the soil around the foundation of a home to act as a shield against termites. The treatments are performed prior to pouring the slab or foundation, shortly after foundations and slabs are poured, and at periodic intervals for the life of the structure. Directions vary according to the chemical used, but these locations are of special concern for chemical application:

- Soil along foundations and crawl spaces;

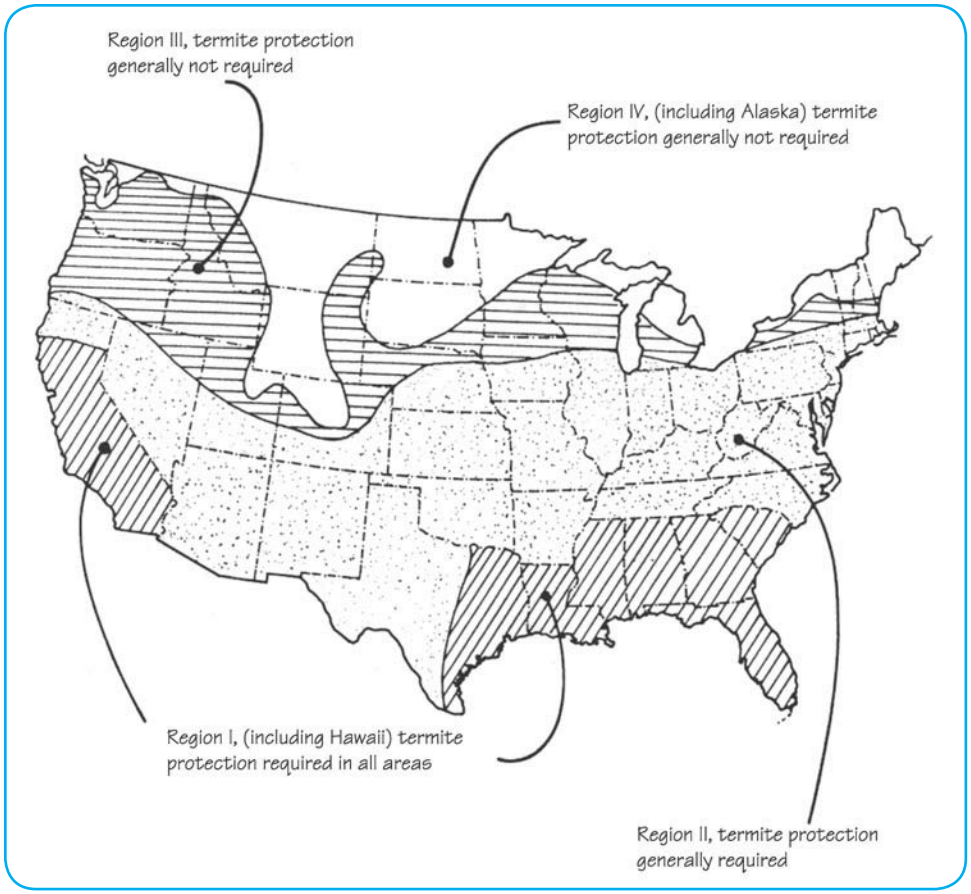


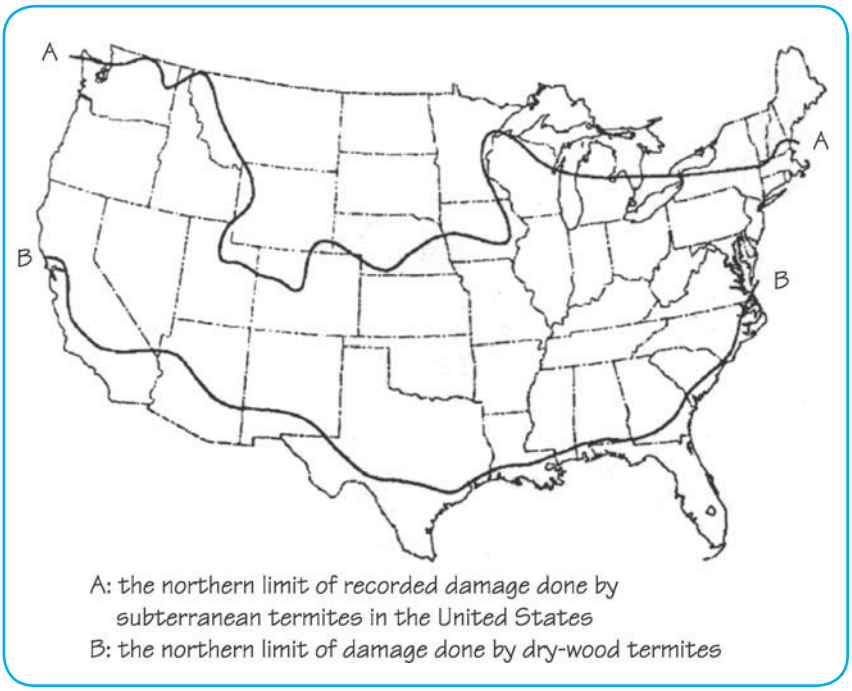
Figure 6.1 - Termite Probability (Hazard) Map

- Areas of soil disturbance such as bath traps;
- Soil under appurtenances such as attached slabs and porches;
- Soil in inaccessible or concealed spaces; and
- Soil in proximity to slab or foundation penetrations due to plumbing, wiring, etc.

Termiticides are applied by one or more of the following methods: trenching around a foundation and flooding the trench with a sprayer; inserting a rod at periodic intervals around a foundation and injecting the chemical in the soil; and drilling holes in masonry slab or foundations and injecting the chemicals into the soil through the holes. Factors such as access to targeted areas, presence of landscaping, and the chemical employed dictate the treatment option used by the pesticide applicator. A certified pest control operator (PCO) is required for application of most termiticides.

Figure 6.2 - Extent of Recorded Termite Damage

Source: Wood Handbook, USDA - Forest Products Laboratory, Madison, WI, 2000.



Performance of termiticides varies considerably with climate, soil type, structure design, and homeowner practice. Locations with frequent precipitation, impermeable or very permeable soils, or great soil disruption from landscaping activities will require frequent re-application in order to maintain termite-resistive properties.

Termite baits are applied to the ground at intervals around the home as prescribed by the product label. Some bait systems employ only a cellulose bait that requires frequent monitoring. Once termite activity is detected, a poison is inserted into the bait housing. Other bait systems contain both termite lure and poison in one formulation. The key to satisfactory performance in a bait system is proper monitoring and placement. Do-it-yourself termite bait kits are available to the general public, but the temptation is to purchase too few and monitor the baits infrequently, thus severely hampering their effectiveness. Many pest control operators offer bait systems which better assure proper bait placement and monitoring.

Re-application and Inspection Services

Chemical termiticides have a limited life because of leaching or chemical degradation. In addition, homeowner activities such as disruptive landscaping tend to limit the effectiveness of chemical treatments. Therefore, many homeowners opt to employ a termite service offered by pest control operations.

Typically, a contract with a PCO involves an initial treatment of the structure with a chemical termiticide or bait system, followed by an annual inspection of the structure with periodic retreatment performed when required. Many PCO's offer warranties that provide free retreatment if infestation is detected. Few offer warranties that pay for repair or replacement of termite-infested materials.

The benefits of an inspection and treatment service include periodic inspection of a home by knowledgeable technicians and quick remedial action when infestation is detected. A client can be better assured of a competent applicator if the PCO is a member of the National Pest Management Association (NPMA). NPMA promulgates the standards that constitute proper treatment of buildings.

6.2.2 Recommendation #2: Termite Shield

A termite shield is placed between a masonry foundation and wood framing to prevent termites from gaining access to the wood framing components. Termite shields (Figure 6.3) must be of termite-resistant materials such as metal or concrete. Some termites are able to chew through plastics and thin metals. Also, any seams in a termite shield must be soldered or otherwise sealed. Since termite shields require a high degree of care in installation, they are best used in combination with soil treatment. They should always be used when there are potential hidden pathways. Construction types known to create hidden pathways for termites include slab-on-grade (except monolithic slabs of good construction), masonry construction, and brick veneer construction.

Hidden pathways allow termites access to wood materials through pathways that cannot be detected during periodic inspection. When there are no hidden pathways in construction, subterranean termites can be easily detected by the presence of shelter tubes—tunnels that are made of mud to protect them from light and keep them moist. Because termite shields are difficult to install on slab-on-grade construction or split-level construction, other methods of termite protection (e.g., soil treatment) are generally preferred for these types of foundations. It is also noteworthy that termites can gain hidden access through cracks as small as 1/32-inch wide. Therefore, if concrete is used as a barrier to termites, it should include welded wire fabric or sufficient reinforcement to control cracking. Examples of concrete as a termite barrier are illustrated in Figure 6.4.

6.2.3 Recommendation #3: Termite-Resistant Building Materials

Wood can be protected against termite damage by use of preservative treated wood (e.g., CCA or Borate). Using treated lumber to frame a home can add as much as $3,000 to the price of a typical home. Such a drastic measure, however, is only used in particularly severe termite hazard areas like Hawaii.

As an alternative, preservative-treated wood may be used in isolated locations such as foundation sills and floor framing directly above the foundation. This practice is particularly appropriate for crawl space construction and for basement construction when ceilings are finished such that these elements are not easily inspected for infestation. Alternatively, naturally decay-resistant wood (e.g., heartwood of redwood and eastern red cedar) may be used, but at even greater expense than preservative treated lumber. For this reason, materials such as galvanized cold-formed steel may be a cost-effective alternative and are frequently used in Hawaii to complement or compete with the use of preservative treated wood. Concrete and masonry building materials are favored alternatives in areas such as Florida.

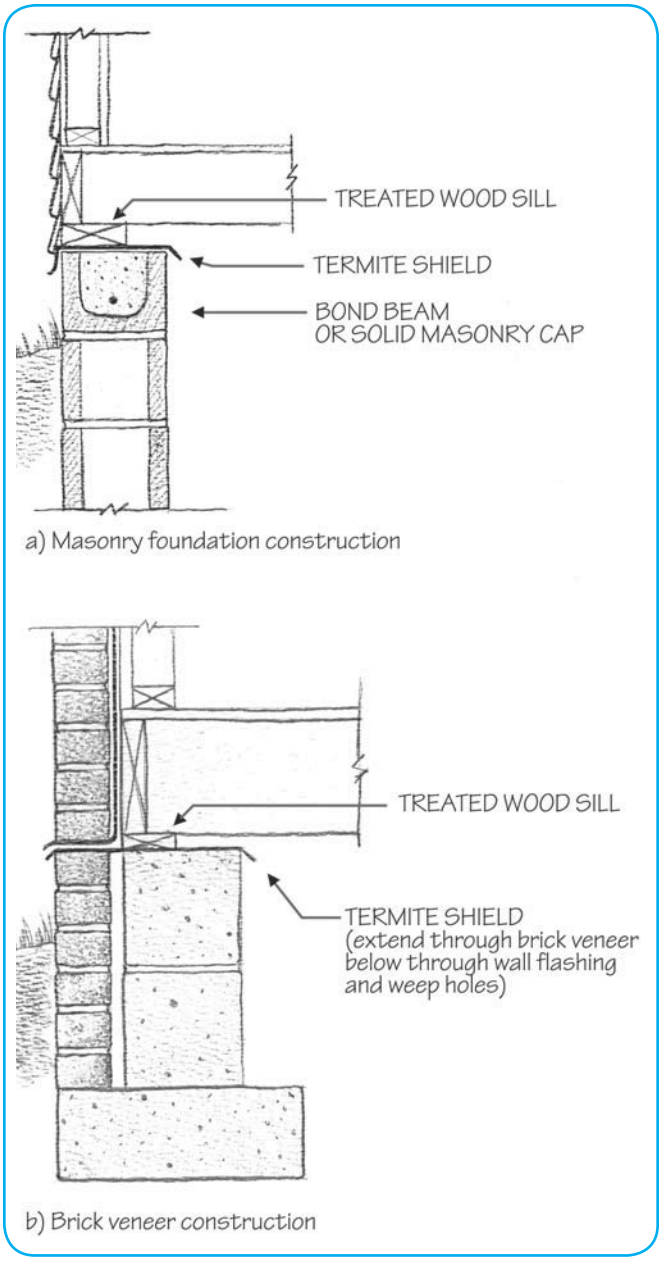


Figure 6.3 - Use of Termite Shields

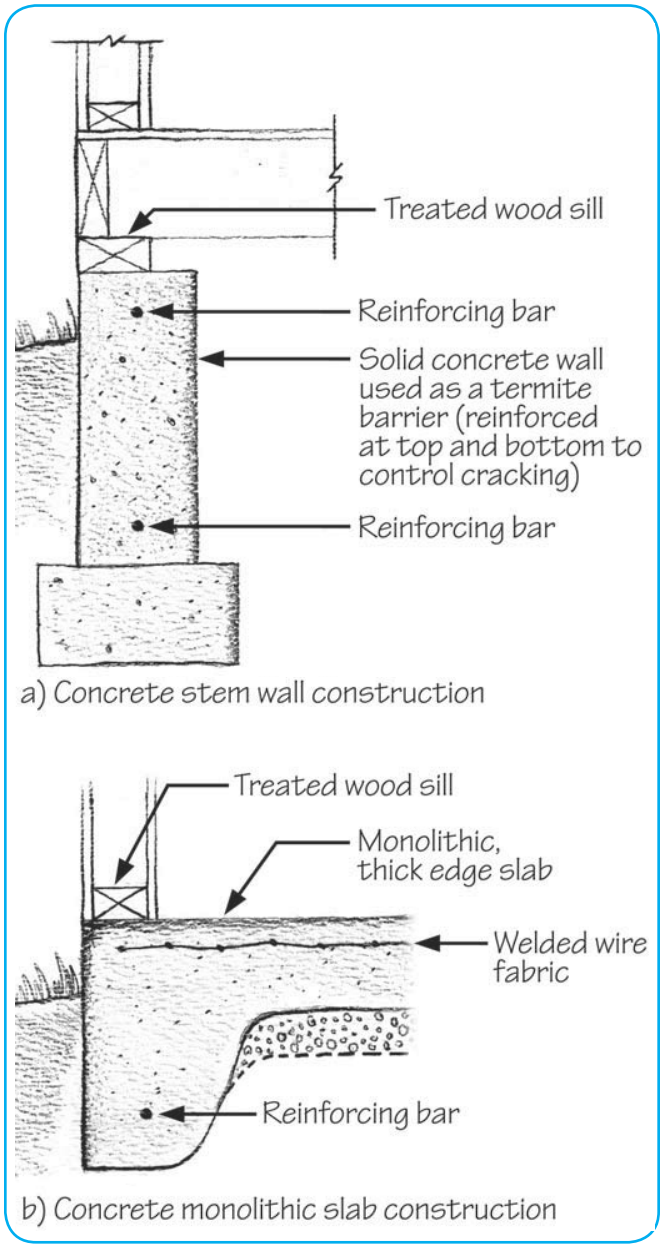


Figure 6.4 - Use of Concrete as a Termite Barrier

CHAPTER 7 | PROTECTION AGAINST DECAY AND CORROSION

7.1 General

At a moisture content of greater than 25 percent, wood is subject to fungal attack or decay. Decay will be rapid when the temperature is in the range of 70 to 85oF. The potential for wood decay when exposed to the outdoors, therefore, varies in accordance with climate (refer to Decay Hazard Map, Chapter 4, Figure 4.3). However, wood exposed to excessive moisture within any building wall in any climate, particularly one with a low drying potential (refer to Chapter 4), will grow mold and rot.

As it is for termites, wood is a food source for certain molds when conditions are right. Therefore, it is generally recommended that untreated wood be maintained in conditions where the moisture content does not exceed 20 percent.

There are essentially three options for preventing wood decay:

- Protect (or separate) wood from moisture;
- Use naturally decay-resistant wood; or
- Use preservative treated wood.

Of equal concern to the exterior use of wood material is the corrosion resistance of fasteners that must hold wood joints firmly together. Finally, it is important to consider cost-effective alternatives to wood that offer potential durability and maintenance benefits. In combination with measures presented earlier in this guide, particularly Chapter 4, recommendations in the following section should address all of the major concerns regarding durability of wood construction.

Naturally decay-resistant wood species include black locust (often used as fence posts) and heartwood of baldcypress, redwood, and cedar. Due to cost and scarcity of these wood materials, however, preservative treated wood is generally the favored choice unless aesthetics demand otherwise. Of course, alternatives to wood such as concrete, masonry, or steel construction may also be considered.

7.2 Recommended Practices

7.2.1 Recommendation #1: Separation from Ground

One of the oldest and most trustworthy practices to prevent wood decay is separation from constant uptake of moisture from the ground. In most normal outdoor exposures, wood will come to an equilibrium moisture content of less than 20 percent, although short periods of greater moisture content can occur. When enclosed in building construction, the moisture content of wood will typically reach equilibrium with the surrounding environment at a moisture content of 8 to 12 percent. However, in constantly damp locations or in conditions of extremely high humidity, the moisture content will increase up to the saturation moisture content of wood (approximately 30 percent). In most cases, this condition is related to the lack of adequate separation from ground moisture. Damp conditions can occur when wood is in direct contact with the ground or when wicking through other materials such as concrete or masonry occurs. Some well-known, code-required details for separation of wood from ground moisture are shown in Figure 7.1. If this separation is not possible, and as a reasonable precaution in all cases, wood sills and other members in direct contact with the ground or concrete/masonry near the ground level should be preservative treated.

7.2.2 Recommendation # 2: Exterior Wood Protective Finishes

Another method for protecting wood from moisture is to apply a protective wood finish. The options for exterior wood finishes are wide ranging and include the following options:

- Natural weathering
- Water repellents
- Water repellent preservatives (pigmented and non-pigmented)
- Pigmented penetrating stains (semi-transparent)
- Solid color stains
- Paints

Outside of aesthetic preferences, the choice of the best finish and its effectiveness will depend on the type of wood, its surface condition, and the climate, among other factors. For example, the smoother a wood surface, the less effectively a finish will adhere or penetrate. Boards with a vertical or edge grain (i.e., cut radially across the growth rings of a log) result in much more durable finishes than the more common flat grain (i.e., cut tangentially to the growth rings) for reason of differences in tendency to shrink, swell, and cup (warp). Edge grain lumber also weathers better than flat grain. The more dense a wood is, the less effectively a finish will adhere or penetrate. Hardwoods often require special preparation due to pores in the wood. Finish life is decreased because of high shrink-swell potential in moist environments. However, in protected environments (such as interior flooring) hardwood floors are known for their beauty and durability. In all cases, the moisture content of the wood must be sufficiently low (i.e., less than 20 percent) to allow for proper application of a durable and effective exterior finish. Wood composites (including veneers such as T1-11) that have the potential to swell require special protection from moisture and should not weather naturally.

Exterior wood finishes require vigilant, periodic maintenance. However, in normal climate conditions, a good exterior wood paint finish should last up to 10 years and stains for as long as 5 years before diminished function or appearance. Water repellents and water repellent preservatives generally require more frequent retreatment, but the treatment effectiveness and longevity improves as the wood weathers and becomes able to absorb more of the treatment. Penetrating stains also experience this effect and will increase in effectiveness during the second and subsequent treatments, with service life extending to as much as 10 years between treatments.

The most important factors to consider are:

- Choosing the most appropriate and cost-effective wood material;
- Matching the selected wood material with a compatible finish;
- Applying the finish properly; and
- Educating the owner on the need for periodic maintenance.

All of these factors will not be very effective without proper moisture control, particularly for natural (untreated) wood siding and trim materials. Refer to Chapter 4 for guidance on measures for moisture control with specific interest in the use of weather barrier construction, vapor retarders, flashing, and overhangs. Overhangs are important in that they modify the exposure that siding and trim materials will experience, and enhance the service life of the finish.

The types of performance problems that may be experienced with finishes when the above factors are not appropriately addressed include:

- Moisture penetration
- Mildew
- Wood pigment staining ("bleed through")
- Peeling
- Blistering
- Checking
- Cracking and "alligatoring"
- Excessive chalking

There are numerous types of paints, stains, and preservatives with varying cost and performance. It is beyond the scope of this guide, however, to go into great detail about the various products. Neither does this guide address special considerations regarding the repainting of wood or painting of other materials, such as galvanized or plain steel. Refer to the following references for a more detailed treatment of exterior and interior wood finishing:

- *Finishes for Exterior Wood* (Forest Products Laboratory, USDA, 1996); and
- *Builders' Guide to Paints and Coatings* (NAHB Research Center, 1993).

The recommendations given in Table 7.1 are intended to give the best exterior finish results for typical conditions and a wide variety of wood materials commonly encountered in home construction and exterior finishing applications.

Judging Paint Quality

The quality of paint is generally determined by the following factors and is usually correlated to price:

- High solids content,
- Low ratio of pigment to vehicle, and
- Type of binder or vehicle.

Unfortunately not all paint labels include the above information. Therefore, consult a paint specialist or the manufacturer for additional information; otherwise, it is generally safe to assume that cost is directly related to quality. When considering price, it is important to realize that paints with less solids content may result in the need for more coats to provide adequate coverage. Therefore, it is usually cost-effective to invest in high quality paints. In general, low gloss or flat paints (high pigment to vehicle ratio) use more pigment content

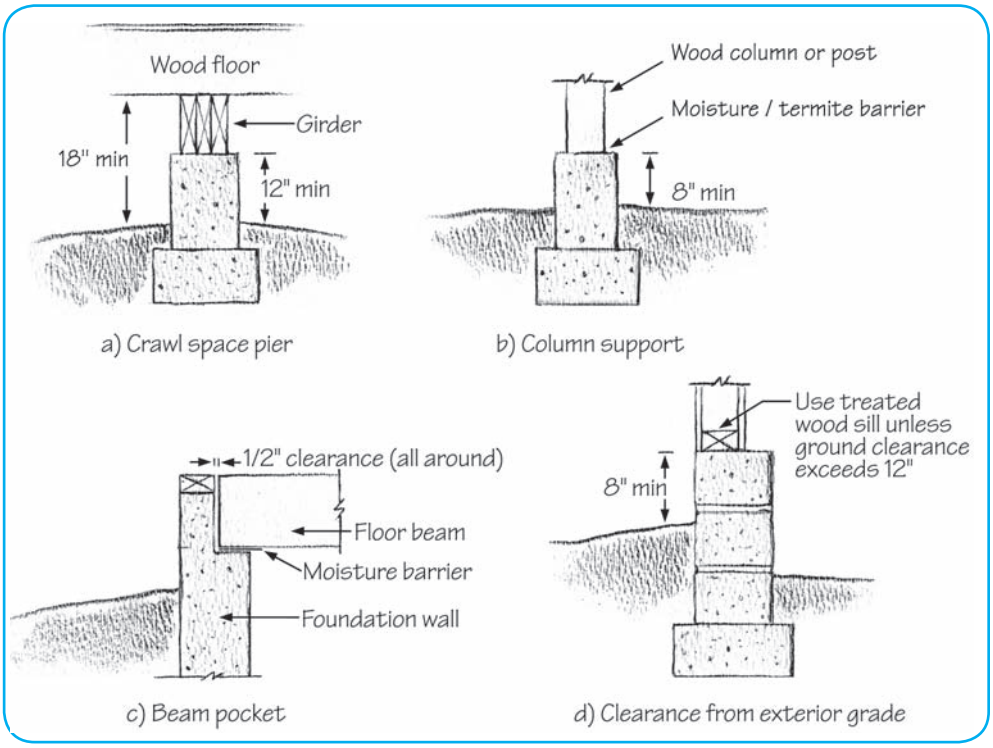


Figure 7.1 - Details to Separate Wood from Ground Moisture

TABLE 7.1 - RECOMMENDED FINISHES FOR EXTERIOR WOOD

Wood Material	Applications	Finish Recommendations (Preferred option is bold)[1]	Special Enhancements
Untreated (natural) wood	Siding, Trim, Railings, and other items not in ground contact	**Paint:** Prime all sides with acrylic latex "stain blocking" primer Apply two coats of all-acrylic latex house paint[4] Opaque stain (latex)[5]: Use same procedure for paint (best for rough surfaces).	(a) Treat end joints with a "paintable" water repellent preservative; allow 2-3 days to dry prior to painting; (b) Top coats and primer should include mildew-cide
Treated wood[2]	Decks, Columns, Framing, Fascia Boards, Trim	Paint: Same as above Opaque stain (latex)[5]: Use same procedure for paint; do not use on decking (best for rough surfaces) **Semi-transparent stain:** Best for wood decks and general use on treated wood; apply two coats	(a) Treated wood is usually high in moisture; let dry for several weeks prior to application of finish (b) Best if wood is slightly weathered for penetrating stain
Naturally decay-resistant wood	Siding , Trim, Decking, Columns, Framing, etc.	Semi-transparent stain: Same as above for treated wood (use decay-resistant wood) **Water-repellent preservative:** Apply two coats; use pigmented version if natural wood color is not desired or use semi-transparent stain for deeper color modification Water repellent: Apply two coats	Painting as for non-decay-resistant wood is also applicable; special care should be taken to make sure stain blocking primer is used.
Wood Composites[3]	Siding, Trim	**Paint:** Same as above for untreated (natural) wood. Opaque (solid color) stains[5]: Same as above for paint; works best on rough surfaces such as T1-11 siding	(a) Treatment of end joints/cuts particularly important to prevent edge swelling (b) Penetrating stains and other "natural" finishes should not be used (c) Use of overhangs as additional protection should be considered depending on climate

General Application Recommendations:

- All surfaces should be clean and dry.
- For painted surfaces (including opaque stains) that are very smooth, the surface should be lightly wetted and allowed to dry for several days, then sanded with #50 to #80 grit sand paper.
- Do not apply paint when temperatures are or will soon drop below 50°F or when heavy dew is suspected prior to complete curing. Avoid painting surfaces that will soon become heated by the sun (i.e., follow the sun around the building).
- Closely follow manufacturer application instructions and coverage recommendations. Coverage is generally around 400 ft^2 per gallon for paint and opaque stains and 200 ft^2 per gallon for penetrating stain. Rougher surfaces will reduce coverage amount per gallon.
- Multiple coats: For penetrating stains, time between coats should allow for drying; for water repellent preservatives, time between coats should not allow drying; for paints, time between coats should allow 2 days for curing, but not more than 2 weeks.
- Brushed on finishes (especially using back brushing technique) will generally improve finish coverage, penetration, and/or adherence to the wood surface.
- Use corrosion resistant fasteners; deformed shank nails should be considered for siding and trim attachment; stainless steel nails should be considered for natural wood finishes. Use hot-dipped galvanized nails for treated wood.
- Use of furring behind siding to create an air gap will increase finish and wood siding service life.

Notes:

1 Based on a subjective consideration of general aesthetics and, primarily, durability relative to other choices.

2 Treated wood refers to wood treated with water-borne preservative such as Copper Chromium Arsenate (CCA). CCA is paintable and stainable and the wood treatment can actually enhance finish performance provided the wood is dry and the surface is not very smooth or weathered. Weathering, however, does enhance the application of penetrating stain.

3 Wood composites include OSB, plywood (i.e., T1-11 textured siding panels), and fiber board or hardboard. Follow manufacturer application, installation, and finishing instructions carefully when using these materials.

4 Paint top coats are generally applied after installation, although the first top coat may be applied prior to installation on all sides, but more importantly the end grain and exposed sides. Second top coat may be omitted if coverage is sufficient and when used only on sides of the building not facing south or west; however, this may shorten the expected service life.

5 Opaque stains are not recommended for horizontal surfaces such as trim and window sills, and it is particularly not recommended for wood decking. Opaque stains work best when applied to rough, un-weathered vertical surfaces.

and are less durable than gloss paints; and latex acrylic paints are more flexible and resilient than oil-based (alkyd) paints. Regardless of the paint selected, application instructions provided by the manufacturer should be carefully followed for best results. Many people falsely believe that painting wood will stop decay. In fact, painting wood that has already begun to decay can trap moisture and promote decay. Paint is primarily used as an aesthetic finish that also serves to protect wood from intermittent wetting (as from rain) and weathering from sunlight (UV radiation). A good quality (moisture resistant) paint will help to moderate the moisture swings through which exterior wood would otherwise be exposed. If frequent wetting occurs to painted wood, it may even be more likely to decay than unpainted wood if not properly maintained, particularly at end joints of lumber trim, siding, and window and door casings.

Wood absorbs moisture nearly 30 times more rapidly through the end grain than through its sides. If moisture is absorbed, painted wood will tend to dry slower than unpainted wood and accelerated rotting can occur near end joints. Therefore, it is always a good practice to keep joint designs simple and to pre-treat all end joints with a water repellent preservative prior to installation and finishing.

7.2.3 Recommendation #3: Preservative Treated Wood

Where wood cannot be protected from moisture or where its service requirements demand resistance to constant moisture exposure, preservative treated wood must be considered for durability purposes. Untreated wood in ground contact or exposed to constant moisture in exterior above-ground applications will rot within a short period of time, generally less than two years.

The most common wood preservative treatment is Copper Chromium Arsenate (CCA). In fact, 98% of all water-born preservatives used to treat wood in 1997 was CCA (source: American Wood-Preservation Association, Wood Preservation Statistics, 1997). CCA, which leaves wood with a light-greenish tint, has excellent decay resistant qualities when properly specified. It lasts more than 30 years without decay in exposure tests when properly treated. CCA also repels insect infestation. The most important characteristic for proper treatment is the amount of chemical that impregnates the wood and that is retained after treatment. Recommended retention levels for CCA are given in Table 7.2.

There are several other CCA-like treatments (e.g., ACQ, boric acid) that require similar levels of retention for effectiveness. It is also worth noting that that CCA is not the recommended treatment for every species of wood. In the west, for instance, Douglas fir treated with CCA shows poor performance.

Some pointers to ensure good performance of treated wood are as follows:

- Allow several weeks for treated lumber to dry before installation (it is generally wet due to the water-borne treatment process); if installed wet, fasten securely to prevent warping and back-out of fasteners.
- For treated wood that is to be installed immediately or painted, consider specification of "kiln-dried after treatment" (KDAT) lumber.
- Treat field-cut ends of preservative treated lumber with an over-the-counter wood preservative; for thick lumber, preservative treatment does not penetrate to the middle of the member.
- Put factory cut and treated ends in the more severe location (e.g., ends of posts in ground).
- Use preservative treated lumber that is labeled and certified by an American Lumber Standard Committee (ALSC) inspection agency and that is treated in accordance with American Wood Preservers' Association (AWPA) standards.
- Once dry or slightly weathered, treat exposed wood with a penetrating stain and water-repellent (unless other finishes are desired).
- Do not use opaque stains or latex paints on deck surfaces; use only special "deck" paint if solid color is desired.

7.2.4 Recommendation #4: Fasteners and Corrosion Resistance

Depending on application conditions, there are several options for fastener selection. Fasteners used within a building's weather barrier are generally protected from corrosion and, therefore, do not usually require special consideration regarding durability. However, in exterior exposures, the durability of fasteners and metal connectors is a major issue. The following recommendations are intended to give reliable, long-term performance:

- Siding nails, as well as nails in treated wood exterior framing (i.e., decks) should be galvanized (preferably hot-dipped). Bolts should also be hot-dipped galvanized rather than electroplated.

TABLE 7.2 - RECOMMENDED PRESERVATIVE RETENTION LEVELS FOR CCA-TREATED LUMBER

Application	Retention (lb. per cu. ft. of wood)
Above grade (decking, trim, railings, etc.)	0.25
Ground contact (sills, posts, not in ground)	0.4
Foundations (below ground)	0.6
Marine	2.5

- In particularly severe environments (e.g., exterior construction subject to salt-spray from the ocean), stainless steel fasteners and hardware should be considered, although thicker than normal galvanic coatings (i.e., G90 or higher) are acceptable. Situations in which galvanized metal fasteners, such as joist hangers, are subjected to periodic salt deposition without the possibility of rinsing from rain (e.g., under a deck) should be avoided.
- Stainless steel siding nails are often used to prevent rust staining in any environment; deformed shank siding nails are also preferable to prevent nail back-out caused by moisture cycling of the wood.
- Siding and roofing nails should be installed in dry wood. Wet wood, when it dries, will lose some of its holding power on the nail.

Proprietary coatings on pneumatic fasteners are available and should be used only as recommended by the manufacturer. These coatings are generally similar to electroplated galvanic coatings, but special alloys are sometimes used to enhance corrosion resistance. Mechanically coated nails are also found in the market with coating thickness and characteristics similar to electroplated galvanic coatings. Galvanic coating thickness and environmental conditions are the primary factors in determining the time until the onset of rust. Service life of nails under normal exterior conditions is shown in Table 7.3.

TABLE 7.3 - NO-RUST SERVICE LIFE OF NAILS EXPOSED TO NORMAL OUTDOOR ENVIRONMENT

Nail Type	Coating Thickness, mils (1/1000 of inch)	Service Life
Galvanized (electroplated or mechanically plated)	0.2 (varies)	5 - 10 yrs
Hot-dipped galvanized	2 to 6	20+ yrs
Stainless Steel	N/A	50+ yrs

Other non-corrosive metals may also be available for some types of fasteners (e.g., copper or aluminum). However, aluminum and copper can be reactive with other metals or environmental conditions. For example, aluminum or copper nails should not be used with galvanized metal connectors. For best results, fasteners and attached metalic materials should always be of the same type of metal.

7.2.5 Recommendation #5: Alternatives to Wood Exteriors

As a final recommendation to prevent the decay of exterior wood, there are many new products available that serve as replacements to wood. Recently, several engineered wood composites have been introduced and subsequently encountered durability failures (see Section 2.5—Common Performance Problems). This has left many builders skeptical of engineered wood products for exterior use. However, with suitable installation and climate conditions, most engineered wood products have performed well. Similarly, exterior insulation finish systems (EIFS) encountered serious problems related to durability and moisture damage. On the other hand, some products like vinyl siding and vinyl-clad or vinyl windows have been used with great success and increased frequency. Therefore, it is worthwhile for designers and builders to consider new materials that offer promise of durability or affordability, or both. Some of these prducts include:

- Vinyl siding and trim products;
- Vinyl windows and doors;
- Plastic trim products;
- Plastic coated foam, molded plastic, or fiberglass trim products that are UV-resistant and that are paintable/stainable;
- Plastic lumber decking and posts;
- Fiber cement siding and trim products; and
- Fiber cement boards, siding, and trim.

Most of these products have been in use for some time and, if required, include UV inhibitors to protect against dry rot.

Untreated, non-decay resistant wood species exposed to the weather (without ground contact or protective coating) will generally last between 2 and 20 years depending on the severity of the climate (see Decay Index Map, Figure 4.3). On the other hand, properly treated or naturally decay-resistant wood will last more than 20 years without significant decay, almost regardless of climate.

Although many new materials can provide desirable qualities, an "old-timer" with a taste for tradition may desire traditional products. In this case, the builder or the client must be willing to pay to get some of the expensive naturally-decay resistant wood products that are still available, such as straight grain red cedar or heartwood Douglas fir. Alternatively, treated wood that can be used with paints and stains may be selected. Coating manufacturer recommendations should be carefully consulted.

The most important concern is to choose appropriate siding and trim material and detailing for the climate. In severe climates (e.g., hot and humid), it may be wise to remain conservative or at least to run "field test" on a shed or some other harmless application. When experimenting, purchase a moisture meter and take the time to observe the performance of the new product as well as some of your current materials and methods. It is always best to run "side-by-side" comparisons of

identical buildings. Alternatively, you may receive some help in performing your own tests or certified laboratory tests by calling the ToolBase Hotline at 800-898-2842 or sending your request for information to askanexpert@nahbrc.org. ToolBase is a service of the NAHB Research Center and is sponsored by NAHB, CertainTeed, HUD, the North American Steel Framing Alliance, the Wood Truss Council of America, the Wood Promotion Network, and others.

CHAPTER 8 | NATURAL HAZARDS

8.1 General

Severe damage to homes is often seen in media reports following major natural disasters, such as Hurricane Andrew in Florida and the Northridge Earthquake in California. As a result, the most prevalent (and less interesting) forms of damage that have "common sense" fixes are rarely given the degree of consideration they deserve.

From past scientific surveys of hurricane damage, it can be seen that damage to roofing and water damage to contents are the most frequent and costly repairs. For example, damage statistics for Hurricane Andrew and Hurricane Opal (Florida) are shown in Table 8.1. It can be seen that the most significant forms of damage were associated with roofing loss. In Hurricane Andrew, a particularly severe Category 5 event, roof sheathing loss and window breakage were also prevalent. Since the data presented in Table 8.1 was collected using a random sample of the housing stock in each event, the findings approximately represent the overall housing stock performance.

Light wood-frame homes are well-known for their resiliency in earthquake events as evidenced by the low frequency of collapse, even in extreme earthquakes. However, because homes are the most common type of structure, they account for much of the overall damage, but usually in the form of cracked interior and exterior finishes. As shown in Table 8.2, more serious forms of structural damage to foundations and walls are a relatively rare occurrence.

Based on the above data, which identifies key issues related to durability of homes in natural disasters and places them in the proper perspective, the following section gives some recommended practices to improve performance at a modest cost. Other forms of disaster include wildfires, hail, tsunamis (tidal waves), etc. For fire resistance, fire resistant siding and roofing materials as well as landscaping that reduces fuel sources near to the home may be used. For hail, resistant roofing products, such as tile or specially rated asphalt shingles, may be considered. Properly installed metal roofing is also a good option for wind, hail, and fire resistance.

TABLE 8.1 - HURRICANE DAMAGE STATISTICS (SINGLE-FAMILY HOMES)

Component	Frequency of Moderate to Severe Damage (% of all homes)	
	Hurricane Andrew [165 mph gusts]	Hurricane Opal [100-110 mph gusts]
Roof sheathing	64%*	2%*
Walls	2%	0%
Foundation	0%	0%
Roofing	77%	4%
Interior finish	85%	Unknown

Sources:

(1) NAHB Research Center, Inc., Assessment of Damage to Single-Family Homes Caused by Hurricanes Andrew and Iniki, U.S. Department of Housing and Urban Development, Washington, DC, 1993.

(2) NAHB Research Center, Inc., Assessment of Damage to Homes Caused by Hurricane Opal, prepared for the Florida State Home Builders Association by the NAHB Research Center, Inc., Upper Marlboro, MD, 1996.

* Percent value of homes which lost one or more roof sheathing panels.

8.2 Recommended Practices

8.2.1 Recommendation #1: Hurricane-Prone Areas

The following recommendations will assist in improving the durability of homes in areas prone to frequent high winds resulting from tropical storms or hurricanes:

- Nail roof sheathing according to manufacturer's fastening schedule, using pneumatic or hand driven 8d deformed shank fasteners or screws.

TABLE 8.2 - NORTHRIDGE EARTHQUAKE DAMAGE STATISTICS (PERCENT OF SINGLE-FAMILY HOMES)

Component	No Damage	Low Damage	Moderate Damage	High Damage
Foundation	90.2%	8.0%	0.9%	0.9%
Walls	98.1%	1.9%	0.0%	0.0%
Roof	99.4%	0.6%	0.0%	0.0%
Exterior finish	50.7%	46.1%	2.9%	0.3%
Interior finish	49.8%	46.0%	4.2%	0.0%

Source: NAHB Research Center, Inc., *Assessment of Damage to Residential Buildings Caused by the Northridge Earthquake,* prepared for the U.S. Department of Housing and Urban Development, Washington, DC, 1994.

- Use the "6-nail" method for attaching 3-tab roof shingles; make sure the roof deck is dry prior to installation; follow installation instructions on the packaging.
- Apply roofing cement (mastic) to the underside of shingle tabs along the roof perimeter and ridge.
- Use 15# felt roofing underlay and flashings as shown in Chapter 4.
- Use moderate sloped roofs of 4:12 to 6:12 to minimize wind uplift while avoiding large lateral loads on the building; in general, hip roofs perform better than gable roofs.
- Consider low-profile plans (i.e., a one-story home is less vulnerable than a two-story home).
- Use hurricane ties or clips to attach the roof to the walls; in severe coastal exposures make sure that the load transfers either through the sheathing or through additional brackets down to the foundation; it doesn't take much effort or hardware to make a big difference.
- If building on the beach, elevate the house above the local base flood elevation and setback as far as possible from the coastline; expect damage at some point in time—coastal exposures are quite threatening in hurricane-prone regions.
- Use the services of a knowledgeable design professional for complex or "non-conventional" plans; make sure the detailing is clearly shown on the plans or construction shop drawings prior to the start of construction.

8.2.2 Recommendation #2: Earthquake-Prone Areas

For areas prone to earthquakes, the following practices may be used to improve durability:

- Use continuous wood structural panel sheathing on all exterior walls.
- Avoid stucco and similar brittle exterior finishes (cracks will be apparent and require repair in moderate to strong events and may also leak in future rain); however, stucco can provide a very stiff and strong building that also minimizes interior finish cracking in moderate earthquakes.
- Avoid steeply sloped sites or sites with "soft" soils that may liquefy during ground shaking.
- Consider low profile plans (i.e., one-story instead of two-story home).
- Avoid heavy roofing materials.
- Use the services of a knowledgeable design professional for complex or non-conventional plans in hazardous earthquake regions.
- Secure heavy equipment such as water heaters and storage tanks and use flexible gas lines to natural gas appliances.
- Advise homeowners to secure furnishings, such as bookshelves and wall hangings, to prevent damage or injury.

8.2.3 Recommendation #3: Inspection

Generally, connections are a key area where wind damage occurs and, to a lesser degree, earthquake damage in single family homes. Care should be taken to inspect for the proper connection of roof and wall sheathing, as well as any required brackets or metal connectors. In high wind areas, inspection of roof sheathing nails into a gable end truss (gable roof) is particularly important. To obtain thorough inspection, some builders and designers include special inspection services within the scope of contracts as a matter of business practice.

To assist builders and framers in obtaining the maximum level of quality possible, the NAHB Research Center has initiated the Framing Quality Assurance Program (1-800-638-8556). The program is ISO 9000 based and requires adoption of effective quality procedures as well as periodic auditing by a third party.

8.2.4 Recommendation #4: Flood-Prone Areas

Flood-prone areas include many coastal zones subject to storms as well as land near waterways that periodically experience flooding. A few simple design considerations for these areas that can increase house durability include:

- Install components like HVAC blowers, electrical receptacles, and hot water heaters at elevated locations in basements. This practice can make recovery easier and less hazardous.
- Consider the use of back-flow restriction valves to reduce the risk of sewer water backup into houses during flood events.
- Do not build in the 100-yr flood plain or follow appropriate construction guidelines and regulations for flood-resistant construction (i.e., elevated foundation).
- Do not use moisture-sensitive building materials and finishes below the first above-grade floor.

CHAPTER 9 | MISCELLANEOUS

9.1 General

The previous chapters of this book have dealt with significant durability issues that can impact the functionality and livability of a home. There are other durability-related issues in homes that do not necessarily increase the risk to the structure or the occupants, but which, nevertheless, are often quite important to occupants. The presence of these nuisance items often lends to perceptions of poor quality and durability. The consumer is no less concerned with these nuisances than a leaking window caused by improper flashing or a damp basement caused by inadequate site drainage. Nuisances include items such as nail pops or premature wear of a product or surface. This chapter focuses on how to address expectations when dealing with some of the more common problems in this category.

One of the largest obstacles to overcome is separating normal wear and tear from premature wear. As in other parts of the home, this requires understanding and managing expectations. For example, carpets, paints and other interior finishes are generally expected to wear out over time. Although there are certainly better grades of these products, they often come with a higher cost. In other words, consumers need to understand that they usually "get what they pay for" when selecting finish materials. Because there is some amount of personal choice involved in selecting finish materials, this document does not attempt to prescribe one type of product over another. However, where appropriate, some options are identified where different types of finishes may prevent premature wear or prevent common problems with finishes.

Recommendation #1: High Traffic Areas

Use wear-resistant surfaces in high traffic areas. Bathrooms, kitchens, and entryways face more severe exposure than other areas of the home. Old standbys like tile, hardwood, and vinyl certainly are good products for some of these areas. Also consider some of the new laminates that give the look of wood but which have better resistance to wear and scratches. A newer trend that appears to be growing is the use of stained or pigmented concrete floors.

Recommendation #2: Finish Selection

Select finishes and colors that can mask dirt in high traffic areas. In addition to wear in high traffic areas, keep in mind that darker colors are better at masking dirt carried in from outside. Although nearly all carpets today are better at resisting stains, evidence suggests that lighter colors contribute to complaints about carpet soiling (see next section).

Recommendation #3: Carpet Soiling

Carpet soiling is a phenomenon where soils, combustion particles, and other particulates accumulate at the base of walls, under interior doors, and other areas. The result is dark, linear stains along these surfaces. In the most severe cases, it cannot be removed by cleaning. Carpet soiling can be minimized through the use of darker carpet colors, multiple return-air grilles (as opposed to central returns), passive returns or jump ducts from bedrooms, and occupant education about the implications of using candles in the home.

Recommendation #4: Stuck Windows

Windows and doors can stick or be difficult to open and close for a number of reasons. Problems typically result from the swelling of framing around openings or excessive deflection in headers.

One way to reduce header deflection is to size the headers with sufficient stiffness. It is important to recognize, however, that even with proper sizing, temporary deflection and even permanent deflection can occur and possibly interfere with window operation. A common practice that contributes to inoperable windows is shimming between the window frame and the header. This space should be left open to allow for deflection of the header.

To avoid the swelling of materials and subsequent problems with the operation of doors and windows, the entry of water must be prevented by the use of proper drainage and flashing details. It is very important to ensure that siding is installed according to the manufacturer's specifications. Do not assume that the same details that work with one type of exterior finish will work with others or that all windows or doors are the same with respect to the frame's water tightness. Finally, when using an air-sealing foam to plug air leaks around window frames, use low-expansion foams that don't deflect the frame as they expand and harden. Non-expanding products, such as caulk or fiberglass, can be used instead. However, some window manufacturers void their warranties if such products are used around their window frames.

Recommendation #5: Nail Pops and Drywall Cracks

Cracks, visible seams, and nail pops are some of the most common interior finish complaints lodged by homeowners. Although it can't be guaranteed that a home will be immune from these problems, some strategies can be adopted to minimize their chances of occurring. One strategy calls for developing specifications for drywall and framing contractors that clearly outlines expectations. Another equally important strategy is follow-up supervision of contractors. During construction, consider adopting the following:

- Install finishes only to sufficiently dry lumber (i.e., 12% moisture content or less) and use a moisture meter to check conditions.
- Heat homes and keep humidity low to limit chances that joint compound will cure either too quickly or slowly and cause seams to crack.
- Reduce shrinkage that causes nail pops and cracks by specifying only kiln-dried lumber.
- Hang drywall to minimize joints directly at the ends or over headers or other openings.
- Consider stiffer floor and ceiling framing to minimize deflection that can create cracks along seams.
- Use two-stud corners and drywall clips to minimize cracks at outside corners.
- When installing drywall on ceilings, float (i.e., do not fasten) the ends of the sheets at wall intersections. This will avoid cracking if the trusses move.

Recommendation #6: Floor Squeaks

Noisy floors are one of the most common callback problems for builders. Floors, like other parts of a home, are subject to movement. The most typical noise is related to loose nails or other fasteners that squeak when a person walks across the floor. Sometimes, noise is the result of movement of the floor sheathing when attachment is insufficient (too few fasteners) or when the sheathing is not pulled tight to the joist. In other cases, fasteners that miss the floor joist below and end up alongside the joist create noise when the joist deflects and the nail rubs against it. Recommendations include:

- Use only kiln-dried lumber, which is marked "KD."
- Install the correct number, spacing, and type of fastener into the sheathing. Specify these items to your trade contractor.
- Consider screws or deformed shank nails as opposed to smooth shank nails to reduce movement of the fasteners.
- Consider the use of adhesives to help limit sheathing movement. Adhesives can stiffen the floor and reduce bounce. But be careful—an adhesive that sets up too soon (e.g., in cold weather applications) can contribute to squeaks by preventing the sheathing from pulling tight to the floor joists.

Recommendation #7: Subfloor Material

Select subfloor material keeping in mind the finished floor, the tolerance of the flooring for unevenness, and the expected weathering that the subfloor will experience during construction. One option is to use special moisture-resistant oriented strand board (OSB) subfloor sheets to reduce edge swelling when exposure to moisture during construction is unavoidable.

Recommendation #8: Paints and Corners

Consider application-appropriate paints to keep walls fresh looking. Glossy paints are easier to clean and should be considered for use on doors, trim, and other high traffic areas. Flat or matte finishes give a softer, more appealing texture for interior wall surfaces while hiding imperfections. Fortunately, there are now paints on the market that come with a flat finish but are washable. These make a great finish in areas such as kitchens, mud rooms, bathrooms, and children's rooms when a flat look is desired.

Also, consider the durability of wall corners to reduce dents, chips, and other damage by occupants by using prefabricated corners to aid in damage reduction. For more information about available products, see the PATH website at www.pathnet.org.

9.2 Plumbing

Recommendation #1: Pipe Material

Choose the right plumbing material for the water supply and local conditions. In most locations of the United States, copper and plastic (e.g., CPVC) are viable products. But sometimes, one is advantageous over the other. It is often advisable to check with local plumbers and code officials to determine if there is a history of local conditions that would lead to a preference for a certain material. For example, are there reports of aggressive soils or water that may attack the material?

Recommendation #2: Washing Machine Leaks

One of the leading causes of insurance claims is water damage from burst washing machine hoses. With the trend toward finished basements and the increasing placement of laundry areas on main floors and second floors, the potential for damage is increasing. Simple tools to remind homeowners to inspect/replace hoses (e.g., magnets with inspection schedules to fill out) are available. Care should also be taken to address drainage in case a leak occurs. A drainage system and catch basin large enough to accommodate the washing machine and the area surrounding the hose connection is always recommended. When replacement hoses are purchased, high quality hoses should be selected.

Recommendation #3: Frozen Pipes

In cold climates, protect water pipes against freezing. The best approach is to keep all water pipes within the thermal envelope. This becomes difficult in vented, unconditioned crawlspaces where risers may need to be insulated and operable vents should be closed in the colder periods of the year. Alternatively, an insulated, unvented crawlspace can be used (see Section 4.2.6).

Recommendation #4: Plumbing Units

Select certified kitchen and bath fixtures to reduce the possibility of premature failure. Tubs, sinks, shower stalls, and countertops of every type and grade should meet some minimum standards to prevent chips, cracks, leaks, or excessive wear and tear. Look for the NAHB Research Center label or other label from a reputable quality assurance agency that lists these products.

Recommendation #5: Bath Room Design

Consider use of seamless tub and shower units to reduce reliance on sealants. Inspect for leakage around bathroom fixtures and replace seals and sealants as required. Use cement-based backer board behind tile finishes.

9.3 HVAC

The issues with HVAC systems primarily relate to comfort, and in a few cases, potential moisture problems. As a side benefit, actions taken to address these issues generally tend to improve the energy efficiency of the home.

Recommendation # 1: Duct Leakage

Leaky ducts can lead to a host of problems—dry air, humid air, condensation, among others. The problems that can occur depend on the location of ducts and the climate. The safest bet is to simply build tightly sealed duct systems. Tight ducts will alleviate potential problems and increase the efficiency of an HVAC system. Designing the home with the duct system entirely within the thermal envelope also helps to head off problems.

Recommendation #2: House Air Leakage

Keep air infiltration through cracks in the building envelope to a low level. Like a leaky duct, a leaky structure also brings in outdoor air and can result in uncomfortably dry indoor conditions during the heating season. Air sealing is becoming a more common component of the energy package for homes and is an effective practice with or without the inclusion of a separate air barrier (i.e., building wrap). But, be aware that an aggressive approach can make a home too tight, which results in the need for supplemental ventilation. A blower door test can be performed to estimate the air infiltration rate.

Recommendation # 3: Load Sizing

Use proper methods such as Air-Conditioning Contractor's Association (ACCA) Manual J (software version is called Right-J) for determining design heating or cooling loads and HVAC equipment sizes. Rules of thumb for sizing should not be used.

Bigger is not always better! Oversized equipment can lead to moisture problems since the air-conditioner may not run long enough to adequately dehumidify indoor air during summer cooling months.

Recommendation # 4: Exhaust Ventilation

Use exhaust fans in all full bathrooms and near other moisture sources in the house, such as kitchen ranges. With larger floor plans and more interior-room bathrooms in homes, moisture from showering has no place to go without an exhaust fan.

Bath fans are often rated for a specific flow at 0.1" water column (wc). This static pressure roughly correlates to an air grille, five feet of 3-inch flex duct, and an end point cap. As-built installations are commonly more extensive than this, and static pressure levels are greater. Therefore, fans will often exhaust as little as Ω of their rated capacities due to long duct runs, hoods, and grilles. It is often advisable to select a fan based on airflow at 0.25" wc. Rated flow is usually listed on the fan packaging, or consult manufacturer's literature. Alternatively, use of a 4-inch or larger diameter fan duct will result in improved air flow in comparison to standard units with 3-inch diameter ducting. Also, rigid metal duct is less restrictive than "flex" duct.

9.4 Exterior Finishes

Recommendation #1: Drainage

Provide positive drainage away from patios, sidewalks, driveways, and other concrete flatwork to reduce frost heave and other water-related damage. Drainage starts with a solid base/subgrade and ends with proper grading at a 2% or greater slope...airentrained concrete can also help improve durability.

Recommendation # 2: Siding Installation

Check siding for appropriate installation to avoid buckling. Vinyl and metal sidings expand and contract from changes in temperature. Nearly all of these products should not be nailed or screwed tight to the structure, but rather, they should be "hung" from the nail or screw to allow for movement. It is also important to leave room where the siding abuts channels or corner trim. When properly installed, each piece of siding should be able to move sideways and up and down slightly.

A problem that commonly occurs with horizontal siding is buckling at rim joists as a consequence of shrinkage of the large dimension lumber. To avoid potential callbacks, consider engineered wood (i.e., OSB) for rim joists. If engineered wood rim joists are used, however, special details for anchoring decks to the house must be used because the web section of many engineered wood joists is not suitable for this purpose.

Recommendation # 3: On-Site Conditions

Protect doors, floor sheathing and other products against delamination or swelling by keeping them protected from the elements when stored at the job site. This practice addresses long-term problems that are not immediately noticeable, such as slight bumps in the floor at cut edges of sheathing that cause increased, localized wear of floor coverings. Other problems that result from site conditions can become noticeable very quickly. Examples include warping of wood products, staining or mold growth, and weakening of some materials.

The best approach is to minimize exposure of sensitive products to the elements. Inspect materials for pre-existing damage when they arrive on site. Stage construction so that sensitive materials are covered as soon as possible or provide a dry storage area for these products.

GLOSSARY

Air barrier (also known as air retarder)—material(s) used in design to reduce the flow of air between indoors and outside. Air barriers may also serve as drainage planes in some cases.

Building code—a set of building construction requirements developed by national bodies which are adopted and administered by local institutions to certify that buildings (residential buildings in this case) meet certain minimum standards for structural integrity, safety, and durability.

Carpet soiling—the discoloration of carpets in houses due to a combination of conditions that usually includes airflow under doors or wall baseplates and a source of dirt, soot, or airborne particulates.

Damproofing, foundation—treatment of concrete or mortar to retard the passage or absorption of water, or water vapor, usually by applying a suitable coating to exposed surfaces.

Drainage plane—the part(s) of a building's weather barrier system that exhibits a high degree of resistance to liquid water from outdoors, usually in the form of a water resistant membrane, layer, or sheet; used in combination with appropriate for flashing and sealing details at discontinuities in the wall assembly (e.g., penetrations for windows, doors, etc.) or at the drainage plane material itself (e.g., lap joints between sheets).

Drying potential—the ability or capacity of a material or combinations of materials to dry once wetted; in residential wall systems this ability is strongly influenced by the presence or absence of a vapor retarder(s) and the driving forces for drying (vapor pressures, temperature).

Durability—the ability of a material, product, or building to maintain its intended function for its intended life-expectancy with intended levels of maintenance in intended conditions of use.

Perm rating (vapor permeance)—a measure, for a given thickness, of a material's ability to transmit water vapor (1 perm = 1 gr/h* ft^2*in.Hg); a high perm rating indicates that a material can readily allow water vapor to pass through it (e.g., gypsum), a low perm rating indicates that a material will not allow water vapor to pass (e.g., plastic sheeting)

Sones—a unit of sound measurement used in HVAC applications to rate fan noise; standard bathroom exhaust fan have ratings of 4 Sones or more.

Swale—a stormwater runoff feature formed from natural materials like soil and vegetation that collects and channels water runoff; swales can serve as an alternative to curb and gutter systems, and allow for some water infiltration back into the ground instead.

Termite barrier—any building material or component which is impenetrable to termites and which drives the insect into the open where its activities can be detected.

Ultraviolet (UV) radiation—a form of energy from the sun in an non-visible wavelength that can cause chemical reactions in exposed materials and subsequent fatigue and discoloration.

Vapor retarder (also known as vapor barrier)—a layer in a building construction (wall, floor, or roof/ceiling) that restricts the diffusion of water vapor. The diffusion of water vapor can be driven by differences in vapor pressure. Water vapor will be driven from a location of high vapor pressure (i.e., high humidity) to low vapor pressure (i.e., low humidity). Typically, in cold climates the indoor air is at a higher vapor pressure than the outdoor air that is dryer and colder. The opposite is true in hot/ humid climates where the lower vapor pressure is indoors (and is accentuated by use of air-conditioners and associated dehumidification). Vapor retarders have a perm rating of 1 or less.

Waterproofing (foundation)—a procedure to make a material impervious to water or dampness. The application of a material or coating to assure water repellency to a structure or construction unit.

Water vapor diffusion—the movement of water vapor (gaseous water) driven by vapor pressure differentials.

Weather barrier—general term for a combination of materials including siding, roofing, flashing, sheathing, finishes, drainage plane, and vapor retarders that, as a system, exhibit vapor retarding and water retarding characteristics and may also possess thermal insulation and air infiltration characteristics.

APPENDIX A— DURABILITY CHECKLISTS

Designer's & Builder's Durability Checklist

- ❑ Have adequate roof overhangs been specified?
- ❑ Does the roof have adequate slope for the roofing material being used?
- ❑ Has valley flashing been adequately detailed?
- ❑ Has shading of the building been considered and planned?
- ❑ Have all roofing penetrations been adequately flashed and detailed?
- ❑ Have gutters been sized and specified?
- ❑ Has downspout size, location, and outlet point been detailed?
- ❑ Has roof drip edge been specified?
- ❑ Has eave ice flashing been specified, if required?
- ❑ Has 15# roofing felt been specified?
- ❑ Has attic vent location and design been specified?
- ❑ Has a secondary drainage plane been specified where required (building wrap, 15# felt, etc.)?
- ❑ Are the drainage plane and flashings at windows and doors properly detailed?
- ❑ Have window head, jamb, and sill flashing details been specified?
- ❑ Have door head flashing details been specified?
- ❑ Has siding corner detail been specified?
- ❑ Has air barrier detailing been specified, if needed?
- ❑ Has siding selection been specified?
- ❑ Have all railing details been specified?
- ❑ Has the location and flashing for utility penetrations been specified?
- ❑ Have all bathroom, dryer, and kitchen vents been specified to be directly vented to the exterior of the building?
- ❑ Does site have adequate slope to remove roof runoff?
- ❑ Has adequate foundation backfill material been specified?
- ❑ Are ground clearances between framing, siding, and ground properly maintained?
- ❑ Is treated lumber used where clearances to ground are not sufficient?
- ❑ Is foundation drain specified with proper aggregate and filter fabric?
- ❑ Are drainpipes located below the top surface of the basement slab?
- ❑ Is the foundation drainage system properly installed to provide positive flow of foundation water away from the building?
- ❑ Is foundation drain outlet specified - either through daylighting or sump pump?
- ❑ Are foundation bleed holes specified, if needed?
- ❑ Is foundation wall damp proofing or waterproofing specified as required?
- ❑ Are termite protection measures specified?
- ❑ Is basement floor gravel layer specified?
- ❑ Has crawlspace, slab, or basement floor vapor barrier been specified?

Homeowner's Durability Checklist

- ❑ Inspect/replace caulk every 2-3 years.
- ❑ Maintain gutters and downspouts in a clean and operating condition.
- ❑ Adjust landscaping sprinklers such that the house is not accidentally "watered" regularly.
- ❑ Repaint every 5-7 years.
- ❑ Maintain exterior grade near foundation for drainage away from the house.
- ❑ Maintain indoor relative humidity levels below 60% through the use of the HVAC equipment (heating during winter, cooling during summer) and auxiliary dehumidifiers in damp areas like basements.
- ❑ Inspect/replace HVAC filter monthly and have an annual service check on equipment.
- ❑ Use exhaust fans whenever showering or generating significant moisture while cooking.
- ❑ Do not exhaust clothes dryer to indoors or enclosed spaces.
- ❑ Use unvented combustion appliances only in accordance with manufacturers recommendations.
- ❑ Address all leaks and floods promptly, however small they may seem.
- ❑ Inspect/replace washer hoses periodically.

APPENDIX B—
ESTIMATED LIFE-EXPECTANCY OF BUILDING MATERIALS AND PRODUCTS

ESTIMATED LIFE EXPECTANCY AND HOMEOWNER MAINTENANCE CHART		
Building Component	**Estimated Life* (years)**	**Homeowner Action**
Concrete/block foundation	100+	Check for cracks or surface deterioration. Consult a professional if you have any leaking or severe cracking. Check for termite tubes on foundation.
Exposed concrete slabs	25	Inspect for cracking. Seal to prevent water penetration.
Siding (Lifespan depends on type)	10 - 100	Clean all types of siding. Paint or seal wood siding (See exterior paints/stains).
Drywall	30 - 70	Inspect, clean, and paint for aesthetic purposes.
Roofing	15 - 30	Inspect for missing or deteriorated shingles. Clean to remove mold buildup.**
Gutters and Downspouts	30	Remove debris.
Insulation	100+	Inspect blown insulation in attic and check floor insulation (crawlspace) to assure that it is in place.
Windows	20 - 50	Inspect and repair weather stripping. Inspect for broken seals in insulated windows. Clean exterior window frames.**
Exterior Doors	25 - 50	Clean and refinish when necessary (See Exterior paints/stains).
Garage Doors	20 - 50	Clean garage door. Lubricate moving parts. Paint or seal as necessary.**
Exterior paints/stains	7 - 10	Clean and inspect. Repaint and caulk as needed.
Wood floors	100+	Clean and wax.
Carpeting	11	Clean annually.
Sinks	5 - 30	Keep free of debris.
Toilets	50	Keep free of debris. Check tank seal and floor wax collar for leaks.
Faucets	13 - 20	Clean screen annually. Check for leaking seals.
Water heater	14	Keep clear of household items. Have professional maintenance annually.
Central air conditioning/ heat pump (outside unit)	15	Keep free of plants and debris. Cover during winter months (A/C only). Conduct annual professional maintenance.
Furnace/heat pump (indoor unit)	18	Keep clear of household items. Conduct annual professional maintenance. Inspect/replace filter according to manufacturer's recommendations.
Refrigerator	17	Clean condensing coils regularly; allow room behind and inside appliance for air circulation.
Dishwasher	10	Clean the drain filter regularly.
Clothes Dryer	14	Clean lint filter regularly. Periodic professional cleanings will reduce risk of fire.
Clothes Washer	13	Keep lint trap free of debris. Clean tank occasionally.
Smoke Detector	12	Test and check batteries.
Wood Framing	100+	(See termite protection.)
Termite protection (chemical treatment)	5	Yearly inspection and retreat as necessary.

* All numbers excerpted and condensed from: NAHB Life Expectancy Survey from "Housing, Facts, Figures and Trends" (1997)

** Use care if power washing. The high pressure water can cause more harm than help if not used cautiously.

Review of Structural Materials for Home Building: 1900 to 2000 Final Exam

1. **With regards to General Housing Characteristics, early 1900's, the average house had 0 to 1 bathrooms.**
   a. True
   b. False

2. **Much of the standardization in home building during the mid-1900's can be attributed to the Federal Housing Administration with its MPRs, or _____.**
   a. Maximal Protection Rights
   b. Maximum Protocol Requisites
   c. Minimum Property Requirements
   a. Minimal Prototype Rules

3. **By the late 1900's, what percent of houses had 2-car garages?**
   a. 50%
   b. 75%
   c. 65%
   d. 85%

4. **According to Table 2, if a home is 13 years old, the percentage of housing stock is ___%.**
   a. 9
   b. 11
   c. 35
   d. 45

5. **According to Table 4, the recommended live and dead load for a roof of heavy construction with heavy slate or title roofing is ___lbs/ft^2 .**
   a. 10
   b. 20
   c. 30
   d. 40

6. **According to Table 5, the presumptive soil bearing value for hard rock _____from the early 1900's to the mid-1900's.**
   a. Decreased
   b. Doubled
   c. Quadrupled
   d. Remained unchanged

7. **Considering Wood-Frame Construction, up through _____, homes were built following traditional timber construction known as braced framing:**
   a. The 1950's
   b. The 1920's
   c. The Depression
   d. Most of the 19th century

8. **In the mid-1800s a new construction method, known as _____, began to be used in the United States, in which repetitive light framing members were utilized.**
   a. Box framing
   b. Platform framing
   c. Balloon framing
   d. Braced framing

9. **In the "honor-built" system, all outside paint is coated _____.**
   a. Once
   b. Twice
   c. Thrice
   d. Four times

10. **Figure 6 depicts:**
    a. Balloon framing
    b. Braced framing
    c. Box framing
    d. Platform framing

11. **According to Table 6, which of the following was a typical framing lumber species used in the late 1900's:**
    a. Spruce-Pine-Fir
    b. Western Larch
    c. Tamarack
    d. All of the above

12. **True or false? In the early 1900's, lumber was often imported from distant regions.**
    a. True
    b. False

13. **With regards to the structural properties of lumber, _____ is perhaps the single most important parameter to consider, as it can be correlated to several structural properties including bending strength and connection capacity.**
    a. Width
    b. Length
    c. Density
    d. Mass

14. **True or false? In the early 1900's, the common lumber grades were strictly defined and followed.**
    a. True
    b. False

15. **According to Table 8, _____ has an extreme fiber stress average ultimate of 4,800 and an average modulus of elasticity of 1,310,000.**
    a. Douglas fir
    b. Longleaf pine
    c. White pine
    d. Spruce

16. **According to Table 9, Eastern Tamarack has perpendicular to grain compression of ___psi.**
    a. 300
    b. 667
    c. 63
    d. 800

17. **According to Table 10, which of the following does NOT have a modulus of elasticity of 1,200,000:**
    a. Alaska cedar
    b. Western larch
    c. Southern cypress
    d. None of the above

18. **According to Table 11, American southern pine has a specific gravity of ____.**
    a. 0.465
    b. 0.455
    c. 0.490
    d. 0.872

19. **Regarding Floor Framing, in the early 1900s, floor joists were typically ____with spans in the range of 12 feet to 14 feet spaced on 16 inch centers:**
    a. 2x6
    b. 2x10
    c. 2x12
    d. 2x8

20. **By the 1930's, a deflection limit of _____ of span was used to produce span tables for joists supporting plaster ceilings.**
    a. 1/90
    b. 1/180
    c. 1/360
    d. 1/400

21. **Over the 20th century, actual vs. nominal framing member sizes have _____ and wall framing methods have changed from balloon to platform frame.**
    a. Decreased
    b. Increased
    c. Remained the same
    d. Augmented

22. **True or false? Single plates are still permitted, and are used occasionally, in modern affordable platform framed homes, specifically in non-load bearing walls or where loads are transferred directly down through studs.**
    a. True
    b. False

23. **Table 14 test data is from:**
    a. 1953
    b. 1995
    c. 1941
    d. 1929

24. **For hip and valley rafters, the following rule of thumb from *Light Frame House Construction* was apparently in use in the early part of the 20th century: for up to a ___ foot horizontal span, use a single hip rafter 2 inches deeper or 1 inch thicker than rafters.**
    a. 6
    b. 8
    c. 10
    d. 12

25. **Cut nails were quickly replaced by _____ nails in the earliest parts of the 20th century.**
    a. Iron
    b. Common wire
    c. Smooth box
    d. Casing

26. **By the _____, pneumatic fasteners dominated the market.**
    a. Early 1900's
    b. Mid-1900's
    c. Late 1900's
    d. 2000's

27. **Separate concrete spread footings, which were introduced in the _____, are found on nearly all homes today.**
    a. Early 1900's
    b. Mid-1900's
    c. Late 1900's
    d. 2000's

28. **At the end of the 20th century, engineered wood products quickly gained acceptance as alternatives to dimension lumber used primarily in floor framing, floor girder applications, and _____.**
    a. Window framing
    b. Door heading
    c. Wall bracing
    d. Sheathing

29. **Which of the following correctly orders the transformation of fasteners:**
    a. Finishing nails → pneumatic fasteners → smooth box nails
    b. Common wire nails → smooth box nails → casing nails
    c. Cut nails → common wire nails → pneumatic fasteners
    d. Smooth box nails → finishing nails → pneumatic fasteners

30. **Wall bracing practices should be re-assessed based on changes in the style, size, and interior finishes used in _____ homes as compared to _____ homes.**
    a. Aged, recent
    b. Modern, older
    c. Historic, fashionable
    d. Antique, contemporary

INTRODUCTION

Americans have greater access to better housing today than ever before. While modern housing may be considered to be better than in the past, the process of improving housing value should include periodic evaluation to confirm past successes, consider the ramifications of past decisions, and foster future advancement in the interest of even better housing value.

This paper examines the evolvement of U.S. housing construction during the 20th century. Of particular interest are changes in construction practices associated with the materials and methods used in home building that affect structural performance. The purpose is to benchmark housing structural characteristics (as implied by historic practice), to identify significant changes that have occurred, and to provide an objective resource for discussion and evaluation of structural design implications. Other related interests, such as construction quality, are also considered.

Home building has always been rooted in practical applications of basic technology. Therefore, this study attempts to align the practical aspects of home building and its history with relevant technical data on structural performance. When available, statistics are cited with respect to housing styles, size, materials, and relevant structural aspects. Where reliable statistical data is unavailable, selected documents that define typical practices are used to arrive at reasonable historic profiles of housing construction and structural characteristics. To a limited degree, personal interviews of home builders with experience dating as far back as 1917 were conducted to compare with information found in the literature.

The study focuses on structural aspects of housing construction and breaks them into three periods of time: early 1900s, mid-1900s, and late 1900s. While it is recognized that change usually occurs slowly and that practices vary regionally, an attempt is made to typify relevant housing construction data and practices in each period. The following sections address:

- General Housing Characteristics,
- Design Loads,
- Foundation Construction,
- Wood-Frame Construction, and
- Construction Quality.

Additional information on thermal insulation materials and methods are reported in Appendix A as a matter of special interest.

1.0 GENERAL HOUSING CHARACTERISTICS

Based on *U.S. Census data, the Builder Practices Survey, Housing at the Millennium: Facts, Figures, and Trends,* and other sources (see Bibliography), a synopsis of American housing in the 20th century may be constructed for each of the following periods:

1.1 EARLY 1900s

The following characteristics describe a typical home and the housing market in 1900:

Population: 76 million (40 percent urban, 60 percent rural)
Median family income: $490
New home price: average unknown[1]
Type of purchase: typically cash
Ownership rate: 46 percent
Total housing units: 16 million
Number of annual housing starts: 189,000 (65 percent single-family)
Average size (starts only): less than 1,000 sq. ft.
Stories: One to two stories
Bedrooms: 2 to 3
Bathrooms: 0 or 1

[1] *Based on Housing at the Millennium: Facts, Figures, and Trends, the average new home cost was less than $5,000. However, this estimate is potentially skewed in that many people could not afford a "house" of the nature considered in the study. Based on Sears, Roebuck, and Co. catalogue prices at the turn of the century, a typical house cost may have ranged from $1,000 to $2,000, including land.*

The front elevation and floor plan of a typical home produced in 1900 is shown in Figure 1. Good examples of traditional housing styles and architectural plans in the early 1900s are found in catalogues produced by Sears, Roebuck and Co., a major producer of traditional American kit homes from about 1910 into the early 1930s (see Bibliography). Likewise, it should be recognized that a large portion of the public lived in rural areas that were not subject to municipal building codes, and housing needs were likely fulfilled in a variety of ways that may not be well documented in the popular literature on housing construction. For example, in Cotton Field's No More it is stated that "more than half of the farmers lived in one-and two-room shacks that had not been whitewashed or painted for many years, if ever. Many of these houses had holes in the roof, wall, and floor." Further, U.S. Census data for 1900 reports that the value of land and buildings per farm in eleven Southern states ranged from $600 to $2,000. By contrast, the values for Indiana and Kansas were $6,550 and $3,718, respectively. Thus, living conditions and housing varied widely in the early 1900s.

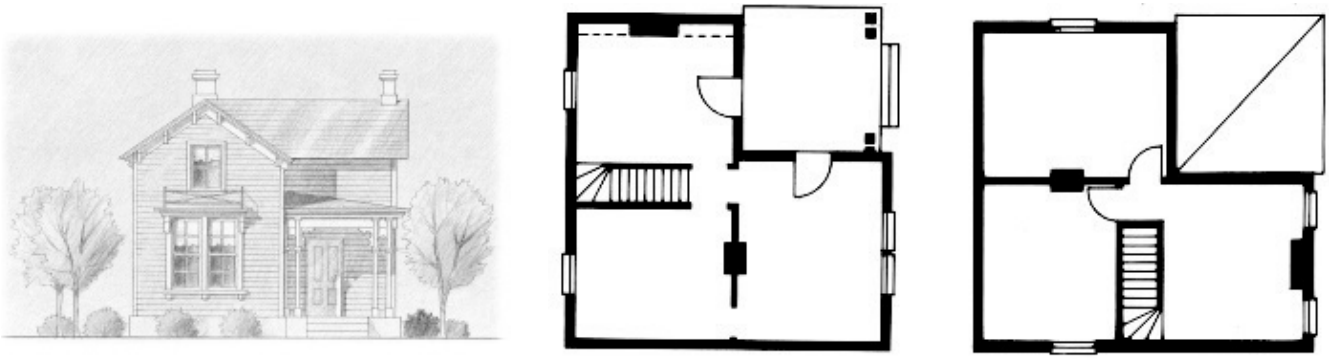


Figure 1. Profile home in 1900 (2 story).[2]

[2]First floor plan is similar to size and shape of a small one-story home.

1.2 MID-1900s

The following characteristics describe a typical home and the housing market in 1950:

Population: 150 million (64 percent urban, 36 percent rural)

Median family income: $3,319

New home price: $11,000

Type of purchase: FHA mortgage, 4.25 percent (few options)

Ownership rate: 55 percent

Total housing units: 43 million

Number of housing starts: 1.95 million (85 percent single-family)

Average size (starts only): 1,000 sq. ft.

Stories: 86 percent one story; 14 percent two or more

Bedrooms: 2 (66 percent); 3 (33 percent)

Bathrooms: 1-1/2 or less (96 percent)

Garage: 1 car (41 percent); 0 (53 percent)

The front elevation and floor plan of a typical home produced in 1950 is shown in Figure 2.

By the mid-1900s, the use of standardized products, materials, and methods of constructing homes had become fairly mature. In particular, lumber grading and sizes had become essentially uniform across the country. Much of the standardization in home building may be attributed to the Federal Housing Administration (current day Department of Housing and Urban Development) with its Minimum Property Requirements (MPRs) which were applied across the country following WWII, and which were eventually superceded by a first edition of the *Minimum Property Standards* (MPS) in 1958. At this point, the older "rules-of-thumb" were giving way to prescriptive construction requirements (e.g., span tables, construction specifications, etc.) that were based on practical as well as basic technical (engineering) criteria. Newer materials such as plywood sheathing were addressed as well as standard construction details. This document was, in the opinion of the author, one of the best organized, instructive, and comprehensive building standards developed in the United States.

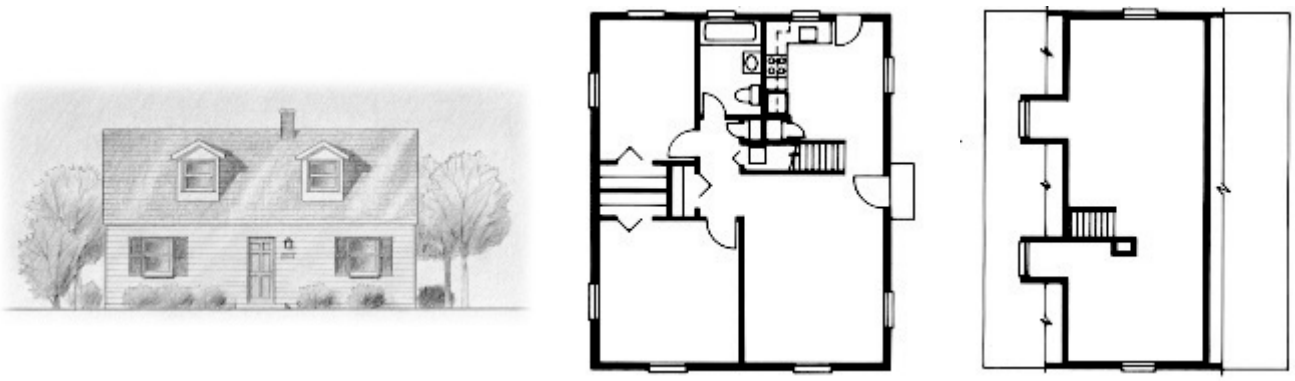


Figure 2. Profile home in 1950 (upper 1/2 story optional)

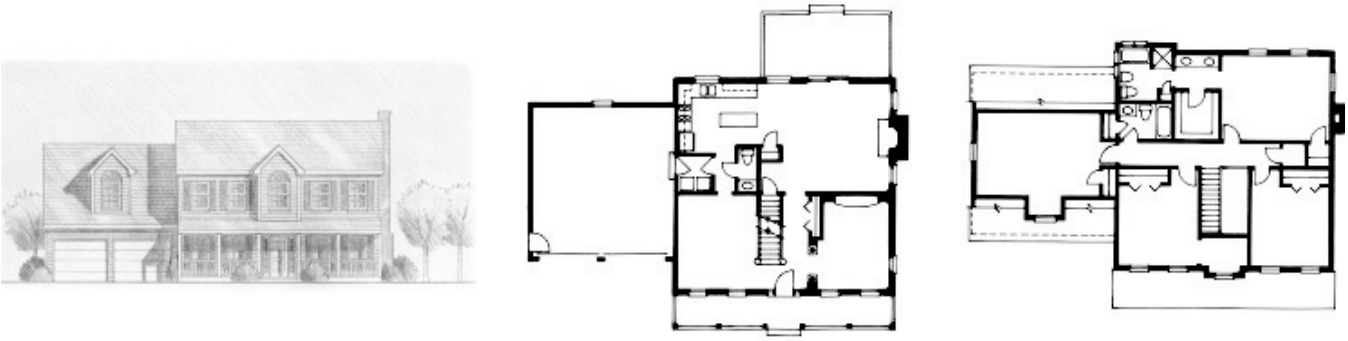


Figure 3. Profile home in 2000 (2 story).

1.3 LATE 1900s

The following characteristics describe a typical home and the housing market in 2000:

Population: 270 million (76 percent urban, 24 percent rural)

Median family income: $45,000

New home price: $200,000

Type of purchase: 8 percent (many financing options)

Ownership rate: 67 percent

Total housing units: 107 million (approx. 50 percent single-family)

Number of housing starts: 1.54 million (80 percent single-family)

Average size (starts only): 2,000 sq. ft. or more

Stories: One story (48 percent); 1-1/2 or 2 story (49 percent)

Bedrooms: 2 or less (12 percent); 3 (54 percent); 4 or more (34 percent)

Bathrooms: 1-1/2 or less (7 percent); 2 (40 percent); 2-1/2+ (53 percent)

Garage: 2 car (65 percent)

The front elevation and floor plan of a typical home produced in 2000 is shown in Figure 3.

By the late 1900s, detailed statistical data on new housing construction (such as collected by the U.S. Census and the NAHB Research Center's *Builder Practices Survey*) had become readily available. Some basic housing construction statistics related to structural features of homes at this time are summarized in Table 1.

The species of framing lumber in the late 1900s generally include Douglas Fir, Hem-Fir, Spruce-Pine-Fir, and Southern Yellow Pine. Wall studs are typically

TABLE 1: BASIC NEW HOUSING CONSTRUCTION STATISTICS IN LATE 1900s

Foundation Type:	Basement (34 percent); Crawlspace (11 percent); Slab (54 percent)
Floor Framing:	Type: lumber, 62 percent; wood trusses, 9 percent; wood I-joists, 28 percent Size of Lumber: 2x8, 8 percent; 2x10, 70 percent; 2x12, 21 percent (of lumber floors) Species of Lumber: SYP 39 percent; DF 23 percent; other 37 percent
Floor Sheathing:	37 percent plywood; 30 percent OSB; 6 percent board
Wall Framing:	73 percent 2x4@16"; 5 percent 2x4@24"; 17 percent 2x6@16"; 3 percent 2x6@24"
Wall Sheathing:	11.2 percent plywood; 44.2 percent OSB; 24 percent foam panels; 20.6 percent other
Ceiling Height:	54 percent 8' ceilings; 29 percent 9' ceilings; 8 percent 10' ceilings
Wall Openings: area on average)	2.3 ext. doors; 1.2 patio doors; 14.5 windows; 1.2 fireplaces (13 to 15 percent of wall
Roof Sheathing:	27.6 percent plywood; 71 percent OSB
Roof Framing:	6 percent rafters; 29 percent I-joist; 65 percent wood truss
Roof Pitch:	7 percent 4/12 or less; 63 percent 5/12 to 6/12; 30 percent 7/12 or greater
Roof Shape:	63 percent Gable; 36 percent Hip

Note: Percentages for floor, wall, and roof sheathing and framing are based on total aggregated floor and wall area for housing starts. Other values are given as a percentage of the housing starts.

TABLE 2: AGE DISTRIBUTION OF EXISTING U.S. SINGLE-FAMILY HOMES (1995)	
Age of Home	**Percentage of Housing Stock**
76 years or older	9
56 to 75 years old	11
25 to 55 years old	35
0 to 24 years old	45

TABLE 3: GEOGRAPHIC DISTRIBUTION OF U.S. SINGLE-FAMILY HOMES BY REGION (1995)	
Region	**Percentage of Housing Stock**
Northeast	19
Midwest	24
South	37
West	20

Stud Grade lumber; roof and floor framing lumber is typically No. 1 or No. 2 grade when dimension lumber is used. Fasteners are typically pneumatic-driven 0.113 to 0.131 inch diameter nails or staples. Most homes are built following locally adopted and modified national model building codes offered by one of three private code development organizations. These codes include the *Uniform Building Code, National Building Code,* and *Standard Building Code*, as well as the *One- and Two-Family Dwelling Code (OTFDC) developed by CABO*, an umbrella for the three national model code organizations.

It is interesting to note that while the cost of housing increased 100-fold or more during the 20th century, family income increased by a factor of about 90. Thus, the cost of a home in 1900 was about 3 times the family income on average while the cost of a home in 2000 was about 4 times the family income on average. Despite this apparent change, the increased availability of private financing options for home purchasers has contributed to a nearly 50 percent increase in the home ownership rate during the past century.

Also of significance is the distribution of age and geographic location of single-family homes in the United States, as shown in Tables 2 and 3. Similar data for the earlier part of the 20th century was not found.

2.0 DESIGN LOADS

In the early 20th century, structural loads for housing design were not well codified or standardized. Houses and members were largely designed using "rules of thumb" which implicitly considered member strength, stiffness, and loading conditions. By 1923, the U.S. Department of Commerce had formed a Building Code Committee that began to standardize design loads to be used specifically for homes. These loads were later used to formulate various design recommendations such as span tables, footing sizes, and other construction specifications. Recommended live and dead loads published in 1928 are shown in Table 4.

It is interesting to note that the relationship of live load magnitude to influence area (tributary area) was recognized by the U.S. Department of Commerce at this early time in a rudimentary fashion:

> *"Although a live load of 40 pounds per square foot should be used in selecting all [individual] floor joists, such a load will not occur over a large floor area at the same time. The larger the area, the less chance there is of its being heavily loaded all over. In fact, the building Code Committee of the Department of Commerce, in 1923, after careful investigation, recommended that, in computing the load on girders carrying floors more* than 200 square feet in area, a live load of 30 pounds per square foot be used."

TABLE 4: RECOMMENDED LIVE AND DEAD LOADS [U. S. Department of Commerce, 1928]	
CONDITION	**POUNDS PER SQUARE FOOT**
Live load, all floors used for living purposes	40
Live load for attic (used for light storage only)	20
Dead weight for average double floor and joists, but without plaster	10
Dead weight of plaster ceiling, including joists on light unfloored attics	10
Roof of light construction, including both live and dead loads	10
Roof of medium construction with light slate or asbestos roofing, including both live and dead loads	30
Roof of heavy construction with heavy slate or tile roofing, including both live and dead loads	40

This practical consideration of influence area for dwelling design was subsequently lost in the development of building codes later in the 20th century. Most modern codes do allow a floor live load of 30 psf to be used for bedroom areas; however, this is a separate issue from that of influence area on design live loads.

At the turn of the century, cities that had comprehensive building laws generally specified dwelling floor live loads ranging from 40 to 70 psf. Specified roof loads ranged from 25 to 50 psf depending on the degree that dead, live, and snow loads were included in the values. Snow load reductions based on simple relations to roof slope were sometimes recognized. Wind loads, where specified, ranged from 10 to 30 psf with 20 psf being most common. However, wind loads did not find explicit consideration in housing design until later in the 1900s, even though they were noted throughout the century. For most of the 20th century, it appears that wind loads, when considered, usually used a simple uniform load to be applied to vertical and horizontal projected building surfaces.

In addition, there appears to have been considerable variation in how loads were applied and analyzed. For example, rafter selections were recommended by using horizontal joist span tables produced in the 1930s. Thus, it is unclear as to how various loads were factored into the design of roofs until later in the 20th century when span tables specifically for rafter design considered roof live, dead, and snow loads explicitly. In some cases the actual rafter sloped span was used and wind loads were accounted. However, a lack of standard procedure for analyzing sloped rafters has remained to this day.

By the mid-1900s, the National Bureau of Standards had produced a document titled *Minimum Design Loads in Buildings and Other Structures* (ASA A58.1-1955). In this document, the design floor live load for apartments and first floors of dwellings was set at 40 psf; second floors and habitable attics at 30 psf; and uninhabitable attics at 20 psf.

Throughout the later half of the 1900s, building codes varied in the requirements for building design loads. However, by the end of the century, the major model building codes began to standardize load requirements into a single format with uniform requirements, in most cases based on the American Society of Civil Engineer's standard ASCE 7-98, *Minimum Design Loads for Buildings and Other Structures* (drawn from a later edition of the National Bureau of Standards document ASA A58.1-55).

3.0 FOUNDATION CONSTRUCTION

Foundation construction at the beginning of the 1900s differed significantly from that used by the end of the century. Residential foundations in the early 1900s rarely had separate spread footings; the first course of masonry was often laid directly on subgrade. The following relevant quote was found in *Structural Analysis of Historic Buildings:*

> *"Portland concrete and reinforced spread footings began to appear at about the turn of the century. They were obviously used sparingly at the beginning, as in the application of any new technology."*

When readily available, it is also found that many homes before 1900 used stone masonry for foundation walls or piers, with or without some type of mortar. Special consideration to foundations and soil support was only given to very unique structures or soil conditions. If engineered, building foundation bearing pressures were usually designed with "appropriate dead and live loads" at the beginning of the 20th century. Even then, the techniques were quite arbitrary and relied heavily on experience and judgment of the designer. Most building designs, at best, were based on a manual probing of the soil and reliance on local practice and/or past performance of nearby building foundations.

Typical presumptive (allowable, permissive, or safe) soil

TABLE 5: PRESUMPTIVE SOIL BEARING VALUES BY TIME PERIOD (pounds per square foot)

EARLY 1900s
Soft/Wet Clay or Sand or Loam (2,000)
Firm Earth (2,500 to 3,500)
Ordinary Clay/Sand Mix and Sand (4,000)
Hard Clay and Firm Course Sand (8,000)
Firm Gravel/Sand Mix (12,000) Shale Rock (16,000)
Hard Rock (40,000)
MID-1900s
Soft Clay (2,000)
Firm Clay and Sand/Clay Mix (4,000)
Fine dry sand (6,000)
Coarse Sand (8,000)
Gravel (12,000)
Soft Rock (16,000)
Hard Rock (80,000)
LATE-1900s
Clay, Sandy Clay, Silty Clay, and clayey silt (1,000)
Sand, silty sand, clayey sand, silty gravel, and clayey gravel (1,500)
Sandy gravel and/or gravel (2,000)
Sedimentary and foliated rock (2,000)
Massive crystalline bedrock (4,000)

bearing values during the 20th century are shown in Table 5. It is noted that presumptive values decreased drastically (became more conservative) in the later half of the 20th century with no compelling reason identified in the literature.

By the mid-1900s and throughout the remainder of the century, the use of concrete footings and masonry (block) or concrete walls had become common practice. The introduction of separate spread footings is not well understood, as few documents used in this study spoke directly to this issue. Perhaps, newer wall construction methods and materials allowed the use of thinner foundation walls which brought about concern with bearing area on the foundation soil. Perhaps a greater concern or lower tolerance for settlement and cracking of foundation walls developed over time, as expectations for use of basements increased over the course of the century. Certainly, basement wall cracks are a major source of homeowner complaints or claims in modern homes; however, it does not appear that this was such a concern earlier in the century. Data on modern foundation construction types is reported in Table 1.

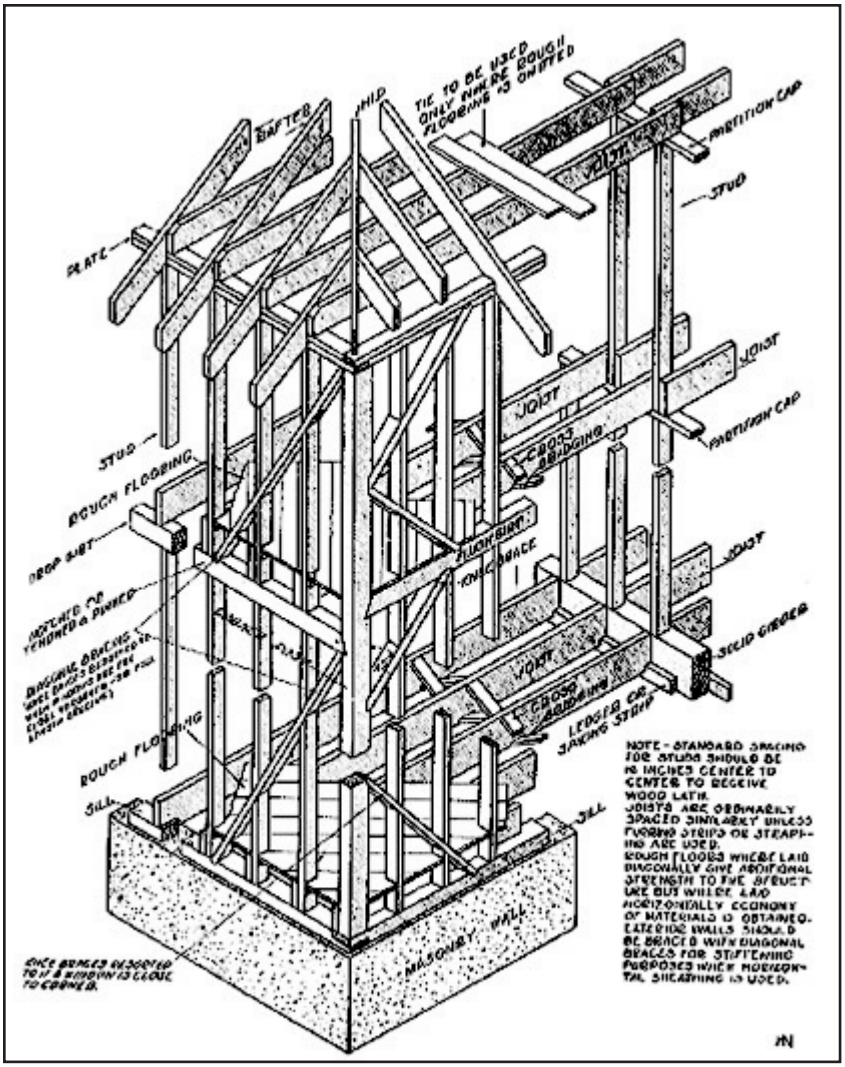


Figure 4. Braced Framing pre-1900.

4.0 WOOD-FRAME CONSTRUCTION

Prior to the 1900s some significant changes in basic framing practices in the United Sates were set in motion. Up through most of the 19th century, homes were built following traditional timber construction known as *braced framing* adopted from England (see Figure 4). In this manner, homes used heavy squared timber frames and beams with diagonal bracing of 4x or larger timbers. Wood joinery methods were used for heavy connections rather than steel fasteners. Intermediate framing members of smaller dimension were used within the structural frame to provide for attachment of finish materials.

In the mid-1800s a new construction method, known as *balloon framing,* began to be used in the United States. This method used repetitive light framing members, generally 2x4s, made available by the proliferation of sawmills. By the start of the 20th century, balloon framing had practically replaced the traditional heavy braced framing technique. The balloon framing technique is illustrated in Figure 5. In some cases, vestiges of early practices such as the use of 4x corner posts, beams, and sill framing members existed well into the 20th century in combination with balloon framing. Balloon framing persisted until after World War II in some parts of the country.

Variations in application of the balloon framing method also recognized trade-offs between economy and performance. For example, Sears, Roebuck and Co., produced two types of pre-cut structural framing systems: one using the "honor-built" system and the other using the "standard-built" system. In advertising the "honor-built" system, the following features were highlighted:

- Rafters, 2x6 or 2x4 inches (larger where needed), 14-3/8 inches apart (16 inches on center).
- Double plates over doors and windows (as headers and trim nailing base).
- Double studdings at sides of doors and windows (as jamb support and trim nailing base).
- Three studs at corners.
- High grade horizontal wood sheathing boards, 13/16 inch thick with tarred felt overlay between sheathing and wood siding.
- Double floors with heavy building paper between the subfloor and finished floor.

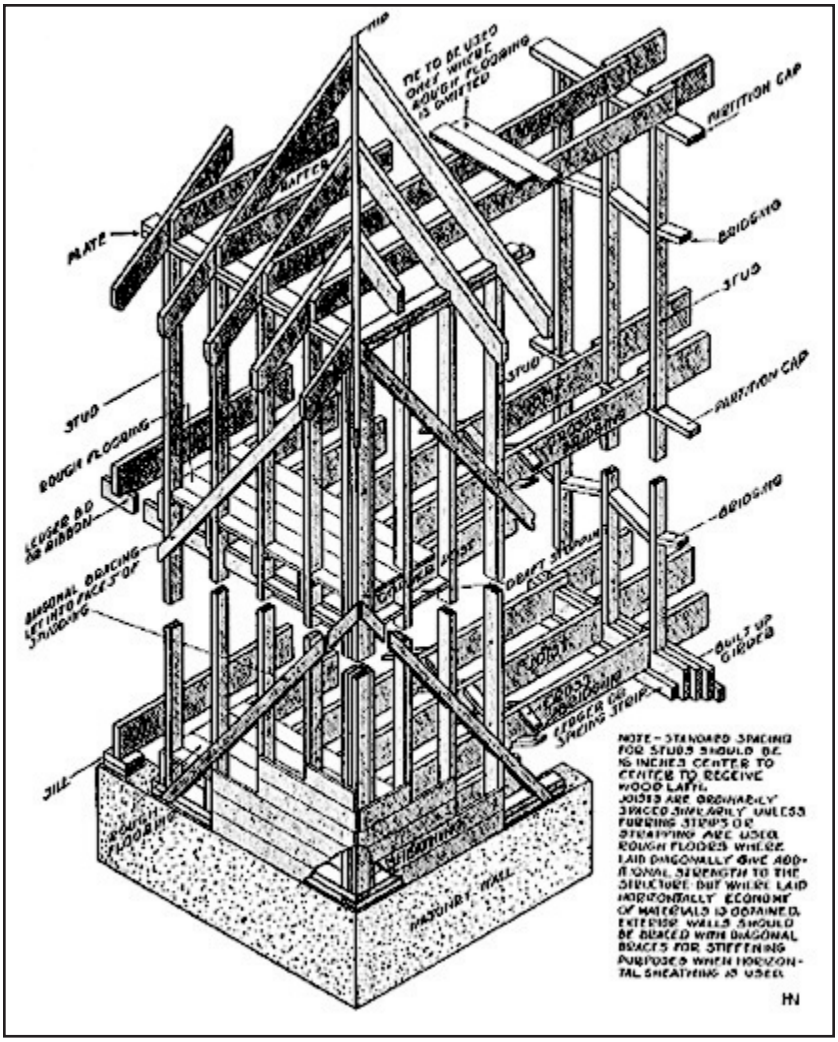


Figure 5. Balloon Framing Technique in Early 1900s.

- 2x8 inch joists, or 2x10 where needed, 14-3/8 inches apart (16 inches on center).
- Studdings, 2x4 inches, 14-3/8 inches apart (16 inches on center), double plate at top and single at bottom of wall, ceiling height of typically 8 feet-2 inches to 9 feet for above grade stories and as low as 7 feet for basements.
- High quality framing lumber (virgin growth, dense grain, from the Pacific Northwest, Douglas-Fir and Hemlock) specially sorted, stored, and dried at Sears lumber yards.
- Common wire nails of sufficient quantity and variety of sizes.
- Genuine cypress window and door casings (exterior trim), 1-1/8 inches thick, naturally weather resistant.
- 3 coats of guaranteed paint on outside.

The "standard-built" construction was advertised (at the back of the 1928 Sears catalogue) as the "most house per dollar invested" for smaller homes of 1 to 1-1/2 stories. The largest home of this type had four rooms within a 24 feet by 36 feet plan. The following are key specifications of Sears' "standard-built" homes:

- Rafters, 2x4 inches, 22-3/8 inches apart (24 inches on center); 2x4 ceiling joists at 16 inches on center (for interior finish).
- Single plates over doors and windows (no headers or trim nailing base).
- Single studdings at sides of doors and windows.
- Two studs at corners.
- No wood sheathing (only exterior wood siding of 1x6).
- No sub-floor (finish flooring applied direct to joists).
- Tarred felt under floors and siding.
- 2x8 inch joists placed 22-3/8 inches apart (24 inches on center), spans generally not exceeding 12 feet.
- Studdings, 2x4 inches, 14-3/8 inches apart (16 inches on center), double plate at top and single at bottom of wall; ceiling heights typically 8 feet-3 inches.
- Framing lumber for walls, floors, and roofs uses No. 1 Douglas Fir or Pacific Coast Hemlock (non-Sears standard construction is noted to use lower quality or No. 2 and No. 3 lumber and species such as Tamarak or White Pine).
- Common wire nails of sufficient quantity and variety of sizes.
- Cypress exterior trim.
- All outside paint, two coats.

Sears also advertised cottage style or portable homes with 2x2 No. 1 yellow pine wall framing, 2x3 roof rafters, and post foundations. The largest size had three rooms with overall plan dimensions of 20 feet by 16 feet, plus a 5 foot covered porch. Sears noted that their "standard-built" homes incorporated some improvements over the common practice of that time, such as the use of three-stud corners and doubled 2x4 members at window and door openings for improved finish attachment. It is unknown how many homes of each type were sold by Sears, Roebuck and Co. But, the catalogues give clear evidence that at least two to three distinctly different levels of dwelling construction were recognized in the early 1900s as a matter of economy verses quality.

By the mid-1900s and during the housing "boom" following WWII, the preferred framing practice had evolved to platform framing, a further refinement of balloon framing. Platform framing is shown in Figure 6. This change was driven by economy and practicality.

For example, balloon framing required the use of long wall framing members (studs) which were more expensive and less available. Also, balloon framing required fire blocking between wall framing at story levels to comply with modern building codes (initiated in the 1920s). In contrast, platform framing is inherently fire blocked by the use of horizontal wall plates at the top and bottom of each story. In addition, the balloon frame approach was essentially limited to "regular" two-story construction and did not readily allow for newer housing styles that featured story offsets (i.e., floor overhangs) and other "irregularities" in design. Finally, the platform framing technique provides a solid and safe work platform from which to stage construction for upper stories. Platform framing has dominated the housing market since the mid-1900s with a few refinements as follows:

- unnecessary use of bridging between studs and floor joists was eliminated;
- panel products have replaced the use of boards for wall, floor, and roof sheathing;
- wall sheathing no longer laps over the floor perimeter (except in some isolated high wind locales); and
- foundation sill members are anchored to the foundation.

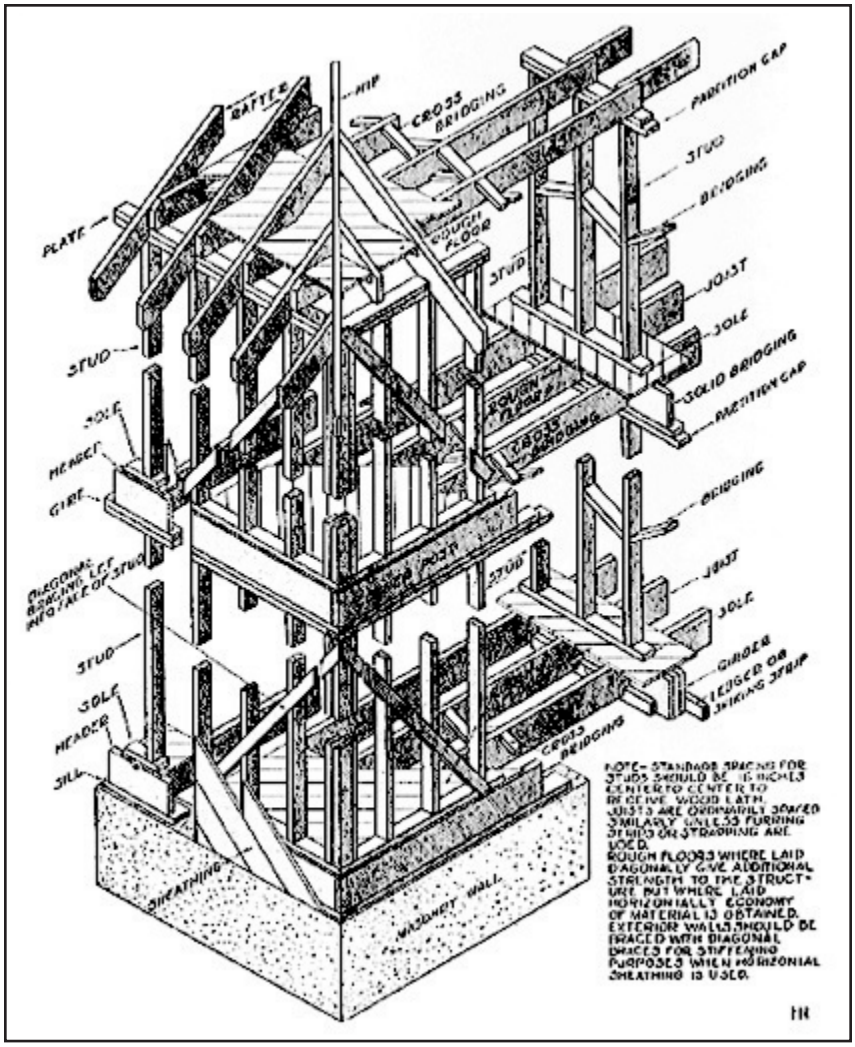


Figure 6. Platform Framing.

Note: Platform framing in Figure 6 is representative of early platform framing. Platform framing in the mid-to late-1900s used panel products in lieu of board sheathing and bridging in floors and walls was eliminated.

Throughout the 20th century, 16 inch on center framing has remained the dominant choice. Interestingly, this practice has been associated with an early concern to provide adequate support for finish materials (i.e., exterior wood siding or sheathing and, particularly, interior lath and plaster finishes). On the other hand, spacing of roof framing members has largely increased from 16 inch on center (early to mid-1900s) to 24 inches on center in the late 1900s. This change is associated with the inception and later dominance of wood roof trusses in the second half of the 20th Century. However, 16 inch on center roof framing still finds limited use today, particularly in complicated roof designs that necessitate rafter framing.

It should be noted that 24 inch on center wall framing has been used throughout the 20th century in at least a small portion of housing construction for reasons of economy and, more recently, for its additional benefits of improved energy efficiency and resource conservation. Changes to panel forms of exterior and interior sheathing materials (including the use of plywood and OSB sheathing panels and gypsum wallboard, as opposed to boards or lath and plaster) have perhaps contributed to a greater use of 24 inch on center framing today than in the early 20th century. Still, 24 inch on center framing is generally used in less than 10 percent of wall area in modern residential construction annually.

Floor construction has also seen some use of alternate spacings such as 19.2 inch and 24 inch. In recent years, increased use of wider spacing for floor framing members may be associated with increased use of engineered wood products such as parallel chord wood trusses and wood I-joists.

4.1 WOOD MATERIALS

4.1.1 Size

Significant changes to sizes of dimension lumber used in balloon framing occurred in the early 1900s. At first, members where often rough sawn (or perhaps only surfaced on two sides) and available in actual (approximate) 2 inch thickness and depths of 4, 6, 8, 10, 12, and even 14 inches. Later, ostensibly to account for surfacing and shrinkage, finished lumber sizes were reduced to 1-3/4 inch thickness with actual depths of 1/4 inch scant of nominal for members up to 4-inch depth and 1/2-inch scant for members over 4-inch depth. Still later, the thickness was reduced to 1-5/8 inch (as in the Sears homes of 1928) and the depth was reduced to 3-5/8, 5-5/8, 7-1/2, 9-1/2, etc. Finally, in the mid-1900s, lumber dimensions were reduced to the standard sizes that are in use today. The nominal size vs. actual size in current use are as follows: 2x4 (1.5 in by 3.5 in), 2x6 (1.5 in by 5.5 inch), 2x8 (1.5 in by 7.25 in), 2x10 (1.5 in by 9.25 in), and 2x12 (1.5 in by 11.25 in).

TABLE 6 TYPICAL FRAMING LUMBER SPECIES BY TIME PERIOD[1]

EARLY 1900S	LATE 1900S
Red Cypress*#	Douglas Fir
Redwood*#	Hem-Fir
Douglas Fir-coastal#	Southern Yellow Pine
Douglas Fir – inland*#	Spruce-Pine-Fir
Pacific Coast Hemlock#	Southern Pine
Western Larch*#	
Eastern Hemlock*#	
Eastern Spruce*#	
California White Pine#	
White Pine (Northern, Idaho, and sugar)#	
Norway Pine#	
Port Orford Cedar#	
White Fir*#	
Tamarack*#	
Long leaf Southern Pine#	
Short Leaf Southern Pine#	
North Carolina Pine#	
Arkansas Soft Pine#	
Southern Yellow Pine#	

[1] *Audel's mentions White Pine as the most common framing lumber on the East Coast in the early 1900s, which is also confirmed by similar references in the Sears catalogues.*

* *Species reported as being appropriate for studs (No. 1 or No. 2 grade recommended)*

\# *Species reported as being appropriate for joists and girders (No. 1 grade recommended)*

4.1.2 Type/Species

Over the 20th century, supply and demand has dictated numerous changes in forestry and availability of wood materials in the United States. At the beginning of the 20th century, virgin growth lumber (also known as old growth) was commonly used. As resources of virgin growth lumber diminished, first in the east and then in the west, use of managed forests became more common and practically essential by the mid-to late-1900s. Wood species typically used for framing lumber in residential construction are shown in Table 6 by time period. As seen in the early 1900s many local species were used. However, Sears boasted in being able to ship the best available Douglas Fir and Pacific Coast Hemlock for their framing lumber. By the late 1900s, wood species were organized into 'species groups' each including several species with similar properties.

4.1.3 Structural Properties

For the purpose of this paper, structural quality deals with characteristics that affect the strength of lumber, not factors such as straightness (although there may be relevant correlation between tendency to warp and structural properties). The primary measures of structural quality are the grading methods used for lumber. However, density is perhaps the single most important parameter to consider, as it can be correlated to several structural properties including bending strength and connection capacity. Grading methods have evolved a great deal over the past century. Typical grades in each time period are shown in Table 7 below. As shown, the grade categories of lumber have increased with time. Modern home construction generally uses two or three grades of dimension lumber and three to four different species or species groups.

By the 1930s, lumber stress values for various species and grades had been used to develop prescriptive span tables for dwelling construction. No. 2 grade lumber was typically recommended for studs while No.1 grade was recommended for joist and rafter framing. The use of No. 2 grade lumber for joists was recognized as a "more economical construction." But, a 2 inch deeper member was recommended for use with span tables based on No. 1 grade lumber. However, in the 1960s, many builders reported using construction grade lumber for floor joists.

Evidently, little analytical concern was placed on structural capacity prior to the 1900s except by way of practical experience, although limited discussions and test data related to structural properties of some commonly used wood species may be found in the

TABLE 7 TYPICAL LUMBER GRADES BY TIME PERIOD

EARLY 1900s *	MID-1900s **	LATE 1900s **
No. 1 No. 2 No. 3 Culls	Select Structural No 1 Dense No 1 No 2 Dense No 2 Dense Construction Construction Standard	Select Structural No 1 Dense No1 No 2 Dense No 2 Stud Construction Standard Utility

* *Audel's describes No 1 as "practically perfect" and No 2 as allowing two sound knots, 1" of sap, and one other blemish. In Light Frame House Construction, No. 2 is noted as OK for economical or temporary construction.*

** *Grade class designations vary by grading agency and lumber species groupings based on 1962 and 1997 industry design specifications.*

literature prior to 1900. However, because of the limited tests conducted, the experimenters often reported different structural property values and used different terminology in describing results. One of the better examples of wood engineering data was produced in 1913 by Carnegie Steel (Table 8) who used timber for the purpose of railroad trestle design. While a larger safety margin of about 5 was used for railroad design, a safety factor of 4 was typically recommended for general use where engineering was applied. The safety factors were typically applied to average ultimate strength values from limited testing to develop allowable or working stress design values.

As discussed later, many wood members for light building construction were probably sized or designed by intuitive "rules of thumb" passed down through years of experience. For example, there were no records found of engineering calculations or test data in the origins of balloon framing techniques in the mid-to late-1800s. However, this outcome is not to suggest that no structural consideration or verification testing was performed, since "proof testing" has historically been a common practice to validate new construction techniques. For example, modern roof trusses were developed using engineering tests and data in the mid-1900s. Proof testing of actual truss constructions (i.e., stacking weights on a trussed roof) was often done to verify performance to a skeptical audience. In essence, the concept of "seeing is believing" has played a significant role in the adoption of new construction technologies.

In summary, it appears that two methods of wood construction verification were emerging in the United States in the late 1800s and early 1900s. The first relied on experience with constructed systems for specific applications (i.e., balloon framing of buildings). The second and newer method relied on engineering analysis of special structures (i.e., railroad trestles) based on evaluation of stresses on individual members using quantified structural properties of various wood species. By the 1920s, allowable stresses for various species and two grades (No.1 and No.2) of structural timbers had been published (see Table 9). Later in the 1920s and 1930s, allowable stresses for structural lumber and timber for dry uses had been published (see Table 10). The following quotation from Light Frame House Construction describes the use of the data in Table 10 in the 1930s:

> *"In Table [10] is given a list of various softwoods used for building construction, with allowable unit working stresses for each species and grade. The species in the upper half of the list are manufactured in structural grades as shown. Definite working stresses have been assigned to all these grades by the manufacturers. For the species in the lower half of the table, structural grades are seldom manufactured as such. Nevertheless, timbers from these species, if carefully selected as to influence of defects, may be rated as 'select structural,' and timbers of lower grade as 'common structural.' The working stresses shown may then be applied."*

It is apparent that the application of grading standards was in its infancy in the 1930s. The common lumber grades (No. 1 and No. 2) were loosely defined in practice and may have varied substantially at the local level of supply. While published bending properties varied by grade and species, they did not differ much according to size of member. Similarly, modulus of elasticity values tended to vary by species, but not by grade.

Early tests of lumber density are not readily found in the available literature. Because of the lack of grading standards at that time, the lack of standard terminology, and the frequent use of locally grown and milled timber, it is difficult to determine the range of lumber densities typifying residential and other building construction earlier in the 1900s. However, in 1885 the data in Table 11 was reported.

By the 1930s, stress values for many popular wood species, and typically two grades each, were available from lumber grading agencies that followed grading standards. Through the mid-to late-1900s structural data on a wide variety of wood species grew rapidly. By the second half of the 20th century, grading rules and agencies were in full swing, and numerous design values were published in wood industry specifications such as the *National Design Specification for Wood Construction* and its supplement of wood design values. While dimension lumber dominated the housing market through most of the 20th century, the late 1990s saw a dramatic increase in the use of engineered wood members such as trusses, wood I-joists, and engineered wood panel products (see Table 1).

TABLE 8: EARLY ENGINEERING DATA FOR STRUCTURAL TIMBERS (Carnegie Steel Co., 1913)

Kind of Timber	UNIT STRESSES (psi)												
	Bending			Shearing				Compression					
	Extreme Fiber Stress		Modulus of Elasticity	Parallel to the Grain		Longitudinal Shear in Beam		Perpendicular to the Grain		Parallel to the Grain		Working Stresses for Columns	
	Average Ultimate	Working Stress	Average	Average Ultimate	Working Stress	Average Ultimate	Working Stress	Elastic Limit	Working Stress	Average Ultimate	Working Stress	Length under 15 x d	Length over 15 x d
Douglas fir	6,100	1,200	1,510,000	690	170	270	110	630	310	3,600	1,200	900	1,200 (1-*l*/60*d*)
Longleaf pine	6,500	1,300	1,610,000	720	180	300	120	520	260	3,800	1,300	975	1,300 (1-*l*/60*d*)
Shortleaf pine	5,600	1,100	1,480,000	710	170	330	130	340	170	3,400	1,100	825	1,100 (1-*l*/60*d*)
White pine	4,400	900	1,130,000	400	100	180	70	290	150	3,000	1,000	750	1,000 (1-*l*/60*d*)
Spruce	4,800	1,000	1,310,000	600	150	170	70	370	180	3,200	1,100	825	1,100 (1-*l*/60*d*)
Norway pine	4,200	800	1,190,000	590	130	250	100		150	2,600	800	600	800 (1-*l*/60*d*)
Tamarack	4,600	900	1,220,000	670	170	260	100		220	3,200	1,000	750	1,000 (1-*l*/60*d*)
Western hemlock	5,800	1,100	1,480,000	630	160	270	100	440	220	3,500	1,200	900	1,200 (1-*l*/60*d*)
Redwood	5,000	900	800,000	300	80			400	150	3,300	900	675	900 (1-*l*/60*d*)
Bald Cypress	4,800	900	1,150,000	500	120			340	170	3,900	1,100	825	1,100 (1-*l*/60*d*)
Red Cedar	4,200	800	800,000					470	230	2,800	900	675	900 (1-*l*/60*d*)
White Oak	5,700	1,100	1,150,000	840	210	270	110	920	450	3,500	1,300	975	1,300 (1-*l*/60*d*)

From Carnegie Steel Co. 1913, 310 (as reported in *Structural Analysis of Historic Buildings)*

TABLE 9: ALLOWABLE STRESSES FOR STRUCTURAL TIMBERS (Voss and Varney, 1926)

		ALLOWABLE STRESSES (PSI)				
		Bending		Compression		
SPECIES	GRADE	Extreme Fiber	Horizontal Shear	Parallel to Grain "Short Columns"	Perpendicular to Grain	Modulus of Elasticity
Cedar, western red	1	900	80	700	200	1,000,000
	2	600	53	467	200	
Cedar, northern white	1	750	70	550	175	800,000
	2	500	47	384	175	
Chestnut	1	950	90	800	300	1,000,000
	2	633	60	533	300	
Cypress	1	1,300	100	1,100	350	1,400,000
	2	867	67	733	350	
Douglas fir	1	1,500	90	1,100	325	1,600,000
	2	1,000	60	750	300	
Douglas fir (Rocky Mountain)	1	1,100	85	800	275	1,200,000
	2	767	57	533	275	
Fir, balsam	1	900	70	700	150	1,000,000
	2	600	47	467	150	
Gum, red	1	1,100	100	800	300	1,200,000
	2	767	67	533	300	
Hemlock, western	1	1,300	75	900	300	1,400,000
	2	867	50	600	300	
Hemlock, eastern	1	1,000	70	700	300	1,100,000
	2	667	47	467	300	
Larch, western	1	1,200	100	1,100	325	1,300,000
	2	800	67	733	325	
Maple, sugar or hard	1	1,500	150	1,200	500	1,600,000
	2	1,000	100	800	500	
Maple, silver or soft	1	1,000	100	800	350	1,100,000
	2	667	67	533	350	
Oak, white or red	1	1,400	125	1,000	500	1,500,000
	2	933	83	667	500	
Pine, southern yellow	1	1,500	110	1,100	325	1,600,000
	2	1,000	70	750	300	
Pine, eastern white, western white, and western yellow	1	900	85	750	250	1,000,000
	2	600	57	500	250	
Pine, Norway	1	1,100	85	800	300	1,200,000
	2	733	57	533	300	
Spruce, red, white, and Sitka	1	1,100	85	800	250	1,200,000
	2	733	57	533	250	
Spruce, Engelman	1	750	70	600	175	800,000
	2	500	47	400	175	
Tamarack, eastern	1	1,200	95	1,000	300	1,300,000
	2	800	63	667	300	

From Voss and Varney 1926, 8 (as reported in Structural Analysis of Historic Buildings without notation regarding safety margins and characteristic structural property data used to derive the working stress design values). Modulus of elasticity is assumed to represent an average characteristics, but does not differentiate between grades.

TABLE 10: ALLOWABLE UNIT STRESSES FOR STRUCTURAL LUMBER AND TIMBER (all sizes, dry locations) (HEW, 1931)

SPECIES OF TIMBER	GRADE	ALLOWABLE UNIT STRESS (PSI) Extreme Fiber in Bending: Joist and Plank Sizes; 4 inches and less in thickness	Beam and stringer sizes; 5 inches and thicker	Modulus of Elasticity
WORKING STRESSES FOR MANUFACTURERS' ASSOCIATION STANDARD COMMERCIAL GRADES				
Douglas fir, coast region	Dense superstructural	2,000	2,000	1,600,000
	Superstructural and dense structural	1,800	1,800	1,600,000
	Structural	1,600	1,600	1,600,000
	Common structural	1,200	1,400	1,600,000
Douglas fir, inland empire	Dense superstructural	2,000	2,000	1,600,000
	Dense structural	1,800	1,800	1,600,000
	No.1 common dimension and timbers	1,135	1,135	1,500,000
Larch, western	No.1 common dimension and timbers	1,135	1,135	1,300,000
Pine, southern yellow	Extra dense select structural	2,300	2,300	1,600,000
	Select structural	2,000	2,000	1,600,000
	Extra dense heart	2,000	2,000	1,600,000
	Dense heart	1,800	1,800	1,600,000
	Structural square edge and sound	1,600	1,600	1,600,000
Redwood	Dense No. 1 common	1,200	1,200	1,600,000
	Superstructural	2,133	1,707	1,200,000
	Prime structural	1,707	1,494	1,200,000
	Select structural	1,280	1,322	1,200,000
	Heart structural	1.024	1,150	1,200,000
WORKING STRESSES FOR STRUCTURAL LUMBER AND TIMBER GRADED UNDER THE STRUCTURAL GRADE EXAMPLES OF THE AMERICAN LUMBER STANDARDS				
Cedar, Alaska	Select structural	1,100	1,100	1,200,000
	Common structural	880	880	1,200,000
Cedar, northern and southern white	Select structural	750	750	800,000
	Common structural	600	600	800,000
Cedar, Port Orford	Select structural	1,100	1,100	1,200,000
	Common structural	880	880	1,200,000
Cedar, western red	Select structural	900	900	1,000,000
	Common structural	720	720	1,000,000
Cypress, southern	Select structural	1,300	1,300	1,200,000
	Common structural	1,040	1,040	1,200,000
Douglas fir, Rocky Mountain region	Select structural	1,100	1,100	1,200,000
	Common structural	880	880	1,200,000

TABLE 10: ALLOWABLE UNIT STRESSES FOR STRUCTURAL LUMBER AND TIMBER (all sizes, dry locations) (HEW, 1931) *(continued)*

SPECIES OF TIMBER	GRADE	ALLOWABLE UNIT STRESS (PSI)		
		Extreme Fiber in Bending		Modulus of Elasticity
		Joist and Plank Sizes; 4 inches and less in thickness	Beam and stringer sizes; 5 inches and thicker	
WORKING STRESSES FOR STRUCTURAL LUMBER AND TIMBER GRADED UNDER THE STRUCTURAL GRADE EXAMPLES OF THE AMERICAN LUMBER STANDARDS				
Fir, balsam	Select structural Common structural	900 720	900 720	1,000,000 1,000,000
Fir, golden, Noble, silver, white (commercial white)	Select structural Common structural	1,100 880	1,100 880	1,100,000 1,100,000
Hemlock, eastern	Select structural Common structural	1,100 880	1,100 880	1,100,000 1,100,000
Hemlock, west coast	Select structural Common structural	1,300 1,040	1,300 1,040	1,400,000 1,400,000
Oak, commercial white and red	Select structural Common structural	1,400 1,120	1,400 1,120	1,500,000 1,500,000
Pine, California, Idaho, and northern white, lodgepole, Pondosa, sugar	Select structural Common structural	900 720	900 720	1,000,000 1,000,000
Pine, Norway	Select structural Common structural	1,100 880	1,100 880	1,200,000 1,000,000
Spruce, Englemann	Select structural Common structural	750 600	750 600	800,000 800,000
Spruce, red, white, Sitka	Select structural Common structural	1,100 880	1,100 880	1,200,000 1,200,000
Tamarack, eastern	Select structural Common structural	1,200 960	1,200 960	1,300,000 1,300,000

Note: The source document (HEW, 1931) did not indicate the margin of safety or characteristic structural property values used to derive the above working stress values. The table values were used to create joist, rafter, and girder span tables in the source document based on a stated extreme fiber working stress.

While difficult to quantify, the references used in the study indicate that a general decline in the structural quality of lumber has occurred. This reduction may be related to the increased use of managed growth lumber, which implies the use of younger, faster growing trees. Based on available reports of lumber density and species usage, it is the authors' judgment that framing (dimension) lumber density has dropped from a typical range of 0.4 to 0.65 earlier in the 20th century to a range of 0.35 to 0.55 by the end of the 20th century – approximately a 10 percent reduction in lumber density. A similar change in the grade quality of lumber may also be inferred. This trend would affect member properties as well as connection properties that are discussed later. While these apparent changes are amply treated in wood engineering specifications and structural property data, the affect on conventional practices suggests the need for re-examination of rules of thumb that are still in use today, particularly with respect to system connections and system performance. On the other hand, it should be noted that many engineered wood products that use laminated veneers and similar methods to create entire members or parts of composite members tend to offset the apparent reduction in dimension lumber quality.

TABLE 11: EARLY DATA ON WOOD SPECIFIC GRAVITY

DESCRIPTION OF WOOD	SPECIFIC GRAVITY
White spruce (Canadian)	0.465
White pine (American)	0.455
Black spruce (American)	0.490
Southern pine (American)	0.872

From Mahon 1885, 125 (as reported in *Structural Analysis of Historic Buildings*).

4.2 FLOOR FRAMING

In the early 1900s, floor joists were typically 2x8 with spans in the range of 12 feet to 14 feet spaced on 16 inch centers (though 24 inch on center placement was indicated for "economical floor construction" when a plaster ceiling was not supported by the joists). For spans of more than 14 feet, 2x10s were recommended when No. 1 grade lumber was used or 2x12 if No. 2 lumber was used. (It was generally recommended that joists be 2 inches deeper or 1 inch wider when lower grade material was used.) One early rule of thumb for sizing joists and beams from *Audel's* states that "Joists longer than 12 times their width [depth] used without intermediate supports are apt to crack plastered ceilings." Obviously, the concern here was with serviceability rather than safety. Rules of thumb for strength were not found in the reviewed literature, but some general guidelines have been passed down. For example, a span to depth ratio limit of 21 is commonly considered as a practical design limitation when beams or joists are laterally supported to prevent twisting. This rule of thumb would allow a 2x8 (1920s actual size 1-5/8" x 7-1/2") to span about 13 feet.

By the 1930s, standardized lumber grades and stress values (see Table 10) were used to specify maximum spans based on engineering analysis of strength limits. A deflection limit of 1/360 of span was used to produce span tables for joists supporting plaster ceilings. Tables were also used to specify maximum horizontal spans

TABLE 12: MAXIMUM SPANS FOR JOISTS AND RAFTERS (feet-inches) (HEW, 1931)

LIVE LOAD (psf)	JOIST SPACING (inches)	2x8 (1-5/8" x 7 -1/2")	2x10 (1-5/8" x 9 -1/2")	2x12 (1-5/8" x 11-1/2")
Plastered ceiling below (deflection not over 1/360 of span)				
10	16	15-4	19-4	23-4
	24	14-6	17-3	20-7
20	16	13-11	17-6	21-1
	24	12-3	15-6	18-7
30	16	12-11	16-3	19-6
	24	11-4	14-4	17-3
40	16	12-1	15-3	18-5
	24	10-4	13-1	15-9
No plastered ceiling below				
30	16	15-6	19-5	23-3
	24	12-10	16-2	19-5
40	16	13-11	17-4	20-11
	24	11-5	14-5	17-5

for sloped roof rafters. Some examples of maximum spans are shown in Table 12.

By the mid-1900s and throughout the remainder of the century, building codes used span tables similar to Table 12; however, the 1/360 of span deflection limit was eventually applied to all floor joists with design loads of 30 psf or 40 psf. Separate tables were eventually created for the selection of roof rafters using different deflection limits (see Section 4.4). In modern codes, deflection limits–not strength limits–control most floor joist selections. The rationale associated with the elimination of the option to design a floor without a deflection limit when no interior finish was supported was to improve the "feel" of the floor (i.e., floor vibration or bounce) and also to minimize long-term deflection (creep). However, affordable homes well into the mid-1900s can be found with 2x8 floor joist at 16 inch centers spanning as much as 14 to 15 feet over unfinished space. Starting in the 1960s, 2x10 floor joists became as popular as 2x8 joists (both comprising a total of 75 percent of the practice and usually of a "construction" grade lumber). Engineered wood joists such as parallel chord wood trusses and I-joists came into use starting in the 1980s (see Table 1). Modern span tables and manufacturer data are readily available for engineered wood products. Because of differences in "feel" and because of greater spans (up to 20 feet and more), many engineered wood I-joist manufacturers recommend a deflection limit of 1/480 of the span.

4.3 WALL FRAMING

4.3.1 Studding

Over the 20th century, actual vs. nominal framing member sizes have decreased somewhat and wall framing methods have changed from balloon to platform frame. By far, the most common stud spacing throughout the 20th century was 16 inches on center; however, 24 inches on center has also been used primarily for single stories. In the early 1900s, it is clear that 16 inches on center framing was considered necessary for the support of lath and plaster interior finishes. While 2x4 studding is exclusively mentioned in the earlier parts of the century for typical dwelling construction, 2x6 studs are sometimes used in modern homes to allow for thicker wall cavity insulation (see Table 1). Because of their greater structural capacity and cost, 2x6 studs are sometimes spaced 24 inches on center where 2x4's would be spaced 16 inches on center.

In the early 1900s, 2x4s spaced 16 inches on center were considered adequate for use in buildings up to three stories in height and for ceiling heights not exceeding 12 to 15 feet. This limit was related to the weak axis of the stud being braced by wall finishes and a maximum stud height to stud depth ratio of 50. For buildings over three stories in height, 2x6s or 3x4s were recommended in the lower stories. In modern codes with 2x4s of smaller standard dimension spaced 16 inches on center, building height is limited to two stories and the maximum 2x4 stud wall height is limited to 10 ft. For buildings over two stories in height, 2x6s or 3x4s are required for the lower stories. Preferred ceiling heights have also changed somewhat over time (see Table 1)which affects the selection of stud lengths.

4.3.2 Plates

While balloon framing generally used single plates at the top and bottom of walls, "standard" modern platform frame construction has adopted the use of double top plates (discussed earlier in Sears' "standard-built" homes). However, single plates are still permitted, and are used occasionally, in modern affordable platform framed homes, specifically in non-load bearing walls or where loads are transferred directly down through studs.

4.3.3 Corners

Three stud corners have been typical throughout the 20th century. A 4x4 corner post was sometimes used in older homes as a hold-over from the 19th century braced frame construction. Two stud corners were also used and are still permitted.

4.3.4 Headers

In the early 1900s, headers were usually considered unnecessary above typical window and door openings because of the load distributing effects in the walls and floor members above the opening. Thus, only a single or double 2x4 flat-wise was used. Doubled 2x4 stud framing at window and door openings was considered as an enhancement to allow for better trim attachment and more sturdy support. Regarding headers in platform frame construction, the following 1923 quote was found in Audel's:

> *"It [platform framing] made the formation of openings for windows and doors easier: a simple header (flat-wise 2x4) could be utilized because the platform above spreads loads from an upper floor or roof uniformly to the stud walls below."*

For framing above larger than normal doors and windows, truss framing using diagonal blocking with cripple studs was recommended, though extensive use of this recommended practice is doubtful. Framing requirements above window and door openings in the early 1900s are summarized in Table 13.

During the last half of the 1900s, built-up headers ranging in size up to two 2x12s for large openings

were provided in span tables in building codes based on various engineering assumptions and loading conditions with disregard for "load spreading" recognized earlier in the century. No clear reason (practical or technical) for this was found in the reviewed literature. It does appear that recognition of different header requirements in load bearing vs. non-load bearing conditions existed throughout the century, although confusion in the field often resulted in the use of headers in either case.

TABLE 13: RECOMMENDED FRAMING ABOVE OPENINGS (HEW, 1931)

OPENING WIDTH	RECOMMENDED HEADER FRAMING
3' or less	2-2x4 edge-wise in load bearing walls 1-2x4 flat-wise in non-load bearing walls
3' to 6'	use a trussed header
greater than 6'	use a girder (built-up header)

4.3.5 Bracing

Wall bracing includes not only the presence of designated bracing members, but also the contribution of various sheathing and finish materials applied to interior and exterior surfaces. In addition, housing style (i.e., amount and size of openings and plan configuration) can have significant effects on the amount and type of lateral bracing provided.

In the early 1900s, wall bracing followed one or more of the following reported practices:

- no bracing (relying solely on interior lath and plaster finish and exterior wood siding);
- 1x4 diagonal bracing (let-in or cut-in); or
- horizontal or diagonal board sheathing.

The following 1931 quote from *Wood Frame House Construction* explains the recommendation for wall bracing when no sheathing is used:

> *"Where sheathing is omitted, the wall should be braced, at each corner and beside each doorway, with let-in strips [1x4] running diagonally from the floor line above to the plate or sill below, and nailed strongly at the upper and lower ends as well as at each intervening stud…Drop siding is more suitable than bevel or common siding for direct application to studs without sheathing…While rabbeted siding serves to brace the building to some extent, it does not add sufficient strength to serve in lieu of other forms of bracing. For this reason the building should be braced, or the bracing effect needed should be supplied in some other way, as by wood lath and plaster, diagonal sheathing, or let-in bracing."*

Based on the above quote, it is apparent that interior finishes (wood lath and plaster) were considered as an adequate primary wall bracing mechanism in the 1930s and earlier. However, it was also recognized that other practices, such as the use of let-in braces or diagonal board sheathing provided enhanced bracing.

The Forest Products Laboratory conducted in-plane shear tests in 1929 on various wall systems representative of the above practices. These tests were conducted to determine the effectiveness of different bracing because "no one knew the relative values of different methods." The bracing tested ranged from horizontal sheathing of green lumber to wood lath and plaster without sheathing. Walls were either solid, framed with a single window opening, or framed with a window and door opening. The standard wall construction was designated as horizontal 1x6 board sheathing of seasoned lumber fastened to each stud with two 8d common wire nails (without interior lath and plaster finish). It was assigned a relative value of 100 percent (i.e., strength and stiffness factors of 1.0). Wall height and length dimensions included two conditions: 9 feet by 14 feet and 7 feet 4 inches by 12 feet. The walls were tested under sufficient vertical restraint (load) to prevent overturning from occurring. The test results for the various solid wall constructions are shown in Table 14; results for walls with openings are shown in Table 15. It is apparent that results varied substantially.

Interestingly, the "no bracing" condition (with lath and plaster only) provided 440 percent more shear capacity than the horizontal board sheathing without lath and plaster used as a comparative baseline. Diagonal board sheathing also provided significant racking strength for solid walls, but, when the diagonal boards were loaded in compression in walls with window and door openings, the shear capacity was less than that achieved with lath and plaster with the same window and door openings. Findings for walls with openings showed that any of the bracing methods that included a 1x4 brace, diagonal sheathing, or plaster and wood lath provided more shear capacity than for the solid wall with horizontal sheathing only.

With the introduction of 4x8 plywood sheathing panels in the mid-1900s, interest in wall bracing using wood sheathing panels was initiated. However, the standard affordable construction apparently remained with the use of 1x4 let-in braces and non-structural sheathing. Later, designated bracing was provided by wood structural panels (i.e., plywood) placed continuously or intermittently (i.e., at corners and at 25' intervals along each wall). Also, a significant number of modern homes used proprietary wall bracing panels such as medium density fiber board, and others. By the end of the century, 7/16-inch-thick oriented strand board (OSB) was commonly used to

TABLE 14: EARLY SHEAR WALL TEST DATA [Forest Products Laboratory, 1929]

SIZE OF PANEL	DESCRIPTION	LOAD (pounds)	STRENGTH FACTOR	STIFFNESS FACTOR	REMARKS
9′ x 14′	8-inch horizontal sheathing, two 8d nails, no braces				
7′-4″ x 12′	8-inch horizontal sheathing, two 8d nails, no braces	2,588	1.0	1.0	No. 20 vibrated 50,000 cycles
7′-4″ x 12′	8-inch horizontal sheathing, two 8d nails, no braces				
9′ x 14′	8-inch horizontal sheathing, two 8d nails, no braces				
9′ x 14′	8-inch diagonal sheathing, two 8d nails, no braces, boards in tension	–	over 8	4.3	Test stopped at 20,000 lb load
7′-4″ x 12′	8-inch diagonal sheathing, two 8d nails, no braces, boards in tension	17,100	6.6	4.3	
9′ x 14′	8-inch diagonal sheathing, two 8d nails, no braces, boards in tension	–	over 8	2.8	Test stopped at 20,000 lb load
9′ x 14′	8-inch diagonal sheathing, two 8d nails, no braces, boards in tension	20,100	7.8	7.3	
9′ x 14′	8-inch horizontal sheathing, two 8d nails, herringbone or bridge 2x4 braces	2,800	1.1	1.3	
9′ x 14′	8-inch horizontal sheathing, two 8d nails, cut -in 2x4 braces	3,700	1.4	1.6	
9′ x 14′	8-inch horizontal sheathing, two 8d nails, let -in 1x4 braces, first arrangement	9,250	3.6	2.6	
9′ x 14′	8-inch horizontal sheathing, two 8d nails, cut -in 2x4 braces, second arrangement	9,000	3.5	4.2	
9′ x 14′	8-inch horizontal sheathing, three 8d nails, no braces	2,330	0.9	1.0	
9′ x 14′	8-inch horizontal sheathing, four 8d nails, no braces	3,550	1.4	1.4	
9′ x 14′	8-inch diagonal sheathing, three 8d nails, no braces, boards in tension	–	over 8	5.2	Test stopped at 20,000 lb load
9′ x 14′	8-inch diagonal sheathing, four 8d nails, no braces, boards in tension	–	over 8	7.5	Test stopped at 20,000 lb load
9′ x 14′	8-inch horizontal sheathing, two 10d nails, no braces	3,500	1.4	1.5	
9′ x 14′	8-inch horizontal sheathing, two 12d nails, no braces	2,800	1.1	1.3	
9′ x 14′	8-inch diagonal sheathing, two 10d nails, no braces, boards in tension	–	over 8	7.5	Test stopped at 20,000 lb load
9′ x 14′	6-inch horizontal sheathing, two 8d nails, end and side matched, no braces	2,550	1.0	1.0	
9′ x 14′	Plaster on wood lath, no sheathing	11,400	4.4	7.2	First plaster crack at 10,600 lb
9′ x 14′	Plaster on wood lath, 8-inch horizontal sheathing, two 8d nails, no braces	14,500	5.6	7.9	First plaster crack at 9,900 lb
9′ x 14′	Plaster on wood lath, 8-inch diagonal sheathing, two 8d nails, no braces	20,300	7.8	9.2	First plaster crack at 12,200 lb
9′ x 14′	Plaster on wood lath, studs and horizontal sheathing, green lumber then seasoned one month	12,700	4.9	6.0	First plaster crack at 8,200 lb
9′ x 14′	8-inch horizontal green sheathing, two 8d nails, no braces, panel seasoned one month	1,700	0.7	0.5	
7′-4″ x 12′	8-inch horizontal green sheathing, two 8d nails, no braces, panel seasoned one month	1,800	0.7	0.7	Vibrated one million cycles
9′ x 14′	8-inch diagonal green sheathing, two 8d nails, no braces, panel seasoned one month	–	–	1.7	
7′-4″ x 12′	8-inch diagonal green sheathing, two 8d nails, no braces, panel seasoned one month	–	–	1.7	
9′ x 14′	8-inch horizontal sheathing, two 8d nails, no braces, alt. sunshine and rain one month	2,175	0.8	0.7	

Note: Panel frames consisted of 2x4 upper and lower plates, vertical studs spaced 16 inches, and triple end posts.

TABLE 15: EARLY SHEAR WALL TEST DATA FOR 9′ X 14′ WALLS WITH OPENINGS [Forest Products Laboratory, 1929]

OPENINGS	DESCRIPTION	LOAD (pounds)	STRENGTH FACTOR	STIFFNESS FACTOR	REMARKS
window	8-inch horizontal sheathing, 1x4 let -in brace	6,500	2.5	3.0	
window	8-inch diagonal sheathing, no braces, broads in tension	13,000	5.0	3.1	
window and door	8-inch horizontal sheathing, no braces	2,100	0.8	0.7	
window and door	8-inch diagonal sheathing, boards in tension	10,240	4.0	1.4	
window and door	8-inch diagonal sheathing, boards in tension	10,150	3.9	1.4	
window and door	8-inch diagonal sheathing, boards in compression	3,250	1.3	0.8	
window and door	8-inch diagonal sheathing, boards in compression	3,400	1.3	1.2	
window and door	8-inch horizontal sheathing, 1x4 let -in braces	5,650	2.2	1.5	
window and door	8-inch horizontal sheathing, no braces, 6-inch bevel siding	3,400	1.3	1.1	
window and door	8-inch diagonal sheathing, no braces, boards in compression, 6-inch bevel siding	8,500	3.3	2.0	
window and door	8-inch diagonal sheathing, no braces, boards in tension, 6-inch bevel siding	13,900	5.4	3.3	
window and door	8-inch horizontal sheathing, 1x4 let-in braces, 6-inch bevel siding	8,880	3.4	2.7	
window and door	Plaster on wood lath, no sheathing	4,200	1.6	2.3	First plaster crack at 1,300 lb
window and door	Plaster on wood lath, no sheathing, 8-inch horizontal sheathing, no braces	5,800	2.2	2.4	First plaster crack at 800 lb
window and door	Plaster on wood lath, 8-inch diagonal sheathing, no braces	11,300	4.4	2.8	First plaster crack at 800 lb
window and door	Plaster on wood lath, 8-inch horizontal sheathing, no braces, 1x4 let -in braces	9,360	3.6	4.1	First plaster crack at 1,500 lb

Notes: 1. Panel frames consisted of 2x4 upper and lower plates, vertical studs spaced 16 inches, and triple end posts.
2. Window rough openings were approximately 33″ x 57″ and door openings approximately 33″ x 76″. Therefore, the total wall area was 126 square feet, the window area was 13 square feet, and the door area was 17.4 square feet.

fully sheath exterior walls. Some statistics on the use of exterior sheathing/bracing are included in Table 1. Various sources of test data on shear resistance of wall materials are summarized in the *Residential Structural Design Guide – 2000 Edition* (HUD, 2000). Approximate ultimate shear values for various modern wall constructions based on research from the mid-to late-1900s are shown in Table 16.

It is evident that the interior finish material, which is not considered explicitly as bracing, actually was the most significant determinant of bracing capacity in many homes built during the first half of the 20th century. During the mid-1900s the preference for interior finishes switched from wood lath and plaster to gypsum board, 2 foot wide gypsum "lath" that was finished with a skim coat of plaster. Soon thereafter, the preferred practice became gypsum wallboard using 4 foot wide panels with taped and finished joints. This practice has remained a standard through the end of the 20th century. It is noted that older lath and plaster interior finishes may provide up to 8 times more shear capacity than typical gypsum board wall finishes used in modern homes (i.e., 100 plf vs. 800 plf). However, all modern homes use either structural panel or let-in/metal braces in addition to support provided by interior finishes.

Since dwelling lateral (shear) capacity is to some degree dependent on interior finishes, it is important to consider changes in the average size of houses as depicted in Table 1, in amounts of interior wall relative to area, and in dead load (relative to seismic or wind design loads). Data on interior wall linear footage per story level as a function of square feet of floor area on a given story level are shown in Table 17. These data are based on a limited sample of house plans that are considered to be representative of a range of home styles constructed in each period. The decrease in the relative amounts of interior walls over the course of the past century is notable. While this trend tends to show a decrease in the amount of ancillary bracing provided by interior walls in newer homes, the lineal footage of exterior walls relative to floor area tend to increase in the newer homes. Thus, the overall bracing impact (considering the changes to interior and exterior walls) may be somewhat offset

TABLE 16: ULTIMATE SHEAR VALUES FOR TYPICAL MODERN WALL CONSTRUCTIONS	
1x4 Let-in brace	>600 lbs/ea (tension) 2,000 lbs/ea (compression)
Metal T-brace (tension only)	1,400 lbs/ea
1/2" Gypsum Wall Board (single side, min. 4d cooler nails at 12"oc)	100 plf
3/8" Plywood or 7/16" OSB (G=0.5, 8d pneumatic nails at standard 6/12 spacing)	650 plf
Exterior 7/8" PC stucco and metal lath w/nails w/staples	 500-750 plf 750-1,580 plf

TABLE 17: INTERIOR WALL AMOUNTS [lin. ft. as a percent of floor area of story]			
OLDER HOMES (early 1900s)[1]		**MODERN HOMES (late 1900s)[2]**	
1 story	9 percent ± 1 percent	1st floor of 1 to 2 story	4.3 percent ± 1 percent
1st floor of 2 story	6 percent ± 1 percent	2nd floor of 2 story	7.9 percent ± 1 percent
2nd floor of 2 story	9 percent ± 1.5 percent		

Notes:
[1]Values based on a small sample of traditional house plans in Sears Catalogues (1910 – 1926) including affordable and more expensive construction of 1 and 2 stories.
[2]Values based on a small sample of representative modern home plans (1990s) including economy and move-up construction (no luxury homes).

by these two countervailing trends. Uncertainty in the effects of increased irregularity in plan configuration of newer homes must also be considered relative to possible impact on resistance to lateral loads. However, one recent study of homes following the Northridge Earthquake seems to indicate that irregularities in wall line offsets cannot be directly associated with any noticeable trend in performance of single family homes (HUD, 1999). The data summarized in this section is provided to suggest the need for a more detailed and thorough evaluation of changes in bracing found in homes over the past century. Thus, the simple comparisons as suggested in this report are not absolute or complete treatments of this subject.

4.4 ROOF FRAMING

4.4.1 Rafters

As noted earlier, roof rafters were typically 2x4 or 2x6 in the early 1900s. The horizontal span of rafters and the rules of thumb mentioned previously for joists were typically used for rafter members as well. For hip and valley rafters, the following rule of thumb from *Light Frame House Construction* was apparently in use in the early part of the 20th century:

- up to 12 foot horizontal span use a single hip rafter 2 inches deeper or 1 inch thicker than rafters; and
- over 12 foot horizontal span use a doubled rafter for the hip rafter.

Since engineering methods have failed to offer reasonably accurate explanations of the system effects related to hip or valley rafter design, similar rules of thumb are still in practice today (unless an engineered design is required). By the mid-1900s, rafter framing (and also floor joists) were commonly provided in engineered span tables using certain design assumptions and methods of analysis considering single elements and not systems. Newer span tables are based on updated lumber properties, but engineering assumptions similar to those used earlier in the century are found in all modern building codes for residential construction. During the mid-1900s, engineered wood roof trusses were introduced and by the late-1900s were used in a great majority of new homes (see Table 1).

4.4.2 Roof Sheathing

In the early 1900s, roof sheathing of 1x6 or 1x8 boards, or minimum 1x3 furring (spaced sheathing) spaced according to weather exposure of wood shingles (up to 6 inches on center) was typical. A minimum of two 8d common wire nails were typically used to fasten random-length boards to each roof rafter. In the mid-1900s plywood roof sheathing entered the market and soon became the standard. By the late 1900s, most roofs were sheathed with some form of wood structural panel sheathing, primarily 7/16-inch-thick OSB (see Table 1); board sheathing methods had become practically extinct. Nailing requirements and types of fasteners changed to accommodate the panels and newer tools, such as pneumatic nail guns.

4.5 FASTENERS AND CONNECTIONS

Trends in the treatment of connections in housing during the 20th century provide important insights into changes in the structural characteristics of homes. This section reviews some of the changes in fastening practices and materials. Where found in the literature, data on structural characteristics of various fasteners or connections are summarized.

Wire nails have been the predominant fastener for wood framing connections throughout the 20th century. Up to the 20th century, the most common nails used were wrought iron or cut nails, which were preceded by the use of wooden pegs and special heavy timber connection details (i.e., wood joinery). Cut nails were quickly replaced by common wire nails in the earliest parts of the 20th century. However, it is worth noting that *Audel's* reports test data indicating that cut nails provide as much as 2 to 3 times the "holding capacity" of common wire nails of similar size. The tests were conducted with several repetitions and wood species, including hardwoods and soft woods and dense soft woods. It is presumed that the difference in withdrawal capacity can be explained by the wedging action created by the tapered shank of a cut nail. Cut nails continued to see infrequent use for some applications such as hardwood flooring, but eventually they became obsolete. In early framing practice, specifications often called for heavier loaded joints or thicker materials to be "securely spiked together." Spikes are similar to common wire nails, but are larger in diameter and greater in length than common wire nails. However, from the literature surveyed, it appears that for home building in the early 1900s, spikes may have been considered to be 20d common wire nails. Rules of thumb for nail selection in the early 1900s are paraphrased as follows from *Audel's:*

> *"Use one penny size for each 1/8-inch of thickness for typical wood density. For softer wood use up to two penny-weights larger, and for harder/denser wood use one to two penny-weights smaller to prevent cracking of wood."*

In the last half of the 1900s, box nails with a smaller shank diameter and a resin coating to increase holding were used to some unknown extent. By the late 1900s, pneumatic fasteners dominated the market. Various fastener sizes and types are addressed in the *Residential Structural Design Guide – 2000 Edition* (HUD, 2000) and other wood design or technology references.

Early requirements for nailing were as much a result of constructability considerations as for structural reason, and varied depending on a particular connection and its perceived role in the structural system. Often, the older requirements for connections used vague terms such as "spike securely" or "adequately nail." Perhaps this subjective approach was in realization that the fastening practice, material choices, and framing methods of the early 1900s were sufficiently conservative and simple as to not require exact specification. While connection requirements for modern residential wood framing can be found in building codes, no data is available that quantifies the variation in actual fastening techniques or practices used in the field. Observation tends to suggest that the variation is quite large. Very little technical data is available to explain the actual performance of various fastener and material choices found in modern home construction practice, particularly when considered at a system level (e.g., multiple joints and fasteners in a load path). Some studies of this nature are summarized in the *Residential Structural Design Guide – 2000 Edition* (HUD, 2000).

The following connection requirements or practices are excerpted and summarized from sources reviewed in this study. They are based on recommendations provided in various framing guidelines and early code documents and, therefore, may not represent actual field practice during the different time periods or in different locales.

4.5.1 Early 1900s

Sill to Foundation—Indicated as "desirable" to anchor sill to foundation (especially if high wind is possible); recommend 3/4 inch bolts extending 18 inches into concrete foundation wall with OG washer and nut. Recommendations for sill bolt spacing ranged from 6 feet to 12 feet on center. Evidently, anchoring was not a required or common practice for typical construction at the beginning of the 20th century.

Joist to Sill or Wall (depending on type of framing)—-(1) Balloon and braced framing: *spike securely* to side of studs (two near bottom and enough at top to hold in place during construction). (2) Platform framing: joists should be *securely toe-nailed* to plate with not less that 8d or 10d nails; box headers should be *spiked securely* into ends of joists with 20d nails (remember, the box header or band joist was treated as a continuous header above all openings in walls below).

Built-up Girders—Use 10d common wire nails at 12 inches on center top and bottom (staggered) to keep individual members from buckling separately or failing independently.

Joist Headers for Floor Openings—End nail through inside trimmer (if doubled trimmer joists) into end grain of each single or built-up header member with two 20d spikes for 2x6; 3 for 2x8 and 2x10; or 4 for 2x12 and 2x14.

Stud to Top and Bottom Plates—"Desirable" to end-nail using two 20d common wire nails.

Ribband to Stud—Let-in 1x6 into studs to support joists in balloon framing; secure ribband to each stud with two 8d common wire nails.

Rafter to Ceiling Joists or Collar Beams (cross ties)—

"Solidly nail" rafters to joists; connect a ceiling joist to every rafter if shallow slope roof or to every second or third rafter for steep roofs. Some old construction drawings suggest that 3 to 5 nails may have been used for this connection.

Rafters to Ridge Board—Toenail or end-nail rafter to ridge board; "not of great significance structurally," but required to hold in place during construction.

Rafters to Wall Plate—Toe nailing was common practice; however, nail sizes and numbers were not shown or reported in any of the literature surveyed. Like foundation anchor bolts, it appears that anchoring of roofs was left to the realm of "accepted construction practice."

Valley and Hip Rafter to Ridge—Provide "adequate fastening to ridge to prevent pulling apart."

Sheathing Boards to Wall or Roof Framing—Two 8d common nails per board up to 1x8; three 8d common nails for greater than 1x8. In the early 1900s cut nails were still frequently used for this connection.

4.5.2 Late 1900s

The mid-1900s can be considered as a transition period in fastening technology. During this period, pneumatic fasteners began to be used (discussed below). Box nails were also used in place of common nails, but to an unknown degree. Other changes that affected fastener specification included the introduction of plywood sheathing, and the use of metal plate connected wood trusses in place of traditional rafter and joist framing. Special metal connectors, such as joist hangers, also came into use for certain connections or conditions.

By the late 1900s, pneumatic fasteners were used predominantly in the home building industry for framing purposes. The requirements for pneumatic fasteners (nails and staples) were provided in a code evaluation report (NER 272). However, connection schedules in codes still addressed primarily common wire nails. Thus, the connection requirements for specific fastener types in common use or approved for use are not consolidated. This condition may explain the variations in actual practice that may fall above or below the minimums implied by or explicitly defined in modern building codes.

5.0 CONSTRUCTION QUALITY

No reliable source of data was found regarding trends in construction quality over the course of the 20th century. However, it should be noted that complaints and concerns with shoddy construction in the references used in this study seem to indicate that it was just as much a concern at the beginning of the century as the end. Unfortunately, the significance of such concerns remain in the realm of anecdotal evidence, which serves to confirm that quality problems existed, but does not allow a quantitative assessment of the degree, frequency, or implications of such problems as related to structural performance in newer or older homes. It appears that the tradespeople of yesterday were just as subject to human error as they are today.

However, assuming no significant change in construction quality, certain changes in construction materials and methods may justify a greater concern in modern times on the basis that the techniques are less "forgiving" of mistakes or tolerances implicit to reasonable standards of workmanship. For example, modern framing members are somewhat smaller and require greater precision in fastener installation. Pneumatic fastening methods and panelized sheathing products tend to create situations where "blind" connections are made to underlying framing members without as close a control as inherent with hand-driven nails to secure boards. While such problems can be avoided with appropriate controls, newer materials and methods (including more varieties and options than in the past) do seem to place the burden of a greater standard of care on the tradesperson.

6.0 SUMMARY AND CONCLUSIONS

Significant changes to construction materials and methods have occurred over the past century that affect the economy and structural performance of homes. In some cases it appears that change has increased structural performance while, in other cases structural performance was reduced. It also appears that different levels of value (i.e., balancing of cost versus performance) have been applied throughout the century to meet varied housing needs or desires in the nation. As a result, minimums based on a compelling need for affordable housing have co-existed with "upgrades" used in homes sold to more affluent buyers. In such a manner, housing supply has served a diverse demand with needed flexibility in establishing an appropriate definition of value based on individual buyers or market segments.

Some significant changes to housing construction methods and materials discussed in this report are summarized as follows:

- Separate concrete spread footings, introduced in early 1900s, are found on nearly all homes by the end of the century. In fact, several enhancements to foundation construction have occurred over the past century.
- Framing method switched from balloon to platform frame technique.
- In 1900, lumber was ungraded and largely reliant on locally available species and "sorts". Later, lumber grades were standardized and resources became more dependent on managed forests and fewer species.

- Lumber size was originally based on full dimensions (i.e., actual size of a 2x4 was 2 inches by 4 inches). During the 1900s, the sizes of "finished" dimension lumber were reduced in several stages to a standard thickness of 1.5 inches and standard widths of 3.5, 5.5, 7.25, 9.25, and 11.25 inches for nominal 2x4, 2x6, 2x8, 2x10, and 2x12 dimension lumber, respectively.
- At the end of the 20th century, engineered wood products quickly gained acceptance as alternatives to dimension lumber used primarily in sheathing, floor framing, and floor girder applications.
- A complete change from boards to engineered wood structural panels (i.e., OSB and plywood) happened relatively quickly early in the second half of the 20th century.
- Headers for windows and doors have seen significant change. At the beginning of the century structural headers, as such, were not normally used over openings; instead there was acknowledgement of system effects in distributing loads over wall openings. By the end of the 20th century, header requirements became more complicated requiring different tables to be considered under various conditions. For unspecified reasons, the earlier acknowledgment of system effects was abandoned. In addition, the apparent desire to simplify construction in the field has often resulted in the "worst-case" condition being applied to all headers in order to eliminate confusion.
- Wall bracing has apparently seen little change in effective capacity required by standardized testing of wall segments, though materials have changed during the course of the 20th century. Specific bracing requirements were implemented in the last half of the century. However, interior finishes have changed from lath and plaster to gypsum wallboard which has the effect of lowering the "reserve capacity" found in older homes relative to newer homes. Changes in house style, size, and design of interior space have also affected the "reserve capacity." However, more recent trends toward total sheathing with structural material such as OSB can readily compensate for other "losses."
- Fasteners changed, first from cut nails to common wire nails, then to pneumatic fasteners. Box or sinker nails were also used. However, little quantitative information is available to determine the functional or performance rationale for connections found in the historic practice or in building codes (not to suggest that data from various single fastener tests do not exist in large quantity). The withdrawal capacity of an 8d cut nail used at the beginning of the 20th century for sheathing was as much as 2 to 3 times more than a comparable 8d common wire nail according to early tests. The 8d common wire nail, in turn, provides greater withdrawal capacity when compared to most 8d (0.113 inch diameter) pneumatic nails commonly used at the end of the 20th century, but only when adhesive coatings on pneumatic nails are not considered. Thus, withdrawal capacity of nails for certain joints may have changed dramatically depending on the effectiveness of adhesives on newer coated nails. Changes in the shear capacity of certain joints, such as sheathing connections, also occurred as a result of the general reduction in nail diameters.
- Construction quality has been a concern through the 20th century with little evidence to suggest that any substantial change (good or bad) has occurred. However, there are some obvious changes in materials and tools that require more precision in construction; thus, there is a greater potential for error, particularly in connections. This problem is not helped by the numerous choices for fasteners (including staples, etc.) now on the market, and the lack of simplicity and uniformity in the regulations that govern connection requirements in modern construction practice.

7.0 RECOMMENDATIONS

The findings and conclusions of this study suggest that certain modern house construction practices should be carefully evaluated in view of changes in historic practice. Some specific recommendations include:

1. Re-evaluate, simplify, and prepare specific details for connections that balance structural needs with the intuition and capability of the tradesperson. For example, can two specific sizes of pneumatic nails be successfully used to specify all or most framing connections in a typical house?
2. Wall bracing practices should be re-assessed based on changes in the style, size, and interior finishes used in modern homes as compared to older homes (early 1900s).
3. Practices for header sizing and engineering analysis of homes in general should incorporate more efficient system-based design principles that were inherently understood in the design and framing practices in the early 1900s.

8.0 BIBLIOGRAPHY

Annual Builder Practices Survey, NAHB Research Center, Inc., Upper Marlboro, MD.

Architectural Graphic Standards, 5th Edition, Charles George Ramsey and Harold Reeve Sleeper, 1956.

Audel's Carpenters and Builders Guide (Vol. 1, 2, 3, and 4), Theo. Audel & Co. -Publishers, New York, NY, 1923.

Cotton Fields No More: Southern Agriculture 1865-1980, Gilbert C. Fite, The University Press of Kentucky, Lexington, KY, 1984.

Dwelling House Construction, Fourth Edition, Revised, by Albert G. H. Dietz, The MIT Press, Cambridge, MA, 1974.

Evaluation of Housing Performance and Seismic Design Implications in the Northridge Earthquake, U.S. Department of Housing and Urban Development, Washington, DC, 1999

Housing at the Millennium, Facts, Figures and Trends, National Association of Home Builders, Washington, DC, 2000.

Housing Statistics, U.S. Census, Washington, DC.

Light Frame House Construction, U.S. Department of Health, Education, and Welfare (HEW), Washington, DC, 1931.

Minimum Property Standards for One and Two Living Units, FHA No. 300, Federal Housing Administration, Washington, DC, 1958.

Old House Measured and Scaled Detail Drawings for Builders and Carpenters, W. A. Radford, Dover Publications, Inc., New York, NY, 1983.

One- and Two-Family Dwelling Code, Council of American Building Officials (CABO), Falls Church, VA, 1989 and 1992 editions.

Pneumatic or Mechanically Driven Staples, Nails, P-Nails, and Allied Fasteners for Use in All Types of Building Construction (NER-272) – Council of American Building Officials, Falls Church, VA, 1989.

Residential Structural Design Guide -2000 Edition, prepared by NAHB Research Center, Inc., for the U.S. Department of Housing and Urban Development, Washington, DC, 2000.

Sears, Roebuck Home Builder's Catalog, 1910 Edition, Dover Publications, Inc., NY, 1990.

Small Housing of the Twenties, the Sears Roebuck 1926 Catalog, Rover Publication, Inc., NY, 1991.

Structural Analysis of Historic Buildings, J. Stanley Rabun, John Wiley & Sons, Inc., New York, NY, 2000.

Wood Frame House Construction, Edited by Gerald E. Sherwood and Robert C. Stroh, Ph.D., for the National Association of Home Builders, Armonk Press, Armonk, NY, 1988.

APPENDIX A THERMAL INSULATION

Very little mention of any requirement for energy efficiency such as thermal insulation was found in the historical sources reviewed (see Bibliography). For example, no information on thermal insulation was found in the Sears catalogues, which were considered an exhaustive catalogue for building materials, although the use of tarred felt paper underneath flooring to prevent draftiness and under the siding for rot protection was mentioned.

Tarred paper was also recognized as an air barrier to prevent air leakage through walls in "poorly built" homes in a University of Wisconsin study in the early 1900s. This study reported various infiltration rates through frame walls and found that "air infiltration through frame wall construction, containing building paper or plaster properly applied, is negligibly small (0.1 to 0.3 cubic feet per hour with a 15 mph wind-induced pressure difference). It is also reported that the United States Bureau of Standards had conducted tests on the strength, rate of air penetration, and moisture proof properties of building papers. Asphalt impregnated papers were reported to weigh from 66 to 163 pounds per 1,000 square feet. It was noted that building paper "must be selected and put on much more carefully than is ordinarily done."

One 1930s framing guide (HEW, 1931) encouraged the use of exterior board sub-sheathing for its structural bracing benefits and for comfort benefits in cold or hot climates since "wood is one of the best natural insulators." In addition, one drawing of roof framing did indicate "insulation material" placed between ceiling joists, which may suggest the relative importance placed on insulation in roofs as compared to other locations. The same guide later describes air leakage and thermal conduction as primary sources of heat loss, and encourages the use of thermal insulation and weather striping of doors to save on the rising cost of coal as well as other sources of heating energy (fuel oil, electric, etc.), and percent reductions in air leakage were cited for practices such as weather stripping and tightly fitting doors.

The National Bureau of Standards (Journal of Research, Vol.6, No.3), reported fuel savings for combinations of weather-stripped doors, insulation, and double (storm) windows. The savings were reported to range from 10 to 60 percent. The higher values were reported for use of 1-inch insulation (probably exterior wood sheathing) and double windows. It is noted that if tarred paper is not placed over sheathing (i.e., board sheathing is omitted) it is probably not worth installing because of air leakage between laps in the building paper. It is not clear that the function of moisture protection was considered reason enough to justify the use of building paper.

In general, energy efficiency did not become a serious consideration in home construction until later in the 1900s. The Minimum Property Standards (HUD, 1958) gave requirements for insulation based on a rudimentary calculation method. By the late 1900s, more sophisticated energy codes had been developed and relatively high levels of insulation were required in virtually every new home. The availability of materials to enhance energy efficiency also flourished (e.g., double glazed windows, various insulation types with high thermal resistivity, sealing and weather-stripping technologies, etc.). In addition to energy codes that addressed new construction, tax incentive programs were introduced in the 1970s to encourage insulation of older homes. In addition, credits were offered through energy efficient mortgage financing programs and demand-management programs offered by various utility companies.