Elements of Log Building Design & Construction

Sponsored by the

LOG HOMES COUNCIL
Leaders in Excellence

Introducing

Rob Pickett

- Industry experience 1977 to 2001
- Founded RP&A in 2001
- Log Homes Council
- ICC-ES / ICC participation

www.timberlogic.com

Associate Member, Building Systems Councils

Rising Pressures Inspire Competitors to Unite

- Energy conservation concerns evolve from environmental awareness of the 60's and Oil Embargo in the 70's
- Broader enforcement of building codes, especially fire ratings
- Call for quality assurance

Introducing the Log Homes Council

- First meeting – Denver, 1977
- 22 Charter Members from the U.S. and Canada
  - Develop and promulgate standards of quality and safety throughout the log home industry
  - Disseminate information about developments in the log home industry to regulatory bodies, governmental agencies, the press, and the general public
- Now – One of NAHB's Building Systems Councils
  - 60 Member Companies

LHC Milestones

- 1980: ASTM D-3957 1st published
- 1981: LHC accredited by NES as Log Grading Agency
- 1983: NBS Thermal Testing
- 1984: LHC mandates log grading 1989: Thermal Mass in MEC
- 1995: LHC-HUD: Guideline for Construction Manuals
- 1997: Urban-Wildland Interface Code
- 1999 and on: Technical papers

Our Heritage

Needs:

Ease of construction, economy, shelter from weather and attack

1915 Harebell Cabin, back country Army cabin in Yellowstone National Park

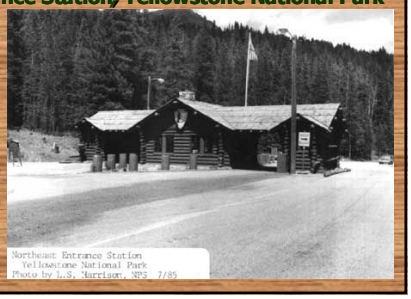
Our National Park Heritage

Old Faithful Inn

- Built: 1903-1904
- 7-story log wall and log frame structure

Northeast Entrance Station, Yellowstone National Park

- Built: 1935 to the specifications of the Park Structures and Facilities
- The native materials used in the Northeast Entrance Station are the logs and stone from the park, and the wood shingles of the roofs.
- A 1932 plat of Silver Gate, the small community just east of the entrance station, proposed that all of the structures in the community be of log construction.



Today's Log Home Market

- 25,000 – 30,000 Log Homes per year
- 5% - 8% of Custom Residential Construction
- 60 Major log home manufacturers
- 400-500 smaller log mills in U.S.

Why?

- Style - American Heritage
- Natural Elements
- De-Stress – Quiet, secure
- Comfort – warm, peaceful, 'home'
- Icon – Nothing like it
- Heirloom – family gathering, enduring

Where?

- PA
- TX
- OH
- NY
- NC
- MI
- CO
- WI
- WV
- TN

Market Trends

WHAT DO LOG HOMES COST?

- 5% - 10% more than stick – starting point
- NOT AVERAGE HOMES
- $150 - $450/sf or more…

Design Trends

Design Trends

Importance

- ICC establishes the Consensus Committee on Log Structures (IS-LOG)
- Consensus of LHC, ILBA, trade magazines, proprietary literature, AF&PA/AWC standards, FPL Wood Handbook
- Enforcement of grading requirement
- Uniformity in evaluation applicable to all log building systems
- Quick reference for technical data
- Broader acceptance with growth of ICC adoption at various levels of government
- Updated every code cycle
- Potential adoption beyond the U.S.

ICC 400

- **Section 1** – Administrative & Referenced Standards
  - Only for log structures
  - Requirements covered by other ICC codes are not included
- **Section 2** – Definitions, Abbreviations
  - Log. Wood member that has been stress graded and grade marked or grade certified using rules of an accredited inspection agency in accordance with ASTM D3957, D3737, or D245 and is incorporated into a structure.

General Requirements

Detail courtesy of Southland Log Homes Inc.

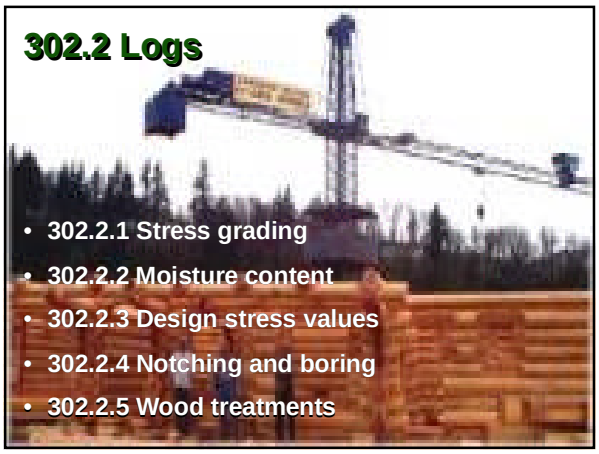
Same as conventional:

- Project planning & preparation
- Design loads and deflection criteria
- Plumb, square and level construction
- Receiving, handling, and protecting materials

Getting Started

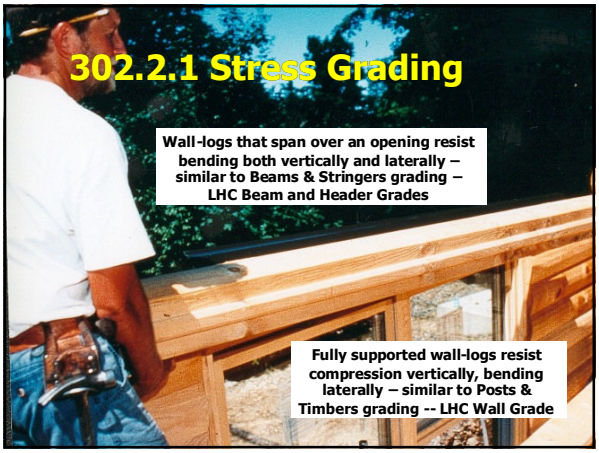
- Keep logs off ground and dry
- Make sure all assembly maintains plumb, level and square, from foundation up
- Use reference points on subfloor to locate the first log course as well as interior partitions and electrical

302.2 Logs



- 302.2.1 Stress grading
- 302.2.2 Moisture content
- 302.2.3 Design stress values
- 302.2.4 Notching and boring
- 302.2.5 Wood treatments

302.2.1 Stress Grading

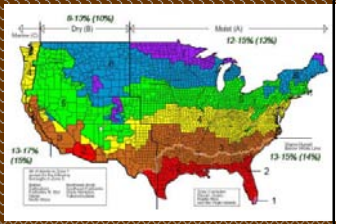


302.2.2.1 Design moisture content (MC_D)

- Prescriptive Option: Evaluate as green (at fiber saturation point, MC_{FSP})
- Certified Option: Certify a specific moisture content under an accredited 3rd-party grading agency

302.2.2.2 Service moisture content (MC_S)

- Prescriptive Option: Per Table 304.2(4) and Climate Zone Map
- Calculation Option: Per ASTM D4933



302.2.3 Design Values

302.2.3.1 Sawn lumber and glued laminated timbers
- Per AF&PA National Design Specification for Wood Construction (NDS)

302.2.3.2 Logs
- Per ICC400 Tables
  - Not limited to only those species combinations and grading agencies published in the tables
- As established by an accredited log grading agency (Log Homes Council, Timber Products Inspection, VTT of Finland)

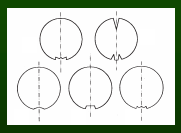
- Adjustment factors are to be applied per NDS or Table 302.2(6) as appropriate.

Wood Species Options

- Strength – Relates to intended use
- Economy – Local, available
- Esthetic – Color, figure, growth characteristics
- Workability – Profiling, staining, controlling drying effects
- Durability – Natural, treated
  - Pressure treated logs limited to 1.6 load duration factor; other considerations per local code

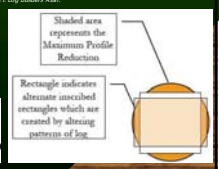
302.2.3.4 Section Properties

Section properties are determined using the largest inscribed rectangle that can be inscribed within the profile.



Scribe-fit Construction Options

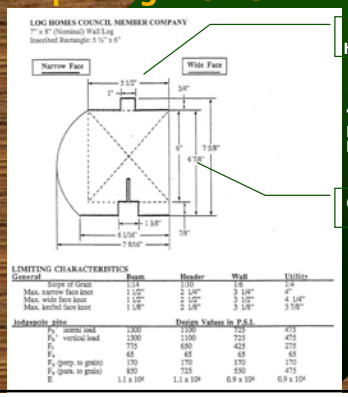
Source: Int'l. Log Builders' Assn.



Machine-profiled Options

- Solid wood
- Glu-laminated

A sample Log Profile:



5-1/2″ = Least horizontal dimension

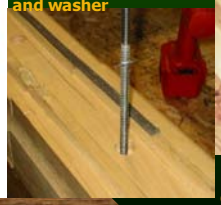
48.35 sq. in. area of profile / H_L = 7-1/32″ log thickness (W_L)

6-7/8″ = Log stack height (H_L)

302.3 Mechanical connections and fasteners

Lag screws in pre-bored holes with countersink for head and washer

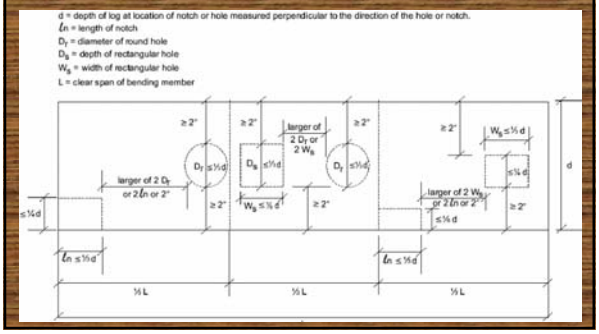
Proprietary Bolting Systems



Log screws – self drilling and countersinking

302.2.4 Notching and boring.

Prescriptive Option per Fig. 302.2.4



302.2.4.1 Wall logs

2/3 of log cross-section can be removed at corners, joints, and intersecting walls but must resist separation

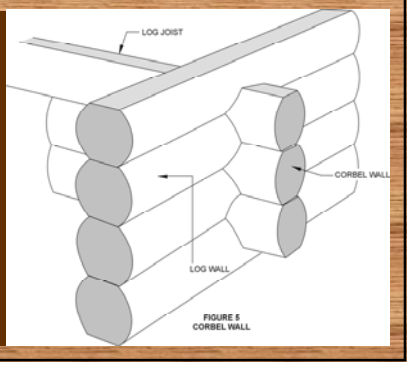
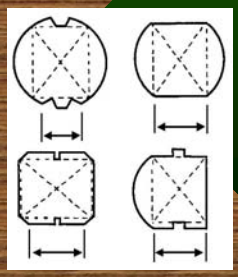


FIGURE 5
CORBEL WALL

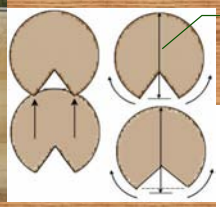
Section 303: Fire-Resistance Ratings



- **Prescriptive Path:** For 1-hour rating, minimum thickness of 6-inches
- **Peformance Path:** Perform ASTM E119 testing at accredited lab
- **Engineered Path:** Calculate per NDS Ch. 16: Char rate and Capacity of Remaining Wood

Section 304: Provisions for Settling

- **Prescriptive Path #1:** Estimate settling at 6%
- **Prescriptive Path #2:** Estimate components of settling
  - Dimensional Change:
    - 3% (Prescriptive Path #2a) or
    - 1% change for each interval of 4% change in moisture content (Prescriptive Path #2b)
  - Compaction: 1.5% unless bearing capacity exceeds loading (compressive strength)
  - Slumping: 1.5% -- applies to scribe-fit log walls
- **Performance Path #1:** Establish settling rate by testing
- **Performance Path #2:** Establish settling rate by field survey



Log stack height

Figure 3–3. Characteristic shrinkage and distortion of flat, square, and round pieces as affected by direction of growth rings. Tangential shrinkage is about twice as great as radial.

Compaction:

- Notch/cope systems compress at bearing points
- Eliminated by adequate bearing across flat or coped surface

Slumping:

- Caused by tangential shrinkage during seasoning
- Drying stress is relieved by notch, which opens wider, becomes shallower, and loses stack height.

Shrinkage:

- Rate and distortion varies
- Reduction at knots, cross grain

304.2.2 Calculated Procedure

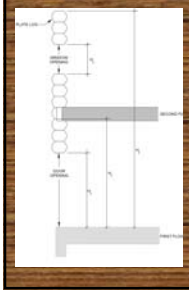
Establish settling rate by analysis

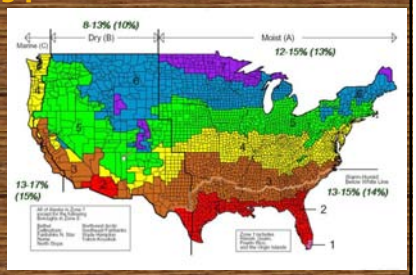
- Set MC at time of milling (design)
- Set MC at site in service (equilibrium)
- Apply radial shrinkage rate by wood species

Table 3-5. Shrinkage values of domestic woods

Species	Shrinkage[a] (% from green to oven-dry moisture content)			Species	Shrinkage[a] (% from green to oven-dry moisture content)		
	Radial	Tangential	Volumetric		Radial	Tangential	Volumetric
Hardwoods				Cat, white-cor.			
Alder, red	4.4	7.3	10.9	Chestnut			
Ash				Chinkapin			
Black	5.0	7.8	11.0	Chinquapin	6.6	9.0	16.7
Blue	3.8	6.0	11.3	Chestnut	3.4	5.0	10.0
Green	5.2	8.1	13.5	Dogwood	6.4	9.8	16.3
Oregon	5.7	8.1	13.6	Flowering (dogwood)	5.4	9.0	14.2
Pumpkin	3.4	6.3	10.0	Elm	5.0	9.0	14.5
White	5.0	7.8	13.0	White	4.6	9.5	16.3
Aspen				Persimmon, common	7.9	11.2	18.5
Bigtooth	3.5	7.9	11.8	Sycamore	4.8	7.2	12.0
Quaking	3.5	6.3	11.0	Sweetgum	5.0	10.3	15.8
Basswood, American	6.6	9.0	15.0	Sycamore, American	3.0	6.4	10.1
Beech, American	5.5	11.0	17.2	Tanoak	4.8	7.6	12.1
Birch				Tupelo			
Alaska paper	6.0	9.9	16.7	Black	4.1	8.7	14.4
Gray	5.1		14.0	Water	5.5	9.5	15.6
Paper	6.2		16.0	Walnut, black	5.5	7.8	13.8
River	4.7	9.0	13.0	Walnut, black	4.4	7.1	12.0
Sweet	6.5	9.0	16.0	Willow, black	6.0	8.2	15.7
Yellow	7.3	9.5	16.0	**Softwoods**			
Butternut, white	3.0	5.0	8.0	Cedar			
Butternut	5.4	8.8	15.6	Yellow	2.9	5.0	9.0
Cherry, black	3.7	7.1	11.0	Eastern white	2.4	4.9	7.7
Chestnut, American	3.4	6.7	11.0	Eastern redcedar	1.7	4.7	7.1
Coffeetree,				Incense	3.3	5.0	7.7
Kentucky	5.0	7.1	12.0	Northern white	2.2	4.0	6.2
Black	3.2	5.0	10.2	Port-Orford	3.8	6.9	9.9
Western redcedar	2.4	5.0	6.6	Western redcedar	2.4	5.0	6.6
Douglas-fir				Douglas-fir			

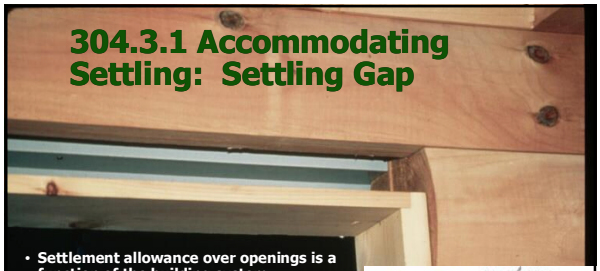
Target MC_D = MC_S+3% to 4% to insure non-settling performance



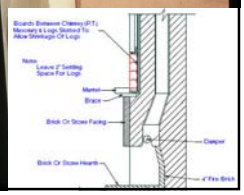


≤0.5% of the involved height = non-settling (1/2" in 8-ft.)

304.3.1 Accommodating Settling: Settling Gap



- Settlement allowance over openings is a function of the building system.
  - The settling space is protected from the exterior by flashing and is sealed with insulation.
- Interior partitions have settling gap between top plate to absorb settling.
- The gap may be provided at the bottom of the logs that pass over the fireplace mantel.



304.3.2 Sliding Joints

Vertical elements attached to log walls use slotted holes to allow for settling.

Where penetrating roof, counterflashing must be properly installed.

304.3.3 Settling Devices

Section 305: Thermal Envelope

- **ASHRAE**
  www.ashrae.org
- **DOE**
  www.energycodes.gov
  www.eere.energy.gov
- **ICC: IECC**
  REScheck™ used to demonstrate compliance

REScheck®

Section 305: Thermal Envelope

R-Value of Log Wall by Average Width and Specific Gravity

Specific Gravity (SG)	Average Width 5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	12 in.	14 in.	16 in.
0.29	8.98	10.64	12.23	13.86	15.48	17.11	20.36	23.61	26.86
0.3	8.76	10.35	11.93	13.51	15.1	16.68	19.84	23.01	26.17
0.31	8.56	10.1	11.64	13.19	14.73	16.27	19.35	22.44	25.52
0.32	8.37	9.87	11.37	12.87	14.38	15.88	18.89	21.89	24.9
0.33	8.18	9.65	11.11	12.58	14.04	15.51	18.44	21.38	24.31
0.34	8	9.44	10.87	12.3	13.73	15.16	18.02	20.88	23.75
0.35	7.84	9.23	10.63	12.03	13.43	14.82	17.62	20.41	23.21
0.36	7.68	9.04	10.41	11.77	13.14	14.5	17.24	19.97	22.7
0.38	7.38	8.68	9.99	11.3	12.6	13.91	16.52	19.13	21.74
0.39	7.24	8.52	9.79	11.07	12.35	13.63	16.18	18.74	21.29
0.41	6.98	8.2	9.43	10.65	11.88	13.1	15.55	18	20.45
0.42	6.85	8.05	9.25	10.45	11.66	12.86	15.26	17.66	20.06
0.44	6.62	7.77	8.93	10.09	11.24	12.39	14.7	17.01	19.32
0.47	6.3	7.4	8.49	9.58	10.67	11.76	13.94	16.12	18.3
0.5	6.02	7.05	8.09	9.12	10.16	11.19	13.26	15.33	17.4
0.51	5.93	6.95	7.97	8.98	10	11.02	13.05	15.08	17.11
0.52	5.85	6.85	7.85	8.85	9.85	10.84	12.84	14.84	16.84
0.53	5.77	6.75	7.73	8.71	9.7	10.68	12.65	14.61	16.58
0.54	5.69	6.65	7.62	8.59	9.55	10.52	12.45	14.39	16.32
0.55	5.61	6.56	7.51	8.46	9.41	10.37	12.27	14.17	16.08
0.59	5.32	6.22	7.11	8.01	8.9	9.8	11.58	13.37	15.16
0.6	5.26	6.14	7.02	7.9	8.78	9.66	11.43	13.19	14.95
0.7	4.69	5.46	6.23	6.99	7.76	8.53	10.07	11.6	13.14

Values are based on 12% moisture content and include the inside and outside air film.

Average width = Cross-section Area / Stack Height

Environmental Impacts

- Wildland Interface Code sections also benefit log home durability
- Rapid seasoning from wind exposure; dry indoor climate from a wood stove
- Hillside winds produce upward precipitation
- Finishes are sacrificed to UV exposure and wind erosion

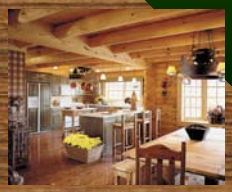
Seal checks and joints without drip edge

A weeping knot needs to be sealed on the exterior

Ch. 4 Structural Provisions

Recommended where the design exceeds

- 3 stories or 33-ft. average grade to average roof elevation
- Length : Width ratio <1:4 or >4:1, or 80-ft.
- Floor-to-floor story height of 10-ft.
- Joist/rafter spacing of 48" o/c
- 4-ft. roof overhangs; 12:12 pitch

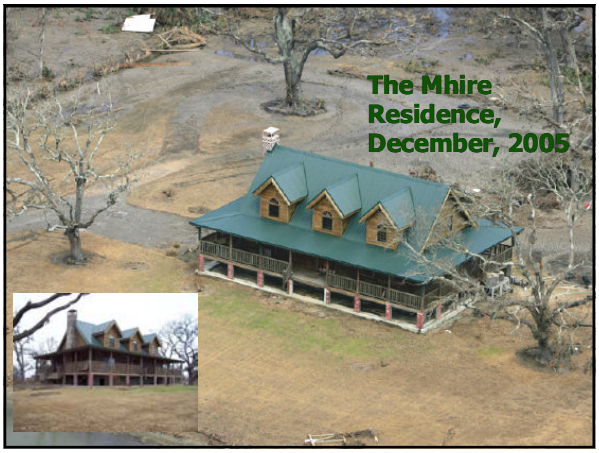


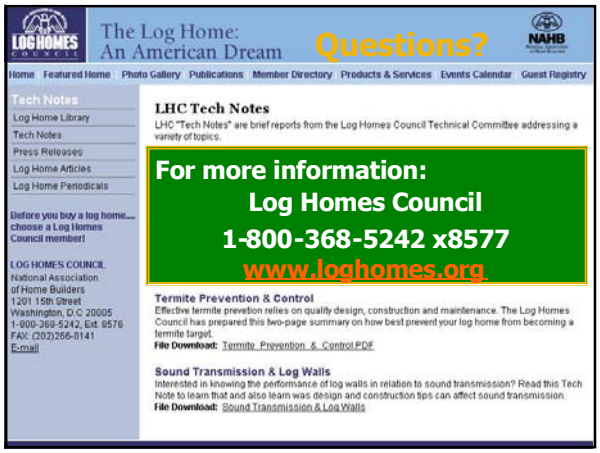
Or where the load exceeds

- 40-psf floor live load
- 70-psf ground snow load
- >90 mph wind speed, exp. C
- Seismic design category >B

The Mhire Residence
Grand Chenier, LA – 2005
Wed., July 25, 2007
Energy Codes 2007
43

Grand Chenier, LA after Hurricane Rita, 9-24-05
Neighboring properties
Wed., July 25, 2007
Energy Codes 2007
44


The Mhire Residence, December, 2005


The Log Home: An American Dream
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LHC Tech Notes
LHC "Tech Notes" are brief reports from the Log Homes Council Technical Committee addressing a variety of topics.
For more information:
Log Homes Council
1-800-368-5242 x8577
www.loghomes.org
Termite Prevention & Control
Effective termite prevention relies on quality design, construction and maintenance. The Log Homes Council has prepared this two-page summary on how best prevent your log home from becoming a termite target.
File Download: Termite Prevention & Control.PDF
Sound Transmission & Log Walls
Interested in knowing the performance of log walls in relation to sound transmission? Read this Tech Note to learn that and also learn was design and construction tips can affect sound transmission.
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