



Wood and Building Codes



WOOD DESIGN & BUILDING SERIES

Wood-frame construction is the predominant method for building homes in the United States, and building designers and contractors are increasingly using wood framing for commercial, industrial and other non-residential structures. Wood-frame buildings are economical to build, heat and cool; they provide maximum comfort and aesthetics to occupants; and they are strong and durable. Wood is also a versatile building material, adaptable to traditional as well as contemporary building styles.

The *International Building Code (IBC)* gives architects, engineers, general contractors and others guidelines and design options along with the freedom to build non-residential wood-frame buildings using different design methodologies. It also offers a number of increased opportunities for wood-frame construction, as compared to those offered by previous codes. In addition, industry associations offer powerful tools to help building professionals design with wood.

IBC Chapter 23: Wood Use

Chapter 23 of the IBC governs materials, design, construction and quality of wood members and their fasteners, covering wood use in buildings of Construction Types III, IV and V:

- **Type III** is construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by the IBC. Fire retardant-treated wood framing complying with Section 2303.2 is permitted within exterior wall assemblies with a two-hour rating or less.
- **Type IV** construction, also known as Heavy Timber or HT, is that in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. Type IV construction must comply with the provisions of Section 602.4 of the IBC. Fire retardant-treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies with a two-hour rating or less.
- **Type V** is construction in which the structural elements, exterior walls and interior walls are of any materials permitted by the IBC.

Aside from its prescriptive conventional construction provisions, much of Chapter 23 is performance-based and relies in large part on references to the design standards of the American Forest & Paper Association (AF&PA), most notably the *National Design Specification® for Wood Construction (NDS®)* and the *Special Design Provisions for Wind and Seismic (Wind and Seismic)*.



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Code developers organized Chapter 23 around three design methodologies:

ALLOWABLE STRESS DESIGN (ASD)

Section 2306 covers IBC guidelines for structural analysis of wood elements in buildings using Allowable Stress Design methods. ASD is the traditional method of engineering structures. As a deterministic design methodology, ASD prescribes maximum load combinations specified by the building code. The one third allowable stress increase for wood loads is no longer allowed under the 2006 IBC. However, the load duration factor is still permitted, as it is unique to wood and wood connections.

LOAD AND RESISTANCE FACTOR DESIGN (LRFD)

Providing an alternative to ASD, U.S. building codes began adopting Load and Resistance Factor Design for wood in the 1990s as a reliability-based design methodology, compared with the deterministic design approach of ASD. As LRFD has become more common, building professionals and agencies must now clearly distinguish which design provisions are appropriate for ASD versus LRFD.

Load combinations and load factoring account for any major advantages in design results when using LRFD versus ASD. The underlying premise of load factoring is to move more of the safety factor, or reliability, to the loads side, since more information is available on loads.

Building professionals have found that an LRFD approach typically results in more efficient wood member sizing and fire resistance design. For example, one study by the American Wood Council (AWC) found that designers could use wood structural members with as much as 30 percent smaller cross sections to carry multiple transient live loads (roof live and occupancy) using LRFD versus ASD load combinations.

ASD/LRFD Comparison of Structural Headers for Multi-story Structures		
Structural Headers	ASD	LRFD
Visually graded #2 HF, DFL, SP, SPF*	Two – 2x10	Two – 2x8
16F Glue-laminated timber	3" x 8-1/2"	3-1/8" x 6-7/8"
1.8 E Laminated Veneer Lumber	Two 1-3/4" x 7-1/4"	Two 1-3/4" x 5-1/2"

*Hem-Fir, Douglas Fir/Larch, Southern Pine, Spruce Pine Fir
Source: American Wood Council

Figure 1

Examples of this application are headers and studs on the first floor of a multi-story non-residential wood building (Figure 1).

The LRFD methodology for wood adopts code-accepted load factors that smooth reliability across load cases. It also adopts the concept of a target reliability index for a reference design case, and then adjusts designs to match that target. LRFD also permits additional adjustment of designs based on individual data set analysis.

The 2005 NDS describes both the ASD and LRFD design methods, and shows design examples using both approaches.

CONVENTIONAL LIGHT-FRAME CONSTRUCTION

Section 2308 of the IBC covers conventional light-frame construction. This methodology describes design and construction techniques that use typical configurations and methods, which do not require calculation of loads or analysis by a design professional; they are based on commonly accepted engineering practice and experience.

The IBC section on conventional light-frame construction defines those situations in which prescriptive requirements apply. It also contains requirements for lateral bracing and continuous load paths, and includes engineered span tables for joists and rafters and for girders and headers.



The award-winning Atlantic Station development in Atlanta includes more than two million square feet of wood-frame structures. Architects relied on wood’s versatility, not only to vary external elevations and add visual interest but to achieve the dual objectives of high density and cost-effectiveness. Contractors used plywood and OSB floor and roof sheathing, glulam and laminated veneer lumber (LVL) beams and other wood products in the \$2 billion project, which included office, retail, condominium, loft and apartment structures.



Source: APA – The Engineered Wood Association

The IBC and its Impact on Wood Construction

Building designers may not be aware of the increased opportunities for wood-frame construction under the IBC, as compared with that allowed under previous codes. IBC provisions offer a number of advantages for wood use in a wide range of non-residential applications.

WOOD ALLOWED FOR TYPE III CONSTRUCTION

Chapter 6 of the IBC covers classification of buildings in terms of type of construction. Section 602.3 stipulates that Type III construction is that in which the exterior walls are of noncombustible materials and the interior building elements may be of any material permitted by code. The IBC permits the use of fire retardant-treated wood framing complying with Section 2303.2 within exterior wall assemblies with a two-hour rating or less, allowing increased use of wood for commercial construction.

USE GROUP SEPARATION AND FIRE WALLS

Under the IBC, designers can use a fire-rated wall to separate a building into two smaller fire areas, neither of which exceeds threshold values that require sprinkler installation. Codes do not consider this rated wall a fire wall separating buildings, but rather a fire separation assembly separating the building into fire areas.

In addition, the IBC allows fire walls of combustible material in buildings of Type V construction, allowing designers to divide the structure into separate buildings, each subject to its own height and area limits.

Under the National Fire Protection Association's NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls and Fire Barrier Walls*, designers may build a two-hour rated fire wall using two contiguous one-hour fire resistance-rated assemblies. Many wood-frame assemblies are capable of achieving the one-hour rating, which offers many opportunities for commercial building designs using wood-frame construction.

UNLIMITED AREAS

Depending on the building's end use, Section 507 of the IBC (*Unlimited Area Buildings*) permits wood buildings of unlimited area when there is a 60-foot spatial separation between the property line and the building, and when the structure is sprinklered and constructed as a Type III building.

If the structure lacks a full 60-foot-wide open perimeter but would otherwise be permitted unlimited area, the building designer can gain increased area for widths from 30-foot separation up to 60-foot separation. In fact, buildings with as little as 20-foot fire separation will be given credit for open perimeter under the IBC.

LARGER SINGLE-STORY AND MULTI-STORY SPRINKLERED BUILDINGS

According to IBC Section 506.3 (*Automatic Sprinkler System Increase*), when a building is equipped throughout with an



approved automatic sprinkler system in accordance with Section 903.3.1.1, designers may increase the area limitation set forth in Table 503 of the IBC by an additional 200 percent for multi-story buildings and an additional 300 percent for single-story buildings. This allowance offers building designers tremendous advantages for wood-frame construction.

Note also Section 504.2, which allows buildings equipped with an automatic sprinkler system to have an increase in height of 20 feet and permits an increase by one story in addition to the above area increases. This may not be done, however, if the sprinkler system was added to decrease the fire rating of an interior wall by one hour (Table 601, Footnote e). Building designers can add sprinklers for increasing heights and areas or for decreasing fire ratings, but not for both at the same time.

FIRE RESISTANCE RATINGS

Section 704.5 of the IBC permits asymmetrically tested fire resistance-rated wall assemblies (tested from the inside only) when the distance from the structure to the property line is at least five feet. This creates new possibilities for exterior wood cladding and interior wood finish work.

If the building designer does not sprinkler the structure for height and area increases, fire resistive requirements can be reduced by one hour, but to not less than one hour for all construction elements except exterior walls.

Major source documents for dimension lumber fire-endurance assemblies include:

- *ASD/LRFD Manual for Engineered Wood Construction, Chapter M16*, AF&PA
- *DCA 3 – Fire Rated Wood Floor and Wall Assemblies*, AF&PA
- *Fire Resistance Directory*, Underwriters Laboratories, Inc. (UL)

Information related to plated trusses, which must be built in accordance with Truss Plate Institute (TPI) standards, can be found in the *Metal Plate Connected Wood Truss Handbook*, Section 17, *Fire Performance of Trusses* and Section 18, *Sound Transmission and Fire Resistance Rated Truss Assemblies*.

Design and construction professionals should also check with their local building department for ordinances that are specific to the jurisdiction.

Design Tools

Approved as an American National Standard with the designation *ANSI/AF&PA NDS-2005*, the 2005 NDS serves as a dual format specification incorporating design provisions for both Allowable Stress Design and Load and Resistance Factor Design. The NDS is adopted by all model building codes in the U.S. and serves as a valuable tool to design wood structures worldwide.

OTHER RESOURCES AVAILABLE

The American Wood Council (AWC) offers several online calculators:

- The *Allowable Heights and Areas Calculator* demonstrates the degree of freedom allowed in wood construction by providing a general summary of allowable wood uses, including building height and area requirements. The web-based calculator determines maximum heights and areas for buildings of various occupancies and fire protection, based on 2006 IBC provisions for combustible Construction Types III through V.
- The *Connection Calculator* provides users with a tool to calculate capacities for single bolts, nails, lag screws and wood screws per the 2005 NDS. The calculator can determine both lateral (single and double shear) and withdrawal capacities. Analysis of wood-to-wood, wood-to-concrete and wood-to-steel connections is also possible.

- The *Maximum Span Calculator for Joists & Rafters* performs span computations for all species and grades of commercially available softwood and hardwood lumber as found in the NDS. The tool determines joists and rafter spans for common loading conditions. A *Span Options Calculator* even allows users to select multiple species and grades for comparison purposes.

Span tables for structural use panels are available from APA – The Engineered Wood Association (APA) and for joists and rafters from the Canadian Wood Council (CWC), Southern Pine Council (SPC) and Western Wood Products Association (WWPA). CAD details are available from APA, AWC and CWC.

Other tools include a free, subscription-based *Online Lumber Technical Guide* offered by the WWPA, featuring detailed engineering and design information for Western lumber. WWPA also offers the *Lumber Design Suite* and *Lumber DesignEasy* programs, which help design professionals calculate horizontal framing (beams and joists), vertical framing (posts and studs) and wood-to-wood shear connections.

The AWC and CWC also offer *WoodWorks* software for wood design, including seismic and wind loads, structural designs and connection details.

SOURCES AND OTHER MATERIALS

American Forest & Paper Association / American Wood Council, www.awc.org

- *Commentary on the International Building Code (IBC); Chapter 23 – Wood*
- *The International Building Code and Its Impact on Wood-Frame Design and Construction*
- *The International Building Code and International Residential Code and Their Impact on Wood-Frame Design and Construction*
- *LRFD versus ASD for Wood Design*
- *International Building Code: More Options with Greater Opportunity for Wood-Frame Design*
- *Structural Wood Design Using ASD and LRFD*
- *Wood Use Provisions in the 1999 SBC and 2000 IBC*
- *Wood Use Provisions in the 1999 BOCA NBC and 2000 IBC*
- *Wood Use Provisions in the 1997 UBC and 2000 IBC*

Southern Pine Council, www.southernpine.com

- *Southern Pine Use Guide*

Materials are also available via the WoodWorks Web site, in the sections titled *Key Issues/Building Codes* and *Publications and Resources*, www.woodworks.org

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