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NAVY REQUIREMENTS FOR WOOD-PLASTIC COMPOSITES AS BUILDING CONSTRUCTION MATERIALS

by

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EXECUTIVE SUMMARY

This NFESC report is a part of the Naval Advanced Wood Composites Research Project headed by Washington State University and sponsored by the Office of Naval Research. The overall goal is to improve the life span and reduce the cost-of-ownership for timber structures on Navy facilities. Specific project objectives are to:

1. Assess the types and condition of timber structures currently owned by the Navy.
2. Evaluate the ability to move advanced building material technologies into the marketplace.
3. Evaluate aspects of material design and processing that effect mechanical and environmental durability of hybrid and traditional wood composites.
4. Assess material damage caused by mechanical and environmental loading.

As part of the Navy timber structures assessment, this report identifies and describes Navy requirements for engineered wood and wood-based components for buildings, including materials specifications and critical properties as applicable, gleaned from military criteria documents. Military standards covered include mostly Military Handbooks and NAVFAC Guide Specifications. In addition, relevant Navy and other Department of Defense (DOD) instructions were reviewed. Specific recommendations and conclusions gleaned from these documents are provided (Section 5.0).

These engineered wood building component descriptions and Navy requirements provide the necessary baseline for planned efforts. Planned efforts will focus on opportunities for improving current wood component performances by taking advantage of advanced wood-plastic composites design characteristics. The final outcome will be a list of product opportunities of highest potential value to the Navy's building infrastructure consistent with Navy requirements for those products.

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1.0 INTRODUCTION

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1. Assess the types and condition of timber structures currently owned by the U.S. Navy.
2. Evaluate the ability to move advanced building material technologies into the marketplace.
3. Evaluate aspects of material design and processing that effect mechanical and environmental durability of hybrid and traditional wood composites.
4. Assess material damage caused by mechanical and environmental loading.

2.0 SCOPE

As part of the Navy timber structures assessment, this report identifies and describes Navy requirements for engineered wood and wood-based components for buildings, including materials specifications and critical properties as applicable, gleaned from military criteria documents. This work is a follow on to descriptions of waterfront timber components and corresponding Navy requirements previously completed by NFESC [1]. Whereas the previous study focused on waterfront timber, this work focuses on engineered-wood building materials. These component descriptions and requirements will help direct the wood-plastic composite (WPC) material and component development phase of this program. In addition, this information, along with a consideration of advanced WPC design characteristics, will be used to develop a list of product opportunities of highest potential value to the Navy's waterfront infrastructure.

3.0 CANDIDATE ENGINEERED WOOD AND WOOD-BASED BUILDING COMPONENTS

In addition to solid sawn wood, various engineered wood and wood-based products are available for building construction. These engineered wood products can be divided into two main categories: panels and beams. The application of engineered wood panels and beams represent target building components for advanced wood-plastic composites under development. Other uses of wood in building construction include window and door framing, doors, and interior trim and molding.

3.1 PHASE OUT OF ARSENIC TREATED WOOD

Wood products exposed to moisture and thus subject to fungal decay and termite damage are typically treated with a wood preservative. A recent announcement by the Environmental Protection Agency (Ref. 2) that arsenic treated lumber will be phased out of the residential market over the next two years creates a greater opportunity for alternative products made from

wood-plastic composites. An example of a building product that is currently arsenic treated is the arsenic-treated base plate of wood framing commonly used in housing construction.

3.2 SAWN LUMBER

Wood construction materials are specified in terms of lumber size and quality. Typically, the wood is then cut on site to meet construction or component needs. Commercial sawn wood used in construction can be categorized as:

- **Boards** – lumber that is nominally less than 2 inches thick and 2 or more inches wide.
- **Dimension lumber** – lumber with a nominal thickness of from 2 to 4 inches thick and a nominal width of 2 or more inches.
- **Beams** – lumber that is nominally 5 inches or more thick, with width more than 2 inches greater than thickness.
- **Posts and Timbers** – lumber that is nominally 5 inches or more in least dimension with width not more than 2 inches greater than thickness.
- **Decking** – lumber that is 2 to four inches nominal thickness, grooved and intended for use as a roof, floor, or wall membrane.

3.3 WOOD-BASED PANEL PRODUCTS

The most common engineered-wood panel products are listed in Table 1. These products can be applied in building construction in a variety of ways (Table 2).

Table 1. Definitions and Standards for Frequently Used Panel Products in Building Construction [3]

Product Category	Definition	Applicable Standards
Plywood	A flat panel built up of sheets of veneer and united under pressure by a bonding agent	PS 1-95, PS 2-92
Oriented Strandboard (OSB)	Structural use panel made from thin wood strands bonded together with waterproof resin under heat and pressure	PS 2-92
Particleboard	Panel produced by consolidating a loose mat of wood particles and adhesives with heat and pressure	ANSI A208.1
Medium-density Fiberboard (MDF)	Panels produced by consolidating a loose mat of wood fibers under high pressure	ANSI A208.2
Hardboard	Same as MDF but is produced under greater pressure and is of greater density	ANSI/AHA A135
Insulation Board	Low-density panel typically without a binder	ASTM C208 ANSI/AHA A194.1

Table 2. Panel Functional Components in Buildings

Building Components	Product Categories Typically Applied
Subflooring	Plywood, OSB, structural-use panels
Underlayment	Plywood, OSB, hardboard, structural-use panels
Wall sheathing	Plywood, OSB, structural-use panels, insulation board, fiberboard, foil-faced insulative sheathing
Roof sheathing	Plywood, structural-use panels
Diaphragms	Plywood, OSB, structural-use panels
Shear walls	Plywood, OSB, structural-use panels
House siding	Hardboard
Paneling substrate	Particle board
Mouldings, interior trim	MDF
Roof decking	Insulation board
Ceiling tiles	Insulation board
Aluminum siding backer boards	Insulation board

3.4 ENGINEERED-WOOD BEAMS

The most common engineered-wood beams are listed in Table 3. These products are often used in place of solid-sawn lumber as building structural members (Table 4).

Table 3. Engineered Wood Beams

Product Category	Definition	Applicable Standards
Laminated Veneer Lumber (LVL)	Veneer laminated with all plies parallel to the length	ASTM D 5456
Parallel Strand Lumber (PSL)	Strips of veneer glued together under high temperatures and pressures	ASTM D 5456
Laminated Strand Lumber (LSL)	Thin wood strands bonded together with waterproof resin under heat and pressure	ASTM D 5456
Oriented Strand Lumber (OSL)	Same as LSL except that shorter strands are used	ASTM D 5456
Glulam	Two or more layers of lumber glued together with grain parallel to length	ASTM D 5456

Table 4. Beam Functional Components in Buildings

Building Components	Product Categories Applied
Flooring stringer and header joists	LVL, PSL, LSL, OSL, Glulam
Studs	LVL, PSL, LSL, OSL, Glulam
Ceiling joists	LVL, PSL, LSL, OSL, Glulam
Rafters	LVL, PSL, LSL, OSL, Glulam
Trusses	LVL, PSL, LSL, OSL, Glulam

4.0 DESIGN REQUIREMENTS FOR WOOD-BASED MATERIALS

4.1. BACKGROUND

Except for round poles or piles, there are no special additional Navy design requirements or specifications for wood or wood-based components used for Navy building construction. Current Navy policy with regard to facility design and construction is to use commercial standards to the greatest extent possible. Virtually all Navy buildings are designed and constructed in accordance with local building codes, specific site requirements, and local custom. Design requirements for wood and wood-based components for construction follow mainly National Design Specifications (NDS) for Wood Construction [4]. NDS Supplement Tables 2 through 5 provides design values for the various commercially available timber species and commodities. Therefore, advanced wood-plastic composites that meet these NDS design values could be used as direct replacements for the original solid wood or engineered wood composite components if other requirements, such as fire safety, are met.

4.2. NAVY REQUIREMENTS

While there are no special Navy design requirements for sawn wood pieces, various recommendations and requirements are provided for specific applications and for the use of new materials, techniques and methods. Since much of the document NFGS-06100Z, "Rough Carpentry" applies to the use of wood and wood-based products it is provided in its entirety as Appendix A (The term Naval Facilities Guide Specification is in the process of being replaced by Unified Facilities Guide Specification). This specification provides detailed specifications and practical guidance in the use of wood and wood-based materials in building construction. The introduction of WPC building materials into Navy practice will first require changes in the applicable portions of this specification. The references cited in Appendix A provide an excellent summary of commercial and Government standards that govern the use of these products. Relevant portions of other Navy guidance documents are provided in the following sections.

4.2.1. From MIL-HDBK-1001/2 - Materials and Building Components (July 87):

The following sections address new wood replacement materials, such as WPC.

2.5.1. Permanent Construction: ...“Select finishes, materials and systems for low maintenance and life cycle costs based on 25 years.”

2.8. New Materials: The use of new materials is encouraged, but specific policies and procedures must be followed to ensure that the standards and qualities of the Department of the Navy are maintained and enhanced.

2.8.1. Navy Policy: ...“new materials, equipment and methods must be adequately tested and proven by actual performance before adoption. Newly developed materials, equipment and methods not included in NAVFAC guide specifications may be used in limited applications with prior approval by the NAVFACENGCOM Engineering Field Division...”

2.8.2. NAVFAC Procedures: New materials, equipment or methods proposed to NAVFAC must meet the following prerequisites:

- a) The item must equal or exceed minimum standards for quality and performance currently included in other criteria
- b) The in-place cost of the item must compete with other acceptable products, or the premium cost of the item must result in long term savings in maintenance or operation costs
- c) The item must be readily available in quantity and in wide geographical areas
- d) The merits of the item must have approved laboratory certification or evidence of satisfactory use under conditions similar to the proposed application
- e) Quality control of manufacturing processes and installation techniques must be guaranteed
- f) Proposed item must be nonrestrictive enough to admit other available and equally acceptable competition

3.2. Construction systems

3.2.1.1. a) Wood frame: “Wood frame systems are not generally recommended for major or permanent construction projects, although laminated or other structural wood systems can be used for certain building types ...”

3.2.3.1. a) Wood walls: “Exterior walls of wood are not permitted for most major or permanent building types ... [they] require constant maintenance, deteriorate rapidly, and offer little fire protection or additional insulation value.”

4.4. Wood and Plastics

4.4.1. Wood: use NFGS-06100 Rough Carpentry and NFGS-06200 Finish Carpentry.

4.4.3. Plastic Laminate: "... [can be used] for architectural woodwork items .."

4.2.2. From MIL-HDBK-1001/5A - Roofing and Waterproofing (August 97)

2.3.3. Wood Board or Plywood Roof Decks. For all wood decks a barrier of rosin sized sheathing paper or similar material should be placed between the roof membrane and the deck to allow relative movement.

2.3.4 Cement-Wood Fiber Panel Roof Decks.

(a) Resistance to wind uplift and lateral movement should be provided by one of the following anchorage techniques: (1) clips, nails, or other devices anchoring the deck directly to the roof framing; or (2) sub-purlins anchored to the roof framing system. Voids around tees should be grouted with material recommended by the deck manufacturer.

(b) Because of the vulnerability to moisture, insects, and in some cases fire, these panels may be prohibited by some Military Construction Offices. Request specific permission to use before specifying.

4.2.3. From MIL-HDBK-1002/1 - Structural Engineering, General Requirements (November 87)

Alternative materials shall provide:

- consistent factor of safety
- fire safety per MIL-HDBK-1008/1 [1008C]

Structures classification:

Class A: bridges, trestles, viaducts and their components

Class B: building-type structures, including portions of piers and wharves

Class C: structures supporting heavy lift cranes, airport runways, storage tanks, ..

4.2.4. From MIL-HDBK-1002/2A - Loads (October 96):

Supersedes MIL-HDBK-1002/2 Structural Engineering, Loads (Sep 88).

Loads in this MIL-HDBK are for general Class A and B structures.

4.2.5. From MIL-HDBK-1002/5 - Timber Structures (March 87):

Design standards for Structures:

Class B, C	NFPA - National Design Specification for Wood Construction
	AITC - Timber Construction Manual
Plywood	APA - Plywood Design Specifications
Wood Trusses	TPI - Purdue University AES Research Bulletin No. 714 and 727.

Details of design:

Stress grade lumber	NFPA standard
Nonstress grade lumber	use "standard" grade or better for <u>blocking</u> , bridging, etc.
Plywood	APA standard, species group 1, 2, or 3
Nondomestic wood	Tropical woods: use strength from supplier (check with tests) and 25% to 33% of strength for allowables
Plywood	Some specifications on allowables are included
Preservative treatments	AWPA - Book of Standards (not applicable to wood-plastic composites)

4.2.6. From MIL-HDBK-1002/6 - Aluminum Structures, Composite Structures, Structural Plastics, Fiber-Reinforced Composites (June 1987):

Section 4: Structural Plastics and Fiber-Reinforced Composites

4.2.1. General: "There is no general design specification for design of thermoplastic or fiberglass reinforced plastic (FRP) components." Note that this is now being superseded by work from Committee ACI 440 of the American Concrete Institute [6, 6]. It is expected that future updates of this handbook will refer to ACI 440 publications. This would be applicable to fiber reinforced engineered wood.

4.2.2. FRP tanks, Ducts, Equipment.

4.2.3. FRP Pultruded Shapes

4.2.4. FRP Panels.

4.2.5. Tension Membranes

4.2.6. Thermoplastics

4.2.7. GFRC Wall Panels

4.2.8. FRC (Fiber Reinforced Concrete)

4.2.9. Polypropylene Fiber Reinforced Slabs on Grade

Appendix B:

1. "Apparent stiffness and strength reduce with long duration loads."
2. "Severe environment ... may degrade structural properties..."
3. "Low stiffness and directional properties require special consideration of buckling and deflection ..."
4. "Lack of ductility ... requires accurate stress analysis and design to eliminate stress concentrations ..."
5. "Low fracture toughness ... requires careful detailing to avoid notches and stress raisers..."
6. "High coefficient of thermal expansion requires careful design to accommodate larger movements or to account for structural consequences of movement restraint."
7. "Few thermoplastics ... can be used ... above 200° F."
8. "Low fire resistance and combustion products that include toxic fumes exclude many plastics ..."
9. "... long term exposure to moisture and weathering usually produces a significant reduction in the strength properties, ductility and toughness."
10. "Movements due to thermal and moisture change and restraint of such movement may induce significant stresses ..."

4.2.7 From MIL-HDBK-1190 – Facility Planning and Design Guide (Sept 1987)

CHAPTER 6: STRUCTURAL CRITERIA

A. SELECTION OF STRUCTURAL SYSTEMS AND MATERIALS

The structural systems and materials to be selected for design of military facilities at Department of Defense installations should be suitable for permanent-type construction; capable of carrying the required loads; and compatible with fire protection requirements, and architectural and functional concepts. Materials used may be any of those listed in Table 6-1, or any combination thereof, selected for desirability, economy, general availability low maintenance costs over the design life of the facility, and resistance to fire.

1. Design Considerations. It is important at the inception of the design that the structural system layout be coordinated properly with the architect to develop an overall effective plan. This joint effort is particularly essential in seismic and high wind areas where the distribution of lateral forces and layout of load-resistant elements are critical in establishing the earthquake and wind resistance for structures.

2. Cost Considerations. In selecting the type of structural system, the total facility should be considered, since the choice will influence the cost of such features as heating, ventilation or air-conditioning, or all three, as well as architectural, lighting, and utility requirements.

3. Structural Materials. When choosing structural materials for a specific project, consideration should be given to:

- a. Availability of labor and materials.
 - b. Design life of the facility and maintenance costs over this period.
 - c. Experience of design and inspection personnel.
 - d. Experience and skill of prospective contractors.
 - e. Feasibility of preassembling or precasting major structural elements.
 - f. Site environment, including accessibility, climate, seismic loadings, subsurface conditions, and wind velocity.
4. Tests of Structural Systems. When the structural system cannot be analyzed on a rotational basis, acceptability of the load carrying capacity of the system shall be determined by suitable load or model tests.

B. DESIGN REQUIREMENTS

1. Design Codes. Design methods and stress allowances or load factors for the various structural materials should be in accordance with the current editions of the codes and specifications listed in table 6-1, except where these codes and specifications are modified or expanded by published design criteria of the Military Departments.

2. Design Loads. The load assumptions for the design of buildings or other structures, including chimneys, tanks, and related structures should conform to the guidance provided in the Joint Army-Air Force Manual, TM-5-809-1, AFM 88-3, Chapter 1 [7], and to the corresponding guidance contained in NAVFAC design manuals.

3. Seismic Design. The seismic design of facilities should be in accordance with the following guidance. The seismic design requirements for essential facilities other than the health care facilities in high seismicity areas should be required to have a post-disaster recovery and continuous operation capability during and after a major earthquake.

a. New Construction. The seismic design should be in accordance with the Joint Services Manual, TM 5-809-10, NAVFAC P-335, AFM 88-3, Chapter 13 [8], except new essential facilities in seismic zone 3 or greater should be in accordance with the Joint Services Guideline Manual, TM 5-809-10.1, NAVFAC P-335, AFN 88-3, Chapter 13, Section A [9].

b. Modifications to Existing Structures. Major additions, alterations, and modernization of existing structures should be in conformance with the criteria in the Joint Services Manual [8]. When the basic structure to which the modification is being made does not meet current seismic criteria, the project should include funds for improving the structure with withstand forces as follows:

(1) Critical Operational Facilities. Facilities that are critical from an operational viewpoint should be provided seismic strengthening for structural and nonstructural elements to that degree feasible and practicable for assuring life safety and continued post-earthquake operations. Essential facilities in seismic zones 3 and 4 shall be in accordance with the Joint-Service Guidelines Manual, Upgrading Existing Buildings, TM 5-809-10.2, NAVFAC P-335, AFM 88-3, Chapter 13, Section B [10].

(2) Other Facilities. For other than the above facilities, as a minimum, the safety of personnel should be assured by structural improvements that will prevent building collapse under seismic forces and preclude damage to equipment or utility systems that would endanger life.

c. Existing Structures. For existing structures having a high loss potential or having critical operational requirements such as communications centers, defense mission essential facilities, and fire stations, studies should be undertaken in order to determine the required strengthening to withstand earthquake forces. These investigations should be initiated in areas where the seismic risk is greatest and proceed to areas of lower risk to the extent warranted. A phased and orderly plan should be developed for providing the structural improvements for these high loss critical facilities and essential post-earthquake operational facilities.

d. Design Development of New Facilities.

(1) Building Design. Seismic structural design and siting considerations may conflict with functional considerations in building design. For instance, shear walls may limit horizontal flexibility and diaphragms may limit vertical circulation. Faults or soil instability may preclude sitings that otherwise would be desirable. Therefore, for all major or complex buildings, including, but not limited to, large administrative buildings, command centers, communications centers, and other similar facilities, and for installation master plans, concept studies at the start of design should include seismic considerations. In addition, they should include functional, flexibility, and siting considerations in order that all requirements may be optimally integrated. Where necessary, trade-off studies based on life cycle costing should be made to determine the optimum building design. In such studies, the cost of lost efficiency through less than desirable functional design and the risk cost of less than ideal seismic design should be included if quantification of such costs is feasible.

(2) Building Configuration. Seismic considerations may require limits on the height of structures and design configurations. Consolidation of several small facilities, possibly serving widely different functions, may be desirable in limiting structural and foundation costs. Since different functions in the same building may be of different criticality (some required to operate post-earthquake, and some not), functions should be studied to group those of greater or lesser typed for seismic design. It should be noted that the building configuration plays an important role in the performance of the structure when subjected to seismic ground motion. To obtain optimal seismic resistance and performance, a symmetrical configuration of the structural system with properly placed lateral resisting structured elements should be considered. Further, the nonstructural elements should be seismic resistant in order to maintain a post-earthquake operational capability.

(3) Siting. Structures should normally not be sited over active geological faults, in area of instability subject to landslides, where soil liquefaction is likely to occur, or in areas subject to tsunami damage. In seismic zone 3 and 4, a seismic geotechnical report should be prepared only when seismic design requirements for the facility are based on the Joint Service Guidelines Manual [9].

(4) Master Plans. The above seismic design requirements should be considered with the functional requirements in developing master plans of military installations.

4. Climatic Considerations. Wind loads, snow loads, and frost penetration should be carefully established for each structure according to the Joint Army-Air Force Manual, TM 5-809-1, AFM 88-3, Chapter 1 [7], and with the local climatic conditions as appropriate.

5. Design for Typhoon and Hurricane Areas. Structures to be constructed in typhoon and hurricane areas should be designed so that structural integrity and continuity are provided from the foundation to the roof, irrespective of the materials selected for the facility. All components of the structure should be positively tied together in order to establish an overall integrated resistance to high wind effects. In designing drag sensitive structures, such as guyed towers, stacks, or suspended pipelines, the effect of maximum wind forces, including pulsating forces on such structures, must be considered. Design criteria for structural framing, openings, and flashing should conform to the provisions of the Joint Army-Air Force Manual, TM 5-809-11, AFM 88-3, Chapter 14 [11], or corresponding guidance contained in NAVFAC design manuals.

6. Design for Explosives Storage Facilities. When it is necessary to design explosives storage facilities in such a manner as to ensure against propagation of explosions between adjacent or nearby facilities, design should conform to the joint Army-Navy-Air Force Manual TM 5-1300, NAVFAC P-397, AFM 88-22 [12].

Table 6-1. Structural Design Methods and Stress Allowances

Materials	Codes or Specifications
Aluminum	The Aluminum Association, "Specifications for Aluminum Structures"
Concrete	American Concrete Institute (ACI). "Building Code Requirements for Reinforced Concrete"
Masonry	American National Standards Institute (ANSI), "American Standard Building Code Requirements for Reinforced Masonry" Brick Institute of America (BIA), "Recommended Building Code Requirements for Engineered Brick Masonry" National Concrete Masonry Association (NCMA), "Specifications for the Design and Construction of Load Bearing Concrete Masonry"
Steel	American Institute of Steel Construction (AISC), "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings"
Steel Joists	Steel Joist Institute (SJI), "Standard Specifications and Load Tables, Open Web Steel Joists and Longspan Steel Joists," and similar publications covering deep longspan steel joists
Steel, Light Gage	American Iron and Steel Institute (AISI), "Specifications for the Design of Cold-form Steel Structural Members"
Wood	National Forest Products Association, "National Design Specifications for Stress Grade Lumber and its Fastenings"

4.2.8 From MIL-HDBK-1008C – Fire Protection for Facilities Engineering, Design, and Construction

1.3 Criteria. This handbook implements the National Technology Transfer and Advancement Act, Public Law 104-113, March 7, 1996, Section 12 (d), identifying the necessary consensus technical standards required to implement policy objectives and activities within the area of fire protection engineering for the DOD. Compliance with criteria issued in accordance with this handbook does not constitute an exception under Public Law 104-113, March 7, 1996, Section 12 (d) (3). Fire protection criteria shall conform to the requirements of this handbook, the National Fire Codes, published by the National Fire Protection Association (NFPA), except as modified herein, and portions of the Uniform Building Code (UBC), published by the International Conference of Building Officials, as specifically referenced herein. Additional criteria include portions of the Loss Prevention Data Sheets, published by Factory Mutual Engineering Corporation (FM), as specifically referenced herein. Buildings that are required to be accessible to the disabled or impaired shall meet the provisions of Federal Standard FED-STD-795, Uniform Federal Accessibility Standards (UFAS), and the Americans With Disabilities Act (ADA) of 1990.

1.3.1 Renovation. This handbook also applies to renovation, modernization, alteration, and rehabilitation work. To the extent possible, renovation, modernization, and rehabilitation work shall comply with the requirements for new construction outlined in this handbook. In repair projects, only the new work must meet the requirements for new construction. The fire protection requirements for repair work shall be coordinated with the authority having jurisdiction as defined in paragraph 1.3.5 of this handbook.

1.3.2 Existing Facilities. Existing facilities that are acceptable to the authority having jurisdiction, and meet the requirements of NFPA 101, Safety to Life From Fire in Buildings and Structures, for existing occupancies do not have to be modified to comply with the provisions of this handbook. However, if the facilities are renovated, modernized, or rehabilitated, the facilities shall meet the requirements for new construction as specified in this handbook.

1.3.3 Absence of Criteria. When a specific application is not covered by the criteria cited herein, follow national building codes, recognized industry standards, and standard engineering practices. In the absence of such technical information, contact the DOD component authority having jurisdiction (refer to par. 1.3.5).

1.3.4 Conflicts in Criteria. If a conflict exists between this handbook and any other DOD document, referenced code, standard, or publication, this handbook shall take precedence.

The individual DOD components may issue technical guidance, which shall take precedence. The Army and Air Force issue engineering technical letters (ETLs); the Navy issues planning and design policy letters (PDPs); and the DLA issues technical policies.

1.3.5 Authority Having Jurisdiction (AHJ). The term "AHJ" as used in the codes and standards referenced in this handbook shall mean the component office of responsibility, i.e., U.S. Army, HQ USACE/CEMP-E; U.S. Navy, NAVFACENCOM HQ Code 150; U.S. Marine Corps, HQMC Code LFF-1; U.S. Air Force, HQ AFCESA/CES; DLA, HQ DLA-D through DLA-MMBI; NIMA, Mission Support (Admin Services); and all other DOD components, ADUSD (ES) Conservations and Installations via the DOD Standing Committee on Fire Protection Engineering.

1.3.6 Waivers. Where a valid need exists, waivers for deviation from established criteria may be approved by the AHJ, if an alternate fire protection engineering design providing equivalent fire protection and life safety is approved. Requests for approval shall include justification, hazard analysis, cost comparison, criteria used, and other pertinent data. Lack of funds or cost savings are not considered sufficient justification for deviation from established criteria. Waivers shall apply only to specific requests under consideration and not to cases with similar circumstances.

1.3.7 Guide Specifications. Guide specifications that are issued and approved by the DOD components shall be used in the procurement of new facilities and processes, as well as modernization, renovation, and repair work on existing facilities. The guide specifications include design criteria, which is not specifically addressed in this handbook.

1.4 Design Analyses. A fire protection design analysis is required for all designs and shall address the fire protection requirements of the project as required by this handbook. The fire protection design analysis shall be summarized and submitted separate from other disciplines. Where applicable, the following minimum fire protection provisions shall be discussed:

- a) Type of construction,
- b) Height and area limitations,
- c) Classification of occupancy,
- d) Building separation or exposure protection,
- e) Specific compliance with MIL-HDBK-1008C and National Fire Codes,
- f) Requirements for fire-rated walls, fire-rated doors, fire dampers with their fire-resistive ratings,
- g) NFPA 101,
- h) Analysis of automatic suppression systems and protected areas,
- i) Water supplies,
- j) Smoke control systems,
- k) Fire alarm system (the type of alarm system and location of the fire alarm equipment and fire zones),
- l) Fire detection system (the type of detection system and location of detectors and fire zones),
- m) Standpipe systems and fire extinguishers,
- n) Interior finish ratings,
- o) Connection to and description of base fire alarm reporting system.

Note: When directed by the cognizant fire protection engineer, projects with little or no fire protection considerations shall not require a fire protection design analysis.

1.6 Fire Protection During Construction. Contract specifications shall reference the Army Corps of Engineering Manual (EM), EM 385-1-1, Safety and Health Requirements Manual, and NFPA 241, Safeguarding Construction, Alteration, and Demolition Operations, and shall contain the requirement that the activity's fire regulations be followed.

2.1.2 Partitions. The UBC fire resistance requirements for permanent partitions shall not apply to non-bearing partitions in Type I and Type II construction. Fire resistance ratings of non-bearing partitions in Type I and Type II construction shall comply with NFPA 101. Occupancy separation walls shall comply with the UBC.

2.7.1 New Construction, Alterations, Renovations. Wall and ceiling finishes and movable partitions shall conform to the requirements of NFPA 101, except as follows:

a) Interior finish for exits, exit passageways, hospital patient rooms, sleeping rooms, and correction facilities shall be Class A only. Class B interior finish may be substituted for Class A interior finish throughout health care facilities that are completely protected with automatic sprinklers and that have quick response sprinklers installed throughout smoke compartments containing sleeping rooms.

b) Flame spread (FS) and smoke development (SD) shall be tested in accordance with ASTM E84 (NFPA 255, Test of Surface Burning Characteristics of Building Materials). Tests shall not exceed FS rating of 25 and SD rating of 50 for Class A materials, FS rating of 75 and SD rating of 100 for Class B materials, and FS rating of 200 and SD rating of 200 for Class C materials. Class C interior finish shall only be permitted in fully sprinklered buildings.

c) Cellular plastics shall not be used as interior wall and ceiling materials. Drop-out ceilings (foam-grid panels) may be used in existing buildings if they are listed by a NRTL for installation under automatic sprinkler systems. Drop-out ceilings shall be installed in strict accordance with testing laboratory instructions; and automatic sprinklers shall be installed above the panels. Where new automatic sprinklers are installed in an existing building, drop-out ceilings shall not be used. Drop-out ceilings shall not be used in new buildings. Drop-out panels shall not be installed above sprinkler systems.

2.9 Roof Coverings and Roof Deck Assemblies

2.9.1 Roof Coverings. Roof coverings shall be approved and listed by a NRTL. The UL Building Materials Directory lists three Classes (A, B, and C) of acceptable roof coverings based on compliance with UL 790, Safety Tests for Fire Resistance of Roof Covering Materials and NFPA 256, Fire Tests of Roof Coverings. Class C roof coverings shall be restricted to housing and buildings under 8000 square feet (743.5 m²) and which are not mission essential. In congested areas, the AHJ may want to stipulate Class A roof coverings as defined by UL 790 and NFPA 256.

2.14 Fire Retardant Treated (FRT) Plywood

2.14.1 New Construction. Use of FRT plywood is prohibited, except as permitted by the UBC. FRT plywood shall not be used in any part of the roof or roofing system.

2.14.2 Existing Construction. FRT plywood installations should be regularly inspected for structural integrity. Replacement of damaged FRT plywood may require additional fire protection measures if FRT plywood is replaced with more combustible materials.

4.2.9 From NAVFACINST 1101.85H – Navy Family Housing Standards (Appendix A – Family Housing)

5.0 UNIT ENGINEERING

5.1 CONSTRUCTION AND MATERIALS

5.2 FLOOR SYSTEMS

5.2.3 Party Floor/Ceiling System

...Party floors shall have a minimum one-hour fire resistance rating, in accordance with ASTM E 119. Floor/ceiling construction between dwelling units (party floors) shall be designed to provide the following sound transmission ratings in accordance with ASTM E 90 and E 492:

- Sound Transmission Class - STC-52
- Impact Isolation Class - IIC-60*
- Floors between dwelling units and garages - STC-50

*Note: A minimum IIC-52 is acceptable at party floor when a bathroom, kitchen or utility room is located directly above a bathroom, kitchen or utility room.

– Tests for air-borne sound shall be made in compliance with ASTM E 336. Tests for impact sound shall be made in compliance with ASTM E 1007.

5.2.5 Balcony Floors

Balcony and upper floor porches, over walks, patios, or private yard areas, shall have sealed solid decking, with an ICBO approved waterproof, slip resistant wear surface. Gutters and downspouts away from patios and/or walks located below shall divert runoff.

5.2.6 Sheathing

Floor sheathing shall be ICBO approved material. Particle board is prohibited. Minimum floor sheathing thickness is 5/8 inch.

5.2.7 Underlayment

Wood floor systems shall be provided with underlayment below all resilient flooring.

5.3 WALL SYSTEMS

5.3.2 Sound Attenuation

Party walls shall provide a minimum sound attenuation rating of STC-55, as determined in accordance with ASTM E 90. Walls between dwelling units and garages shall have a minimum STC rating of 52.

5.3.3 Exterior Wall Finish

■ Vinyl siding shall conform to ASTM D 3679, rigid Poly Vinyl Chloride (PVC) Siding, minimum 0.044 inch thick, maximum five inch exposure (double-four, double-five, triple-four sidings are desirable).

5.3.5 Sustainable Framing

...Maximum use of engineered wood material is encouraged.

...Use of alternative building systems (i.e., Structural Insulated Panels, Foam-Form Concrete, Autoclaved Aerated Concrete, etc.), where cost effective, is desirable. [Note: Use/requirement of alternative building system prototypes is encouraged. Prototypes shall look and operate similar to conventionally framed units, and shall NOT impact total project cost.]

5.4 ROOF AND CEILING SYSTEMS

5.4.2 Roof Surface

...Wood shakes or shingles and parapets are prohibited

5.4.4 Roof Soffits, Fascias and Rakes

...Plywood, hardboard, or gypsum board is prohibited for soffits, fascias or rakes.

5.4.5 Sheathing & Radiant Barrier

Roof sheathing shall be International Congress of Building Officials (ICBO) approved material, minimum 1/2 inch thick.

5.10 STRUCTURAL STANDARD AND DESIGN

5.10.1 General

■ Standards: Structural design (materials and construction) shall comply with the Uniform Building Code (UBC), except for structures which qualify as "Manufactured Homes" under the Federal Manufactured Housing Construction and Safety Standards (FMHCSS), or as specified herein.

■ Design Criteria: Structures shall be designed and engineered to the following minimum criteria:

- Floor live load - 40 psf
- Balcony live load - 60 psf
- Roof live load - [EFD insert (20 psf typical)]
- Dead load - Actual
- Snow Load [EFD insert]
- Wind load - [EFD insert load in MPH or psf]
- Seismic zone - [EFD insert]

Note: Loads may be reduced as permitted by the UBC. This criterion is NOT waived by FMHSCC structural criteria. (See Section 7.0 for tie down requirements) TRI-Service TI 809-04 of Dec 98 is applicable.

5.10.2 Lateral Forces

Walls, when used or required for lateral resistance to wind or seismic loads, shall be considered bearing walls and full foundations.

5.0 SUMMARY AND CONCLUSIONS

Engineered-wood beams and panels are the main target product forms for advanced wood-plastic composites under development. These beams and panels are used in a variety of building component applications from subflooring to roof rafters.

Except for round poles or piles, there are no special Navy design requirements for wood or wood-based components used for Navy construction. Navy buildings follow National Design Specifications (NDS) for Wood Construction and are constructed in accordance with local building codes, specific site requirements and local custom.

The NAVFAC Guide Specification 06100, "Rough Carpentry" is the primary Navy document for specifying wood and wood-based products for building construction. The introduction of WPC building materials into Navy practice will first require changes to applicable portions of this specification. In addition this guide provides an excellent summary of commercial and government standards that govern the use of these products.

The following summarizes key requirements and issues relating to the use of advanced WPC in building construction gleaned from Navy criteria documents:

General Requirements or Issues for New Materials:

- Newly developed materials, equipment and methods not included in NAVFAC guide specifications may be used in limited applications with prior approval by the responsible NAVFAC Engineering Field Division.
- The item must equal or exceed minimum standards for quality and performance.
- The in-place cost or life-cycle cost of the item must be competitive.
- The item must be readily available in quantity and in wide geographical areas.
- The item must have approved laboratory certification or evidence of satisfactory use under conditions similar to the proposed application.
- Quality control of manufacturing processes and installation techniques must be guaranteed.
- Use of alternative building systems (i.e., structural insulated panels, foam-form concrete, autoclaved aerated concrete, etc.), where cost effective, is desirable in Navy housing.
- Roof sheathing for Navy housing shall be ICBO-approved material, minimum 1/2 inch thick.

Fire Safety Requirements

- Alternative materials shall provide fire safety per MIL-HDBK-1008/1 (1008C).
- Fire protection safety requirements for interior combustible components are complex. Fire protection criteria shall conform to the requirements of MIL-HDBK 1008C, the National Fire Codes, published by the National Fire Protection Association (NFPA), except as modified by MIL-HDBK-1008C, and portions of the Uniform Building Code (UBC).
- A fire protection design analysis is required for all building designs that references specific compliance with MIL-HDBK-1008C and National Fire Codes.
- Navy family housing flooring shall have a one-hour fire resistance rating, in accordance with ASTM E 119.

Relevant Wood, Plastic, and Wood-Plastic Issues

- Wood frame systems are not generally recommended for major or permanent construction.
- Exterior wood walls are not permitted for most major or permanent building types.
- Particle board is prohibited for floor sheathing in Navy housing.
- Maximum use of engineered-wood material is encouraged for wall framing in Navy housing.
- Plywood, hardboard or gypsum board is prohibited for soffits, fascias or rakes in Navy housing.
- Use of fire-retardant treated plywood is prohibited.
- Finger-jointed lumber is not allowed for Air Force construction.
- Cement-wood fiber panel roof decks may be prohibited by some Military Construction Offices because of vulnerability to moisture, insects, and in some cases fire.
- Materials currently listed as suitable for permanent construction do not include plastics or wood-plastic composites.
- Use of structural plastics are discouraged - a long listing of inferior engineering qualities is cited.
- Low fire resistance and combustion products that include toxic fumes exclude many plastics as construction material.
- Cellular plastics shall not be used as interior wall and ceiling materials.

It is anticipated that these waterfront component descriptions, requirements, and relevant issues along with a consideration of commercially available wood-plastic composites design characteristics will be used in the development of product opportunities of highest potential value to the Navy's waterfront infrastructure.

6.0 ACKNOWLEDGEMENT

This work was sponsored by the Office of Naval Research, ONR 332, under the direction of Dr. Ignacio Perez.

7.0 REFERENCES

1. Malvar, L.J., Hoffard, T.A., Pendleton, D.E., Hoy, D.E., "Description and Requirements for Candidate Waterfront Engineered Wood Materials and Components," Special Publication SP-2035-SHR, Naval Facilities Engineering Service Center, Port Hueneme, CA, March 1998.
2. Los Angeles Times, "Wood with Arsenic to be Phased out," by Elizabeth Shogren, February 13, 2002
3. Forest Products Laboratory, "Wood Handbook – Wood as an Engineering Material," Gen. Tech. Rep. FPL-GTR-113, U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI, March 1999.
4. National Design Specifications and Supplement, American Forest and Paper Association, American Wood Council, Washington, D.C.
5. American Concrete Institute, "Guide for the Design and Construction of Concrete Reinforced with FRP Bars," ACI 440.1R-01, 2001.
6. American Concrete Institute, "Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures," ACI (in preparation), 2001.
7. Joint Army-Air Force Manual, TM 5-809-1, AFM 88-3, Chapter 1, "Load Assumptions for Buildings," September 27, 1966.
8. Joint Services Manual, TM 5-809-10, NAVFAC P-355, AFM 88-3, Chapter 13, "Seismic Design for Buildings," February 15, 1982.
9. Joint Services Guidelines Manual, TM 5-809-10.1, NAVFAC P-355.1, AFM 88-3, Chapter 13, Section A, "Seismic Design Guidelines for Essential Building," 1986.
10. Joint Services Guidelines Manual, TM 5-809-10.2, NAVFAC P-355.2, AFM 88-3, Chapter 13, Section 13, "Seismic Design Guidelines for Upgrading Existing Buildings," 1987.
11. Joint Army-Air Force Manual, TM 5-809-11, AFM 88-3, Chapter 14, "Design Criteria for Facilities in Areas Subject to Typhoons and Hurricanes," June 21, 1983.
12. Joint Army-Navy-Air Force Manual, TM 1300, NAVFAC P-397, AFM 88-22, "Structures to Resist the Effects of Accidental Explosions," March 1, 1971.

APPENDIX A: NFGS-06100Z Rough Carpentry (September 99)
(UFGS-06100N) (SEP 99)

DEPARTMENT OF THE NAVY
NAVAL FACILITIES
ENGINEERING COMMAND
GUIDE SPECIFICATION

NFGS-06100Z
30 September 1999

Superseding NFGS-06100Y (03/98)

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN FOREST PAPER ASSOCIATION (AFPA)

AFPA NDS (1991) National Design Specification for Wood Construction and Supplement 1991 Design Values for Wood Construction

AFPA WCD1 (1988) Wood Frame Construction Data No. 1

AMERICAN INSTITUTE OF TIMBER CONSTRUCTION (AITC)

ANSI/AITC A190.1 (1992) Structural Glued Laminated Timber

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.2.1(1981; R 1996) Square and Hex Bolts and Screws Inch Series

ANSI B18.5.2.1M (1981; R 1995) Metric Round Head Short Square Neck Bolts

ANSI B18.6.1 (1981; R 1997) Wood Screws (Inch Series)

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA E30 (1996) Design/Construction Guide, Residential and Commercial

APA E445 (1996) Structural-Use Panels (APA PRP-108)

APA F405 (1995) Performance Rated Panels

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME/ANSI B18.2.2 (1987; R 1993) Square and Hex Nuts (Inch Series)

ANSI/ASME B18.5.2.2M (1982; R 1993) Metric Round Head Square Neck Bolts

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 653/A 653M (1996) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A 687 (1993) High-Strength Nonheaded Steel Bolts and Studs

ASTM C 79/C 79M (1997) Gypsum Sheathing Board

ASTM C 208 (1995) Cellulosic Fiber Insulating Board

ASTM F 1667 (1995) Driven Fasteners: Nails, Spikes, and Staples

AMERICAN WOOD-PRESERVERS' ASSOCIATION (AWPA)

AWPA C1 (1996) All Timber Products - Preservative Treatment by Pressure Processes

AWPA C2 (1996) Lumber, Timbers, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes

AWPA C9 (1996) Plywood - Preservative Treatment by Pressure Processes

AWPA C20 (1996) Structural Lumber - Fire-Retardant Treatment by Pressure Process

WPA C27 (1996) Plywood - Fire-Retardant Treatment by Pressure Process

AWPA C28 (1995) Structural Glued Laminated Members and Laminations Before Gluing, Pressure Treatment

AWPA M2 (1996) Inspection of Treated Timber Products

AWPA M6 (1996) Brands Used on Forest Products

COMMERCIAL ITEM DESCRIPTIONS (CID)

CID A-A-1923 (Rev. A) Shield, Expansion (Lag Shield)

CID A-A-1924 (Rev. A) Shield, Expansion (Self Drilling Tubular Expansion Shell)

CID A-A-1925 (Rev. A) Shield Expansion (Nail Anchors)

FACTORY MUTUAL ENGINEERING AND RESEARCH CORPORATION (FM)

FM LPDS 1-49 (1985) Perimeter Flashing

FEDERAL SPECIFICATIONS (FS)

FS MM-T-371 (Rev. E) Ties, Railroad, Wood (Cross and Switch)

FS FF-B-588 (Rev. E) Bolt, Toggle: and Expansion Sleeve, Screw

FS UU-B-790 (Rev. A Reinst) Building Paper, Vegetable Fiber: (Kraft, Waterproofed, Water Repellent and Fire Resistant)

FS FF-T-1813 Tack

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)

ICBO UBC (1994) Uniform Building Code

NORTHEASTERN LUMBER MANUFACTURERS ASSOCIATION (NELMA) NELMA

NELMA SGRNL (1997) Standard Grading Rules for Northeastern Lumber

NATIONAL HARDWOOD LUMBER ASSOCIATION (NHLA)

NHLA RMIHC (1994) Rules for the Measurement and Inspection of Hardwood and Cypress

U.S. DEPARTMENT OF COMMERCE PRODUCT STANDARDS (PS)

PS-1(1995) Construction and Industrial Plywood

PS-2 (1993) Wood-Base Structural-Use Panels

PS-20 (1970; R 1986) American Softwood Lumber Standard

PS-56 (1973) Structural Glued Laminated Timber

PS-58 (1974) Basic Hardboard

REDWOOD INSPECTION SERVICE (RIS)

RIS GCRL (1995) Grades of California Redwood Lumber

SOUTHERN CYPRESS MANUFACTURERS ASSOCIATION (SCMA)

SCMA GSC (1986; Supp. 1993) Grades of Southern Cypress

SOUTHERN PINE INSPECTION BUREAU (SPIB)

SPIB SPIBGR (1994) Southern Pine Inspection Bureau Grading Rules

TRUSS PLATE INSTITUTE (TPI)

ANSI/TPI-1 (1995) National Design Standard for Metal Plate Connected Wood Trusses

TPI HIB (1991) Handling, Installing and Bracing of Metal Plate Connected Wood Trusses
WEST COAST LUMBER INSPECTION BUREAU (WCLIB)

WCLIB 17 (1996; Supp. VII VIII) Standard Grading and Dressing Rules for Douglas Fir, Western Hemlock, Western Red Cedar, White Fir, Sitka Spruce Lumber

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA WLGR (1995) Western Lumber Grading Rules

1.2 SUBMITTALS

NOTE: Where a "G" in submittal tags follows a submittal item, it indicates Government approval for that item. Add "G" in submittal tags following any added or existing submittal items deemed sufficiently critical, complex, or aesthetically significantly to merit approval by the Government. Submittal items not designated with a "G" will be approved by the QC organization.

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

[Structural glued laminated members; G]

[Trussed rafters; G]

[Trussed joists; G]

[Fabricated structural members; G]

Modifications of structural members; G

SD-05 Design Data

Modification of structural members; G

- SD-06 Test Reports
 - Preservative-treated lumber and plywood
- SD-07 Certificates
 - Certification of grade

1.3 DELIVERY AND STORAGE

Deliver materials to the site in an undamaged condition. Store materials off the ground to provide proper ventilation, with drainage to avoid standing water, and protection against ground moisture and dampness. Store materials with a moisture barrier at both the ground level and as a cover forming a well ventilated enclosure. Remove defective and damaged materials and provide new materials.

1.4 GRADING AND MARKING

1.4.1 Lumber

NOTE: Finger-jointed lumber is not allowed for Air Force construction.

Mark each piece of framing and board lumber or each bundle of small pieces of lumber with the grade mark of a recognized association or independent inspection agency. Such association or agency shall be certified by the Board of Review, American Lumber Standards Committee, to grade the species used.

1.4.2 Structural Glued Laminated Timber

Mark each member with the mark of a recognized association or independent inspection agency that maintains continuing control over the quality of structural glued laminated timber products. The marking shall indicate compliance with ANSI/AITC A190.1 and shall include all identification information required by ANSI/AITC A190.1. [Structurally end-jointed lumber shall also be certified and grade marked in accordance with ANSI/AITC A190.1.]

1.4.3 Plywood

Mark each sheet with the mark of a recognized association or independent inspection agency that maintains continuing control over the quality of the plywood. The mark shall identify the plywood by species group or span rating, exposure durability classification, grade, and compliance with PS-1.

1.4.4 Structural-Use and OSB Panels

Mark each panel with the mark of a recognized association or independent inspection agency that maintains continuing control over the quality of the panel. The mark shall indicate end use, span rating, and exposure durability classification. Oriented Strand Board (OSB), APA F405.

1.4.5 Preservative-Treated Lumber and Plywood

The Contractor shall be responsible for the quality of treated wood products. Each treated piece shall be inspected in accordance with AWPA M2 and permanently marked or branded, by the producer, in accordance with AWPA M6. The Contractor shall provide Contracting Officer's Representative (COR) with the inspection report of an approved independent inspection agency that offered products comply with applicable AWPA Standards. The appropriate Quality Mark on each piece will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

1.4.6 Fire-Retardant Treated Lumber

NOTE: Do not use fire-retardant treated plywood.

Mark each piece in accordance with AWPA M6, except pieces that are to be natural or transparent finished. In addition, exterior fire-retardant lumber shall be distinguished by a permanent penetrating blue stain. Labels of a nationally recognized independent testing agency will be accepted as evidence of conformance to the fire-retardant requirements of AWPA M6.

1.4.7 Hardboard, Gypsum Board, and Fiberboard

Mark each sheet or bundle to identify the standard under which the material is produced and the producer.

1.5 SIZES AND SURFACING

PS-20 for dressed sizes of yard and structural lumber. Lumber shall be surfaced four sides. Size references, unless otherwise specified, are nominal sizes, and actual sizes shall be within manufacturing tolerances allowed by the standard under which the product is produced. Other measurements are IP or SI standard.

1.6 MOISTURE CONTENT

Air-dry or kiln-dry lumber. Kiln-dry treated lumber after treatment. Maximum moisture content of wood products shall be as follows at the time of delivery to the job site:

- a. Framing lumber and boards - 19 percent maximum
- b. Timbers 125 mm 5 inches and thicker - 25 percent maximum
- c. Materials other than lumber - Moisture content shall be in accordance with standard under which the product is produced

1.7 PRESERVATIVE TREATMENT

NOTE: Water-borne preservative treatment with either ammoniacal copper arsenate (ACA), ammoniacal copper zinc arsenate (ACZA), or chromate copper arsenate (CCA), should be used in accordance with AWPA C1 and either AWPA C2, C9 or C28 for the appropriate product.

Water-borne preservatives are leach resistant, paintable, and easily worked. Whenever certain exposed uses require minimized swelling, shrinking, or splitting, then require that a water repellent be added to the treatment. Requirement of an independent inspection agency report or the AWPA Quality Mark verifies that the product was prepared and treated in accordance with its appropriate AWPA Standard and other specification requirements. Consult the EFD applied biologist for further guidance regarding specific treatments listed or additional treatments that may be required for special use items. All lumber and woodwork in the Key West and South Florida areas shall be preservative treated.

Treat lumber and timber in accordance with AWPA C1 and AWPA C2, and plywood in accordance with AWPA C1 and AWPA C9. Treat structural glued laminated timber in accordance with AWPA C1 and AWPA C28. All wood shall be air or kiln dried after treatment. Specific treatments shall be verified by the report of an approved independent inspection agency, or the AWPA Quality Mark on each piece. [Do not incise surfaces of lumber that will be exposed.] Brush coat areas that are cut or drilled after treatment with either the same preservative used in the treatment or with a 2 percent copper naphthenate solution. [All lumber and woodwork shall be preservative treated.]

The following items shall be preservative treated:

- a. Wood framing, woodwork, and plywood up to and including the subflooring at the first-floor level of structures having crawl spaces when the bottoms of such items are 600 mm 24 inches or less from the earth underneath.
- b. Exterior wood steps, platforms, and railings; and all wood framing of open, roofed structures.
- c. Wood sills, soles, plates, furring, and sleepers that are less than 600 mm 24 inches from the ground, furring and nailers that are set into or in contact with concrete or masonry.
- d. Nailers, edge strips, crickets, curbs, and cants for roof decks.

1.8 FIRE-RETARDANT TREATMENT

NOTE: Items to be treated should be listed in this paragraph. Fire-retardant treatment should be specified when necessary to provide required fire resistance for the structure. Where wood will be exposed to heat or high humidity, as well as where wood is exposed on the exterior of buildings, specify exterior fire retardant treatment.

Treat the following items in accordance with AWPA C20 or AWPA C27. Such items which will not be inside a building, and such items which will be exposed to heat or high humidity, shall receive exterior fire-retardant treatment.

- a. [_____].

1.9 QUALITY ASSURANCE

1.9.1 Drawing Requirements

For fabricated structural members, trusses, glu-lam members, indicate materials, details of construction, methods of fastening, and erection details. Include reference to design criteria used and manufacturers design calculations. Submit drawings for all proposed modifications of structural members. Do not proceed with modifications until the submittal has been approved.

1.9.2 Data Required

Submit calculations and drawings for all proposed modifications of structural members. Do not proceed with modifications until the submittal has been approved.

1.9.3 Certificates of Grade

Submit certificates attesting that products meet the grade requirements specified in lieu of grade markings where appearance is important and grade marks will deface material.

PART 2 PRODUCTS

2.1 LUMBER

2.1.1 Structural Lumber

NOTE: When the minimum allowable unit stresses for structural lumber are not indicated on the drawings, check with the structural engineer. The following minimum allowable unit stresses are commonly used:

1. 7200 kPa Fb, 4800 kPa Ft, 5400 kPa Fc with 8300 MPa E 1050 Fb, 700 Ft, 780 Fc with 1,200,000E for engineered uses, i.e., structural lumber used in fabrication of bolted trusses and other fabricated structural members for engineered uses, except trussed rafters.
2. 8300 kPa Fb, with 8300 MPa E 1200 Fb, with 1,200,000E for repetition member uses, i.e., joists, rafters including trussed type, decking, and headers.

[Except where a specific grade is indicated or specified,] Any of the species and grades listed in AFPA NDS that have allowable unit stresses in kPa pounds per square inch (psi) not less than [[_____] Fb, [_____] Ft, [_____] Fc, with [_____] E] [allowable unit stresses indicated]. Use for joists, rafters, headers, trusses, beams (except collar beams), columns, posts, stair stringers, girders, and all other members indicated to be stress rated. [Structural lumber exposed to view in [_____] shall be appearance grade [of [_____] species] [of any species] meeting the allowable unit stresses [specified] [indicated].]

2.1.2 Framing Lumber

NOTE: Finger-jointed lumber is not allowed for Air Force construction.

NOTE: Except for projects requiring huge quantities of lumber, delete species and grades not normally used where project is located. Edit the listing to suit the locality and the project.

Framing lumber such as studs, plates, caps, collar beams, cant strips, bucks, sleepers, nailing strips, and nailers and board lumber such as subflooring and wall and roof sheathing shall be one of the species listed in the table below. Minimum grade of species shall be as listed. [Finger-jointed lumber may be used in the same applications as solid lumber of an equivalent species and grade, provided the finger-jointed lumber meets all the requirements of the certification and the quality control programs of the rules writing agency having jurisdiction and all applicable requirements of PS-56.]

Table of Grades for Framing and Board Lumber

<i>Grading Rules</i>	<i>Species</i>	<i>Framing</i>	<i>Board Lumber</i>
WWPA WLGR standard grading rules	Aspen	All Species:	All Species:
	Douglas Fir-Larch	Standard Light	No. 3 Common
	Douglas Fir South	Framing or No.	
	Engelmann Spruce	3 Structural	
	-Lodgepole Pine	Light Framing	
	Engelmann Spruce	(Stud Grade for	
	Hem-Fir	2x4 nominal size,	
	Idaho White Pine	3 m and shorter)	
	Lodgepole Pine		
	Mountain Hemlock		
	Mountain Hemlock		
	-Hem-Fir		
	Ponderosa Pine		
	-Sugar Pine		
	Ponderosa Pine		
	-Lodgepole Pine		
	Subalpine Fir		
White Woods			
Western Woods			
Western Cedars			
Western Hemlock			
WCLIB 17 standard grading rules	Douglas Fir-Larch	All Species:	All Species:
	Hem-Fir	Standard Light	Standard
	Mountain Hemlock	Framing or No.	
	Sitka Spruce	3 Structural	
	Western Cedars	Light Framing	

	Western Hemlock	(Stud Grade for 2x4 nominal size, 3 m and shorter)	
<i>Grading Rules</i> SPIB SPIBGR standard grading rules	<i>Species</i> Southern Pine	<i>Framing</i> Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 3 m and shorter)	<i>Board Lumber</i> No. 2 Boards
<i>Grading Rules</i> SCMA GSC standard specifications	<i>Species</i> Cypress	<i>Framing</i> No. 2 Common	<i>Board Lumber</i> No. 2 Common
<i>Grading Rules</i> NELMA SGRNL standard grading rules	<i>Species</i> Balsam Fir Eastern Hemlock -Tamarack Eastern Spruce Eastern White Pine Northern Pine Northern Pine Cedar	<i>Framing</i> All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 3 m and shorter)	<i>Board Lumber</i> All Species: No. 3 Common except Standard for Eastern White and Northern Pine
<i>Grading Rules</i> RIS GCRL standard specifications	<i>Species</i> Redwood	<i>Framing</i> All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 3 m and shorter)	<i>Board Lumber</i> Construction Heart
<i>Grading Rules</i> NHLA RMIHC rules for the measurement and inspection	<i>Species</i> Cypress	<i>Framing</i> No. 2 Dimension	<i>Board Lumber</i> No. 2 Common

of hardwood
and cypress
lumber

<i>Grading Rules</i>	<i>Species</i>	<i>Framing</i>	<i>Board Lumber</i>
WWPA WLGR standard grading rules	Aspen Douglas Fir-Larch Douglas Fir South Engelmann Spruce -Lodgepole Pine Engelmann Spruce Hem-Fir Idaho White Pine Lodgepole Pine Mountain Hemlock Mountain Hemlock -Hem-Fir Ponderosa Pine -Sugar Pine Ponderosa Pine -Lodgepole Pine Subalpine Fir White Woods Western Woods Western Cedars Western Hemlock	All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 10 feet and shorter)	All Species: No. 3 Common

<i>Grading Rules</i>	<i>Species</i>	<i>Framing</i>	<i>Board Lumber</i>
WCLIB 17 standard grading rules	Douglas Fir-Larch Hem-Fir Mountain Hemlock Sitka Spruce Western Cedars Western Hemlock	All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 10 feet and shorter)	All Species: Standard

<i>Grading Rules</i>	<i>Species</i>	<i>Framing</i>	<i>Board Lumber</i>
SPIB SPIBGR standard grading rules	Southern Pine	Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 10 feet and shorter)	No. 2 Boards

<i>Grading Rules</i>	<i>Species</i>	<i>Framing</i>	<i>Board Lumber</i>
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SCMA GSC standard specifications	Cypress	No. 2 Common	No. 2 Common
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<i>Grading Rules</i> NELMA SGRNL standard grading rules	<i>Species</i> Balsam Fir Eastern Hemlock -Tamarack Eastern Spruce Eastern White Pine Northern Pine Northern Pine Cedar	<i>Framing</i> All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 10 feet and shorter)	<i>Board Lumber</i> All Species: No. 3 Common except Stan- dard for Eastern White and Northern Pine
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<i>Grading Rules</i> RIS GCRL standard specifications	<i>Species</i> Redwood	<i>Framing</i> All Species: Standard Light Framing or No. 3 Structural Light Framing (Stud Grade for 2x4 nominal size, 10 feet and shorter)	<i>Board Lumber</i> Construction Heart
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<i>Grading Rules</i> NHLA RMIHC rules for the measurement and inspection of hardwood and cypress lumber	<i>Species</i> Cypress	<i>Framing</i> No. 2 Dimension	<i>Board Lumber</i> No. 2 Common
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2.1.3 Structural Glued Laminated Timber

NOTE: Specify appearance grade of lumber in glued laminated members when required by aesthetic considerations. Insert stress requirements necessary when not indicated on drawings. Wet condition should be specified when moisture content of member in service will exceed 16 percent for repeated and prolonged periods. Architectural or Premium Appearance Grade should be specified only when appearance is of major importance. Special stains and sealers may be specified in lieu of a penetrating sealer when required by aesthetic considerations. Individual wrapping should be specified when protection during erection is necessary. Preservative treatment in lieu of sealing should be specified for exposure conditions named in

American Institute of Timber Construction AITC 109, Treating Standard for Structural Glued Laminated Timber.

ANSI/AITC A190.1, allowable working stress values for loads of normal duration in kPa pounds per square inch (psi) not less than the following:

Bending Members, [_____] Fb, [_____] Fv, [_____] E.]
Compression Members, [_____] Fc, [_____] E.]
Tension Members, [_____] Ft, [_____] E.]

Fabricated with wet-use adhesives. Members shall be [Industrial] [Architectural] [Premium] Appearance Grade, sealed with a penetrating sealer, and [individually wrapped] [bundle wrapped] as standard with the manufacturer and approved. Members shall be complete with hardware for joining laminated members and for their connection to other construction.

2.2 PLYWOOD, STRUCTURAL-USE, AND ORIENTED STRAND BOARD (OSB) PANELS

NOTE: Thicknesses and index or Span Rating numbers 16 ratings are used at 400 mm (modular SI spacing). Thickness and index or Span Rating number are minimums for usual loading and support spacing. Specific job conditions such as unusual loading, support spacing, surfacing material, and exposure may necessitate using other types of plywood or structural-use panels. Refer to American Plywood Association construction guides for additional guidance on specifying structural panel products.

PS-1, PS-2, APA E445, and APA F405 respectively.

2.2.1 Subflooring

NOTE: Plywood, structural-use, and OSB panels, to receive floor finishes may be applied as (1) subflooring only; (2) combination subfloor-underlayment; or (3) subflooring with underlayment applied over the subfloor.

Use subparagraph entitled "Plywood" or "Structural-Use and OSB Panels" for plywood or structural-use or OSB panel subflooring to receive direct application of T G finish wood flooring or to receive underlayment for floor covering such as carpet, resilient tile, linoleum, and other nonstructural floor finishes.

Use subparagraphs entitled "Plywood" and "Structural-Use and OSB Panels" in conjunction with paragraphs entitled "Underlayment" and "Hardboard Underlayment" when a separate underlayment application is desired.

2.2.1.1 Plywood

NOTE: Identification Index 32/16 or Span Rating 24/16 should be specified for supports 400 mm 16 inches o.c. and 48/24 should be specified for supports 600 mm 24 inches o.c. Plywood or

structural-use panel subflooring to receive square-edge wood flooring shall be specified to have T G edges or edges to be supported by approved blocking or framing.

C-D Grade, Exposure 1 durability classification, Span rating of [24/16] [48/24] or greater.

2.2.1.2 Structural-Use and OSB Panels

NOTE: Identification Index 32/16 or Span Rating 24/16 should be specified for supports 400 mm 16 inches o.c. and 48/24 should be specified for supports 600 mm 24 inches o.c. Plywood or structural-use panel subflooring to receive square-edge wood flooring shall be specified to have T G edges or edges to be supported by approved blocking or framing.

Sheathing grade with durability equivalent to Exposure 1, Span Rating of [32/16] [48/24] or greater. OSB, APA E445, Rated Sturd-I-Floor.

2.2.2 Combination Subfloor-Underlayment

NOTE: Use subparagraph entitled "Plywood" "Structural-Use and OSB Panels" for combination subfloor-underlayment where application of an underlayment is not desired. This method is suitable for most types of finish flooring or floor covering and is normally more economical than an application of subflooring with an application of underlayment.

2.2.2.1 Plywood

[Underlayment Grade, Exposure 1] [, or] [Exterior Type, C-C (Plugged) Grade]. Minimum thickness shall be as listed below [except where indicated to have greater thickness].

<u>Support Spacing</u>	<u>Underlayment Minimum Thickness</u>
400 mm	12.7 mm for Group 1 species 15 mm for Group 2 and 3 species 18 mm for Group 4 species
600 mm	18 mm for Group 1 species 22 mm for Group 2 and 3 species 25 mm for Group 4 species
	<u>Underlayment Minimum Thickness</u>
<u>Support Spacing</u>	
16 inches	1/2 inch for Group 1 species 19/32 inch for Group 2 and 3 species 23/32 inch for Group 4 species
24 inches	23/32 inch for Group 1 species

7/8 inch for Group 2 and 3 species
one inch for Group 4 species

2.2.2.2 Structural-Use Panel

Combination subfloor-underlayment grade with durability equivalent to [Interior plywood with Exterior glue (Exposure 1)] [Exterior plywood], Span Rating of [16] [20] [24] [48] or greater.

2.2.3 Wall Sheathing

2.2.3.1 Plywood

NOTE: Plywood wall sheathing 9.5 mm 3/8 inch thick should be specified for supports spaced 400 mm 16 inches on center, and 12.7 mm ½ inch thick plywood wall sheathing should be specified for supports spaced 600 mm 24 inches on center.

C-D Grade, Exposure 1, and a minimum thickness of [9.5] [12.7] mm [3/8] [1/2] inch [except where indicated to have greater thickness].

2.2.3.2 Structural-Use and OSB Panels

NOTE: Structural-use panels 9.5 mm 3/8 inch thick with a Span Rating of 16/0 or greater should be specified for supports 400 mm 16 inches o.c. and panels 11 mm 7/16 inch thick with a Span Rating of 24/0 or greater should be specified for supports 600 mm 24 inches o.c.

Sheathing grade with durability equivalent to Exposure 1, Span Rating of [16/0] [24/0] or greater. OSB, APA Rated Sheathing.

2.2.4 Roof Sheathing

2.2.4.1 Plywood

C-D Grade, Exposure 1, with an Identification Index of not less than [24/0] [_____].

2.2.4.2 Structural-Use Panel

Sheathing grade with durability equivalent to Exposure 1, Span Rating of [24/0] [_____] or greater.

2.2.5 Underlayment

Plywood, Underlayment Grade, Exposure 1, or Exterior C-C (Plugged) Grade, minimum thickness [6 mm] [1/4 inch] [_____]. OSB Underlayment Grade 6 mm 0.225 inch.

2.2.6 Diaphragms

2.2.6.1 Plywood

[Structural I] [Structural II], [C-C] [C-D] grade, Exposure 1, and a minimum thickness of [_____] mm inch.

2.2.6.2 Structural-Use and OSB Panels

Sheathing grade with durability equivalent to Exposure 1 and a minimum thickness of [_____] mm inch.

2.2.7 Shear Walls

2.2.7.1 Plywood

[Structural I] [Structural II], [C-C] [C-D] [_____] Grade and a minimum thickness of [_____] mm inch.

2.2.7.2 Structural-Use and OSB Panels

Sheathing grade with durability equivalent to Interior plywood with Exterior glue (Exposure 1) and a minimum thickness of [_____] mm inch.

2.2.8 Other Uses

2.2.8.1 Plywood

Plywood for [_____.]

2.2.8.2 Structural-Use and OSB Panels Structural-use and OSB panels for [_____.]

2.3 OTHER MATERIALS

2.3.1 Hardboard Underlayment

PS-58, service class, sanded on one side, 6 mm 1/4 inch thick 1200 mm 4 feet wide.

2.3.2 Fiberboard Wall Sheathing

ASTM C 208, 600 mm wide by [13 mm thick for supports 400 mm (o.c.)] [20 mm thick for supports 600 mm o.c.] or 1200 mm wide by [13 mm thick for supports 400 mm o.c.] [20 mm thick for supports 600 mm o.c.], except only 1200 mm wide by 13 mm thick sheathing over supports at 400 mm o.c. may be applied without corner bracing of framing 2 feet wide by [1/2 inch thick for supports 16 inches (o.c.)] [25/32 inch thick for supports 24 inches o.c.] or 4 feet wide by [1/2 inch thick for supports 16 inches o.c.] [3/4 inch thick for supports 24 inches o.c.], except only 4 feet wide by 1/2 inch thick sheathing over supports at 16 inches o.c. may be

applied without corner bracing of framing. Sheathing shall be asphalt impregnated or asphalt coated to render the sheathing water resistant but vapor permeable.

2.3.3 Gypsum Wall Sheathing

ASTM C 79, 12.7 mm 1/2 inch thick [fire retardant (Type X) 16 mm 5/8 inchthick]; 1200 mm 4 feet wide with square edge [for supports 400 mm 16 inches o.c. with or without corner bracing of framing] [or] [for supports 600 mm 24 inches o.c. with corner bracing of framing]; 600 mm 2 feet wide with V-tongue and groove (T G) edge for supports [400] [or] [600 mm [16] [or] [24] inches o.c. with corner bracing of framing.

2.3.4 Foil-Faced Insulative Sheathing

Wood fiber core, chemically treated for water resistance, with aluminum foil laminated under pressure to both sides with water-resistant adhesive; 1200 mm 48 inches or 48 3/4 inches wide; 2 mm 0.078 inch thick when used with corner bracing, 2.9 mm 0.115 inch thick with studs up to 400 mm 16 inches o.c. without corner bracing, or 3.5 mm 0.137 inch thick with studs up to 600 mm 24 inches o.c. without corner bracing. The sheathing and installation shall have been accepted by ICBO as conforming to ICBO UBC. The sheathing alone shall have a thermal resistance value (R value) of not less than 0.20.

2.3.5 Building Paper

FS UU-B-790, Type I, Grade D, Style 1.

2.3.6 Trussed Rafters

Metal plate connected trusses designed in accordance with ANSI/TPI-1 and TPI HIB and fabricated in accordance with ANSI/TPI-1.

2.3.7 Trussed Joists

Metal plate connected parallel chord wood trusses designed and fabricated in accordance with ANSI/TPI-1.

2.3.8 Wood Bumpers

FS MM-T-371, Type I, Form A or B, and shall be oak.

2.4 ROUGH HARDWARE

Unless otherwise indicated or specified, rough hardware shall be of the type and size necessary for the project requirements. Sizes, types, and spacing of fastenings of manufactured building materials shall be as recommended by the product manufacturer unless otherwise indicated or

specified. Rough hardware exposed to the weather or embedded in or in contact with preservative treated wood, exterior masonry, or concrete walls or slabs shall be zinc-coated. [Nails and fastenings for fire-retardant treated lumber and woodwork exposed to the weather shall be copper alloy.]

2.4.1 Bolts, Nuts, Studs, and Rivets

ANSI B18.2.1, ANSI B18.5.2.1M, ANSI/ASME B18.5.2.2M, ASME/ANSI B18.2.2, and ASTM A 687.

2.4.2 Expansion Shields

CID A-A-1923, CID A-A-1924, and CID A-A-1925. Except as shown otherwise, maximum size of devices shall be 10 mm 3/8 inch.

2.4.3 Lag Screws and Lag Bolts

ANSI B18.2.1.

2.4.4 Toggle Bolts

FS FF-B-588.

2.4.5 Wood Screws

ANSI B18.6.1.

2.4.6 Wire Nails

ASTM F 1667

2.4.7 Tacks

FS FF-T-1813.

2.4.8 Joist Hangers

Steel or iron, zinc coated, sized to fit the supported member, of sufficient strength to develop the full strength of the supported member in accordance with ICBO UBC, and furnished complete with any special nails required.

2.4.9 Tie Straps

For joists supported by the lower flange of steel beams, provide 3 by 40 mm 1/8 by 1 1/2 inch steel strap, 600 mm 2 feet long [except as indicated otherwise].

2.4.10 Joist Anchors

For joists supported by masonry walls, provide anchors 5 by 40 mm 3/16 by 1 1/2 inch steel tee or strap, bent and of length to provide 100 mm 4 inches embedment into wall and 300 mm 12 inches along joist [except as indicated otherwise]. For joists parallel to masonry or concrete walls, provide anchors 6 by 30 mm 1/4 by 1 1/4 inch minimum cross-sectional area, steel strap, length as necessary to extend over top of first three joists and into wall [100] [200] mm [4] [8] inches, and with wall end of bend or pin type [, except as indicated otherwise].

2.4.11 Door Buck Anchors

Metal anchors, 3 by 30 mm 1/8 by 1 1/4 inch steel, 300 mm 12 inches long, with ends bent 50 mm 2 inches [, except as indicated otherwise]. Anchors shall be screwed to the backs of bucks and built into masonry or concrete. Locate 200 mm 8 inches above sills and below heads and not more than 600 mm 24 inches intermediately between. [Anchorage of bucks to steel framing shall be [as indicated] [as necessary to suit the conditions].]

2.4.12 Metal Bridging

[Where not indicated or specified otherwise,] No. 16 U.S. Standard gage, cadmium-plated or zinc-coated.

2.4.13 Toothed Rings and Shear Plates

AFPA NDS.

2.4.14 Beam Anchors

Steel U-shaped strap anchors 6 mm 1/4 inch thick by 40 mm 1 1/2 inches wide [except as indicated otherwise].

2.4.15 Metal Framing Anchors

Construct anchors to the configuration shown using hot dip zinc-coated steel conforming to ASTM A 653/A 653M, Z275 G90. [Except where otherwise shown,] Steel shall be not lighter than 18 gage. Special nails supplied by the manufacturer shall be used for all nailing.

2.4.16 Panel Edge Clips

Extruded aluminum or galvanized steel, H-shaped clips to prevent differential deflection of roof sheathing.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to AFPA WCD1 unless otherwise indicated or specified. Fit framing lumber and other

rough carpentry, set accurately to the required lines and levels, and secure in place in a rigid manner. Do not splice framing members between bearing points. Set joists, rafters, and purlins with their crown edge up. Frame members for the passage of pipes, conduits, and ducts. Do not cut or bore structural members for the passage of ducts or pipes without approval. Reinforce all members damaged by such cutting or boring by means of specially formed and approved sheet metal or bar steel shapes, or remove and provide new, as approved. Provide as necessary for the proper completion of the work all framing members not indicated or specified. Spiking and nailing not indicated or specified otherwise shall be in accordance with the Nailing Schedule contained in ICBO UBC; perform bolting in an approved manner. Spikes, nails, and bolts shall be drawn up tight. [Timber connections and fastenings shall conform to AFPA NDS.] [Provide 50 mm 2 inch minimum clearance between chimneys and wood framing; provide 100 mm 4 inch minimum clearance at fireplaces. Fill the spaces with strips of approved noncombustible material.] Use slate or steel shims when leveling joists, beams, and girders on masonry or concrete. Do not use shimming on wood or metal bearings.

3.1.1 Sills

Set sills level and square and wedge with steel or slate shims; point or grout with non-shrinking cement mortar to provide continuous and solid bearing. Anchor sills to the foundations as indicated. [Where sizes and spacing of anchor bolts are not indicated, provide not less than 16 mm 5/8 inch diameter bolts at all corners and splices and space at a maximum of 1800 mm 6 feet o.c. between corner bolts. Provide at least two bolts for each sill member. Lap and splice sills at corners and bolt through the laps or butt the ends and through-bolt not more than 150 mm 6 inches from the ends.] Provide bolts with plate washers and nuts. Bolts in exterior walls shall be zinc-coated.

3.1.1.1 Anchors in Masonry

[Except where indicated otherwise,] Embed anchor bolts not less than 400 mm 15 inches in masonry unit walls and provide each with a nut and a 50 mm 2 inch diameter washer at bottom end. Fully grout bolts with mortar.

3.1.1.2 Anchors in Concrete

[Except where indicated otherwise,] Embed anchor bolts not less than 200 mm 8 inches in poured concrete walls and provide each with a nut and a 50 mm 2 inch diameter washer at bottom end. A bent end may be substituted for the nut and washer; bend shall be not less than 90 degrees. Powder-actuated fasteners spaced 900 mm 3 feet o.c. may be provided in lieu of bolts for single thickness plates on concrete.

3.1.2 Beams and Girders

Set beams and girders level and in alignment and anchor to bearing walls, piers, or supports with U-shaped steel strap anchors. Embed anchors in concrete or masonry at each bearing and through-bolt to the beams or girders with not less than two bolts. Provide bolts not less than 12 mm 1/2 inch in diameter and with plate washers under heads and nuts. Install beams and girders

[not indicated otherwise] with 200 mm 8 inch minimum end bearing on walls or supports. Install beams and girders into walls with [12 mm 1/2 inch clearance at the top, end, and sides] [or] [standard steel wall-bearing boxes]. Provide joints and splices over bearings only and bolt or spike together.

3.1.3 Joists

Provide joists of the sizes and spacing indicated, accurately and in alignment, and of uniform width. Joists shall have full bearing on sills, [plates,] [beams,] [girders,] [and] [trusses]; provide laps over bearing only and spike. Where joists are of insufficient length to produce a 300 mm 12 inch lap, butt joists over bearing and provide wood scabs 2 nominal inches thick by depth of joists by 600 mm 24 inches long or metal straps 6 by 40 mm 1/4 by 1 1/2 inch by not less than 450 mm 18 inches long nailed to each joist with not less than four 10-penny nails, or approved sheet metal connectors installed in accordance with the manufacturer's recommendations. Provide joists built into masonry with [a beveled fire cut so that the top of the joist does not enter the wall more than 25 mm one inch] [or] [standard steel wall bearing boxes]. Provide metal hangers for joists framing into the side of headers, beams, or girders. [When a portion of the joist extends above the top flange of a steel beam or girder, provide a 10 mm 3/8 inch space between the top flange and the extended portion of the joists to allow for shrinkage of joists.] The minimum joist end bearing shall be 100 mm 4 inches, and joists built into concrete or masonry shall have a 12 mm 1/2 inch minimum clearance at the top, end, and sides. For joists approved to be bored for the passage of pipes or conduits, bore through the neutral axis of the joist. [Provide steel joist hangers of proper size and type to receive the ends of all framed joists.]

3.1.3.1 Doubled Joists

Provide under bearing walls and partitions running parallel with the floor joists[, around [stairways,] [chimneys,] [fireplaces,]] and at other openings where joists are cut and framed. Double, space for clearance, block apart 1200 mm 4 feet on center, rigidly frame, and spike together joists under partitions that are to receive ducts, pipes, and conduits.

3.1.3.2 Tie Straps

For joists supported by the lower flange of steel beams, provide straps at every fourth joist and the corresponding fourth joist on the opposite side. Tie joists across the top of the steel beam with a steel strap. Form straps to lie flat across the top of the beam and twist at the ends to provide flat contact with the side of each joist. Nail each strap at each end with three 10-penny nails spaced 50 mm 2 inches o.c.

3.1.3.3 Joist Anchors

Provide anchors for each fourth joist supported by a masonry wall. Build wall end of anchors into the wall. Nail anchor to the joist with three 10-penny nails spaced 50 mm 2 inches o.c. Anchor the first three joists parallel to concrete or masonry walls at bridging points, but not less than 2400 mm 8 feet o.c. from end walls. Let anchors into the tops of each joist and spike to the top of joist with one 10-penny nail. Extend anchors at least [100] [200] mm [4] [8] inches into

the wall.

3.1.4 Bridging

Provide bridging for floor and ceiling joists and for roof rafters having slopes of less than 1/3. Locate bridging as indicated and as specified herein. Provide bridging for spans greater than 1800 mm 6 feet , but do not exceed 2400 mm 8 feet maximum spacing between rows of bridging. Install rows of bridging uniformly. Provide metal or wood cross-bridging, except where solid bridging is indicated. Do not nail the bottom end of cross-bridging until the subfloor has been laid.

3.1.4.1 Wood Cross-Bridging

Provide wood cross-bridging not less than [1 by 3] [2 by 3] [2 by 4] nominal size. Nail wood cross-bridging at each end with [two 8-penny nails for 25 by one by thick material] [and] [three 8-penny nails for 2 by thick material.]

3.1.4.2 Metal Cross-Bridging

Shall be the manufacturer's standard product, not less than 16 gage before forming and coating. Metal bridging shall be the compression type, lodged into or nailed to the wide faces of opposite joists at points diagonally across from each other near the bottoms and tops of joists.

3.1.5 Subflooring

3.1.5.1 Plywood, Structural-Use, and OSB Panels

NOTE: Edges shall be supported with blocking for square-edged wood finish flooring, unless a separate underlayment layer is installed. Apply best side up with the grain of outer plies or the long dimension at right angles to joists. Stagger end joints and locate over the centerline of joists. [Support panel edges by nominal 2 by 4 members framed between joists so the edge joints of subfloor occur over the centerline of blocking.] Allow 3 mm 1/8 inch spacing at panel ends and 6 mm 1/4 inch at panel edges. Panels shall be continuous over two or more spans. Nail panels 150 mm 6 inches o.c. at supported edges and 250 mm 10 inches o.c. over intermediate bearing. Nails shall be 8-penny common or 6-penny threaded. Provide at least 12 mm 1/2 inch clearance between subflooring and masonry or concrete walls.

3.1.5.2 Combination Subfloor-Underlayment

NOTE: Edges shall be supported with blocking for square-edged wood finish flooring, unless a separate underlayment layer is installed. Apply with the grain of the face plies or the long dimension at right angles to joists. Panels shall be continuous over two or more spans. Stagger end joints of adjacent panels. Panel edges shall be T G or supported by 2 by 4 members framed between joists so the edge joints of subfloor-underlayment occur over the centerline of blocking. Provide end joints of panels over the centerline of joists. Allow 3 mm 1/8 inch spacing between panel edge and end joints. Nail panels 150 mm 6 inches o.c. at ends and edges and 250 mm 10 inches o.c. along intermediate bearings unless they are glue-nailed in accordance

with APA E30 . Nails shall be 8-penny coated common or 6-penny threaded. Provide at least 12 mm 1/2 inch clearance between subfloor-underlayment and masonry or concrete walls. [Lightly sand all joints to receive [resilient flooring] [____].]

3.1.5.3 Depressed Subfloors

Provide depressed subfloors to receive [ceramic] [and] [quarry] tile floors. Nail cleats or ledgers of one by four material to the sides of joists to support the flooring material. Place the cleats at a depth below the top of the joists sufficient to allow the installation of the subflooring below the tops of joists. Snugly fit subflooring as specified herein between joists.

3.1.6 Underlayment

Install underlayment over subfloor just prior to laying of [resilient flooring] [____] and protect from water and physical damage. Underlayment shall be [hardboard] [or] [plywood] [or] [OSB]. Stagger end joints of underlayment with respect to each other, and stagger all joints with respect to paralleling panel joints in subfloor. Space panels 2 mm 1/16 inch apart at ends and 3 mm 1/8 inch apart at edges and at least 12 mm 1/2 inch from concrete or masonry walls. Nail panels 150 mm 6 inches o.c. along edges and 150 mm 6 inches o.c. each way throughout panel, but not closer than 10 mm 3/8 inch to panel edges. Nails shall

be 4-penny annular ring or screw type and shall be countersunk 2 mm 1/16 inch. [Lightly sand all joints to receive [resilient flooring] [____].]

3.1.7 Columns and Posts

Set columns and posts, plumb, in alignment, and with full and uniform bearing. Do not embed the bottom and bearing surfaces of [posts] [columns] in concrete or set in direct contact with concrete slabs on grade.

[Provide post and beam construction with [wood bolsters] [steel post caps] in such a manner that the post above will tier directly over the one below; fabricate the assembly in a rigid and substantial manner using bolts or lag screws.]

3.1.8 Wall Framing

3.1.8.1 Studs

Select studs for straightness and set plumb, true, and in alignment. In walls and partitions more than 2400 mm eight feet tall, provide horizontal bridging at not more than 2400 mm 8 feet o.c. using nominal 50 mm 2 inch material of the same width as the studs; install the bridging flat. Sizes and spacing of studs shall be [____] [as indicated]. Double studs at jambs and heads of openings and triple at corners to form corner posts. Frame corner posts to receive sheathing, lath, and interior finish. Truss over openings exceeding 1200 mm 4 feet in width or use a header of sufficient depth. Toe-nail studs to sills or sole plates with four 8-penny nails or fasten with metal nailing clips or connectors. Anchor studs abutting concrete or masonry walls thereto

near the top and bottom and at midheight of each story using expansion bolts or powder-actuated drive studs.

3.1.8.2 Plates

Use plates for walls and partitions of the same width as the studs to form continuous horizontal ties. Splice single plates; stagger the ends of double plates. Double top plates in walls and bearing partitions, built up of two nominal 2 inch thick members. Top plates for nonbearing partitions shall be single or double plates of the same size as the studs. Nail lower members of double top plates and single top plates to each stud and corner post with two 16-penny nails. Nail the upper members of double plates to the lower members with 10-penny nails, two near each end, and stagger 400 mm 16 inches o.c. intermediately between. Nail sole plates on wood construction through the subfloor to each joist and header; stagger nails. Anchor sole plates on concrete with expansion bolts, one near each end and at not more than 1800 mm 6 feet o.c., or with powder-actuated fasteners, one near each end and at not more than 900 mm 3 feet o.c. Provide plates cut for the passage of pipes or ducts with a steel angle as a tie for the plate and bearing for joist.

3.1.8.3 Firestops

Provide firestops for wood framed walls and partitions and for furred spaces of concrete or masonry walls at each floor level and at the ceiling line in the top story. Where firestops are not automatically provided by the framing system used, they shall be formed of closely fitted wood blocks of nominal 2 inch thick material of the same width as the [studs] [and] [joists]. [Lightweight concrete units may be used at the first-floor level to serve jointly as firestopping and ratproofing.]

3.1.8.4 Diagonal Bracing

Provide diagonal bracing at all external corners and internal angles and at maximum 12000 mm 40 foot centers in stud walls, except that bracing may be omitted where diagonally applied wood sheathing, plywood or structural-use panel sheathing, 1200 by 2400 mm 4 by 8 foot fiberboard sheathing, or gypsum board sheathing is used. Bracing shall be of 1 by 6 material, let into the exterior face of studs. Extend bracing from top plates to sill at an angle of approximately 45 degrees and double nail at each stud. When openings occur near corners, provide diagonal knee braces extending from the corner post above headers to top plates and from below window sills to the main sill. Nail bracing at each bearing with two 8-penny nails.

3.1.9 Wall Sheathing

3.1.9.1 Plywood, Structural-Use, and OSB Panel Wall Sheathing

Apply horizontally or vertically. Extend sheathing over and nail to sill and top plate. Abut sheathing edges over centerlines of supports. Allow 3 mm 1/8 inch spacing between panels and 3 mm 1/8 inch at windows and doors. If sheathing is applied horizontally, stagger vertical end joints. Nail panels with 6-penny nails spaced 150 mm 6 inches o.c. along edges of the

panel and 300 mm 12 inches o.c. over intermediate supports. Keep nails 10 mm 3/8 inches away from panel ledges. Provide 2 by 4 blocking for horizontal edges not otherwise supported.

3.1.9.2 Fiberboard Wall Sheathing

Apply fiberboard wall sheathing allowing a 3 mm 1/8 inch joint at edges to permit expansion, except at frames and openings where sheathing shall be fitted snugly. Pre-expand sheathing before application, allowing sheathing to condition for humidity as recommended by the sheathing manufacturer. Provide 2 by 4 blocking for horizontal edges not otherwise supported.

- a. Fiberboard wall sheathing used with diagonal-braced framing shall be either 600 or 1200 mm 2 or 4 feet wide. Sheathing 600 mm 2 feet wide shall have T G or shiplapped edges and shall be applied horizontally with vertical joints staggered. Apply sheathing with tongued edge up and nail at edges and intermediate bearings with 45 mm 1 3/4 inch long, zinc-coated steel roofing nails spaced on maximum 115 mm 4 1/2 inch centers. Apply sheathing 1200 mm 4 feet wide either horizontally or vertically. Nail sheathing with 45 mm 1 3/4 inch long, zinc-coated steel roofing nails spaced 100 mm 4 inches maximum o.c. at edges and 200 mm 8 inches maximum o.c. at intermediate bearings.
- b. Fiberboard wall sheathing used with unbraced framing shall be 1200 mm 4 feet wide. Apply sheathing vertically. Extend sheathing over and nail to sill and top plates. Locate joints over centerlines of supports. Nail sheathing with 40 mm 1 1/2 inch long, zinc-coated steel roofing nails with 9.5 mm 3/8 inch diameter heads. Space nails 75 mm 3 inches o.c. at edges and ends and 150 mm 6 inches o.c. at intermediate bearings.

3.1.9.3 Gypsum Sheathing Board

Apply gypsum sheathing board either horizontally or vertically. Butt joints and locate over the centerlines of supports. Horizontally applied sheathing shall be T G, applied with tongued edge up. Stagger vertical joints and abut sheet closely to frames of openings. Nail sheathing with 11 gage, 9.5 mm 3/8 inch head, zinc-coated nails 40 mm 1 1/2 inches long for 12.7 mm 1/2 inch sheathing and 45 mm 1 3/4 inches long for 16 mm 5/8 inch sheathing, spaced 10 mm 3/8 inch minimum from edges. Provide 2 by 4 blocking for horizontal edges of 1200 mm 4 foot wide panels not otherwise supported.

- a. Gypsum Sheathing Board Used with Diagonal-Braced Framing: Sheathing shall be either 600 or 1200 mm 2 or 4 feet wide. Apply sheathing 600 mm 2 feet wide horizontally. Nail 100 mm 4 inches maximum o.c. at edges and over intermediate bearings. Apply sheathing 1200 mm 4 feet wide either horizontally or vertically. Nail 150 mm 4 inches maximum o.c. at edges and 200 mm 8 inches maximum o.c. at intermediate bearings.
- b. Gypsum Sheathing Board Used with Unbraced Frames: Sheathing shall be 1200 mm 4 feet wide and applied vertically. Extend sheathing over and nail to both sill

and top plates. Nail 100 mm 4 inches maximum o.c. at edges and 200 mm 8 inches maximum o.c. at intermediate bearings.

3.1.9.4 Foil-Faced Insulative Sheathing

Apply sheathing vertically. Butt or overlap joints and locate over centerline of supports. Attach sheathing to framing with 30 mm 1 1/4 inch , large, flat-head, 11 gage, galvanized roofing nails or 16 gage, 11 mm 7/16 inch minimum crown, galvanized staples with 30 mm 1 1/4 inch legs. For nonstructural application (with corner bracing), space fasteners 150 mm 6 inches o.c. on all panel edges and 300 mm 12 inches o.c. on intermediate supports, regardless of sheathing thickness, for studs not more than 600 mm 24 inches o.c. For structural application (without corner bracing), for studs not more than 400 mm 16 inches o.c., space fasteners 75 mm 3 inches o.c. on all edges and 150 mm 6 inches o.c. on intermediate members using minimum 2.9 mm 0.115 inch thickness; for studs up to 600 mm 24 inches o.c., space fasteners 75 mm 3 inches o.c. on all edges and 75 mm 3 inches o.c. on intermediate supports using minimum 3.5 mm 0.137 inch thickness.

3.1.10 Building Paper

Provide building paper [where indicated] [on wood board sheathing for all types of exterior siding]. Apply paper shingle fashion, horizontally, beginning at the bottom of the wall. Lap edges 100 mm 4 inches , and nail with 25 mm one inch , zinc-coated roofing nails, spaced 300 mm 12 inches o.c. and driven through tin discs.

3.1.11 Ceiling Joists

Size as indicated and set accurately and in alignment. Toe-nail joists to all plates with not less than three 10-penny nails. Frame openings in ceilings with headers and trimmers.

3.1.12 Rafters

Size as indicated, set accurately, and form a true plane. [Ridge] [hip] [and] [valley] members shall be of ample depth to receive beveled ends of rafters and shall be nominally 2 inches thick. Rafters shall [be notched and] have full and solid bearing on plates. Toe-nail rafters to plates and [ridge] [valley] [hip] member with at least three 10-penny nails and nail to adjoining ceiling joists with at least four 10-penny nails. Adequately frame openings in roofs with headers and trimmers. Double headers and trimmers carrying or supporting two or more rafters.

3.1.13 Metal Framing Anchors

Provide framing anchors at every [other] [rafter] [or] [trussed rafter] to fasten [rafter] [or] [trussed rafter] to plates and studs against uplift movement and forces as indicated. Anchors shall be punched and formed for nailing so that nails will be stressed in shear only. Nails shall be zinc-coated; drive a nail in each nail hole provided in the anchor.

3.1.14 Trusses

Metal plate connected wood trusses shall be handled, erected, and braced in accordance with TPI HIB and as indicated.

3.1.15 Structural Glued Laminated Timber Members

Brace members before erection. Align members and complete all connections before removal of bracing. Unwrap individually wrapped members only after adequate protection by a roof or other cover has been provided. Treat scratches and abrasions of factory applied sealer with two brush coats of the same sealer used at the factory.

3.1.16 Plywood and Structural-Use Panel Roof Sheathing

NOTE: The following requirements for size, type, and spacing of nails represent the minimum recommended by APA for roof sheathing. Modify these requirements to agree with UL or FM requirements for wind-tested roof assemblies.

Install with the grain of the outer plies or long dimension at right angles to supports. Stagger end joints and locate over the centerlines of supports. Allow 3 mm 1/8 inch spacing at panel ends and 6 mm 1/4 inch at panel edges. Nail panels with 8-penny common nails or 6-penny annular rings or screw-type nails spaced 150 mm 6 inches o.c. at supported edges and 300 mm 12 inches o.c. at intermediate bearings. Do not use staples in roof sheathing. Where the support spacing exceeds the maximum span for an unsupported edge, provide adequate blocking, tongue-and-groove edges, or panel edge clips, in accordance with APA E30 .

3.1.17 Stair Framing

Cut carriages to exact shape required to receive treads and risers, with risers of uniform height and treads of uniform width. Provide trimmers, nailers, and blocking as required to support finish materials.

3.2 MISCELLANEOUS

3.2.1 Wood Roof Nailers, Edge Strips, Crickets, Curbs, and Cants

Provide sizes and configurations indicated or specified and anchored securely to continuous construction.

3.2.1.1 Roof Nailing Strips

Provide roof nailing strips for roof decks as [indicated] [and] [specified herein]. Apply nailing strips in straight parallel rows in the direction and spacing [indicated] [specified in Section "[_____, "_____."] Strips shall be [surface applied] [embedded in concrete].

- a. Surface-Applied Nailers: Shall be 75 mm 3 inches wide and of thickness to finish flush with the top of the insulation. Anchor strips securely to the roof deck with powder actuated fastening devices or expansion shields and bolts, spaced not more than 600 mm 24 inches o.c. [On decks with slopes of 25 mm one inch or more, provide surface applied wood nailers for securing insulation [and for nailing of roofing felts].]
- b. Embedded Nailers: Shall be nominal 2 by 3 with 2 inch sides beveled. Set and anchor nailers to finish flush with the roof deck surface.

3.2.1.2 Roof Edge Strips and Nailers

NOTE: For SOUTHNAVFACENGC.COM, indicate the anchorage type and spacing for all nailer attachments on the project drawings.

Provide at perimeter of roof, around openings through roof, and where roofs abut walls, curbs, and other vertical surfaces. Except where indicated otherwise, nailers shall be 150 mm 6 inches wide and the same thickness as the insulation. Anchor nailers securely to underlying construction. Anchor perimeter nailers in accordance with FM LPDS 1-49. [Strips shall be grooved [as indicated] for edge venting; install at walls, curbs, and other vertical surfaces with a 6 to 12 mm 1/4 to 1/2 inch air space.]

3.2.1.3 Crickets, Cants, and Curbs

Provide wood saddles or crickets, cant strips, [curbs for scuttles and ventilators,] [and wood nailers bolted to tops of concrete or masonry curbs] [and at expansion joints,] as indicated, specified, or necessary and of [lumber] [or [_____] mm inch thick exterior plywood].

3.2.2 Rough Wood Bucks

[Size as indicated] [2 inch nominal thickness]. Set wood bucks true and plumb. Anchor bucks to concrete or masonry with steel straps extending into the wall 200 mm 8 inches minimum. Place anchors near the top and bottom of the buck and space uniformly at 600 mm 2 foot maximum intervals.

3.2.3 Wood Blocking

Provide proper sizes and shapes at proper locations for the installation and attachment of wood and other finish materials, fixtures, equipment, and items indicated or specified.

3.2.4 Wood Grounds

Provide for fastening wood trim, finish materials, and other items to plastered walls and ceilings. Install grounds in proper alignment and true with an 2400 mm 8 foot straightedge.

3.2.5 Wood Furring

Provide where shown and as necessary for facing materials specified. Except as shown

otherwise, furring strips shall be nominal one by 3, continuous, and spaced 400 mm 16 inches o.c. Erect furring vertically or horizontally as necessary. Nail furring strips to masonry. Do not use wood plugs. Provide furring strips around openings, behind bases, and at angles and corners. Furring shall be plumb, rigid, and level and shall be shimmed as necessary to provide a true, even plane with surfaces suitable to receive the finish required. Form furring for [cornices,] offsets and breaks in walls or ceilings on 1 by 4 wood strips spaced 400 mm 16 inches o.c.

3.2.6 Wood Bumpers

Dress to the sizes indicated, and bevel edges. Bore, countersink, and bolt bumpers in place.

3.2.7 Temporary Closures

Provide with hinged doors and padlocks and install during construction at exterior doorways and other ground level openings that are not otherwise closed. Cover windows and other unprotected openings with polyethylene or other approved material, stretched on wood frames. Provide dustproof barrier partitions to isolate areas as directed.

3.2.8 Temporary Centering, Bracing, and Shoring

Provide for the support and protection of masonry work during construction as specified in Section "[_____, "_____.]" Forms and centering for cast-in-place concrete work are specified in Section 03300, "Cast-In-Place Concrete."

3.2.9 Wood Sleepers

Run wood sleepers in lengths as long as practicable and stagger end joints in adjacent rows. [Sleepers for gymnasium floors are specified in Section entitled "Gymnasium-Type Hardwood Strip Flooring Systems."]

3.2.10 Diaphragms

NOTE: For plywood, select laying pattern, nail size, and spacing based on Table 25J of Uniform Building Code. For structural-use panels and OSB refer to APA Construction Guide. Install plywood, structural-use, or OSB panels with the long dimension [parallel] [perpendicular] to supports. End joints shall be [continuous] [staggered] and located over the centerline of supports. Longitudinal joints shall be [continuous] [staggered] [and provided with blocking]. Nail panels with [6] [8] [10]-penny nails spaced not more than [_____] mm inches on centers around the diaphragm boundaries [and along continuous panel edges] and [_____] mm inches on centers at all other supported edges and 300 mm 12 inches o.c. over intermediate bearings.

3.2.11 Shear Walls

NOTE: For plywood, select nail size and spacing based on Table 25K of Uniform Building Code. For OSB and structural-use panels refer to APA Construction Guide. Install plywood or structural-use panels with long dimension parallel or perpendicular to supports. Provide

blocking behind edges not located over supports. Nail panels with [6] [8] [10]-penny nails spaced not more than [_____] mm inches on centers along panel edges and 150 mm 6 inches o.c. over intermediate bearings.

3.3 ERECTION TOLERANCES

- a. Framing members which will be covered by finishes such as wallboard, plaster, or ceramic tile set in a mortar setting bed, shall be within the following limits:
 - (1) Layout of walls and partitions: 6 mm 1/4 inch from intended position;
 - (2) Plates and runners: 6 mm in 2400 mm 1/4 inch in 8 feet from a straight line;
 - (3) Studs: 6 mm in 2400 mm 1/4 inch in 8 feet out of plumb, not cumulative; and
 - (4) Face of framing members: 6 mm in 2400 mm 1/4 inch in 8 feet from a true plane.
- b. Framing members which will be covered by ceramic tile set in dry-set mortar, latex-portland cement mortar, or organic adhesive shall be within the following limits:
 - (1) Layout of walls and partitions: 6 mm 1/4 inch from intended position;
 - (2) Plates and runners: 3 mm in 2400 mm 1/8 inch in 8 feet from a straight line;
 - (3) Studs: 3 mm in 2400 mm 1/8 inch in 8 feet out of plumb, not cumulative; and
 - (4) Face of framing members: 3 mm in 2400 mm 1/8 in 8 feet from a true plane.

3.4 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements. Typical conversion is as shown:

PRODUCTS	INCH-POUND <u>Nominal</u>	METRIC <u>Conversion</u>
Sawn lumber	2 x 4 1 by	38 x 89 mm 19 mm by
Stud spacing	16 inches If not 48 inches panel	400 mm 406 mm
Plywood	48 by 96 inches	1200 by 2400 mm

-- End of Section --