Fire-Resistant Materials and Assemblies

Homeowners, business owners, design professionals and builders in wildfire-prone regions can benefit from understanding general fire resistance characteristics of common construction materials and building products. This Recovery Advisory aims to provide a list of materials that can withstand higher exposure and help slow the spread of fire, but it is important to remember that fire-resistant does not mean fire-proof. Fire resistance depends on a variety of factors including intensity and duration of fire exposure, type of building material, age of the material, detailing at joints and interfaces, methods of construction, and how each element and assembly are used in combination to create a fire-resistant exterior. A licensed fire protection engineer or other design professional should be consulted to assure incorporation of appropriate fire-resistant materials and construction methods to achieve the highest level of fire performance before installation or construction.

Important topics for protecting homes and communities are covered in the companion Maui Wildfires MAT Recovery Advisories listed below, and should be holistically implemented:

Maui Wildfires Mitigation Assessment Team Recovery Advisory #1 (RA-1) Wildfire Recovery Resources for Maui

Maui Wildfires Mitigation Assessment Team Recovery Advisory #2 (RA-2) Reducing Wildfire Risk to Your Home

Maui Wildfires Mitigation Assessment Team Recovery Advisory #3 (RA-3) Designing New Residential Structures to Decrease Wildfire Risk

Key Terminology

- **Noncombustible** – A material that, in the form in which it is used and under the condition anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.
- **Fire-resistant** – Fire-resistant materials possess characteristics that allow them to withstand fire and heat for an extended period. These materials are especially crucial for enhancing life-safety and property protection due to their ability to reduce the likelihood of ignition and slow the spread of a fire. Reducing the likelihood of ignition helps limit the size of a fire and loss potential. Slowing the spread of fire allows more time for evacuation, reduces life safety risks to the public and firefighters and reduces damage to buildings and infrastructure. Fire-resistant materials include various building materials such as asphalt shingles, treated fabrics, special coatings, etc.
- **Fire-resistance rating** – A technical term used to define the time, in minutes or hours, that an element, component or assembly has withstood a standard fire exposure as established in accordance with an approved test procedure appropriate for the structure, building material, or component under consideration (e.g., ASTM E119, ANSI/UL 263).
- **Assembly** – An assembly is any combination of materials or individual components constructed together to serve a purpose. For fire safety design, the purpose may include load bearing capacity, insulation and/or integrity under fire conditions. A roof assembly, for example, is typically comprised of the roof deck, vapor barrier,

insulation, roof covering, coatings, sealants, toppings, or any combination thereof. The details of the entire roof assembly determine its ability to achieve fire resistance (e.g., 1-hour, 2-hour), not the fire performance characteristics of the individual materials or components that make up the assembly.

Materials

Building owners and designers should consider using materials that decrease risk of ignition and fire spread. The table below provides helpful information regarding material options and considerations.

Building Component	Options to decrease risk of ignition and fire spread	Goal
Structural	▪ **Concrete:** Concrete is inherently noncombustible with low thermal conductivity. The thickness of the concrete determines, in part, the fire resistance. Adequate cover should be provided over the reinforcement (rebar). Your design professional can advise on the amount of cover needed to achieve desired fire resistance. ▪ **Steel:** Steel is inherently noncombustible; however, fireproofing material should be applied to ensure that failure does not occur due to high temperatures. ▪ **Masonry**: Masonry is inherently fire-resistant and noncombustible. Masonry should always be reinforced as unreinforced masonry is subject to failure in high winds, floods and seismic events. ▪ **Wood**: Wood is combustible; however, fire resistance can be achieved if a protective sheathing is provided, such as Type X gypsum wall board. **Avoid** unprotected wood or steel framing and unreinforced masonry/concrete.	Reduce chance of ignition and maintain strength of superstructure
Interior Walls and Ceiling	▪ **Gypsum board (drywall)** is a protective finishing material that increases fire resistance of load-bearing or non-load-bearing elements (e.g., wood or metal stud walls, steel beams/columns). Fire resistance is determined by assembly design. Gypsum boards can be found as regular, “Type X” or “Type C.” ○ **Type X gypsum board** is a type of fire-resistant drywall, typically denser than regular gypsum board and with special additives, ranging in thickness from 1/2-inch, 5/8-inch, and 1-inch. Multiple layers can be used to achieve a higher level of fire resistance. ○ **Type C gypsum board** is a type of fire-resistant drywall, with enhanced fire performance compared to Type X. ▪ **Plaster**: Plaster is fire-resistant but highly dependent on the thickness of the underlayment. Plaster over gypsum, masonry or cement backer board provides a higher level of fire resistance. However, avoid plaster over plywood or other wood-based material. **Avoid** natural materials, fabrics, or wood products for interior walls and ceilings such as wood paneling or decorative reclaimed wood accents.	Reduce the chance of ignition and fire spread throughout the building.

Building Component	Options to decrease risk of ignition and fire spread	Goal
Interior Flooring	▪ **Concrete** ▪ **Ceramic Tile** ▪ **Vinyl Flooring** tested in accordance with ASTM E648 and EN 13501-1 ▪ **Stone Flooring** ▪ **Wool Carpet** **Avoid** wood flooring that is not treated with a factory applied fire-retardant chemical.	Reduce the chance of ignition and fire spread throughout the building.
Roof Material	▪ Look for roof covering products that have a Class A rating in accordance with UL 790. Always use a Class A Roof Assembly. ○ **Asphalt Shingles:** Most asphalt shingles can meet the requirements for a Class A rating. Shingle roof coverings must also be high wind rated: ASTM D3161 Class F or ASTM D7158 Class G or H. ○ **Clay and Concrete Tiles:** Tile roofs can meet the requirements for a Class A roof rating. Consider an enhanced underlayment such as mineral surface cap sheet rated for use in a Class A roof assembly. Install a layer of fiberglass gypsum panelized product between a wood deck and the roof covering. Ensure that the gaps between the tiles are sealed to prevent embers from accumulating beneath them. ○ **Metal Shingles or Sheet**: Metal shingles or roof can meet the Class A assembly. Where metal shingles or roofs are installed over a wood deck, install a minimum of 5/8-inch Type X gypsum roof board tested in accordance with ASTM C1177 over the decking. **Avoid** wood shingles (even when listed as fire retardant as the long-term performance of fire retardant wood shingles in a hot, moist environment is unknown) and materials that do not specify a Class A rating. Avoid installing sheet metal or metal shingles directly over wood or adjacent to a mineral cap sheet.	Reduce chance of ignition and fire spread.
Solar (PV) Panels	▪ **Class A solar panels** tested in accordance with ASTM E84 and UL 790. ▪ Choose a **metal racking system**. Additional requirements for wind and seismic loading may apply. **Avoid** ballasted PV panels and those that do not mount flush to the roof.	Limit ignition of solar panel and fire spread to roof.
Gutters	▪ **Metal gutters** are recommended. ▪ Gutter Guard Materials: Select guards that are made from noncombustible, non-corrosive materials. This could include: ○ Metal mesh with openings no larger than 1/8-inch ○ Fire-resistant foam insert ○ Gutter hood ▪ **Rain-chains** instead of gutters **Avoid** vinyl or plastic gutters and those without a gutter guard.	Limit debris accumulation in gutter and ignition of gutter.

Building Component	Options to decrease risk of ignition and fire spread	Goal
Skylights	▪ Glass: **Double-paned tempered glass skylight**. ▪ Frame: **Metal frame** **Avoid** plastic/vinyl skylights and wood framed skylights.	Minimize the chance of breakage of skylight.
Cladding (exterior wall siding)	▪ Choose noncombustible, fire-resistant materials, such as: ○ **Concrete** ○ **Fiber cement** ○ **Stucco** ○ **Masonry** ○ **CMU blocks** **Avoid** wood siding, even when listed as fire retardant, vinyl siding, and exterior insulation finishing system (EIFS) unless it specifically indicates fire resistance. ▪ Note: Metal transmits heat, requiring additional noncombustible insulation and separation from combustible members. Vinyl siding may melt exposing the combustible materials below.	Prevent fire spread and intrusion of fire into the building.
Windows	▪ UL rating “Fire Window Frame” with 1-hour or greater “Fire Rating”, or similar language. ▪ Frame: **Metal or noncombustible window frame** ▪ Glass: **Double paned tempered glass** window (may require impact-resistant glazing for windborne debris protection) ▪ Screens (if applicable): Non-corrosive **Metal** screens **Avoid** jalousie windows, single paned windows, and wood framed windows.	Reduce chance of window breakage and ignition of window frame.
Doors	▪ UL rating of at least 1-hour or greater “Fire Rating”, or similar language. Consider self-closing door or latch. ▪ Doors: Choose **steel doors** or where infeasible, solid core wood doors with noncombustible finish or coating of at least 1¾-inch thick with no or limited windows. ▪ Frame: **Metal door frame** ▪ Gaps and Joints: **Weather stripping** to seal gaps around and under door **Avoid** hollow wood doors and doors with large windows.	Limit ignition of door and ember/debris entry around doors.
Sliding Door / French Doors	▪ Glass: **Double paned tempered glass** (may require impact-resistant glazing for windborne debris protection) ▪ Screen (if applicable): **Metal Screen** ▪ Frame: **Metal door frame** **Avoid** wood and vinyl/plastic frames and single paned sliding/French doors.	Limit breakage of glass to reduce chance of interior ignition.

Building Component	Options to decrease risk of ignition and fire spread	Goal
Screen Door	▪ Frame: **Metal door frame** ▪ Screen: **Non-corrosive metal screen** **Avoid** plastic screens and wood framed doors.	Limit ignition of screen.
Garage Door	▪ Door: **Metal garage doors** without windows. ▪ Gaps and Joints: **Weather stripping** to seal hinges and joints in and around door ▪ Consider reinforcing garage doors with girts and by strengthening the wheel tracks. Look for garage doors that meet or have been tested in accordance with ASTM E330, ANSI/DASMA 108 or the Florida Building Code TAS 202. ▪ Provide battery backup for automatic garage door opener. **Avoid** wood garage doors and those with windows.	Limit ignition of garage door and ember/debris entry around garage door.
Exterior decks, stairs and landings	▪ Consider a **stone or paver patio** instead of a standard elevated deck. ▪ Deck Boards: **Mineral composite** deck boards, **aluminum** decking or **fiber cement** deck boards ▪ Deck substructure: Consider metal joists, posts and railings ▪ Steps: **Concrete** or **masonry** steps **Avoid** wood materials, even when listed as fire retardant. If wood composite is used, choose those with a Class A rating only.	Prevent ignition and fire spread from deck to building.
Fence	▪ **Chain link** ▪ **Metal** ▪ **Stone** ▪ **Brick** ▪ **Reinforced concrete** ▪ **Masonry** **Avoid** wood, vinyl/plastic and unreinforced masonry/concrete fencing. Choose stone only when combined with mortar and preferably reinforced– stacked stone may fail during a high wind or seismic event.	Prevent ignition and fire spread from fence to building.
Vents	▪ Vents: Vents tested in accordance with **ASTM E2886.** The state of California maintains a products page that provides information on acceptable vents at https://osfm.fire.ca.gov/what-we-do/fire-engineering-and-investigations/building-materials-listing ▪ Vent coverings: **non-corrosive stainless steel mesh with gaps not larger than 1/8-inch** ▪ Gaps and Joints: For sealing gaps and joints, look for **fire-resistant sealants**, e.g. fire caulk. **Avoid** plastic vents and those without coverings.	Prevent embers from entering vents to reduce chance of interior ignition.

Building Component	Options to decrease risk of ignition and fire spread	Goal
Shutters	▪ **Metal roll-down shutters** **Avoid** louvered shutters, vinyl or wood shutters. Additional requirements may apply for high wind areas.	Prevent ignition of shutter.

Fire Tested Assemblies

This section provides design professionals and builders with fire-safety resources to construct 1-hour and 2-hour fire resistance rated building elements, components and assemblies (e.g., roofs, exterior walls) for residential buildings. The information is based on existing fire-safety prescriptive codes and standards and recognized guidance.

Fire resistance rated construction depends on a variety of factors including type of materials used, methods of construction for the individual building components or assemblies and required detailing for joining each element and sub-assembly into 2D and 3D building systems. A licensed fire protection engineer, Certified Wildfire Mitigation Specialist (CWMS) or other wildfire safety professional should be consulted to (1) determine the required level of fire resistance given the site-specific wildfire/fire hazard conditions, and (2) identify appropriate materials and construction methods to achieve desired fire performance.

PRESCRIPTIVE FIRE-RATED WALL AND ROOF ASSEMBLIES

The following table provides some examples of prescriptive fire rated (e.g., 1- and 2-hour rated) roof- and wall-assemblies from Chapter 7 of the 2021 International Building Code (IBC) for residential home construction. Refer to the IBC Tables 721.1(2) and 721.2(3) for details and additional examples.

For residential construction, the minimum requirements for fire resistance are provided in the Hawaii State Residential Code which references the 2018 International Residential Code. See Chapter 3 of the International Residential Code for more details on the minimum requirements for fire resistance.

Note: While a one- or two-hour wall can provide protection against wildfire, adding noncombustible cladding in addition to the wall assembly provides an additional level of fire resistance.

Common Roof Assemblies	Details for Fire Resistance Rating(s)	Reference
Solid Concrete Roof	▪ **Overall thickness** by hourly rating: ○ **1-hour** = 3.2 inches thick (carbonate aggregate), 3.5 inches thick (siliceous aggregate) ○ **2-hour** = 4.6 inches thick (carbonate aggregate), 5 inches thick (siliceous aggregate) ▪ Minimum Cover – 3/4-inch	2021 IBC Table 721.1(3)

Common Roof Assemblies	Details for Fire Resistance Rating(s)	Reference
Steel Roof Deck w/ Wood Fiber Insulation	▪ **Roof assembly detailing** by hourly rating: ○ **1-hour** • **Roof construction:** 1 1/2-inches-deep steel roof deck on steel-framing and wood fiber insulation board, 17.5 pcf density on top applied over a 15-lb asphalt-saturated felt. Class A roof covering*. Topping slab thickness = 1-inch. • **Ceiling construction:** Ceiling of gypsum plaster on metal lath. Lath attached to 3/4-inch furring channels with 0.049-inch (No. 18 B.W. gage) wire ties spaced 6 inches on center. 3/4-inch channels saddle tied to 2-inch channels with doubled 0.065-inch (No. 16 B.W. gage) wire ties. 2-inch channels spaced 36 inches on center suspended 2 inches below steel framing and saddle tied with 0.165-inch (No. 8 B.W. gage) wire. Plaster mixed 1:2 for scratch coat and 1:3 for brown coat, by weight, gypsum-to-sand aggregate for 1-hour system.	2021 IBC Table 721.1(3)

Common Exterior Wall Assemblies	Details for Fire Resistance Rating(s)	Reference
Solid Concrete Wall	▪ **Overall member thickness** by hourly rating: ○ **1-hour** = 3.2-inch thick (carbonate aggregate), 3.5-inch thick (siliceous aggregate) ○ **2-hour** = 4.6-inch thick (carbonate aggregate), 5-inch thick (siliceous aggregate) ▪ **Concrete cover** thickness requirement is determined by hourly rating	2021 IBC Table 721.1(2)
CMU Wall	▪ **Effective thickness** by hourly rating: ○ **1-hour** = 2.8-inch (calcareous or siliceous aggregate) ○ **2-hour** = 4.2-inch (calcareous or siliceous aggregate)	2021 IBC Table 721.1(2)

Common Exterior Wall Assemblies	Details for Fire Resistance Rating(s)	Reference
Metal Stud (CFS) Wall	▪ **Wall assembly details** by hourly rating: ○ **1-hour** = 3 5/8-inch No. 16 gage noncombustible studs 16 inches on center with 7/8-inch cement plaster (measured from the face of the studs) on the exterior surface. Interior surface treatment as required for interior, nonbearing, noncombustible stud partitions in this table. Plaster mix 1:4 for scratch coat and 1:5 for brown coat, by volume, cement-to-sand. Overall minimum wall thickness varies. ○ **2-hour =** 4-inch No. 18 gage, non-load-bearing metal studs, 16 inches on center, with 1-inch Portland cement lime plaster (measured from the back side of the 3/4-pound expanded metal lath) on the exterior surface. Interior surface to be covered with 1-inch of gypsum plaster on 3/4-pound expanded metal lath proportioned by weight -- 1:2 for scratch coat, 1:3 for brown, gypsum-to-sand. Lath on one side of the partition fastened to 1/4-inch diameter pencil rods supported by No. 20 gage metal clips, located 16 inches on center vertically, on each stud. 3-inch-thick mineral fiber insulating batts friction fitted between the studs. Overall wall thickness = 6 1/4-inches	2021 IBC Table 721.1(2)
Wood Stud Wall - Plaster	▪ **Wall assembly details** by hourly rating: ○ **1-hour** = 2-inch × 4-inch wood studs 16 inches on center with metal lath and 3/4-inch cement plaster on each side. Lath attached with 6d common nails 7 inches on center driven to 1-inch minimum penetration and bent over. Plaster mix 1:4 for scratch coat and 1:5 for brown coat, by volume, cement-to-sand. Overall wall thickness = 5 3/8-inches	2021 IBC Table 721.1(2)
Wood Stud Wall – Gypsum Board	▪ **Wall assembly details** by hourly rating: ○ **1-hour** = 2-inch × 6-inch wood studs at 16 inches with double top plates, single bottom plate; interior and exterior sides covered with 5/8-inch Type X gypsum wallboard, 4 feet wide, applied vertically with all joints over framing or blocking and fastened with 2 1/4-inch Type S drywall screws, spaced 12 inches on center. R-19 mineral fiber insulation installed in stud cavity. Overall wall thickness = 6 3/4 inches ○ **1-hour** = Exterior surface with 3/4-inch drop siding over 1/2-inch gypsum sheathing on 2-inch x 4-inch wood studs at 16 inches on center, with interior surface treatment as required for 1-hour rated exterior. Gypsum sheathing nailed with 1 3/4-inch by No. 11 gage by 7/16-inch head galvanized nails at 8 inches on center. Siding nailed with 7d galvanized smooth box nails. Overall wall thickness varies. ○ **2-hour** = 2-inch x 4-inch wood studs at 16 inches on center with two layers of 5/8-inch Type X gypsum wallboard on each side. Base layers applied vertically and nailed with 6d cooler or wallboard nails at 9 inches on center. Face layer applied vertically or horizontally and nailed with 8d cooler or wallboard nails at 7 inches on center.	2021 IBC Table 721.1(2)

Resources and Useful Links

Catalogs of Fire Tested Assemblies

- Gypsum Association Fire Resistance and Sound Control Design Manual GA-600: This design manual contains nearly 800 fire-resistance rated building systems and assemblies containing gypsum board products.
- American Wood Council – Design for Code Acceptance (DCA 3): This document provides design details for various 1- and 2-hour fire-resistance rated wood-framed assemblies. Note: Fire-resistance ratings are provided for wall-assemblies from either exposure on one side or both sides. For wildfire applications, exterior wall assemblies should be rated for exposure from both sides and for exterior conditions.
- Underwriters Laboratories (UL) Directories or Product IQ: This online search engine provides UL-tested fire-resistant building products, systems and assemblies used to achieve code compliant installations. The Building Materials, Systems and Installations directory provides fire tested products.
- Intertek Directory of Building Products: This online search engine provides Intertek-tested fire-resistant building products, components and systems used to achieve code compliant installations for various fire test standards (e.g., ASTM E119, ASTM E84, ASTM E108).
- California Department of Forestry and Fire Protection (CAL FIRE) WUI Products Handbook: This handbook provides a listing of building components, products and assemblies that meet WUI codes standards for the State of California.

Calculated Fire Resistance: These resources can be used for calculating fire-resistance ratings of materials and assemblies, in lieu of using prescriptive designs or fire-tested assemblies. Calculated methods are generally permitted by the model building codes and standards to achieve code compliance. However, review and approval is still required by the local building and/or fire authority.

General

- ASCE 7-16: Minimum Design Loads and Associated Criteria for Buildings and Other Structures, Appendix E. This design standard provides performance-based standards for fire effects on structures.
- SEI/ASCE/SFPE 29-05: Standard Calculation Methods for Structural Fire Protection. This document provides methods for calculating fire resistance of structural members and barrier assemblies comprised of structural steel, plain or reinforced concrete, timber and wood, concrete masonry, and clay masonry.
- ASCE MOP 138: Structural Fire Engineering. This technical manual provides current practices for designing a structure to withstand the thermal load effects of fire, thermal and structural analysis methods, and available information to support structural fire engineering design.
- The Society of Fire Protection Engineers (SFPE) International Handbook of Structural Fire Engineering. This handbook focuses on structural resilience in the event of fire. It serves as a single point of reference for practicing structural and fire protection engineers on the topic of structural fire safety.
- SFPE Handbook, 5th Edition Chapter 52: Structural Fire Engineering of Building Assemblies and Frames. This chapter provides calculation methods for fire resistance of building assemblies and frames.

- NFPA Handbook, 21st Edition Section 19: Structural Fire Protection: Provides general information on achieving desired structural fire performance.

Concrete and Steel

- NIST Technical Note 1681: Best Practice Guidelines for Structural Fire Resistance Design of Concrete and Steel Buildings. This document provides best practices for fire-resistant design of concrete and steel structures. More specifically, it guides the implementation of a fire-resistant design approach for concrete and steel buildings, rather than a step-by-step approach.
- American Institute of Steel Construction Steel Design Guide 19: Fire Resistance of Structural Steel Framing. This guide provides detailed guidance for the selection of rated designs for columns, beams, and trusses, along with comprehensive design examples and W/D tables for common protection configurations.
- ACI Code 216.1-14(19): Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies. This standard provides procedures for determining the fire resistance of concrete and masonry members and building assemblies.
- SFPE Handbook, 5th Edition: Chapter 53 and 54 provide details on determining the fire resistance of steel and concrete members.

Wood

- AWC Technical Report No. 10: Calculating the Fire Resistance of Wood Members and Assemblies. This technical report assists designers of timber framed structures in meeting fire endurance requirements.
- SFPE Handbook, 5th Edition Chapter 55: Analytical Methods for Determining Fire Resistance of Timber Members. This chapter provides a methodology for calculating the fire resistance of timber members.

Additional Resources

- 2024 International Wildland Urban Interface Code: Optional model code with provisions that help protect life and property from wildland fires, adjacent structure fires, and fires spreading from structures to wildland fuels.
- 2021 International Building Code, Section 722: Calculated Fire Resistance: Contains procedures by which fire resistance of specific materials or combinations of materials is established.
- SFPE WUI Virtual Handbook: Resource materials and fire mitigation strategies for fire departments for property risk assessments in the Wildland-Urban Interface.
- Wildfire Home Retrofit Guide: Specific retrofit recommendations to help a home survive wildfires.
- Harmathy's Ten Rules: Provides concept-based rules on general principles surrounding fire resistance.
- NFPA 1140 includes 1144, Standard for Reducing Structure Ignition Hazards from Wildland Fire
- NIST Hazard Mitigation Methodology (HMM): A performance-based approach to WUI fire hazard mitigation for structures, parcels, and communities.
- IBHS Model Ordinances for Construction in WUI Area: Provides wildfire resistance code/ordinance options for one- and two-family dwellings.