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GLASS MAT GYPSUM SHEATHING

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RESIDENTIAL DESIGN GUIDE

gypsumsheathing.org

Introduction

Developed in the 1980s, glass mat gypsum sheathing is a specialized gypsum panel for installation on the exterior face of wood or steel framing members. Used as a substrate, glass mat gypsum sheathing can be applied under a variety of cladding materials including:

- Brick or Stone Veneer
- Stucco
- Exterior Insulation and Finish Systems (EIFS)
- Wood, Vinyl, and Composite Siding

ASTM C1177, *Standard Specification for Glass Mat Gypsum Substrate for use as Sheathing*, is the manufacturing standard for glass mat gypsum sheathing used in North America.[i] The *International Building Code* (IBC) and the *International Residential Code* (IRC) reference the ASTM C1177 standard as the material standard for glass mat gypsum sheathing.[ii] The standard was first released in 1991. Compliance with the standard assures a consistent level of product quality and performance.

General Material Use

In the U.S., most governmental entities use the IRC to regulate the construction of detached one- and two-family residential dwellings and townhouses not more than three stories above grade plane. This document explains and supports the use of glass mat gypsum sheathing in IRC-compliant construction.

Some residential dwellings are constructed using the IBC. These are typically dormitories, hotels, apartments, condominiums, and large, special circumstance single-family homes. Information on the use of glass mat gypsum sheathing in IBC-compliant construction is available from the Gypsum Association and individual glass mat gypsum sheathing manufacturers.

Existing information on the use of glass mat gypsum sheathing as an exterior substrate material typically focuses on applications to structures designed, engineered, and constructed to the IBC. Demand for alternate sheathing materials has increased builder interest in exploring the use of glass mat gypsum sheathing in dwellings constructed to the IRC.

Basic Attributes of Gypsum Panels & Glass Mat Gypsum Sheathing

Glass mat gypsum sheathing is part of a family of materials called gypsum panel products, the most common and well-known being standard interior gypsum board. Used throughout residential construction for over one hundred years, gypsum board is the material of choice for interior walls and ceilings.

Gypsum is a safe, abundant, and naturally fire-resistant mineral. It is the primary core constituent of all gypsum panel products.

The gypsum core of a gypsum panel is noncombustible. Gypsum panels also have many other positive attributes:

- Naturally Fire-Resistant
- Dimensionally Stable
- Easy to Cut and Fasten
- Easy to Repair
- Displays Consistent Quality

With proper detailing and installation, gypsum panels are not susceptible to the impacts of freezing and thawing and are a cost-effective option. They are also widely available throughout North America.

Glass mat gypsum sheathing has characteristics beyond those inherent to interior gypsum board including an enhanced moisture-resistant core and fiberglass facers that provide extended protection against water and air infiltration from the external environment. These characteristics help protect sheathing exposed to weather during the construction process.

The core enhancers and facers also help keep glass mat gypsum sheathing from warping or swelling when exposed to moisture. The glass fiber facers are mold-resistant and vapor permeable. In addition, glass mat gypsum sheathing is not susceptible to attack by wood-boring insects because it contains no cellulose.

All gypsum panel products display consistent structural attributes and can be used as bracing within specific limits. Gypsum board, when attached to the interior face of an exterior wall, increases the assembly's structural lateral force-resisting ability.

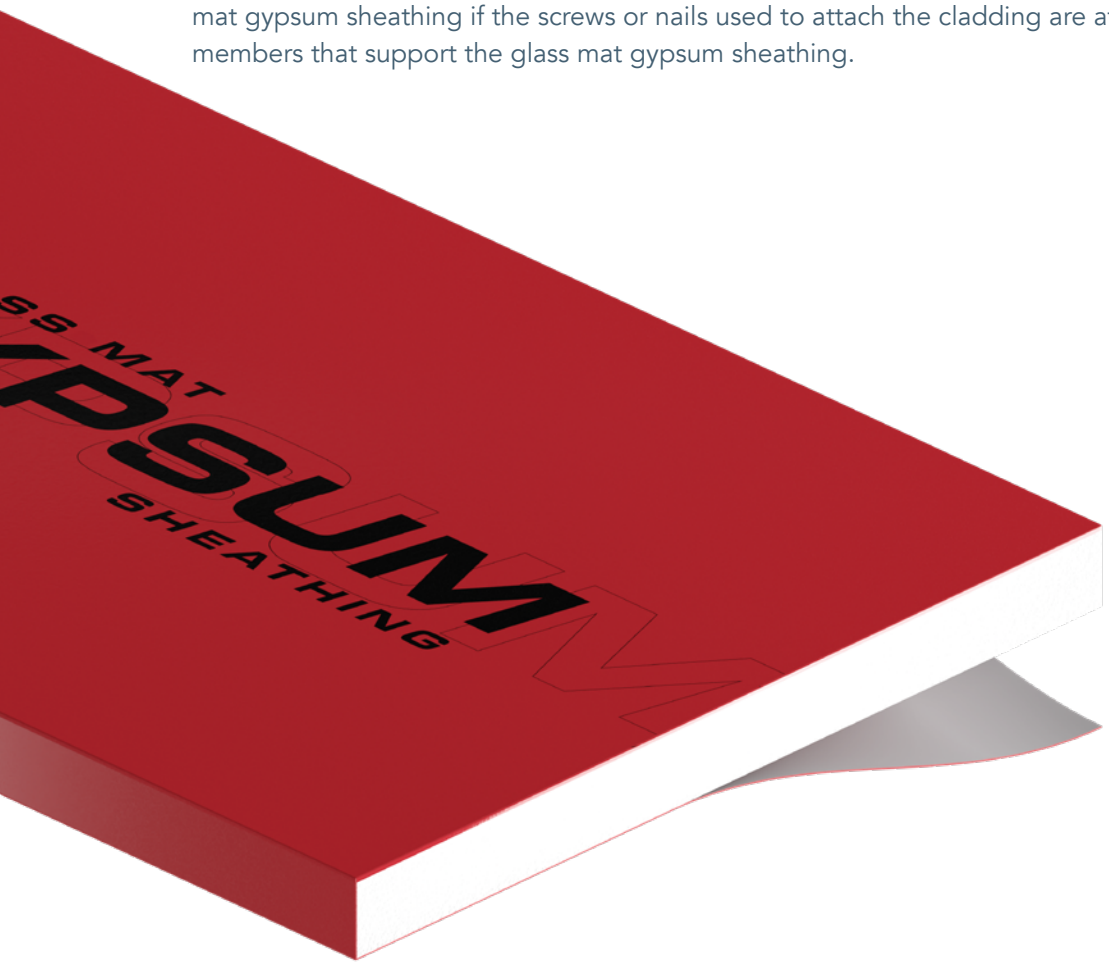
Application of Glass Mat Gypsum Sheathing

The application techniques for glass mat gypsum sheathing parallel those for interior wallboard. To comply with the requirements of the IRC, glass mat gypsum sheathing must be installed in accordance with the prescriptive requirements of either ASTM C1280, *Standard Specification for Application of Exterior Gypsum Panel Products for Use as Sheathing*[iii] or GA-253, *Application of Gypsum Sheathing*.[iv] In fire-rated assemblies, installation is also to be in accordance with the listing specifications and explanatory notes in GA-600 *Fire Resistance and Sound Control Design Manual*. Unlike some other sheathing materials, the edges and ends of glass mat gypsum sheathing panels need not be spaced or gapped because the product does not swell and is dimensionally stable.

Glass mat gypsum sheathing is fastened with screws or nails. Screws can be easily installed using a properly set screw-gun.

Joints between glass mat gypsum sheathing panels are not regularly treated or finished, unless required by the specific cladding system. Joints in systems that incorporate an integrated barrier system may require treatment with a mastic, sealant, or similar material as defined by the product manufacturer. The glass mat gypsum sheathing panel manufacturer and the barrier system manufacturer should be consulted.

The continuous surface created by installed glass mat gypsum sheathing panels provides an excellent base for adhesive-attached systems such as EIFS. Fastener-attached claddings can be used with glass mat gypsum sheathing if the screws or nails used to attach the cladding are attached to the framing members that support the glass mat gypsum sheathing.



Using Glass Mat Gypsum Sheathing to Construct a Dwelling

General Design Considerations

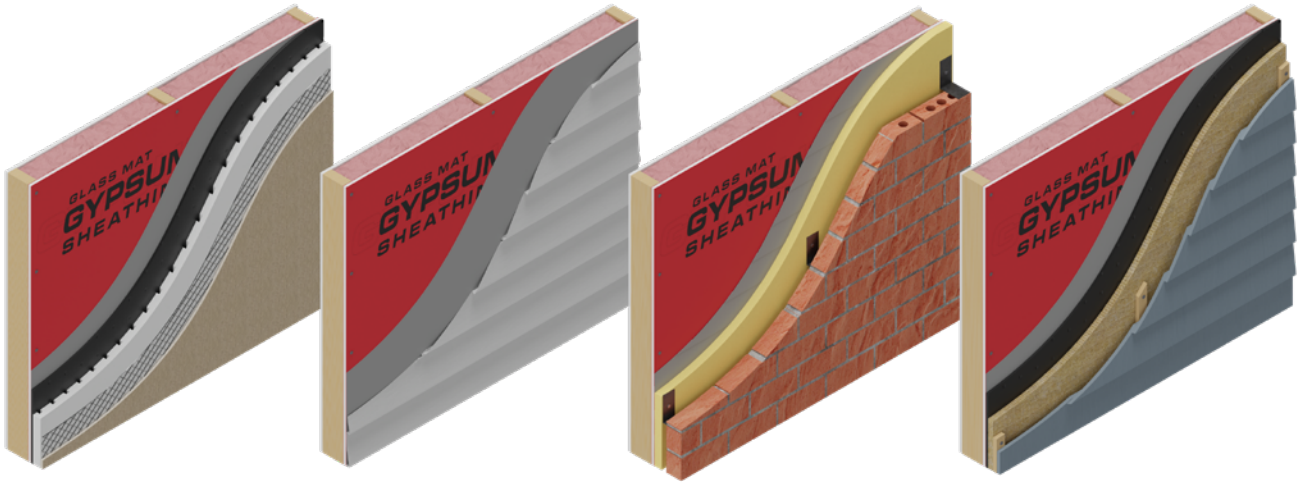
Most exterior wall systems are composite assemblies that incorporate many components, with each component serving a specific purpose. The exterior wall system on a dwelling performs three fundamental functions:

- Insulates the dwelling and keeps exterior elements such as rain and snow out of the dwelling
- Contributes to the dwelling's structural integrity
- Protects the occupants from the wind

When glass mat gypsum sheathing is used on an exterior wall system, it:

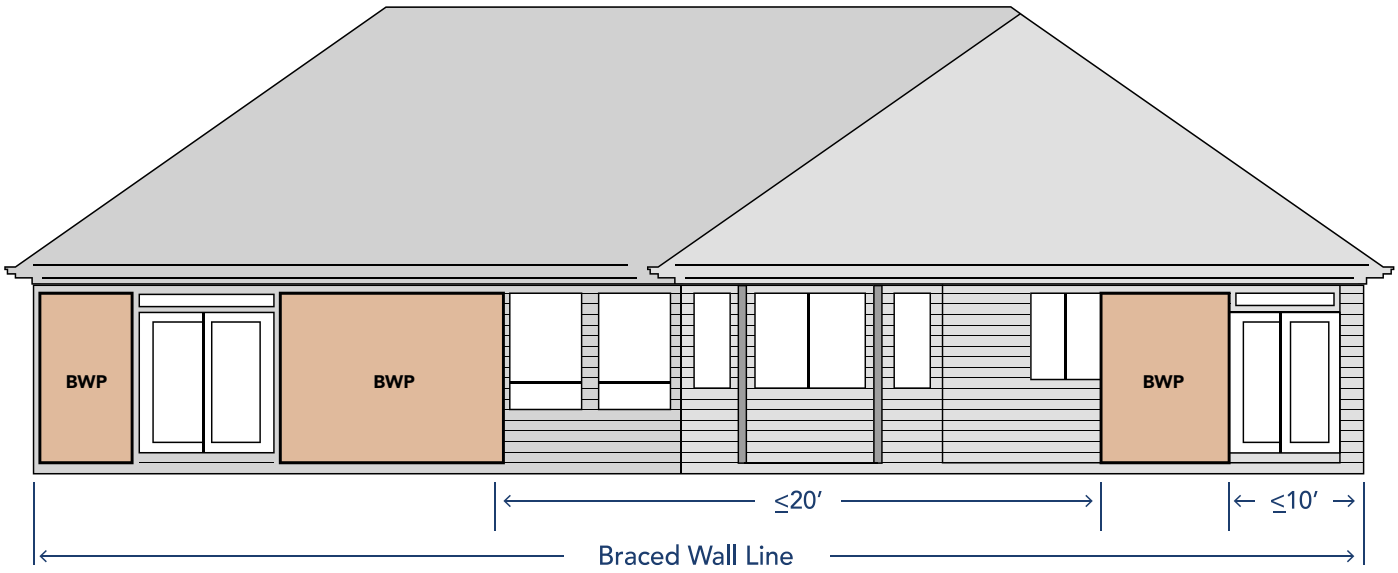
- Serves as a component in an insulating system, either by allowing the creation of a stud cavity that can be insulated or serving as a substrate for a rigid insulation material
- Keeps exterior elements out of the dwelling because its glass mat facing repels moisture
- Helps keep the dwelling structurally intact because it can be used as a lateral force-resisting element in many structural applications
- Keeps wind from blowing through the dwelling because its regular shape can be fitted to eliminate gaps

Keeping moisture out of a dwelling involves many factors: the cladding used, the installation of a water-resistive barrier, the possible use of a drainage layer under the cladding, fenestration, and construction methods. The glass mat facing on installed glass mat gypsum sheathing keeps moisture out of a residence. If the facing is somehow breached and the enhanced core of the panel is temporarily exposed to moisture, it will remain intact.



Structural Design Considerations

A single-family residential dwelling can be constructed using gypsum board as the interior bracing element and glass mat gypsum sheathing as the exterior bracing element on the Braced Wall Panels (BWP) that are used for structural support. BWPs are full-height sections of walls constructed to resist in-plane shear loads through the interaction of framing members, sheathing material, and anchors. BWPs are used to create the Braced Wall Lines (BWL) that provide the dwelling with resistance against wind and seismic forces.



Braced Wall Line (BWL) for a prototype 32′ x 50′ single-family dwelling with BWLs on all four sides. Braced Wall Panels are identified by BWP.

The IRC describes numerous bracing methods for a residential dwelling. While the individual methods incorporate different sheathing materials, all the methods commonly use gypsum board as the bracing element on the interior face of BWLs. One bracing method, Method GB, uses gypsum panels as the bracing element on the exterior face of the BWLs. As a result, BWLs constructed to Method GB have gypsum panels applied to both faces of the exterior walls of the dwelling.

The construction of a BWL is primarily a function of the length and spacing of the walls and the height and location of the dwelling. The final design is also influenced by the location of the dwelling, the dimensions of the dwelling, and the prescribed construction method factors mandated by the IRC.

The total length of a BWL needed to resist the lateral forces on the structure is determined using these factors. The total length of the BWPs required per BWL is calculated and distributed based on the building wall layout and specific requirements as defined in the IRC.

IRC Requirements

The IRC requirements define the length (measured as the panel's horizontal width) and placement parameters for individual BWPs, the number of BWPs required in a specific BWL and the construction requirements for the gypsum panels used to sheath one or both faces of a BWP.

For example, IRC Prescriptive Provisions for Method GB as the lateral resistance method require:

- For walls up to ten feet in height, each BWP must be a minimum of four feet in width. Higher walls, to a maximum of twelve feet, expand the required panel width as prescribed in IRC Table R602.10.5
- Each BWL must have a BWP that starts within 10 feet of each end of the BWL
- A BWL cannot contain an offset BWP that is greater than 4 feet in length
- A BWL greater than 16 feet in length must contain at least two BWPs
- Clear spacing between the ends of BWPs cannot be greater than 20 feet
- All ends and edges of the panels in a BWP must be fastened to common studs or common blocking as prescribed in the IRC

If these requirements cannot be met, the lateral force resistance of the specific BWL must be specially engineered before glass mat gypsum sheathing can be used on the exterior of the dwelling.

Method GB requirements for the fastening of interior and exterior gypsum panels are prescribed in Table R602.10.4 of the IRC where the size and type of nail, screw, or staple to be used and the spacing for fasteners is identified. The identified fasteners are typically those used in residential construction.

Table R602.10.4 requires minimum ½-inch-thick gypsum panels to be installed on one or both faces of a BWP. This requirement is easily accommodated by the standard manufactured thickness of interior gypsum wallboard commonly installed throughout the interior of 95% of constructed dwellings and standard 1/2-inch or 5/8-inch thickness of glass mat gypsum sheathing. Interior gypsum wallboard shall be compliant with ASTM C1396, *Standard Specification for Gypsum Board*.

Installation of Gypsum Panels

Glass mat gypsum sheathing is typically installed with its long (bound) edge parallel to vertical framing members. When installed in this manner the joints between the ends and edges of the panels are placed over and attached to common studs.

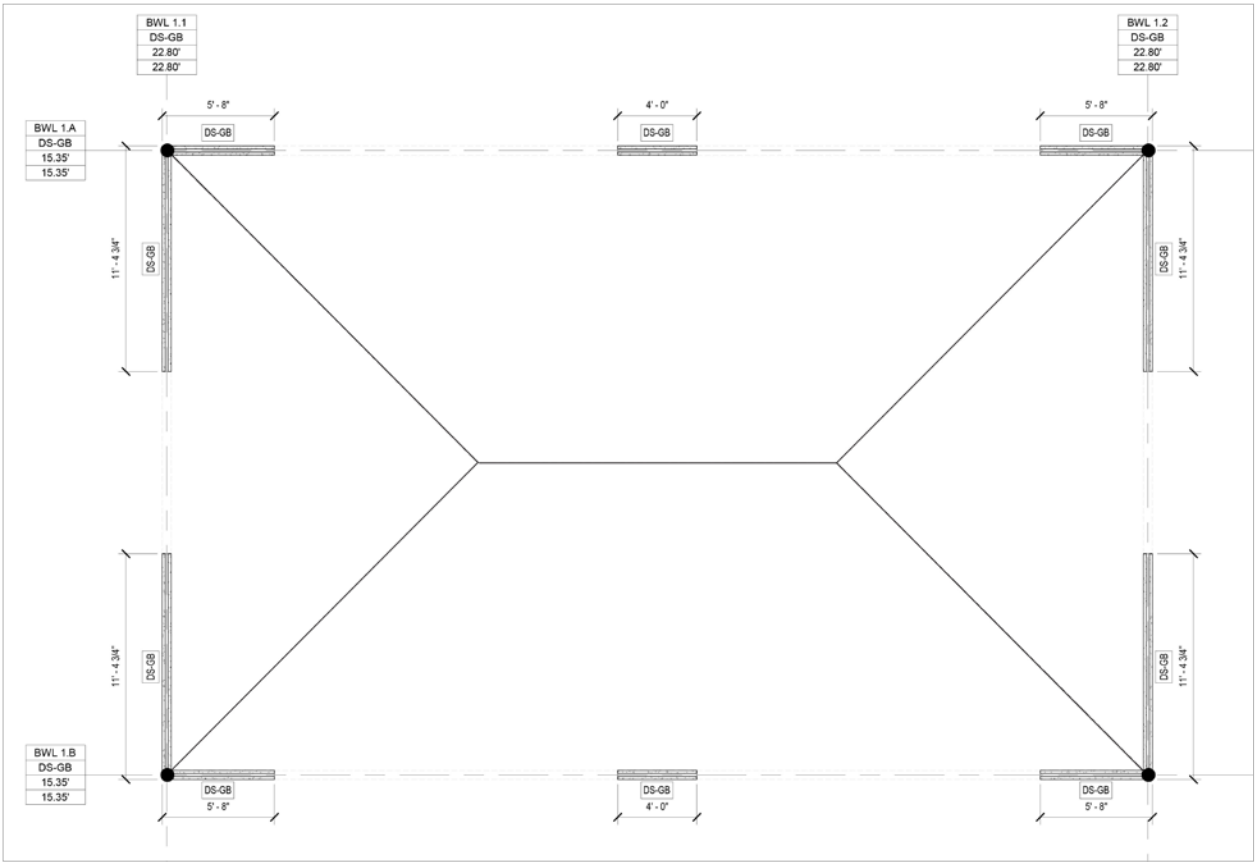
Interior wallboard panels are typically installed with the long (bound) edge horizontal to framing members. In instances when the horizontal joint between panels occurs within a BWP, the joint must be supported by common blocking to satisfy the requirements of the IRC. The requirement for backing does not apply to the parts of a BWL that are not a BWP (unless it is required for another purpose) and can be satisfied using auxiliary bracing or support as determined by an engineer.

A Prototype Dwelling

To illustrate the use of glass mat gypsum sheathing in dwelling construction, a prototype single-family residence was designed to the requirements of the 2021 IRC. All four exterior walls on the rectangular dwelling served as BWLs and each BWL contained framed window and door openings. The exterior walls were finished with ½-inch-thick gypsum board panels on the interior side of the wall and 5/8-inch-thick glass mat gypsum sheathing on the exterior side.

The single-story dwelling featured 9-foot ceilings and a 32-foot by 50-foot footprint. It incorporated a hipped roof and was designed using the following assumptions:

- A 115-mph ultimate wind speed
- Exposure category: B (*Urban and suburban areas*)
- Seismic design category: A-C
- Maximum roof slope: 36.87° (9-12)
- Unblocked wood sheathed roof diaphragm
- Joints between panels are fastened to common studs or common blocking



Basic 32' x 50' single-family dwelling with BWLs on all four sides.

The design parameters selected are typical for a large part of the Continental U.S. Notwithstanding some specific regions' special wind areas, much of the U.S. is in the 115-mile per hour or less category, the primary exceptions being the eastern, gulf, and southeastern coasts; Alaska and Hawaii; and some U.S. territories.

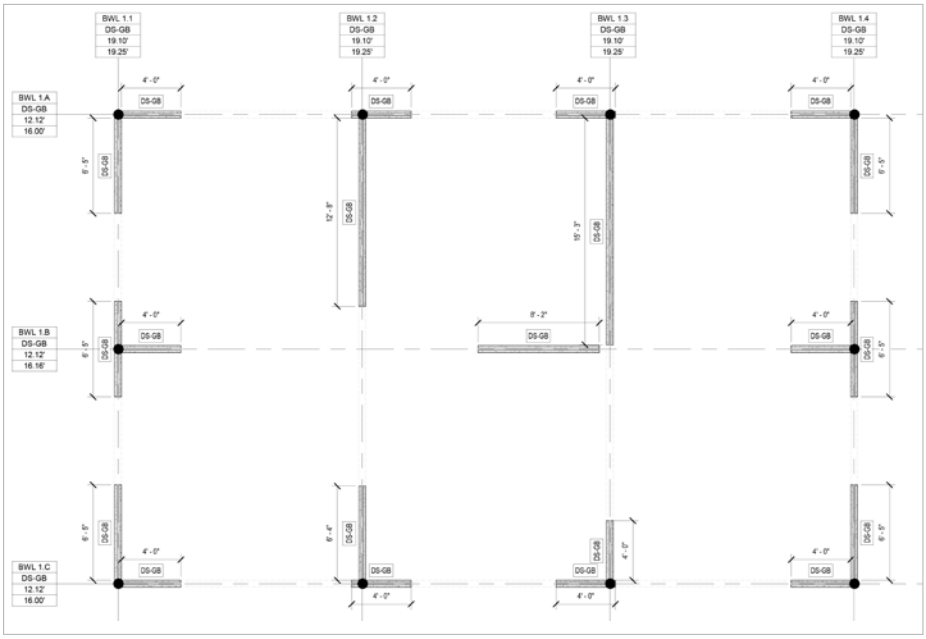
The same applies to seismic design as much of the continental U.S. is not significantly impacted by seismic design requirements, including most of the area east of the Continental Divide. Per IRC Section R301.2.2, the residential lateral design is governed by the wind-force design information in the IRC in areas classified with a low seismic design category.

It is in this large geographic area that features modest ultimate wind speeds and low seismic activity that glass mat gypsum sheathing works best as an element in BWL systems.

Modifying the Prototype Dwelling

Gypsum panels – interior gypsum wallboard and exterior glass mat gypsum sheathing – perform well as bracing elements when installed in accordance with the prescriptive IRC requirements for lateral bracing using gypsum board. In some instances, however, additional structural support or the use of a different sheathing material may be required if the dwelling design exceeds the parameters of IRC lateral panel design.

For example, adding a second story to the prototype dwelling increases its exterior surface area impacted by wind forces, thus influencing the number of lateral force-resisting elements required and necessitating that some of the first-story interior walls be designed as BWLs. If the quantity, design, and spacing of the additional interior BWLs are sufficient to comply with requisite code and engineering requirements, the interior BWLs would be sheathed on both faces with a minimum ½-inch gypsum board with all joints blocked by common studs or blocking as described previously.



First floor of basic 2-story 32' x 50' single-family dwelling with BWLs on all four sides and selected interior walls serving as BWLs.

Modifying the two-story dwelling by eliminating one of the interior braced wall lines and creating an open room approximately 30 feet wide would increase the load on the remaining BWLs such that the lateral load resisting capabilities of the gypsum board would be exceeded. In this instance, either a different code-prescribed sheathing method or additional in-wall bracing may be required on some or all of the structure.

A similar issue occurs if the edge of a window or entry door is placed near the end of a BWL in the single-story prototype. This would violate Method GB prescriptive minimum width BWP requirements and the entire BWL could not be braced using gypsum panels. Instead, a code-prescribed continuous sheathing method or additional in-wall bracing would be required. A long run of glazed openings creates a similar issue because it pushes the BWPs too far apart to permit compliance with Method GB spacing requirements.

The described dwelling was designed and engineered solely to provide an example of how a dwelling unit in a specific wind exposure and seismic design area could be constructed using glass mat gypsum sheathing. The design and engineering of the described dwelling are not to be used to construct a dwelling without further engineering input and review. Each dwelling unit must be designed in accordance with applicable code requirements and standard engineering principles. Requirements for dwellings located in higher wind and seismic zones are typically more rigid than those illustrated herein.

Use of Glass Mat Gypsum Sheathing in an IWUIC Exterior Wall System

A 2021 report by the National Association of State Foresters named over 63,000 communities in the U.S. at risk of wildland fire.[v] As part of their risk-reduction response plan, many communities have adopted the International Wildland-Urban Interface Code (IWUIC). The IWUIC is used by a jurisdiction to supplement the requirements of the IRC in areas at risk of wildland fire. Glass mat gypsum sheathing can be used in IWUIC construction because it complies with exterior wall construction compliance language in Chapter 5 of the code.

Given the complexity of wildfire issues, the IWUIC is often modified on the local and state basis and some jurisdictions now require a fully IWUIC-compliant structure to be constructed with a tested fire-rated exterior wall system. In such instances, designs for typical rated wall systems can be found in the Gypsum Association's GA-600, *Fire Resistance and Sound Control Design Manual*.[vi]

Note joints and fastener heads in one-hour fire-rated glass mat gypsum sheathing systems are typically not finished. This is allowed by language contained in GA-600 and ICC Evaluation Services (ICC-ES) Evaluation Report ESR-1338[vii], sponsored by the Gypsum Association.

The Evaluation Report specifically allows the taping and finishing of joints and fasteners to be omitted when square-edge sheathing is installed in a fire-resistive system. Glass mat gypsum sheathing has a square edge.

Annex

IRC Method GB is based on general gypsum panel allowable force data contained in the National Design Specification for Wood Construction (NDS).[viii]

While the NDS data is acceptable for use with C1177 glass mat gypsum panels, testing sponsored by the Gypsum Association has created allowable force data specific to ASTM C1177 panels. The data is presented in Table X and may be used to engineer the use of ASTM C1177 panels on the exterior face of a braced wall.

The testing was performed in accordance with Sections 14 and 15 of ASTM E72-15, *Standard Test Methods of Conducting Strength Tests of Panels for Building Construction*. It was conducted by the Gypsum Association at an ISO 17025 accredited test lab and was verified by an accredited third party, ICC NTA, LLC.

While the tests were conducted for use with residential dwellings, the information in Table X may be used, where appropriate, in non-residential wood-frame construction. All notes and ancillary information remain applicable.

Note that the values in Table X reflect wet specimen testing and the test specimens were constructed with a double top plate and a single bottom plate.

The information in Table X shall not be used without proper engineering review and analysis. Any engineering analysis is subject to review by the Authority Having Jurisdiction.

Table X: Design Values for ASTM C1177 Glass Mat Gypsum Panel Sheathed Shear Walls[a, b, e]

Sheathing Material	Material Thickness (inch)	Fastener Type and Size	Max. Fastener Spacing (in.)	Max. Stud Spacing (in.)	Blocking	V_n[c, d, f] (plf)	G[a] (kips/in.)
Glass Mat Gypsum	1/2	#6 x 1-1/4 Bugle Head Drywall Screw	4 inch perimeter 6 inch interior	16	Blocked	218	2.8
		0.121. X 1.5 galvanized smooth shank roofing nails		16	Blocked	243	3.3
	5/8	#6 x 1-1/4 Bugle Head Drywall Screw		16	Blocked	227	2.5
		0.121. X 1.75 galvanized smooth shank roofing nails		16	Blocked	244	3.0

a. Panel shall be installed vertically backed by 2-inch nominal or wider framing members. Intermediate studs shall be spaced a maximum of 16 inches on center. Framing members shall be minimum #1 Douglas Fir. For framing of other species, values may be modified in accordance with ANSI AWC NDS.

b. Fasteners shall be installed with a minimum 3/8-inch edge and end distance. Fasteners installed around the perimeter of the panel shall be spaced a maximum of 4 inches on center. Fasteners along intermediate framing members shall be spaced a maximum of 6 inches on center.

c. Values address walls with gypsum sheathing applied to 1 side of the wall only. Maximum load reported is based on test data. In accordance with the American Wood Council *Special Design Provisions for Wind and Seismic* (SDPWS) Section 4.1.4 a value of Ω=2.8 for ASD or a value of ϕ=0.5 for LRFD shall be applied.

d. The aspect ratio (h/b) for glass mat gypsum sheathed walls shall not exceed 2:1.

e. Values are applicable for Individual Full-Height Wall Segments as described in SDPWS Section 4.3.2.1.

f. Deflection of shear walls shall be determined based on the data in Table 3 and calculated in accordance with SDPWS Section 4.3-1 using the following equation:

Where:

$$\partial_{sw} = \frac{8vh^3}{EAb} + \frac{vh}{1000G_a} + \frac{h\Delta_a}{b} \quad (4.3\text{-}1)$$

G_a = Apparent shear wall shear stiffness from nail slip and panel shear deformation (kips/in.).

Δ_a = Vertical deformation of the wall overturning anchorage system (including fastener slip, device elongation, rod elongation, and uncompensated shrinkage) plus the vertical compression deformation, the effects of which are measured at the ends of the shear wall and associated with the unit shear force induced by the design load in the shear wall, in.

E = Modulus of elasticity of end posts, psi (1,900,000 psi for DF)

A = Area of end post cross-section, in^2.

b = Shear wall length, ft.

h = Shear wall height, ft.

δ_{sw} = Shear wall deflection, in.

v = Unit shear force induced by design load, lb/ft.

Reference Documents:

1) ANSI AWC NDS – 2024 National Design Specification (NDS) for Wood Construction, American Wood Council, October 16, 2023.

2) ANSI AWC – 2021 Special Design Provisions for Wind and Seismic (SDPWS), American Wood Council, July 22, 2020.

Resources

i *ASTM C1177 Standard Specification for Glass Mat Gypsum Substrate for use as Sheathing* is available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428.

ii The IRC and IBC are available from the International Code Council, 200 Massachusetts Avenue NW, Suite 250, Washington, DC 20001.

iii ASTM C1280, *Standard Specification for Application of Exterior Gypsum Panel Products for Use as Sheathing* is available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428.

iv GA-253, *Application of Gypsum Sheathing* is available from the Gypsum Association, 962 Wayne Avenue, Suite 620, Silver Spring, MD 20910.

v https://www.stateforesters.org/wp-content/uploads/2022/06/NASF-2021-Communities-At-Risk-Report.pdf

vi GA-600, *Fire Resistance and Sound Control Design Manual* is availablefrom the Gypsum Association, 962 Wayne Avenue, Suite 620, Silver Spring, MD 20910.

vii ICC Evaluation Services (ICC-ES) Evaluation Report ESR-1338 is available from ICC-ES https://icc-es.org/report-listing/esr-1338/

viii The *National Design Specification for Wood Construction* is available from the American Wood Council, 50 Catoctin Circle NE, Suite 201, Leesburg, VA 20176.

The Gypsum Association is the technical center for the application, finishing, and overall use of gypsum panel products. In addition to responding to technical inquiries, the Association maintains a library of technical publications, most of which are free to architects, specifiers, builders, contractors and code officials.