Tech Solutions 518.0

DuPont™ ArmorWall™ Systems Utilize the Fire-Resistant Power of Magnesium Oxide

Summary

Magnesium is present in large quantities all over the planet, where it is the eighth most abundant mineral on Earth. It's the third most common element in seawater. Magnesium is an essential mineral element for plants and is nontoxic to organisms. However, magnesium cannot be found free in nature; it exists as compounds in other natural minerals such as Epsom salts (magnesium sulfate), magnesite (magnesium carbonate), or magnesia (magnesium oxide), the compound this article focuses on.[1]

Magnesium is a part of many different chemical compounds that provide various unique properties for commercial and industrial use. While in isolation, magnesium has a considerably high ignition point compared to other common construction materials. When it undergoes one of a variety of processing techniques, it becomes inert, making it highly fire-resistant.

Magnesite being mined from the earth to create magnesium
Photo courtesy of PremierMagnesia

A calcination oven used to heat $MgCO_3$ or $MgCL_2$ to create MgO
Photo courtesy of Henan Zhengzhou Mining Machinery Co.

Mining and Extraction

Though magnesium is abundant across the planet, how does one go about mining or extracting it to produce Magnesium Oxide (MgO)? The majority of magnesium is mined from the Earth in the form of magnesite. Extraction is another way to obtain magnesium oxide, either from highly concentrated brine wells or from seawater in the form of magnesium chloride.[1]

Forming Magnesium Oxide

In order to form Magnesium Oxide (MgO) as a compound for use in manufacturing, it must be isolated from magnesite ($MgCO_3$) or magnesium chloride ($MgCL_2$), which requires a heating process that reaches temperatures around 700-1000°C. This process is called ***calcination***, wherein the magnesium oxide becomes light-burned, or reactive.[2] The same calcination process is used when manufacturing the primary ingredient in Portland cement (CaO). However, Portland cement requires a much higher temperature to calcinate, up to 1450°C.[3]

The higher temperatures necessary to calcinate Portland cement requires substantial energy and fuel consumption that generates around 5-7% of anthropogenic CO_2 emissions annually.[4] MgO has the ability to absorb CO_2 from the atmosphere, forming byproducts such as carbonates and hydroxycarbonates. This lends itself to the discussion of the possibility of carbon-neutral cements, wherein the cement could absorb the same amount of CO_2 in its lifetime as it produced during manufacturing.[2]

Manufacturing Magnesium Oxide Board

Once calcined, the resulting magnesium oxide is pulverized into a powder form and can be used in various applications. When used in the construction industry, it is made into commonly used building materials, such as magnesium oxide board. One method of producing magnesium oxide board is to combine:

- Magnesium Oxide (Powder)
- Magnesium Brine (Liquid)
- Wood Fiber
- Perlite
- Other Composite Materials

When combined, the mixture becomes a cementitious slurry that is applied onto an assembly line, where glass cloth, or fiberglass, is added. It is then pressed into shape, cut into the desired board lengths, and cured in a controlled environment for a predetermined length of time.

Global Manufacturing Locations and Standards

Presently, the majority of MgO board is manufactured in China, where the raw mineral supply is readily available, and where a large manufacturing industry has been developed. Manufacturers must abide by Chinese and international standards, which are extensively vetted for quality, carbon emission, and other important requirements for responsible manufacturing. Additionally, efforts are currently underway to develop quality and certification standards for MgO production in North America.

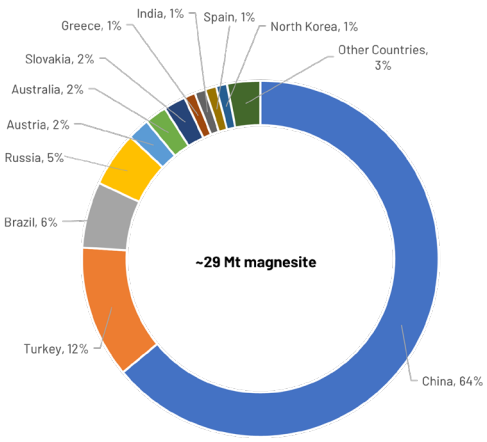


Fig. 1. Percentages of the Amount of Magnesite Available Globally[5]

Industry professionals are expecting manufacturing to begin in other countries, including the U.S., in the coming years. Importantly, this would enable North American MgO to be produced and transported to job sites with less energy used and less carbon emitted. North American MgO manufacturing offers a promising outlook in the coming years.

Magnesium Oxide in the Construction Industry

Magnesium oxide has natural fire-resistant capabilities, making it an ideal raw material for a wide variety of fire and heat-related applications. For decades, it has been used as a base material by the aerospace, automotive, construction, and even medicinal industries.

Magnesium oxide, once manufactured into a board, is used either alone or with other materials to create a highly durable, fire-resistant, and sustainable building material. MgO boards are used in applications that include, but are not limited to:

- Building Enclosures
- Prefabrication
- Roofing and Underlayment
- Duct Covers
- Flooring
- Cladding
- Doors

A typical assembly line used to create magnesium oxide boards
Photo courtesy of Yurui Machinery Co.

New York's infamous Brooklyn Bridge was built with the help of magnesium oxide
Photo courtesy of Suiseiseki, CC BY-SA 3.0 via Wikimedia Commons

Notable Uses of Magnesium Oxide Over Time

Magnesia cement has been used in both new and ancient masonry construction, with some dating back to civilizations many millennia in the past. It was used in the Great Wall of China, New York City's Brooklyn Bridge, and more recently, in all 101 stories of Taipei 101, the world's tallest Platinum LEED building, located in Taipei, Taiwan.

In the U.S., magnesia cement boards were first approved for construction use around 2003. Since that time, many new uses for MgO have been identified. In the past few years in the U.S., rising prices for many construction materials provide reason to consider MgO boards as a replacement. For many projects, MgO panels could be used as a replacement material in items such as:

- Interior walls to replace drywall panels
- Fire walls and fire-rated partitions
- Tile backer board in bathrooms
- Shaft liners
- Ceilings, soffits and fascia
- Replacement for exterior uninsulated sheathing such as gypsum, plywood and OSB

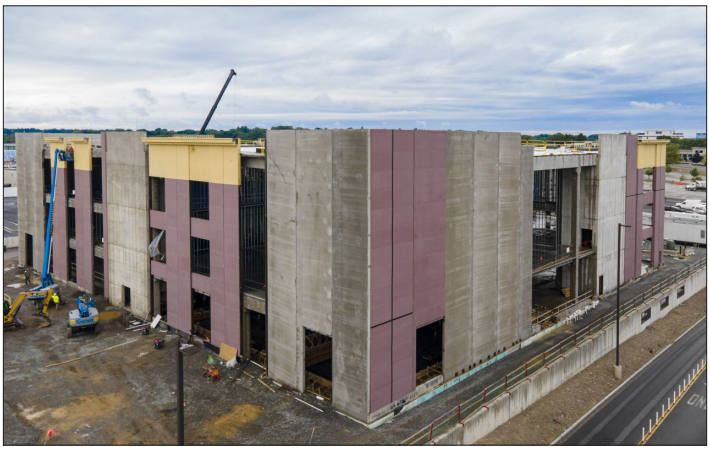
Code and Standards References

Magnesium oxide boards have been extensively tested in China, Canada, the U.S., and other countries to ensure performance and safety. Key codes and standards references include:[6]

- ***Mildew and Mold:*** MgO board is resistant against mildew and mold when tested in accordance with ASTM C1338
- ***Fire Safety:*** MgO board passes ASTM E84 with no flame spread or smoke developed index
- ***Water:*** MgO board passes ASTM E331 testing for water-resistance when combined with a weather-resistant barrier
- ***Impact:*** MgO board is impact-resistant as tested by (TAS) 201-94
- ***Fastener Strength:*** MgO board provides a solid substrate suitable for screw fastening per ASTM D1761 testing for fastener withdrawal

ArmorWall™ with the Strength of Magnesium Oxide

DuPont™ ArmorWall™ Plus and ArmorWall™ SP Plus Fire-Rated (FR) Structural Insulated Sheathing (SIS) panels, part of the DuPont™ ArmorWall™ System, utilize a 1/2" layer of magnesium oxide sheathing coated with a factory applied air and water-resistive barrier on the exterior face, and fused to a poured polyurethane insulation layer. Doing so combines the fire, structural and other benefits of the MgO with the other core components of ArmorWall™ Systems for air and water-resistance and insulation benefits.



DuPont™ ArmorWall™ Plus Fire-Rated (FR) Structural Insulated Sheathing (SIS) prefabricated panels being installed as part of the DuPont™ ArmorWall™ System. ArmorWall™ Plus FR SIS has a 1/2" layer of magnesium oxide board fused to the exterior face.

By replacing common gypsum and cementitious compounds that are commonly found in other construction materials with MgO, ArmorWall™ Plus and ArmorWall™ SP Plus FR SIS deliver top of the line fire-resistance, durability, and strength. Mold and mildew are not an issue for ArmorWall™ Plus or ArmorWall™ SP Plus FR SIS, as MgO panels do not provide a hospitable environment to attract their growth.

The structural strength of the insulated panel also allows direct attachment of cladding to the exterior face, without the requirement of locating the studs or substrate beyond. Because of this, cladding can be mechanically fastened to virtually any location on the exterior MgO face of the ArmorWall™ Plus or ArmorWall™ SP Plus FR SIS panel. With its ability to move the stud face to the exterior face of the sheathing, ArmorWall™ Plus and ArmorWall™ SP Plus FR SIS have been tested to support loads equivalent to most building cladding finishes, with minimal creep while under load.

In addition, each ArmorWall™ Plus and ArmorWall™ SP Plus FR SIS panel comes with fastener guides printed directly onto the exterior face, making it simple to field measure, layout, and install ArmorWall™ Plus and ArmorWall™ SP Plus FR SIS panels into the studs or substrate. These and other benefits create a structural sheathing board that is unmatched in many of today's performance categories.

For more information, contact us at:

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Or, visit the DuPont Performance Building Solutions (PBS) Resource Center for resources on magnesium oxide, ArmorWall™, and other innovative building enclosure products that are manufactured by DuPont.

Sources Cited

[1] Hanusa, T. P.. "magnesium." Encyclopedia Britannica, June 25, 2021.

[2] Sam A. Walling and John L. Provis. (2016). Magnesia-Based Cements: A Journey of 150 Years, and Cements for the Future?. Chemical Reviews 2016 116 (7), 4170-4204. DOI: 10.1021/acs.chemrev.5b00463

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[5] United States Geological Survey 2019. Magnesium compounds. In: Mineral commodity summaries 2019. United States Geological Survey, <https://doi.org/10.3133/70194932>, pp. 100–101.

[6] DuPont de Nemours, "DuPont™ ArmorWall™ Plus Fire-Rated Structural Insulated Sheathing," 43-D101109-enNA-1221, May 2022.

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43-D101196-enUS-0922