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ORIGINAL ARTICLES

Using Magnesium Oxide Wallboard as an Alternative Building Façade Cladding Material in Modern Cairo Buildings

Mohamed Adel El-Gammal, Ayman M.H. El-Alfy and Nermin M. Mohamed

Civil & Architectural Engineering Department, National Research Center, Dokki, Giza, Egypt

ABSTRACT

Magnesium Oxide is a versatile material widely used in Asian residential and commercial buildings. Major (magnesite) deposits are found in China, Middle East, and Canada. Egypt is one of the Middle East countries that mines magnesite. Magnesium Oxide wall cladding is a new technique in Egyptian construction field, some of Cairo's modern buildings facades applied locally manufactured Magnesium Oxide wallboard as external shaping material. The research paper illustrates through site observations followed by a comparative study between Cairo's traditional façade shaping technique using Cement Plaster on metal lath and using Magnesium Oxide wallboards, The research ends up by showing the advantages and disadvantages of using Magnesium Oxide wallboard for external claddings in Cairo.

Key words: Magnesium Oxide wallboard, façade claddings, modern Cairo buildings, Sustainable building materials.

Methodology:

- Historical background about the use of Magnesium Oxide material as building façade cladding material.
- Illustration of the environmental sustainability of Magnesium Oxide material.
- Environmental and financial comparison of building facades shape forming traditional cement plaster on expanded metal lath technique used in Cairo Egypt and external wall cladding using Magnesium Oxide wallboards.
- Site investigation on the results of applying Magnesium Oxide wallboards as a new shape forming technique in modern Cairo buildings showing its advantages and disadvantages and its application capabilities in Cairo's weather conditions.

Introduction

Environment sustainability, safety and finance are the major factors that affect the prefer ability of choice for building materials. Magnesium Oxide material was used as an adhesive material in the Great Wall of China and other ancient landmarks. Roman cement also is contained high levels of MgO. (Substance distributing, Inc.)

Construction materials that consume less energy during its production phase and site transportation are considered environment sustainable materials. For that reason it is preferable to use natural building materials with minimum manufacturing steps or material that its residue is locally mined. Presently Magnesium Oxide board is widely used in Asia as a primary construction material. It was designated as the 'official' construction specified material of the 2008 Summer Olympic Games and was used in extensively on the inside and outside of all the walls, fireproofing beams, and as the sub-floor sheathing in the world's second tallest building,Taiwan.

Magnesium is the lightest metal commonly used for structural purposes, having a density of 1.74, only 65% of that of aluminum and 22% of that of iron. Magnesium is in plentiful supply and is widespread globally; it is the eighth most abundant element in the earth's crust and the third most plentiful element dissolved in seawater. World resources of Magnesium are enormous and Mgbearing brines contain a resource estimated in billions of tones (USGS, 2008).

Magnesite deposits are found in East South areas of Egypt. It is locally extracted and Magnesium Oxide boards are recently locally manufactured in Egypt, but its application as an external building façade shaping technique is considered new for the Egyptian construction sector that is traditionally using Cement plaster on expanded metal lath as the main façade shaping technique which takes long time to construct and ends up with less plaster surface finish quality.

Corresponding Author: Mohamed Adel El-Gammal, Civil & Architectural Engineering Department, National Research Center, Dokki, Giza, Egypt

Wallboard, drywall or plasterboard, was invented in 1916 by U.S. Gypsum Corp., as an alternative to plaster walls, but it did not become a popular and almost universal building material until the 1950s. It got a big boost during World War II, when the government needed a lot of buildings in a hurry and plastering was too slow. (http://www.ehow.com).

Cairo's hot weather in the summer days has a negative effect on the traditional technique of external use of cement plaster on expanded metal lath due to the expansion of the steel supporting structure. As a result surface plaster cracking happen very often.

1-1 Historical background about the use of Magnesium Oxide as building façade cladding material:

Magnesium Oxide's was used in mostly masonry construction is ancient. It was used primarily as a mortar component and stabilizer for soil bricks. Magnesium Oxide has also been identified in the Great Wall of China and other ancient landmarks. Roman cement is reported to have contained high levels of Magnesium Oxide.

In the West, Portland cement has replaced Magnesium Oxide for masonry uses. However, New York City's Brooklyn Bridge base is made from locally mined cement, a mixture of calcium Oxide and Magnesium Oxide commonly called Rosendale Natural Cement, the only natural non-fired cement made in the US.

Magnesium Oxide boards were approved for construction use in the US around 2003. Due to its fire resistance and safety ratings, New York and New Jersey were early adopters of Magnesium Oxide boards. Florida has adopted Magnesium Oxide for its mold/mildew resistance. While Magnesium Oxide sheeting was the "official" specified construction material of the 2008 World Olympics buildings in Beijing (Burstow, Clive, 2000).

1-2 Purpose and use:

Magnesium Oxide board is a factory-made, non-insulating sheathing board product. It can be used for a number of interior or exterior applications including wall and ceiling linings, fascias, soffits, countertop, shaft-liner & area separation wall board, exterior sheathing, substrates for coatings and insulated systems such as: direct-applied finish systems, (painting & Stucco), it can be used as tile backing and under laments.

Magnesium Oxide is widely used primarily as wallboard alternative to conventional gypsum-based drywall –but with much improved characteristics such as fire resistance, weather ability, strength, resistance to mold and mildew and so on. The Magnesium Oxide boards can be scored and snapped, sawed, drilled and fastened to wood or steel framing. Magnesium Oxide boards are a good example of the advances made in construction materials to meet changes in building safety and durability codes. Magnesium Oxide is available in many forms, and for building construction purposes it is produced in various thicknesses and sheet sizes with various grades, such as smooth finishes, rough textures and utility grades. It is white, beige or light gray in color.

1-3 Ratings, Advantages and Disadvantages:

• Ratings and testing (Wikipedia, 14 /1/ 2012).
- Fire-resistant (UL 055 and ASTM-Tested and A-Rated)
- Waterproof (Freeze/Thaw-Tested for 36 months)
- Mold/fungus/bug free (non-nutritious to mold, fungus, insects ASTM G-21)
- Impact-resistant (ASTM D-5628)
- NYC Approved (MEA # 359-02-M)
- Silica/asbestos Free
- Florida hurricane tested [*peacock term*]
- STC-Rated 53-54

Advantages:

- Can be used in the place of traditional drywall or cement boards. No special tools required.
- Hard non-absorbent surface – with no paper backing.
- It can be used in applications like cement-based siding.
- Available in various colors.
- Environmentally friendly
- It is removed from ore at about 25% of the temperature (400-800 °F) required to form Calcium Oxide, (the starting material for the preparation of slaked lime or portlandite used in common mortar and plaster).

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Disadvantages:

- Magnesium Oxide board for the use in the indoors is more expensive than conventional gypsum drywall material.
- Wall lining materials are typically used on exposed interior surfaces in a building for decoration, acoustical correction, surface insulation, or structural fire resistance. However, in a fire, these materials provide fuel and surfaces that allow a fire to spread. Heat, smoke and toxic gases are then transported to other parts of a compartment or to other compartments, thereby endangering the safety of people and property. Therefore, the fire performance of such materials must be evaluated. (Kuang-Chung Tsai, 2009).

2- Green features of sustainable building materials:

A chart of the criteria, grouped by the affected building life-cycle phase helps compare the sustainable qualities of different materials used for the same purpose. The presence of one or more of these "green features" in a building material can assist in determining its relative sustainability. Fig.(1) shows the key to the green features of sustainable building materials. (Jong-Jin Kim, Brenda Rigdon, 1998).

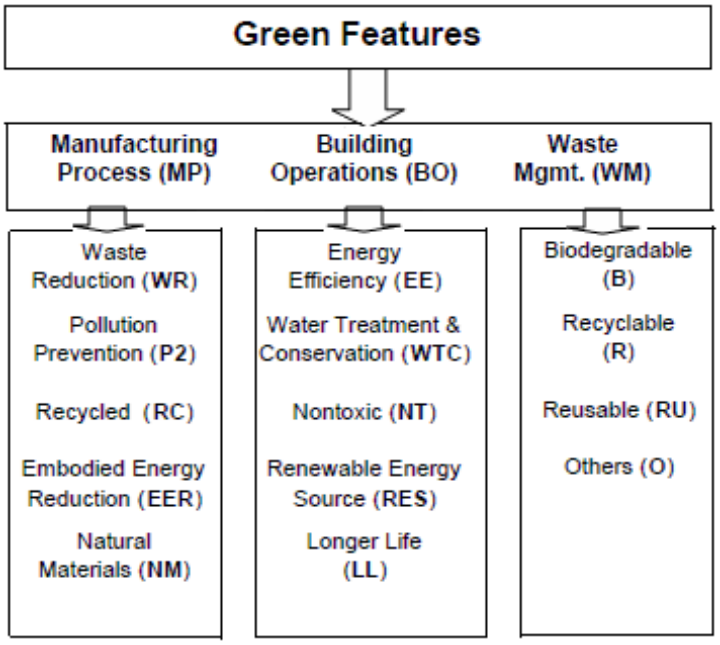

Fig. 1: Key to the green features of sustainable building materials.

2-1 Green Features Of Magnesium Oxide Boards:

Manufacturing Process:

- *Natural Material (NM):*

Magnesium is the eighth most abundant element and constitutes about 2% of the Earth's crust, and it is the third most plentiful element dissolved in seawater (Burstow, Clive, 2000) .Although Magnesium is found in over 60 minerals, only dolomite, magnesite, brucite, carnallite, and olivine are of commercial importance. Magnesium and other Magnesium compounds are also produced from seawater, well, lake brines and lake bitterns. ; Magnesium compounds, primarily Magnesium Oxide, are used mainly as refractory material in furnace linings for producing iron and steel, nonferrous metals, glass and cement. Magnesium Oxide and other compounds also are used in agricultural, chemical, and construction industries. Magnesium alloys also are used as structural components of automobiles and machinery (USGS, 2010).

Magnesium Oxide, or magnesia, is a white solid mineral that occurs naturally as periclase and is a source of Magnesium. It has an empirical formula of MgO and it is formed by an ionic bond between one Magnesium and one oxygen atom.

The majority of Magnesium Oxide produced today is obtained from the processing of naturally occurring minerals such as magnesite (Magnesium carbonate), Magnesium chloride rich brine, and seawater. In addition to sea water and lake brine sources include also, Carnalite, Dolomite, and Serpentine Magnesite.

- *Embodied Energy Reduction (EER):*

The total energy required to produce one ton of Magnesium is around 35 to 40 man working hour for both the electrolytic and thermal routes. The electrolysis only step component ranges down to just 12 man working hour per ton with the latest technology (U.S. Environmental Protection Agency, 2010).

Three basic types or grades of "burned" Magnesium Oxide can be obtained from the calcination step with the differences between each grade related to the degree of reactivity remaining after being exposed to a range of extremely high temperatures.

Magnesium Oxide board:

Magnesium Oxide board is a “low tech” and “energy-friendly” product. CO2 is high on the list of “greenhouse” gases, which are said to contribute to the global warming phenomenon. Magnesium Oxide production is simple, energy efficient, and produces few “greenhouse” gases. This aspect of Magnesium Oxide, from the standpoint of being a ‘green’/eco-friendly product. (George Swanson , Oram Miller and Wayne Federer,2008)

Magnesium Oxide boards are harder than drywall, and are somewhat like the Portland cement board used in bathtub enclosures. Magnesium Oxide is ‘worked’ in a manner like a combination of drywall and cement boards. It can be scored and snapped, although it is stronger than drywall and requires a bit more effort. It can be cut with a power saw, drilled-through and fastened like other similar boards. As when sawing Portland cement boards, dust is created and thus precautions against inhalation need to be taken, but the dust itself is basically inert. It’s an easy-to-install product.

Like any sheathing board, Magnesium Oxide board can absorb water but its performance is unaffected. Thus it can be used indoors and outdoors, and in damp locations. If Magnesium Oxide is used outdoors in an exposed location, it needs some form of coating, such as paint. Magnesium Oxide boards are not completely homogeneous, but do not have a separate facing like drywall or glass matt-faced gypsum board. Hence delaminating is not an issue–for practical purposes it is a solid material.

Magnesium Oxide board is more flexible than Portland cement boards and less flexible than drywall. Thin sheets of Magnesium Oxide can be bent or warped to follow gentle curves. Magnesium Oxide is not as brittle as Portland cement boards, but “edge distance” (closeness of fasteners to the edge of a sheet) is an issue in using certain types of fasteners. For instance, it can be nailed, but the hammering of the surface by the tool when setting the nail can damage the surface, although the nail itself does not. It’s basically like drywall or cement boards, in terms of ease-of-installation. (Raugei M, Ulgiati S, Cherubini F, 2008).Table (1) shows the future of MgO Board.

Table 1: MgO Board Comparison. Source: www.mgoboards.co.za.

	MgO Board	Gypsum Board	Cement Board	Plywood	O.S.B.
Flame Spread	0	15	0	High	High
Smoke Developed	None	Low	None	High	High
Water Resistant	Yes	No	No	No	No
Mold/Mildew Resistant	Yes	No	Yes	No	No
Termite Resistant	Yes	Yes	Yes	No	No
Thermal / R Value per inch	1.2	0.9	0.8	1.2	1.0
Impact Strength	High	Low	Low	Medium	Medium
Weight LSB / Sq Ft	2.2	2.4	3.1	1.6	2.0
Combustibility	None	Facing Burns	None	Burns	Burns
Structural	Yes	No	No	Yes	Yes
Environmental	High	Poor	Medium	Medium	Poor
Freeze/Thaw	Good	Poor	Good	Good	Good
Finish Interior	Tape / Paint	Tape / Paint	Provide Cladding	Provide Cladding	Provide Cladding
Exterior	Stucco / Cladding	Interior Only	Apply Paper / Stucco	Apply Paper / Stucco	Apply Paper / Stucco

- *Recycled (RC):*

Newly manufactured Magnesium oxide wall boards use 30%recycled material.

Building Operations:

- *Energy Efficiency (EE):*

Using Magnesium Oxide wall boards for external building envelope saves heating and cooling energy as the wall boards of 10Mm thickness has thermal insulation R Value of 219 Watt/Mt Kelvin.

- *Non Toxic (NT):*

Magnesium oxide wall boards are manufactured from 100% natural material; it does not produce toxic emissions that affect the building indoor air quality.

Waste Management:

- *Biodegradable (B):*

Magnesium oxide wall boards contain 100% natural material, so the demolished product produces a fully biodegradable natural material.

- *Recyclable (R):*

Demolished Magnesium wallboards produces Magnesium oxide powder which can be used in either the manufacturing process of new boards or in many other products that use magnesium oxide as one of its components.

2-2 Green Features Of Cement Plaster on expanded metal lath:

Manufacturing Process

- *Natural Material (NM):*

Cement plaster on expanded metal lath technique uses steel section frames and rods and Cement – Sand mortar for plastering which are all manufactured materials.

- *Recycled (RC):*

Cement plaster on expanded metal lath does not use any recycled material.

Building Operations:

- *Energy Efficiency (EE):*

Cement plaster on expanded metal lath used for external façade shaping does not directly affect the building occupant comfort temperature although it is not a good thermal insulator.

- *Non Toxic (NT):*

Cement plaster on expanded metal lath does not produce toxic emissions that affect the building indoor air quality.

Waste Management:

- *Biodegradable (B):*

Cement plaster on expanded metal lath after demolishing produces Portland cement parts and steel rods that are not bio degradable

- *Recyclable (R):*

Cement plaster on expanded metal lath after demolishing does not produce recyclable materials

3 - Comparison between application techniques of Cement plaster on expanded metal lath and wall cladding using Magnesium Oxide wall boards:

3-1 Cement plaster on expanded Metal lath:

Cement plaster on expanded Metal lath technique was common building technique around the world in the 1950s, see figure (2), its construction steps is as follow:
* Welded steel structural frame of various steel sections is constructed to support
6 - 8 Mm diameter steel rod grid at 40 Cm x 40 Cm intervals.
* Galvanized steel expanded metal sheets are surface fixed on the supporting grid using steel metal wire every 30 Cm, while 10 Cm overlaps are required for the connections between expanded metal sheets.
* Smooth trowel is used to apply a layer of the plaster over the expanded metal sheets. The plaster should be about 5Mm thick. Pressing plaster on the expanded metal is a must form hooks. Plaster is allowed to dry for 24 hours.
* A second layer of plaster is applied to the wire mesh, creating an even finish. Scooping plaster up with the trowel and smooth it. This second layer should be approximately 6 Mm thick. Plaster is allowed to dry for 24 hours. The final layer of plaster is left to dry for at least 48 hours before applying any finishing paint or stucco.

Fig. 2: Steel Frame to support Cement plaster on expanded metal lath.

3-2 Façade wall cladding using Magnesium Oxide wall boards:

* Galvanized steel U shape steel rods are fixed through rivets on rough wall surface, used as main supporting frame distributed evenly at 60 Cm apart distances. Or it might be shaped to get the desired form. Fig. (3)
* Secondary omega shaped galvanized steel are riveted on perpendicular direction to the main U shape rods on intervals of 60 Cm. Fig. (4,5)
* Magnesium oxide boards are directly riveted to the secondary omega shaped rods.
* Mesh and plaster are applied at the connection joints between the boards to prevent cracking.
* Final finish (paint or stucco) is applied to the boards.

4 – Financial Comparison:

Table (2) shows a comparison between the cost in Cairo Egypt (March 2012) of one square meter cement plaster on expanded metal lath, Magnesium oxide board 10 mm thickness and Gypsum board for internal use thickness 10mm. (ESDCO).

Material	Price LE
one square meter cement plaster on expanded metal including frame plaster and workmanship	120
Magnesium oxide board 10 mm thickness including support frame and workmanship	125
Gypsum board for internal use thickness 10mm including supporting frame	105

Magnesium oxide board 10 mm thickness including support frame and workmanship is more expensive than Gypsum board for internal use thickness 10mm including supporting frame, and one square meter cement plaster on expanded metal including frame plaster and workmanship, but MgO board a lower life cycle cost because of their durability and longevity.

Fig. 3: Using Magnesium oxide boards as Building Façade shaping material.

Fig. 4: Using Magnesium oxide boards supporting metal frame.

Fig. 5: Using Magnesium oxide boards as Ceiling shaping material

5- Results:

Shaping building facades in many of the existing and newly constructed buildings in Cairo Egypt depend on using cement plaster on expanded metal lath which showed by time plenty of cement plaster cracking problems due to the expansion of metal supporting structure. External façade cladding using Magnesium Oxide wall boards is a new applied technique for façade shaping in some modern building in Cairo Egypt. According to site observation visits for a chosen sample of Cairo buildings that had applied Magnesium Oxide cladding technique after its construction completion by varying periods of time. Painted or plastered Magnesium Oxide wall cladding showed its capability to match Cairo's climate, no surface cracking had appeared, smooth curved surfaces with no hand plastered defects can be formed. Magnesium Oxide wall cladding technique in comparison to Cairo's traditionally used cement plaster on metal lath showed a great improvement construction speed and the finishing quality.

6- Conclusion:

Magnesium Oxide is a natural material which are available in Egyptian mines. Utilizing local materials in the construction industry helps improving building economy and energy saving. Magnesium Oxide wall boards physical characteristics serves environmental sustainability both in its production stage and after demolishing stage. Laboratory tests do not usually show the full capability of a material to be used in outdoors especially in different weather conditions. An experimental building site application and site observation during a round year of time shows material capability to withstand the local weather conditions. The research study is based on a comparison between the local applied façade shaping technique in Cairo buildings which is cement plaster on structurally framed expanded metal lath and the newly applied cladding technique using Magnesium Oxide wall boards. The site observations showed great benefits of applying of Magnesium Oxide wall boards and its full capability for application in Cairo's weather conditions.

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