

Single-Use Plasters: Process and Waste in Gypsum Wallboard Systems

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2017 marked the 100th Anniversary of Sheetrock.¹ Sheetrock, a proprietary eponym for gypsum wallboard, is the dominant material used in the construction and finishing of interior partitions. It, along with other stock materials used in interior finishing, is a readily available commodity and is specified in nearly all new construction. Despite its proliferation, both the product manufacturing and installation methods of Sheetrock have remained essentially unchanged in its hundred-years of existence.

As a result of the unchallenged product manufacturing and installation methods, contemporary construction issues related to labor, waste, and environmental health are not addressed throughout the gypsum wallboard material system. Considering these issues, this paper outlines the environmental and carbon impacts of the entire material system of this lasting, ubiquitous material. The purpose of this work is to inform future innovation and development of the products and processes included in common interior finishing practices. This research summarizes an understanding of the current context of the gypsum wallboard material system gained through on-site observation and discussions with industry contacts. Successes and shortcomings discovered within the material system serve as design criteria for the reconsideration of contemporary interior finishing practices, e.g. the installation of gypsum wallboard and the application of joint compound, as a single modular system. Physical testing and prototyping of the modular system considers industry impact including sustainable construction practices, the reduction of debris and material waste, and shortages in skilled labor as well as aesthetic and functional qualities of the interior.

INTRODUCTION

Gypsum wallboard is a pervasive building material used in nearly every project currently in construction. Approximately 30 billion square feet of gypsum wallboard is consumed annually in the United States, making it the leading world consumer of gypsum wallboard.² Being a mass-produced and mass-consumed commodity, gypsum wallboard's environmental, ecological, and economic impacts extend far beyond the

realm of the interior. Because of this, when considering the carbon impacts of our architectural environments, we must also consider the impacts of building products both within those environments and from each aspect of the entire material system. In the same vein, to reduce the carbon impact of our architectural environments we must reconsider the products and construction processes contributing to the embodied carbon of those environments.

In order to reevaluate a product so ingrained in our construction practices as gypsum wallboard, the entire material system must be understood. Therefore, this research acknowledges the necessity to investigate, comprehend, and operate within the current context of the gypsum wallboard material system. This is achieved through a review of academic and industry resources, interviews and discussions with industry players, and on-site observations as well as physical testing. The preliminary research of the gypsum wallboard material system was then used to inform design-build explorations and prototyping aimed at redesigning gypsum wallboard as a modular panel system responsive to current shortcomings within the material supply chain.

CONTEXT

In the case of Sheetrock, a proprietary eponym for gypsum wallboard, 2017 marked its 100th anniversary.³ Despite its proliferation in contemporary practices, both the product manufacturing and installation methods of Sheetrock have remained consistent in the hundred-year span of its existence. Prior to the use of Sheetrock and its predecessor Sackett Board, plaster and lath construction was the standard. This assembly required a high level of skill and was considered a craft. With the advent of paper facing and edging in 1910, plaster could be produced in board form – allowing for large-scale manufacturing and transporting.⁴

As a result of its industrialization, gypsum wallboard became framed as a temporary building product. The board format decreased installation time and simplified installation practices. Compared to previous plaster and lath practices, the temporary nature of gypsum wallboard made demolition and reconstruction a more viable option.⁵ Therefore, waste became an embedded aspect of the use of gypsum wallboard products.

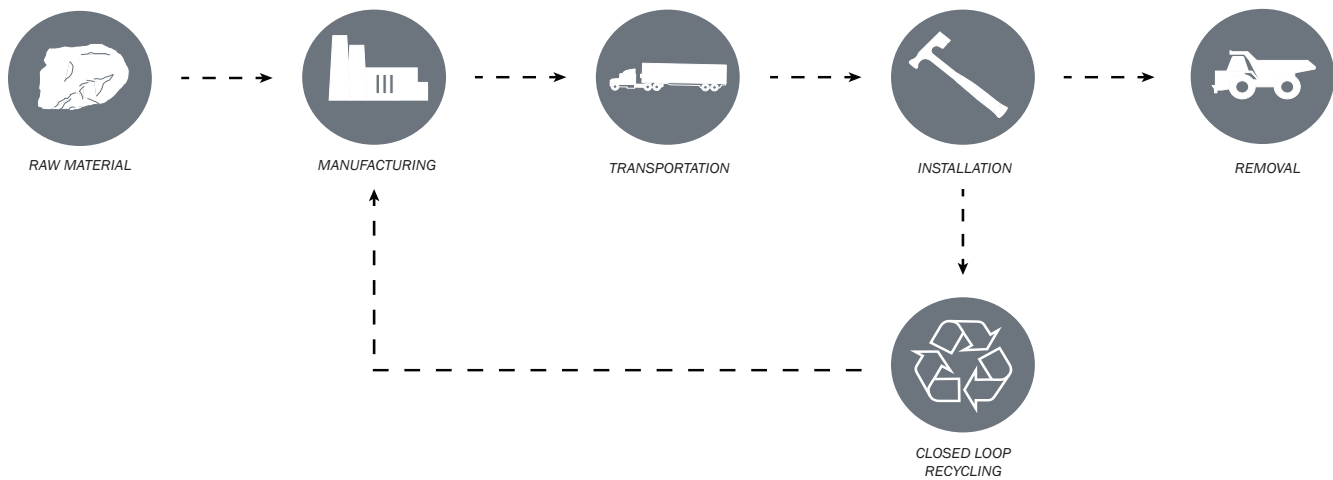


Figure 1. Diagram showing each major phase of the Gypsum Wallboard Material Supply Chain. Image by Author.

Despite the mass-production of panels, the gypsum wallboard finishing process including drywall tape and joint compound still required highly skilled labor and was, and still is, considered to be an art form by industry players. This process creates homogeneity from modularity, an effect that is increasingly more difficult to achieve due to a shortage in skilled labor. Eliminating the modular nature of gypsum wallboard through finishing also eliminates the possibility for deconstruction and reuse. As a result, over 13 million tons of drywall debris are generated every year – 85% of which is landfilled.⁶

THE GYPSUM WALLBOARD MATERIAL SYSTEM

In order to further understand and address areas of concern surrounding gypsum wallboard production and installation practices, this research is couched in the greater context of its material supply chain system. As with most aspects of our industrialized economy, there are inherent links and relationships that must be acknowledged in order to make impactful change. Throughout this research, this is achieved by understanding each phase of the gypsum wallboard material supply chain – including Raw Material Procurement, Manufacturing, Transportation, Installation, Recycling, and Waste Removal – as well as through building relationships with industry-experts within each phase to understand how changes to the product design or installation practices could influence supply chain phases up or downstream.

Like any manufactured product, gypsum wallboard production begins with raw material procurement. Gypsum, or calcium sulfate dihydrate, is a mineral - surface-mined in approximately 19 states.⁷ The mining of raw gypsum accounts for 2/3 of the annual production of gypsum within the United States.⁸ Despite it being a naturally occurring feedstock material, the mining process is energy-intensive and impacts surrounding areas through air and water pollution.

The other 1/3 of the total gypsum supply consists of synthetic

gypsum or coal flue gas desulfurization, also called FGD. FGD is a by-product of coal-fired power plants and is extracted from the emissions process.⁹ While using recycled-content from a carbon-intensive process is a resourceful solution, there are growing concerns over elevated mercury levels in both FGD gypsum wallboard products as well as areas surrounding gypsum wallboard manufacturing plants.¹⁰ Also, with the movement away from coal-fired power production, plants are closing or being converted to natural-gas-fired plants – reducing the FGD gypsum feedstock available for new gypsum wallboard production.¹¹

Gypsum, whether raw, synthetic, or recycled, is then transported to manufacturing plants where it is crushed, ground, dried, and mixed with water along with other additives to create a stucco. The stucco is poured directly onto paper backing that has folded edges which act as a mold for the wet material. A second sheet of paper is then placed on top to sandwich the stucco. The paper and stucco assembly is then rolled across a board line to cure. The board line allows for the production of a continuous wallboard typically 4 feet wide by hundreds of feet in length. The continuous wallboard is cut into desired typical lengths of 8 feet, 10 feet, 12 feet, etc. before the boards are sent to the kiln to fully cure.¹²

While custom sizes can be requested for large-scale orders, typically manufacturers produce standard module sizes of gypsum wallboard. The module size is a significant consideration since it impacts installation practices and waste generated from board cutoffs on-site. For example, Alana Parker, owner of the gypsum wallboard supplier Rocket City Drywall, notes that most home builders throughout the Alabama region order 4-foot by 12-foot boards to reduce the number of cuts needed to cover a wall surface. Since these boards are run horizontally and typical rooms sizes can be smaller than 12 feet in length or width, systematic on-site waste is inherent to the installation process.¹³



Figure 2. Documentation of on-site observation of gypsum wallboard installation and finishing shows varying board orientations and finishing at seams, corners, and screw locations. Image by Author.

To further exacerbate embedded waste practices, sub-contractors are not financially incentivized to create efficiencies and minimize waste. Their fee is based on purchased material quantities and, therefore, they do not benefit from conserving material by ordering more accurate material quantities or by making use of board cutoffs. They do financially benefit, however, by using large board sizes which decreases the number of seams that require finishing. This reduces time-consuming and highly skilled finishing practices and, therefore, reduces labor costs.¹⁴

The intensive finishing process necessary with gypsum wallboard assemblies creates a homogenous surface from a modular system. The application of drywall tape, joint compound, and the act of sanding creates a smooth transition between boards but requires skill and time. The level of finish quality is dependent on the skill of the laborer and coordination amongst trades. Also, beveled factory edges make it easier to produce higher quality finishing of seams, but these edges are lost when boards are cut into smaller sections.¹⁵

In addition to finishing products, the gypsum wallboard industry has influenced and impacted a market of tools and accessories aimed at producing installation efficiencies and higher quality finish work with less required skill. Aside from

the advent of these products and tools, the primary product of an interior partition assembly, gypsum wallboard, has remained unchanged and unresponsive to the challenges currently facing the building product and construction industry.

During the installation process, waste is created from board cutoffs left over from customizing the modular wallboard panels to fit wall and ceiling surfaces of varying dimensions. These board cut-offs are typically commingled with other construction debris and taken to a landfill. However, with closed-loop recycling practices, board cutoffs can be sourced separated on-site and hauled to a wallboard processor. Wallboard processors then separate the gypsum from the paper so that the gypsum can be crushed and reused. The gypsum can be downcycled into agricultural fertilizer or it can be recycled as part of a closed-loop system where it is used as feedstock, replenishing the raw material supply for manufacturers.¹⁶ The closed-loop recycling process requires all parties to actively participate from general contractors - changing their waste removal practices—to manufacturers—accepting gypsum feedstock that may not match their proprietary blends. Building Product Ecosystems has formed the Closed Loop Wallboard Collaborative working group involving players from across the industry to discuss and address this process.¹⁷

Lastly, after use, gypsum wallboard is demolished. Due to the taping and finishing process as well as years of patching holes and applying paint, coatings, and coverings, the original module is not visual and cannot be used to disassemble the system. Best demolition practices destroy the panels, creating gypsum debris in lieu of sizeable panels that could be reused. This debris is then landfilled which has significant environmental and health impacts - such as groundwater contamination and odor problems related to the conversion of sulfate to hydrogen sulfide.¹⁸

While there has been significant progress regarding gypsum wallboard manufacturing and recycling practices, issues of production and waste still remain in the gypsum wallboard material system. Much of the focus in reconsidering the gypsum wallboard material system has been directed towards supply chain processes such as raw material procurement or closed-loop recycling. Outside of process-driven improvements, gypsum wallboard as a designed product has remained unchanged and unresponsive to contemporary construction issues. Therefore, through a comprehensive understanding of the gypsum wallboard material supply chain, we can begin to reconsider the product in addition to the processes and couch those reconsiderations in the greater context of the material system.

RECONSIDERING GYPSUM WALLBOARD

By thoroughly understanding the impacts of the gypsum wallboard supply chain, the shortcomings serve as design criteria to reconsider the product. Through physical prototyping and



Figure 3. Full scale framing mock-up used to test various module sizes of gypsum wallboard. Image by Author.

testing, this research considers the modular size as well as edge and surface conditions of gypsum wallboard panels as points of redesign. The purpose of working within these parameters is to reduce on-site waste, allow for deconstruction and reuse or renewed feedstock, eliminate finishing practices, and reduce the dependency on highly skilled labor.

The findings of the preliminary research informed physical explorations, beginning with the creation of a full-scale framed mock-up to serve as a testing ground for understanding installation practices as applied to various module sizes. Each tested module size was derived by the division of a standard 4-foot by 8-foot sheet of gypsum wallboard and installed by a single, amateur laborer. The installation of each module size was examined based on the following criteria.

Orientation: Except for the square module, each module had an inherent directional orientation based on its proportion of width to height. In addition to the panel's orientation, each panel could be installed orientated vertically or horizontally on the framing. The orientation of both the panel and installation impacted the laborer's ability to grip, lift, and hold the panel during installation as well as the panel patterning needed to complete the wall surface.

Pattern: In this test, seams were to remain unfinished and would therefore be visible. As a result, the module size impacted the number and placement of seams across the wall surface, creating a pattern. Patterns could be oriented

horizontally or vertically and were affected based on the ability of the module size to complete standard wall dimensions.

Ease of Installation: Modules of various sizes had different implications relative to installation. Modules were considered based on how they were gripped, their weight when being moved, their center of gravity and weight while lifting into place, and their ability to be held in place while being attached to the framing.

Attachment: Modules were secured to the wall framing using traditional drywall screws. Screws were needed on all edges of each module as well as on 16-inch intervals within the surface of the module. Any seam between gypsum wallboard panels doubles the amount of hardware needed to secure each panel, and panels with a small surface area are dependent on attachment at the edges to secure the panels to the framing.

Initial findings determined that mid-sized panels, such as panels 2 feet, 4 inches wide by 4 feet tall, were manageable for a single, amateur laborer to hold, lift, and install while still covering a significant wall area and maintaining enough surface area for secure attachment. Smaller panels, while easy to move and install and best for creating a range of module patterning options, did not have enough surface area for secure attachment and created more seams, requiring more hardware.

Despite its shortcomings, the smallest panel size, 16 inches by 16 inches, was used to test small scale production methods of



Figure 4. First gypsum cast in test mold. Image by Author.



Figure 5. Cast panel prototype. Image by Author.

custom panels that replicated techniques used in large scale manufacturing of gypsum wallboard. In this work, a pedestrian version of stucco – quick-setting gypsum plaster and water – was poured or cast into molds lined with a paper backing. While the casting technique is still in development, this method allows for the creation of custom panels that can test a variety of module sizes as well as edge and surface conditions. The development of this process allows for the design and testing of gypsum wallboard product advances that address issues associated with installation and finishing practices as well as aesthetic concerns.

This work serves as a response to the micro and macro impacts of the gypsum material system and the unchallenged product manufacturing and installation methods of gypsum wallboard products. By focusing this work on the products within the gypsum wallboard material system in addition to the processes, positive advances that would reduce carbon outputs and environmental hazards become ingrained within the material system. Features embedded into the design of gypsum wallboard products including module size, surface quality, and edge conditions can address large-scale issues within the

gypsum wallboard material system including shortages in skilled labor and the excess production of debris and waste. As we advance this research, we will continue to engage with industry-experts throughout the gypsum wallboard material system to ensure we are couched within a context informed by embodied industry knowledge while simultaneously considering possible futures for the gypsum wallboard industry.

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