Concrete Masonry in Green Buildings

Specifying CMU as part of a naturally sustainable design

Sponsored by Oldcastle® Architectural | *By Peter J. Arsenault, FAIA, NCARB, LEED AP*

At the Banner MD Anderson Cancer Center in Gilbert, Arizona, CMU construction combined strong aesthetic appearance, structural support, and green building attributes.

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Concrete masonry units (CMUs) are well known by architects, contractors, and owners because of their enduring history over thousands of years, demonstrating proven performance in many building types around the world. From a design standpoint, they provide flexibility, variety, and code compliance within a range of standardized and modularized shapes and sizes. From a construction standpoint, they are commonly available and installed by local masons using established construction techniques. From an owner's perspective, they provide affordable, durable, and safe facilities with comparatively low maintenance. But beyond all of this, their inherent characteristics and properties also contribute substantially to green and sustainable design. As we will explore further, they do this in multiple ways due to their inherently green nature.

CMU OVERVIEW

Architects have commonly specified CMUs for a variety of specific, traditional reasons recognizing that they can provide both structure and aesthetics in a single manufactured product. As a building material, modular manufactured CMUs provide construction assemblies that are durable and readily resistant to abuse, making it an ideal choice for commercial, institutional, and industrial applications. In designing a building requiring versatility, the variety of finishes, styles, and textures of CMUs offers a considerable design palette of choices to create successfully designed interior and exterior spaces. Conversely, while different units may appear to look the same on the outside, inside they can vary in weight, detailing, and reinforcing to suit a load bearing structural condition or be simply designed for lightweight non-load bearing partitions. The modular sizes of any of these hollow or solid units contribute to their overall economy and efficiency in design and construction. Since these sizes are typically larger than clay masonry units, they can be installed in less time and with less labor than smaller units and prove to be generally very cost effective overall. In applications where fire codes are a prevailing design priority, CMU walls provide a readily documentable level of fire resistance for extended time periods. In fact, in many cases, actual results of fires have shown that interior furnishings and materials may have burned completely while CMU-enclosed areas remain standing and in many cases can be readily cleaned and re-used. As a result, they have demonstrated their ongoing structural

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Learning Objectives
After reading this article, you should be able to:

1. Identify and recognize the traditional attributes and features of concrete masonry unit (CMU) construction.
2. Assess the strengths and limitations of CMUs for use in green building design including inherent green building characteristics.
3. Investigate and compare different strategies to increase green building performance using CMU construction.
4. Explore the types of innovative design applications and positive life-cycle attributes of CMU construction.

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Demonstrating the resilience of CMU, the West Street Building by Cass Gilbert was reopened in 2005 after being damaged by the World Trade Center collapse and a five-day fire in 2001.

integrity even under the duress of fires, storms, floods, and other disasters.

Beyond the traditional reasons to use CMUs, architects and owners seeking to design green and sustainable buildings have begun to discover and realize that all of these inherent attributes of concrete masonry attest to its true long-term sustainability. That is, it holds up well over time providing a very durable and resilient building that is easy to care for and maintain. And in most cases, it offers very positive life-cycle qualities related to cost and environmental impact.

Green building design is based on a variety of principles particularly related to the products used in construction. CMUs have gained attention in recent years for being very consistent with these green principles including its qualities of:

Use of natural materials. CMUs are manufactured around the world from sand, aggregate, and Portland cement, all of which are common and natural materials.

Low environmental impact. The materials that go into a CMU can be obtained using processes and procedures that respect the environment and restore areas where material is extracted. Further, recycled content is not only possible, but quite common, thus avoiding further extraction.

User comfort. High levels of acoustic, thermal and visual comfort are achievable using CMUs in interior and exterior spaces.

Energy reduction. CMU walls can be readily insulated and in many cases can contribute to additional thermal mass in a building which will reduce temperature swings, lower HVAC usage, and save on energy costs.

Noise transmission control. CMU walls typically achieve favorable sound transmission class (STC) ratings and help separate quiet areas from noisier areas.

> The modular nature of concrete masonry is actually quite optimal for dense sites that are short on space but high on pedestrian or vehicular traffic.

These inherent characteristics of CMUs have been described as making them "naturally green" in that they have already been doing for centuries the things that we are paying more attention to in building design today. Most notably, the green building movement in this country has given rise to quantifiable rating systems that seek to establish specific levels of achievement in the creation and performance of green buildings. The best known of these green building rating systems has been developed by the U.S. Green Building Council and known as the LEED® rating system. This is actually a family of ratings that apply to different building situations (e.g. new or existing buildings, core and shell, interiors) and in some cases building types (schools, healthcare, retail, homes, etc.). All of the LEED rating systems have been subject to ongoing changes and updates since their inception, but the basic categories of defining green buildings have remained the same across the different versions over time. With that in mind, we'll look at the contributions that CMU can make in each of these green building categories.

SUSTAINABLE SITES USING CMUs

The focus of this category of green building design is on enhancing the positive aspects of a building site while minimizing the negative impacts that adding a building can have on that site and the surrounding area. Generally, there are three areas that concrete masonry can help achieve this overall goal for sustainable sites:

Development Density

Providing denser buildings with smaller footprints has been demonstrated to be an important part of sustainable and walkable communities. The fire resistance capability of concrete masonry directly enables greater building density by meeting fire code requirements for separation of spaces. Further, the structural attributes of CMUs allow for vertical building design that can help minimize building footprints. In particular the modular aspect of concrete masonry lends itself to working well within small or irregular shaped building lots as easily as larger ones. In terms of optimizing the most appropriate use of a site, it is worth noting that segmented retaining walls (SRW) made of concrete masonry has the potential to allow for the utilization of sites previously considered to be unsuitable due to slope or irregular terrain. In all, creating denser clusters of buildings can be coupled with a high ratio of open space that promotes biodiversity and effective environmental site design.

Community Connectivity

The modular nature of concrete masonry is actually quite optimal for dense sites that are short on space but high on pedestrian or vehicular traffic. The use of concrete masonry pavers of different types and styles introduces a design element that helps weave a particular building or series of buildings into the community fabric it is located within. This can be an attractive and effective way to create pedestrian access between the project site and neighborhood buildings and services.

Stormwater Management

In the interest of reducing disruption to natural hydrology patterns and minimizing the potential for pollution due to stormwater runoff, permeable paving has emerged as a very effective strategy. CMU pavers that are non-pervious and allow stormwater to permeate between them are not only effective in this regard, they provide an attractive aesthetic with a variety of colors and textures compared to monolithic paving choices such as asphalt or concrete. By properly specifying and designing with CMU site pavers, green building objectives can be met by reducing impervious ground covering thus increasing on-site infiltration and reducing stormwater runoff. From a general design standpoint, this approach can also increase the usable space on a site while requiring very little maintenance. For more detailed information on this strategy, designers can consult the National Concrete Masonry Association (NCMA) technical bulletin titled “NCMA TEK 11-11: Permeable Pavements for Commercial Parking Lots.” Open grid paving systems are also recognized as reducing heat island effects and can thus provide this additional benefit as described further below.

Heat Island Reduction, Non-Roof

Developed areas are known to have higher air temperatures than non-developed areas due in large part to the presence of dark-colored surfaces that produce heat when the sun shines on them. This phenomenon is referred to as a “heat island” and can notably affect the localized microclimate, producing an unwanted warming effect on people and buildings. As such, strategies to reduce this generated heat focus on either shading dark surfaces or providing hardscape surfaces that reflect rather than absorb sunlight to keep temperatures cooler. The unit of measurement for a material to be effective in reducing the heat island effect is the solar reflectance index (SRI). Based on a scale of 1 to 100 per standard ASTM procedures, a score of 0 would apply to a standard black surface (highly non-reflective) while a score of 100 would apply to a white surface (very reflective). The green building standard is to achieve a minimum SRI of 29 across hardscape materials. Happily, typical new gray CMU pavers have been tested at an SRI of 35 thus exceeding the minimum benchmark by over 20 percent.

By using a combination of these CMU-based strategies in sustainable site design, designers can readily achieve a substantial number of points under the LEED rating system toward an overall green building certification level.

ENERGY AND ATMOSPHERE CONTRIBUTIONS FROM CMUs

Optimizing energy performance is what most people think of when they think green buildings. In all cases, the LEED rating system now requires some minimum performance levels to be achieved and offers the greatest number of potential points under this critical category. Using CMUs as part of an overall building envelope and construction strategy can contribute to over half of the available points here, but more importantly can dramatically reduce energy costs and the carbon footprint associated with a building in various ways.

Optimize Energy Performance through Continuous Insulation

The place where architects spend a lot of time addressing energy conservation is in the building envelope and specifically in how to effectively insulate the envelope from thermal heat loss or unwanted heat gain. It has become increasingly recognized in energy codes and standards as well as in LEED that insulation is most effective at achieving thermal performance results when it is truly continuous and not interrupted by framing or structural members thus avoiding energy-draining thermal bridges. Stud space insulation installed only between studs or other structural members dramatically decreases the effective insulation R-values of walls well below the intended design level. Conversely, it has been common for CMU cavity wall construction to place insulation between the layers or wythes of masonry such that the insulation is truly continuous and uninterrupted by any other structural members. This means that the full value of the insulation is available without compromise other than needed fasteners and intended openings, which of course need to be properly detailed. Further, the amount of insulation installed can vary based on a particular building’s needs and the climate it is located in thus seeking to optimize the performance of the wall. And since this is such a common practice, different modular products and insulation approaches are available. Some innovative approaches have even gone beyond the common cavity wall approach creating multi-part CMU systems that include an inner and outer CMU module with a middle piece of rigid insulation, which stops thermal breaks and contributes to overall energy performance.

Optimize Energy Performance through Thermal Mass

Buildings have become increasingly lighter in weight over the past 100 years, which means that the amount of pure mass in them is reduced compared to prior eras. In the process a significant thermal benefit was lost which is now being realized and incorporated again into green buildings. The physics of returning mass to a building allows the space to be thermally tempered; thermal mass slows the rate of temperature swings in a space creating a slower thermal lag. One of the easiest and most common ways of adding this thermal mass to a building is by using CMUs, but it must be located inside of

Photos courtesy of Oldcastle® Architectural

Permeable CMU site pavers allow stormwater to penetrate into the soil, thus avoiding unwanted run off, reducing pollution, and reducing the heat island effect.

the insulation layer to be truly effective for energy and comfort performance. The basic premise is simple. The thermal mass absorbs heat from the surrounding area when it is warm and re-radiates it back out thus cooling afterwards. Typically this means that the mass is absorbing heat during the daytime, helping to keep a space from overheating, and radiating at night, helping to keep a space appropriately warm. If you have ever walked into a masonry church or monument during the summertime you have likely felt the pleasant temperature difference immediately and then realized that there is likely no air conditioning at play. This natural ability for masonry to absorb and store heat produces multiple benefits to the owners and occupants of a building including:

- Peak heating and cooling loads can be reduced since the high and low temperatures of the space are moderated and temperature variations are reduced.
- Peak heating and cooling loads can be shifted to non-peak hours saving the owner on peak electricity rates and saving the utility company on overall peak energy supply requirements.
- The size of HVAC systems can be reduced since the high and low temperature points that the systems need to perform to can likely be trimmed—hence less heating and cooling capacity is needed.
- Building energy codes have come to recognize the energy benefits of thermal mass with prescriptive credit and trade-offs that can be garnered to show code compliance that might otherwise be unavailable.

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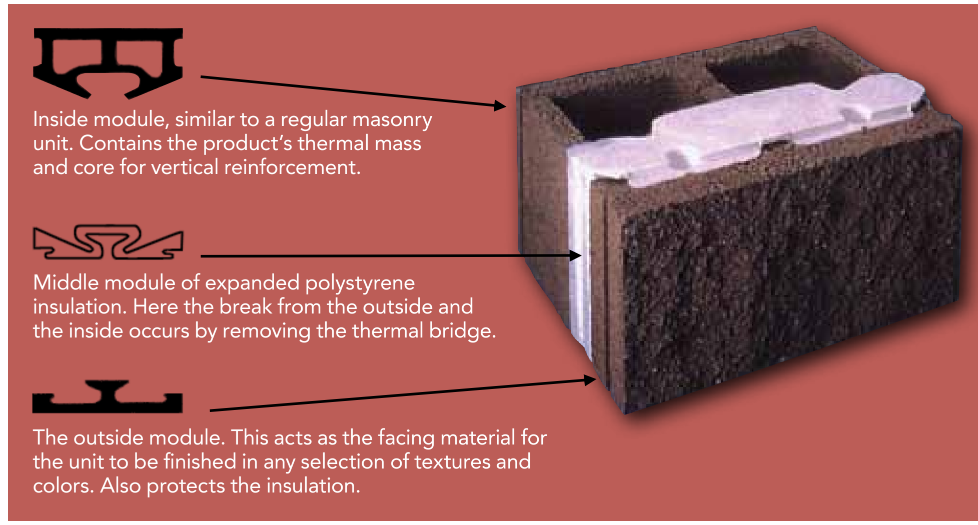

Some innovative CMU products provide multi-part units with a full thermal break avoiding thermal bridging.

It is important to recognize that there is a misconception that designing a building with added thermal mass will always use less energy and reduce energy costs overall. No one can realistically make that claim since there are many other variables that go into the design of a building and the systems that serve it. Therefore, it is important to look at the whole picture and perform computerized energy modeling if needed to see the potential energy savings for any given design. Nonetheless, adding thermal mass to a building does very often create all of the benefits stated above including the very real savings in many cases of buying energy during off peak hours. And maybe even more important to users, it is rather consistent in increasing occupant comfort. If the space is perceived as comfortable, then there is less likelihood to change the thermostat settings to a more energy-consuming level.

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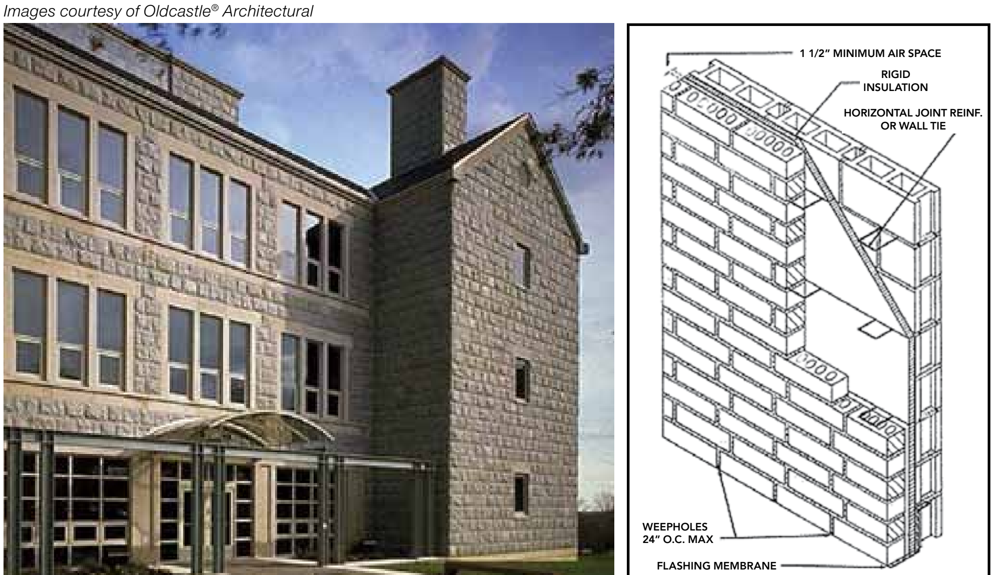

Typical cavity wall concrete masonry construction with continuous rigid insulation

Passive Solar Design

As we saw in the heat island example, solar energy works. Specifically when sunlight strikes a darker surface, it turns to heat as anyone who has ever walked barefoot in summer on asphalt paving can attest. It does this without the need for any mechanical equipment or outside energy, hence the use of the word "passive." In green buildings, the key is to capture that available solar heat and use it to the benefit of the building occupants. LEED recognizes the use of on-site renewable energy such as passive solar based on calculating the percentage of annual energy costs that are offset by this on-site energy. Points are awarded for as little as a 1 percent contribution with up to 7 points available for a 13 percent contribution to the annual energy needs of a building. Beyond LEED, the U.S. Department of Energy (DOE) estimates that energy cost reductions in the 30 to 50 percent range are possible using a combination of energy conservation and passive solar strategies.

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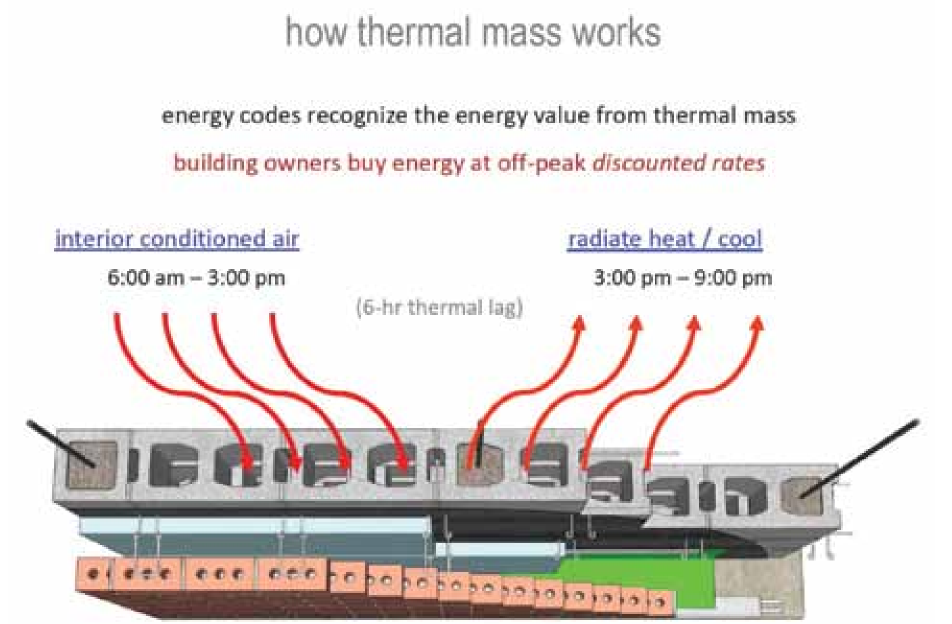

Thermal mass reduces the thermal peaks and valleys, creating a more even range of temperature inside the building envelope.

In order to capture passive solar energy in buildings, architects must first provide windows facing the sun that let the sunlight through but also help to keep the heat inside. A car sitting in the sun does that quite well, but of course the problem is that it gets too warm too fast and not all of the heat is usable or desirable. This is where thermal mass becomes important again. By adding CMU walls and paver floors to the building, the temperature spike is moderated since this thermal mass will absorb and store the passive solar heat during the day and then naturally release it during the night when it is needed. This is the basis of all passive solar strategies, but there are several common and somewhat different design methodologies to accomplish the desired results in buildings:

- Direct gain: This is the simplest conceptual approach relying on sunlight streaming directly into the habitable spaces and warming the rooms and the people accordingly. In order to avoid the unwanted "hot car" issue, thermal mass must be placed directly in the living spaces where the sunlight enters. This can be done using CMU pavers on the floor or incorporating CMU walls in the back and sides of the sunlit spaces, ideally allowing the light to strike them directly.
- Sunspaces: Since direct gain systems can sometimes produce unwanted results such as glare, an alternative approach using a separate room or sun space has been popular in some areas. This approach is also referred to as indirect gain since the solar energy is intended to first be captured in a separate room and then distributed to other areas of the building. Hence the living space is heated indirectly by the sun after being captured, absorbed, and tempered by the sun space. In residential design, sunspaces have sometimes taken on a role as a green house or a "three-season" room where the temperature is moderated but allowed to fluctuate since its primary purpose is to serve the main building. It should be noted that some atriums and similar spaces in commercial buildings act in this manner, whether they were specifically designed to do that or not. Understanding this design approach will help designers recognize the potential positive effects of a sun space and avoid its inadvertent use that can actually reduce energy performance if more cooling is needed to address it. In cases where the temperature needs to be moderated in the sun space, then thermal mass is needed as in the direct gain example.
- Thermal storage wall: This approach is the closest thing to a solar collector in passive solar terms. Sometimes referred to as isolated gain it relies on separating or isolating the passive solar collection and absorption from the space. This is commonly done by constructing a thermal mass wall, typically of dense masonry or CMUs, behind glazing. The glazing side of the wall absorbs the solar energy thus heating up the wall and transferring that heat to the rear of the wall which is exposed to the habitable spaces where the heat slowly radiates outward. This method, named for its French inventor is also called a Trombe wall and was originally conceived with openings at the top and bottom to allow free flow of air between the rooms and the glazed side of the wall. However, studies have shown that keeping the wall continuous and relying on direct heat transfer through the wall provides better results overall. Nonetheless in warm periods when heating is not needed, ventilating the space between the glazing and the wall surface will exhaust any heat and keep it from transferring through the wall.

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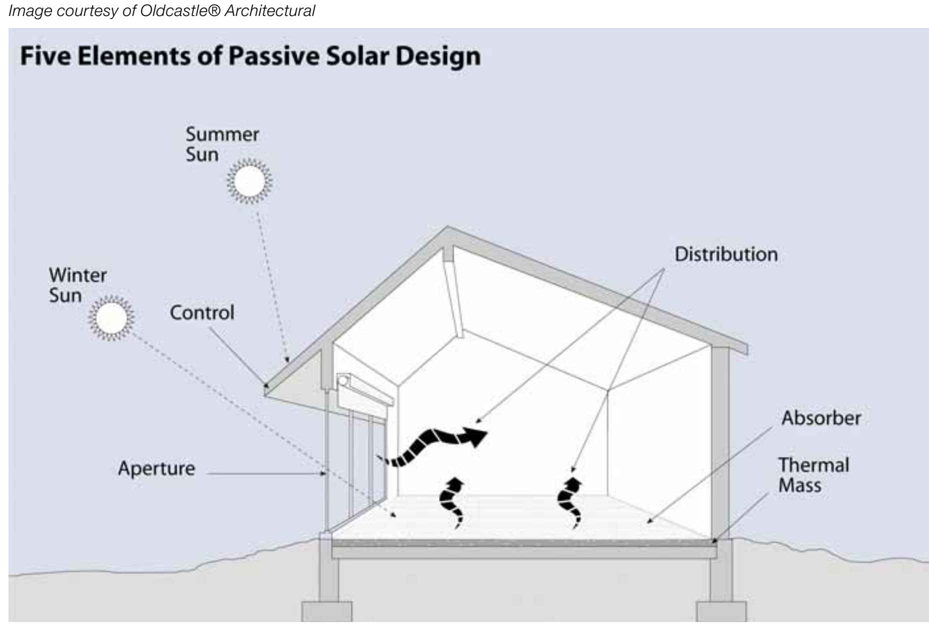

The common design approaches to using passive solar energy in a building all require an aperture (windows), control (overhangs), an absorbing surface, thermal mass in the walls or floor, and a means of heat distribution.

The best passive solar strategy is the one that will serve the needs of the building and its occupants and not be hindered or compromised by other building or user factors. Hence selecting a passive solar design strategy in the larger context of the building and overall energy goals will yield the most positive results and greatest on-site energy benefit.

MATERIAL AND RESOURCE CONTRIBUTIONS OF CMUs

Reduce, re-use, and recycle has become a mantra of green buildings and operations because it makes a dramatic difference on the environmental impact of those buildings. This is true in terms of the impact of production from virgin materials and in terms of the amount of embedded energy needed to create building products and materials. This is another area where CMU construction can make substantial contributions as part of an overall green building design:

Recycled Content

Through the use of partial cement substitutes CMUs can often demonstrate a significant percentage of recycled content calculated by weight. This can be added to other recycled content calculations to achieve an overall content goal for the building. Commonly, CMU manufacturers will incorporate recycled content in glazed block that has a smooth, impervious glazing on the surface or in ground face and polished block where one or more of the surfaces have the aggregate exposed. In terms of the actual recycled content, post-consumer materials take the form of recycled glass that is turned into powder and used in glazed or polished block. From a pre-consumer (reclaimed from manufacturing processes) standpoint, industrial recycled materials are common in many types of CMUs and include fly ash, silica fume, slag cement, and recycled aggregate.

Regional Materials

CMU plants are very common across the US and typically one can readily be found that is located with 50 to 100 miles of any developed area where project job sites are found. That means that it is typically very easy to demonstrate the use of regional materials when specifying CMUs since the LEED standard is within 500 miles of a project site.

Building Re-Use

Since CMUs are exceptionally durable with a service life that is measurably longer than many other building envelope products, it is very common to see buildings made from CMUs adaptively re-used and designed around pre-existing CMU walls, paver areas, etc. That means a substantial renovation of an existing building can be worked very successfully and economically when the building is found to contain substantial amounts of CMUs.

Photos courtesy of Oldcastle® Architectural

Glazed and polished CMUs in particular can be specified with significant amounts of recycled content that contribute to successful green building designs.

Materials Re-Use

When CMUs are crushed they break down into smaller pieces of irregularly shaped material. Since it is a composite of natural materials to begin with, it is readily re-usable as an aggregate in other applications.

Construction Waste Management

In cases where CMUs need to be demolished or removed from buildings, then crushing and recycling it is an immediate means of diverting it from the waste stream. This crushed material can readily be used as aggregate or fill in road beds, pipe bedding, in other manufactured concrete products, or simply as general construction site fill. Hence a substantial amount of weight that might have otherwise gone to a landfill is diverted and put to productive use elsewhere in the community.

Note that all CMUs must meet the stringent standards of ASTM C90 therefore any recycled content or re-used materials must not compromise the quality of the finished product or its ability to meet that standard. It is also worth noting that products with recycled content vary regionally, so specifiers would do well to confirm with local suppliers what is readily available or not.

INDOOR ENVIRONMENTAL QUALITY WITH CMU

The quality of the indoor environment has received growing attention in recent years particularly related to the health and performance of occupants. While this is true of all building types, schools especially have been the focus of attention since so many children and adults spend so much time together inside these buildings. It is logical then that the definition of green building includes attention to this critical component of building use. In this case, CMU construction a significant player not so much for what it does do, but for what it does not do and the things that are not present from CMU materials including the following:

Mold Avoidance

The presence of mold growth in buildings has been front and center in recent years as a serious concern. It is commonly understood that three things are needed for such mold growth—water, organic material as a food source, and air. A mold avoiding strategy recognizes that if mold spores are ever present in the air, and water intrusion is a possibility, the building materials should not be made out of organic materials that provide a food source for mold. Hence, choosing non-organic building components that will not support mold growth is called for. CMUs are just such a material since it is completely inorganic and simply does not promote mold growth—period. Hence, one of the best defenses against mold growth in buildings is to specify concrete masonry.

Elimination of VOCs

LEED and other design standards promote greatly limiting or reducing the amount of volatile organic compounds (VOCs) that are present inside a building. These are commonly found in applied finishes such as paints and stains or in adhesives to secure other materials in place. These VOCs have been shown to directly cause adverse health effects on many occupants and are often accompanied by odors all too familiar in many newly finished spaces. A very realistic approach to eliminating VOCs in

Photo courtesy of Oldcastle® Architectural

CMUs are available in a wide range of prefinished colors and textures that eliminate the use of VOC-containing site finishes while also eliminating the possibility of mold growth in buildings.

many cases is to choose materials for walls and partitions that simply do not require application of paints or finishes and hence do not contain any VOCs at all. CMUs are just such a product that can be prefinished without the use of any VOCs. Further, they are available in a variety of textures, colors, and other finishes providing a versatile range of options without the need for adding other finishes later in the life of the building.

Acoustics

This is an indoor environmental issue that is gaining increasing attention, particularly in schools. Independent studies have shown that the performance of children in schools is, not surprisingly, directly affected by their ability to hear and discern the verbal instructions being given in classrooms. As such, LEED for Schools has added both pre-requisites and optional credits for improving and enhancing the acoustical performance of walls. The requirements address Sound Transmission Class (STC) ratings of walls which is a measure of how much sound passes through an assembly. A higher STC rating means that more sound is blocked by the wall (i.e., quieter), while a lower rating means that more sound passes through (i.e., noisier). In schools, it is common to seek an STC rating in the range of 45 to 60 to create effective indoor acoustical spaces. As has commonly been demonstrated, CMU walls are quite effective at achieving these increased STC levels and creating superior acoustics in interior spaces.

The second criterion for enhancing acoustical performance is the absorption of sound to reduce or eliminate echoes and keep speech fully intelligible. This characteristic is directly a result of the materials or treatments used in the space. CMU structural products have been developed specifically to meet this need of acoustical absorption acting much the way a car muffler works. The shapes of these block units are closed on the ends but include vertical slots in the face of the block to allow sound to penetrate, resonate inside, and dissipate harmlessly within the CMU. Sound absorbing insulation may be added if needed inside a portion of the open cores of the CMUs particularly in cases of difficult to control low frequency noise. The surface appearance of such CMUs are available in glazed, ground face or common gray block units of choice. For more detailed specific information on using CMUs for acoustic control, NCMA TEK bulletins 13-1 B and 13-2 provide guidance.

Specifying and designing with concrete masonry, particularly in interior spaces, then, directly contributes to positive indoor environmental quality through the elimination of mold, the elimination of VOCs and the control unwanted noise or sound reverberation.

INNOVATIONS AND OTHER CONSIDERATIONS

Recognizing the need to allow for creativity and innovation in green buildings, LEED and other rating systems allow for designers to demonstrate specific ways that a building can excel and provide more than the minimum level of performance related to green building criteria. One of the ways to demonstrate long term high performance is to prepare a Life Cycle Analysis (LCA) on the building and the systems within it. Materials that provide long term durability, do not need replacement in 10 or 20 years, have low maintenance requirements, and

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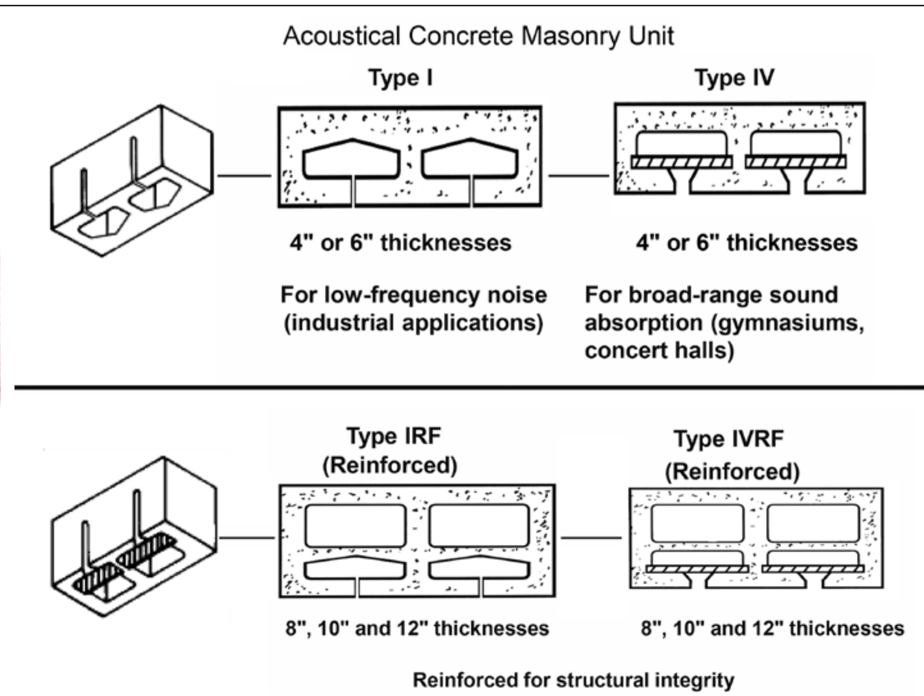

CMUs specifically manufactured to create enhanced acoustical performance in interior spaces includes slots to receive and dissipate sound plus acoustical insulation inserts where needed.

contribute to the long term thermal performance of a building will typically demonstrate a lower total life cycle cost compared to other materials that do not possess these traits. Hence, since CMUs have been shown to embody all of these characteristics, it will readily help a building demonstrate an overall positive life cycle analysis.

Of course, most owners are interested in first costs as well as long term costs. Appropriately addressing this question is a matter of identifying what a comparison is being made against. Conventional wood framed or light gauge steel construction has typically been found to be the least expensive means of construction, but does not have the same qualities and characteristics of concrete masonry buildings. Nonetheless, in some cases, the first cost difference between CMUs and these conventional framing systems can actually be negligible or only slightly more in the overall building cost since there are savings in finishing and other work. Pre-cast or poured in place concrete construction is typically more expensive than all of these, even with the use of insulated concrete forms (ICF) systems. Further, since some concrete masonry can be fashioned with the appearance of large sized brick, it can provide a desired appearance with less labor cost than clay masonry construction. In many cases, then, CMU compares favorably in first costs as well as long term costs.

In terms of innovations in the use of materials, the color and reflectivity of CMUs is a particularly good place to look. Using light colored, high albedo concrete pavers will help reduce heat island effect as discussed earlier. However at night, they will reflect artificial light too which can lead to lower outdoor lighting costs. Similarly, these reflective pavers can help reflect desired daylight into a space during the day thus contributing to the use of day-lighting and lowering electric lighting costs during the day as well.

CONCLUSION

As all of the above has shown, green building design and CMU construction are naturally compatible and completely consistent with each other. Concrete masonry pavers make distinct community design statements that can also allow stormwater to permeate through and reflect back unwanted heat from the sun. CMU walls that allow for continuous insulation and add thermal mass contribute to optimizing the energy performance of a building while incorporating passive solar design principles allows for on-site renewable solar energy to be harvested. As a durable, fire resistant, and low maintenance material, CMUs can also be re-used and recycled for long term environmental contributions. Indoors, CMUs can help eliminate mold, VOCs, and unwanted sound. From a cost standpoint, it performs favorably in first cost and life cycle costs. With all of these naturally green attributes, it is easy to see why concrete masonry has endured for so long and is just as likely to continue on well into the future.

Photos courtesy of Oldcastle® Architectural

Highly reflective concrete masonry paving reduces the need for outdoor lighting and can lower energy costs at the same time.

QUIZ - FOR REFERENCE ONLY

1. Traditional attributes of CMUs include which of the following?
a. CMUs provide construction assemblies that are durable and readily resistant to abuse.
b. CMUs offer a considerable design palette of choices to create successfully designed interior and exterior spaces.
c. The modular sizes of any of these hollow or solid units contribute to their overall economy and efficiency in design and construction.
d. All of the above

2. Actual results of fires in buildings using CMUs have shown that:
a. interior furnishings don't burn in CMU buildings.
b. interior furnishings and materials may have burned completely while CMU-enclosed areas remain standing and in many cases can be readily cleaned and re-used.
c. after a fire, CMU buildings always have to be demolished.
d. CMU walls aren't left standing after a fire.

3. By properly specifying and designing with CMU site pavers, green building objectives can be met by:
a. reducing impervious ground covering thus increasing on-site infiltration and reducing stormwater runoff.
b. improving the overall green appearance of the building area.
c. reducing site construction time.
d. channeling water to run away quickly into the storm drainage system.

4. In order to demonstrate a reduction in the heat island effect, site pavers need to have a minim solar reflectivity index of:
a. 0.
b. 29.
c. 35.
d. 100.

5. Insulation is most effective at achieving thermal performance results when it is truly continuous and not interrupted by framing or structural members thus avoiding energy draining thermal bridges.
a. True
b. False

6. Designing a building with added thermal mass will always use less energy and reduce energy costs overall.
a. True
b. False

7. By adding CMU walls and paver floors to a passive solar building, the temperature spike is moderated since this thermal mass will:
a. get hot very quickly and radiate directly back into the space.
b. keep the building cool all day and all night.
c. absorb and store the passive solar heat during the day and then naturally release it during the night when it is needed.
d. fluctuate rapidly between hot and cold temperatures so the space doesn't fluctuate.

8. From a pre-consumer standpoint, industrial recycled materials are common in many types of CMUs and include fly ash, silica fume, slag cement, and recycled aggregate.
a. True
b. False

9. Indoor environmental quality can be improved using CMUs through:
a. mold avoidance.
b. elimination of VOCs.
c. acoustic performance.
d. All of the above

10. Since CMUs provide long-term durability, do not need replacement in 10 or 20 years, have low maintenance requirements, and contribute to the long-term thermal performance of a building they will typically demonstrate a lower total life-cycle cost compared to other materials that do not possess these traits.
a. True
b. False

Quiz Answer Key

Question	Answer
1.	D
2.	B
3.	A
4.	B
5.	A
6.	B
7.	C
8.	A
9.	D
10.	A