Less than Expected and more

Competitive Advantage of Lightweight CMU
by Jeff Speck, PE, FASTM, FACI

As labor costs continue to increase, block manufacturers are looking for ways to help mason contractors gain a competitive edge, increasing production while reducing installed wall cost. The 24" lightweight concrete masonry unit (CMU) weighs less than a normal weight 16" CMU. The combination of greater size and less weight correlates to less time to lay up a wall. Although every block measures 50% more area than the traditional 16" unit, it is a bit lighter than a normal weight 16" unit, so it can easily be laid in the same time that the 16" unit can. The result is a 50% increase in production, greatly reducing the labor cost. And still with all the benefits of traditional CMU: structural load-bearing and shear walls, superior fire resistance, durability, water resistance and more.

Reduction in Wall Cost Labor costs account for up to 60% of the cost of a masonry wall. By increasing the size of the CMU by 50%, but maintaining or reducing the weight of the unit, the mason is able to increase his productivity by 50% while maintaining his normal pace and quality. This increase in productivity lowers the labor portion of the wall cost, more than offsetting the cost of the unit, (only about 15% of the cost of the wall). Cost savings can be substantial – certainly enough to sway the decision on material choice from tilt-up or precast concrete to CMU.

Doing the Math The 24" unit is not new. It has been around since at least the 1960s. Although the look of this oversize unit really makes a statement, in some areas, labor rules require two masons to lay units that are over a specified weight. The 24" 55 lb normal weight units fall into that category more often than not. The math changes with the introduction of the lightweight 24" unit weighing in at about 35 lb, making it much easier for one mason to handle. By eliminating the extra mason, and allowing the mason to maintain his normal production rate on the wall, labor costs go down dramatically, instead of up.

Thus, lightweight units are now more economical. Capitalizing on labor speed, the 24" lightweights beat the cost of the normal weight CMU wall. (see Table) And that’s what matters! A 16" normal weight CMU typically weighs about 38 lb. A normal weight 24" unit weighs about 55 lb. The increased labor cost associated with 24" normal weight units rendered them more expensive.

Time and labor required to construct the CMU walls at the Maryland Science Center in Baltimore were reduced by one-third. The project, which included six 75,000 sf office-warehouses, had a strict completion deadline and a tight budget. The contractor was able to deliver by converting from standard 16" units to lightweight 24" units. This type of project is especially well-suited to 24" units: long, straight walls with few openings that allow the masons to maintain a productive pace.

What Makes Lightweight Units Lighter? Lightweight 24" CMU are made with structural grade expanded shale, clay or slate (ESCS) lightweight aggregate. Using a process invented in 1918, ESCS lightweight aggregate is produced in a rotary kiln similar to a cement kiln. ESCS lightweight aggregate is made from select raw materials that are fired to approximately 2000° F. At this temperature the raw material becomes molten, undergoes a phase change and bloats. The process imparts tiny, non-connected air voids within the solid matrix. Upon cooling, the material is no longer shale, clay or slate, but a ceramic aggregate that is strong, tough, durable and inert. And less than half the density of typical concrete aggregate. By replacing ordinary, heavy aggregate with lightweight, the block producer is able to reduce the density of the concrete and the weight of a CMU. The amount of lightweight aggregate replacement determines the final density and weight reduction.

Upon reading the article you will:

1. Differentiate chemical properties of normal weight and lightweight CMU.
2. Compare and contrast variables of a CMU wall constructed of normal weight and lightweight CMU in regard to items such as schedule, cost, strength, fire rating and thermal performance.
3. Evaluate sustainable characteristics of lightweight CMU.
What about Strength, Fire Resistance and R-Value?

Today’s lightweight CMU are made to meet or exceed requirements of ASTM C90, Specification for Loadbearing Concrete Masonry Units. They are typically made to exceed the compressive strength requirement of C90 and can achieve significantly higher compressive strengths when specified, allowing the structural engineer to optimize the masonry wall design in accordance with the Masonry Standards Joint Committee’s (MSJC) Building Code Requirements (TMS 402/ACI 530/ASCE 5). Compressive strengths of 3000 to 4000 psi are easily achievable with lightweight CMU. Other properties also factor into the structural design, including the unit weight (which affects the wall weight) and section properties that are a function of the unit configuration.

Superior fire resistance is a well-known attribute of all concrete masonry. Concrete masonry walls provide passive fire protection – it’s always there, protecting life and property without relying on sensors or systems that are prone to failure due to lack of maintenance. The 24” lightweight CMU provides better fire resistance than 6” normal weight units. In fact, lightweight units require less equivalent thickness to achieve a given fire rating than normal weight units. For example, a 35 lb, 8X8X24 lightweight CMU will provide a 2-hour fire-rated wall with an equivalent thickness of only 3.8”, while a 38 lb 8X8X16 normal weight unit requires an equivalent thickness of 4.2” to achieve the same 2-hour rating. Smaller equivalent thickness means less concrete in the unit, saving material and further reducing wall weight.

The same insulating properties that give lightweight CMU greater fire resistance also enhance the thermal energy performance of the wall. According to ACI 122R, Guide to Thermal Properties of Concrete and Masonry Systems, the thermal conductivity of concrete with a density of 90 lb/cf is less than half that of concrete with a density of 140 lb/cf. The lower conductivity of lightweight CMU, combined with low diffusivity and high specific heat, provide optimum thermal performance in a concrete masonry wall. Added insulation, whether in the cores of the unit or in the cavity between two wythes of masonry, is made more efficient when combined with lightweight CMU. For example, according to NCMA TEK 6-2B, a normal weight 8” uninsulated wall has an R-value of 1.9, while a lightweight wall built with the 35 lb 24” unit has an R-value of 2.5. That’s a 32% improvement! The same two walls with the cores filled with foam insulation have R-values of 3.4 and 7.9, respectively. The lightweight wall provides a 132% increase in R-value!

Sustainability Optimized  Every building project today tries to maximize sustainability. Often this is done using LEED® programs as a measure of success. When evaluating construction materials, there is frequently an emphasis on recycled content, and indeed there is a point or two available for recycled content if all the materials in a project reach a certain threshold. Lightweight concrete masonry can contribute to the recycled content credits, as well as the regional materials credits. But there are other, often overlooked aspects of sustainability provided by lightweight CMU. For example, because lightweight CMU are lighter, more of them can be transported on each truck load. This not only reduces the delivery cost, but it also reduces the number of truck loads required, reducing fuel consumption, exhaust emissions and traffic. In other words, the project’s carbon footprint is reduced. What could be more sustainable?

The durability and longevity of concrete masonry increase the service life of structures. More often than not, concrete masonry walls can be reused when a building is renovated, another sustainability strategy.

Maryland Science Center included six 75,000 sf office warehouses. Time and labor to construct enclosure walls were reduced by 33% using 24” lightweight CMU.

As mentioned earlier, lightweight CMU enhance the thermal performance of the building envelope. The 19 Optimize Energy Performance credits available in LEED are an indication of the importance of energy conservation in the sustainability equation. Lightweight concrete masonry helps reduce peak heating and cooling loads, allowing the use of smaller HVAC equipment. Smaller equipment that runs continuously uses less energy than large equipment running intermittently in response to peak loads. Smaller equipment also costs less, uses less material and requires less energy to manufacture and transport. As noted earlier, insulated lightweight CMU walls achieve higher R-values which can be utilized to counter the effects of increased daylighting.

Indoor Environmental Quality is another sustainability consideration. Lightweight concrete masonry contains zero volatile organic compounds (VOCs), so it is not only a low-emitting material, it is a “no emitting” material! VOCs include a variety of chemicals that may be emitted as gases from products and materials, potentially affecting human health.

Midwest Cost Information - Masonry Advisory Council Cost Guide
(Based on Bricklayer / Laborer / Operating Engineer 6/01/11 Labor Rates)

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<th>Unit Size</th>
<th>Unit Cost</th>
<th>Density</th>
<th>Weight of Unit</th>
<th>Productivity Units/8hrs</th>
<th>Time to lay 1 Unit</th>
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Making it Work Frequently asked questions include concerns about water penetration, strength, acoustics, color and texture. Let’s discuss them one at a time:

• Water Penetration Today’s second generation integral water repellant admixtures have solved, once and for all, the question of water penetration in concrete masonry walls (see photo). Many people incorrectly believe that the porous lightweight aggregate can provide a path for water to pass through the block. As mentioned earlier, lightweight aggregate pores are not connected to one another, so water can’t pass through the aggregate particles. Aggregate gradation is critical, because poorly graded aggregate creates pore spaces between aggregate particles, which does provide a path for water intrusion. New integral water repellant admixtures are able to seal those pore spaces and prevent water penetration, even under wind-driven rain conditions. Of course, the best strategy for preventing leaky walls, especially single wythe walls, is to use breathable integral water repellant admixtures and exterior sealant – a “belt and suspenders” strategy.

• Compressive Strength Addressed earlier, this bears repeating. Lightweight concrete masonry units can be produced to achieve the same compressive strengths as other CMU, allowing the engineer full flexibility in selecting design compressive strength of masonry (Fm).

• Acoustical Properties Lightweight CMU provide sound transmission coefficients one would expect from concrete masonry. An 8” lightweight CMU wall provides an STC of 45, even at a density as low as 80 pcf. Of course, the STC can be increased by filling the cores with grout or granular fill. For noise reduction within a room, lightweight CMU walls provide noise reduction coefficients that are typically 65% greater than normal weight CMU walls. Noise reduction is greater for unpainted walls, but even for painted walls, the ratio is maintained.

• Color and Texture Traditionally, lightweight concrete masonry has been used where standard grey units are specified. Today, lightweight CMU are produced in many colors and finishes, giving architects and designers more choices than ever. Available colors are affected by aggregate color, so check with your block producer.

Less than Expected…and More Lightweight 24” units have the potential to help the masonry industry once again provide architects and owners the most flexible, economical structural wall system, especially for projects that have buildings with long, straight walls, such as schools, shopping centers and big box retail stores, distribution centers and warehouses. In addition to the Maryland Science Center, lightweight 24” units were used in building the Waukesha County Jail in Wisconsin, and numerous projects in Kentucky and Michigan.

The 24” units can be made in a 2-core or 3-core configuration. Currently, only the 3-core units are available in the upper Midwest. They have the same size cores as conventional 16” units and are laid in one-third bond to accommodate rebar and grout alignment. The dimensions of the 24” units provide a more brick-like scale (length vs height), but the size makes them reminiscent of stone masonry.

At first glance, you expect them to be heavy, but when you pick one up, you find that it weighs far less than you expected. But it offers so much more.