A White Paper Report on Green Building, Sustainable Design and Concrete Masonry as Manufactured and Constructed in California and Nevada

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for
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Background on Green Building

Over the past several years, "green" has gone from unusual to mainstream. This is true of everything from household products to construction. In the area of construction, there are green rating programs to assess infrastructure as well as commercial and residential buildings. For buildings, the best known green rating program is the Leadership in Energy and Environmental Design Rating System, or as it is better known, LEED®. Other green building assessment programs include Green Globes®, the International Green Construction Code™ (IGCC™) and CALGreen for commercial construction; and the National Green Building Standard™ and Energy Star Homes for residential construction; and the Collaborative for High Performance Schools (CHPS) for schools.

These green building programs have many elements in common. All strive to improve building performance in the areas of energy use, water use, building materials, indoor environment, and the project site. And though the specifics of each program may vary somewhat, all recognize buildings that use less energy, less water, provide daylighting, and limit construction waste. Table 1 provides the general categories found in the IGCC, LEED and CALGreen. Note that the table is for comparative purposes only, and does not provide a complete list of all topics covered by each rating program.

Green Building vs. Sustainable Design

Green building rating programs commonly include the following areas that relate to concrete masonry:

- Environmentally responsive site planning
- Energy efficient building shell
- Thermal comfort
- Energy analysis
- Superior indoor air quality
- Environmentally preferable materials and products

Sustainability is often described as a three-legged stool that strives to balance environmental, economic and social goals. Sustainable design goes beyond the rather narrow focus of green building to also include the following attributes [Ref. 2]:

- Durability
- Low maintenance
- Safety/security
    - Fire resistance
    - Impact resistance
- Acoustic performance
- Superior indoor air quality
    - Mold resistance (not included in most green building programs)
    - Low/no VOC content
- Environmentally preferable products and materials (some of these attributes are considered by green building programs, but many are not)

    - Abundance of raw materials
    - Efficient use of raw materials
    - Use of recycled materials
    - Sustainable measures in acquisition or manufacture
    - Use of regionally available raw materials (near to building project site)
    - Regional manufacture or fabrication (near to building project site)
    - Recyclable
    - Salvageable
    - Durable
    - Non-toxic (not made of toxic materials)
    - Avoidance of construction waste
- Life cycle cost

This white paper examines concrete masonry and related products and construction in the broader context of these sustainable attributes. References to green building programs, such as LEED, are also provided.

Concrete Masonry and Related Products

The concrete masonry products evaluated and included in this report are typical of those manufactured by CMACN members. The following list of concrete products has been evaluated.

- Concrete masonry units with no recycled content
- Concrete masonry units with recycled aggregate
- Concrete paving units with recycled aggregate
- Segmental retaining wall units with recycled aggregate
- Grout with fly ash and/or granulated blast furnace slag cement (slag)

Evaluating the applicability to sustainable design strategies requires an understanding of the use of the product and its manufacture. Several aspects of manufacturing and construction that differentiate concrete masonry in CA and NV from the rest of the U.S. have environmental benefits. Based on information received from CMACN and that obtained online, the following generalizations can be made.

<u>Raw Materials</u>

Concrete masonry products are primarily composed of cement, fine aggregates (i.e. sand), coarse aggregates (i.e. gravel) and water. Most concrete masonry producers in CA and NV incorporate crushed concrete masonry units as aggregate in their concrete block units and many also include it in paver and/or SRW units. Some producers manufacture units with a 25% post-consumer recycled content. [REF. 3] Most concrete masonry producers source their raw materials from within 200 miles of their manufacturing plants which are located throughout the region. In many cases, raw materials travel less than 25 miles to the plant.

Manufacturing

Most concrete masonry producers incorporate a number of best practices to increase their manufacturing efficiency and lower costs, which also provide environmental benefits. Best practices include minimizing material waste, recycling water, reducing energy use, and sourcing raw materials as close as possible to the plant. In addition, while the machinery used to manufacture concrete masonry units, pavers, and SRW units is typical of that used throughout the U.S., there are several aspects of manufacture in the CA/NV region that result in units with a lower embodied energy and fewer environmental emissions as compared with other regions of the country.

- *Many concrete masonry producers steam cure their units for 24 hours or less.* Because of the temperate climate, curing for shorter periods and in some cases without steam is possible which results in much lower energy use. Also unlike other parts of the U.S., in many cases the manufacturing facilities are unconditioned spaces, which decreases the energy associated with manufacture.
- *Many concrete masonry producers operate on electrical grids supplied by hydro-electric generating plants and gas-fired electric generating plants rather than coal-burning electrical plants*. Hydro-generated and natural gas-generated electricity are associated with lower emissions to the environment.
- *All concrete masonry producers spend a significant effort monitoring water usage and storm water run-off.* Water usage and storm water are highly regulated in CA and NV.
- *Smoke stack emissions are highly regulated and all equipment used in production and transportation is required to meet very strict emission standards.* These regulations result in lower emissions to the environment.

The most common loadbearing concrete masonry unit shape produced is the H and A shaped blocks. These units have one or two open ends that allow for easy placement around reinforcement. Concrete masonry units produced by the members of CMACN meet the corresponding ASTM specifications for loadbearing concrete masonry units (ASTM C90), concrete masonry pavers (C936), and segmental retaining wall units (C1372). These specifications ensure quality and performance. In recent years as the demand for green building materials has increased, manufacturers have moved to incorporate recycled and non-traditional materials into the mix. While these materials can be an important strategy in sustainable design, it is important that building products still meet the appropriate material specifications in order to ensure expected performance. Non-traditional building products should be carefully evaluated for performance and durability before specifying.

Construction

Due to the high seismic risk in CA and NV, a majority of concrete masonry construction requires fully grouted reinforced walls. In a fully grouted 8-inch thick concrete masonry wall, half the volume of the wall is masonry grout. Because of this, grout with a high percentage of supplementary cementitious materials (SCM) is the norm. A combination of fly ash and granulated blast furnace slag cement, both pre-consumer recycled materials, is typically used to replace up to 50% or more of the Portland cement used in grout. This results in walls with a lower embodied energy and lower carbon footprint than equivalent tilt-up concrete walls. One

study [REF. 1] found that an 8-inch fully grouted concrete masonry wall used 25% less cement than a 6-inch tilt-up concrete wall.

The steel reinforcement used in grouted concrete masonry walls also contains a high percentage of recycled materials. According to information provided by the Concrete Reinforcing Steel Institute, steel reinforcing bars can be assumed to have a total (combined pre- and post-consumer) recycled content of 97%.

Sustainable Design and Concrete Masonry

Concrete masonry products and construction can play an important role in achieving green or sustainable building designs. Concrete masonry and related products, especially as produced by members of CMACN, may incorporate many desirable attributes including durability, thermal mass, recycled content, local/regional production, lower embodied energy, smaller carbon footprint, fire resistance, and ballistic and impact resistance. In addition, concrete masonry and related products can be utilized in numerous sustainable design strategies to achieve superior acoustic performance, take advantage of thermal mass and passive energy strategies, reduce and manage storm water runoff, reduce construction waste, and provide safety and security. These attributes and strategies are discussed in detail in the sections that follow.

This white paper contains information that is applicable to concrete masonry products generally, as well as information specific to concrete masonry products and construction as found in California and Nevada and as produced by members of CMACN. Though many of these strategies may also be appropriate for residential construction, the residential market has several unique aspects that are not covered here.

<u>Environmentally Responsive Site Planning</u>

Environmentally responsive site planning includes consideration of site selection, site disturbance, storm water management, and effect of the building on its surroundings.

Site Selection. The location of the building site influences many aspects of sustainable design from heating and cooling loads on the building to the efficacy of alternate/public transportation. Locating a building in an already developed area, such as an urban infill project, minimizes the need for new infrastructure and often provides ready access to public transporation. *Concrete masonry construction* is well-suited to such applications, providing benefits of fire safety, impact resistance, acoustic isolation, flexible design and minimal access requirements. Concrete masonry construction allows for more flexibility both on-site and in design, especially as compared with tilt-up concrete construction which requires large casting areas and is limited to only a few stories in height.

Heat Island Effect. The heat island effect is that effect whereby dark colored surfaces retain excess heat creating a microclimate. This is why oftentimes nighttime temperatures in the countryside are much cooler than in a city. The heat island effect can be reduced by shading of horizontal surfaces and by utilizing light-colored, reflective materials. Recently this notion has been expanded to also include vertical surfaces. Generally the requirements apply to opaque

wall surfaces only. *Concrete masonry units, pavers, and SRW units* can all be produced in colors that meet the solar reflectance criteria found in the various green building programs for both walls and hardscape surfaces.

Storm Water Management. Limiting the amount of storm water runoff and treating storm water on-site, can help reduce the negative effects on lakes and rivers. Permeable paving systems are a sustainable design strategy that is essential in controlling and treating storm water. Permeable paving systems allow storm water to permeate the paving system, cleansing the water and allowing it to recharge the aquifer. *Concrete pavers* can be used as part of a permeable paving system for pedestrian sidewalks, courtyard and other hardscape areas as well as for roads and parking areas.

Energy efficient building shell, Thermal Comfort, and Energy Analysis

An energy efficient building envelope is a key component in sustainable building design. Achieving an energy efficient building envelope includes consideration of both the fenestration and the opaque portions of the wall and is best achieved by utilizing a performance, rather than prescriptive, approach to design. Limiting the glazing can improve the energy efficiency of the entire building envelope. In addition, it is important to consider both the thermal mass of materials as well as their insulating value.

Concrete masonry units, because of their weight, provide energy efficient thermal mass. Incorporation of thermal mass into a building can provide numerous energy benefits, including the reduction of peak heating and cooling loads, moderation of indoor temperature swings (improved thermal comfort), and potential reduction in the size of the HVAC system. In order to thoroughly account for the benefits of thermal mass, energy analysis using simulation software is necessary. Energy Plus or eQuest [REF. 6] are the most suited to analysis of buildings with large amounts of thermal mass.

Durability and Low maintenance

Concrete masonry products are long lasting with lifespans of over 100 years, and require little maintenance. As a result, the environmental impacts associated with concrete masonry construction, such as embodied energy, are reduced when considered on an annualized basis, spread out over a long lifespan.

Safety and security

Safety and security are two aspects of sustainable design that are not covered by the LEED-NC Rating System. Fire-resistant construction and resistance to impacts and wind-borne debris promotes occupant health and safety. *Concrete masonry* is non-combustible and provides resistance to impacts.

Acoustic comfort

Acoustic comfort is another important element in sustainable designs. Walls with high Sound Transmission Class (STC) values provide superior acoustic insulation. The STC values for *concrete masonry units* range from 44 for 4 inch units to 45 to 50 for most hollow units, to 60 for

fully grouted 12-inch walls. [REF. 4] In addition, acoustic sound-absorbing block are also available which provide noise reduction coefficients (NRC) of 0.50 to 0.85 in addition to superior STC ratings. Most rating systems with acoustic criteria require a minimum STC for walls of 50 and 35 for fenestration. Many of the concrete masonry units evaluated meet these criteria.

Superior indoor air quality

Superior indoor air quality encompasses both the reduction/elimination of pollutants in a building (i.e. tobbaco smoke, chemical pollutants) as well as moisture control to avoid mold. *Concrete masonry products* are inert, are not food for mold, and do not produce volatile organic compounds (no VOCs). Several of the green building programs, including the IGCC, have recognized this inherent property and have listed concrete masonry and concrete pavers as "deemed to comply" with the VOC limits of the code.

Environmentally preferable materials and products

Consideration of the environmental impact of building materials and products is an important element in a sustainable design, though it is only one of several criteria to be considered for product selection. Materials should be evaluated over their entire life cycle, from raw material extraction to end of useful life. This life cycle assessment (LCA) of a building material or product must include accurate evaluation of product service life.

There are several aspects to consider in the environmental evaluation of building materials. Life cycle assessment allows for a complete examination of all aspects of building material manufacture and use. It includes all impacts from raw material acquisition to manufacturing to building maintenance and end of building life. This is often called "cradle to grave" for building materials. However in the U.S., life cycle assessment of building materials is often lacking. Few manufacturers can provide such robust information about their products. As a result, green building rating systems such as LEED-NC have developed surrogate measures of environmental impact such as recycled content, as well as measures that reflect on-site construction practices. However LEED provides only a limited examination of attributes. A more comprehensive look at environmentally preferable products should include one or more of the following strategies:

- Abundance of raw materials
- Efficient use of raw materials
- Use of recycled materials
- Sustainable measures in acquisition or manufacture
- Use of regionally available materials (near to building project site)
- Regional manufacture or fabrication (near to building project site)
- Recyclable
- Salvageable
- Durable
- Non-toxic (not made of toxic materials)
- Avoidance of construction waste

Concrete masonry, paver and SRW units may incorporate several of these strategies. All are made from sand and gravel which are considered abundant raw materials, and most raw materials are available regionally. Many producers incorporate recycled materials into their products. CMACN member producers incorporate numerous sustainable measures in their manufacture and acquisition of raw materials. These are described in more detail in the sections Raw Materials and Manufacturing, but include recycling of waste water, use of electric carts, sourcing of raw materials close to the plant, and others.

Concrete masonry, pavers and SRW units have little on-site construction waste and are themselves recyclable, as is their packaging. Units can be salvaged and reused, particularly non-mortared units. *Concrete masonry products* are durable, lasting 100 years or more, and require minimal maintenance. *Concrete masonry products* are inert and are not made from toxic materials.

Life cycle cost analysis

Costs of building materials should be considered over the entire life span of the building. Durable materials like concrete masonry products generally have an advantage in that because of their long life and low maintenance, their life cycle costs are often low as compared with products that have a low initial cost but high life cycle cost.

Concrete Masonry and the LEED Rating Program

Many of the sustainable attributes discussed are covered in the LEED rating program. Table 2 provides a quick reference to specific credits in the LEED 2009 New Construction Rating System (updated July 2012) related to the concrete masonry products covered in this report. The specific requirements for each of the LEED credits can be found in the LEED 2009 Rating System and corresponding Reference Guide. [REF. 5] Note that the U.S. Green Building Council is anticipating a new version of LEED (LEEDv4) to be published in June/July 2013 which will be substantially different from LEED 2009 in the area of Materials and Resources. However, it is anticipated that LEED 2009 will continue to be used until at least 2015.

Regional Priority Credits and Pilot Credits offer additional ways for building projects to earn LEED points. Regional Priority Credits are credits found in the 2009 LEED Rating System that have been selected by the regional USGBC chapters as important to the region and thus deserving of “bonus points”. Regional Priority Credits are based on the zip code of the building project. If a project earns a credit that is listed on the Regional Priority Credit list for that zip code, it is also awarded one bonus point. A given project can earn up to 4 Regional Priority Credits. Regional Priority Credits related to concrete masonry in the CA/NV regions are listed in Table 3.

Unlike Regional Priority Credits, Pilot Credits include areas not currently covered in the LEED 2009 Rating System and items proposed for inclusion in LEEDv4. Examples include things such as Whole Building Life Cycle Assessment and Acoustic Performance. Pilot Credits are awarded through the Innovation in Design Credit Path 3. Up to 5 points can be earned through

Pilot Credits. A complete list of Pilot Credits can be found on USGBC's website at www.usgbc.org/pilotcreditlibrary, and Table3 includes those most relevant to concrete masonry products and construction.

Concrete Masonry and the 2010 CALGreen (with July 1, 2012 Supplement)

The 2010 Title 24, Part 11, California Green Building Standards Code, known as the 2010 CALGreen code, contains mandatory and optional provisions for green building for those agencies that choose to follow it. In July 2012, a Supplement was introduced that modified many of the provisions of the 2010 edition. The CALGreen code contains many provisions that are similar to the LEED Rating System criteria. Those strategies that utilize concrete masonry products are summarized in Table 4.

Conclusion

Sustainable building design incorporates consideration of more than just recycled content of building materials. Sustainable building design also considers among other things the durability of the building and building products, environmental concerns, safety and security, as well as life cycle cost. Concrete masonry products can be utilized in numerous sustainable building design strategies to achieve high performing, environmentally-friendly, long-lasting buildings. In addition, concrete masonry producers incorporate many best practice measures in their production to provide products that meet or exceed the code required specifications and performance expectations while lessening their environmental footprint.

Table 1: Comparison of Primary Categories in Commercial Green Building Programs

2012 IGCC chapters	LEED 2009 categories	CALGreen 2010 chapters/sections
Chapters 1-2 – Administration and Definitions		Chapters 1-2 – Administration and Definitions
Chapter 3 – Jurisdictional Requirements and Life Cycle Assessment		Chapters 3-4 – Voluntary Measures and Adoptions
Chapter 4 – Site Development and Land Use	Sustainable Sites	Section 5.1 – Planning and Design
Chapter 5 – Material Resource Conservation and Efficiency	Materials and Resources	Section 5.4 – Material Conservation and Resource Efficiency
Chapter 6 - Energy Conservation, Efficiency and CO2*e* Emission Reduction	Energy and Atmosphere	Section 5.2 – Energy Efficiency
Chapter 7 - Water Resource Conservation, Quality and Efficiency	Water Efficiency	Section 5.3 – Water Efficiency and Conservation
Chapter 8 - Indoor Environmental Quality and Comfort	Indoor Environmental Quality	Section 5.5 – Environmental Quality
Chapter 9 – Commissioning, Operation, and Maintenance		
Chapter 10 – Existing Buildings		
Chapter 11 – Existing Building Site Development		
Chapter 12 – Referenced Standards		Chapter 6 – Referenced Standards
	Innovation and Design Process	

Table 2: LEED 2009 (updated July 2012) Credits Related to Concrete Masonry Products

LEED 2009 Credits p = prerequisite c = credit	**Concrete Masonry Strategy**
Sustainable Sites (SS)	
SS c2: Development Density and Community Connectivity	Concrete masonry provides benefits of fire safety, impact resistance, acoustic isolation, flexible design and minimal access requirements in urban locations.
SS c6: Stormwater Design	Concrete masonry pavers can be used as part of a permeable paving system for pedestrian sidewalks, courtyard and other hardscape areas as well as for roads and parking areas.
SS c7.1: Heat Island Effect – Non-roof	Concrete masonry pavers with a Solar Reflectance Index (SRI) of 29 or higher meet the requirements for this credit.
Energy and Atmosphere (EA)	
EA p2: Minimum Energy Performance	Concrete masonry walls provide thermal mass to help meet the minimum energy efficiency requirements.
EA c1: Optimize Energy Performance	Concrete masonry walls provide thermal mass to help exceed the minimum energy efficiency requirements.
Materials and Resources (MR)	
MR c1: Building Reuse	Masonry buildings are often reused due to their longevity and beauty.
MR c2: Construction Waste Management	Scrap or waste concrete masonry products can easily be salvaged or recycled, as can their packaging materials.
MR c3: Materials Reuse	Sand-set concrete masonry pavers and SRW units can easily be salvaged and reused.
MR c4: Recycled Content	Recycled aggregate can be found in many concrete masonry products, and fly ash and slag cement are commonly used in grout. Steel reinforcing bars contain high recycled content.
MR c5: Regional Materials	Concrete masonry producers are regionally located and often source their raw materials from less than 200 miles of the manufacturing facility.
Indoor Environmental Quality (EQ)	
EQ c4: Low-Emitting Materials	Concrete masonry walls and pavers used on the interior of a building are inherently low-emitting if no surface applied coatings are used.

Table 3: LEED 2009 Regional Priority and Pilot Credits

Regional Priority Credits – CA*	**Credit Requirements**
SS c2: Development Density	Awarded for development in typically urban areas.
SS c7.1: Heat Island Effect – Non-roof	Awarded if 50% of hardscape meets requirements for shading, high solar reflectance (SRI), or open grid system.
Regional Priority Credits – NV*	**Credit Requirements**
SS c7.1: Heat Island Effect – Non-roof	Awarded if 50% of hardscape meets requirements for shading, high solar reflectance (SRI), or open grid system.
EA c1: Optimize Energy Performance	Awarded for a 30% improvement in energy efficiency for new construction.
MR c2: Construction Waste Management	Awarded for 50% diverted from landfill.
Pilot Credits**	**Credit Requirements**
PC 53: MR – Responsible Sourcing of Raw Materials	Use building products whose manufacturers have demonstrated compliance/commitment to responsible sourcing (Framework for Responsible Mining for quarried materials).
PC 54: MR – Avoidance of Chemicals of Concern in Building Materials	Use building products that do not contain specific substances from a designated list.
PC 61: MR – Material Disclosure and Assessment (EPD)	Use building products and materials that have an Environmental Product Declaration (EPD).
PC 63: MR – Whole Building Life Cycle Assessment	Projects must demonstrate at least 10% reduction in environmental impacts in 3 of 6 categories through whole buiding life cycle assessment.
PC 21: EQ – Low-Emitting Interiors	Up to 2 points can be earned for walls and floors meeting requirements. Concrete masonry products without surface coatings are deemed to comply.
PC 24: EQ - Acoustics	Requires STC ratings for walls from 45 to 60 depending upon use of space.

*Regional Priority Credits are specific to zip code and are subject to change. Check the USGBC website for most up-to-date information. There may be other Regional Priority Credits available in the CA/NV area not listed in this table.

** Pilot Credits are subject to change. Pilot Credits may be revised, deleted, or new ones added at any time. Check the USGBC website for most up-to-date information.

Table 4: 2010 CALGreen (July 1, 2012 Supplement) Provisions Related to Concrete Masonry Products (non-residential)

2010 CALGreen Provisions A= appendix	**Concrete Masonry Strategy**
Site Development	
A5.106.3 Low-Impact Development (reduce storm water)	Concrete masonry pavers can be used as part of a permeable paving system for pedestrian sidewalks, courtyard and other hardscape areas as well as for roads and parking areas.
A5.106.7 Exterior Wall Shading	Opaque exterior walls that have an aged Solar Reflective Index (SRI) of 25 or higher do not have to be shaded. Concrete products without colorant, utilizing grey Portland cement has an aged SRI of 19 to 32 according to the Portland Cement Association.
A5.106.11.1 Heat Island Effect – Hardscapes	Concrete masonry pavers with an initial solar reflectance value of at least 0.30 meet the requirements for this credit. Open grid pavements or permeable pavement systems also comply with this section.
Energy Efficiency	
5.201 Energy Efficiency	Concrete masonry walls provide thermal mass to help meet the minimum energy efficiency requirements.
Material Conservation and Resource Efficiency	
5.408. Construction Waste Reduction 5.408 .1.3 Waste Stream Reduction Alternative	Scrap or waste concrete masonry products can easily be salvaged or recycled, as can their packaging materials.
A5.405.4 Recycled Content* *does not apply to components of the structural frame	Recycled aggregate can be found in many concrete masonry products, and fly ash and slag cement are commonly used in grout.
A5.405.1 Regional Materials	Concrete masonry producers are regionally located and often source their raw materials from less than 200 miles of the manufacturing facility.
A5.409 Life Cycle Assessment	Concrete masonry construction in CA/NV uses less cement than comparable tilt-up concrete construction.
Indoor Environmental Quality	
5.504.4 Finish Material Pollutant Control	Concrete masonry walls and pavers used on the interior of a building are inherently low-emitting if no surface applied coatings are used.
5.507.4 Acoustical Control	Concrete masonry walls provide superior sound performance to meet the requirements of this section.

References

1. CMACN Monthly, March 2009, “Less Cement – The Choice is Concrete Masonry”

2. *High-Performance School Buildings Resource and Strategy Guide*, Sustainable Buildings Industry Council
https://www.nibs.org/store/view_product.asp?id=1250097&hhSearchTerms=High-Performance+and+School+and+Buildings+and+Resource

3. ICC-ES Verification of Attributes Reports (VAR), http://www.icc-es.org/reports/index.cfm?csi_num=04 22 00&view_details.

4. NCMA TEK 13-1B (2008), Sound Transmission Class Ratings for Concrete Masonry Walls

5. USGBC LEED 2009 and LEED 2009 Reference Guide, www.usgbc.org/leed

6. Website for California-approved energy modeling tools can be found at http://www.energy.ca.gov/title24/2008standards/2008_computer_prog_list.html.