The amount of energy used by buildings is nearly 40% of the total US energy consumption, about 40 quadrillion BTUs, according to the US Energy Information Administration. As a result, many programs and plans for decreasing this amount are being codified and designers have to reevaluate systems they use for ever-increasing rigor around energy performance consideration.

3 Paths to Compliance

Prescriptive Path. As a result of increasing energy codes, single wythe masonry walls were in jeopardy of being written off as viable options for meeting preset, prescriptive minimum R-value requirements in many climate zones. Recent modifications to ASTM C90 allow producers to change the web number and thicknesses of a concrete masonry unit (CMU), which can increase it’s thermal resistance (R-value) enough to make it part of a wall system that can meet prescriptive minimums in certain climate zones. (see Table 1). Until market-demand for such units cause them to become mass
Produced nationwide, designers will face the same challenge. (see A-Block Enhances Energy Performance on page 14)

Fortunately, achieving compliance with today's energy requirements put forth in documents like the 2009 International Energy Conservation Code (IECC), which has been adopted by 34 states, includes two paths to compliance other than the prescriptive method. This performance evaluation with programs like DOE2 and EnergyPlus is one option. This method requires some expertise by the software-user in order to obtain the best, most accurate results.

Table 1 | Opportunities for Compliance with Prescriptive Path

<table>
<thead>
<tr>
<th>Options</th>
<th>Exposed CMU on Interior and Exterior</th>
<th>Non-Exposed CMU on Interior and/or Exterior Face</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 R-Value (R-12) of Insulation Alone</td>
<td>Not Applicable</td>
<td>• Cont. Insulation on Interior Face</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cont. Insulation on Exterior Face</td>
</tr>
<tr>
<td>#2 U-Factor of the Assembly</td>
<td>• Cell Insulation</td>
<td>• Cont. Insulation on Interior Face</td>
</tr>
<tr>
<td></td>
<td>• Conventional CMU</td>
<td>• Cont. Insulation on Exterior Face</td>
</tr>
<tr>
<td></td>
<td>• A-Shape CMU</td>
<td>• Cell Insulation</td>
</tr>
<tr>
<td></td>
<td>• H-Shape CMU</td>
<td>• Conventional CMU</td>
</tr>
</tbody>
</table>

1. 40% maximum fenestration in above grade walls
2. R-Values vary per inch per manufacturer
3. 2 web, 2 core. (LW, MW, NW)
4. 2 web, 1 core. (LW, MW, NW). ASTM C90-11b (web configuration options)
5. 1 web, (LW, MW, NW). ASTM C90-11b (web configuration options)

Performance Path. Whole building performance evaluation with programs like DOE2 and EnergyPlus is one option. This evaluation accounts for the total building energy use for every hour of every day for one year using average weather data and compares a baseline reference building to the proposed building as a means of demonstrating improved energy performance. For best results with mass masonry walls, data entered must be dynamic, accounting for temperature changes throughout a day, rather than steady-state, or unchanging, to account for the thermal mass benefits of the wall type. Whole building modeling is complex and requires some expertise by the software-user in order to obtain the best, most accurate results.

System Evaluation Path. Another option is a simplified performance method using COMcheck, free software developed by the US Department of Energy – energycodes.gov/comcheck. COMcheck provides a trade-off compliance method that allows for more design flexibility than prescriptive tables because areas of a building envelope with R-values exceeding code can trade with areas struggling to achieve compliance.

Putting It to the Test A new YMCA in northern Michigan is being constructed to include a 450' x 132' indoor tennis facility. Located in ASHRAE climate zone 6, the prescriptive minimum R-value requirement for the insulation alone for a mass masonry wall is R13.3 (continuous insulation). According to Smaller Webs=Higher R-Value article by Jason Thompson of the National Concrete Masonry Association (NCMA) in MasonryEdge/the StoryPole vol 7 no 2 (dynamicsofmasonry.com/digital-archives), the highest R-value a single wythe 8" concrete masonry wall assembly can achieve with lightweight aggregate materials (conventional three web and two core unit) and installation practices is R7.9 with all cells containing foam-in-place insulation. Typically, in Michigan most masonry walls are designed as partially insulated. By the prescriptive method, such a wall would be out of the question for the tennis courts of the Grand Traverse Bay YMCA by not complying with either of the prescriptive options allowed:

1. Doesn’t meet the minimum R-value requirement for the insulation alone because for this project the insulation is not continuous.
2. Doesn’t meet the maximum U-factor for overall wall assembly because for climate zone 6 the maximum U factor allowed is 0.080. Taking the reciprocal of R7.9 (8" CMU) yields a U-factor for the assembly of 0.13. (see above)

Representatives for this YMCA, like most others, want a building with an aesthetic that complements its surroundings, that has a long life-expectancy and is durable and resilient. A masonry building easily achieves with lightweight aggregate materials to the COMcheck program. A series of drop-down menus allow envelope information to be entered, component by component, but it is important to note that the data can also be user-entered to more accurately describe the systems employed in lieu of the defaults. The program calculates input data with embedded geographically-specific weather data to assess whether or not the entire building envelope (roof, walls and floor) will meet code and by what percentage.

In the case of this YMCA, the 60,389 sf pitched roof and a U-Factor of 0.037 was one line item and the slab on grade, insulated 1,165 lineal feet along the floor.
perimeter was another line item. The walls, because they were comprised of both single wythe CMU and metal panels, each required two line item entries per elevation, for a total of 10 line items.

For both metal and masonry wall portions, the other option (U-factor) was selected from the drop-down menu, so that flexibility provided by U-factor could be gained. Selecting from the drop-down menu means a wall follows some built-in assumptions. For example, when selecting 8", Partially Grouted, Cells Insulated from the drop-down menu, COMcheck assumes the wall is grouted 48" oc horizontally and 32" oc vertically. It is also assumed the wall has loose fill insulation, which has an R-value of 2.5 to 3.5, depending on type, which is much lower than spray foam insulation.

The Best Option Single wythe walls at the tennis courts are engineered for partial grouting and reinforcement 56" oc vertically. Project structural engineers Mark Bryce and Jim Edmonson at Trison Engineering Group worked with the Michigan Masonry Coalition’s engineer Scott Walkowicz during schematic design to help determine the optimized wall performance solution. Using an engineering software program, they were able to design the wall with maximized grout spacing while maintaining a modest #5 reinforcing bar size (to minimize lap splices and cost) to meet wind load demand. Spreading grout and bars beyond the default 32" oc still allowed the wall to meet loading requirements, but also saved on quantity of grout and bars minimizing labor stoppage time in wall construction, while optimizing thermal performance by making more cells available for insulation.

All other cores are insulated with an aminoplast spray foam that is injected into the CMU once the wall is erected. In order to obtain the R-values and U-factors to enter into COMcheck, there are several options available;

1. NCMA TEK 6-2C, R-Values and U-Factors of Single Wythe Concrete Masonry Walls, 2. NCMA Thermal Catalog of Concrete Masonry Assemblies
3. NCMA was consulted since the CMU was 141 pcf, a density higher than listed in a TEK or the Thermal Catalog. NCMA provides tech support to any architect or contractor requesting assistance and can provide data for non-standard unit weights. It is not uncommon for split face units to have a higher strength and a higher density. A unit’s density may have direct and indirect influence on design calculations as more weight typically means better performance, until a tipping point is reached. Higher density usually translates to higher strength.

Calculating the U-factor of an assembly can be more time-consuming as information must be gathered, but asking each manufacturer of an assembly to provide this information is more accurate and worth the effort than using defaults which may not be applicable.

Heat capacity of mass walls was required for COMcheck. This data only needs to be manually entered with the other assembly type (U-factor option) selected. Heat capacity is the amount of heat (measured in BTUs) necessary to raise the temperature of 1 sf of wall 1˚F. This information can also be easily looked up in NCMA TEK 6-16A, Heat Capacity Values for Concrete Masonry Walls.

Once all the metal and masonry wall information was gathered and entered, along with roof and floor data, envelope calculations were run and COMcheck returned a result of +2%, confirmation that the design is 2% better than code. An Envelope Compliance Certificate summarizing the project information and documenting the passing percentage is automatically generated.
Achieving the Desired Result Early preconstruction meetings with potential bidders, producers and other interested parties, before drawings were even complete provided the design team access to creative problem solving to achieve the desired result — an energy-code compliant single wythe concrete masonry and metal hybrid wall system.