WHITE PAPERS

# REDUCE COMMERCIAL BUILDING LIFE CYCLE COSTS BY PLANNING ENERGY EFFICIENCY INTO DESIGN

COMMERCIAL BUILDING OWNERS are all familiar with the basic principle of accounting—revenue minus cost equals profit. In recent years, steadily increasing energy costs have thrown the "cost" side of this equation into stark relief. In fact, heating and cooling costs alone represent about 32 percent of a building's operating budget. A relatively obscure term, however, has the potential to bring back the balance. Today, maximizing profits is all about understanding "R-value."

### Thermal Conductance: How to Measure Effectively

The most important factor in maximizing the energy efficiency of commercial buildings is in the design, materials and construction of exterior wall systems. But before deciding which materials and wall construction methods will enhance energy savings, owners must first be familiar with the thermal calculation techniques.

"R-value" is a unit of measurement that describes the resistance of construction materials to the flow of heat. Unfortunately, some of the most common methods of calculating a building's energy efficiency using R-values are the least accurate. Here's why.

Even though heat is transferred by several methods (by conduction, radiation, and convection), heat always flows from warm to cold. In fact, heat transfer is similar to fluid movement in many ways. Because fluids take the path of least resistance, they will usually find a way through almost any material. If a plastic sheet – which is essentially impermeable – has a pinprick in it, water will flow through the pinprick as fast as the hole will allow. The permeability of that sheet, in essence, becomes the same as the permeability of the pinprick, rendering the permeability of the plastic unimportant. In the same way, heat will find the path of least resistance in a building, making the R-value equal to the least insulated portion of the wall. Failure to recognize this can lead to inaccuracies in calculating a building's R-value.

The most common method of calculating R-values for wall systems is to add the R-values of all the materials that make up the panel. For example, with a wall panel that has a 3-inch layer of concrete, a 2-inch layer of foam, and another 3-inch layer of concrete, the total R-value would simply be the combined R-value of all the materials. This method assumes a steady-state heat flow, in which the difference in temperature across all material layers is steady at all times.

Owners should be aware, however, of the impact of thermal breaks on R-value. Thermal breaks are areas that violate the insulation area and greatly reduce energy efficiency. With wall panels, thermal breaks can range from the obvious, such as doors and windows, to those which are invisible to the eye, such as highly conductive structural ribs embedded in the wall. In the previous example of two concrete panels sandwiching a layer of foam, a wall panel like this often uses metal ties and concrete to hold the different layers together. These metal ties create thermal breaks that allow heat to pass through the concrete layer, reducing energy efficiency.

Besides thermal breaks, owners should also consider the effects of thermal mass. The force behind conductive heat flow between the exterior and interior of a wall can change significantly and even reverse during the day. For example, if the temperature on the inside of the building is cooler than on the outside, heat will conduct from the outside surface of the wall inward. But as the exterior temperature falls at night, the driving force for heat flow reverses. Energy, as heat, is drawn from the inside to the outside of the building through conductive heat transfer.

With high mass materials, such as concrete, this heat transfer is delayed and even blocked by the high heat retention capacity of the wall mass. This "mass effect" has an advantageous effect on a wall's energy efficiency that cannot be determined by R-value alone.

So, before beginning new commercial construction, owners should examine the R–value of different materials, take into account the mass effect produced by certain high-capacity materials and ask contractors about the presence of thermal breaks. Otherwise, the owner should be prepared for energy cost surprises down the road.

### Examining Construction Options: Maintenance, Structural Integrity and Energy Efficiency

Masonry, metal and concrete are the most common materials used to build an exterior wall. When deciding between building materials and construction methods, owners need to examine the energy efficiency, maintenance and structural integrity of each option.

### Masonry

Masonry's widespread use makes it the most popular wall construction method. Brick walls offer security, quality and long-term durability. With masonry, because the finished face is brick, you get high aesthetic values, including a variety of colors and patterns.

But because of the sheer number of components bound by mortar, masonry is the most susceptible to cracking of any exterior wall option. When cracks appear, it's necessary to tuck-point—a time-consuming and costly repair.

Masonry is also porous and needs a sealer (most often paint) to be applied at installation and at regular intervals ranging from 2-15 years (depending on the quality of sealer applied and the skills of those doing the sealing). Again, this is an added cost.

Finally, the porous nature of masonry requires an added insulation layer to simply meet code, further driving up installation costs. And if the building owner wants a smooth finish on the interior walls, the masonry must be furred out and sheet rocked. All of these added requirements increase the cost of the building initially and throughout its life cycle.

### Metal

In situations where aesthetics and longevity are not key issues, metal buildings can be a cost-effective, viable option. The metal wall system is the least expensive of wall construction options, yet it is not nearly as affordable as it first may appear. Metal-based walls are not as inherently strong or as durable as concrete or masonry. A hailstorm, strong wind or misguided delivery truck can easily disfigure a metal exterior.

The extensive stud work associated with a metal wall creates a natural passageway for air, negatively affecting the energy efficiency of a building. And when an exterior skin of thin metal panels covers a metal frame, each screw and cut edge acts as a miniature point of failure—for air penetration, as well as rust. The energy efficiency decreases with each possible point of air penetration.

The design limitations of metal walls also can be a concern. Large steel frames of beams and columns need to bear the load, which can be especially inhibiting for retail and distribution outlets where storage space is at a premium. Columns, which often extend 2- 3 feet from the wall into interior space, impede the placement of racks, pallets and other storage devices making the space less flexible.

### Concrete

Because of its high structural integrity and low maintenance requirements, concrete is often the material chosen for exterior walls on commercial buildings. Unlike other building materials, concrete actually gains strength over the life of a building, since hydration causes the compounds in cement to elongate, lengthen, intertwine and create an impermeable surface. As a result, concrete walls require minimal maintenance. A sporadic, high-pressure wash-down is all that is needed to maintain its finish, and re-caulking about every 15 years helps eliminate fissions that may appear over time. Because concrete is a high-capacity material with strong heat retention capabilities, it also can take advantage of the mass effect phenomenon.

Yet not all concrete-based wall systems are created equal. There are three primary types, each having unique insulating characteristics: composite precast concrete wall panels, tilt-up concrete wall panels, and non-composite precast concrete wall panels. Knowing the difference between each can help building owners pinpoint the construction method that will best minimize their life cycle costs.

Composite wall panels are those that combine two separate layers of concrete with steel ties. Typical composite wall panels are constructed with a 3- to 7-inch exterior layer of concrete, a 2-inch layer of foam, and a 3-inch interior layer of concrete. The Department of Energy (DOE) examined the thermal efficiency of composite wall panels. It reported that the steel ties resulted in a 60.59 percent loss of the claimed heat-flow resistance (or R-value) of 10.14, reducing it to only 4.13. Another drawback is that because the inside and outside of the panel are forced to work together, thermal difference from the interior to the exterior can force the panels to bow. This further strains the panels and the joints between them.

Tilt-up wall systems are similar to composite type precast panels, without the advantage of being manufactured in a controlled environment. The concrete for tilt-up panels is generally poured outside, and its exposure to environmental conditions, such as rain and freezing temperatures, can alter its structural integrity and durability. Most tilt-up panels are also created without insulation. This requires the interior surface to be furred out and insulated, increasing energy efficiency for an additional cost.

With composite or tilt-up sandwich wall panels, it's possible to achieve either strength or energy efficiency, but not both. Composite panels use ties, which may not create acceptable composite action, or they use solid concrete blockouts, which negatively impact R-value. Plus, tilt-up panels must be constructed outdoors, their quality and structural integrity depends on the weather and skills of the installer.

The third type is a non-composite panel, which combines a structural core, a rigid insulation layer and a non-structural façade for exceptional strength without the need for a thermal bridge. Eliminating highly conductive thermal breaks increase overall energy efficiency. For example, Fabcon Inc. produces non-composite precast sandwich wall panels composed of an 8-inch hollow core layer of concrete, a 2.5-inch layer of foam, and a 1.5-inch layer of concrete. Due to its high density, a Fabcon wall panel has an R-value of up to 21 for the 12-inch panel.

With as much as fifty-eight percent recycled content, VersaCore™, the newest precast concrete panel from Fabcon, is more energy efficient than other products in the market. The new panels test an average of three points higher in R-value. Additionally, the VersaCore+Green™ product helps owners qualify for LEED certification points and potential tax credits for their building projects.

The National Resources Defense Council reports that improved energy efficiency can cut energy use for major building uses, such as heating, by 30 to 50 percent. Besides the calculated energy efficiency, the thermal mass effect of Fabcon's non-composite wall panels can further increase the R-value. This improves livability for building occupants by eliminating cold spots in the building's walls. With a wide variety of exterior and interior finishes, non-composite panels also increase the aesthetic options available for commercial buildings. Fabcon's non-composite panels are completely manufactured indoors, ensuring consistent quality.

### Energy Efficiency: A Planning Process Issue

The fluctuating supply and price of energy has led many building owners to look for ways to reduce energy consumption. Concerns over energy efficiency will continue to increase as new energy regulations are put in place, and energy-optimizing choices will no longer be an option; they will be a necessity.

With a thorough understanding of R-value and the efficiency of different construction materials and methods, owners can select the most advantageous wall panels -- reducing total cost of ownership and keeping the cost/profit equation in their favor.

To help determine the best exterior wall system for your needs, ask the following questions:

***How can I maximize the energy efficiency?*** Ask about R-value. The higher the R-value, the more energy-efficient your building will be, lowering your heating and cooling costs.

***Will temperatures be fluctuating significantly throughout the day?*** If so, does it make sense to use a high-capacity material to take advantage of "mass effect" and a higher effective R-value?

***Will there be thermal breaks or highly conductive structural ribs that will violate the insulation layer, reducing thermal resistance?***

***What kind of maintenance is needed?*** Paint, tuck-pointing, caulking, and damage repair can all add to the cost of a building. While some maintenance procedures are relatively inexpensive, such as caulking (approximately 35 cents per square foot of wall space), other procedures, such as tuck-pointing, can be surprisingly high.

***How can I reduce wall "movement?"*** Falling ceiling tiles, failing caulk joints and deteriorating connections are just a few calamities of water and air penetration. Ask about the thermal differences expected with each type of exterior, and each option's tendency to bend, flex and bow. Also, ask if the wall can be load-bearing or ask about each method's effectiveness as a vapor retarder.

***How can I achieve maximum building flexibility using a particular option?*** Adding a window, pedestrian door or a new addition to a building is much easier if the wall system can handle varying load capacities, if the wall panels can be moved and re-used, and if extra openings require no special structural supports.

***How can quality be assured?*** With precast, ask if the supplier is PCI (Precast Concrete Institute) certified. Ask about the reputation and experience of the people erecting the panels.