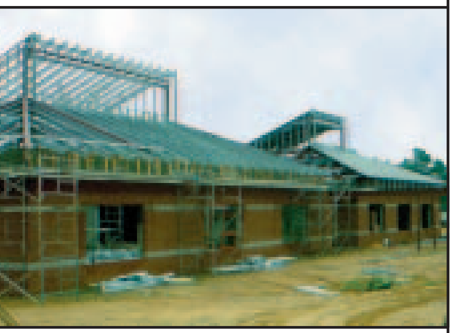
Design Guidelines for an Energy-Efficient Building Shell

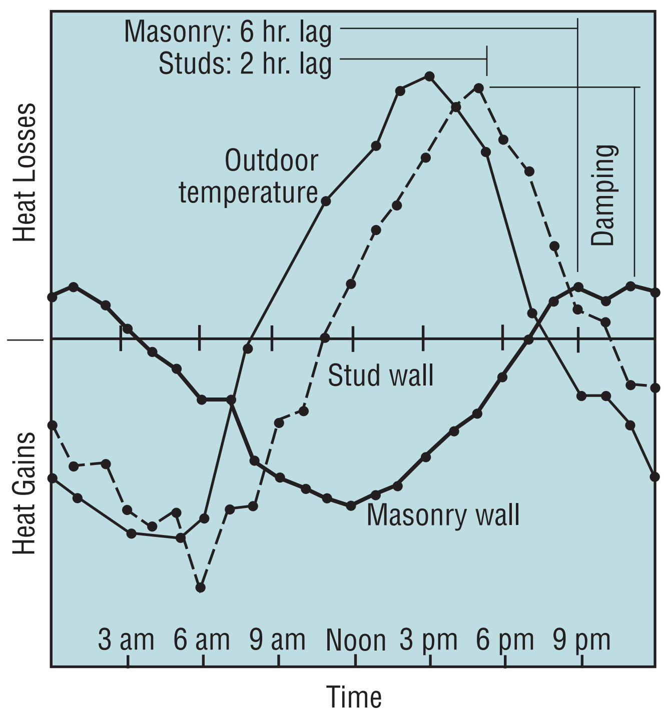
Massive Wall Construction

In hot and humid climates, high-mass construction techniques have been historically employed to moderate the heat gain experienced during the hot days. This delays and reduces the impact until the nighttime when ventilation strategies during the swing months can cool the interior spaces. If adequate mass is incorporated, these strategies are just as effective today, particularly since schools are typically not occupied during evening hours.

- Employing high-mass wall construction techniques to lag the heat gains using 16-inch brick-block and block-block cavity walls with rigid cavity insulation can delay thermal gains by up to 12 hours.



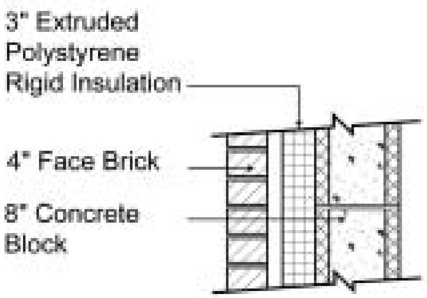
High-mass construction techniques, incorporating a brick-block cavity wall, lag the heat gain experienced during the daytime well into the evening.



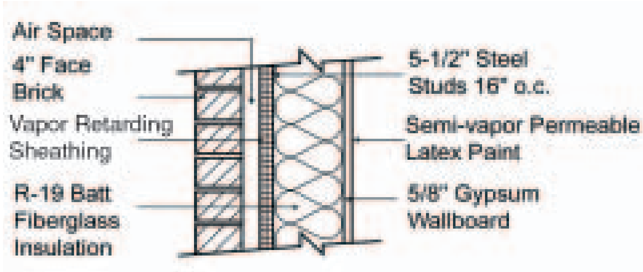
Heat Gain Lags in High-Mass Walls

Using high-mass wall construction techniques can delay thermal gains by up to 12 hours.

- Newer wall systems using insulated concrete forms or tilt-up insulated concrete panels have also proved effective.



Brick Masonry Wall



Brick Veneer Wall

High-Mass Wall Sections

By incorporating high-mass construction, cooling loads can be reduced and air conditioning equipment can be downsized.

Moisture and Infiltration Strategies

Controlling air flow and moisture penetration are critical elements in reducing energy consumption, maintaining structural integrity, and ensuring a healthy indoor environment.

- Because of the high temperature and humidity typical of this climate, vapor retarding sheathing should be installed on the exterior of the insulation.
- In hot and humid climates, air flow retarders should be installed on the exterior of the building, and building assemblies should protect the outside wall surface from getting wet. Any moisture should be allowed to drain away or dry toward the interior, using permeable interior wall finishes and avoiding wall coverings.
- Since air leakage can carry significant amounts of moisture into the building envelope, caulk and seal any building shell penetrations.

Insulation Strategies

Energy-efficient building design starts with implementing optimum insulation levels. Evaluating the cost-effectiveness of varying insulation R-values allows you to maximize long-term benefits.

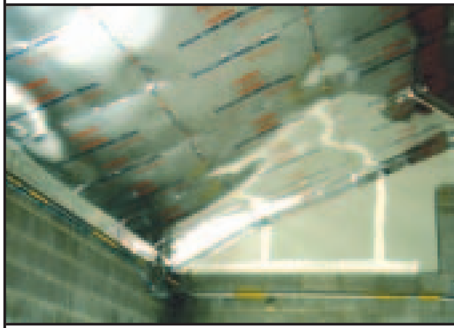
- When selecting insulation levels, refer to ASHRAE Standard 90.1. R-values required by local building codes should be considered a minimum.
- When determining the choice of insulation, you should consider not only energy efficiency and initial cost but also long-term performance. Carefully research insulation products for stability of R-value over time, and make comparisons based on the average performance over the service life.

An energy-efficient building shell requires that the designer view the wall assembly as a system within the “whole building.”

Stopping Radiant Heat Gains

In hot and humid climates, creating a building shell that is massive and well-insulated can effectively address conduction gains and losses, but it is critical to also take into account radiant solar gains. In the warmer months, up to 90% of the cooling load coming from the roof area can be attributed to radiant heat gain. By addressing this problem, you can decrease your cooling load significantly.

- Incorporate radiant barriers in the roof assemblies to reduce up to 95% of radiant heat gain. When solar radiation strikes a roof, a certain percentage of radiation is reflected away, and the balance is absorbed. When this occurs, it heats up that material, and the material reradiates downward. The low-emissivity properties of the aluminum in the radiant barrier stop this radiant process, allowing only 5% of the radiation to pass through. Radiant barriers that have coatings to protect against oxidation help ensure long-term performance. These types of radiant barriers are superior to reflective roofing strategies that tend to lose their reflective qualities over time. Dust accumulation on radiant barriers reduces their performance. When possible, they should be suspended from the joists or rafters to reduce dust accumulation.
- To reflect solar gain away before it can create negative radiant impacts within the spaces below, incorporate highly reflective roofing systems. This strategy is important, particularly in areas where radiant barriers cannot practically be installed.
- Select a light color for the exterior finish to reflect solar radiation.
- Shade exterior walls with architectural elements (or landscaping) to enhance performance.



Radiant heat gain can be responsible for 90% of the heat entering through the roof. The use of a radiant barrier can block up to 95% of this gain.

Reflectance Values for Exterior Surfaces

		% Reflected	% Absorbed
Roofing Material (1)			
Single-Ply Roof Membrane	Black EPDM	6%	94%
	Gray EPDM	23%	77%
	White EPDM	69%	31%
Asphalt Shingles	Black	5%	95%
	Medium Brown	12%	88%
	Green	19%	81%
	Gray	22%	78%
	White	25%	75%
Metal Roof	Aluminum	61%	39%
	Metal White	67%	33%
Exterior Wall Material (2)			
Brick	Light Buff	45%	55%
	Dark Buff	40%	60%
	Dark Red	30%	70%
Concrete	Light	55%	45%
	Medium	20%	80%
	Dark	15%	85%

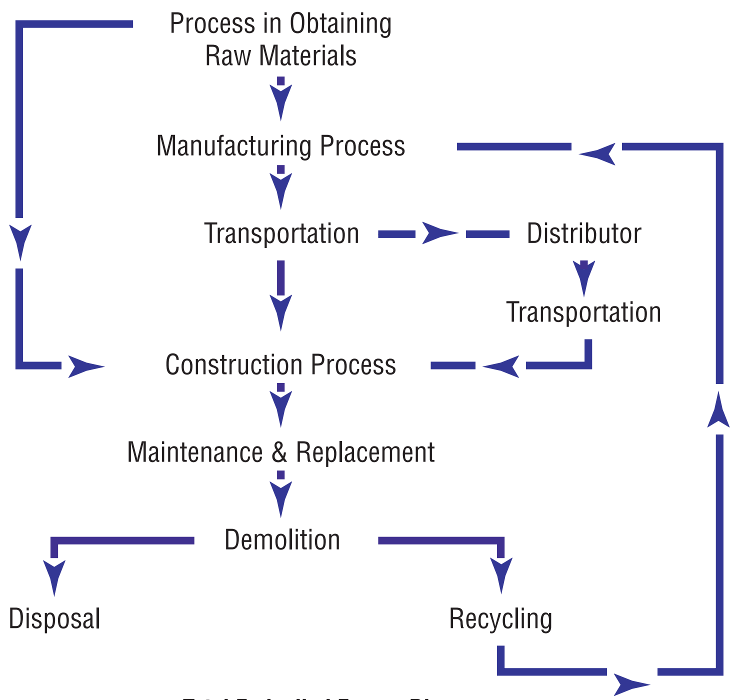
(1) Source: Berdahl 2000. “Cool Roofing Material Database,” LBNL
(2) Source: 1981 IES Lighting Handbook

This chart indicates the reflectance of various typical roofing materials when first installed. Materials that maintain their reflective characteristics should be preferred.

Light-colored roofing materials reflect solar radiation and can assist daylighting strategies.

Embodied Energy

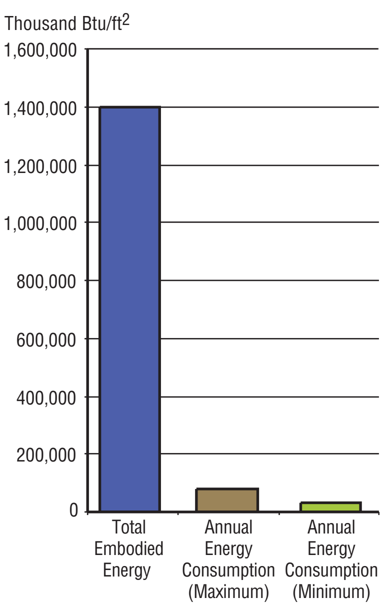
When selecting the building materials, consider that, in many cases, the amount of energy embodied in constructing the school is equal to more than two decades of a school's energy consumption. To seriously address the overall impacts of energy consumption, consider the energy involved in making each product, transporting the product to the site, and implementing the component into the school.



Total Embodied Energy Diagram

Products, materials, equipment, and processes incorporated into construction

- Because often half or more of the embodied energy involved in constructing a school is related to transportation, select locally made products and construction materials.
- Consider the energy intensity of the manufacturing process involved in making materials and products incorporated in the school.
- Encourage the use of recycled products.
- Evaluate the recyclability of products once the building has passed its useful life.
- If existing structures on the school site are to be demolished, consider how the typically wasted materials could be used in the new construction.



Total Embodied Energy per Square Foot for Educational Buildings

The embodied energy of a school building exceeds the annual energy consumption of the school.