The Principles of Exterior Wall Systems

Zimmer Gunsul Frasca Architects in Partnership with Portland State University

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ABSTRACT

To assist designers and clients alike in understanding, investigating, and detailing wall systems, Zimmer Gunsul Frasca Architects has created a document known as the Principles of Exterior Wall Systems (PEWS). This assemblage of information highlights their main types of wall systems including rain screens, mass walls, curtain walls and other systems while consisting of graphic models, sections, and diagrams. In an effort to further enhance the PEWS document, an investigation of alternative material options provides additional consideration to provoke conversation and deliberation. This additional materials database documents a variety of different interior and exterior insulation types. Detailing the attributes of each product, measurements of each material's thermal performance, cost, and embodied energy are compared in graphic form to allow the reader to quickly gather an evaluation of their characteristics. This research documents a methodology of databasing and selecting materials and products that can optimize the performance of a given wall system.

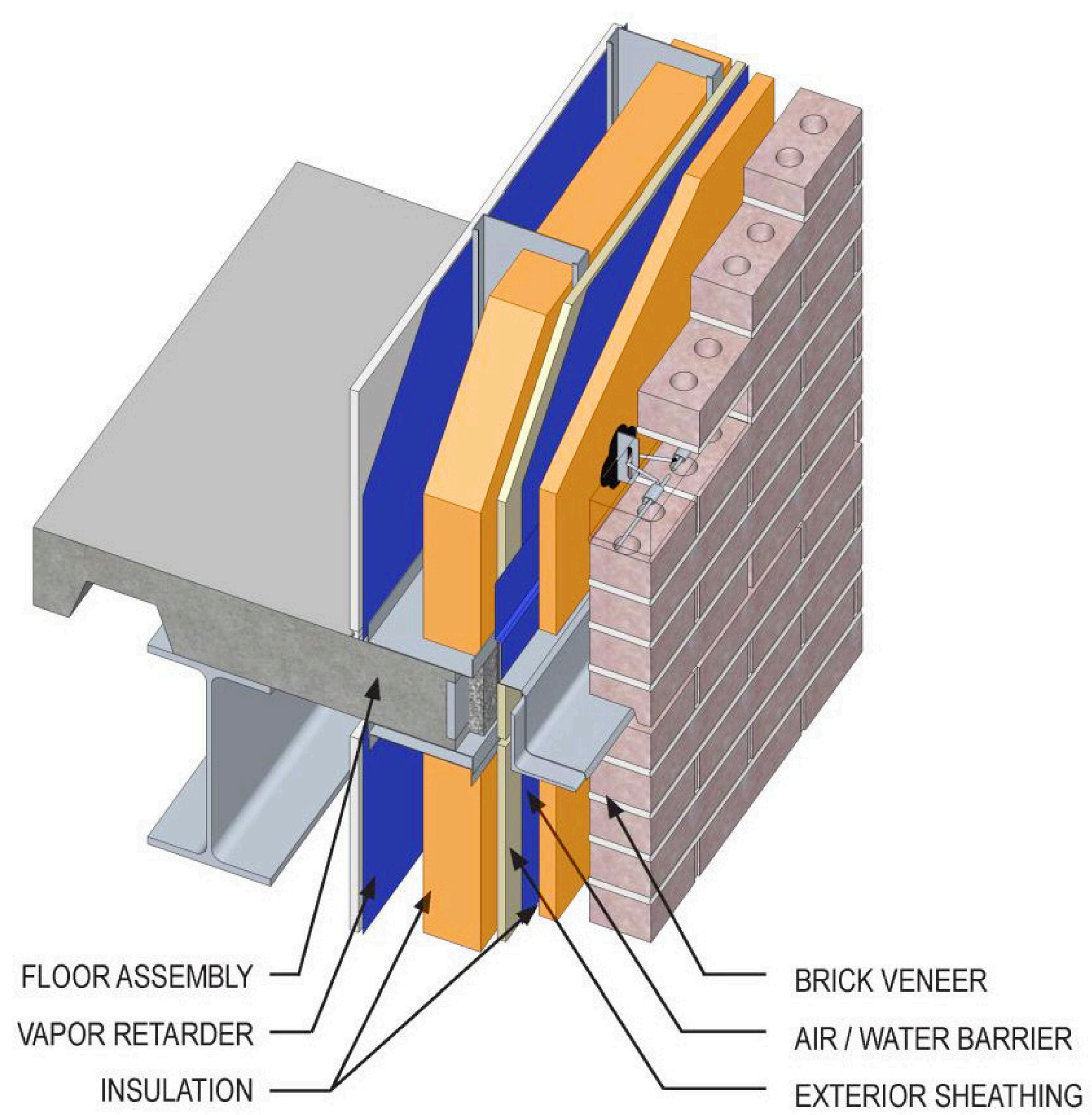

Figure 1.1 Brick Breathable Rainscreen Section

BRICK BREATHABLE RAIN SCREEN

The brick breathable rain screen wall assembly has been specified by ZGF as the most useful design to analyze due to its versatility in application, it's common use by the firm, and its similarly applicable design to other wall assemblies in the PEWS. The brick breathable rain screen features a rain screen veneer on the outermost assembly of a steel stud structure. Located within the wall assembly are two layers of insulation located on both interior and exterior sides of the air/water barrier and exterior sheathing. This double insulated design allows for differences in insulation placement based on the climactic conditions of the building. The steel stud structure houses the placement of interior batt insulation, although simultaneously contributes to thermal bridging as the studs provide a break in the insulated layer.

To begin the process of understanding the efficiency and function of the brick breathable rain screen, it was necessary to create a methodology. The first step in this procedure of analyzing the wall system was to break down the assembly into a list of individual components. For each component type (insulation, sheathing, vapor barrier, etc.), an exploration of available products was conducted and documented, noting product specification such as manufacturer, dimensions, R-value, weight, and cost. After this initial gathering of information it was necessary to compile it all into a structured database, importantly noting each material's aforementioned attributes and embodied energy.

		Embodied Energy Calculations						
System Component	ICE Material Category	Total Number of Units	Total EE of Unit - MJ	Total EE of Standard Bay - MJ / Sqft	Component Percentage of Total EE	Assumptions	Brand / Source	Product Type
Cladding								
Brick Veneer	Brick	384	6.9	55.20	58%	Assuming average weight of 2.3 kg	Belden Brick Company	Standard Size
Stainless Steel Brick Tie	Steel	13.5	3.97	1.12	1.2%	N/A	Masco Brick Ties	Seismic Strap Anchor
Shelf Angle	Steel	1	258.69	5.39	5.7%	Assuming average recycled content steel on ICE	Galintel Steel Lintels	Tradition Angle 100 x 75 x 10 Category D
Wall Assembly								
Metal Flashing	Aluminum	4	21.7	1.81	1.9%	N/A	Grace Construction Products	Perm-A-Barrier Wall Flashing
Insulation Board	Plastics	1.5	196.692	6.15	6.5%	N/A	ACH Foam Technologies	Foam-Control EPS Sheathing
Membrane Flashing	Aluminum	4	18.60	1.55	1.6%	Assuming general aluminum on ICE	Grace Construction Products	Perm-A-Barrier Aluminum Wall Membranes
Air / Water Barrier (Vapor Breathable)	Plastics	1	33.90	0.71	0.7%	Assuming general polyethylene on ICE	DuPont Tyvek CommercialWrap	Tyvek CommercialWrap D
Exterior Sheathing	Timber	1.5	14.10	0.44	0.5%	N/A	Structural Board Association (SBA)	OSB
Insulation	Insulation	6	120.35	15.04	15.68%	N/A	RockWool Manufacturing Company	Delta-CW4A Curtain Wall Insulation Board
Steel Studs	Steel	3	86.43	5.40	5.7%	Assuming average recycled content steel on ICE	ClarkDietrich ProSTUD	ProSTUD 20XD Drywall Stud 600PDS125-22
Vapor Retarder	Plastics	1	33.90	0.71	0.7%	Assuming same EE as Air / Water Barrier (Vapor Breathable)	DuPont Tyvek CommercialWrap	Tyvek CommercialWrap D
Interior Sheathing	Plaster	1.5	45.72	1.43	1.5%	N/A	Georgia-Pacific ToughRock	Regular Gypsum Drywall
			Total EE for Wall Assembly	94.94	MJ / Sqft			

Figure 2.1 Embodied Energy Calculation Chart

EMBODIED ENERGY

Raw values of material embodied energies were sourced from the Inventory of Carbon and Energy (ICE). To determine an appropriate sampling of material quantity in a wall system, a 4-foot by 12 foot section of wall served as our sample area. From this area the quantity of a product in kilograms was determined based on the manufacturer specified material density or product weight. Multiplying these values by the ICE provided embodied energy values; the embodied energy of material in mega joules is then calculated. This resulting figure can then be divided by the total square footage of the sample size (48 square feet) to determine the embodied energy of the material per square foot. By comparing these values side by side, clear results can be drawn regarding the major wall components that contribute to the overall embodied energy of the assembly. These standout components therefore allow for the biggest reduction in contributed environmental impact, and indicate where improvements can be made.

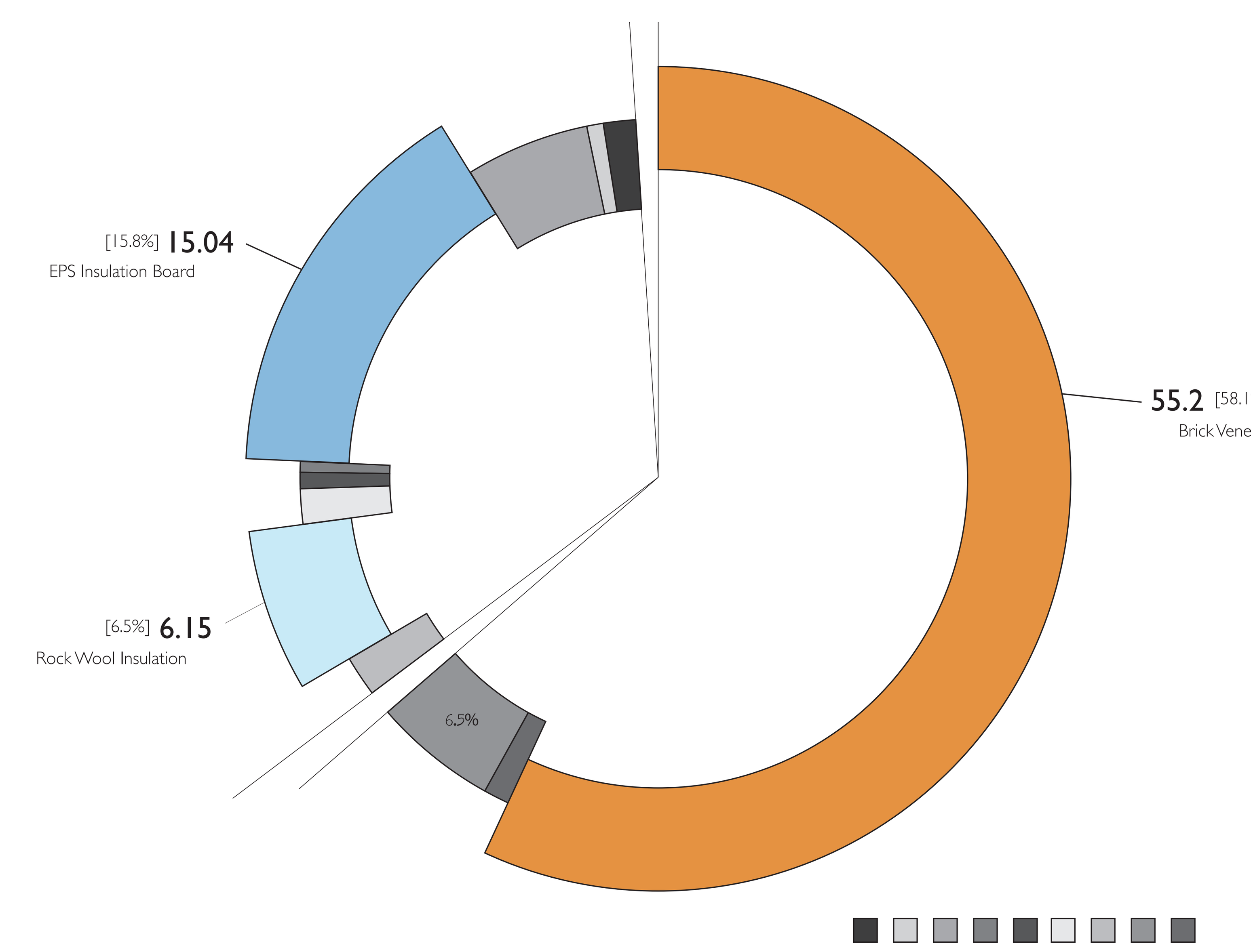

Figure 2.2 Embodied Energy Calculation Graph

After calculating each individual product's embodied energy by unit of square feet, some stood out clearly as favorable and others as undesirable. Rock wool and spray polyurethane expressed the highest levels of embodied energy. The manufacturing process of rock wool demands that rock be superheated to a molten state and then spun into it's cotton candy-like form, requiring very high amounts of energy. All other in-stud insulations showcased low levels of embodied energy when in comparison with these two aforementioned products. When compared to rigid insulation board however, all of these insulations were dwarfed. The three rigid insulations express very high levels of embodied energy per square foot, which states that they require a much higher environmental impact to manufacture.

THERMAL PERFORMANCE

Maximizing the R-value of components that create the wall assembly will create more resistance and therefore create a better performing wall system. Also the reduction of thermal bridging in the design of the wall assembly will minimize any heat transfer through the building envelope. To apply a measurement of thermal performance to the materials under consideration, their resistance to heat transfer has been standardized by their reported R-value. These tested R-values are provided by the product manufacturer and give an accurate measurement of their thermal performance under controlled conditions. To determine the calculated R-value of a wall system, the values of all wall components must be added together. This resulting sum is known as the wall's calculated R-value, and is inaccurate from the realistic effective R-value that the wall will have when thermal bridging is considered. The individual consideration of all material's R-values is included within the material specifications provided in the addition to PEWS. The thermal performance of the various insulations being analyzed can be directly compared to conclude which resist thermal conductance best.

	Basic Brick Breathable Rain Screen			
System Component	Product	R-Value	U-Value	Contribution
Cladding				
Air Film	None	0.17	5.88	1%
Brick Veneer	Boral Standard Brick	0.80	1.25	2%
Stainless Steel Brick Tie	Thermal Bridge			
Shelf Angle	Thermal Bridge			
Wall Assembly				
Metal Flashing	Thermal Bridge			
Weep Hole	Thermal Bridge			
Mortar Net	Thermal Bridge			
Air Cavity	None	1.00	1.00	3%
Insulation Board	2" AchFoam Polystyrene	8.40	0.12	26%
Membrane Flashing	Thermal Bridge			
Air/Water Barrier-Vapor Breathable	DuPont Tyvek Commercialwrap	0.12	8.33	0%
Tube Steel Shim	Thermal Bridge			
Exterior Sheathing	1/2" GP Stedi-R	1.32	0.76	4%
Insulation	CertaPro 6.25" Fiberglass Batt	19.00	0.05	59%
Vapor Retarder	Mel-Rol Polymeric Membrane	0.12	8.33	0%
Interior Sheathing	American Gypsum EagleRoc	0.45	2.22	1%
Air Film	None	0.68	1.47	2%
	Total R-value for Wall Assembly	32.06	0.03	

	Improved Brick Breathable Rain Screen			
System Component	Product	R-Value	U-Value	Contribution
Cladding				
Air Film	None	0.17	5.88	0%
Brick Veneer	Boral Standard Brick	0.80	1.25	2%
Stainless Steel Brick Tie	Thermal Bridge			
Shelf Angle	Thermal Bridge			
Wall Assembly				
Metal Flashing	Thermal Bridge			
Weep Hole	Thermal Bridge			
Mortar Net	Thermal Bridge			
Air Cavity	None	1.00	1.00	3%
Insulation Board	2" Foamular Polystyrene	10.80	0.09	27%
Membrane Flashing	Thermal Bridge			
Air/Water Barrier-Vapor Breathable	DuPont Tyvek Commercialwrap	0.12	8.33	0%
Tube Steel Shim	Thermal Bridge			
Exterior Sheathing	1/2" GP Stedi-R	1.32	0.76	3%
Insulation	6" Roxul Rock Wool	24.00	0.04	61%
Vapor Retarder	Mel-Rol Polymeric Membrane	0.12	8.33	0%
Interior Sheathing	American Gypsum EagleRoc	0.45	2.22	1%
Air Film	None	0.68	1.47	2%
	Total R-value for Wall Assembly	39.46	0.03	

Figure 3.1 Calculation R-value vs. U-value Chart

COST

Varying from project to project due to countless factors including purchasing volume, labor rates, and installation conditions, a resource that combined and simplified all factors of cost was necessary to get an accurate value for price. The Means Construction Estimator provided an invaluable resource for locating information regarding all material cost. Nearly all values of material cost was sourced from this database, allowing for accurate results that are simplified by square foot to keep a consistent unit of measurement. The results drawn from this source offer clear and direct comparisons of product cost so that decisions of expense may inform material selection.

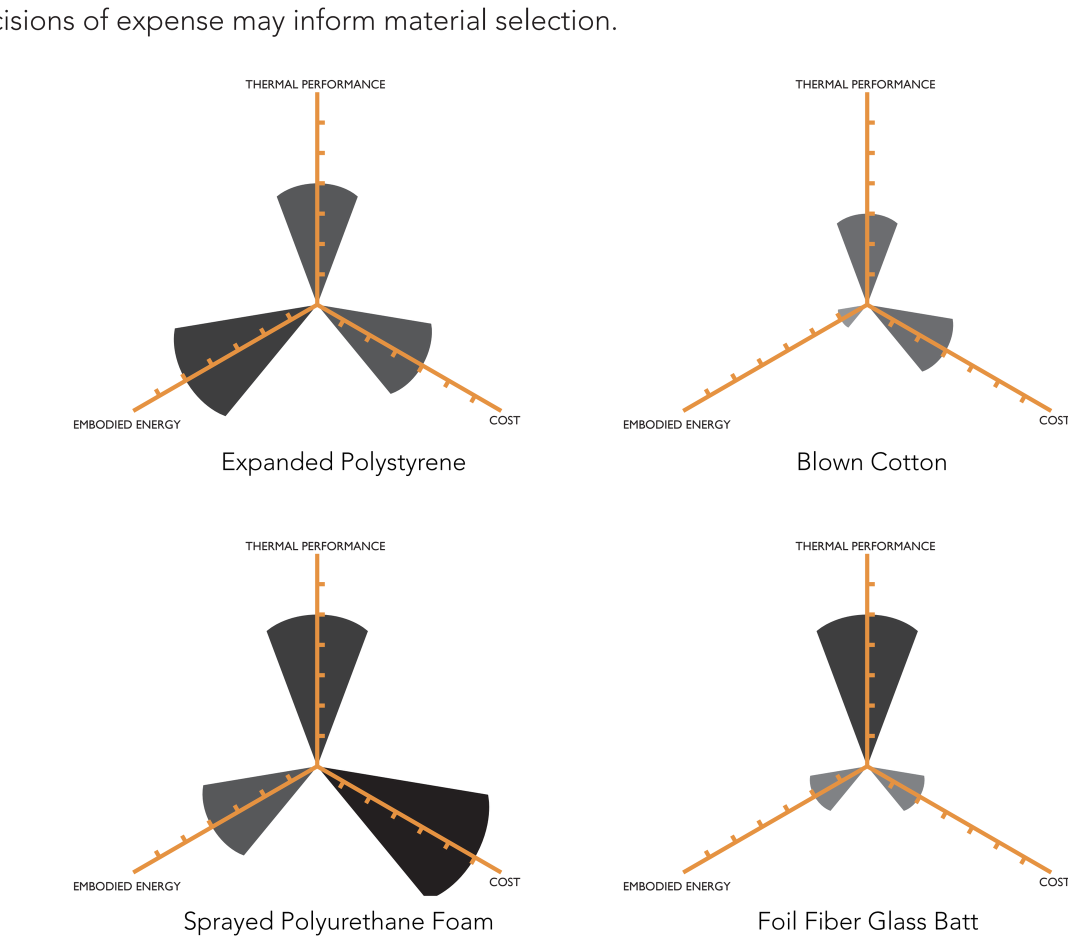

Figure 3.2 Performance Rose Comparisons

Figure 4.1 Evaluation Material