A Kingspan Summary

of a Building Science Corporation Report
Exterior Wall Assembly Performance

The need for global energy reduction and conservation has never been higher in the public and business community consciousness than it is today. While excessive energy consumption of transportation and industry are well documented, it is important to note that the energy consumed during the construction and operation of buildings form a major share (up to 40%) of total human energy consumption. Growing concerns about climate change, rising energy costs and energy supply security has led to an accelerated focus on reducing the energy consumption of buildings.

This whitepaper utilizes an independent study conducted by Building Science Corporation (BSC), a building science consulting firm specializing in building technology with offices in Boston, Massachusetts and Waterloo, Ontario. BSC focuses on preventing and resolving problems related to building design, construction and operation. Internationally recognized for their expertise in moisture dynamics, indoor air quality, and building failure investigations. BSC believes in promoting energy efficiency and environmental responsibility within the constraints of marketable and affordable building technology.

BSC compares and contrasts the most commonly chosen building wall envelopes in the design and construction of a large single story retail, manufacturing, or warehouse building. Seven typical building systems were reviewed and assessed against a set of eleven separate criteria chosen by BSC for their relevance to building construction and sustainability. The criteria are listed in the overall performance summary table, and for the purpose of this whitepaper are further grouped into three broader categories of energy efficiency, cost, and durability – key aspects at the forefront of sustainable construction.

Baseline Building

<table>
<thead>
<tr>
<th>Building Geometry</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>400 ft</td>
</tr>
<tr>
<td>Depth</td>
<td>250 ft</td>
</tr>
<tr>
<td>Height</td>
<td>28 ft</td>
</tr>
<tr>
<td>Floor Area</td>
<td>100,000 ft²</td>
</tr>
<tr>
<td>Wall Area</td>
<td>34,750 ft²</td>
</tr>
<tr>
<td>Window Area</td>
<td>750 ft²</td>
</tr>
<tr>
<td>Door Area</td>
<td>900 ft²</td>
</tr>
<tr>
<td>Volume</td>
<td>2,800,000 ft³</td>
</tr>
</tbody>
</table>

To help isolate the areas of interest and to score and rate assembly performance a baseline building and performance rating scale was established. The size and shape of the base building was chosen to be representative of common large single story retail, manufacturing, or warehouse buildings. Where appropriate conductance and infiltration information is presented for five diverse climate zones aimed at covering a broad cross section of North American climates. In addition, the broader BSC report presents information accounting for low, moderate, and high occupancy levels. However, for ease of reading and brevity this paper reports on moderate occupancy only.

Each assembly type was given a performance rating ranging from low to high (on a scale of low = 1 to high = 10). The rating tries to account for both the performance of the assembly due to the nature of the materials used and physics involved, as well as providing some consideration for the difficulty (or ease) of executing the system as designed to achieve the intended performance. Each performance score was weighted against an importance factor from low to high (on a scale of low importance = 1 and high importance = 5). The importance factor was weighted for this base building and would vary by particular project types.
For consistency, each building is designed with a near flat roof assembly. Typical connection details between the roof and the wall assembly are used in the analysis, however any additional factors affecting the roof performance are not considered.

Highlighted throughout this paper are the following distinguishing benefits that make insulated metal panels a perfect fit in the sustainable building world:
- Superior assembled R-value
- Unsurpassed airtightness
- Exceptional moisture and vapour drive management
- Speed of construction allows quick “dry-in” and accelerated construction schedule
- Ease of construction (single pass system) results in less dependency on multiple trades and workmanship

Weighted Overall Performance Summary

<table>
<thead>
<tr>
<th>Importance Factor</th>
<th>Insulated Steel Stud with Masonry Veneer</th>
<th>Insulated Steel Stud with EIFS Cladding</th>
<th>Insulated Steel Stud with Split-faced Masonry Block with Interior Insulated Steel Stud Wall</th>
<th>Tilt-up Concrete Panel with Interior Insulated Steel Stud Wall</th>
<th>Insulated Precast Concrete</th>
<th>Insulated Metal Panels</th>
<th>Prefabricated Metal with Draped Vinyl Faced Batts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductance</td>
<td>5</td>
<td>30</td>
<td>30</td>
<td>40</td>
<td>20</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Infiltration</td>
<td>5</td>
<td>30</td>
<td>30</td>
<td>40</td>
<td>20</td>
<td>30</td>
<td>50</td>
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<tr>
<td>Unit Cost</td>
<td>5</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>10</td>
<td>30</td>
<td>40</td>
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<tr>
<td>Installation Speed</td>
<td>4</td>
<td>24</td>
<td>24</td>
<td>16</td>
<td>40</td>
<td>40</td>
<td>40</td>
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<tr>
<td>Weather Installation Sensitivity</td>
<td>3</td>
<td>24</td>
<td>18</td>
<td>24</td>
<td>24</td>
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<td>24</td>
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<tr>
<td>Liquid Water Management</td>
<td>5</td>
<td>50</td>
<td>10</td>
<td>50</td>
<td>20</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Air Transported Moisture Management</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Vapor Diffusion Management</td>
<td>3</td>
<td>6</td>
<td>18</td>
<td>6</td>
<td>6</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Exterior Impact / Abrasion Resistance</td>
<td>3</td>
<td>30</td>
<td>12</td>
<td>30</td>
<td>30</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Interior Impact / Abrasion Resistance</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Mold Growth Resistance Management</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>40</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>240</td>
<td>208</td>
<td>232</td>
<td>290</td>
<td>344</td>
<td>394</td>
<td>256</td>
</tr>
</tbody>
</table>

The most energy efficient, cost effective, durable and sustainable building envelope solution is insulated metal panels with an overall score of 394 in total performance.
Building Systems

The following seven common wall assemblies were reviewed and analyzed. It is recognized that these systems are not all inclusive and that other assemblies and detail variations are possible.

Insulated Steel Stud Wall with Masonry Veneer
- Interior gypsum
- Vapor retarder
- Infill metal studs
- Fiberglass batt cavity insulation
- Exterior grade gypsum
- Building wrap
- Air space
- Brick veneer

Insulated Steel Stud Wall with EIFS Cladding
- Interior gypsum
- Vapor retarder
- Infill metal studs
- Fiberglass batt cavity insulation
- Exterior grade gypsum
- Trowel applied water / air barrier
- Expanded polystyrene
- Acrylic stucco

Split Faced Concrete Block with Interior Insulated Steel Stud Wall
- Interior gypsum
- Vapor retarder
- Infill metal studs
- Fiberglass batt cavity insulation
- Split-faced masonry block

Tilt-Up Concrete Panels with Interior Insulated Steel Stud Wall
- Interior gypsum
- Vapor retarder
- Infill metal studs
- Fiberglass batt cavity insulation
- Concrete tilt-up panel

Insulated Precast Concrete Panels
- Insulated precast panel
  (Painted interior concrete layer, Extruded polystyrene, Exterior concrete layer)

Insulated Metal Panels
- Insulated metal panels with structural steel support
  (Pre-finished interior metal skin, Foamed in place polyisocyanurate insulation, Pre-finished exterior metal skin)

Prefabricated Metal with Draped Vinyl Faced Batts
- Interior gypsum
- Infill metal studs
- Vinyl faced Fiberglass batt (draped over structure)
- Exterior pre-finished metal cladding
1 Energy Efficiency

Energy efficiency is one of the most important overall metrics of a building’s sustainability performance. The energy consumed during the construction and operation of buildings form a major share of total human energy consumption. Hence, energy consumption must be given serious consideration. Numerous studies have repeatedly demonstrated that the lowest cost approach to reduce expenditure on energy is improved insulation and airtightness in order to respond to climate change, rising energy costs, and concerns about energy supply security.

Overall Energy Performance Summary

<table>
<thead>
<tr>
<th>Importance Factor</th>
<th>Prefabricated Metal with Draped Vinyl Faced Batts</th>
<th>Insulated Metal Panels</th>
<th>Insulated Precast Concrete Panels</th>
<th>Tilt-up Concrete Panels with interior Insulated Steel Stud Wall</th>
<th>Split-faced Masonry Block with interior Insulated Steel Stud Wall</th>
<th>Insulated Steel Stud with EIFS Cladding</th>
<th>Insulated Steel Stud with Masonry Veneer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductance</td>
<td>5 30 30 40 20 30 50 50 50 50 50 100 40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50 30</td>
</tr>
<tr>
<td>Infiltration</td>
<td>5 30 40 20 50 50 50 10 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>60 70 60 70 80 100 40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

☑ Insulated metal panels score 100 in total energy performance.
1 Energy Efficiency

Thermal Conductance: an analysis of the assemblies propensity to transfer heat across the wall system.

The thermal efficiency of the various wall assemblies was examined by determining the effective R-values for the entire assembly. The assemblies were analyzed using THERM, a two dimensional heat flow analysis software package developed by Lawrence Berkley National Laboratories (LBNL). This analysis takes into account effects of thermal bridging across the insulation layer and the effects of air voids within the assemblies. Each assembly was modelled based on an 8-foot section of wall. The sections included interior cladding, framing, insulation, cladding, and / or panel joints. Insulation types and thickness were chosen to be representative of common construction.

The insulation values used in the below analysis were chosen as common insulation levels for particular assembly type. For assemblies that use steel studs and batts, the thermal bridging of steel studs create a significant reduction in the overall thermal resistance of the assemblies.

Thermal Efficiency of Wall Assemblies

**Insulated Steel Stud Wall with Masonry Veneer**
*(2x6 studs with R-19 fiberglass batt)*

U-value = 0.084 Btu/ft² • hr • °F
R-value = 11.9 °F • hr • ft²/Btu

**Insulated Steel Stud Wall with EIFS**
*(2x6 studs with R-19 fiberglass batt)*

U-value = 0.086 Btu/ft² • hr • °F
R-value = 11.6 °F • hr • ft²/Btu

**Wall System III: Split faced Concrete Block with Interior Insulated Steel Stud Wall**
*(2x6 studs with R-19 fiberglass batt)*

U-value = 0.068 Btu/ft² • hr • °F
R-value = 14.7 °F • hr • ft²/Btu

**Tilt-Up Concrete Panels with Interior Insulated Steel Stud Wall**
*(2x6 studs with R-19 fiberglass batt)*

U-value = 0.123 Btu/ft² • hr • °F
R-value = 8.2 °F • hr • ft²/Btu

**Insulated Precast Concrete Panel**
*(2" XPS, R-10)*

U-value = 0.090 Btu/ft² • hr • °F
R-value = 11.1 °F • hr • ft²/Btu

**Insulated Metal Panels**
*(3" PIR, R-22.5)*

U-value = 0.046 Btu/ft² • hr • °F
R-value = 21.8 °F • hr • ft²/Btu

**Prefabricated Metal with Draped Vinyl Faced Batts**
*(R-13 batt)*

U-value = 0.091 Btu/ft² • hr • °F
R-value = 11.0 °F • hr • ft²/Btu
Insulation R-value Compared to Assembly R-value

The effect of thermal bridging can be clearly seen when comparing insulation R-value and assembly R-value. **Insulated metal panels** and precast concrete panels have the closest R-value retention due to the continuous insulation and minimal thermal bridges.

**Insulated metal panels** can reach the highest assembled R-value of up to 45, by simply increasing the thickness of the insulation foam during manufacturing. It is important to note that most assemblies are limited to the amount of insulation they can use.
1 Energy Efficiency

Conductance Statistics

Overall, going from a minimally insulated wall assembly (R5) to a well insulated wall assembly (R30) results in building energy consumption reduction on the order of 2.8% to 10.1%, depending on the climate zone. The energy savings realized in cold climates were much greater than in warmer climates (8% to 13% for cold climates; 2% to 6% for hot climates).

Applying the assembly R-values from the relative performance of each of the wall assemblies determined energy transfer reduction.

### Conductance Analysis Results

<table>
<thead>
<tr>
<th></th>
<th>Minneapolis, MN Reduction (%)</th>
<th>Boston, MA Reduction (%)</th>
<th>Seattle, WA Reduction (%)</th>
<th>Austin, TX Reduction (%)</th>
<th>Phoenix, AZ Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>R-10</td>
<td>5.9</td>
<td>5.3</td>
<td>6.2</td>
<td>2.9</td>
<td>2.8</td>
</tr>
<tr>
<td>R-15</td>
<td>7.9</td>
<td>7.1</td>
<td>8.4</td>
<td>3.8</td>
<td>3.8</td>
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<tr>
<td>R-20</td>
<td>9.0</td>
<td>8.0</td>
<td>9.5</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>R-25</td>
<td>9.7</td>
<td>8.5</td>
<td>10.2</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>R-30</td>
<td>10.1</td>
<td>9.0</td>
<td>10.6</td>
<td>4.8</td>
<td>4.8</td>
</tr>
</tbody>
</table>

### Energy Transfer Reduction by Location

![Energy Transfer Reduction by Location Chart]

*Insulated metal panels were the best performing wall type and offered the greatest potential for energy transfer reduction in all climate zones*

Projected cost savings were determined using the following assumed utility rates of:

**Electricity: $0.10 / kWh**

**Natural Gas: $1.50 / Therm**

Insulated metal panels were the best performing wall type and offered the greatest potential for energy transfer reduction in all climate zones. Based on these assumed utility rates the estimated utility cost savings for all seven building types were compared to a similar base building with an exterior wall enclosure thermal resistance of R5. It should be noted that these utility rates have risen at a much higher rate than inflation, and close to the rate of interest on building mortgage rates. Hence, the annual savings times the expected lifespan provides a good estimate of total energy savings, including the cost of interest on extra capital cost.
In terms of energy efficiency, infiltration through the enclosure is of greatest concern. The loads associated with infiltration can be very significant. Every unit of air that is brought into a building displaces a unit of conditioned air, and therefore that volume needs to be reconditioned to maintain the desired interior conditions. Infiltration is of greater concern in climates where the temperature difference across the enclosure is greatest i.e. cold climates. Infiltration is also of concern in humid climates where the latent (moisture-based) load on a building can cause concerns with higher interior relative humidities and increase energy use for dehumidification. Prefabricated metal buildings and masonry block assemblies are likely to have the most associated air leakage. Framed assemblies such as brick veneer are potentially slightly better performers, while EIFS clad buildings will be reasonably air tight provided the connection at the base of the wall is made.

The best performers are likely to be insulated metal panels, insulated precast panels and tilt-up concrete.
1 Energy Efficiency

Infiltration Statistics

Overall, changing from a relatively leaky building air changes per hour (ACH 0.5) to a fairly airtight building (ACH 0.1) resulted in building energy consumption reduction on the order of 5% to 35%, depending on the climate zone. The energy savings in cold climates were much greater than in warmer climates ranging from (25% to 35% for cold climates – 5% to 16% for hot climates).

Infiltration Analysis Results

<table>
<thead>
<tr>
<th></th>
<th>Minneapolis, MN Reduction (%)</th>
<th>Boston, MA Reduction (%)</th>
<th>Seattle, MA Reduction (%)</th>
<th>Austin, TX Reduction (%)</th>
<th>Phoenix, AZ Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaky Building</td>
<td>ACH 0.5</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>ACH 0.4</td>
<td>7.50</td>
<td>8.00</td>
<td>5.60</td>
<td>3.60</td>
</tr>
<tr>
<td>Built to ASHRAE 90.1</td>
<td>ACH 0.3</td>
<td>14.90</td>
<td>16.10</td>
<td>11.10</td>
<td>6.30</td>
</tr>
<tr>
<td></td>
<td>ACH 0.2</td>
<td>22.00</td>
<td>22.80</td>
<td>16.60</td>
<td>9.10</td>
</tr>
<tr>
<td>Airtight Building</td>
<td>ACH 0.1</td>
<td>27.90</td>
<td>29.90</td>
<td>22.10</td>
<td>11.90</td>
</tr>
</tbody>
</table>

It is important to consider lifecycle utility costs and potential savings based on the airtightness levels of the assemblies. The following graph uses assumed utility rates as previous.

Lifecycle (20 years) Utility Savings by Air Changes per Hour (ACH) per Location

In all climate zones **insulated metal panels** offer the greatest amount of annual utility cost savings. As an example, in the Boston, MA climate zone insulated metal panels (assuming airtightness of ACH 0.1) offered annual utility cost savings of $48,500. Furthermore insulated metal panels offered lifecycle utility cost savings of $970,000.
Lifecycle Utility Cost Savings for Assumed Combinations of Building Envelope Airtightness and Thermal Performance Location: Boston, MA

How much utility costs can an energy efficient building save? The following graph illustrates a leaky building with low R-value, a building built to ASHRAE 90.1 and an airtight building with high R-value in Boston, MA.

An airtight building of (ACH 0.1) with an R-value of 30 achievable with insulated metal panels indicates annual utility cost savings of $62,840. Lifecycle cost savings of $1,256,800, almost 3 times more than $474,700, a building built to ASHRAE 90.1.
2 Construction Cost

Project cost is an overriding factor for any building project. Multiple elements come into consideration when examining the cost impacts associated with construction and building operation. The initial capital cost of components and assemblies is a significant factor in the design. The study examined all seven building assemblies and their unit costs for both industrial and architectural applications.

Unit Costs

RS Means construction estimating guides were used as reference to provide the cost comparison data for the assemblies considering both labor and materials. Due to the variety of possible materials and finish choices a range of approximate costs were estimated.

Assembly Costs

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Industrial Cost Range</th>
<th>Architectural Cost Range</th>
<th>Assembly R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulated Steel Stud with Masonry Veneer</td>
<td>$15-20/ft²</td>
<td>$20-25/ft²</td>
<td>11.9</td>
</tr>
<tr>
<td>Insulated Steel Stud with EIFS Cladding</td>
<td>$10-15/ft²</td>
<td>$15-20/ft²</td>
<td>11.6</td>
</tr>
<tr>
<td>Insulated Precast Concrete Panels</td>
<td>$15-20/ft²</td>
<td>$10-15/ft²</td>
<td>14.7</td>
</tr>
<tr>
<td>Split-faced Masonry Block with Insulated Stud Wall</td>
<td>$9-12/ft²</td>
<td>$10-15/ft²</td>
<td>8.2</td>
</tr>
<tr>
<td>Tilt-up Concrete Panels with Interior Insulated Steel Stud Wall</td>
<td>$12-15/ft²</td>
<td>$20-30/ft²</td>
<td>11.1</td>
</tr>
<tr>
<td>Prefabricated Metal with Draped Vinyl Faced Batts</td>
<td>$9/ft²-10/ft²</td>
<td>$15/ft²-20/ft²</td>
<td>21.8</td>
</tr>
</tbody>
</table>

The above figures illustrate the low cost to achieve a high R-value of 21.8 with insulated metal panels.
Construction Scheduling

Another important factor is the overall construction schedule. Buildings that take less time to construct are more cost effective, less onerous on resources and allow for quicker intended use, and there by increase potential for revenue generation. When looking at the construction schedule, factors that affect the critical path of the schedule are the most important.

Often a part of the critical path is the installation of the building enclosure assemblies and “dry-in” of the building. This does not require the complete construction of the enclosure assembly, only the liquid water management portion (eg. The interior framed walls do not need to be constructed or insulated at this stage). The construction schedule is also impacted by weather sensitivity and delays.

Installation Performance Summary

<table>
<thead>
<tr>
<th>Importance Factor</th>
<th>Installation Speed</th>
<th>Weather Installation Sensitivity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulated Steel Stud with Masonry Veneer</td>
<td>4</td>
<td>3</td>
<td>48</td>
</tr>
<tr>
<td>Insulated Steel Stud with EPS Cladding</td>
<td>24</td>
<td>24</td>
<td>58</td>
</tr>
<tr>
<td>Insulated Steel Stud with Interior Insulated Steel Wall</td>
<td>16</td>
<td>24</td>
<td>40</td>
</tr>
<tr>
<td>Steel-faced Masonry Block with Interior Insulated Steel Wall</td>
<td>40</td>
<td>24</td>
<td>64</td>
</tr>
<tr>
<td>Tilt-up Concrete Panels with Interior Insulated Steel Wall</td>
<td>40</td>
<td>24</td>
<td>64</td>
</tr>
<tr>
<td>Insulated Precast Concrete Panels</td>
<td>40</td>
<td>24</td>
<td>64</td>
</tr>
<tr>
<td>Insulated Metal Panels</td>
<td>40</td>
<td>24</td>
<td>64</td>
</tr>
<tr>
<td>Insulated Metal Panels with Draped Vinyl Faced Battens</td>
<td>40</td>
<td>24</td>
<td>64</td>
</tr>
</tbody>
</table>

Installation Speed

The lightweight nature of insulated metal panels makes them easy to handle and install. Insulated precast panels are relatively quick to install, however, the weight of the panels make them difficult to maneuver and set into place.

Weather Sensitivity and Delay Concerns

Almost any construction that happens outdoors is subject to delays due to weather. Certain assemblies are more weather sensitive than others, and different weather conditions affect different construction types.
2 Construction Cost

Building Systems Component Analysis

Assemblies with multiple components are more likely to experience delays in construction due to the scheduling of multiple trades.

<table>
<thead>
<tr>
<th>System</th>
<th>#</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulated Metal Panels</td>
<td>1</td>
<td>Foamed-in-place Insulated Metal Panel with pre-finished ext / int metal skins</td>
</tr>
<tr>
<td>Traditional Metal Cladding</td>
<td>5</td>
<td>Interior metal cladding; Infill metal studs; batt insulation; Vapor barrier; Exterior metal cladding</td>
</tr>
<tr>
<td>Single Skin Metal Cladding</td>
<td>4</td>
<td>Interior gypsum; Infill metal studs; draped vinyl faced fiberglass batt; Exterior metal cladding</td>
</tr>
<tr>
<td>Aluminium Composite Metal Panels</td>
<td>5</td>
<td>Interior gypsum; Infill metal studs; Vapor barrier; Rigid insulation; ACM panel</td>
</tr>
<tr>
<td>Exterior Insulated Finish System (EIFS)</td>
<td>11</td>
<td>Interior gypsum; Vapor barrier; Infill metal studs; Batt insulation between studs; Gypsum sheathing; Trowel applied air barrier; Abrasive (Insul); EPS Insulation; Base Coat; Reinforcing Mesh; Finish Coat</td>
</tr>
<tr>
<td>Masonry Veneer</td>
<td>7</td>
<td>Interior gypsum; Vapor barrier; Infill metal studs; Batt insulation between studs; Gypsum sheathing; building wrap (air barrier); Brick or Arch Block</td>
</tr>
<tr>
<td>Tilt-Up Concrete Panels</td>
<td>6</td>
<td>Interior gypsum; Vapor barrier; Infill metal studs; Batt insulation; Concrete tilt-up panel; Caulk joints</td>
</tr>
<tr>
<td>Precast Concrete Panels</td>
<td>2</td>
<td>Precast Concrete Panel; Caulk joints</td>
</tr>
</tbody>
</table>

✔ Insulated metal panels as a single component system increases speed of build, minimizes delays and the need for multiple trades
Kingspan Case Study

Consultants for a large retail chain, estimate construction schedule time savings of up to five weeks were achieved in a multiple unit construction program in Canada with **insulated metal panels**.

An average retail store with profits of $35,000 a week can potentially save $175,000 profit in this time as the building is open for business and revenue is generated.

**Construction Schedule**

The lightweight nature of Kingspan **insulated metal panels** makes them easier to handle and get into position.

The panel as a single component reduces the need for multiple trades on site.

Panels can be installed in all weather conditions.

**Indirect Cost Saving Potential**

Implementation of the airtightness and thermal performance construction methodologies outlined in Section 1 have the potential to deliver significant capital cost savings on building HVAC systems. The design and construction of the building enclosure significantly affect the design of the HVAC systems.
3 Durability

It is important that a building remains durable through its expected service life. Premature failure of a building and its components would require resources for replacement and disposal of the failed assemblies.

The overall durability of a building is dependent on the environmental loads that the materials of the assembly are subjected to. In this regard, a material (or assembly) itself is neither durable nor non-durable; it is the interaction of the material (or assembly) in its environment that determines its durability. Other than natural disasters, the most common damage functions on a building are from moisture, mold growth, ultraviolet radiation, heat, impact abrasion / fatigue and the subsequent effects on indoor air quality.

For the purposes of this paper, durability performance considers resistance to moisture, mold growth, abrasion and the management of liquid air and water.

Durability Performance Summary

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<th>Importance Factor</th>
<th>Prefabricated Metal with Draped Vinyl Faced Batts</th>
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<th>Tilt-up Concrete Panels with interior Insulated Steel Stud Wall</th>
<th>Split-faced Masonry Block with interior Insulated Steel Stud Wall</th>
<th>Insulated Steel Stud with EIFS Cladding</th>
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<td>30</td>
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<td>20</td>
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<td>Total Durability Criteria</td>
<td>112</td>
<td>66</td>
<td>102</td>
<td>122</td>
<td>190</td>
<td>200</td>
<td>112</td>
</tr>
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</table>

**Insulated metal panels** score 200 in total durability performance, higher than precast and tilt-up.
Liquid Water Management

Moisture is currently the leading cause of material deterioration in building assemblies. The ability of the exterior wall assemblies to manage water infiltration is often very important for the overall performance on the building. Water damage of wall assemblies or any materials within the building due to poor moisture management of the exterior assembly would represent a fundamental failure of the enclosure assembly. For the building analyzed, the common concerns relating to moisture management stem predominantly from liquid rainwater intrusion.

There are three fundamental rain control strategies: Drained / Screen, Mass / Storage, Perfect Barrier.

Screened / drained walls assume some rainwater will penetrate the outer surface (hence the cladding “screens” rain) and remove this water by designing an assembly that provides drainage within the wall. Some examples of drained wall systems include cavity walls, brick and stone veneer, vinyl siding, and drained EIFS.

Mass walls require the use of an assembly of materials with enough safe storage capacity and moisture tolerance to absorb all rainwater that is not drained or otherwise removed from the outer surface.

The infiltration occurs through micro cracks and pores in the assembly and is driven predominantly from gravity and capillary forces. In a functional mass or storage wall, evaporative drying and diffusion eventually removes moisture before it reaches the inner surface of the wall.

Perfect barriers stop all water penetration at a single plane. Such perfect control requires the use of modern materials such as metal and glass. Although difficult to build and maintain a perfect barrier wall, some systems, usually factory built, provide wall elements that are practical perfect barriers.

Insulated metal panels can be considered a perfect barrier, however, the panel joinery is key to the systems performance as a perfect barrier. The joints between perfect barrier elements may be also designed as perfect barriers (eg. a single line of caulking or gasketing). The joints can be designed as screened / drained assemblies to manage water at the panel joints (two-stage joints). It is strongly recommended that all joints in prefabricated panel systems and windows should be drained and vented (this is often called a “rainscreen”).
3 Durability

Kingspan Engineered Joinery

- Kingspan panel joints are designed with an overlap nosing that deflects rainwater, protects and conceals the panel fastener.
- Designed to the rainscreen principle, the pressure equalization chamber behind the nosing acts as a second line of defense intercepting and draining water effectively back to the exterior. The balancing of positive air pressure outside with air pressure in the equalization chamber prevents rain water from reaching the sealant in the panel joint.
- Kingspan panels are designed with double tongue and groove (two-stage) joints allowing for:
  - Application of a continuous butyl sealant on the warm side groove provides for air, vapour and moisture resistance (mandatory).
  - Application of a butyl sealant to the outer side groove provides an additional weather barrier (best practice).

Kingspan Rainscreen Joint

Air Transported Moisture Management

Air infiltration / exfiltration concerns air leakage through the enclosure. Air movement through the assembly is driven by differences in air pressure between the interior and the exterior. These air pressure differences can come from a combination of wind, stack effect (natural thermal buoyancy of air), and mechanical pressurization. The combined effect of these forces can be quite significant and lead to a substantial air movement. To control air movement through the assembly, a continuous barrier to air movement is required; however, the location of the air barrier in the assembly is not important (this is not the case for convective loops). The air barrier can be on the interior, exterior, at a location in the middle, or it can be composed by the entire composite assembly. For the air barrier to be effective, it must be continuous in the field of the wall as well as at the connections to other components (such as to the foundation, roof, and windows and doors).

The air barrier can be a single material or a layer of materials acting together as a composite to resist the imposed air pressure loads without rupturing. Flexible materials such as sheet polyethylene or taped foil or Kraft facings, have historically demonstrated poor performance as an air barrier due to their inability to resist the air pressure loads. Masonry materials (such as masonry block) do not function as air barriers; however, materials such as an SBS sheet membrane adhered to a solid substrate (gypsum, masonry block) have demonstrated high performance (i.e., attaching a flexible membrane to a solid substrate).
The air barrier must also be continuous from one assembly to another (roof to wall, wall to foundation, and window / door to wall). If the air barrier is not continuous, then air leakage will occur. The path of air movement will depend on the design of the assemblies and the location of the discontinuity.

Condensation within the assembly will occur if moisture-laden air moving through the assembly comes into contact with a cold surface (surface temperature below the dew point temperature of the air). Therefore, for interstitial condensation problems to occur, there must be air movement and cold surfaces along the path of flow. Since the panels are air impermeable and the insulation is composite to the system (no insulated framed cavity wall is generally added to the assemblies) cold interior surfaces are eliminated, and interstitial condensation is not a concern.

Climatic Vapor Drive

From a fundamental perspective, a lower permeability (vapor retarder) layer should be installed on the side of higher absolute moisture content of air to control the rate of vapor flow into the assembly. This has led to a general rule of thumb for cold climates that the vapor retarder layer is installed on the interior side of the insulation. Conversely, in hot humid climates, it should be located on the exterior. Unfortunately, in most areas, the vapor drive is not always in one direction, and will change depending on the time of year or other circumstances. This is most apparent in mixed climates (the area between cold climates and hot humid climates) where both drives are significant.

In these locations, it is often recommended to allow vapor to freely flow through the assembly in order to prevent moisture accumulation.

For most site built systems, where there is a potential for water intrusion or accumulation between the layers (from water leakage or air leakage), having impermeable layers on both sides would not be recommended. However, in the case of insulated metal panels given that the system is a composite panel, and that water infiltration and air infiltration in between the two layers of metal is not a concern, the inability of the system to dry to either side is inconsequential.

Insulated metal panels function very well in managing vapor drive from both sides of the assembly. Insulated metal panels have vapor impermeable layers on both sides of the polyurethane foam core, thus blocking moisture movement in either direction.
3 Durability

Insulated metal panel systems are generally very resistant to mold growth due to the non-moisture sensitive nature of the materials used in the construction as well as the lack of a cavity or concealed space that can trap construction debris.

Inward Solar Drive

An additional concern relating to vapor diffusion is the inward solar-driven moisture from storage assemblies or absorptive (“reservoir”) cladding systems. Solar radiation after a rainstorm will heat the cladding material, causing the absorbed moisture to be driven into the wall assembly. If an impermeable layer is installed on the interior, this can lead to moisture accumulation in the cavity.

Cladding systems that are non-absorptive such as insulated metal panels do not have any concern relating to inward vapor drive from solar heating.

Impact / Abrasion Management

A concern for some building owners is from low-level impact on building enclosures from traffic (e.g., cars and forklifts). In some cases, security is also a concern, and a high impact resistant material at the ground level is critical. In these cases, a highly impact resistant wall assembly (interior and exterior) may be appropriate. Given that the requirement is really only to protect the base of the wall, it is also possible that a high impact assembly on the bottom portion of the wall can be combined with a less impact resistant assembly outside of the high risk area for impact and abrasion. To deal with mechanical impact and abrasion in high traffic areas, cost effective solutions to protect building cladding are available. For example, brick or architectural split face block at the base of the building. Using insulated metal panels as a back up to these systems, therefore maintaining the same air, thermal, moisture and barrier properties of the overall wall system.

Mold Growth Resistance

Mold in assemblies requires several conditions to grow and spread. Fundamental to this is the presence of moisture. In addition, most molds need oxygen, a food source and temperatures typically between 40 ºF (4 ºC) and 140 ºF (60 ºC). Assemblies that are likely to be more prone to problems with mold growth will be those constructed in whole or in part with organic materials such as wood and paper (Paperfaced Drywall), or assemblies that are more prone to attract and trap construction dust and moisture debris (Batt Insulation).
Conclusion

At the forefront of sustainability, insulated metal panels offer a superior cost effective, energy efficient solution, designed to stand the test of time.

Insulated metal panels can contribute to LEED certification potentially earning points in energy and atmosphere, indoor environmental quality, innovation in design and material and resources. This energy efficient solution has a high percentage of recycled content in the steel, can be reused and is 100% recyclable at the end of life.

The growing presence of Kingspan across North America makes insulated panels readily available to all regions.
Kingspan Insulated Panels

Boston Convention Center, Boston, Massachusetts
Home Depot, Ontario, Canada

The Hamilton Art Gallery, Hamilton, Ontario