INTRODUCTION

The Ministry of Housing of the Kingdom of Bahrain has commissioned an exercise to identify best practices linked to thermal insulation value and costing. The aim of this exercise is to ensure that new housing units in the Kingdom of Bahrain are built in an efficient and cost-effective manner with regards to thermal insulation. Best practices in design have been identified according to regional and global standards and guidelines with consideration to construction techniques, materials and supply chain.

The thermal insulation guidelines for Bahrain has been produced as a tool to assist designers and engineers in the decision making process and selection of appropriate materials and systems for the development of new housing units in Bahrain.

The Guidelines are divided into two main sections as follows:

1. The introductory section provides the thermal performance parameters, thermal classification and a case study that demonstrates a fully worked out example of a housing unit utilizing different systems. The performance parameters that contribute to the overall building envelope performance which should be taken into consideration throughout the design phase are provided with emphasis on thermal performance (U-Values in particular).

2. The building systems section includes different construction options for walls, roof, glazing, doors and floors. Upon reading the description of each system, its capabilities and thermal performance, the reader can select the system (or group of systems) which is relevant and most applicable to their design. The U-Values have been calculated for each system type, taking into consideration the potential U-Value for each system depending on varied insulation thicknesses where applicable.

Disclaimer

This catalogue provides various options for building wall, floor, glazing, door and roof systems which provide ranges of thermal performance and cost. Engineers are not limited to the sole selection of systems presented within this catalogue. Costs are estimated at the time of writing through assessment of existing systems and market status. This is no indication of future market conditions or system costs. Costs have been averaged and actual costs depend on multiple factors including quantity, project location and market status at time of purchase.
**Infiltration Rate**
Infiltration is the uncontrolled leakage of air through cracks and gaps in any building element and around the windows and doors of a building. Infiltration is caused by pressure differences across these elements due to wind, inside and outside temperature differences and imbalance between supply and exhaust air systems.

**Light Transmittance**
Light transmittance is a property of transparent and translucent materials, measuring their capacity to transmit light all the way through themselves. Opaque materials have a transmittance of zero as no light at all gets through. The transmittance of an object or instance of material measures its effective transmission, given as a ratio of the total amount of light or electromagnetic radiation that is transmitted compared to the total amount incident upon it.

**Roofing Material SRI**
SRI is a measure of the constructed surface’s ability to stay cool in the sun by reflecting solar radiation and emitting thermal radiation. It is defined such that a standard black surface (initial solar reflectance 0.05, initial thermal emittance 0.90) has an initial SRI of 0, and a standard white surface (initial solar reflectance 0.80, initial thermal emittance 0.90) has an initial SRI of 100. To calculate the SRI for a given material, its solar reflectance and thermal emittance are obtained via the Cool Roof Rating Council Standard (CRRC-I). SRI is calculated according to ASTM E 1980 and the calculation of the aged SRI is based on the aged tested values of solar reflectance and thermal emittance.

**Solar Heat Gain Coefficient (SHGC)**
SHGC is the ratio of the solar heat gain entering a space through a transparent/translucent element to the incident solar radiation on the element. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then re-radiated, conducted or convected into the space.

**Shading Coefficient (SC)**
SC is one of the factors which determine the thermal performance of a glass unit. It is the ratio of solar gain (due to direct sunlight) passing through the glass unit to the solar gain through 3mm clear float glass. SC is an indicator to how the glass is thermally shading/insulating the interior when exposed to direct sunlight. This value depends on the colour of glass and degree of reflectivity and usually ranges from 1.00 to 0.00. The lower the rating, the less solar heat is transmitted through the glass and the better its shading ability.

**Thermal Bridging**
Thermal bridges are localized areas with higher thermal conductivity than their neighbouring areas. Thermal bridging and the rate of heat flow depends on several factors such as the temperature difference between the heat source and heat “sink”, the cross-sectional area of thermal bridge, the thermal conductivity of the materials as well as the area of the surface facing the source of heat and those facing the heat sink.

**Thermal conductivity (k)**
K is the property of the material which determines the heat flow by conduction through unit thickness of unit area of the material across a unit temperature gradient. Thermal conductivity is influenced by the density, the porosity, water contents, and specific heat of the material. The unit of measurement is (W/mK).

**Thermal Resistivity (r)**
r is the reciprocal of the thermal conductivity (1/k) is the thermal resistivity of the material. It is the resistance to heat flow through unit thickness when there is a unit temperature difference between the two surfaces. In the metric system, the unit of measurement is m²K/W.

**Thermal Resistance (R)**
R is the thermal resistance of a material is the resistance to heat flow through a unit area of homogeneous material when there is a unit temperature difference between two surfaces and its unit of measurement is (m²K/W).

**Thermal Resistance R of a material is calculated by dividing the thickness of the material by the thermal conductivity of the material (k) or by multiplying the thickness of the material by the thermal resistivity of the material.**

**U-Values**
The U-Value is the heat transmission in unit time through the unit area of a material or construction and the boundary air films, induced by unit temperature difference between the environments on each side. The units of U-Value are W/m²K. The lower the U-Value, the better the insulating capacity of the system. As per industry standard, U-Values are presented throughout this catalogue to 2 decimal places.

**Window to Wall Ratio (WWR)**
WWR is calculated by dividing the building’s total glazed area by its exterior envelope wall area. Increased glazing in buildings may pose unnecessary energy burdens. For this reason, available standards and guidelines have specified limits to the area of glass/renovation which should be adequate to provide optimal daylighting and view. For higher window to wall ratio, higher performance glazing technologies are available to reduce the heat gain and unwanted glare in occupied spaces.
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<td>AAC</td>
<td>Autoclaved Aerated Concrete</td>
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<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigerating and Air Conditioning Engineers</td>
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<tr>
<td>CoP</td>
<td>Coefficient of Performance</td>
</tr>
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<td>DGBR</td>
<td>Dubai Green Building Regulations</td>
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<td>EIFS</td>
<td>Exterior Insulation &amp; Finish System</td>
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<td>Energy Water Authority</td>
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<td>GFA</td>
<td>Gross Floor Area</td>
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<td>GRC</td>
<td>Glass Reinforced Concrete</td>
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<td>HVAC</td>
<td>Heating, Ventilation and Air Conditioning</td>
</tr>
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<td>ICF</td>
<td>Insulated Concrete Formwork</td>
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<tr>
<td>IES</td>
<td>Integrated Environmental Solutions</td>
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<td>IESNA</td>
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<td>IG</td>
<td>Insulating Glass</td>
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<td>Low-e</td>
<td>Low Emissivity</td>
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<td>LPD</td>
<td>Light Power Density</td>
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<td>Middle East North Africa</td>
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<td>MoH</td>
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<td>R-SKY</td>
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**THERMAL GUIDELINES PROCESS CHART**

**STEP 1:**
Select the type of construction, between a new construction or a refurbishment (Retro-fit)

**STEP 2:**
Choose between:
Villa - below 4 stories
High-rise - Equal to or Above 4 stories

**STEP 3:**
Depending on the building type the thermal performance classification should be reviewed for each construction type.

**SYSTEMS CATALOGUE**

<table>
<thead>
<tr>
<th>#</th>
<th>Code</th>
<th>Structural Composition</th>
<th>U-value</th>
<th>Cost</th>
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**STEP 3.1:**
The Cost Benefit Analysis Matrix evaluates each of the systems against a number of criteria including thermal potential, assembly cost, life cycle cost, durability, embodied energy, availability in the Bahrain market and the buildability in order to assist the user in the decision making process.

**STEP 3.2:**
The catalogue contains one page per construction type where all the information is combined. This includes system build up, description, reference images, thermal potential, cost and the relevant extract from the Cost Benefit Analysis Matrix. Refer to the next page for layout information.
## 1.5. CAVITY WITH BLOCK WORK WALL

### System Code

**W-CBW**

- Suitable for: Retrofit, New Build, High Rise

### Key Information

- **Description**
  - Internal finish (25mm) is a plastering layer; the thickness depends on the uniformity of the wall using a finishing trowel.
  - External finish (200mm): This type of blockwork is used in this system. A block of concrete, cement or similar material. These blocks have low thermal resistance and thereby relatively poor insulating values.
  - Insulation (60-80mm): Insulation should be accompanied by geometric detailing to avoid thermal transfers by bridging through window and door frames, by radiation through window openings or by convection through skylights.
  - Castability (400 mm)
  - Mitred (150 mm)

### Insulation Thickness / U-Value

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<td>Cavity with Blockwork Wall</td>
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### Technical Information

**Total System Cost**

- 275 $/Qm

For the cost estimation, 60 mm mineral wool insulation has been considered.

- Generally thicker layers are made up of numerous 50mm thick sheets at around 90$ per additional layer.

### Comments / Recommendations

1. Metal brackets: Generally only stainless steel or aluminum should be used outside the vapor barriers.
2. Front of the slab and front of the frame structure should be insulated to avoid thermal bridging.
3. Insulation joint required to accommodate shrinking movements.
4. Suitable for Retrofit or New Build.

### Information extract from the system matrix

**Legend**

- **COMMENTS**
- **RETROFIT OPTION**

- **WWR** Window to Wall Ratio
- **SHGC** Solar Heat Gain Coefficient
- **SRI** Solar Reflective Index
BAHRAIN CLIMATE

BAHRAIN MICRO-CLIMATE

The climate in Bahrain is extremely hot in summer and relatively mild in winter. Bahrain is located in the west central Gulf where the highest point is Jebel Al Dukhan Hills 134 meters above sea level in the centre of the main island. Regional features include dust and sand basins of Iraq approximately 350 nautical miles to the north west and the mountain range of the Zagros of Iran, 120 nautical miles at their nearest to the north east. These features, along with the Gulf waters, have the main influence on the climate of Bahrain. The Zagros hills cause the low-level winds to be directed to below mainly from the north west or southeast by steering or influence on the pressure pattern. The dust bowls of Iraq and northern Saudi Arabia provide an abundance of fine dust particles easily transported by north westerly winds which cause visibility reductions at Bahrain, mainly in the months of June and July. The Gulf waters provide a low-level moisture supply.

Seas are relatively shallow around Bahrain and heat up quickly in the summer to give high dew point values and humidity, especially at night. Sea temperatures may reach 35 °C during the summer.

GENERAL CLIMATE

Bahrain has an arid climate and receives little precipitation. However, during winter months rare rainfall events can occur. The mean annual rainfall is irregular and is recorded as approximately 70.8mm per year. Broadly speaking, the year may be divided into two main climatic periods from June to September and from December to March, separated by two transitional periods April/May and October/November.

The summer period is one of mainly cloudless skies and persistently high temperatures. A shallow dome of relatively cool moist air over the Gulf is overlaid by hot dry air causing a marked temperature inversion in the first 1,000 to 1,500 feet of the order of 5 to 10 °C. The seasonal rise in temperature peaks in August with a mean daily maximum of 38 °C. During June and July a period of persistently strong north westerly winds known locally as the “summer shimal” occurs and causes marked wind shears at times in the boundary layer of the order of 5-6 knots per 100 feet. The shimal transports dust from Iraq and visibility at Bahrain on occasions is reduced to less than 1,500 metres over this period mainly between 2000Z to 0600Z.

The winter period is the season of changeable weather when low pressure disturbances with their associated fronts transit the mid Gulf. Surface winds alternate mainly between south east ahead of these features and north west behind. The mean number of days per annum with measurable rain of 1mm or more are 9.9 with the highest being 2 days in the month of January. Thunderstorms occur on average on 7.8 days per annum with March having the highest mean average of 1.9 days. The average number of days per annum that visibility is reduced to 1000 metres or less by fog is 6.6 and by thick dust haze is 4.5. January averages 1.7 days of fog and is the highest monthly frequency. July has the highest frequency of thick dust haze occurrence (1.1 days on average).

The transition periods during October/November introduces the first incursions of cool air from the north west occur and replace the quiet conditions of late summer. The spring transition is known as the sarrayat where sudden changes in wind can occur caused by relatively weak instability features, and low level wind shear has been observed with these sudden changes.
THERMAL PERFORMANCE PARAMETERS INTRODUCTION

There are several factors affecting the performance of a building envelope which are identified in this section of the Guidelines. These performance parameters have been assessed and identified as follows:

1. Building Orientation
2. Façades Shading
3. Glazing % / Window to Wall Ratio (WWR)
4. Solar Heat Gain Coefficient (SHGC)
5. Roofing Material Solar Reflectance Index (SRI)
6. U-Value
7. Thermal Bridging

Recommended values and ranges have been provided for each of the parameters in accordance with international standards and best practice whereas. The table below summarizes the U-Value for each envelope element (walls, doors, windows, glazing, roof and floor) investigated separately highlighting the current EWA standards as well as optimal U-Values from international standards. The best practice U-Value ranges for each envelope assembly are available in detail in the thermal classification section.

<table>
<thead>
<tr>
<th>System/ Component</th>
<th>Existing Legislation</th>
<th>Good practice U-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All New Construction (EWA)</td>
<td>Low Rise</td>
</tr>
<tr>
<td>Roof</td>
<td>0.6</td>
<td>0.2-0.3</td>
</tr>
<tr>
<td>Glazing: Fenestration</td>
<td>&lt; 5.1 single insulated</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&gt; 2.4 double insulated</td>
<td></td>
</tr>
<tr>
<td>Glazing: Curtain Wall</td>
<td>&lt; 2.1</td>
<td>1.9-2.1</td>
</tr>
<tr>
<td>Skylight</td>
<td>&lt; 2</td>
<td>1.9</td>
</tr>
<tr>
<td>Wall</td>
<td>0.75*</td>
<td>0.35 - 0.5</td>
</tr>
<tr>
<td>Door</td>
<td>Insulation is required but no value specified</td>
<td>1.65 for glazed doors</td>
</tr>
<tr>
<td>FLOOR</td>
<td>Insulation is required but no value specified</td>
<td>0.4-0.5</td>
</tr>
</tbody>
</table>

* Ministerial Decree states that the U-Value for walls shall be changed from 0.75 to 0.57 effective by the end of March 2018.

Additionally, different retrofit strategies have been identified to improve existing building’s thermal performance. This includes changes or modifications which can be made to walls, floors, roof and glazing. The addition of thermal insulation, insulation on roofs, shading devices or modification of window openings and sizes are some of the options which can be implemented towards improving the envelope performance. These options are indicated with a retrofit mark (R) as part of the catalogue on relevant assemblies.

First, refer to the thermal performance parameters for each of the assemblies in the building (as shown on the below figure) and note the special considerations or values that are applicable to the design by exploring the available options.
**THERMAL PERFORMANCE PARAMETERS**

### BUILDING ORIENTATION

Building orientation should be studied at initial design stages to ensure that glazing on the Western and Southern facades is reduced. It is good practice that 50-60% of the glazed area have a predominantly North orientation and that South and West glazed areas are treated through improved U-Values, SHGC and shading.

![Diagram of building orientation](image)

**SHADING**

It is good practice to provide vertical shading on the Western facades and horizontal shading devices on the Southern facade that serves and compliments the overall design of the building. The consideration of shading devices should be carried out in conjunction with the SHGC, since the integration of façade shading can allow for less conservative values of SHGC.

![Shading diagrams](image)

**GLAZING % WINDOW : WALL RATIO**

It is good practice not to exceed 20% WWR for low rise buildings and that the WWR would be between 20-40% for high rise buildings.

![Glazing ratio diagrams](image)
**Solar Heat Gain Coefficient (SHGC)**

For low-rise buildings:
- ≤20% WWR - SHGC = 0.4 max
- >20% WWR - SHGC = 0.25 max

For high-rise buildings:
- ≤40% WWR - SHGC = 0.35 max
- 40-60% WWR - SHGC = 0.3 max
- ≥ 60% WWR - SHGC = 0.22 max

For skylight:
- SHGC < 0.2175

---

**ROOF Solar Reflective Index (SRI)**

Roof SRI value should comply with 78 for a minimum of 75% of the roof area. Recommended materials are reflective and/or emissive, that is, they reflect sunlight and re-emit absorbed heat back to the sky before it is conducted into the structure.
THERMAL PERFORMANCE CLASSIFICATION

U-VALUES

Next, U-Values should be calculated for walls, roof and floor systems as demonstrated in the case study. In the second section of the Guidelines, the U-Values are calculated and listed for each of the presented assemblies. For certain assemblies, the U-Values can be improved by varying the thickness of the insulation layer. The average weighted U-Value calculation should be performed on the whole facade and through which the classification can be identified. The Thermal Classification and Case Study sections provide more details on U-Value calculations.

THERMAL PERFORMANCE CLASSIFICATION FOR HIGH-RISE BUILDINGS

A basic thermal performance classification system has been developed for each building envelope component. The purpose of this exercise is to highlight the recommended thermal performance for building components and to encourage installation of higher performance building envelopes.

The calculated U-Value for each assembly can be evaluated based on the ranges presented graphically to the right. For example, a wall assembly with 200 mm blockwork, 50 mm insulation and render as a finish would have a U-Value of 0.61 W/m²K which would be considered of ‘Poor’ performance, while increasing the insulation thickness of the same assembly to 100 mm would reduce the U-Value to 0.35 W/m²K, which contributes to a better performing envelope classified as ‘Excellent’.

Key:

Poor           Excellent
THERMAL PERFORMANCE CLASSIFICATION

THERMAL PERFORMANCE CLASSIFICATION FOR LOW-RISE BUILDINGS

The same process has been completed to identify the thermal performance classification of differing U-Values for walls, roof, windows and floors of low-rise (villa) buildings. The classification of the U-Value range for each of the systems is dependent on the associated energy conservation achieved by different U-Values, as well as the feasibility of achieving such U-Values for a low-rise building.

Wall U-Value range in low rise buildings

Glazing U-Value range in low rise buildings

Roof U-Value range in low rise buildings

Floor U-Value range in low rise buildings

Key:
Poor → Excellent

THERMAL INSULATION GUIDELINES

2018

AESG
COMPOSITE U-VALUE CALCULATION

The following illustrates how the wall average weighted U-Value calculations have been calculated for each of the three case studies.

The figure on the right demonstrates the steps that have been taken in order to correctly calculate the average weighted U-Value for walls.

**STEP 1**
Identify wall types on elevations (color coded for ease of reference).
Variations in backwalls, finishing materials and overall thickness would be considered as different wall types.

**STEP 2**
Identify wall compositions.
Draw wall sections identifying build up for each wall including materials and thicknesses.

**STEP 3**
Perform calculations for each wall type as per EWA Guidelines.
Refer to detailed step 3 for reference.

The thickness and thermal conductivity of each layer should be provided and the calculation is done as follows:

\[
\text{Thermal Resistance} = \frac{\text{Thickness}(\text{mm})}{1000}/\text{Thermal Conductivity}\]

\[
\text{Thermal Resistance of assembly} = \frac{1}{R1+R2+R3+Rn}
\]

*Thermal Conductivity values for different materials are provided in Appendix B

**STEP 4**
Compute the areas of each wall type.
Refer to detailed step 4 for reference.
The area of each wall construction and the corresponding U-Value are used to calculate the Average Weighted U-Value as follows:

\[
\text{Average Weighted U-Value} = \frac{\text{Sum(Area x U-Value)}}{\text{Sum Area}}
\]
CASE STUDY 1 - Insulated render on Insulated Blockwork Type 4 (20 mm External only)

Identify wall types on elevations (color coded for ease of reference). Variations in backwalls, finishing materials and overall thickness would be considered as new wall types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Construction Type 1</td>
<td>1</td>
</tr>
<tr>
<td>Insulated render on insulated Blockwork Type 4 (recessed 245mm)</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 2</td>
<td>2</td>
</tr>
<tr>
<td>Insulated render on insulated Blockwork Type 1 - 250 mm</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 3</td>
<td>3</td>
</tr>
<tr>
<td>Render on Concrete 250 mm</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 4</td>
<td>4</td>
</tr>
<tr>
<td>Metal Screen on Blockwork 250 mm</td>
<td></td>
</tr>
<tr>
<td>Parapet - excluded from U-Value calculations</td>
<td></td>
</tr>
</tbody>
</table>
CASE STUDY 1 - Insulated render on Insulated Blockwork Type 4 (20 mm External only)

STEP 2

Identify wall compositions.
Draw wall sections identifying build up for each wall including materials and thicknesses.

<table>
<thead>
<tr>
<th>Wall Construction Type</th>
<th>Description</th>
<th>Ref #</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Insulated render on blockwork (recessed)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Insulated render on blockwork</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Render on concrete</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Metal screen on blockwork 250 mm</td>
<td>4</td>
</tr>
</tbody>
</table>

Parapet - excluded from U-Value calculations

STEP 3

Perform U-Value calculations for each wall type.
Wall Construction Type 2 U-Value calculation is provided below for reference.

**Illustration of U-Value Calculation for Wall Type Ref #2 - Perlite on blockwork**

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Thickness (mm)</th>
<th>Thermal Conductivity 'k' (W/m.K)</th>
<th>Thermal Resistance 'R' (Km²/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internal Surface Resistance</td>
<td></td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Interior Finish - plaster</td>
<td>15</td>
<td>0.22</td>
<td>0.14</td>
</tr>
<tr>
<td>3</td>
<td>Insulated Block Type 4 (slotted)</td>
<td>200</td>
<td>0.316</td>
<td>0.633</td>
</tr>
<tr>
<td>4</td>
<td>Insulated Render</td>
<td>20</td>
<td>0.046</td>
<td>0.031</td>
</tr>
<tr>
<td>5</td>
<td>External Surface Resistance</td>
<td></td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

Wall Construction Type 2, U-Value: 0.72 W/m²K
**CASE STUDY 1 - Insulated render on Insulated Blockwork Type 4 (20 mm External only)**

**Step 4**

Calculate the surface area of each wall construction type. Note: Doors, glazing and parapets are excluded from wall average weighted U-Value calculation.

### Front Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>9.1</td>
<td>0.72</td>
<td>6.6</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>31.8</td>
<td>0.67</td>
<td>21.3</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 3</td>
<td>23</td>
<td>2.19</td>
<td>50.4</td>
</tr>
<tr>
<td>4</td>
<td>Wall Construction Type 4</td>
<td>1.3</td>
<td>1.06</td>
<td>1.4</td>
</tr>
</tbody>
</table>

### Back Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>1</td>
<td>0.72</td>
<td>0.7</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>37</td>
<td>0.67</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 3</td>
<td>24</td>
<td>2.19</td>
<td>52</td>
</tr>
<tr>
<td>4</td>
<td>Wall Construction Type 4</td>
<td>10</td>
<td>1.06</td>
<td>0</td>
</tr>
</tbody>
</table>

### Left Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>11.6</td>
<td>0.72</td>
<td>8.4</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>79.6</td>
<td>0.67</td>
<td>53.4</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 3</td>
<td>28.9</td>
<td>2.19</td>
<td>63.4</td>
</tr>
<tr>
<td>4</td>
<td>Wall Construction Type 4</td>
<td>10</td>
<td>1.06</td>
<td>0</td>
</tr>
</tbody>
</table>

### Right Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>13.4</td>
<td>0.72</td>
<td>11.1</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>80.1</td>
<td>0.67</td>
<td>53.8</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 3</td>
<td>29.1</td>
<td>2.19</td>
<td>63.8</td>
</tr>
<tr>
<td>4</td>
<td>Wall Construction Type 4</td>
<td>10</td>
<td>1.06</td>
<td>0</td>
</tr>
</tbody>
</table>

### Average Weighted U-Value

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Total Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>37.1</td>
<td>0.72</td>
<td>26.84</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>278.8</td>
<td>0.67</td>
<td>153.57</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 3</td>
<td>104.7</td>
<td>2.19</td>
<td>229.6</td>
</tr>
<tr>
<td>4</td>
<td>Wall Construction Type 4</td>
<td>1.3</td>
<td>1.06</td>
<td>1.4</td>
</tr>
</tbody>
</table>

**Sum** | 371.88  | 411.38  | 1.11           **Wall Average Weighted U-Value**
CASE STUDY 2 - Cavity Wall Thermally Broken at Concrete Slab

STEP 1

Identify wall types on elevations (color coded for ease of reference). Variations in backwalls, finishing materials and overall thickness would be considered as new wall types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Construction Type 1</td>
<td>1</td>
</tr>
<tr>
<td>Cavity Wall 575 mm</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 2</td>
<td>2</td>
</tr>
<tr>
<td>Render on concrete 250 mm</td>
<td></td>
</tr>
<tr>
<td>Perspective excluded from U-Value calculations</td>
<td></td>
</tr>
</tbody>
</table>

FRONT ELEVATION

LEFT ELEVATION

BACK ELEVATION

RIGHT ELEVATION
CASE STUDY 2 - Cavity Wall Thermally Broken at Concrete Slab

STEP 2
Identify wall compositions.
Draw wall sections identifying build up for each wall including materials and thicknesses.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Construction Type 1</td>
<td>1</td>
</tr>
<tr>
<td>Cavity Wall 520 mm</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 2</td>
<td>2</td>
</tr>
<tr>
<td>Render on Concrete</td>
<td></td>
</tr>
<tr>
<td>Plaster - excluded from U-Value calculations</td>
<td></td>
</tr>
</tbody>
</table>

---

STEP 3
Perform U-Value calculations for each wall type.
Wall Construction Type 2 U-Value calculation is provided below for reference.

**Illustration of U-Value Calculation for Wall Type Ref #1 - Cavity Wall**

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Thickness (mm)</th>
<th>Thermal Conductivity 'k' (W/m.K)</th>
<th>Thermal Resistance 'R' (Km²/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internal Surface Resistance</td>
<td></td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Interior Finish plaster</td>
<td>15</td>
<td>0.22</td>
<td>0.114</td>
</tr>
<tr>
<td>3</td>
<td>Concrete Block</td>
<td>200</td>
<td>0.270</td>
<td>0.260</td>
</tr>
<tr>
<td>4</td>
<td>Insulation- Rockwool</td>
<td>150</td>
<td>0.033</td>
<td>4.545</td>
</tr>
<tr>
<td>5</td>
<td>Air Gap</td>
<td>50</td>
<td>1.060</td>
<td>0.047</td>
</tr>
<tr>
<td>6</td>
<td>Block</td>
<td>150</td>
<td>0.770</td>
<td>0.195</td>
</tr>
<tr>
<td>7</td>
<td>External Surface Resistance</td>
<td></td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

Wall Construction Type 1 U-Value

0.19 W/m²/K
CASE STUDY 2 - Cavity Wall Thermally Broken at Concrete Slab

Calculate the surface area of each wall construction type. Note: Doors, glazing and parapets are excluded from wall average weighted U-Value calculation.

### Front Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>42.2</td>
<td>0.19</td>
<td>22.5</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>23</td>
<td>2.19</td>
<td>12.86</td>
</tr>
</tbody>
</table>

### Back Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>38</td>
<td>0.19</td>
<td>20.22</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>24</td>
<td>2.19</td>
<td>13.42</td>
</tr>
</tbody>
</table>

### Left Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>91.2</td>
<td>0.19</td>
<td>48.52</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>28.9</td>
<td>2.19</td>
<td>16.16</td>
</tr>
</tbody>
</table>

### Right Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>95.5</td>
<td>0.19</td>
<td>50.81</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>29.1</td>
<td>2.19</td>
<td>16.32</td>
</tr>
</tbody>
</table>

### Average Weighted U-Value

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Total Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>266.9</td>
<td>0.19</td>
<td>50.7</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>104.7</td>
<td>2.19</td>
<td>229.3</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td>371.88</td>
<td></td>
<td>200.5</td>
</tr>
</tbody>
</table>

Average Weighted U-Value: 0.75
CASE STUDY 3 - EIFS on Slotted Block (27 mm Insulation only)

Identify wall types on elevations (color coded for ease of reference). Variations in backwalls, finishing materials and overall thickness would be considered as new wall types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Construction Type 1</td>
<td>1</td>
</tr>
<tr>
<td>EIFS on Blockwork 272 mm</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 2</td>
<td>2</td>
</tr>
<tr>
<td>EIFS on Concrete 272 mm</td>
<td></td>
</tr>
<tr>
<td>Parapet - excluded from U-Value calculations</td>
<td></td>
</tr>
</tbody>
</table>

FRONT ELEVATION

LEFT ELEVATION

BACK ELEVATION

RIGHT ELEVATION
CASE STUDY 3 - EIFS on Slotted Block (27 mm Insulation only)

STEP 2

Identify wall compositions.
Draw wall sections identifying build up for each wall including materials and thicknesses.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Construction Type 1</td>
<td>1</td>
</tr>
<tr>
<td>EIFS on Blockwork - 272 mm</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 2</td>
<td>2</td>
</tr>
<tr>
<td>EIFS on Concrete - 272 mm</td>
<td></td>
</tr>
<tr>
<td>Plaster - excluded from U-Value calculations</td>
<td></td>
</tr>
</tbody>
</table>

Wall Construction Type 1
EIFS on blockwork

Wall Construction Type 2
EIFS on concrete

STEP 3

Perform U-Value calculations for each wall type.
Wall Construction Type 2 U-Value calculation is provided below for reference.

| Illustration of U-Value Calculation for Wall Type Ref #1 - EIFS on blockwork |
|----------------------------------|-------------------------------|
| #      | Type             | Thickness (mm) | Thermal Conductivity 'k' (W/m.K) | Thermal Resistance 'R' (Km²/W) |
| 1      | Internal Surface Resistance |               | 0.15                             |                                |
| 2      | Interior Finish plaster      | 15             | 0.22                             | 0.114                           |
| 3      | Thermally Broken Insulated Block | 200          | 0.316                           | 0.633                           |
| 4      | Insulation - Rockwool        | 27             | 0.033                           | 0.018                           |
| 5      | Mesh & Render                | 20             | 0.800                           | 0.025                           |
| 6      | External Surface Resistance  | 0.05           | 0.66                            |                                 |

Wall Construction Type 2 U-Value
0.36 W/m²/K
## CASE STUDY 3 - EIFS on Slotted Block (27 mm Insulation only)

**STEP 4**

Calculate the surface area of each wall construction type. Note: Doors, glazing and parapets are excluded from wall average weighted U-Value calculation.

### Front Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>42.2</td>
<td>0.56</td>
<td>23.5</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>23</td>
<td>0.59</td>
<td>12.86</td>
</tr>
</tbody>
</table>

### Back Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>38</td>
<td>0.56</td>
<td>20.22</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>24</td>
<td>0.59</td>
<td>13.42</td>
</tr>
</tbody>
</table>

### Left Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>91.2</td>
<td>0.56</td>
<td>48.52</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>28.9</td>
<td>0.59</td>
<td>16.16</td>
</tr>
</tbody>
</table>

### Right Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>95.5</td>
<td>0.56</td>
<td>50.81</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>29.1</td>
<td>0.59</td>
<td>16.32</td>
</tr>
</tbody>
</table>

### Average Weighted U-Value

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Total Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>266.9</td>
<td>0.56</td>
<td>142.0</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>104.7</td>
<td>0.59</td>
<td>58.5</td>
</tr>
<tr>
<td>Sum</td>
<td>371.88</td>
<td></td>
<td></td>
<td>200.5</td>
</tr>
</tbody>
</table>

**Average Weighted U-Value**: Very Good, 0.57
CASE STUDY 4a- EIFS on Slotted Block (80 mm Insulation)

Identify wall types on elevations (color coded for ease of reference). Variations in backwalls, finishing materials and overall thickness would be considered as new wall types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref #</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIFS on Blockwork 275mm</td>
<td>1</td>
</tr>
<tr>
<td>EIFS on Concrete 250 mm</td>
<td>2</td>
</tr>
<tr>
<td>Parapet - excluded from U-Value calculations</td>
<td></td>
</tr>
</tbody>
</table>
CASE STUDY 4a- EIFS on Slotted Block (80 mm Insulation)

STEP 2
Identify wall compositions.
Draw wall sections identifying build up for each wall including materials and thicknesses.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Construction Type 1</td>
<td>1</td>
</tr>
<tr>
<td>EIFS on Blockwork - 325 mm</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 2</td>
<td>2</td>
</tr>
<tr>
<td>EIFS on Concrete - 325 mm</td>
<td></td>
</tr>
<tr>
<td>Insipet - excluded from U-Value calculations</td>
<td></td>
</tr>
</tbody>
</table>

STEP 3
Perform U-Value calculations for each wall type.
Wall Construction Type 2 U-Value calculation is provided below for reference.

<p>| Illustration of U-Value Calculation for Wall Type Ref #1- EIFS on blockwork |
|---------------------------------------------------------------|---------------------------------|</p>
<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Thickness (mm)</th>
<th>Thermal Conductivity 'k' (W/m.K)</th>
<th>Thermal Resistance 'R' (Km²/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internal Surface Resistance</td>
<td></td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Interior Finish plaster</td>
<td>15</td>
<td>0.22</td>
<td>0.114</td>
</tr>
<tr>
<td>3</td>
<td>Thermally Broken Insulated Block</td>
<td>200</td>
<td>0.316</td>
<td>0.633</td>
</tr>
<tr>
<td>4</td>
<td>Insulation- Rockwool</td>
<td>10</td>
<td>0.033</td>
<td>2.424</td>
</tr>
<tr>
<td>5</td>
<td>Mesh &amp; Render</td>
<td>20</td>
<td>0.000</td>
<td>0.025</td>
</tr>
<tr>
<td>6</td>
<td>External Surface Resistance</td>
<td></td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 1 U-Value</td>
<td></td>
<td></td>
<td>0.29</td>
<td>W/m²/K</td>
</tr>
</tbody>
</table>
Calculate the surface area of each wall construction type. Note: Doors, glazing and parapets are excluded from wall average weighted U-Value calculation.

### Front Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>42.2</td>
<td>0.29</td>
<td>22.5</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>23</td>
<td>0.30</td>
<td>12.86</td>
</tr>
</tbody>
</table>

### Back Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>38</td>
<td>0.29</td>
<td>20.22</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>24</td>
<td>0.30</td>
<td>13.42</td>
</tr>
</tbody>
</table>

### Left Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>91.2</td>
<td>0.29</td>
<td>48.52</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>28.9</td>
<td>0.30</td>
<td>16.66</td>
</tr>
</tbody>
</table>

### Right Elevation

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>95.5</td>
<td>0.29</td>
<td>50.81</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>29.1</td>
<td>0.30</td>
<td>16.32</td>
</tr>
</tbody>
</table>

### Average Weighted U-Value

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Total Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>266.9</td>
<td>0.29</td>
<td>142.0</td>
</tr>
<tr>
<td>2</td>
<td>Wall Construction Type 2</td>
<td>104.7</td>
<td>0.30</td>
<td>58.5</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td>371.88</td>
<td></td>
<td>200.5</td>
</tr>
<tr>
<td>Average Weighted U-Value</td>
<td>Very Good</td>
<td></td>
<td>0.30</td>
<td></td>
</tr>
</tbody>
</table>

THERMAL INSULATION GUIDELINES

AESG 2018
CASE STUDY 4b - Cavity Wall Construction (80 mm Insulation)

Identify wall types on elevations (color coded for ease of reference).
Variations in backwalls, finishing materials and overall thickness would be considered as new wall types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Construction Type 1</td>
<td>1</td>
</tr>
<tr>
<td>Cavity wall on Blockwork 505 mm</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 2</td>
<td>2</td>
</tr>
<tr>
<td>Cavity wall on Concrete 505 mm</td>
<td></td>
</tr>
<tr>
<td>Parapet - excluded from U-Value calculations</td>
<td></td>
</tr>
</tbody>
</table>
CASE STUDY 4b - Cavity Wall Construction (80 mm Insulation)

STEP 2

Identify wall compositions.
Draw wall sections identifying build up for each wall including materials and thicknesses.

<table>
<thead>
<tr>
<th>Type</th>
<th>Ref #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Construction Type 1</td>
<td>1</td>
</tr>
<tr>
<td>Cavity wall on Blockwork 505 mm</td>
<td></td>
</tr>
<tr>
<td>Wall Construction Type 2</td>
<td>2</td>
</tr>
<tr>
<td>Cavity wall on Concrete 505 mm</td>
<td></td>
</tr>
<tr>
<td>Pebble - excluded from U-Value calculations</td>
<td></td>
</tr>
</tbody>
</table>

Wall Construction Type 1: Cavity Wall on blockwork
Wall Construction Type 2: Cavity Wall on concrete

STEP 3

Perform U-Value calculations for each wall type.
Wall Construction Type 2 U-Value calculation is provided below for reference.

<p>| Illustration of U-Value Calculation for Wall Type Ref #1 - Cavity wall on blockwork |
|-----------------------------------------------|-----------------------------------------------|</p>
<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Thickness (mm)</th>
<th>Thermal Conductivity 'k' (W/m.K)</th>
<th>Thermal Resistance 'R' (K.m²/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internal Surface Resistance</td>
<td></td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Internal Finish Plaster</td>
<td>15</td>
<td>0.22</td>
<td>0.114</td>
</tr>
<tr>
<td>3</td>
<td>Solid Concrete Block</td>
<td>100</td>
<td>0.770</td>
<td>0.260</td>
</tr>
<tr>
<td>4</td>
<td>Insulation - Rockwool</td>
<td>50</td>
<td>0.033</td>
<td>2.424</td>
</tr>
<tr>
<td>5</td>
<td>Air Gap</td>
<td>100</td>
<td>1.060</td>
<td>0.047</td>
</tr>
<tr>
<td>6</td>
<td>Solid Concrete Block</td>
<td>150</td>
<td>0.770</td>
<td>0.195</td>
</tr>
<tr>
<td>7</td>
<td>External Surface Resistance</td>
<td></td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Wall Construction Type 1 U-Value</td>
</tr>
</tbody>
</table>
CASE STUDY 4b - Cavity Wall Construction (80 mm Insulation)

Calculate the surface area of each wall construction type. Note: Doors, glazing and parapets are excluded from wall average weighted U-Value calculation.

**Front Elevation**

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>42.2</td>
<td>0.31</td>
<td>13.04</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>23.0</td>
<td>0.28</td>
<td>6.53</td>
</tr>
</tbody>
</table>

**Back Elevation**

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>38.0</td>
<td>0.31</td>
<td>11.74</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>24.0</td>
<td>0.28</td>
<td>6.82</td>
</tr>
</tbody>
</table>

**Left Elevation**

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>91.2</td>
<td>0.31</td>
<td>28.2</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>28.9</td>
<td>0.28</td>
<td>8.21</td>
</tr>
</tbody>
</table>

**Right Elevation**

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>95.5</td>
<td>0.31</td>
<td>29.51</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>29.1</td>
<td>0.28</td>
<td>8.26</td>
</tr>
</tbody>
</table>

**Average Weighted U-Value**

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Total Area (m²)</th>
<th>U-Value (W/m²K)</th>
<th>Area x U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wall Construction Type 1</td>
<td>266.9</td>
<td>0.31</td>
<td>82.5</td>
</tr>
<tr>
<td>3</td>
<td>Wall Construction Type 2</td>
<td>104.7</td>
<td>0.28</td>
<td>29.8</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td>371.88</td>
<td></td>
<td>112.3</td>
</tr>
<tr>
<td>Average Weighted U-Value</td>
<td>Very Good</td>
<td></td>
<td>0.30</td>
<td></td>
</tr>
</tbody>
</table>
I. WALLS

This section provides various options for wall systems, demonstrating a range of thermal performance and costs.
WALL SYSTEMS

W-IB1  INSULATED BLOCKWORK – TYPE 1
W-IB2  INSULATED BLOCKWORK – TYPE 2
W-IB3  INSULATED BLOCKWORK – TYPE 3
W-IB4  INSULATED BLOCKWORK – TYPE 4
W-CBW  CAVITY WITH BLOCKWORK WALL
W-CRC  CAVITY WITH REINFORCED CONCRETE WALL
W-CMC  CAVITY WITH METAL STUD WALL
W-DIF  DOUBLE INSULATED FORMWORK
W-SIF  SINGLE INSULATED FORMWORK
W-SWP  SANDWICH PANEL
W-PCC  PRECAST CONCRETE CLADDING
W-PSP  PRECAST CONCRETE SANDWICH PANEL
W-RBW  RAISSCREEN ON BLOCKWORK WALL
W-RMS  RAISSCREEN ON METAL STUD WALL
W-IR1  INSULATED RENDER TYPE 1 W/INS. BLOCKWORK
W-IR2  INSULATED RENDER TYPE 2 W/INS. BLOCKWORK
W-EBW  EIFS WITH BLOCKWORK WALL
W-ERC  EIFS WITH REINFORCED CONCRETE WALL
W-EMS  EIFS WITH METAL STUD WALL
W-EML  EIFS WITH LIGHTWEIGHT STEEL FRAME WALL
W-EMW  EIFS WITH WOOD STUD WALL

COST BENEFIT ANALYSIS (U-VALUE VS. COST)

THERMAL INSULATION GUIDELINES

2018

AESG
I.1. INSULATED BLOCKWORK - TYPE I

TYPICAL BUILD-UP

1. Internal finish (25mm): Layer "finish coat" will be plastering layer. A minimum of 25 mm thickness is required for the uniformity of the wall.
2. Interior Blockwork layer (190mm)
3. Insulation (75mm): Expanded polystyrene inside. This provides thermal insulation.
4. Protective skin (35mm): the texture should be rough for bonding of plaster and stucco.
5. External finish (25mm): Layer "finish coat" will be render layer.

DESCRIPTION

TYPE I : 300 mm (12") continuously insulated sandwich hollow block

REFERENCE IMAGES

TECHNICAL INFORMATION

TOTAL SYSTEM COST

18.5 BHD/sqm
Baseline cost date is 1st Qrt. 2018

INSULATION THICKNESS / U-VALUE

The calculated U-Value for this system using insulated block which is load bearing is 0.42 W/m²K.

COMMENTS / RECOMMENDATIONS

- Brackets recommended to support the section of the blockwork that sits beyond the slab edge.
- Front of the slabs should be insulated
- This type of insulated blockwork has a continuous thermal barrier.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1B1</td>
<td>Ins. blockwork - Type I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

THERMAL INSULATION GUIDELINES

2018

AESG
1.2. INSULATED BLOCKWORK - TYPE 2

**Description**

TYPE 2 : 200 mm (8") continuously insulated sandwich hollow block

1. Internal finish (25mm): Layer "finish coat" will be plastering layer. The thickness depends on the uniformity of the wall using a finishing trowel.
2. Interior blockwork (90mm)
3. Insulation (75mm): Expanded polystyrene inside. This gives thermal insulation.
4. Protective skin (35mm): Texture should be rough for bonding of plaster and stucco.
5. External finish (25mm): Layer "finish coat" will be render layer.

**Technical Information**

**Total System Cost**
16.5 BHD/sqm
Baseline cost date is 1st Qrt. 2018

**Insulation Thickness / U-Value**

The calculated U-Value for this system using insulated block with hollow core is 0.51 W/m²K.

**Comments / Recommendations**

- Brackets recommended to support the section of the blockwork that sits beyond the slab edge.
- Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
- Horizontal joint required to accommodate building movements.
- This type of insulated blockwork has a continuous thermal barrier.

**Key:**

Poor → Excellent

---

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-IB2</td>
<td>Ins. blockwork - Type 2</td>
<td></td>
<td></td>
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</table>
1.3. INSULATED BLOCKWORK - TYPE 3

**Typical Build-Up**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
</table>

**Description**

**Type 3: 300 mm (12") slotted block**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.

2. Blockwork (300mm): A block that is multi-layered with constricted cross webbing that creates individual cells that are filled with foam insulation inserts.

3. Insulation inserts come in two sizes: Long and Short. Each fits into its corresponding block cavity. The vertical mortar joints are insulated due to the overlapping feature (from block-to-block) of the short insert.

4. External finish (25mm): Layer “finish coat” will be render layer.

**Reference Images**

- Insulation
- Block with foam
- Thermal Transmittance Diagram

**Technical Information**

**Total System Cost**

22.5 BHD/sqm

Baseline cost date is 1st Qtr. 2018

**Insulation Thickness / U-value**

- The calculated U-Value for this system using the insulated unique block is 0.35 W/m²K.

**Comments / Recommendations**

- C1 Brackets recommended to support the section of the blockwork that sits beyond the slab edge.
- C2 Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
- C3 Horizontal joint required to accommodate building movements.
- ⚡ This type of insulated blockwork has thermal bridge.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
</tr>
</thead>
<tbody>
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<td>W-IB3</td>
<td>Ins. blockwork - Type 3</td>
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</tbody>
</table>
1.4. INSULATED BLOCKWORK - TYPE 4

**Typical Build-Up**

1. **TYPE 4 - 200 mm (8") slotted block**
   - Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
   - Slotted Insulated Blockwork (200mm): is a block that is multi-layered with constricted cross webbing that creates individual cells that are filled with foam insulation inserts.
   - Insulation inserts come in two sizes; Long and Short. Each fits into its corresponding block cavity. The vertical mortar joints are insulated due to the overlapping feature (from block-to-block) of the short insert.
   - External finish (25mm): Layer “finish coat” will be render layer.

**Technical Information**

**Total System Cost**
17.5 BHD/sqm

Baseline cost date is 1st Qtr, 2018

**Insulation Thickness / U-Value**

![Graph showing U-Values for different block types]

The calculated U-Value for this system using the insulated unique block is 1.02 W/m²K.

**Comments / Recommendations**

- **C1**: Brackets recommended to support the section of the blockwork that sits beyond the slab edge.
- **C2**: Front of the slabs should be insulated to avoid thermal bridging
- **C3**: Horizontal joint required to accommodate building movements
- **C4**: This type of insulated blockwork has thermal bridge

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
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</tbody>
</table>

THERMAL INSULATION GUIDELINES
1.5. CAVITY WITH BLOCKWORK WALL

**Typical Build-Up**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Interior blockwork (200mm): The type of blockwork used on this system is blocks of concrete, cement, or similar material. These blocks have low thermal resistance and therefore relatively poor insulation values.
3. Insulation (50-200mm): foil or bulk insulation. Wall insulation should be accompanied by appropriate detailing to avoid thermal transfers by bridging through window and door frames, by radiation through window openings or by convection through leakage.
4. Cavity (40-60 mm)
5. Blockwork (150 mm)

**Technical Information**

**Total System Cost**

27.5 BHD/sqm

For the cost estimation 50 mm mineral-wool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around 8D4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

**Insulation Thickness / U-Value**

The calculated U-Value for this system varies between 0.14 - 0.47 W/m²°C depending on type/thickness of insulation.

**Comments / Recommendations**

- Metal brackets. Generally only stainless steel 316 or aluminium should be used outside the vapor barrier.
- Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
- Horizontal joint required to accommodate building movements
- Suitable for Retro-fit or New Build.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
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</thead>
<tbody>
<tr>
<td>W-CBW</td>
<td>Cavity with Blockwork Wall</td>
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</tbody>
</table>

**Thermal Insulation Guidelines**

2018

AEG

31
1.6. CAVITY WITH REINFORCED CONCRETE WALL

**Typical Build-Up**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Reinforce concrete (200mm): Concrete wall with steelbars, strands, mesh, etc., to absorb tensile and shearing stresses. The concrete wall will have low thermal resistance and therefore relatively poor insulation values. It should be combined with internal and external air films and insulation layer.
3. Insulation (50-200mm): Foil or bulk insulation. Wall insulation should be accompanied by appropriate detailing to avoid thermal transfers by bridging through window and door frames, by radiation through window openings or by convection through leakage.
4. Cavity (40-60mm)
5. Blockwork (150mm)

**Description**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Reinforce concrete (200mm): Concrete wall with steelbars, strands, mesh, etc., to absorb tensile and shearing stresses. The concrete wall will have low thermal resistance and therefore relatively poor insulation values. It should be combined with internal and external air films and insulation layer.
3. Insulation (50-200mm): Foil or bulk insulation. Wall insulation should be accompanied by appropriate detailing to avoid thermal transfers by bridging through window and door frames, by radiation through window openings or by convection through leakage.
4. Cavity (40-60mm)
5. Blockwork (150mm)

**Technical Information**

**Total System Cost**

43.5 BHD/sqm

For the cost estimation 50 mm mineral-wool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around BD4/m² per additional layer.

Baseline cost date is 1st Qtr, 2018

**Insulation Thickness / U-Value**

The calculated U-Value for this system varies between 0.14-0.38 W/m²K depending on type/thickness of insulation.

**Comments / Recommendations**

- Brackets needed to support the blockwork.
- Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
- Horizontal joint required to accommodate building movements.
- This detail is typically used locally in front of RC columns or shear walls.
- Suitable for Retro-fit or New Build.

**Thermal Insulation Guidelines**

Ministry of Housing

AESC

2018
1.7. CAVITY WITH METAL STUD WALL

TYPICAL BUILD-UP

DESCRIPTION
1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Metal stud wall (200mm): A wall stud is a vertical framing member in a building’s wall of smaller cross section than a post. They are a fundamental element in frame building. Metal framing next to an outside wall will transfer the heat, therefore extruded polystyrene insulation should be considered between the outside wall and the metal to act as a thermal break.
3. Insulation (50-200mm): foil or bulk insulation. Wall insulation should be accompanied by appropriate detailing to avoid thermal transfers by bridging through window and door frames, by radiation through window openings or by convection through leakage.
4. Cavity (40-60mm)
5. Blockwork (150 mm)

REFERENCE IMAGES

Structural tubular steel stud: Light steel stud:

TECHNICAL INFORMATION

TOTAL SYSTEM COST
28.5 BD/sqm
For the cost estimation 50 mm mineral-wool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around 8D4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

KEY:
Poor ➔ Excellent

INSULATION THICKNESS / U-VALUE

The calculated U-Value for this system varies between 0.10 - 0.20 W/m²K depending on type/thickness of insulation.

COMMENTS / RECOMMENDATIONS
C1 Brackets recommended to support portion of blockwork.
C2 Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
C3 Horizontal joint required to accommodate building movements.
RF Suitable for Retro-fit or New Build.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
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<tr>
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<td>Cavity with Metal stud Wall</td>
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</table>

THERMAL INSULATION GUIDELINES

2018

AEGS
1.8. DOUBLE INSULATION FORMWORK

**Typical Build-Up**

1. Internal finish (25mm)
2. Insulating foam (60 mm)
3. Reinforced concrete (150 mm)
4. Insulating foam (60-120 mm)
5. Render

**Description**

Insulated formwork construction system using insulating panels or blocks as the formwork for in-situ concrete. Once the concrete has been poured, the panels remain in place to act as thermal insulation. Typically either expanded polystyrene insulation (EPS) or extruded polystyrene (XPS) is used.

**Reference Images**

- **Concrete**
- **Tongue and Groove**
- **Steel Ties**
- **Furring Strips**
- **Polystyrene**

**Technical Information**

**Total System Cost**

125 BD/km²

For the cost estimation, 50 mm mineral-wool insulation has been considered.

Generally, thicker layers are made up of numerous 50mm thick sheets, at around 7D4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

**Insulation Thickness / U-Value**

![U-Value Chart]

**Comments / Recommendations**

- Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.

- The calculated U-Value for this assembly using the typical 60 mm EPS on two sides and 150 mm concrete is 0.25 W/m²K while increasing the exterior insulation to 120 mm would provide an improved U-Value of 0.18 W/m²K.

**Table: Double Insulation Formwork**

<table>
<thead>
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<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
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<td>(Green)</td>
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<td>(Red)</td>
<td>(Red)</td>
<td>(Red)</td>
</tr>
</tbody>
</table>
1.9. SINGLE INSULATION FORMWORK

**TYPICAL BUILD-UP**

1. Internal finish (25mm)
2. Reinforced concrete (150 mm)
3. Metal stud
4. Insulating foam (60-120 mm)
5. Finish (20 mm)

**DESCRIPTION**

Insulated formwork construction system using insulating panels or blocks on the exterior layer as the formwork for in-situ concrete. Once the concrete has been poured, the panel remain in place to act as thermal insulation. It’s use typically either expanded polystyrene insulation (EPS) or extruded polystyrene (XPS).

**REFERENCE IMAGES**

![Sealed Envelope](image1)

![Utilities](image2)

![Insulated Exterior Wall](image3)

![Finished Surface](image4)

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

120 BHD/m²

For the cost estimation 50 mm mineral-wool insulation has been considered.

Baseline cost date is 1st Qrt. 2018

**INSULATION THICKNESS / U-VALUE**

![Diagram](image5)

The calculated U-Value for this assembly using the typical 60 mm EPS on one side and 150 mm concrete is 0.45 W/m²K while increasing the exterior insulation to 120 mm would provide an improved U-Value of 0.25 W/m²K.

**COMMENTS / RECOMMENDATIONS**

Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.

**Code** | **Structural Composition** | **Thermal Potential U-Value** | **Assembly Cost** | **Life Cycle Cost** | **Durability / Maintenance Factor** | **Embodied Energy** | **Supply Chain** | **Buildability**
---|---|---|---|---|---|---|---|---
W-SIF | Single Insulation Formwork | | | | | | | |
**1.10. SANDWICH PANEL**

**DESCRIPTION**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer; the thickness depends on the uniformity of the wall using a finishing trowel.
2. Interior blockwork (200 mm): The type of blockwork used on this system consists of concrete, cement, or similar material. These blocks have low thermal resistance and therefore relatively poor insulation values.
3. Steel stud (50mm): The panel are fixed directly to the substructure.
4. Sandwich panel (45-140mm): is made of three layers: a low-density core, and a thin skin-layer bonded to each side. Sandwich panels are used as single-skin, insulated roof and wall claddings consisting of industrially manufactured composite elements (sandwich elements).

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

38.5 BHD/sqm

For the cost estimation 50 mm mineral-wool insulation has been considered.

Baseline cost date is 1st Qrt. 2018

**INSULATION THICKNESS / U-VALUE**

The calculated U-Value for this system varies between 0.21–0.57 W/m²K depending on type / thickness of insulation

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<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
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<th>Buildability</th>
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<td>Sandwich Panel</td>
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</table>

**COMMENTS / RECOMMENDATIONS**

- **C1**: Design the edge members, splices and joints in the cores and faces to avoid the thermal break.
- **C2**: Horizontal joint required to accommodate building movements.
- **R**: The Sandwich Panel is suitable for Retrofit Suitable for Retro-fit or New Build.
1.11. PRECAST CONCRETE CLADDING

**Typical Build-Up**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Interior blockwork (200 mm): The type of blockwork used on this system consists of concrete, cement, or similar material. These blocks have low thermal resistance and therefore relatively poor insulation values.
3. Insulation (50-200mm): foil or bulk insulation. Wall insulation should be accompanied by appropriate detailing to avoid thermal transfers by bridging through window and door frames, by radiation through window openings or by convection through leakage.
4. Precast concrete cladding (100 - 150 mm): is a form of concrete that is prepared, cast and cured off-site, usually in a controlled factory environment, using reusable moulds. Precast concrete elements can be joined to other elements on site to form a complete cladding structure.

**Technical Information**

**Total System Cost**
23.5 BHD/ sqm
For the cost estimation 50 mm mineral-wool insulation has been considered.
Generally thicker layers are made up of numerous 50mm thick sheets, at around 804/m² per additional layer.
Baseline cost rate is 1st Qtr. 2018

**Key:**

Poor → Excellent

---

**Insulation Thickness / U-Value**

The calculated U-Value for this system varies between 0.15 - 0.46 W/m²K depending on type / thickness of insulation.

**Comments / Recommendations**

C1. Brackets recommended to support portion of blockwork.
C2. Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
C3. Horizontal joint required to accommodate building movements.
C4. Suitable for Retro-fit or New Build.

---

**Therm insulation guidelines**

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<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
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<td>Precast Concrete Cladding</td>
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</table>
1.12. PRECAST CONCRETE SANDWICH PANEL

**Typical Build-up**

1. Internal finish (25mm) : Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Insulated precast concrete wall panel (310mm) with two layers of concrete separated by a layer of rigid insulation. The two layers of concrete are interlinked by connecting systems.
3. Insulation (50-150 mm) : Three types of insulation are commonly used in insulated precast concrete wall panel construction.
   - Expanded polystyrene (EPS)
   - Extruded polystyrene (XPS)
   - Polyisocyanurate, R-value
   - Mineralwool insulation

**Technical Information**

**Total System Cost**

24 BHD/sqm

For the cost estimation 50 mm mineral-wool insulation has been considered.
Baseline cost date is 1st Qtr, 2018

**Insulation Thickness / U-Value**

The calculated U-Value for this system varies between 0.21-0.57 W/m²K depending on type/thickness of insulation.

**Comments / Recommendations**

- C1: Brackets needed to support the precast panels.
- C2: Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
- C3: Horizontal joint required to accommodate building movements.
- C4: Load bearing and non-load bearing panels are available in the market.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
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<tr>
<td>W-PSP</td>
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</table>

Thermal Insulation Guidelines
1.13. Rainscreen on Blockwork Wall

Typical Build-Up

1. Internal finish (25mm): layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Interior blockwork (200mm): The type of blockwork used for this system are blocks of concrete, cement, or similar material. These blocks have low thermal resistance and therefore relatively poor insulation values.
3. Insulation (50-150mm): foil or bulk insulation. Wall insulation should be accompanied by appropriate detailing to avoid thermal transfers by bridging through window and door frames, by radiation through window openings or by convection through leakage.
4. Cavity (40-60mm)
5. Rainscreen (20-200mm): an outer layer of rear-ventilated cladding to keep out the rain and an inner layer to provide thermal insulation, prevent excessive air leakage and carry wind loading. Types: metal, GRC or stone.

Description

Technical Information

Total System Cost

$8.5 BHD/sqm

For the cost estimation 50 mm mineral-wool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around BD4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

Comment / Recommendations

1. Brackets needed to support the rainscreen.
2. Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
3. Horizontal joint required to accommodate building movements.
4. The U-Values varies depending on the cladding material.
5. Suitable for Retro-fit or New Build.

Insulation Thickness / U-Value

The calculated U-Value for this system varies between 0.19 - 0.47 W/m²K depending on type / thickness of insulation. The U-Value varies depending on the type of finish. Calculations have been done for Aluminium panels.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
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</tbody>
</table>

Thermal Insulation Guidelines
1.14. RAINSCREEN ON REINFORCED CONCRETE WALL

**TYPICAL BUILD-UP**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Reinforced concrete (200mm): concrete wall with steel bars, strands, mesh, etc., to absorb tensile and shearing stresses. The concrete wall has low thermal resistance and therefore relatively poor insulation values.
3. Insulation (50-150mm): foil or bulk insulation. Wall insulation should be accompanied by appropriate detailing to avoid thermal transfers by bridging through window and door frames.
4. Cavity (40-60mm)
5. Rainscreen (20-200mm): the outer layer of reassembled cladding to keep out the rain and an inner layer to provide thermal insulation, prevent excessive air leakage and carry wind loading. Types: metal, grc or stone.

**DESCRIPTION**

- **REFERENCE IMAGES**

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

SR 59.5 BHD/sqm

For the cost estimation 50 mm mineral-wool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets at around BD4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

**KEY:**

<table>
<thead>
<tr>
<th>Poor</th>
<th>Excellent</th>
</tr>
</thead>
</table>

**INSULATION THICKNESS / U-VALUE**

The calculated U-Value for this system varies between 0.18 - 0.42 W/m²K depending on type / thickness of insulation. The U-Value varies depending on the type of finish. Calculations have been done for Aluminium panels.

**COMMENTS / RECOMMENDATIONS**

- C1: Brackets needed to support the blockwork.
- C2: Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
- C3: The U-Values varies depending on the cladding material.
- RF: Suitable for Retro-fit or New Build.
1.15. RAINSCREEN ON METAL STUD WALL

**TYPICAL BUILD-UP**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Metal stud wall (200mm): A wall stud is a vertical framing member in a building’s wall of smaller cross section. They are a fundamental element in framed buildings. Metal framing next to an outside wall will transfer the heat.
3. Insulation (50-150mm): foil or bulk insulation. Wall insulation should be accompanied by appropriate detailing to avoid thermal transfers by bridging through window and door frames.
4. Cavity (40-60mm)
5. Rainscreen (20-200mm): an outer layer of rear-vented cladding to keep out the rain and an inner layer to provide thermal insulation, prevent excessive air leakage and carry wind loading. Types: metal, GRC or stone.

**DESCRIPTION**

**REFERENCE IMAGES**

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

59.5 BHD/sqm

For the cost estimation 50 mm mineral-wool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around 8D4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

**INSULATION THICKNESS / U-VALUE**

The calculated U-Value for this system varies between 0.12 - 0.22 W/m²K depending on type / thickness of insulation. The U-Value varies depending on the type of finish. Calculations have been done for Aluminium panels.

**_COMMENTS / RECOMMENDATIONS**

- **C1**: Brackets needed to support the blockwork.
- **C2**: Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
- **C3**: The U-Values varies depending on the cladding material.
- **RE**: Suitable for Retro-fit or New Build.

**Code**

<table>
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<tr>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
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<th>Supply Chain</th>
<th>Buildability</th>
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<td>W-RMS</td>
<td>Rainscreen on Metal Stud</td>
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</tbody>
</table>

THERMAL INSULATION GUIDELINES
1.16. INSULATED RENDER TYPE 1 WITH INSULATED BLOCKWORK

**TYPICAL BUILD-UP**

**DESCRIPTION**
1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Insulated Blockwork - Type 1
3. Insulated render: expanded volcanic glass material commonly used in hydroponics due to its ability to hold water. It occurs naturally and has very low thermal conductivity with a maximum working temperature in excess of 1,000 degrees C.

**REFERENCE IMAGES**

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**
19.5 BHD/sqm

Baseline cost date is 1st Qtr, 2018

**INSULATION THICKNESS / U-VALUE**

![Insulation Thickness Chart]

The calculated U-Value for this system using the insulated render is 0.35 W/m²K.

**COMMENTS / RECOMMENDATIONS**
1. Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
2. Horizontal joint required to accommodate building movements.
3. Perlite render - Suitable for Retro-fit or New Build.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
</tr>
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<tbody>
<tr>
<td>W-PK</td>
<td>Perlite Render</td>
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</tbody>
</table>

**THERMAL INSULATION GUIDELINES**

2018

AESC
1.17. INSULATED RENDER TYPE 2 WITH INSULATED BLOCKWORK

**Typical Build-Up**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Insulated Blockwork - Type 1
3. Insulated Render: a high-quality blend of white portland cement and mineral based lightweight aggregates which is developed as a replacement to job-site mixed scratch & brown base coats and stucco.

**Technical Information**

**Total System Cost**

$44.5 Bn/6sqm

Baseline cost date is 1st Qtr. 2018

**Insulation Thickness / U-value**

The calculated U-Value for this system using the U-Stucco is 0.24 W/m²K.

**Comments / Recommendations**

- C1: Brackets recommended to support the section of the blockwork that sits beyond the slab edge.
- C2: Front of the slabs and front of the frame structure should be insulated to avoid thermal bridging.
- C3: Horizontal joint required to accommodate building movements.
- RF: U-Stucco - Suitable for Retro-fit or New Build.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
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<th>Buildability</th>
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<tr>
<td>W-ST</td>
<td>U-Stucco</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
**TYPICAL BUILD-UP**

Section

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.
2. Interior blockwork (200mm): The type of blockwork used on this system consist of concrete, cement, or similar material. These blocks have low thermal resistance and therefore relatively poor insulation values.
3. EIFS (50-150mm): Exterior Insulation and Finish System (EIFS) is a non-load bearing, exterior wall cladding system that consists of an insulation board attached either adhesively or mechanically, or both, to the substrate; an integrally reinforced base coat; and a textured protective finish coat.

**DESCRIPTION**

**REFERENCE IMAGES**

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

285 BHD/sqm

For the cost estimation 50 mm rockwool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around BD4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

**KEY:**

Poor → Excellent

**INSULATION THICKNESS / U-VALUE**

- The calculated U-Value for this system varies between 0.19-0.47 W/m²K depending on thickness of insulation.

**COMMENTS / RECOMMENDATIONS**

- CI: Horizontal joint required to accommodate building movements.
- RF: EIFS - Suitable for Retro-fit or New Build.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
</tr>
</thead>
</table>
1.19. EIFS WITH REINFORCED CONCRETE WALL

**Typical Build-Up**

**Description**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.

2. Reinforcement (200mm): concrete wall with steel bars, strands, mesh, etc., to absorb tensile and shearing stresses. The concrete wall has low thermal resistance and therefore relatively poor insulation values. It should be combined with internal and external air films and insulation layer.

3. EIFS (50-200mm): Exterior Insulation and Finish System (EIFS) is a non-load bearing, exterior wall cladding system that consists of an insulation board attached either adhesively or mechanically, or both, to the substrate: an integrally reinforced base coat; and a textured protective finish coat.

**Technical Information**

**Total System Cost**

445 BHD/sqm

For the cost estimation 50 mm rockwool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around BD4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

**Insulation Thickness / U-Value**

The calculated U-Value for this system varies between 0.15-0.43 W/m²K, depending on thickness of insulation.

**Comments / Recommendations**

RF - EIFS - Suitable for Retro-fit or New Build.

<table>
<thead>
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<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
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</thead>
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<tr>
<td>W-ERC</td>
<td>EIFS - Reinforced Concrete</td>
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</tr>
</tbody>
</table>

**Thermal Insulation Guidelines**

2018

AESG
1. **EIFS WITH METAL STUD WALL**

**DESCRIPTION**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.

2. Metal stud wall (200mm): A wall stud is a vertical hot rolled steel framing member in a building’s wall of smaller cross section than a post. They are a fundamental element in frame buildings. Metal framing next to an outside wall will transfer the heat. Therefore extruded polystyrene insulation should be considered between the outside wall and the metal to act as a thermal break.

3. EIFS (50-150mm): Exterior Insulation and Finish System (EIFS) is a nonload bearing, exterior wall cladding system that consists of an insulation board attached either adhesively or mechanically, or both, to the substrate an integrally reinforced base coat; and a textured protective finish coat.

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

29.5 BHD/sqm

For the cost estimation 50 mm rockwool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around BD4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

**INSULATION THICKNESS / U-VALUE**

The calculated U-Value for this system varies between 0.12- 0.22 W/m²/°C depending on thickness of insulation.

**COMMENTS / RECOMMENDATIONS**

(EIFS - Suitable for Retro-fit or New Build.

**KEY:**

Poor ← Excellent

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-EMS</td>
<td>EIFS with Metal Stud Wall</td>
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</tr>
</tbody>
</table>
### 1.21. EIFS WITH LIGHTWEIGHT STEEL FRAME WALL

#### Typical Build-Up

1. **Section**
   - Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.

2. **Metal Stud Wall (200mm):** A wall stud is a vertical cold rolled steel framing member in a building’s wall of smaller cross section than a post. They are a fundamental element in frame buildings. Metal framing next to an outside wall will transfer the heat. Therefore extruded polystyrene insulation should be considered between the outside wall and the metal to act as a thermal break.

3. **EIFS (50-150mm):** Exterior Insulation and Finish System (EIFS) is a non-load bearing, exterior wall cladding system that consists of an insulation board attached either adhesively or mechanically, or both, to the substrate; an integrally reinforced base coat; and a textured protective finish coat.

#### Description

1. **Lightweight steel Stud Wall:**
   - Single panel
   - Smooth finish coat
   - 1/8 inch thick structural cement applied in 2 coats
   - Expanded polystyrene cladding core

#### Technical Information

**Total System Cost**

29.5 BDH/sqm

For the cost estimation 50 mm rockwool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around BD4/m² per additional layer.

Baseline cost date is 1st Qtr, 2018

**KEY:**

Poor ↔ Excellent

#### Insulation Thickness / U-Value

The calculated U-Value for this system varies between 0.10-0.14 W/m²°C depending on thickness of insulation.

#### Comments / Recommendations

- **RF**
  - EIFS - Suitable for Retro-fit or New Build.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
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</thead>
<tbody>
<tr>
<td>W-EML</td>
<td>EIFS with Lightweight Steel</td>
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</tbody>
</table>

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**ThermAL Insulation Guidelines**

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AEGSG

2018
I.22. EIFS WITH WOOD WALL

**Typical Build-up**

1. **Section**
   - RF

2. **Plan**
   - CI

**Description**

1. Internal finish (25mm): Layer “finish coat” will be plastering layer, the thickness depends on the uniformity of the wall using a finishing trowel.

2. Wood stud wall (200mm): A wall stud is a vertical framing member in a building’s wall of smaller cross section than a post. They are a fundamental element in frame buildings. Therefore extruded polystyrene insulation should be considered between the outside wall and the metal to act as a thermal break.

3. EIFS (50-200mm): Exterior Insulation and Finish System (EIFS) is a non-load bearing, exterior wall cladding system that consists of an insulation board attached either adhesively or mechanically, or both, to the substrate, an integrally reinforced base coat; and a textured protective finish coat.

**Reference Images**

*Wood Stud Wall*

*EIFS System*

**Technical Information**

**Total System Cost**

32.1 BD/sqm

For the cost estimation 50 mm rockwool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around BD4/m² per additional layer.

Baseline cost date is 1st Qtr. 2018

**Key:**

- Poor ➔ Excellent

**Insulation Thickness / U-Value**

The calculated U-Value for this system varies between 0.09 - 0.16 W/m²K depending on thickness of insulation.

**Comments / Recommendations**

- **RF** EIFS - Suitable for Retro-fit or New Build.

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<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-EMW</td>
<td>EIFS with Wood Wall</td>
<td></td>
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</tr>
</tbody>
</table>
2. GLASS

This section provides various options for glass systems, demonstrating a range of thermal performance and costs.
GLASS SYSTEMS

G-UCW  UNITIZED CURTAIN WALL - VISION GLAZING AREAS
G-USP  UNITIZED CURTAIN WALL - SPANDREL PANELS
G-SCW  STICK CURTAIN WALL - VISION GLAZING AREAS
G-SSP  STICK CURTAIN WALL - SPANDREL PANELS
G-WIN  WINDOW
G-GS   GLAZING SELECTION

COST BENEFIT ANALYSIS (U-VALUE VS. COST)
# 2.1. UNITIZED CURTAIN WALL - VISION GLAZING AREAS

## TYPICAL BUILD-UP

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vertical Mullion (170mm)</td>
</tr>
<tr>
<td>2</td>
<td>Insulated double glazing + gasket (30-50mm)</td>
</tr>
<tr>
<td>3</td>
<td>Fire stop insulation</td>
</tr>
</tbody>
</table>

## DESCRIPTION

In the unitized system, the curtain wall is composed of sizesable storey-height units that are assembled and fully glazed in the factory, shipped to the site and erected on the building. Vertical mullions and horizontal transoms of the modules are mated together. Where required, modules of such curtain walls can be also constructed up to two stories tall and every module may incorporate numerous panels and glazing units.

## TECNICAL INFORMATION

<table>
<thead>
<tr>
<th>TOTAL SYSTEM COST</th>
<th>U-VALUE</th>
<th>COMMENTS / RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 BHD/sqm</td>
<td>typical values in the Mi'NA region.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U-Value range = 1.6 - 2.1 W/m²K</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recommended max U-Value is 1.9 W/m²K</td>
<td></td>
</tr>
<tr>
<td>Baseline cost date is 1st Qtr. 2018</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### KEY:

- Poor
- Excellent

## TABLE

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
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</thead>
<tbody>
<tr>
<td>G-UCW</td>
<td>Unitized Curtain Wall</td>
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</tbody>
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**THERMAL INSULATION GUIDELINES**

---

**AESC**
2.2. UNITIZED CURTAIN WALL - SPANDREL PANELS

**Typical Build-Up**

**Section**

1. **Description**
   - Unlike vision glazed areas, which are meant to be transparent, spandrel glass is designed to be opaque in order to help hide features between the floors of a building, including vents, wires, slab ends and mechanical equipment. To create this effect, the fabrication process for monolithic glass spandrels and insulated glass (IG) spandrels involves applying an opacifier, which is typically made from silicone-based paint or ceramic frits, to the indoor surface of a glass lite.

   1. Transom (170mm)
   2. Glazed spandrel (30mm)
   3. Insulation (80mm)
   4. Metal Pan

**Reference Images**

**Technical Information**

**Total System Cost**
84 BHD/m²
For the cost estimation double glazing unit with air in-fill and single silver coating on beryllium tinted glass has been considered.

The price would vary depending on the build up, cavity in-fill and coating selection, for more information refer to chapter 2.6 Glazing Selection.

Baseline cost date is 1st Qtr. 2018

**U-Value**

Typical values in the MENA region.

U-Value range = 1.6 - 2.1 W/m²K

Recommended max. U-Value is 1.9 W/m²K

**Comments / Recommendations**

1. Horizontal stack joint between the units required to accommodate building movements.
2. Front of the slabs should be insulated.

**Table**

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
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<td>Unitized Curtain Wall</td>
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</tbody>
</table>

**G-USP**

**Suitable For**
High-rise
2.3. STICK CURTAIN WALL-VISION GLAZING AREAS

**TYPICAL BUILD-UP**

**DESCRIPTION**

The oldest curtain wall type is the stick built system. In the stick system, the curtain wall frame, comprising mullions and transoms are assembled and installed on site using various hardware components such as anchors, connectors, setting blocks, pressure plates, gaskets, capping, etc. The glazing panels are then glazed/ssealed on site.

1. Vertical Mullion (170mm)
2. Insulted double glazing + gasket (30-50mm)
3. Fire stop insulation

**REFERENCE IMAGES**

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

120 BHD/m²

For the cost estimation, double glazing unit, with air infill and single silver coating, on body tinted glass has been considered.

The price would vary depending on the build up, cavity infill and coating selection, for more information refer to chapter 2.6 Glazing Selection.

Baseline cost date is 1st Qrt. 2018

**U-VALUE**

Typical values in the MENA region.

U-Value range = 1.6 - 2.1 W/m²K

Recommended max. U-Value is 1.9 W/m²K

**COMMENTS / RECOMMENDATIONS**

- Horizontal stack joint between the units required to accommodate building movements.
- Front of the slabs should be insulated.

**KEY:**

Poor ← Excellent

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-SCW</td>
<td>Stick Curtain Wall</td>
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<td></td>
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</tbody>
</table>

**THERMAL INSULATION GUIDELINES** 2018

**AESG**
2.4. STICK CURTAIN WALL - SPANDREL PANELS

**TYPICAL BUILD-UP**

**Section**

1. Transom (170mm)
2. Glazed spandrel (30mm)
3. Insulation (80mm)
4. Metal Panel

**Plan**

**DESCRIPTION**

Unlike vision glazed areas, which are meant to be transparent, spandrel glass is designed to be opaque in order to help hide features between the floors of a building, including vents, wires, slab ends and mechanical equipment. To create this effect, the fabrication process for monolithic glass spandrels and insulated glass (IG) spandrels involves applying an opacifier, which is typically made from silicone-based paint or ceramic frits, to the indoor surface of a glass lite.

**REFERENCE IMAGES**

![Reference Image](image_url)

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

84 BD/qsm

For the cost estimation double glazing unit, with air infill and single silver coating, on bocci tinted glass has been considered.

The price would vary depending on the build up, cavity infill and coating selection, for more information refer to chapter 2.6 Glazing Selection.

Baseline cost date is 1st Qtr. 2018

**U-VALUE**

Typical values in the MENA region.

U-Value range = 1.6 - 2.1 W/m²K

Recommended max. U-Value is 1.9 W/m²K

**COMMENTS / RECOMMENDATIONS**

- Horizontal stack joint between the units required to accommodate building movements.
- Front of the slabs should be insulated.

**KEY:**

Poor ➔ Excellent

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
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<th>Buildability</th>
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</thead>
<tbody>
<tr>
<td>G-SCW</td>
<td>Stick Curtain Wall</td>
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</tbody>
</table>
2.5. WINDOW

**G-WIN**

**Typical Build-Up**

1. Window frame
2. Double glass (30-50mm)
3. Wall

**Description**

**Reference Images**

1. Bottom Hung
2. Top Hung
3. Side Mounted
4. Combination
5. Sliding
6. Parallax
7. Pivot

**Technical Information**

**Total System Cost**

50 BHD/sgm

For the cost estimation double glazing unit, with air infill and single silver coating, on body tinted glass has been considered.

The price would vary depending on the build up, cavity infill and coating selection, for more information refer to chapter 2.6 Glazing Selection.

Baseline cost date is 1st Qrt. 2018

**Key:**

Poor ← Excellent

**U-Value**

Typical values in the MENA region.

U-Value range = 1.6 - 2.1 W/m²K

Recommended max. U-Value is 1.9 W/m²K

**Comments / Recommendations**

- Horizontal stack joint between the units required to accommodate building movements.
- Front of the slabs should be insulated.
- Suitable for Retro-fit or New Build.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
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<tbody>
<tr>
<td>G-W</td>
<td>Window</td>
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</tbody>
</table>
## 2.6. GLAZING SELECTION

### GLAZING SELECTION PROCESS

<table>
<thead>
<tr>
<th>STEP 1: GLAZING BUILD-UP</th>
<th>STEP 2: CAVITY INFILL</th>
<th>STEP 3: COATING</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINGLE GLAZING</td>
<td>AIR</td>
<td>Single Silver +</td>
<td>Benchmark</td>
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<tr>
<td></td>
<td></td>
<td>Body Tinted</td>
<td>+1%</td>
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<tr>
<td>DOUBLE GLAZING</td>
<td>ARGON</td>
<td>Double Silver +</td>
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<td></td>
<td></td>
<td>Clear</td>
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</tr>
<tr>
<td>TRIPLE GLAZING</td>
<td>Constricts on supply chain</td>
<td>Triple Silver +</td>
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<td>Clear</td>
<td>+4%</td>
</tr>
</tbody>
</table>

*Light Transmittance values for a fixed 0.25 G-Value

### COST

- Benchmark
- +14%
- +42%

### COMMENTS / RECOMMENDATIONS

For safety / structural or acoustic considerations, Heat Strengthened glass panels may need to be replaced for Fully Tempered or laminated in the design.

- FT glass comes at 15-25% increase in cost as compared to HS.
- Laminated glass comes at 20-40% increase in cost as compared to HS.

**NOTE:**
The cost is been based on a double glazing unit, with air infill with single silver coating on body tinted glass, because it is the most suitable option selection according to cost effective performance.
3. DOORS
This section provides various options for door systems, demonstrating a range of thermal performance and costs.
DOORS SYSTEMS

D-SDNR  SWING DOOR - NON REBATED
D-SDR  SWING DOOR - REBATED
D-SLD  SLIDING DOOR
D-BD  BIFOLD DOOR
D-RD  REVOLVING DOORS
3.1. SWING DOOR - NON REBATED (NON PRESSURE LOCK)

**Typical Build-Up**

**Description**
The Swing door is pivoted or hung on double-sided hinges so that it can open either way. Non rebated: it has a thermal break and is generally the most common one. Materials: PVC, Aluminium, Glazed, Timber

1. Thermal break
2. Threshold
3. Kickboard
4. Exterior finish floor
5. Metal flashing
6. Interior finish flooring
7. Door

**Technical Information**

**Total System Cost**
175 BHD/sqm
Baseline cost date is 1st Qrt. 2018

**Insulation Thickness / U-Value**
Typical values in the MENA region.
U-Value range = 1.6 - 2.1 W/m²K
Recommended max U-Value is 1.9 W/m²K

**Key:**
Poor ≤ ≤ ≤ ≤ Excellent

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
<th>Supply Chain</th>
<th>Buildability</th>
</tr>
</thead>
</table>
3.2. SWING DOOR - REBATED (PRESSURE LOCK)

**Typical Build-Up**

- The Swing door is pivoted or hung on double-sided hinges so that it can open either way. Rebated: the door has a portion of frame into which the door fits. One half of the edge projects beyond the other half, usually by 13mm.
- Materials: PVC, Aluminium, Glazed, Timber
  1. Gasket
  2. Threshold
  3. Kickboard
  4. Exterior finish floor
  5. Metal flashing
  6. Interior finish flooring
  7. Door

**Technical Information**

**Total System Cost**

175 BHD/sqm

Baseline cost date is 1st Qtr. 2018

**Insulation Thickness / U-Value**

Typical values in the MiNA region.

U-Value range = 1.6 - 2.1 W/m²K

Recommended max. U-Value is 1.9 W/m²K

**Key:**

Poor → Excellent

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
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<td>D-SDR</td>
<td>Swing Door - Rebated</td>
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</tbody>
</table>
3.3. SLIDING DOOR

**Typical Build-Up**

- Standard sliding doors are the cheapest in the market but are not recommended because of their low air and water tightness and poor acoustic insulation. The following alternative sliding doors are recommended:
  - Lift and slide: Good acoustic and dust infiltration performance
  - Tilt and slide: Enhance acoustic and dust infiltration performance

**Technical Information**

**Total System Cost**

210 BHD/sqm
Baseline cost date is 1st Qtr. 2018

**Insulation Thickness / U-Value**

Typical values in the ME/NA region.
U-Value range = 1.6 - 2.1 W/m²K
Recommended max. U-Value is 1.9 W/m²K

**Key:**
Poor ➔ Excellent

<table>
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<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
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<td>Sliding Door</td>
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</tr>
</tbody>
</table>

**Reference Images**

- Image of sliding door system.
### 3.4. BIFOLD DOORS

#### Typical Build-Up

![Typical Build-Up Diagram]

#### Description

The frames are quite visible when closed but offer full visibility when opened. Fixed pane not in the same plane as opening line in closed position.

Opening should be done by maintenance personnel and not very often.

Requires space to fully open.

Materials: PVC, Aluminium, Glazed, Timber

1. Bifold doors
2. Rail
3. Threshold
4. Exterior finish floor
5. Metal flashing
6. Interior finish flooring

#### Technical Information

<table>
<thead>
<tr>
<th>TOTAL SYSTEM COST</th>
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<tr>
<td>400 BHD/sqm</td>
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Baseline cost date is 1st Qrt. 2018

<table>
<thead>
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<th>INSULATION THICKNESS / U-VALUE</th>
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<td>Typical values in the MENA region.</td>
</tr>
<tr>
<td>U-Value range = 1.6 - 2.1 W/m²K</td>
</tr>
<tr>
<td>Recommended max U-Value is 1.9 W/m²K</td>
</tr>
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</table>

#### Key:

- Poor
- Excellent

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<th>Code</th>
<th>Structural Composition</th>
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<tbody>
<tr>
<td>D-BD</td>
<td>Bifold Door</td>
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</tbody>
</table>

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**THERMAL INSULATION GUIDELINES**

 ministry of housing

AESC 2018
3.5. REvolving DOORS

**Typical Build-Up**

1. Revolving doors
2. Thermal break
3. Threshold
4. Exterior finish floor
5. Metal flashing
6. Interior finish flooring

**Description**

A revolving door typically consists of three or four doors that hang on a central shaft and rotate around a vertical axis within a cylindrical enclosure.

Materials: PVC, Aluminium, Glazed

**Reference Images**

**Technical Information**

**Total System Cost**

22000 BD/12cm
Baseline cost date is 1st Qtr. 2018

**Insulation Thickness / U-Value**

N/A

**Key:**

Poor ← Excellent

<table>
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<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
<th>Durability / Maintenance Factor</th>
<th>Embodied Energy</th>
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<tr>
<td>D-RD</td>
<td>Revolving Doors</td>
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4. FLOOR

This section provides various options for flooring systems, demonstrating a range of thermal performance and costs.
FLOOR SYSTEMS

F-INS  INSULATED FLOOR
F-NINS NON-INSULATED FLOOR

COST BENEFIT ANALYSIS FOR FLOOR OPTIONS

Cost Benefit Analysis (U Value vs. Cost)

Cost (BHD)

U-Value (W/m2K)

F-INS

F-NINS
4.1. INSULATED FLOOR

**TYPICAL BUILD-UP**

1. Finish floor (50-100 mm)
2. Insulation (50-200mm)
3. Slab (0-250mm)
4. Gravel layer

**DESCRIPTION**

Insulating a floor means adding an insulating material beneath the floorboards, thereby reducing heat escaping through the floor into the ground. Approximately 15% of heat is lost from a house via this route. Insulation also acts to prevent draughts coming up through the floorboards. In addition, the household should also consider insulating the gaps between the skirting boards and the floor, which also helps in reducing draughts.

**REFERENCE IMAGES**

![Image of insulated floor]

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

47.25 £/10sqm

For the cost estimation 50 mm insulation and 50mm finish floor has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around 80£/m² each layer.

Baseline cost date is 1st Qtr. 2018

**KEY:**

- Poor
- Excellent

**INSULATION THICKNESS / U-VALUE**

![Graph showing insulation thickness and U-value]

U-Value is 0.49 to 0.16 W/m²K

**COMMENTS / RECOMMENDATIONS**

- Insulated layer on the floor. Suitable for Retro-fit or New Build.
- In the case of suspended slab (soffit) over un-conditioned space, such as parking, insulation should be applied to the underside of the soffit.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
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<td>Insulated Floor</td>
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</tbody>
</table>

**THERMAL INSULATION GUIDELINES**

2018

AESG
4.2. NON INSULATED FLOOR

**TYPICAL BUILD-UP**

Concrete slab floors come in many forms. Slabs can be on-ground, suspended, or a mix of both. They can be insulated both underneath and on the edges. Conventional concrete has high embodied energy. It has been the most common material used in slabs but several new materials are available with dramatically reduced environmental impact.

Different types: Slab on ground, Suspended slab, Precast slab.

1. Finish floor (50-100 mm)
2. Slab (0-250mm)
3. Gravel layer

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

37.25 BD/sqm

For the cost estimation 50mm finish floor and 250mm slab thickness has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets at around 804$m^2$ each layer.

Baseline cost date is 1st Qtr. 2018

**INSULATION THICKNESS / U-VALUE**

U-Value is 1.99 W/m²K

**KEY:**

- Poor
- Good
- Excellent

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
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<th>Embodied Energy</th>
<th>Supply Chain</th>
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<tbody>
<tr>
<td>F-NINS</td>
<td>Non Insulated Floor</td>
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5. ROOF

This section provides various options for roof systems, demonstrating a range of thermal performance and costs.
ROOF SYSTEMS

R-RC   REINFORCED CONCRETE ROOF
R-HC   HOLLOW CORE CONCRETE ROOF
R-MR   METAL ROOF
R-SKY  SKYLIGHT

COST BENEFIT ANALYSIS FOR ROOF

Cost Benefit Analysis (U-Value vs. Cost)

R-RC
R-HC
R-MR
R-SKY

U-Value (W/m²K)

Cost (R-IQ)

0  0.2  0.4  0.6  0.8  1  1.2  1.4  1.6  1.8  2

800
700
600
500
400
300
200
100
0
5.1. REINFORCED CONCRETE ROOF

**Typical Build-up**

1. **1. Chipped stone (150 mm)**
2. **2. Drainage + root barrier**
3. **3. Insulation (100-300 mm)**
4. **4. Waterproof membrane**
5. **5. Slab (300 mm)**

**Description**

- Roof platform which is either horizontal or inclined up to 10 degrees (to prevent ponding).
- Usually surrounded by fascia/parapet wall.
- Suitable for large and tall buildings.
- Functional requirements: Stability, Strength, Durability, Fire resistance, Thermal properties, Exclusion of rain and wind, Sound insulation.

**Technical Information**

**Total System Cost**

60.65 BHD/m²

For the cost estimation 300 mm mineral-wool insulation has been considered.

Generally, thicker layers are made up of numerous 50 mm thick sheets, at around 3D4/m² each layer.

Baseline cost date is 1st Qrt. 2018

**Key:**

- Poor ➔ Excellent

**Insulation Thickness / U-Value**

0.11 to 0.28 W/m²K, dependent on the thickness of the insulation.

**Comments / Recommendations**

The proper design of falls in a flat roof is an essential consideration in the overall drainage of the roof. Falls create flow paths to direct the drainage of rainwater away from the roof to suitable discharge points. To be effective, it is essential to clear surface water as rapidly as possible from the flat roof to avoid ponding or stagnation of water on the roof itself.

**R-RC**

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
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<td>Reinforce Concrete</td>
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</table>

**Thermal Insulation Guidelines**

2018

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5.2. HOLLOW CORE CONCRETE ROOF

**DESCRIPTION**
The precast concrete slab has tubular voids extending the full length of the slab, typically with a diameter equal to 2/3–3/4 of the slab.

This makes the slab lighter than a solid concrete floor slab of equal thickness or strength.

1. Chipped stone (150 mm)
2. Drainage + root barrier
3. Insulation (100-300 mm)
4. Waterproof membrane
5. Hollow core concrete (300 mm)

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**
47.75 BHD/\text{sqm}

For the cost estimation 300 mm mineral-wool insulation has been considered.

Generally, thicker layers are made up of numerous 50 mm thick sheets, at around 304/m² each layer.

Baseline cost date is 1st Qrt. 2018

**INSULATION THICKNESS / U-VALUE**

0.11 W/m²K to 0.28 W/m²K, dependent on the thickness of the insulation.

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
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<th>Assembly Cost</th>
<th>Life Cycle Cost</th>
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<tbody>
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<td>Hollow Core Concrete</td>
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</tbody>
</table>

**Suitable for:**

Villa Housing
5.3. METAL ROOFS

**TYPICAL BUILD-UP**

A metal roof is a roofing system made from metal pieces or tiles. Originally, metal roofs were made of corrugated galvanized steel: a wrought iron–steel sheet was coated with zinc and then roll-formed into corrugated sheets. Another approach is to blend zinc, aluminium and silicon-coated steel.

1. Metal ceiling
2. Concrete
3. Waterproof membrane
4. Insulation (300 mm)
5. Waterproof membrane
6. Metal sheet

*For C - go to comments

**REFERENCE IMAGES**

![Metal Roof Image](image)

**TECHNICAL INFORMATION**

**TOTAL SYSTEM COST**

47 BHD/sqm

For the cost estimation 300 mm mineral-wool insulation has been considered.

Generally thicker layers are made up of numerous 50mm thick sheets, at around BD4/m² each layer.

Baseline cost date is 1st Qrt. 2018

**INSULATION THICKNESS / U-VALUE**

- Insulation: 300 mm
- U-Value: 0.11 W/m²K

**COMMENTS / RECOMMENDATIONS**

- Most commonly used for industrial buildings, not common in residential buildings.

---

**CODE**

<table>
<thead>
<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
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</tbody>
</table>

**THERMAL INSULATION GUIDELINES**

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5.4. SKYLIGHT

Typical Build-Up

- Skylights are widely used in designing daylighting for residential, public, and commercial buildings. Increased daylighting can result in less electrical use and smaller-sized window glazing (sidelighting), saving energy, lowering costs, and reducing environmental impacts.

1. Chipped stone (150 mm)
2. Drainage + root barrier
3. Waterproof membrane
4. Insulation (300 mm)
5. Waterproof membrane
6. Concrete slab
7. Vertical insulation
8. Skylight - safety glazing

Reference Images

Technical Information

<table>
<thead>
<tr>
<th>TOTAL SYSTEM COST</th>
<th>INSULATION THICKNESS / U-VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>750 BD/25m²</td>
<td>Recommended U-Value 1.9 W/m²K</td>
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</tbody>
</table>

For the cost estimation 300 mm mineral-wool insulation has been considered. Generally thicker layers are made up of numerous 50mm thick sheets, at around BD44/m² each layer.

Baseline cost date is 1st Qtr. 2018

KEY:
- Poor
- Excellent

<table>
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<tr>
<th>Code</th>
<th>Structural Composition</th>
<th>Thermal Potential U-Value</th>
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<tr>
<td>R-SKY</td>
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Suitable for:
- Villa
- Highrise
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