Calculation of the Embodied Energy Payback in Expanded Shale Clay and Slate
When Used in Lightweight Concrete Masonry

Introduction and Executive Summary: Expanded Shale, Clay and Slate (ESCS) lightweight aggregate is produced using energy. That energy investment is paid back during use of the material in a number of ways. For example, because the aggregate is lower density than commonly used “normal weight” aggregates, transportation of the raw materials and finished products saves energy. Structural lightweight concrete made with ESCS in building floors allows thinner floor sections to be designed, which means less concrete is used, and less supporting materials (concrete and structural steel in columns and foundations) are needed. The energy saved by not using these other materials is properly attributed to the use of ESCS.

There are a number of other energy saving factors that are important in the life cycle of ESCS. This publication focuses on using ESCS in the production of concrete masonry units. Concrete masonry is consistently the largest single market for ESCS and comprises over 50 percent of shipments according to our most recent market analysis. The energy payback is found to be less than one year, which is important both economically and when considering the contribution of ESCS to sustainable construction.

Methodology: Calculate the energy used to produce Expanded Shale, Clay and Slate (ESCS) aggregate. Then calculate the payback period for energy savings that result from using ESCS aggregate in a lightweight concrete masonry unit, instead of using heavy weight aggregate for the same concrete masonry unit. These calculations assume the masonry is used in single wythe integrally insulated exterior building walls, which is a typical application.

Calculations: The ESCS production BTU input of 1,340,000 Btu/cubic yard and 1242 lb/cu yd average density is per the November 20, 2006 Embodied Energy Update survey from ESCSI.

A typical mix design for 8” Lightweight cmu meeting ESCSI’s SmartWall® specification density and strength and yielding 75 blocks per batch is:

<table>
<thead>
<tr>
<th>Component</th>
<th>lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>176</td>
</tr>
<tr>
<td>Fly Ash</td>
<td>59</td>
</tr>
<tr>
<td>ESCS Aggregate</td>
<td>967</td>
</tr>
<tr>
<td>Sand Aggregate</td>
<td>599</td>
</tr>
<tr>
<td>Water</td>
<td>112</td>
</tr>
<tr>
<td>Totals</td>
<td>1913</td>
</tr>
</tbody>
</table>

This mix uses:

\[
\frac{967 \text{ lb}}{\text{Batch}} \times \frac{1242 \text{ lb}}{\text{Cu Yd ESCS}} \times \frac{75 \text{ Blocks}}{\text{Batch}} = 0.0104 \text{ Cu Yd ESCS/Block}
\]

\[
1,340,000 \text{ Btu} \times 0.0104 \text{ Cu Yd ESCS/Block} = 13,936 \text{ Btu/Block}
\]

The energy saved in use in an exterior wall is documented in ESCSI Information Sheet 3530 for a “big box” building located in Omaha, Nebraska. The difference in wall conductivity values between a SmartWall lightweight cmu and a cmu made with normal weight aggregate is shown as 0.157; using this value in the calculations:

\[
0.157 \frac{\text{Btu}}{\text{hr} \cdot \text{Ft}^2 \cdot ^\circ \text{F}} \times \frac{6201 \text{ o F}}{\text{Day}} \times \frac{24 \text{ Hr}}{\text{Day}} = 23,365 \frac{\text{Btu}}{\text{Ft}^2 \cdot \text{Yr}}
\]

\[
23,365 \frac{\text{Btu}}{\text{Ft}^2 \cdot \text{Yr}} \times \frac{128 \text{ In}^2/\text{Block}}{144 \text{ In}^2/\text{Ft}^2} = 20,769 \frac{\text{Btu}}{\text{Block} \cdot \text{Yr}}
\]
Calculate the payback period by dividing the one-time energy input to the ESCS aggregate in the lightweight cmu by the annual energy savings per block:

\[
\frac{13,936 \text{ Btu}}{\text{Block}} = 0.67 \text{ year}
\]

\[
\frac{20,769 \text{ Btu}}{\text{Block} \cdot \text{Yr}}
\]