High Performance Concrete Building Design

Insulating Concrete Forms – a solution to current and future Energy and Building Codes in North America

Kevin Davis
Director of Sales
Quad-Lock Building Systems
A consortium operating under the auspices of the Ontario Ready Mix Association.
FACT #1: Our buildings consume the largest percentage of our total energy use.

U.S. Energy Consumption, 2013: 97.4 Quadrillion Btu

- Industrial: 32.2%
- Commercial: 18.4%
- Residential: 21.7%
- Transportation: 27.7%

U.S. buildings represent 40.1% of total energy use.

Source: US Energy Information Agency
FACT #2: The “Appetite for Energy” of our buildings is driven 50% by space heating & cooling demands

Source: US Energy Information Agency
Can We Change Cultural Priorities?

Change a culture that is focused on the glittering amenities?

Change a culture that is focused on “first-cost” vs total cost of ownership?

*Not very likely!*
The Secret Is In Our Name

“Insulating”
Two layers of high value EPS insulation provide **continuous** thermal barrier.

“Concrete”
Reinforced concrete provides **durable structure** & protection of occupants.

“Forms”
Lightweight EPS forms are **easily shaped** & adapted to architectural designs.
Two ICF Use-Categories:

- **Vertical concrete structures**
  - Two-sided ICFs

- **Flat, pitched or tilt-up concrete structures**
  - One-sided ICFs
How do ICFs control heat gain/loss?

Strategic use of 3 unique qualities:

- High R-Value & Unbroken Insulation Layers
- Zero Porosity Concrete Air Barrier
- High Mass for Thermal Storage

How do ICFs control heat gain/loss?
ICF vs. Neighbors
ICF vs. Neighbors
ICF Progress in the Market
Available Insulation Options

R-22 [U-0.28]
R-28 [U-0.21]
R-38 [U-0.15]
R-43 [U-0.14]
R-53 [U-0.11]
R-59 [U-0.10]
<table>
<thead>
<tr>
<th>Desired Characteristics <strong>Code Mandated</strong></th>
<th>Wood Frame</th>
<th>Steel Frame</th>
<th>Conv. Concrete</th>
<th>ICF Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Resistant**</td>
<td>↓</td>
<td>$$</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wind Resistant**</td>
<td>$$</td>
<td>$</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Seismic Resistant**</td>
<td>$$</td>
<td>$</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Thermal Continuity**</td>
<td>$</td>
<td>$$</td>
<td>$$</td>
<td>Yes</td>
</tr>
<tr>
<td>Fire Resistant**</td>
<td>↓</td>
<td>$$</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Safe/Non-toxic**</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Impact Resistant</td>
<td>↓</td>
<td>↓</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Adaptable to Design &amp; Utilities</td>
<td>$</td>
<td>$$</td>
<td>$$</td>
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</table>
ICF/Concrete Wall Reinforcement

Prescriptive Designs to 150 mph (all exposures)

<table>
<thead>
<tr>
<th>Basic wind speed (mph)</th>
<th>Exposure category</th>
<th>Maximum unsupported wall height per story</th>
<th>Minimum vertical reinforcement – bar size No. and spacing (in.)</th>
<th>Nominal wall thickness (in.)</th>
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</thead>
<tbody>
<tr>
<td>B</td>
<td>C</td>
<td>D</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
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<td></td>
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<td>192</td>
<td>163</td>
<td>150</td>
<td></td>
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</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm; 1 foot = 0.3048 m; 1 mph = 0.447 m/s

PCA 100-2012, Prescriptive Design of Exterior Concrete Walls

for One- and Two-Family Dwellings

IRC Prescriptive Designs

Table 4.1. Minimum Vertical Reinforcement for Flat Above-Grade Walls
## Lateral Strength Comparison

<table>
<thead>
<tr>
<th></th>
<th>Wood Frame</th>
<th>ICF &amp; Concrete</th>
<th>Concrete % Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global Lateral Stiffness (lbs/in)</strong></td>
<td>18,500</td>
<td>708,000</td>
<td>+3,827%</td>
</tr>
<tr>
<td><strong>Load at First Major Damage (lbs)</strong></td>
<td>3,500</td>
<td>8,500</td>
<td>+243%</td>
</tr>
<tr>
<td><strong>Displacement at First Major Damage (in)</strong></td>
<td>0.51</td>
<td>0.06</td>
<td>+850%</td>
</tr>
<tr>
<td><strong>Maximum Lateral Resistance (lbs)</strong></td>
<td>4,553</td>
<td>34,254</td>
<td>+752%</td>
</tr>
<tr>
<td><strong>Displacement at Max. Lateral Resist. (in)</strong></td>
<td>0.89</td>
<td>2.66</td>
<td>+299%</td>
</tr>
</tbody>
</table>

Test performed by PCA based on ASTM E564-95
Relevant Codes and Standards: USA

- **International Residential Code**
  - Chapters 3, 6 & 11

- **International Building Code**
  - Chapters 16 & 19

- **International Energy Conservation Code**

- **ACI 318**
  - Building Requirements for Structural Concrete

- **ASCE 24-05**
  - Flood Resistant Design & Construction
Relevant Codes and Standards: Canada

**National Building Code of Canada or Provincial Codes**
- Parts 3, 4, 5 & 9
- Post-Disaster Category

**CAN/CSA A23.3**
- Design of Concrete Structures

**2011 National Model Energy Code for Buildings**

**ASCE 7**
- Minimum Design Loads for Buildings

**ASCE 24-05**
- Flood Resistant Design & Construction
Disaster Resistant ICF/Concrete Designs
ICF Designs For Efficiency and Survivability

Community Centres

Custom Homes

Building Types

Schools

Elevated Single Family Residence
Construction Time With ICF.

Thermal Resistance.

- ICFs are considered by ICC and IECC as mass walls with continuous insulation.
- Typical whole wall ICF assembly has an R value of R24.
- ICFs exceed the requirements for all climate zones for commercial thermal envelopes above and below grade.
Kevin Davis  
Director of Sales / Quad-Lock Building Systems  
Email:  kevin.davis@quadlock.com  
Phone:  (604)590-3111 extension 244  
Mobile:  (604)314-1065