Generalization of Structural Insulated Panels Test Data

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Laboratory Testing—Idealized

Actual Construction—Generalized
The Problem

- Adapt Test Data to Actual Conditions
  - Apply short-duration test data to long-term loads
  - Generalized loading conditions
  - Generalized support conditions
The Solution

- Engineered Design
  - Identify design limits states
  - Develop engineering properties based on engineering mechanics
  - Testing serves to validate predicted behavior
The Solution

- Key Limit States
  - Flexural Stiffness
  - Creep Effects
  - Shear Strength
  - Axial Strength
- Other limit states exist—consult design guide
Flexural Stiffness

- Simply supported deflection equation including shear under uniform loads:

\[
\Delta = \Delta_b + \Delta_s = \frac{5wL^4 \times 1728}{384E_b I} + \frac{wL^2}{4(h + c)G}
\]
Flexural Stiffness

Generalization of SIP Data

- OSB Strong-Axis
- OSB Weak-Axis

Slope, 1/G

Y-Intercept, 1/Eb
Flexural Stiffness

Generalization of SIP Data
Flexural Creep

- Creep effects incorporated in manner similar to that used for wood and concrete
- Total deflection considering creep (NDS):

\[ \Delta_T = K_{cr} \Delta_{LT} + \Delta_{ST} \]

- Need value for creep coefficient, \( K_{cr} \)
Flexural Creep

# Flexural Creep

<table>
<thead>
<tr>
<th>Material</th>
<th>Creep Coefficient, $K_{cr}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPS, XPS Core SIP</td>
<td>4.0</td>
</tr>
<tr>
<td>Urethane Core SIP</td>
<td>7.0</td>
</tr>
<tr>
<td>Seasoned Lumber</td>
<td>1.5</td>
</tr>
<tr>
<td>OSB or Wet Lumber</td>
<td>2.0</td>
</tr>
<tr>
<td>Reinforced Concrete</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Flexural Creep

- Creep Deflection Equation for SIPs

\[ \Delta_T = \sum K_{cr_i} \Delta_i \]

- Consider \( K_{cr} \) based on load type

<table>
<thead>
<tr>
<th>Load Type (ASCE 7)</th>
<th>Creep Coefficient, ( K_{cr} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EPS/XPS</td>
</tr>
<tr>
<td>D, F, H, T</td>
<td>4.0</td>
</tr>
<tr>
<td>L</td>
<td>3.0</td>
</tr>
<tr>
<td>E, W, S, R, L_r, F_a</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Flexural Creep

- Creep Rupture (Long-Term Strength)
  - Same creep model applies
  - Inverse of $K_{cr}$ may be applied to reduce strength
  - Creep rupture study has not been conducted to validate model
Transverse Shear

- Factors affecting core shear strength
  - Core type (EPS, XPS, urethane)
  - Foam density and thickness
  - Additives (flame retardant, insecticide)
  - End support conditions

- Shear Equation:

\[ F_v = \frac{V}{6(h + c)} \]
Transverse Shear

Shear Strength, $F_v$ (psi)

Overall Thickness, $h$ (in.)

Generalization of SIP Data
Transverse Shear

- Depth correction factor required
- Procedure from ASTM D198

\[ C_{Fv} = \left( \frac{h_o}{h} \right)^m \]

- Additional adjustment factors required (e.g. support method)
Transverse Shear

\[ C_v = 1.0 \]

Bearing Support

\[ C_v = 0.4 \]

Spline Support
Transverse Shear

\[ C_v = 0.4 \]

\[ 0.4 < C_v \leq 1.0 \]

Support of Top Facing

Core in tension

Additional support of bottom facing provided by fasteners
Axial Strength

Axial Strength (Secant Formula):

\[ P_e = C_e F_c A_f \]

\[ C_e = \frac{1}{1 + \frac{ey_c}{r^2} \sec \left( \frac{12L}{2r} \sqrt{\frac{3P}{A_f E_b}} \right) + \frac{3Pey_c}{2A_v GI}} \]
Axial Strength Model

Axial Strength (lbf)

Slenderness Ratio, L/r
Summary

- SIP panels behave in manner consistent with engineering mechanics
- Using data to establish and validate engineering mechanics permits rigorous design of SIPs for general loading and support conditions
- Currently *NTA SIP Design Guide* provides detailed design methodology based on properties found in SIPA code report: www.sips.org
Thank You

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