Design of SIPs Used as Diaphragms

When utilizing SIPs in roof and floor applications, design professionals face two main design considerations: evaluating SIPs' ability to handle gravity loads in transverse bending and ensuring they serve effectively as diaphragms against lateral loads from wind or seismic events.

Transverse Bending:

The capacity of SIPs to withstand gravity loads in transverse bending is well-documented through extensive laboratory testing conducted by SIPA member manufacturers, adhering to ICC-ES AC04 standards. These tests cover both uniformly applied loads and concentrated loads and are summarized in load/span design tables within manufacturers' ICC-ESR code evaluation reports. Design professionals and code officials widely recognize these results as meeting code requirements.

Diaphragms:

In contrast, data on the lateral load performance of SIP diaphragm systems is more limited and typically remains proprietary, detailed in code evaluation reports held by various SIPA member manufacturers. To address this gap, APA – The Engineered Wood Association, the USDA Forest Products Laboratory (FPL), and the Structural Insulated Panel Association (SIPA) conducted a joint research study at the APA Research Center in Tacoma, WA.

The study involved testing 12 SIP diaphragms (8′ x 24′ in plan) with various configurations, covering parameters such as longitudinal and transverse SIP joints and the use of SIP screws at different intervals. Here's an overview of the test configurations:

- Longitudinal SIP joint: No joint vs. one joint, testing a full 8′ x 24′ panel and two 4′ x 24′ panels.
- Transverse SIP joint: No joint vs. one joint, testing the full 8′ x 24′ panel and two 8′ x 12′ panels.
- Both longitudinal and transverse joints: One longitudinal and one transverse joint with four 4′ x 12′ panels, and one longitudinal and two transverse joints with six 4′ x 12′ panels.
- SIP screws spacing: Testing with screws spaced at 6 inches and 3 inches on center to connect SIPs to subframing members.

Each SIP diaphragm underwent testing following ASTM E455 standards. The study aimed to assess both the standalone structural capacity of SIP diaphragms and their capacity when connected to framing members. The results are detailed in FPL-RP-700, "Lateral Load Performance of Structural Insulated Panel (SIP) Diaphragms."

Stand-alone Test Results:

- Shear strength differences between SIP diaphragms with varying segments were minimal, with a nominal increase observed for diaphragms composed of four and six segments.
- Average peak load across all tests was 1240 lbf/ft, equating to a shear design capacity of 415 plf.
- Deflection increased notably for SIP assemblies with multiple joints.

SIPs Attached to Sub-framing using SIP Screws:

- Similar trends were observed regarding shear strength with variations in the number of SIP segments.
- Average peak load across all tests was 2220 lbf/ft, representing a shear design capacity of approximately 740 plf, an 80 percent increase compared to stand-alone diaphragms.
- Deflection differences were within ±10 percent for most configurations.

Tests with SIP screws spaced at 3 inches on center showed a 60 percent increase in shear capacity compared to panels with screws spaced at 6 inches. The shear capacities observed exceeded those in SIPA member manufacturer reports.

The FPL report can be accessed from the FPL website (fpl.fs.fed.US).