



Introduction

The use of off-site construction has been growing globally as the building industry and policymakers look to address challenges in workforce availability, supply chains, availability and affordability of housing, jobsite safety, industry productivity and sustainability. Off-site construction can take many forms, including volumetric and panelized systems. ICC/MBI Standards 1200 and 1205 define off-site construction as “a modular building, modular component or panelized system that is designed and constructed in compliance with this standard and is wholly or in substantial part fabricated or assembled in manufacturing plants for installation—or assembly and installation—on a separate building site and has been manufactured in such a manner that all parts or processes cannot be inspected at the installation site without disassembly, damage to, or destruction thereof.”

Panels can be manufactured and approved under a variety of schemes. The degree of plan review and inspection required can vary based on requirements in place in the jurisdiction where the panels will ultimately be assembled into a building. This variation can lead to a lack of investment in increasingly advanced systems that may increase capital costs while improving accuracy and productivity but without a commensurate recognition by the regulatory body of the level of quality and replicability in the manufacturing process.

In the US, all states with off-site construction programs currently provide for the plan review and inspection of volumetric modules, but their coverage of panelized systems vary. This has led to confusion amongst panelization companies, limiting their willingness to invest in more advanced technologies that could lead to safer and more efficient construction. Globally, approval processes for panels can also vary based on jurisdictional requirements (in fact, this guideline

captures best practices from regulatory processes around the globe). This guideline can support the development and implementation of advanced panelization in any jurisdiction.

The processes outlined in this guideline are intended to address any panel that meets the definition of “advanced panelization” contained herein and “off-site construction,” as defined in ICC/MBI Standard 1200 or which otherwise falls outside of the definition for “open construction” in ICC/MBI Standard 1200. Manufacturers may find that the process outlined here could serve as an alternative approval approach or address regulatory gaps for a variety of panelized systems.

Why focus on panelization?

Panelized systems present an opportunity to infuse automation into the construction process, bringing the benefits of increased precision, enhanced productivity and reduced waste. Unfortunately, many of the benefits of automation and the accompanying digital tools are not being leveraged in the existing approvals process, stifling investment in such approaches. Automated processes allow for direct translation of requirements from approved plans into a computer-guided assembly process (limiting opportunities for errors). Automated processes also often come with enhanced monitoring of the process. The premise of this guideline is that automated processes with a robust quality-assurance program, extensive documentation (including video) of the production process and product traceability change the approach needed to verify compliance. This guideline outlines the necessary characteristics for such an approach to be effective.

Additionally, panelization offers the opportunity to create numerous configurations based on a core set of subpanels (e.g., wall subpanels, window subpanels, door subpanels and floor/ceiling cassettes). This guideline identifies the criteria under which subpanels could be





approved and how configurations of those panels could be approved as part of a modularized panel system. A similar approach is currently applied for structural insulated panels (SIPs) where the base panel is approved with some allowance for modification. See ICC-ES AC04.

Following this process allows for panels to be treated as evaluated products.

Outcomes of the Advanced Panelization Process

The process for advanced panelization outlined in this guideline is intended to provide multiple outcomes. It is intended to reduce confusion on how closed panels are treated from jurisdiction to jurisdiction, opening up opportunities for a greater degree of finish and potentially increased investment in automation based on that certainty. It also allows for panels to be considered building components under a product evaluation/listing-type process similar to other finished products (e.g., windows, doors and HVAC equipment). Such an approach is not unprecedented—similar approaches are used effectively in Europe and Japan.

Panels produced through this process have followed a rigorous quality-assurance process that can instill confidence in state and local authorities having jurisdiction (AHJs), designers, contractors and developers that the panels meet the code and other project requirements. The manufacturers of the panels have a third-party accreditation of their quality-assurance program and meet documentation and traceability requirements for each panel produced. The designs for each panel have been reviewed by an accredited third-party agency or have been approved by the state and/or AHJ where the project is being constructed to avoid any code compliance conflicts. The manufacturing process itself is monitored at regular intervals defined by the approval body, at least monthly and with

in-factory surveillance inspections on a recurring quarterly basis.

Under this approach, panels are delivered to the job site with the documentation and labels necessary to support local AHJ verification that this process has been followed. This can take the form of an evaluation report from an approved source. Local AHJs just need to verify the documents and labels and that the panel attributes meet the specific needs of the project.

Scope

This guideline will provide information on and approaches for the verification of compliance of panelized products based on level of quality assurance and documentation and the approval of panelized systems made up of preapproved subpanels, whether subpanels or super-panels. The guideline will draw on lessons learned from international approaches to panelization and approvals. The guideline aligns with ICC/MBI Standards 1200 and 1205 and existing building code requirements.

This guideline is intended to cover the following aspects of advanced panelization, including wall panels and floor/ceiling cassettes:

- Structural performance.
- Fire performance.
- Insulation and energy performance.
- Integration of windows and doors.
- Water-resistive, vapor and/or air barriers.
- Exterior and interior finishes.

The guideline could be used as the basis for approval of other panel contents (e.g., mechanical, electrical and plumbing systems), but such contents are not the primary focus.

Panels approved under the processes contained in this guideline are not necessarily assigned to a specific project and



can be used as components in any project where the panels meet the necessary code requirements for that project.

This guideline on advanced panelization addresses panelized processes at two scales: producing individual panels or producing panels as part of a modularized panel system. Both scales require a rigorous approval and quality-assurance process. The guideline includes recommendations for establishment of a general advanced panelization process and specific requirements based on the scale. It does not address the local permitting of projects that use an advanced panelization process.

This guideline acknowledges that the panels developed under this process can be delivered to the job site in their panelized form or may be components in the further assembly into volumetric modules in a factory. In the case of further assembly into volumetric modules, additional design approvals and inspections for the volumetric modules may be required. Attention should be paid to ensure that such a process does not counterbalance the benefits provided by the panelization process.

Definitions

Terms used in this guideline reflect the definitions used in ICC/MBI Standards 1200 and 1205. Additional definitions are provided below.

Accreditation Body: See the *International Building Code*[®].

Advanced Panelization: The process for design, fabrication and delivery of panels that feature a degree of finish such that all parts or processes cannot be inspected at the installation site without disassembly, damage to, or destruction thereof and that features an enhanced level of quality assurance and documentation as outlined in this guideline.

Approval Body: A government entity with the authority to approve the use of panels or panelized systems in their jurisdiction or a third-party entity accredited to ISO 17065 with the expertise, experience and equipment sufficient to evaluate the compliance of panels or panelized systems with building code and other performance requirements (for example, the ICC Evaluation Service).

Authority Having Jurisdiction (AHJ): See ICC/MBI Standards 1200 and 1205.

Automation: A process whereby digital information is transmitted to a machine that translates the digital information to an action.

Off-Site Construction: See ICC/MBI Standard 1200.

Open Construction: See ICC/MBI Standard 1200.

Panel: See ICC/MBI Standard 1200.

Panelized System: See ICC/MBI Standard 1200.

Modularized Panel System: An engineered system for the design, manufacture and assembly of buildings or parts of buildings made up of preapproved panels that, when assembled in compliance with manufacturer's instructions, meet the code requirements at the final job site.

Subpanel: A discrete panel unit with a specific configuration that is approved individually, or approved collectively as part of a super-panel, and can be, subject to specified criteria, connected to other approved subpanels to form a super-panel. Examples include, but are not limited to, window panels, door panels, solid wall panels, bracing wall panels and floor/ceiling cassettes.

Super-Panel: The final configuration of a panel made up of one or more approved subpanels, that do not require additional approval or inspection, in compliance with the requirements established by an



approval body. A super-panel could be assembled in the same or a different factory than where the subpanels were fabricated or at the final job site.

Systems Manual: Documentation of the processes, materials and methods of constructing a type of panel or system described by plans, specifications and other documentation that together establish a set of limits on the manufacturer and demonstrate meeting building codes, standards and other requirements that may include structural, energy, electrical, mechanical, plumbing and fire protection systems and other systems affecting health and safety.

Third-Party Inspection Agency: See ICC/MBI Standard 1205.

Third-Party Review Agency: See ICC/MBI Standard 1205.

Traceable: The ability of approval bodies, manufacturers and AHJs to locate and identify a panel following its manufacture for the purpose of quality assurance throughout its life.

Core Components of an Advanced Panelization Process: Advanced Assembly, Monitoring and Documentation

Panels and panel manufacturers that follow the criteria outlined in this guideline demonstrate a high-level of quality assurance and provide a robust mechanism for panel traceability, not unlike the process used for approval of building components through a product evaluation or product listing. By meeting these criteria, AHJ confidence in the compliance of the panels is enhanced, allowing for a streamlined level of inspection and oversight commensurate with that confidence. The process outlined below brings together elements of off-site construction regulatory programs (as cap-

ured in ICC/MBI Standards 1200 and 1205) and product evaluation to create an approach that will drive manufacturer efficiency while assuring safety.

This process brings together an assessment by the approval body of the manufacturer, its quality assurance processes and an evaluation of the panels produced (including evaluation of plans, conduct of in-factory inspections and regular monitoring of documentation) to provide a robust product-evaluation process. By following this process, an advanced panel should receive an evaluation report and/or jurisdiction seal that demonstrates compliance with relevant requirements. The local AHJ is then responsible for verifying that the documentation provided with the panel matches with the project requirements and that it is installed per the manufacturer instructions and other code requirements. Additional approvals for the panel should not be required on-site.

In some states where panels are included in the industrialized building programs explicitly, state-level oversight may still be required. To avoid redundant approval and inspection processes, the states should recognize the processes incorporated in this guideline and the recognition by a third-party approval body as meeting the state program requirements. Where state jurisdictional seals are required for such components, the state should consider applying such requirements on a larger scale than individual panels (for example, on a square-foot basis) to streamline the labeling process. The state seal/label fee structure for advanced panels should remain similar to current modular programs and prevent a cost prohibitive fee schedule for panelized construction.

Panel traceability starting with its manufacturing provides several benefits including:

- The ability to retroactively identify and then rectify any panels that may possess deficiencies identified