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2023 ICC G6 Guideline on Advanced Panelization

Preface

About this Guideline

This Guideline is intended to be used in conjunction with the product evaluation process to provide specific requirements for panelized systems that meet the criteria outlined in the sections below. The Guideline also leverages best practices captured in ICC/MBI Standards 1200 and 1205.

ICC Guideline 6 provides national, state/provincial and local jurisdictions with guidance on the approval of panelized systems that meet specific criteria that help efficiently verify their compliance with existing criteria including building codes, standards and acceptance criteria. The Guideline is intended to provide assurance to governments while encouraging innovation in the panelization process, leveraging technology, extensive digital monitoring and documentation, and third-party plan review and inspection processes.

The Guideline provides a specific approach to the approval of prefabricated systems under the International Building Code (specifically Sections 104.11 and 1703.6) and International Residential Code (Section R104.4) but can be used to satisfy building code requirements contained in other codes as well.

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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 U.S., 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. However, the processes included herein could also be applied to open panels.

Why focus on panelization?

Panelized systems present an opportunity to infuse automation into the construction process bringing the benefits of increased precision and enhanced productivity. 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 changes the approach needed to verify compliance. This guideline outlines the necessary characteristic for such an approach to be effective.

Additionally, panelization offers the opportunity to create numerous configurations based on a core set of sub-panels (e.g., wall sub-panels, window sub-panels, door sub-panels). The guideline identifies the criteria under which sub-panels 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 SIPs where the base panel is approved with some allowance for modification.

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 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, 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 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 AHJ where the project is being constructed. The manufacturing process itself is monitored at least monthly and in-factory inspections occur on a 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 Service Report. 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 pre-approved sub-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 code requirements.

The Guideline is intended to cover the following aspects of closed panels including wall panels and floor/ceiling cassettes: structural performance, fire performance, insulation and energy performance, integration of windows and doors, vapor or air barriers, and 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. This 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.

The Guideline contemplates 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 Standard 1200-2021. Additional definitions are provided below.

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).

Automation – A process whereby digital information is transmitted to a machine that translates the digital information to an action. In the case of panelization this could include translating pre-approved drawings for the configuration of framing and nailing to a robotic nailing machine.

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 pre-approved panels that when assembled in compliance with manufacturer instructions meet the code requirements at the final job site.

Sub-Panel – A discrete panel unit with a specific configuration that is approved individually and can be, subject to specified criteria, connected to other approved sub-panels to form a super-panel. Examples include, but are not limited to, window panels, door panels, solid wall panels, bracing wall panels.

Super-Panel – The final configuration of a panel made up of one or more approved sub-panels, which themselves 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 sub panels were fabricated or at the final job site.

Traceable – The ability of approval bodies, manufacturers and AHJs to determine the location of a panel at any stage of a panel's life-cycle.

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

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 captured 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.

Panel traceability from its manufacture through its placement on-site provides several benefits including:

- The ability to retroactively identify and then rectify any panels that may possess deficiencies identified at any point in the verification process (including post installation);
- Assurance that panels being used in a specific project meet the applicable requirements for that project (including but not limited to code-based requirements).
- Establishment of a feedback loop from panel manufacture to assembly and in-building performance allowing for continual improvement by the manufacturer.

Manufacturer Approval

The process for approval of advanced panels is predicated on both the procedures for review of the panels themselves and on the competence of the manufacturer. To that end, verification and ongoing monitoring of the manufacturer's competence is required. In addition to the requirements in Section 601.2 of ICC/MBI Standard 1205, the manufacturer should meet one of the following requirements or approved equivalent for each facility approved to produce advanced panels:

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- Maintain a Quality Assurance Process, as verified by the approval body, that meets the requirements in Chapter 5 of ICC/MBI Standards 1200 and 1205 or a continuous compliance program acceptable to the Approval Body
 - Be accredited as a fabricator for the relevant system type by an ISO/IEC 17011-compliant accreditation body like the International Accreditation Service
 - Be certified to the latest edition of ISO 9001 or ISO 9002 by an approved certification body
- The manufacturer should also maintain a documentation system as outlined below.

Panel Design Approval/Approval Criteria

As part of its initial submission for approval as an advanced panel manufacturer a systems manual should be prepared providing the common characteristics of the panels to be manufactured to include:

- The system type or other important characteristics for the panels the manufacturer is seeking approval (e.g., materials used (wood, light-gauge steel, other), connection types (nails, plates, other), tolerances) and any limitations on the systems produced (e.g., only residential occupancies, only climate zones 1-6, only for design wind speeds below 150mph)
- Table of materials to be used including product listings and evaluation reports and any alternative products that may be substituted
- Code and other core requirements the panels are designed and built to achieve
- The systems manual may contain a set of core designs representing the major variations in panel design anticipated. These core designs should be stamped and sealed by a registered design professional and include all relevant calculations for demonstrating compliance with code requirements. These core designs may include provisions for a range of configurations based on the inclusion of necessary calculations (e.g., panel size ranges from 8 to 20 feet, window openings up to 36 inches by 60 inches, etc.).
- The Approval Body may require a research report in accordance with IBC 104.11.1 if alternative materials and methods of construction are to be employed

Before production, the systems manual should be approved by the approval body. Once the manual is approved, any core designs in the systems manual are considered approved designs. Each panel produced under a core design should be recorded as such in the documentation system and on relevant labels. The systems manual should be reviewed by the manufacturer and the approval body in compliance with requirements in the quality assurance plan, but at least annually. Any changes in the core designs or systems manual criteria require approval by the approval body.

Where panels will be used in a specific project that has plans already approved by the project's AHJ, the designs of walls approved in those plans should be deemed as approved panel designs as long as they are within the system type parameters contained in the approved systems manual. The project plans should be included in the documentation system and the following note should be included with the provided documentation: "The plans associated with this panel have been approved by the AHJ and have not been verified by the approval body. It has been fabricated under an approved advanced panelization program." The remaining requirements in this Guideline should be followed.

Any variations from the pre-approved core designs or project-specific designs require additional approval from the approval body. Design documents should be prepared for each variation to demonstrate that the variation does not impact compliance with code requirements. The design must

be signed and sealed by a registered design professional before fabrication begins. Before a completed panel leaves the manufacturing facility the design must be approved by the approval body.

Panels should comply with all relevant code requirements based on their level of finish and use. Where additional actions are required on-site to meet code requirements such requirements should be documented and delivered as manufacturer instructions (and be inspected and approved by the local AHJ when assembled on-site).

Fabrication

All materials used in the fabrication of panels should: (1) meet requirements contained in the relevant codes including being listed as required; (2) possess an evaluation report from an accredited evaluation agency such as ICC-ES; or (3) be approved by the AHJ. Each panel fabricated should be in accordance with approved plans and the documentation requirements outlined below.

Documentation

For each approved panel fabricated under this process the following documentation is required. This documentation must be accessible by the manufacturer's QA personnel, the approval agency, and the AHJ upon request. The documentation must be searchable by panel serial number, date of manufacture, fabrication station(s), fabrication personnel, and QA personnel.

- High resolution photos and/or video recordings of panels at locations and stages of production as outlined in the approved QA/QC manual
- Panel manufacture details including serial number, date of manufacture, fabrication line (if applicable), personnel responsible for fabrication and QA, any automated machinery used, any testing or inspection reports as required by the QA/QC manual
- Chain of custody from manufacturer to other parties through to final assembly at the job site (note: This will require collection and entry of documentation following the panel leaving the manufacturing facility. This is important to meet the traceability and feedback requirements outlined below. While this requirement may not impact the approval of individual panels, it should be a factor in certification of the manufacturer and facility.)
- Report from approval body indicating that the panel is produced in compliance with the identified requirements
- QA/QC manual in place at the time of production
- Drawings of the panel signed and sealed by a registered design professional with sufficient detail and documentation to demonstrate compliance with the evaluation criteria. This includes specific materials to be used, their specifications and any evaluation reports; dimensions, lumber, headers, bucks, placement, nailing pattern, and sheathing; etc. (note: Sections 302 and 303 of ICC/MBI Standard 1205 provides requirements for plan approval and should be followed to the extent practical).

The code requirements and other performance attributes met by the approved panels shall be documented by the approval body and the manufacturer shall provide such documentation with the panel either physically or through electronic means (e.g., QR code or RFID tag that are affixed to the panel) consistent with the labeling requirements below. For example, where a panel may be used in multiple occupancy types those occupancies should be listed on the drawing cover sheet to meet requirements in ICC/MBI Standard 1205 Section 302.4. Sections 302.9, 303.2, 303.3, 303.5 would not be

applicable. Requirements in Section 303.1 that would apply to a whole building should either be modified or removed to reflect the approved performance of the panel.

Labeling and Reporting

Each approved panel should have the following information permanently affixed, printed, or etched into the panel in a location that is easily accessed and read by personnel (assemblers and inspectors) at the job site:

- Panel manufacturer
- Panel serial number
- Conformity assessment mark of the approval agency and applicable report number
- Other information as required by the AHJ or approval body

Additional information on the panel must be provided but may be provided in such a manner that it is available until installation has been inspected and approved by the AHJ at the job site. This could include having documentation affixed to the panel in a manner in which it is unlikely to be removed, damaged or destroyed until authorized or via electronic means easily accessed by on-site personnel (for example a QR Code). This additional data includes:

- The panel's conformity report which includes data on the performance attributes of the panel as described and approved by the approval body including information required by Section 701.4 Manufacturer's data plate of ICC/MBI Standard 1205.
- Manufacturer instructions for proper installation and any additional requirements necessary to achieve code compliance
- Where the panel has been designed and fabricated for a specific project, the address of the project and the specific panel location

The manufacturer should maintain records with all of the above labeling requirements, reports of inspection, tests and any corrective actions for not less than 10 years from the date of manufacture consistent with ICC/MBI Standard 1205 Section 701.5 Record retention. As a panel meeting the requirements of this Guideline, the manufacturer should also maintain all the information identified in the documentation section above plus the quality assurance manual in use at the time of manufacture and any documentation required by the QA/QC plan for not less than 10 years.

Approval Body Qualifications

The third-party responsible for in-plant inspections, review of documentation between in-factory inspections, evaluating quality control procedures, approval of engineering and systems manuals and plans should meet the requirements contained in ICC/MBI Standard 1205 Chapter 4-Third Party Review and Inspection Agencies.

Inspections

In order to ensure that the manufacturer and quality assurance system is capable of delivering advanced panels that meet the requirements of this process and the requisite performance requirements, the approval body should perform an initial in-factory inspection (in each facility) of at least 10 panels or 120 linear feet, whichever is greater, in a phase of construction to verify that construction is in compliance with the approved construction documents and the approved quality assurance documents and that additional documentation measures identified above are functioning properly.

Once the initial inspections are completed to the satisfaction of the approval body, in-factory inspections may be conducted at a minimum of once a quarter. In addition to inspection of the fabrication process, quality assurance process and documentation measures, the approval body may select a limited number of previously completed panels from the manufacturer's inventory to verify compliance with the design documentation and labeling requirements.

In the intervening periods between inspections, the approval body should have remote access to the documentation outlined above, allowing for periodic monitoring without in-factory inspection. This review of documentation should occur at least monthly.

Section 505 of ICC/MBI Standard 1200 should also be required.

[Approval of Modularized Panel Systems using Pre-Approved Sub-Panels](#)

This approach is informed by [ICC Guideline 1](#) and [2021 International Building Code Appendix N](#) on Replicable Buildings and ICC-ES AC543 on Structural Performance of Modular Buildings.

The design of a modularized panel system may be owned by one entity (e.g., designer, developer, contractor) with manufacturing conducted by a different entity or multiple approved entities. The relevant criteria outlined below should apply to each entity based on their role in the process.

Unless an alternative section is provided below, the general requirements for advanced panelization apply to providers of modularized panel systems.

[Panel Design Approval/Approval Criteria](#)

In addition to the criteria outlined above, the systems manual should contain core designs for the sub-panels to be used within the modularized panel system (including any provisions for a range of configurations based on the inclusion of necessary calculations) and the requirements for interconnection of sub-panels into super-panels (including calculations to demonstrate compliance with required code or other performance requirements).

A manufacturer may fabricate a super-panel as a single component without the prior fabrication of its constituent sub-panels if the sub-panel elements are fabricated as approved and the connections between sub-panel elements meet the connections required in the approved system.

Subject to approval by the approval body and if captured in the systems manual, sub-panels could be assembled in a configuration other than on the same plane as the adjacent panel (e.g., adjoining perpendicular walls, floors, ceilings).

[Labeling and Reporting](#)

Since sub-panels and super-panels may be fabricated and assembled under several scenarios, the requirements for labeling and reporting under such scenarios are described separately below.

[Individual Sub-Panels Shipped](#)

If individual sub-panels are shipped from the factory, each sub-panel should have the following information permanently affixed, printed, or etched into the sub-panel in a location that is easily accessed and read by personnel (assemblers and inspectors) prior to assembly into a super-panel:

- Panel manufacturer
- Panel serial number

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- Conformity assessment mark of the approval agency and applicable report number
- Identification of the modularized panel system the panel belongs to
- Other information as required by the AHJ or approval body

Additional information on the sub-panel must be provided, but may be provided in such a manner that it is available until assembled into a super-panel and that super-panel has been installed, inspected and approved by the AHJ at the job site. This could include having documentation affixed to the panel in a manner in which it is unlikely to be removed, damaged or destroyed until authorized or via electronic means easily accessed by on-site personnel (for example a QR Code). This additional data includes:

- The approval body's conformity report including information on the performance attributes of the panel as described and approved by the approval body
- Manufacturer instructions for proper installation and any additional requirements necessary to achieve code compliance

Sub-Panels Assembled into Super-Panels or Super-Panels Fabricated Directly

Where sub-panels are assembled or where a super-panel is fabricated without the prior fabrication of sub-panels, the following information should be permanently affixed, printed, or etched into the super-panel in a location that is easily accessed and read by personnel (assemblers and inspectors) prior to installation of the super-panel at a job site:

- Panel manufacturer and super-panel assembler (if different)
- Panel serial number
- Conformity assessment mark of the approval agency and applicable report number
- Identification of the modularized panel system the super-panel is assembled under
- Identification of the sub-panels that make up the super-panel
- Other information as required by the AHJ or approval body

Additional information on the super-panel must be provided but may be provided in such a manner that it is available until that super-panel has been installed, inspected and approved by the AHJ at the job site. This could include having documentation affixed to the panel in a manner in which it is unlikely to be removed, damaged or destroyed until authorized or via electronic means easily accessed by on-site personnel (for example a QR Code). This additional data includes:

- The approval body's conformity report including information on the performance attributes of the panel as described and approved by the approval body
- Manufacturer instructions for proper installation and any additional requirements necessary to achieve code compliance

Where sub-panels are assembled into a super-panel in the same facility as the sub-panels are fabricated, individual sub-panel labeling is not required (however, sufficient processes must be in place to assure proper sub-panel use—e.g., travelers).

Sub-Panels Assembled into Super-Panels at the Final Job Site

Where sub-panels are assembled at the final job site in an accepted super-panel configuration additional labeling on the panels is not required. Responsibility for verifying proper configuration falls to the local

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AHJ. The AHJ should be provided with manufacturer’s instructions on proper configuration and connections consistent with the approved systems manual.

[Referenced Codes, Standards and Acceptance Criteria](#)

ICC International Building Code

ICC International Residential Code

ICC/MBI Standard 1200-2021 - Off-Site Construction: Planning, Design, Fabrication, and Assembly

ICC/MBI Standard 1205-2021 - Off-Site Construction: Inspection and Regulatory Compliance

ISO/IEC 17011 Conformity assessment—General requirements for accreditation bodies accrediting conformity assessment bodies

ISO/IEC 17020 Conformity assessment—Requirements for the operation of various types of bodies performing inspection

ISO/IEC 17065 Conformity assessment—Requirements for bodies certifying products, processes and services

ICC-ES AC04 Sandwich Panels

ICC-ES AC543 Structural Performance of Modular Buildings

ICC G1 Replicable Buildings

[Appendix A: Advanced Panelization Process Diagram](#)

