Building code compliance for off-site construction

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Abstract: There are increasing concerns over building code/regulation compliance and quality assurance issues in adopting off-site construction in the construction industry to meet client expectations and regulatory requirements. Performance-based building regulations often allow for space for innovation, but not a 'safe space' for those who intend to introduce new construction techniques not prescribed in building regulations. Through a series of surveys conducted in Sweden, Switzerland, the United Kingdom, China, Singapore and Australia, this paper identifies approaches and practices used in these countries that overcome compliance challenges when adopting off-site construction. The findings show that the manufacturer's self-certification approach appears predominant for meeting code of compliance requirements, and a fit-for-purpose regulatory compliance system also warrants fair allocation of risks and liabilities to anyone involved in the supply chain. However, a healthy and functional regulatory system for off-site compliance requires a third-party certification for products/factories and traceability. It is hoped that the lessons learned can help policymakers introduce changes to product standards and other legislation to improve the compliance and performance of off site construction. This research calls for a chain of custody approach to address quality concerns surrounding adopting prefabrication technology in countries that are increasingly exploring greater use of manufacturing in construction.

Keywords: Building code, compliance, off-site construction, off-site manufacturing, prefabrication, international practice

1. Introduction

Off-site construction, commonly known as prefabrication or off-site manufacturing in construction, is considered a modern construction method (Martinez et al., 2008, Hoonakker et al., 2010, Bock and Linner, 2015). However, this method is not a new concept and has been widely used since the Second World War when there was a need for speedy reconstruction and social housing (Jaillon and Poon, 2009, Grimscheid, 2010). Since Henry Ford standardized the production line for car manufacturing, attempts have been made to transfer the knowledge from automobile mass production to low-cost housing production (Gann, 1996, Warszawski, 2003). Over the past several decades, off-site construction has, in various degrees, relied on manufacturing principles to use modularized building parts, products, components and systems in one building (Fruin, 1994, Fujimoto, 1999, Gibb, 1999, Balaguer et al., 2002, Winch, 2003). In recent years, more advanced off-site construction has aimed to achieve an endto-end design and building process utilizing manufacturing industry automation and data exchange technologies and processes, such as cloud computing and artificial intelligence, cyber-physical systems, and the internet of things (Johnson, 2007, Khoshnevis et al., 2006, Bock and Linner, 2012, Willmann et al., 2016).

Worldwide market for prefabricated buildings is anticipated to rise considerably between 2020 and 2025 (McKinsey & Company, 2017, Smith and Quale, 2017). It is estimated that the prefabricated residential building system market value could reach $USD 130 billion in Europe and the United States by 2030 (McKinsey & Company, 2019). A recent report on modern construction methods in the United Kingdom (UK) revealed that 40% of the UK's residential builders were investing in manufacturing facilities (NHBC Foundation & Cast, 2018). In addition, the Singapore Government aims to build between 20,000 and 30,000 apartment units using off-site manufacturing annually from 2020 onward (HDB, 2020).

Prefabrication has long been perceived to provide more efficiency compared to traditional on-site construction practices (Blismas et al., 2006, Goodier and Gibb, 2007, Tam et al., 2007, Kamali and Hewage, 2016). Prefabrication has advantages in key productivity metrics, including project schedules, costs, safety, quality, waste and sustainability (Modular Building Institute, 2016, Quale and Smith, 2019, Razkenari et al., 2020). A McGraw Hill Construction survey revealed that 35% of construction firms that used prefabrication reported a reduction in the schedule by four weeks or more, 41% of companies reported a reduction in cost by 6%, and another 44% of companies suggested that construction site waste could be reduced by 5% (McGraw Hill Construction, 2011). Other studies show that using prefabrication can also bring social value to society on a large scale to help meet global housing demand (Barbosa and Woetzel, 2017, McKinsey & Company, 2019).

Despite prefabrication technology's benefits, its broader adoption in the housing sector has faced many challenges, such as perceived low quality, social inertia and lack of regulatory support (Grimscheid, 2010, Hoonakker et al., 2010). In particular, many countries face the challenge of inspecting the quality of prefabricated buildings and ensuring they meet local building codes and standards requirements (Smith, 2010). Unless building officials and certifying agencies scrutinize each modular component, using those components in one assembled building would be considered a significant liability risk to local authorities (Hoonakker et al., 2010, Lee and Kim, 2017, Quale and Smith, 2019). Smith (2010) and Gan et al. (2018) suggested that it is difficult to advocate using prefabrication in construction without an enabling regulatory environment that supports integrated quality assurance and building compliance codes.

Several studies have investigated quality assurance and compliance for off-site construction (Arashpour et al., 2015, Lee and Kim, 2017). However, understanding what constitutes an efficient legal framework that supports the adoption of modernized construction methods, including prefabricated building technology in the housing sector, has proved difficult (Wong et al., 2017, Fenner et al., 2018, Salama et al., 2018, Jiang et al., 2018). Given that the concern over the quality of prefabrication appears to be the major hindrance in its broader application (Barbosa and Woetzel, 2017, McKinsey & Company, 2019), this paper aims to investigate compliance and quality assurance practice in six case studies from Sweden, Switzerland, the UK, China, Singapore and Australia, where manufactured buildings play a significant role in their housing sectors.

This research contributes to the body of knowledge of off-site manufacturing by providing insights into the quality compliance and assurance processes associated with prefabrication. The practice and lessons learned from the six countries will help prefabrication stakeholders, particularly policymakers, understand what is considered effective compliance and quality assurance practice for off-site construction and the associated regulatory implications to facilitate the uptake of prefabrication technology in construction.

2. Literature review: Building code of compliance practice for prefabrication

A thorough review of the literature and government reports summarizes the building code of compliance practice for prefabrication into the following six categories: 1) factory self-certification, 2) independent third-party certification, 3) product identification and traceability, 4) industry-led quality assurance systems, 5) product authentication and 6) insurance schemes.

2.1 Factory self-certification

Factory self-certification is a program utilized by building manufacturers to prove that a product or a process conforms to specific performance requirements and that its use in a building can meet building codes and standards (Dirkesn et al., 1997). This scheme involves defining a quality assurance procedure for certification to meet the relevant building regulations (CMHI, 2015) and auditing the manufacturing facility based on a set of tests (Hoyle, 2005). Quality is inspected rigorously after each production step through quality checklists to detect mistakes early and save time and cost (JPA, 2020). A certificate of compliance is issued if the manufacturing facility meets every standard element in a predefined process (Dreyfus et al., 2004, Hoyle, 2005). During the manufacturing process, the quality of building products/systems will be determined by a first-party audit, called an internal audit (Kim and Hwang, 2014), to monitor the execution process through different production line stations and ensure they meet production standards (MLIT, 2020). This holistic practice of self-assessment (Ford et al., 2004) helps manufacturers set internal benchmarks and identify quality improvement areas (Ritchie and Dale, 2000). Self-assessment practices also enable manufacturers to evaluate ongoing prefabrication processes and monitor performance changes (Kim and Hwang, 2014) while establishing a learning environment for employees in quality control of the products manufactured in a plant (Jørgensen et al., 2003).

2.2 Independent third-party certification

Although self-certification does not generally require a third-party test (Dirkesn et al., 1997), it does not preclude a manufacturer from utilizing a certified third-party inspection body to ensure that the panelized or volumetric products or systems meet the quality requirements (CMHI, 2015). This external independent entity often acts as a certification body (Russell, 2012) that audits and issues certificates stating that a product or process complies with a specific set of standards (Corsin et al., 2007, MHAPP, 2016, MLIT, 2020). In some countries, this third-party certification body is a governmental agency, whereas it is an independent private organization in others. Inspections are generally conducted following a set of schedules, and if the process or product complies with the standards, a certificate is issued according to the regulations set by the certification scheme (MHAPP, 2016). As a result, manufacturers who complete the certification program are provided with a performance labeling system (Dirkesn et al., 1997, MLIT, 2020), indicating that the products from these prefabrication manufacturers meet the requirements for housing performance evaluation (QAI Laboratories, 2018).

2.3 Product identification and traceability

Product identification and tracking technologies are often used to ensure quality assurance for manufactured building products and systems (Yin et al., 2009). Product identification can comprise codes, numbers, labels, names and other records that distinguish a product from others (Jaselskis and El-Misalami, 2003). For example, Ergen et al. (2007) suggested tracking and locating components in a precast storage yard at the design stage so the product identity can be allocated to the building design and later, its location can be tracked using radio frequency identification technology (RFID) and global positioning system (GPS). The advent of product identification and its advanced sensing technologies have provided greater flexibility for quality control, enabling recording and eliminating product defects (Yin et al., 2009, Torrent and Caldas, 2009, Razavi and Haas, 2011). In addition to RFID and GPS, various other automated identification technologies have been used, such as barcodes (Rasdorf and Herbert, 1990, Finch et al., 1996), two-dimensional barcodes (McCullouch and Lueprasert, 1994), optical character recognition (Jaselskis and El-Misalami, 2003) and touch probes (Ergen et al., 2007). In particular, through RFID technology, prefabrication components and operation quality can be improved with instant tracking and monitoring of information relevant to quality control inspections (Song et al., 2006) through a grid of transponders (Ergen, 2002) and RFID tags (Wang, 2008).

2.4 Industry-led quality assurance systems

The industry-led quality assurance system is an award certification that the prefabrication industry body organization leads to ensure that a product meets a defined set of criteria (Dirkesn et al., 1997). The industry-led quality assurance system has been considered essential in achieving the operational performance of prefabricated buildings (Gotzamani and Tsiotras, 2002, Boiral, 2003, HerasSaizarbitoria et al., 2011). Such certification ensures that a manufacturing facility has quality control, inspection systems and skilled people (MHAPP, 2016). For many large prefabrication companies, an industry-led quality assurance system offers a quality guarantee for their consumers (Johnson, 2007). In Singapore, for instance, the industry-led quality assurance system is combined with a manufacturer accreditation scheme where a production facility certified by the prefabrication industry must be accredited by the Singapore Government (BCA, 2020b). The two-fold quality assurance scheme requires both the prefabrication manufacturer industry and the government to take responsibility for producing high-quality prefabricated systems (BCA, 2020a).

2.5 Product authentication

Product authentication is a consumer protection regulation to drive improvements in quality performance and facilitate prefabrication for a broad range of products. An example of this can be found in Singapore, where government policymakers can enforce a buildability score regulation to facilitate the authentication process for prefabricated products (Park et al., 2011). The regulation requires building designs to have a minimum buildability score based on various indicators such as wall design, structural systems and other buildable design features (BCA, 2011). With the enforcement of this regulation, buildability score has become one of the main criteria for authentication for prefabricated buildings (Park et al., 2011). In addition, prefabrication companies can also be required to implement other maintenance and service strategies under housing defect warranty legislation (Bock and Linner, 2012, Smith and Quale, 2017).

2.6 Insurance schemes

In a country of high insurance penetration, manufacturers or suppliers can fulfil their responsibilities for defect warranties by depositing security funds or taking out insurance (Smith and Quale, 2017, JPA, 2020). To prove a prefabricated house's performance, quality, and durability, insurance for quality and defects is often in place at the handover of the house (Bock and Linner, 2012).

3. Research methodology

A case study method was utilized for this research due to its theory-building nature (Eisenhart, 1989). Yin (2003) suggested that a case study method provides an empirical investigation of a contemporary phenomenon within its context. A case study approach allowed for the understanding of multiple perspectives from relevant professionals in different countries. Six countries, namely Sweden, Switzerland, UK, China, Singapore and Australia were selected as case studies since they all hold a considerable share of the prefabrication market in their housing sectors (McKinsey & Company, 2019). The practices these countries use and the lessons learned could greatly assist other countries in introducing legislative changes needed to facilitate the broader adoption of prefabrication in construction.

A questionnaire survey was used for data collection in each case study. Targeted survey participants included manufacturers that manufacture prefabricated building products, off-site construction builders or contractors, or building inspectors from the local authorities. The survey was developed to understand building code of compliance practice for prefabricated buildings and participants' perspectives about what mechanisms should be implemented to reduce regulatory burdens for building houses using prefabrication technology.

The sampling strategy utilized research collaborators' existing networks. Survey data was collected for six months from February to August 2019. To ensure data consistency and quality, the questionnaire survey used for all six countries comprised a common structure of questions (see Table 1).

Researchers from the six countries distributed an online survey link or a digital copy of the survey to appropriate participants in their networks. The survey was sent to 374 stakeholders, and by the end of August 2019, 122 stakeholders had completed the survey, with a response rate of approximately 33% (see Table 2).

The survey data was analyzed using descriptive statistics, followed by a comparative cross-country analysis. By comparatively analyzing the results, the primary code of compliance measures and good practices across a range of countries were identified.

4. Results

4.1 Information about the survey respondents

Figure 1 presents demographic information about the survey respondents. Out of 122 respondents, 26% were builders who were prefabricated house installers, and another 25% were builders providing "one-stop shop" services to manufacture and install prefabricated components or systems. 21% of respondents were building product manufacturers or fabricators. Participants from local authorities accounted for 10%, followed by 8% who were suppliers of building products, and 4% identified themselves as product importers. The remaining respondents who represented the lowest percentages were housing developers (2%), architectural designers (1%), property managers (1%), and construction project facilitators (1%).

As shown in Figure 2, 39% of respondents reported that their company had less than six years of operating time in the market. 28% of respondents indicated that their organization had operated for over 20 years; 24% came from organizations that had operated between 6 and 10 years; and 8% worked for organizations that had operated between 10 and 20 years.

Figure 3 shows the types of prefabricated products and buildings manufactured by the respondents' companies. Approximately 35% of the participants' organizations produced volumetric systems (3D), and another 28% manufactured panelized systems (2D). 35% of organizations manufactured simple building elements, and 2% of manufacturers provided services to make house and trussing systems (see Figure 3).

4.2 Building code of compliance practice for off-site construction

Table 3 presents a synthesized summary of survey results from questionnaires distributed in the six countries, including the mechanisms for code of compliance, comments on the effectiveness of such a mechanism and the best practice perceived by respondents.

In Sweden, with fewer regulatory interventions, there seemed to be a culture that promotes quality stewardship in its prefabrication industry. 38% of respondents indicated that the companies themselves took control of their product compliance processes, followed by third-party product certifiers. In order to minimize waste and maximize production line efficiency, some large off-site building manufacturers surveyed in Sweden had adopted Toyota's production method. These companies gained competitive advantages through assembly line robotics streamlining their production methods. Meanwhile, it appears that regulators and lawmakers had paid attention to mainly non-compliant products by prescribing consumer purchase laws and the relevant certification processes for those products.

Although the response rate from Switzerland was considerably low, it should be noted that all seven respondents represented an organization that had been active for over 20 years in the prefabrication industry. The respondents suggested that the self-certification measure, combined with independent third-party certification and a product traceability system, formed their current regulatory compliance approach. They believed that the responsibility for quality assurance and compliance with building codes should fall on individual companies.

Similarly, in the UK, an independent third-party certification futureproofed the quality of off-site building products and systems, whether for panelized or volumetric components. Such certification included three main types as shown in Table 3. However, most respondents did not consider these product certification regulations as the only solution to ensuring compliance for off-site construction. Survey results revealed that the current compliance approach in the UK is a chain of custody, where manufacturers assure the quality of building products through the quality control process during manufacturing and third-party certification of the factory (e.g., British Board of Agreement certification and Build offsite Property Assurance Scheme). Such compliance practice could not be achieved without the support and involvement of different bodies and parties, such as off-site construction industry organizations, building sector associations, lending institutions, and insurance companies.

Manufacturers and builders in China used a broad range of quality assurance methods to ensure the code of compliance for off-site construction (see Table 3). The survey responses from China show a similar situation to Sweden, where product compliance is the responsibility of individual companies

(35%), with third-party product certifiers playing a minor role. Meanwhile, legislation such as the Building Act and Consumer Guarantee Act ensures that legal obligations are being fulfilled by builders when procuring products.

Survey participants from Singapore also indicated that manufacturers and builders of modular homes tend to have multiple quality assurance approaches (see Table 3). The survey results showed that individual companies such as manufacturers and builders (44%), third-party certifiers (22%) and local authorities (17%) played a significant role in guarding the quality assurance of manufactured products. However, central government building regulators (6%), insurers (6%) and industry bodies (6%) were considered to play minor roles.

The survey findings provide valuable insights into the practice in New South Wales, Australia. However, the number of respondents (four survey participants) was too small to generate any statistically meaningful results. Individual prefabricators and manufacturers assumed a primary role in guaranteeing building product quality, as the industry certification schemes are voluntary in Australia. Meanwhile, the Australian Government made improvements to its current building regulatory frameworks (i.e., the National Construction Code, other laws and Australian standards) to ensure that products and systems made off-site conform to Australian standards by mandating independent verification systems and setting restrictions for non-conforming products.

4.3 Cross-country comparisons and common themes

Cross-country comparisons of code of compliance methods used for prefabricated building products and components are shown in Figure 4. The majority of respondents reported a code of compliance system that combined a product chain of custody from manufacturers to builders and a traceability system.

Figure 5 reports the comparative cross-country analysis of the importance of each code of compliance practice perceived by respondents. More than half of the respondents thought it was essential to allocate risks and liabilities evenly across the supply chain by taking a proportionate riskbased approach to dealing with quality compliance issues. In addition, 46% of respondents considered penalties, policing and enforcement of existing regulations equally important to ensure compliance. A third-party product certification (37%), factory certification (36%), and traceability system (33%) were also considered highly important. The surveillance and screening of imported building products (44%), traceability systems (43%), and factory certification (42%) were measures that were needed for the future. Meanwhile, 43% of survey respondents recommended standardization of interpretation of code compliance within local authorities; 39% suggested having a task force in the local authorities to manage building consents for off-site construction; and 38% thought it was important for workers in factories and on site to be certified.

The findings also revealed that self-certification was the primary quality assurance method used in Switzerland, Sweden, Australia and China. In comparison, the UK and Singapore primarily utilized independent third-party certification. Therefore, to maintain the integrity of a compliance system, introducing a certification scheme from a third party into the chain of custody would be a significant benefit.

5. Discussion

This research highlights the quality issues related to the building code of compliance for off-site construction in the housing sector. The findings from the six countries illustrate that compliance concerns are tied to risk management practices across the supply chain. This is not surprising given that there is varying risk allocation among manufacturers, construction companies that adopt prefabrication technology, and local authorities that inspect quality and compliance for manufactured buildings (Yin et al., 2009). However, one of the essential enabling conditions for a compliance regime is establishing a chain of custody in the supply chain, where each party takes due responsibility (Australian Government Senate Economics References Committee, 2016). The cross-country comparison highlighted the importance of the manufacturer's self-certification regime, combined with a third-party certification scheme, which can be for products, factories and processes to meet the quality requirements stipulated in building regulations. According to MLIT (2020) and Razavi and Haas (2011), third-party certification, if combined with a traceability or accreditation system, can provide a competitive advantage for off-site manufacturers.

However, the role of lending agencies or insurance companies in the compliance process was unclear from the survey responses. Smith et al. (2017) suggested that a sound lending scheme will boost the confidence of prefabrication manufacturers and builders in expanding their share in the off-site construction market. The insurance-guaranteed prefabricated houses in the UK, for instance, can help create certainty of quality assurance for potential homebuyers (Construction Excellence, 2018). While manufacturers and prefabrication builders can play a role in facilitating the adoption of prefabrication technology, local authorities need to address those complexities within the prefabrication quality inspection process and remove regulatory ambiguity for developers and builders who look to off-site construction solutions.

With increased global interest in modern construction methods, governments should look at how to work with local authorities and the prefabrication industry to develop a set of guidelines for the industry to demonstrate the quality and performance of buildings when using off-site construction methods (Gharbia et al., 2020). Furthermore, case studies show that to smooth compliance processes for prefabricated buildings, there is a need for a national or regional register of compliant building products and systems which are certified by internationally accredited third parties. The register serves as a product database which often assists product suppliers and importers in understanding building code requirements as well as helping architects and designers choose compliant products (Allison and Hartley, 2020).

However, central government agencies are ideally placed to introduce varied building standards for the off-site construction market. These can range from the minimum standard quality mark to the highest standard, considering energy efficiency and sustainability standards. As suggested by JPA (2020), mandatory factory certification plus an independent auditing process could provide a promising solution to overcoming the shortcomings of an inspection approach which relies on local authorities or any third parties.

6. Conclusions

Off-site construction or prefabrication provides a way forward for meeting the quality and affordable housing demand in many countries. However, to leverage its productivity key, a conducive regulatory environment to support the code of compliance is essential (Fenner et al., 2018, Salama et al., 2018, McKinsey & Company, 2019). Using a cross-comparison case study approach, this research collected data regarding compliance and assurance practices from Sweden, Switzerland, UK, Australia, Singapore and China, where off-site construction plays a main role in their country.

A questionnaire survey distributed amongst the six countries (case studies) revealed that the manufacturer's self-certification approach seems to be predominant for meeting code of compliance requirements, and a fit-for-purpose regulatory compliance system also warrants fair allocation of risks and liabilities to anyone involved in the supply chain. Evidence shows that a healthy and functional regulatory system for off-site compliance requires third-party certification for products, factories and a traceability system.

The lessons learned could inform the development of standards, regulatory guidelines and other laws to address building codes of compliance regarding off-site construction. Hopefully, the building quality compliance lessons identified by this research will inform government agencies' decision-making in countries that recognize the value of using prefabrication technology in housing construction. It may also give the prefabrication construction industry directions for thinking about how they could work within the local context to reduce regulatory burdens and associated red tape in quality inspections. In addition to mandating quality assurance schemes, whether led by government, industry or third parties as shown in this research, it is equally essential to develop the capability of these schemes by using new digital technologies to identify and trace products across the entire supply chain. Overall, quality assurance is the key to addressing compliance codes for prefabricated buildings.

Data availability statement

All data supporting this study's findings are available from the corresponding author upon reasonable request.

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Table 1. Structure of the questionnaire survey

Questionnaire structure	Data/ information collected
SECTION A	Type of organization
Participant information	Type of building products
	Duration of trading
SECTION B	Comment on the code of compliance system
Code of compliance and quality assurance	Code of compliance practice used
	Effectiveness of code of compliance methods/practice used
	What worked well and what did not
	Who guarded the product quality
	Mechanisms needed for a successful prefabrication code of compliance system
	Legal remedies for non-compliant products
SECTION C	Classification of manufactured buildings
Manufacturing in	Mechanisms for prefabricated buildings being mainstream accepted construction
	Barriers to market acceptance
	Benefits of prefabrication/manufacturing in construction
SECTION D	Consent process
Regulatory environment for offsite construction	Duration of the consent process
	Comments on how to improve the consent process
	Channels of quality assurance and compliance education

Other levers to support code of compliance of offsite construction

Table 2. Questionnaire survey response rate

Country	Number of people the survey was distributed to	Number of responses	Response rate
Sweden	114	29	25%
Switzerland	50	7	14%
UK	40	10	25%
Singapore	30	13	43%
Australia	40	4	10%
China	100	59	59%

Table 3

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Table 3. Summary of survey results about primary mechanism(s) for code of compliance and best practice

Country	Primary mechanism(s) for code of compliance	Perceived effectivess	Perceived best practice
Sweden	Self-certification (43%)	Extremely effective 7% Effective 57% Neutral 37%	• Self-monitoring • A third-party and ISO auditing the overall production processes • Raising compliance awareness can be undertaken by presenting cost and benefit for quality assurance and quality deviation at the factory level
Switzerland	Self-certification combined with third-party certification and a traceability system (70%)	Effective: 4 (out of 7 participants) Neural: 3 (out of 7 participants)	• Individual companies are responsible for the quality and compliance of building codes
UK	• Product design and production process certification (24%) • Factory certification (20%) • Products certification (16%)	Extremely effective 43% Effective 43% Neutral 16%	• Introduce assurance schemes supported by the industry • Digitizing quality assurance to integrate with enterprise resource planning systems at a factory • Manufacturers to establishing shop floor metrics for quality control and assurance
China	• Self-certification for construction products with a lower risk of non-compliance (18%) • Independent third-party certification (36%) • Traceability (9%) and authority-led product authentication (8%) for high risk noncompliant building products	Extremely effective 19% Effective 40% Neutral 33% Ineffective 8%	• Self-certification of the manufacturer via an in-house quality control system • ISO certification for products • Traceability to increase information sharing and product identification • Accredited training agencies to certify installers; • Consumer law and bond requirements to be enforced in the construction contract
Singapore	• Third party independent product certification (20%) • Self-certify (15%) • Third party factory certification (15%) • Third party manufacturing process certification (15%)	Extremely effective 80% Effective 10% Neutral 10%	• Quality assurance scheme, i.e. ISO; • Third-party certification for products, factories, and production lines/processes; • Quality control during production and quality assurance upon delivery

Table 4

Australia	• Self-certify (20%) • Third party independent product certification (20%) • Industry-lead assurance system (16%) • Traceability (16%)	Effective (100%)	• Regulations such as the Australian Building Act and Consumer Law; • Third-party certification schemes to discover nonconformity building products • Manufacturer to initiate a quality assurance system

Figure 1 Click here to access/download;Figure;Figure 1.pdf

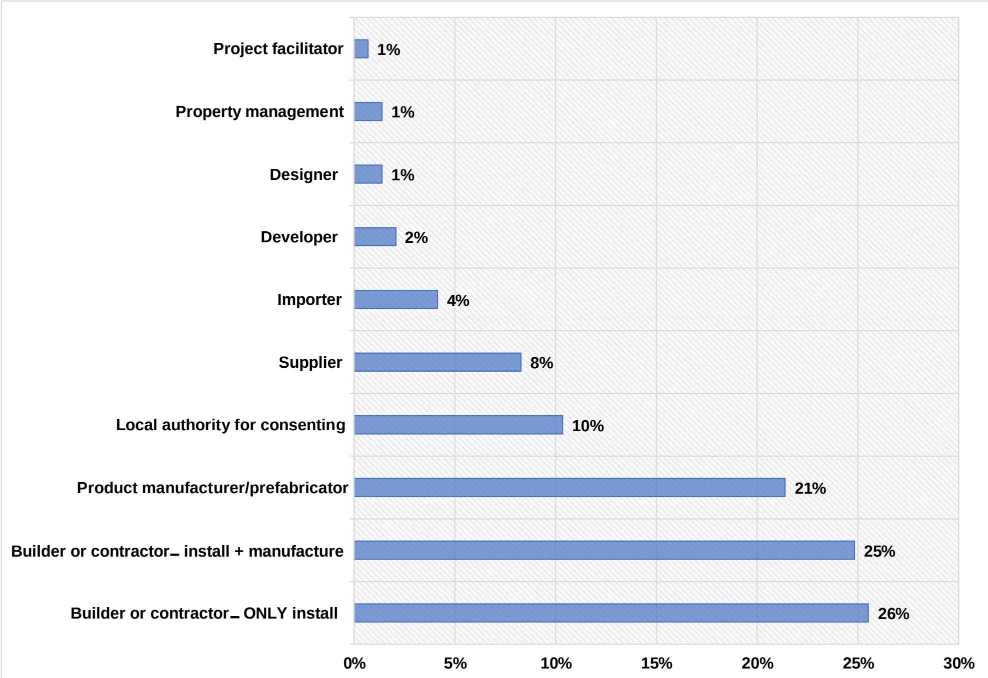

Figure 1. Occupational profile of survey participants

Figure 2 Click here to access/download;Figure;Figure 2.pdf

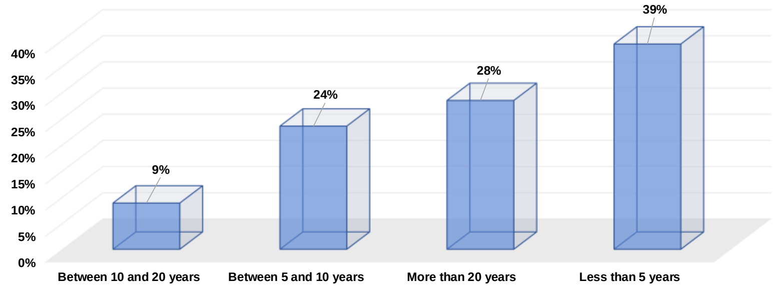

Figure 2. Duration of operational time of the organization in which survey participants affiliated

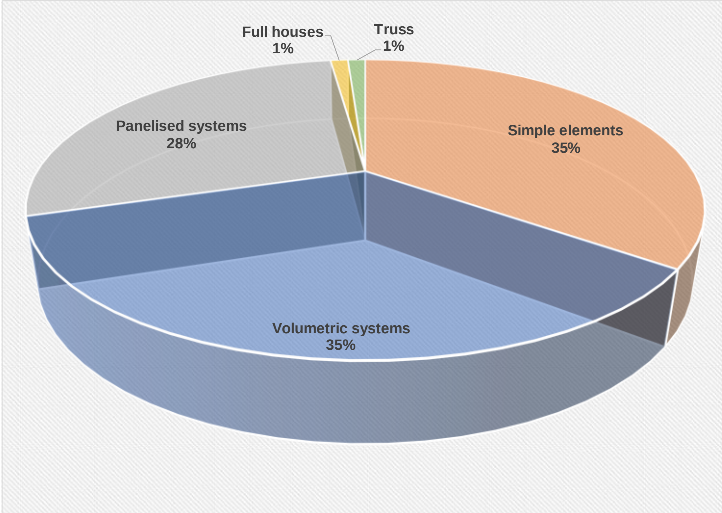

Figure 3. Types of building products manufactured by the respondents' companies

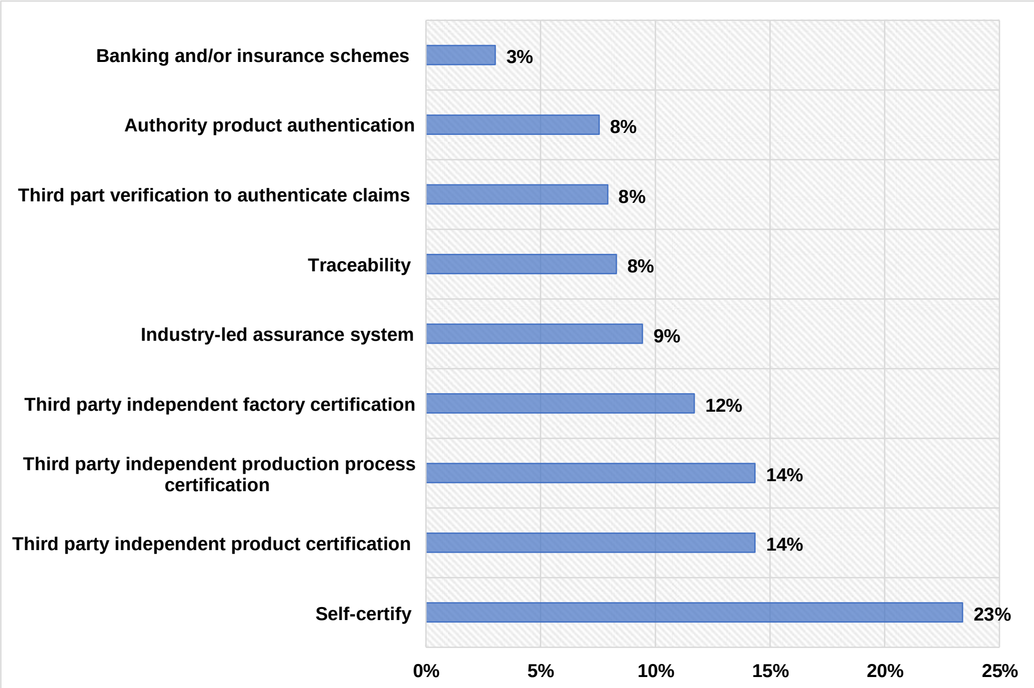

Figure 4. Code of compliance practice used for offsite construction in six countries surveyed

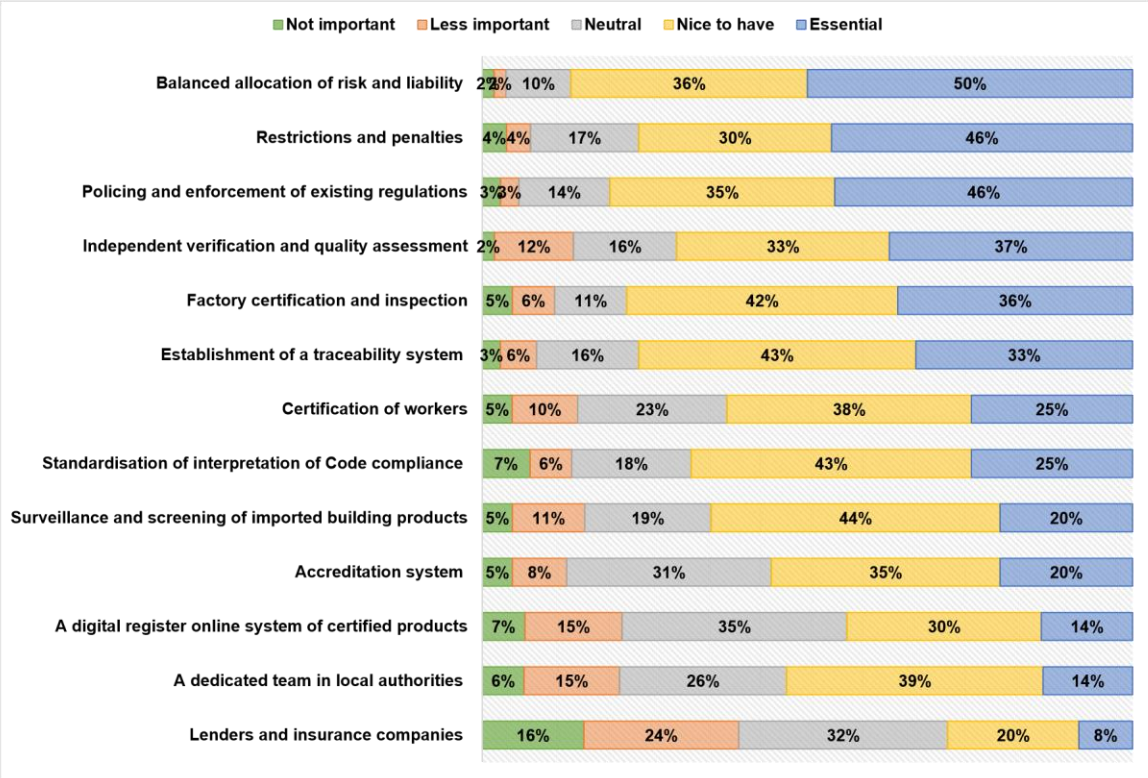

Figure 5. Mechanisms recommended by survey participants for future code of compliance of offsite construction

Figure Caption List