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CREATION OF STANDARDISED RESIDENTIAL CONSTRUCTION DETAILS FOR LIGHT-GAUGE STEEL PANELISED OFFSITE CONSTRUCTION

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Abstract: This paper presents the STANDARDIZE project, which is developing standardised construction details for Category 2 Modern Methods of Construction (MMC) to support regulatory compliance and wider adoption in the residential sector. A structured evaluation of MMC typologies—modular steel, modular precast concrete, panelised timber, panelised light-gauge steel (LGS), panelised precast concrete, and insulated concrete formwork—was conducted through an industry stakeholder-driven workshop. Based on criteria including technical maturity, typology, industry needs, certifiability, risk mitigation and scalability, panelised LGS systems were selected. This paper presents a development methodology comprising: (i) consolidation of existing Agrément-certified Category 2 LGS systems; (ii) gap analysis against Irish Building Regulations and performance requirements; and (iii) targeted experimental validation to address identified deficiencies and expand the evidence base for standardised details. The experimental testing of LGS system that covers structural performance, fire resistance, durability, moisture behaviour, and acoustics, will be conducted to relevant EN standards at accredited testing facilities. Results will be made openly accessible to support industry uptake. In parallel, industry stakeholders are advancing the development of an Irish Standard for Category 2 MMC, informed by the project outcomes.

Keywords: Instructions; Light-gauge Steel; Panelised Off-site Construction; Standardisation,

1. INTRODUCTION

In many developed economies, there is growing demand on the construction industry to provide housing at higher quality, speed, and scale while also dealing with labour shortages, growing costs, and stricter regulations (Masters and Drover 2023). These challenges are especially severe in Ireland, where ongoing shortages in the housing supply have sparked an increase in interest in Modern Methods of Construction (MMC) as a possible way to boost build consistency, productivity, and quality assurance. MMC includes a broad range of techniques with different levels of off-site production and on-site assembly, from volumetric modular systems to panelised and hybrid structural systems (Brodrick and Hickey 2024). Despite the recognised benefits of MMC, their adoption within residential construction has remained inconsistent. A number of studies attribute this to regulatory uncertainty, fragmented technical guidance, and the absence of trusted and widely accepted standard construction details (Farmer 2016). In particular, the lack of regulator-recognised system-level detailing—especially at key junctions and interfaces—has been identified as a significant obstacle to wider implementation. As a result, projects frequently rely on bespoke design solutions, leading to repeated testing, duplicated technical assessments, and extended approval processes (Sun et al. 2020, Meacham 2022).

These issues are particularly pronounced in jurisdictions such as Ireland, where compliance with Building Regulations must typically be demonstrated through formal certification and supporting test evidence (NESDO report on housing supply in Ireland 2024). Within such regulatory environments, the availability of recognised standards and established construction details is critical to providing assurance for designers, building control authorities, and insurers. Previous research on off-site and industrialised construction systems consistently highlights the role of standardisation in facilitating industry acceptance and enabling scalable delivery models (Payne and Serin 2023).

Timber frame construction provides a notable example of this process. The development of national standards and widely accepted detailing practices has played an important role in establishing confidence across the supply chain, supporting its integration into mainstream residential construction (DGLGH report on building homes 2025, IS440 2009). By comparison, many emerging MMC systems lack equivalent publicly accessible technical guidance that aligns with regulatory expectations.

The resulting technical uncertainties are further compounded by broader industry challenges, including limited sharing of performance data, unclear intellectual property arrangements, and the absence of collaborative structures to coordinate the development of shared standards (CIF-MMC report 2021). Without effective mechanisms for cooperation between manufacturers, designers, regulators, and certification bodies, MMC projects often revert to project-specific solutions. This undermines the efficiency, repeatability, and risk reduction that industrialised construction approaches are intended to provide.

Against this backdrop, structured construction sector stakeholder engagement has emerged as an important approach for addressing complex industry barriers. Collaborative workshops that integrate quantitative survey data with qualitative discussion have proven effective in identifying shared priorities, revealing underlying constraints, and building consensus around potential pathways for standardisation in multi-stakeholder environments where regulatory, technical, and commercial considerations overlap (Sweeney 2024).

The STANDARDIZE project aims to (a) identify industry needs for standardised construction details, their required performance and durability, then (b) produce acceptable MMC construction details based on EN standards testing, and finally (c) publish open-source testing and verification data to simplify and widen access to MMC. The objectives of this paper are to (a) present the outcomes of two industry–academia stakeholder workshops as part of the STANDARDIZE project and identify priority needs of the industry, and (b) outline the rationale for selecting Category 2 LGS system for further research. These objectives clearly facilitate the first STANDARDIZE project objective, i.e. specification of the industrial need for standardised details and their performance and durability requirements.

The first workshop focused on identifying and selecting the MMC system and material most suitable for the development of standardised construction details. The second workshop examined the selected system in greater depth, identifying priority construction details, testing requirements, and opportunities for improved information sharing across the industry. This paper outlines the rationale for selecting Category 2 LGS systems and presents the key outcomes from both workshops, including the identification of priority industry needs.

There are several national and international standards organisations, such as Building Control Amendment Regulations (BCAR) in Ireland; National Standards Authority of Ireland (NSAI); National House Building Council (NHBC) in the United Kingdom; or the British Board of Agrément (BBA), which set frameworks for building systems and their compliance. The STANDARDIZE project builds on those standards and creates MMC-specific “acceptable construction details”, ensuring additional guidance and broader performance assurance. This project is funded by the Department of Housing, Local Government and Heritage in Ireland through Enterprise Ireland, and in collaboration with the NSAI. The outputs of the project aim to reduce risk, simplify design and regulatory compliance processes, and broaden MMC adoption for residential buildings.

2. RESEARCH METHODS

The STANDARDIZE project adopted a stakeholder-driven approach to address the recognised shortage of system-specific, accessible performance and detailing data required to support the wider adoption of residential MMC in Ireland according to the roadmap as shown in Figure 1. The project roadmap involves reviewing existing Agrément-certified Category 2 LGS systems to establish a baseline understanding of current designs, performance characteristics, and certification evidence. Comparative assessments of structural, thermal, fire, and acoustic performance are undertaken alongside evaluations against Irish Building Regulations to identify compliance gaps and under-tested areas. A targeted testing programme is then developed and implemented to generate new technical evidence and validate system performance. The findings are subsequently used to develop refined design guidance and standardised construction details, which are verified through stakeholder review and disseminated to support industry implementation and regulatory acceptance. The first in-person workshop brought together stakeholders representing a range of MMC categories and material systems. Its objective was to gather detailed industry insights on different MMC approaches to inform the prioritisation process within the STANDARDIZE project. Following the prioritisation outcomes of Workshop I, a second workshop was organised with a more focused scope centred on the selected MMC system. Workshop II aimed to articulate clearly defined industry needs and to identify both experimental and non-experimental data that could be shared to support the development of standardised construction details and performance requirements.

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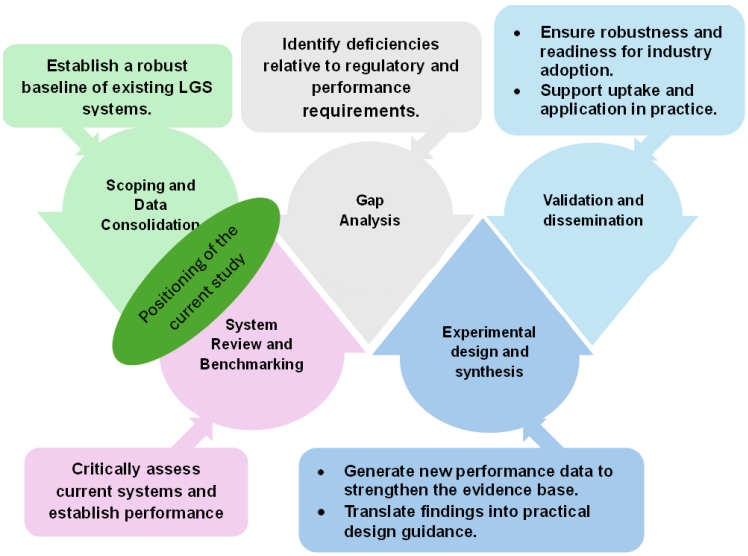

Figure 1: Roadmap to achieve STANDARDIZE project objectives

Together, the two workshops form a progressive research framework that moves from high-level system scoping and prioritisation to more targeted technical refinement. This staged approach provides a transparent and evidence-informed foundation for advancing MMC standardisation efforts in Ireland.

3. WORKSHOP DESCRIPTION AND THEIR IMPACT

The first in-person STANDARDIZE workshop took place on 17 June 2025 at the School of Civil Engineering, University College Dublin (UCD). Workshop I aimed to gather cross-sector insights on the maturity of MMC systems, their market readiness, and key technical gaps, to inform the comparative prioritisation of MMC categories for detailed standardisation. Key organisations and industry representative bodies were invited to participate in the workshop. Following the first workshop, Workshop II was conducted with 27 stakeholders of MMC Category 2 LGS on 21st of October 2025 at Croke Park, to discuss the feasibility of exchange of industry data that will aid in determining testing and advanced simulation for all pertinent sections of the Building Regulations. These included MMC Ireland, the Construction Industry Federation

Smart Offsite Association (CIF SOSA – report on 3D modular capacity 2024), the Irish Timber Frame Manufacturing Association (ITFMA MMC presentation 2025), the Irish Concrete Federation (ICF Annual report 2024), Engineers Ireland (EI webinar on MMC 2025), the Royal Institute of the Architects of Ireland (RIAI architecture report 2026), the National Standards Authority of Ireland (NSAI report on timber frame 2009), the Department of Enterprise, Trade and Employment (DETE -MMC conference 2025), Enterprise Ireland's Built to Innovate program (2022), the Association of Consulting Engineers of Ireland (ACEI report on MMC 2025), and the Department of Housing, Local Government and Heritage (DHLGH -SDA Workshop I & II report 2024). The key outcomes arising from the workshops are presented in this section.

3.1 Workshop I: MMC system scoping and prioritization

The workshop facilitated the identification and prioritisation of one MMC category and material for the STANDARDIZE project based on the responses of stakeholders across the MMC sector. Drawing on the classification framework presented in (DHLGH -SDA Workshop I & II report 2024, DHLGH report on timber frame growth 2025), the selection process considered the following MMC systems: Category 1/2/3 Concrete and Precast Concrete; Category 1 Steel Frame; Category 2 Light Gauge Steel; Category 7 Insulated Concrete Formwork; and Category 1/2 Mass Timber and Timber Frame. The selected above systems were highlighted in the DHLGH standardised design approach study as being the most typical MMC categories/materials in the Irish residential sector.

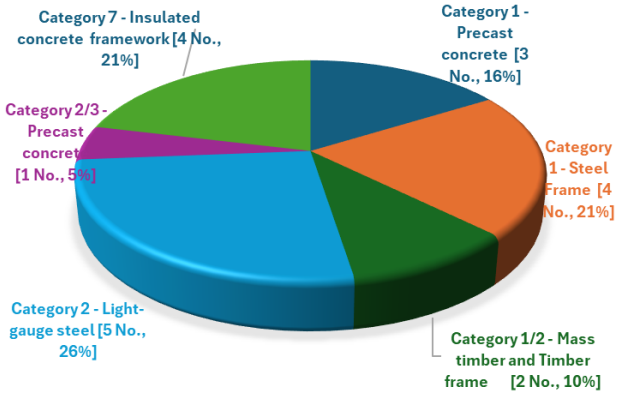

Figure 2: Distribution of the MMC participants in Workshop I (19 participants)

A survey conducted during the workshop captured the distribution of participants across different MMC stakeholder groups, as illustrated in Figure 2. A group with 1 or 2 participants in some categories is considered as a limitation for this survey. The main aim of the survey was to get some quantitative data that might help in deciding on the category/material of MMC to proceed with in this project. Workshop I also incorporated structured worksheets (Figure 3 and 4) designed to gather targeted feedback from participants. These worksheets addressed three key aspects: (i) relevant MMC typologies (as defined in (SDA Workshop II report 2025)) and their application scope; (ii) priority interfaces and gaps in existing technical detailing; and (iii) the current availability of standards, willingness to share technical data, and the expected benefits of standardisation. The insights obtained from both the survey and the worksheet exercises informed the selection of MMC systems for which building regulations–compliant standardised details will be developed within the project. Survey responses indicate that most MMC systems are perceived as capable of delivering a broad range of residential typologies (DHLGH -SDA Workshop I & II report 2024); however, this does not consistently align with market adoption or regulatory feasibility. Category 2 LGS and Category 1 steel frame systems were identified as highly versatile, with application across residential, student accommodation, and mixed-use schemes. Timber-based systems were perceived as constrained in multi-storey contexts, primarily due to fire performance and regulatory limitations.

3.2 MMC system selection

3.2.1 Workshop I Findings – System Evaluation Overview

Following the first workshop, a comparative evaluation of construction systems was undertaken, producing Based on the responses in worksheet shown in Figure 3 and 4, a ranking matrix was developed (Table 1) to guide future selection. Each category or material was evaluated on a scale from 1 to 5, with 1 representing very low, 2 low, 3 medium, 4 high and 5 being very high. Since not all factors carry the same level of importance, weightings were also assigned to each factor, as presented in Table 1. Three weighting levels were used: 0.5 (low) for market maturity as there is not sufficient data to know the levels, 1.0 (medium) for industry need, typologies and scalability, and 1.5 (high) assigned to engagement, commitment and risks for medium/high-rise as it was felt these were the most important factors affecting selection of the system. The total score for each item was calculated by multiplying the individual scores and the assigned weightings. The ranking matrix shown in Table 1 indicates that Category 2 LGS achieved the highest aggregate score (37.5), followed by Category 1 Steel Frame and Category 7 Insulated Concrete Formwork (ICF), both scoring 34.5. The three top systems scored very close together, so Category 2 LGS was not picked on its score alone. Four things pointed to it, i.e. it scored highest in the weighted matrix; it works well with Category 1 Steel Frame (because LGS panels can be used as infill inside steel frames); its embodied carbon is about the same as ICF (see below). Taken together, these reasons made Category 2 LGS the best system to take forward in the STANDARDIZE project, with the strongest potential for impact. Mass Timber reflected a moderate alignment, while Concrete/Precast and Timber Frame showed lower need. This was due to the existing standards (e.g. IS440) for timber frame and a history of use with significant guidance available to precast concrete in the context of market maturity and adoption, as assessed via adoption levels and certification. This was highest for Concrete (Category 1/2/3) and Timber Frame (Category 2), moderate for LGS and ICF, and lower for Steel Frame and Mass Timber. This indicates that, while some systems are widely established, others are emerging and may benefit from further support or validation. In terms of flexibility across building types, Steel Frame, LGS and Concrete offer the broadest applicability, whereas ICF, Mass Timber and Timber Frame are less versatile. When scalability is considered, Concrete and ICF lead, whereas Steel Frame and Mass Timber face constraints that limit wider adoption. On risk for taller structures, medium and high-rise applications carry inherent risks such as fire or disproportionate collapse. Steel Frame, LGS and Concrete are associated with higher risk as they are used in high-rise construction, ICF with moderate risk and Mass Timber and Timber Frame with comparatively lower risk. In terms of the constraints and opportunities, planning approval emerged as the most significant barrier, followed by certification requirements and labour availability. Importantly, stakeholders expressed a strong willingness to share data, highlighting a fertile environment for collaborative research and standardization initiatives. It should be noted that the ranking matrix was not intended to provide a definitive quantitative hierarchy, but rather to function as a decision-support mechanism. It is anticipated that STANDARDIZE work will be carried out on broader MMC types in the future.

Table 1: Ranking matrix (1-very low, 2-low, 3-medium, 4-high, 5-very high)

Category of MMC:		**1**	**2**	**1, 2,3**	**1**	**2**	**7**
Factor	**Weight**	**Steel Frame**	**LGS**	**Concrete**	**Mass timber**	**Timber frame**	**ICF**
Engagement	1.5	5	5	3	3	2	5
Commitment	1.5	4	5	3	3	2	4
Industry needs	1.0	4	4	1	3	1	4
Market maturity	0.5	3	4	5	2	5	4
Typologies	1.0	5	5	5	3	2	4
Scalability	1.0	3	4	5	3	4	5
Risks for medium/high-rise	1.5	5	5	5	2	2	4
Total score		**34.5**	**37.5**	**29**	**22**	**18.5**	**34.5**

Accordingly, responses from the survey conducted during the workshop under six categories such as building system, typologies, capacity, pipeline, constraints for pipeline and existing data, were interpreted in an indicative manner, particularly considering the limited sample size informing the evaluation. After Workshop 1 took place, a report by the Department of Housing, Local Government and Heritage (DHLGH) (DGLGH building homes - report 2025) provided estimates of upfront embodied carbon for selected MMC systems, as illustrated in Figure 5. The reported values indicate that Category 2 LGS exhibits an embodied carbon intensity of approximately 180–210 $kgCO_2e/m^2$, comparable to that reported for Category 7 ICF (180–220 $kgCO_2e/m^2$), the two ranges overlapping across almost their entire extent. This comparability supports the prioritisation of Category 2 LGS within the study rather than distinguishing the two systems on carbon grounds. The same report also identifies Category 2 Timber systems as having the lowest embodied carbon intensity among the systems assessed, with a value of approximately 165 $kgCO_2e/m^2$.

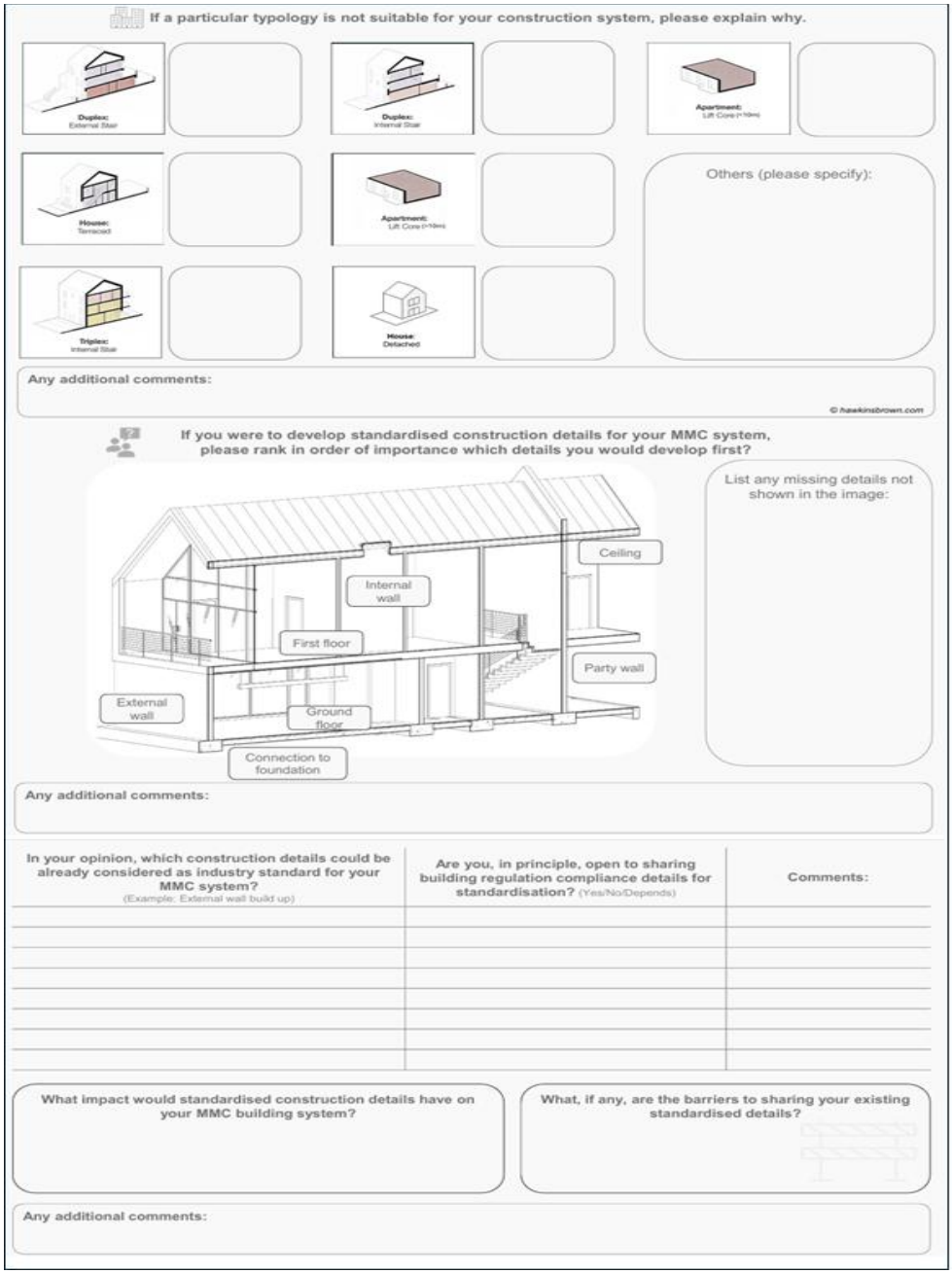

Figure 3: Worksheets used during Workshop I

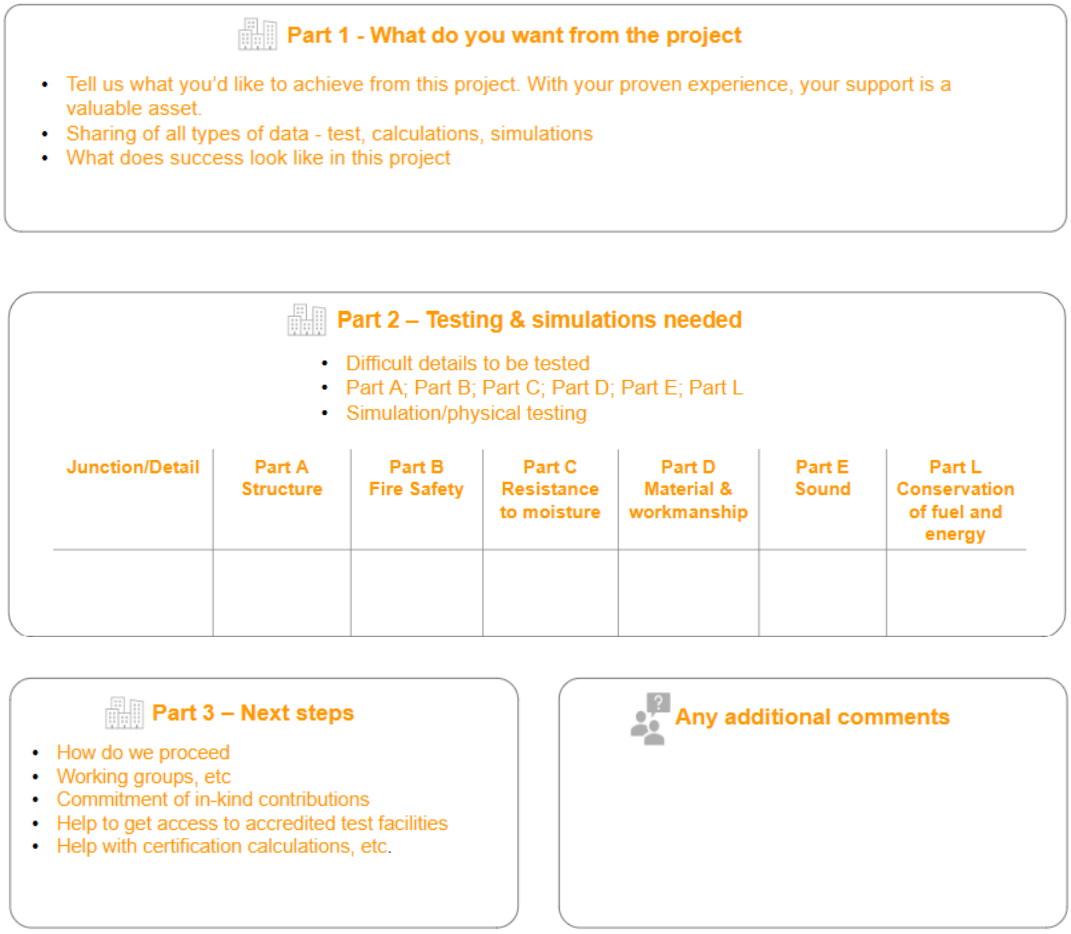

Figure 4: Worksheets used during Workshop II

The outcomes of first workshop were as follows: i) Engagement and commitment are the most decisive factors in system selection, ii) Category 2 LGS emerges as the most promising system due to strong alignment, high engagement, and commitment, iii) Timber-based systems offer lower structural risk but face limitations in scalability and typological flexibility, iv) Overall, the workshop results reveal a collaborative culture ready to support joint standardization efforts as long as relevant governmental frameworks and intellectual property issues are taken into account.

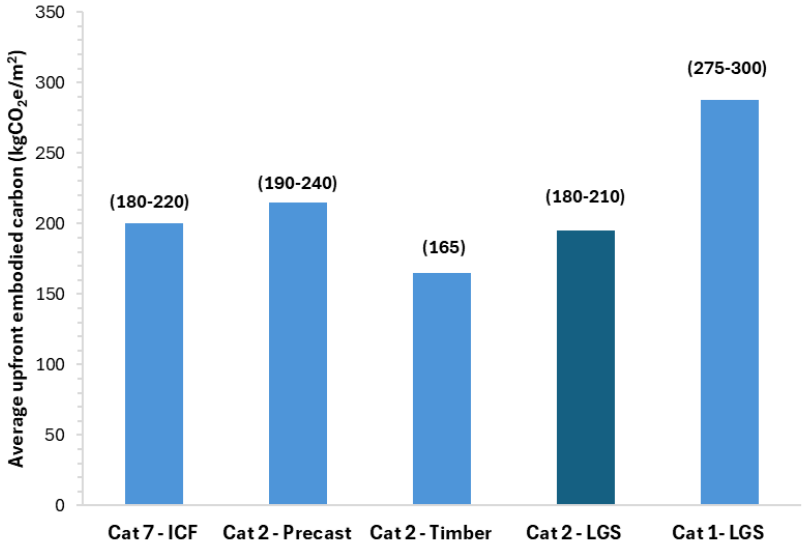

Figure 5: Average upfront embodied carbon in different MMC systems (DGLGH building homes report 2025)

3.2.2 Workshop II: system-focused refinement and pathway to standardization

Workshop II engaged 27 stakeholders representing the MMC Category 2 LGS sector. The structured worksheets deployed during Workshop II (Figure 4) were designed to facilitate systematic identification and exchange of industry-generated data required to inform experimental testing protocols and high-fidelity numerical simulations. The data collection process aimed to support evidence-based evaluation across the relevant provisions of the Building Regulations (TGD from DHLGH – Part A to E). Emphasis was placed on performance domains including progressive collapse resistance (Part A), fire safety (Part B), structural integrity encompassing robustness and hygrothermal durability with respect to moisture ingress and condensation control (Part C), and acoustic insulation and sound transmission performance (Part E). The outputs of this exercise were intended to establish a qualitative and quantitative framework for identifying physical testing and advanced simulation methodologies applicable to MMC LGS systems. Fire performance was identified as the governing parameter for medium-rise MMC Category 2 LGS applications, particularly under multi-exposure conditions at critical junctions including party walls, floor–wall interfaces, and external wall openings. These scenarios necessitate full-scale system testing and resilience-based assessment to capture complex fire spread mechanisms. Acoustic performance requirements were mainly associated with party floors and façade junctions, with concerns regarding the in-situ acoustic reliability and flanking transmission potential of single-stud LGS assemblies. Structural robustness, including vertical tying and resistance to disproportionate collapse, was highlighted as a key distinction between low-rise and medium-rise applications. Moisture performance of rainscreen façades was linked to the requirement for Centre for Window and Cladding Technology testing or similar testing for rainscreen façades to assess resistance to wind-driven rain. Collectively, these findings emphasise the need for integrated system-level validation rather than isolated discipline-specific compliance.

The prioritisation of MMC Category 2 LGS identified from Workshop I reflects its greater need for standardisation within the Irish housing sector. Following the prioritisation stage, workshop II defined the scope and delivery pathway for standardisation of Category 2 LGS systems and clarified that a credible national standard for LGS must be supported by coordinated testing and modelling across all principal parts of the Building Regulations (TGD from DHLGH – Part A to E) with a focus on Part B (fire), Part E (acoustics), Part A (structure), and Part C (moisture).

Regulatory compliance and performance risks are primarily concentrated at building junctions and interfaces rather than within isolated elements. Party wall junctions emerged as the highest-risk interface, requiring careful detailing to ensure 60-minute fire resistance, acoustic separation, airtightness continuity, and proper integration with intermediate floor systems. External wall interfaces—particularly around

windows, doors, and service penetrations—were identified as critical due to the interplay of fire stopping, airtightness, and building services. Foundation connections and base details were highlighted as vulnerable for structural integrity and moisture control, while roof interfaces, including eaves, parapets, and penetrations, frequently relied on bespoke solutions, resulting in inconsistent performance outcomes. These interfaces correspond to the five priority interface groups identified during system selection (party walls; floor-to-wall junctions; external wall openings and service penetrations; foundation connections; and roof interfaces), which frame the testing and simulation scope set out further. Standardisation efforts were recommended to focus on developing documents analogous to Acceptable Construction Details (ACD-TGD Part L Building Regulations 2021- Steel Frame Insulation) that explicitly define system-level performance, providing regulatory certainty while maintaining design flexibility. Additionally, the LGS stakeholder meetings have led to the establishment of an NSAI technical committee to develop an Irish Standard for LGS offsite residential construction.

4. CONCLUSIONS

This study presents a stakeholder-driven framework for prioritizing and advancing MMC standardization in Irish residential construction. Evidence from two workshops with over 35 stakeholders indicates that adoption barriers are largely systemic-centred on regulatory confidence, data governance, and interface performance—rather than material-specific.

Category 2 LGS systems were identified as the candidate to develop specific standardised construction details for residential construction, reflecting strong stakeholder engagement, broad typological applicability, and regulatory exposure in medium-rise applications. Engagement with key stakeholders identified a clear requirement for integrated, system-level design guidance targeting high-risk junctions, including party walls, floor-to-wall interfaces, external wall openings, foundation connections, and roof interfaces. These areas were consistently recognised as critical to achieving regulatory compliance and robust in-service performance. Stakeholders emphasised that such guidance must be underpinned by a coordinated, multi-disciplinary evidence base addresses fire performance, acoustic behaviour, structural integrity, and hygrothermal response. This evidence framework should combine full-scale experimental testing, advanced numerical simulation, and resilience-based assessment methodologies to capture both standard performance criteria and sensitivity to real-world variability, construction tolerances, and long-term service conditions.

The next phase of the STANDARDIZE project is structured around a phased development of ACD for LGS Category 2 MMC systems underpinned by formal governance structures including Steering and Technical Working Groups, and supported by robust, standardised data-sharing mechanisms. This framework is intended to ensure consistency in methodology, transparency in evidence generation, and alignment with regulatory expectations. By integrating cross-sector stakeholder consensus with a regulator-focused evidence base, the approach facilitated the systematic development of validated construction details with clearly defined performance compliance pathways. The methodology is inherently scalable, providing a transferable template for the standardisation of other MMC categories. Sustained collaboration between industry, regulatory authorities, and research institutions will be critical to maintaining technical rigour, ensuring regulatory acceptance, and enabling continuous refinement. Collectively, this positions Ireland to strengthen its role as a leader in MMC standardisation, certification, and construction innovation.

The project will deliver open-access, regulation-compliant LGS Category 2 MMC details, covering structural, fire, thermal, acoustic, moisture, and durability performance with EN-standard testing.

By reducing dependence on proprietary certification pathways and project-specific technical approvals, the approach enables a more streamlined and standardised route to compliance, improving efficiency and reducing time and cost burdens associated with repeated assessment and validation. This, in turn, strengthens confidence among designers, regulators, and manufacturers by providing transparent, evidence-based construction details with clearly defined performance criteria.

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