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Methods of Construction to the Meet Housing Crisis in the UK Residential Sector: A Comparative Study between Timber Frame and Masonry Construction

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Abstract: Major efforts have been invested in the UK Residential sector to meet the increasing housing demands, deliver sustainability, and improve its resiliency against many uncertainties. While data/information within the UK residential sector relating to location, sizes and volumes are annually updated, there is limited emphasis on the methods of construction that support meeting housing demands. Over the years, it has been recognised that the UK residential sector has been dominated by two methods of construction: timber frame and masonry. This study aims to holistically compare timber frames with masonry as the two domineering construction methods for the UK residential sector. The comparison will be based on build costs, preference and drivers by construction professionals, longevity and consumer confidence, and sustainability. The research methodology was developed based on applying mixed methods of quantitative data analysis of build costs and qualitative data assessment of semi-structured interviews. The findings showed that, from a build cost perspective, masonry methods of construction are a more cost-effective choice with major variation in material cost. However, although the masonry method of construction was more favoured, in many respects, small-in-size developers show more tendency to timber frames, as this is being rationalised by meeting sustainability targets. Practical implications show that the future of the residential sector in meeting the housing demands would heavily depend on Modern Methods of Construction (MMC), as it offers a more optimised mechanism; however, the uptake of this is considerably low. Future studies will enquire into pillars to make MMC efficient in the UK residential sector.

Keywords: housing; methods of construction; timber frame; masonry; sustainability; MMC

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1. Introduction

The UK residential sector is recognised as being continuously demanding for both academics and practitioners. This is justified by the number of challenges they have faced over the years, but the ultimate task has been meeting housing demands [1,2]. In fact, back in 2019, it was highlighted that the residential market will rise by 300,000 per year in order to succinctly meet the market demand [2]. In response to the housing crisis, many strategies were proposed including the strategic plans [3], governmental policies [4] and even innovative approaches such as off-site manufacturing [5]. Simultaneously, it is imperative to consider that the UK housing sector is facing many pressures to improve sustainability and the ways in which this is being integrated as part of the whole lifecycle [6]. This requires careful assessment of environmental impacts associated with all stages of a product's life, economic accountability of various cost implications, and different considerations towards communities and societies [7]. Despite continued efforts to improve the UK residential market, statistically sound outputs that illustrate effective mechanisms that support improving efficiency to meet the housing demand are considerably limited. More importantly, while sustainability is seen as one of the major challenges within the UK housing agenda, this does not necessarily support the speed of meeting housing demands. In fact, according to the RICS, 90% of housing developers utilise the use of traditional construction methods [8], which mostly are timber frames and masonry.

On the one hand, the timber frame is recognised as one of the earliest known forms of construction in the UK. Scotland is leading the market in embracing the use of timber-framed construction in the UK, where it is estimated that 85% of new homes are built using wood. One of the biggest issues with timber-framed construction is accessibility on construction sites, and, in recent years, the shortage of supply, resulting in timber frames being a less preferable option. On the other hand, masonry construction has dominated the UK housing building market for decades, where a report by the RICS showed that it accounts for approximately 65% of the market [9]. In comparison to the timber frame, the greatest strength of masonry construction is its longevity during the lifecycle [10]. When compared with timber-framed construction, traditional masonry construction is comparatively slow. This is perhaps due to to the increased time associated with masonry due to the labour-intensive process involved with this form of construction. Whilst data on timber frames and masonry as traditional methods of construction for housing exist, a detailed and overarching comparison would provide solid and succinct ground for more informed decision making when it comes to housing projects. More importantly, a lack of coherent comparisons between timber frame and masonry have limited the potential focus of supply chain-specific issues within the housing market in the UK. Another significance is the fact that modern methods and techniques such as MMC are being adopted by housing developers, hence focusing on masonry and timber frames as the two most utilised materials for housing in the UK can potentially unfold many of the challenges faced by developers. Therefore, this research provides a comparative analysis between timber frames and masonry, elaborating on built costs, preference and drivers by construction professionals, longevity and consumer confidence, and sustainability. This comparison will support current knowledge and enrich our current understanding of both materials within the UK housing market, and perhaps shed light on the issues and complexities that are encountered when attempting to meet housing targets and demands.

2. Literature Review

2.1. UK Residential Sector: Deficits and Shortfalls

The housing deficit can be traced back to the 1980s, as the Right to Buy scheme and governmental discounts introduced by the Housing Act 1980 accelerated the number of council tenants purchasing their homes. Simultaneously, sums of money for councils to build new homes were reduced while a drastic fall was experienced in terms of replacement properties [1]. In the 1990s, the shortfall in housing supply became increasingly evident. For instance, in 1992, a total of "164,150" new homes were constructed in the UK compared to "272,470" new homes built in 1978, indicating a 40% drop in new homes delivered nationwide over 14 years [11]. In 2015, the government decided to set an aim to secure 1 million net additions to the housing stock by 2020 [2]. In the white paper published by the "Department for communities and local government" in 2017, three-phased strategies were outlined to tackle the housing supply crisis: "plan for the right homes in the right places", "Build Homes Faster" and "diversify the housing market" [3]. The three-phased plan was anticipated to deliver from" 225,000" to "275,000" or more homes per year to keep up with population growth. In 2019, the UK faced an increased demand of a minimum of "300,000" new homes per year to equal demand, and higher than ever predicted housing requirements [2]. Despite the Government's efforts to encourage house building, the success was limited, which was partly due to the COVID-19 pandemic. A recent report pointed out [12] that it might take up to at least 15 years according to current building rates to close the housing market gap. It is agreed that initiatives introduced by the government to tackle UK housing demands have experienced a major shortfall. Similarly, whilst numbers of new dwellings are increasing, with "173,660 new homes built for the year ending June

2019—representing an 8% increase compared with the previous year alone"—it is still some "126,340" short of the "300,000" new homes per annum target.

Data related to construction preference are limited, even though UK statistics on output by volume and sector are quite impressive. It would appear there is a disconnect between Governmental policies such as "The White Paper which promotes house building", and UK developers' building methods. This is highlighted by "The Office for National Statistics", who commented on the "often-blurred boundaries between the different types of work" [4]. It was stated by RICS that traditional construction accounts for over 90% of housebuilding in the UK [8]. Within the UK residential sector, methods of construction in the UK are generally timber frame and masonry. The House of Commons was informed that the "use of offsite manufacture was the only way to achieve the government target of 300,000 homes per annum." [5]. Yet, information relating to the reasons for failure linked to the two traditional methods is limited. A more in-depth analysis of these two building methods will be presented in this report.

2.2. Timber Framed Construction: Overview and Usage

Timber-framed construction is one of the earliest known forms of construction in the UK. In 2016, the Structural Timber Association report confirmed that the timber frame market accounts for 28.4% of UK house building (around "52,702" dwellings) and the demand was expected to increase covering 88,000 by 2021 [13]. The greatest period of timber building in England and Wales was between 1200 AD and 1700 AD [14]. Early timber-framed construction gradually started to phase out during the late 17th century as a result of the Great Fire of London, during which 13,200 houses and 87 parish churches were destroyed [15]. The "Act for the Rebuilding of the City of London", passed in 1667, proposed that all new buildings had to be constructed of brick or stone against the future perils of fire [16]. The demand for building new houses at a higher speed after the Second World War caused a rise in timber-framed construction (between the 1940s to 1950s). In 1942, the "Burt Committee" was set up by the wartime coalition Government to provide guidance on the housing shortage and recommended prefabricated housing as a solution to the problem [17]. The idea behind the mass-produced factory homes was to produce short-term accommodation that required minimally skilled labour to construct. In the early 1960s, a new wave of Swedish and American/Canadian timber-framed homes began to make its appearance in the UK. These new specification timber-framed houses were larger and more aesthetically pleasing than the immediate prefabricated post-war designs. The growth in timber frame construction was driven by an export drive by the Canadian Government in the early 1960s which also coincided with the UK government's policy to further develop industrialised systems of building [18]. It is important to point out that early timber frame construction was largely constructed offsite and although the use of equipment and transportation differs greatly from modern-day prefabricated timber, a recognition of the benefits of off-site construction exists. Popular species used in early construction were Oak, Elm, Sweet chestnut, Poplar, and the many varieties of softwoods [19,20]. In the modern era, there is evidence of increased growth in the timber frame, especially with the continual efforts toward offsite construction [9]. In the UK, it is recognised that Scotland is leading the market in embracing the use of timber-framed construction in the UK, where it is estimated that 85% of new homes are built using wood. However, the rest of the UK does not currently follow suit; timber is overwhelmingly imported from EU countries, with 42% of sawn timber imports coming from Sweden alone [21]. The UK imports timber due to a lack of available local species, as it has just 13% forest cover area compared to other European countries with an average of "37%" forest area [22]. The UK may have to look at increasing home-grown production if the timber frame market share is to grow.

2.3. Timber Framed Construction: Value and Benefits

It can be stated that one of the major benefits of timber frames is the speed of construction where reports suggested that the construction procedure can take 41 weeks for timber, whereas it can take up to 49 weeks for masonry [23]. This saves time by increasing mechanisation both in design and construction by opting for offsite construction [24]. The offsite construction allows frames to be precision-engineered offsite and craned into position onto pre-cast foundations. Off-construction by its controlled factory environment provides improved quality regulator where materials can thoroughly be inspected [24]. Similarly, increased factory production minimises the volume of skilled labour required onsite, which can solve the problem introduced by the Federation of Master Builders regarding increasing difficulties in recruiting in almost all key trades in the first quarter of this year [25]. With a large portion of timber frame construction completed offsite, it allows the volume of skilled onsite construction to drop considerably. In fact, changes to Building Regulations with the addition of Part L1A "conservation of fuel and power in new dwellings" in 2010 have highlighted the thermal performance of timber-framed homes. The regulations state that all new dwellings in England and Wales must achieve an increased minimum energy efficacy level. Timber-framed construction can achieve this because the insulation can be fitted inside the timber frame portion of the wall. A pre-insulated factory frame is compliant on arrival at the site, eliminating potential issues with compliance for the developer. Therefore, it can be stated that timber frame has considerable qualities such as time efficiency, reduced site labour, increased thermal efficiency, and decreased material waste.

2.4. Timber Framed Construction: Issues and Complexities

One of the biggest issues with timber-framed construction is accessibility on construction sites. Timber frames are generally transported by lorry and craned into a fixed structural position onsite. Construction sites are not always green flat fields and may have some physical and logistical challenges for ensuring unhindered and safe access, so smooth transportation and craning of large components mostly are very difficult or impossible [24]. In certain situations, developers are left with little alternative other than more traditional methods of construction involving smaller units. The Structural Timber Association confirm that "badly laid and inaccurate substructure is the single biggest problem faced on-site by the timber frame erector" [8]. According to current NHBC standards, footings and blockwork must be within a "10 mm tolerance" to allow for compliant installation [26]. The Structural Timber Association confirmed that "if foundations are not within recommended tolerances, they must be rectified before panel erection starts as errors cannot be rectified at a later stage". This puts pressure on the developer to achieve high levels of accuracy during the groundwork phase. Errors made will ultimately prove costly if the frame does not accurately fit the sub-structure provided. There is a perception that timber-framed homes are susceptible to wet-rot and ultimately structural failure. Issues with wet-rot are not uncommon and are generally linked to the initial setting out stage. If uprising damp finds a way to penetrate the sole plate due to a rip or poorly installed DPC then Wet-Rot can occur. It is the "vulnerability of timber which is of particular concern", the risk of decay at a moisture content "above 20% is inevitable" [27]. The consequences of wet-rot in the sole plate are likely to remain unnoticed until the timber perishes, and resultant structural instability may occur. In general, it can be stated that the complexity of applying the use of timber frames mainly lies in the challenges of importing timber from Europe. Another issue is that the uptake of using timber frames by many UK contractors is considerably low, but at the same time to make use of it in line with national home building standards.

2.5. Masonry Construction: Overview and Usage

Compared to methods of construction, masonry construction has dominated the UK housing building market for decades. The RICS reports that masonry construction accounts for approximately 65% of the market [9]. In comparison to timber frame, a share of 28.4% of the UK house building masonry has a commanding following of developers [13]. It should be considered that the natural availability of stones has been responsible for masonry being the oldest building material known to humans [28,29]. In the UK, rubble stonework was considered among the earliest use of masonry construction, while the stonework needed no mortar and was laid dry. By the 1st century AD, techniques of producing fire clay bricks came from the Roman Empire into the UK [30]. The bricks produced by the Romans were generally thinner and wider than those associated with current-day brickwork. However, "when the Romans left Britain in the 5th century, so too did brickmaking" [31]. Construction in the UK returned to either dry stone or timber construction until brickwork began to reappear during the 16th and 17th centuries. Notice that brickwork was not generally widespread due to the cost of manufacturing and transportation, and it was mostly confined to those at the upper echelons of society, in both church and state" [32]. The City of London saw the most widespread use of brickwork following the Great Fire of London in 1666. A survey completed by Modern Masonry in 2018 involving over 2000 households highlighted customer trust in masonry construction. The report stated that only 3% believed timber to be a strong solution, compared to 80% who felt masonry offers the most robust homes [33].

It is important to also understand the method of early masonry construction and how it differs from modern-day constructional practice. Solid wall construction was typical during early masonry construction with either rubble stone, brick, or a combination of materials. Wall construction predating the 1920s was typically 215 mm or one brick thick to provide reasonable weather protection [27]. English and Flemish bond brickwork was commonplace due to the regulation of header courses providing wall strength. Moisture was a major concern for early masonry construction. Historic England confirmed that most traditional buildings are made of permeable materials and do not incorporate the barriers to external moisture such as cavities, rain-screens, damp-proof courses, vapour barriers and membranes which are standard in modern construction [34]. It was not until the Victorian period that architects and builders began to experiment with early damp-proof courses in solid wall construction. The earliest forms found in Victorian construction included "tar and sand, or hessian soaked in tar; more prestigious buildings sometimes included lead or cooper; however, this was considered a costly inclusion" [18]. The 1970s saw major advances in cavity wall construction that were so significant that the same constructional practices apply today. Heightened scrutiny of the thermal performance of external walls resulted in changes in building regulations during the early 1970s. As a result, cavity insulation was a natural solution for builders and architects faced with this new requirement. By fitting insulation within the existing void, it was possible to conceal the insulation layer while also minimising any increases in the thickness of the external walls [35]. The materials used in the construction of cavity walls also changed during this period. The use of concrete blocks was popularised due, in part, to the speed of construction: concrete blocks measure the same length as two bricks and the height of three bricks with 10 mm mortar joints, resulting in faster build times [36].

2.6. Masonry Construction: Value and Benefits

The benefits of masonry construction are well known within the construction industry, and it is considered a treasured building method by many. Perhaps the greatest strength of masonry construction is its longevity [10]. The exact life span of brick construction is not recorded and will undoubtedly vary depending on the quality of craftsmanship involved in the original construction. Adaptability is another major contributor to the popularity of masonry construction. Unlike timber-framed buildings which are precision engineered and difficult to adapt onsite as a result. Bricks benefit from being forgiving and can easily deal with any discrepancies in foundations, levels, or measurements. This also means that they will accommodate any changes in the design as the building evolves [37]. The Brick Association comment further on the ease of adaptability; when looking at the re-use of an existing structure, adapting the functionality from commercial to residential and vice versa is also easier than modular forms of construction [38]. Another benefit of masonry construction is fire protection which is considered particularly poignant in the construction sector in the wake of disasters such as Grenfell Tower [39]. The exceptional fire resistance and durability of brick are accepted amongst many construction professionals as being one of the finest fire-resistant building materials. This is particularly significant to developers looking to build semi-detached, terraced or apartment-style properties where the risk of fire spreading is heightened. It is confirmed that there are no special measures required for masonry buildings during construction regarding fire risk, whereas there are extensive measures for timber buildings [40]. In summary, it can be stated that masonry construction within UK residential construction was driven as a result of timber shortages [9]. The adaptability and longevity of masonry are considered more beneficial when looking at the whole lifecycle considerations; however, in spite of all the highlighted values, a number of challenges face masonry construction, which will be explained in the next section.

2.7. Masonry Construction: Issues and Complexities

Whilst the advantages of masonry construction have been considered, it is essential to reflect on any disadvantages. Firstly, when compared with timber-framed construction, traditional masonry construction is comparatively slow. One of the main contributors to the increased time associated with masonry construction is the labour-intensive process involved with this form of construction. An article published in the *Financial Times* entitled "where have all the bricklayers gone?" confirmed that construction companies are finding it increasingly hard to support professional bricklayers and other skilled workers [41]. Moreover, another report highlighted that the skilled labour shortage will likely result in a decrease of 20–25% in the workforce over the next decade. The Federation of Master Builders stated that 38% of its members had reported bricklayer shortages, up from 22% in the last quarter of 2020, and 34% were struggling to hire carpenters and joiners, up from 23% [24]. Another drawback of masonry construction is that it is weather-dependent; for instance, in cold weather, brickwork must be protected to not dry out fast during hot weather [32]. Rain is potentially the biggest threat to masonry construction in the UK due to the persistence of wet weather throughout the year. In 2020, there were approximately 170.5 days in which 1 mm or more of rain fell [42]. The result of such weather can have an adverse effect, not only structurally but also cosmetically, on brickwork. Efflorescent staining is the most common side effect of wet weather during construction and can be seen nationally. This efflorescent originated from excessive wetting or saturation of recently built brickwork.

2.8. Timber Frame vs. Masonry: An Insight into Sustainability

It is imperative that the UK housing sector be under increasing scrutiny, not only to produce more homes but also to improve the sustainability of new developments [6]. The Future Homes Standard will require new build homes to be future-proofed with low carbon heating and world-leading levels of energy efficiency [43]. As a result, developers are carefully considering material choices and construction methods and how they play during the whole building's lifecycle. This will be through assessing environmental impacts associated with all stages of a product's life from cradle to grave, which begins with the extraction of raw materials from the earth to create the product through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling [7].

On the one hand, it can be recognised that timber-framed construction may provide the most sustainable form of construction [8]. This is because timber frame housing has the lowest embodied CO_2 of any commercially available building material, helping to reduce the energy consumption of a large, detached house by up to 33% [44]. In fact, the RICS (2018) investigated the primitive stages of timber frame construction and claimed that the energy needed to convert trees into wood and, hence, into structural timber is significantly lower than that required by other structural materials such as steel and concrete, giving timber-framed houses a lower carbon footprint. On the other hand, the longevity of masonry construction cannot be ignored when considering the sustainability of UK building practices. Research conducted by the Concrete Centre found that "medium-weight and heavyweight masonry and concrete homes should have lower total energy consumption and CO_2 emissions over an assumed 100-year life than lightweight timber homes". However, the BRE Green Guide for specification challenges the effectiveness of assessing the longevity of masonry. The BRE Guide suggests that timber longevity is stretched to 60 years when evaluating the whole life environmental performance of buildings (Mundy, 2015). This approach evaluating the lifespan of timber is limited, especially acknowledging that buildings may have different lifespans [44]. The Green Homes Guide states that "new housing should be designed to last a minimum of 200 years". With this in mind, masonry would appear to be an ideal material in this respect as it is capable of lasting centuries [44,45].

It can be stated that the suitability of both timber frames and masonry as sustainable materials tends to be evaluated differently and independently. Each material is represented by numerous independent bodies such as the "Structural Timber Association" (TRADA) and "The Brick Development Association". However, each individual group forms a biased opinion of the sustainability of the preferred product. Similarly, from a developers' perspective, sustainability is compartmentalised into various factors such as economics, accessibility, and compliance. A more holistic view on sustainability considering changes to 'The Future Homes Standard Parts L and F', alongside matters such as social impact and longevity, should be considered. A report into UK construction by Savills UK stated that there is a need to improve energy efficiency and reduce the environmental impact of housing and housebuilding, which is a further driver of change [8]. In total, the UK appears to be committed to improve the energy performance of new homes with documents such as 'The Future Homes standard' and 'Net Zero' policies. However, there is a lack of comparative analysis of the environmental performance of the two materials.

Through the literature reviewed, it is evident that masonry construction is the dominant material used within the housing market. This can be reasoned by several factors but mainly accessibility and longevity. Timber frame, on the other hand, is perceived as one of the most sustainable materials utilised within the housing market, and timber frame-based houses have relatively quicker pace when it comes to speed of construction. Taking the above into account, it is difficult to predict an optimum decision for materials usage for housing in the UK, and existing data lack rigorous grounds to evidently support decisions by housing developers in the UK. Parameters including drivers of material choice by housing developers, build costs, longevity, consumer confidence and sustainability will support an overarching comparison, as these parameters impact housing projects throughout the whole life cycle. Therefore, this research will compare both timber frames and masonry in an attempt to support providing more informed decisions about material usage for the UK residential sector.

3. Research Methodology

For this research, and to provide more informed research outputs, a mixed-methods research methodology was adopted. This combined evidence using quantitative and qualitative methods, to provide a dynamic and negotiated reality and, equally, a fixed and measurable reality [46,47]. Mixed methods offer an advantage because construction covers both measurable data, such as build costs, but also developers' personal beliefs and preferences. For the nature of this research, opting for just a qualitative or quantitative approach could leave knowledge gaps and can result in a lack of solidified research outputs. The qualitative data was collected via semi-structured interviews with 5 UK-based housing developers from different regions within the UK. Initially, the top 10 (in terms of years of experience) housing developers were contacted, but only 5 agreed to participate in the study. The rationale behind targeting long-established housing developers is the level of awareness in terms of material usage, challenges associated with choice of materials and decisions taken over the years to cope with meeting housing demands. Aiming to provide more meaningful research outcomes, participants at the directorate level were targeted as they are expected to provide strategic views and insights, as well as the experience of material usage and potential complexities within the UK residential sector. The interviews allowed direct contact with principal decision makers involved within the UK housing sector: fundamentally, the people on the front line of UK house building. The interviews covered a cross-section of developers working in various geographical locations, sectors (public/private) and niches. This was to provide greater depth of information and to prevent bias gained by interviewing a limited part of the market [48]. In the context of this research, semi-structured interviews can provide the interviewer with more scope to expand on lines of response from the interviewee, leading to new lines of enquiry and greater richness of data. The main interview questions in this study were as below:

- From your experience, what has been the dominant construction method adopted by your organisation within the residential scheme?
- Based on the projects executed, could you explain why masonry construction is the main construction method adopted in the residential sector?
- In your opinion, what role does longevity or consumer confidence play when selecting materials for residential projects?
- In your organisation, how are managing the integration of Net Zero standards, and achieving sustainability targets?
- Looking at the current situation within the housing market, what is your view in terms material selection process, say within the next 5 years?

In addition to the qualitative data collected, the research used quantitative data through collecting build costs based on the design and layout of a Permian Cottage designed by one of the involved developers in the study. The costs were broken down into both labour and material costs associated with the two forms of construction: timber frame and masonry. The build costs were produced by qualified quantity surveyors, whereas dwelling/plans were provided by an architect firm. Both the qualified quantity surveyor and the architecture firm were involved in the development of a new housing project planned by the selected housing developer. It is important to indicate that access to both the quantity surveyor and the architecture firm was provided by the housing developer. It is essential to use the same dwelling/plans to achieve unbiased results and a true comparison of build costs, with the only variation being two principal methods of construction method used. The emphasis was placed on the collection of numerical data, the summary of those data and the drawing of inferences from the data. The research design process is illustrated in the diagram below for further clarity (See Figure 1).

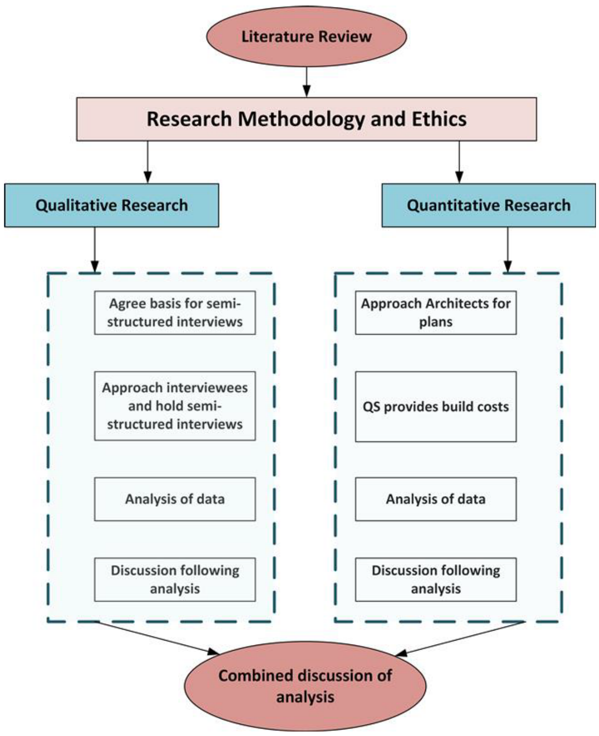

Figure 1. Research Design Process.

4. Results and Analysis

4.1. Analysis of Build Cost (Quantitative Data)

To provide more informed and logical outcomes from this research, build costs were used as one of the main indicators to compare timber frames and masonry. The study has chosen one of the dwellings to provide comparative measures between masonry and timber frame using build costs (See Figure 2). The build cost consisted of labour, material and build time costs. The cost information was obtained from a surveying firm and supplemented by the housing development firm. The below tables (See Tables 1 and 2), respectively, provide build cost and build time and a breakdown of shell construction according to the material's type. Due to confidentiality issues related to the cost data, the full breakdown of built cost and time is not provided by this paper.

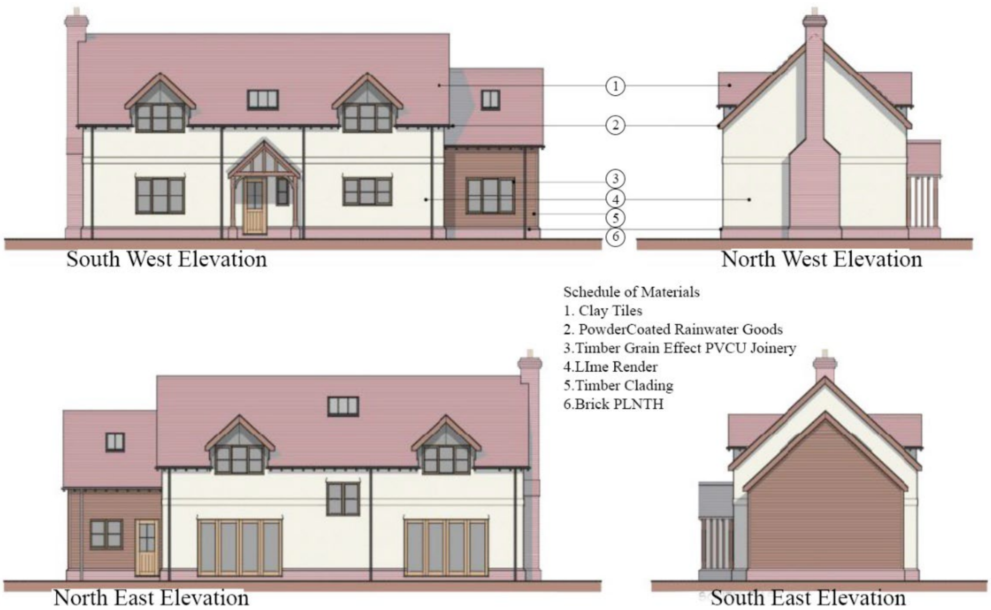

Figure 2. The dwelling selected in this study to conduct the comparison between timber frame and masonry.

Table 1 highlights the overall build cost for both construction methods along with material/labour costs and build duration. The table highlights masonry construction as being the most cost-effective building method, not only from a labour perspective but also materially. This, however, contradicts with some of the findings by the industry who highlighted that using timber frame has 2.8% cost savings [23] and one of the main reasons for timbe frame to be recognised as a cost-effective solution is relying on unskilled site labour [27]. While Marshall's report presents a view on cost savings relating to labour that has not been wildly misplaced in the 8 years since publishing *The Construction of Houses*, the current report does provide evidence of an increase in labour costs associated with timber frame. The 2021 review suggested that timber frame labour costs are 1.13% higher than masonry labour costs and while this figure is marginal in the scheme of construction costs, it is significant when considered against the documented advantages of timber frames. In terms of estimated build schedules, the data revealed that build time was estimated to be 27 weeks for masonry and 26 weeks for timber frame. Although the build time is nearly the same between timber frame and masonry, it was stated that timber frame is 6–13 weeks quicker than masonry [23]. However, some of the main shortfalls that impacted build time for timber frame is the shortage of supply [49] and also those erected onsite (the situation in this study) when compared to Modular Units. Shortage of timber frame supply can also be a reason why the material cost was 18.19% higher than masonry. According to some reports, the cost of timber indeed increased by 80% during 2021. Elaborating further on material costs, Table 2 provides a breakdown of shell construction with respect to timber frame and masonry costs.

Table 1. Build cost and time comparison between timber frame and masonry.

Building Type by the Material Specification	Labour Cost	Material Cost	Build Time	Total Build Cost
Timber Frame	£136,319.70	£142,015.04	26 weeks	£278,334.74
Masonry	£134,781.48	£118,331.14	27 weeks	£253,334.74
The difference in cost/time by percentage	+1.13% (Timber Frame)	+18.19% (Timber Frame)	+3.77% (Masonry)	+9.49% (Timber Frame)

Table 2. Breakdown of shell construction by timber frame vs. masonry.

Timber Frame Cost Summary	Price	Masonry Cost Summary	Price
Scaffolding	£6187.62	Scaffolding	£6187.62
Enabling works	£1253.60	Enabling works	£1253.60
Excavations and foundations	£4632.63	Excavations and foundations	£4632.63
Drainage	£9353.95		
Foundation Masonry	£2306.90		
Brickworks	£5798.50		
Timber Frame manufactured kit	£25,905.00		
Timber Frame Erecting	£425.00		
Roof Carpentry	£3347.46	Roof Carpentry	£3347.46
Roof Covering	£9448.28	Roof Covering	£9448.28
Total Cost	£68,658.94	Total Cost	£48,703.00

Table 2 highlights a 34% price difference in timber frame materials associated with shell construction. There are several contributing factors which resulted in cost variation: firstly, timber frame construction involves 10 constructional steps compared to 8 required for masonry to reach the same shell stage. Secondly, each constructional step requires material and inevitable cost, and thirdly, the greatest cost associated with timber frame construction is, unremarkably, the manufacture of a timber frame kit which equates to 37.72% of the overall shell material cost. It is important to indicate that, in addition to the above costs, timber frame and masonry involve a further 18 itemise stages of construction past the load-bearing shell. It can be concluded that, cost variation is one of the vital indicators when considering the choice of material for residential developments. The next section will support a further comparison between timber frame and masonry.

4.2. Thematic Analysis (Qualitative Data)

In this section, the results from the five semi-structured interviews are presented and analysed to provide a clear picture of the results and assist in producing an informed conclusion. All participants opted to remain anonymous. As a result, interviewees are referred to by numbers (e.g., Interviewee 1). Table 3 provides a brief introduction to the interviewees with specifics linking the individuals to their organisation removed. As mentioned in the methodology, participants at the directorate level were selected as this would provide a more holistic perception of strategic decisions within the residential sector in the UK, and this includes informed justification of material selection.

Table 3. Interviewees' backgrounds, organisations and positions.

Interviewee #	Background	Position
1	A leading housing authority producing over 1000 new homes/year, while maintaining a portfolio of over 60,000 homes	Construction and Technical Director
2	A leading housing authority responsible for one of the largest new-build affordable home schemes in the UK, approaching 6000 new homes	Planning and Technical Director
3	A small development company producing up to 50 high-quality homes/year, for sale on the open market	Director, head of development
4	A nationwide housing developer, homes are predominately for sale on the open market along with limited affordable housing	Director
5	A small-scale family development firm producing between 5–10 homes/year, for sale on the open market	Director

4.2.1. Timber Frame vs. Masonry: Material Choice and Drivers

Based on the responses received from participants, the results showed that interviewees 3 and 5 both produced predominately timber-framed homes. It should be considered that interviewees 3 and 5 represent the smallest in terms of dwellings created per annum, yet both build entirely from timber frames. Interviewee 3 states "*the sites are fairly bespoke and include up to 10 dwellings. We opt almost exclusively for timber frame as a construction method*". In comparison, interviewees 1, 2 and 4 are larger organisations but collectively adopt a masonry build approach. Interviewee 1 claims to build 20% timber frame which is very similar to interviewee 2's organisation, which, to quote "*reports only 15% of properties constructed have been timber-framed*". Analysing the results suggests that interviewee 4 builds the highest percentage of masonry homes at approximately 90%. However, interestingly, interviewee 4 states "*we do build some timber-framed homes, generally to front sites in busy locations*". While it appears that there is a correlation between the volume of dwellings created and material choice, it is essential to understand the drivers behind the organisation's preference. Clearly, the above statement from interviewee 4 suggested that there is a method behind the organisation's build strategies.

To establish why the five organisations adopted their chosen build route, the key drivers associated with the two material choices must be established. The key drivers have been established by analysing the results of the semi-structured interviews and past literature. According to interviewees 3 and 5, both build exclusively with timber frames and produce the lowest volume of homes of the five interviewees. Speed of construction has proven to be a major driver for their material choice: interviewee 5 said "*timber frame allows us to build quickly and accurately*". However, interviewee 4, responsible for the largest volume of new build homes, also highlighted the speed of timber frame construction as a key driver of material selection. Interviewee 4 suggested the organisation opts for a limited volume of timber-framed homes. Interviewee 4 explains the reasoning behind this "*by fronting the site with timber-framed homes, particularly on busy roadside locations we can produce a pleasant appearance quickly*". There is a strong link between the speed of timber-framed construction and cash flow with interviewees 3 and 5. Smaller companies relying heavily on bank-based borrowing require shorter construction times to repay lending and improve cash flow. This is highlighted by interviewee 3 when saying "*often plots are presold meaning the incentive is to build quickly to recycle capital*". Interviewee 5 confirms like-minded views when stating "we borrow funds generally on a 12-month basis meaning that site turnaround is important". However, there is a considerable difference between the two smaller developers (3 & 5) and the three larger developers (1, 2 & 4) when considering cash flow related to material selection. As highlighted, it appears that interviewees 3 and 5 used timber frame construction to speed up construction, therefore, quickening cash flow and site turnaround. It can be stated that this decision is based heavily on borrowing costs; as indicated by interviewee 5, the developers appear to borrow funds on a short-term basis. Yet, it would appear that interviewees, 2 and 3 use masonry construction to deliberately slow cash flow on larger sites. Looking at these data in greater detail it was uncovered that the larger developers associated timber frames with high cash flow, largely associated with the frame or shell construction. Unlike masonry, which is a slow and labour-intensive form of building, timber frame arrives onsite and is erected in one phase, resulting in high capital output for the developer in a short time frame. Interviewee 2 commented on the impact of timber frames on cash flow prior to erection when stating "*from a financial point of view timber-framed construction is heavy on cash flow, the frames are expensive and usually require 30–40% down payments*".

The developers suggested timber frame offered limited benefits if the time gained in construction was lost in lead time between build completion and occupancy. In fact, Interviewees 1, 2 and 4 shared a similar opinion; for instance, interviewee 1 stated "*supply and demand must always be considered, we don't want finished homes unoccupied*". This opinion was echoed by interviewee 2 who commented "*homes are produced slowly but in line with sales improving cash flow*". The link between material, cash flow and speed of development was perhaps best summarised by interviewee 4: "*we can also dictate the speed of development more with masonry by simply applying more labour to build quickly or reduce labour if properties are selling slowly*". The availability of labour and the cost of materials influences the three larger developers' (1, 2 & 4) build route preference. For instance, interviewee 2 commented "*brickwork is well practised in the UK, although numbers of bricklayers are declining it is still easy to find contractors willing to work in traditional masonry construction*". Similarly, interviewee 1 shared views on the difficulty of adapting build routes with contractors when stating "*we have certainly found contractors reluctant to move away from their established build methods which make embracing timber-framed technology difficult*". This highlighted a potential shortfall in UK workforce labour skills with larger developers unable to recruit contractors willing to work outside their predetermined skill set. The smaller developers (3 and 5) did not comment on the availability of labour. Interviewees 1, 2 and 4 all highlighted material costs as a key driver involved in the build route decision process. Interviewee 2 captured the view of the three larger developers when stating "*masonry construction costs do not vary greatly, we can build nationwide for similar rates. Timber prices are far more volatile, currently prices are 60–80% up during 2020*". Interviewee 1 discussed profit margins related to material selection, stating "developers work on as little as 20% profits, any increase in build cost can have catastrophic effects on the viability of a site". Interestingly the high material cost associated with timber appears to be accepted by the smaller developers with interviewee 3, stating "we accept that the cost may be higher than brick and block construction, but cash flow is greater providing build times are reduced". This again demonstrates that smaller developers value the speed of construction offered by timber-frame. One of the drivers highlighted was energy efficiency, where interviewees elaborated on the level of importance of such a driver when selecting a material. Only interviewees 2 and 5 believed energy compliance is a driver behind the material selection. Interviewee 5 commented "*our preferred timber frame supplier has in-house SAP assessors meaning that frames arrive pre-insulated and totally compliant*". Interestingly, energy compliance was not considered a key driver by the three larger developers that favour masonry construction. In summary, it can be stated that key drivers impacting the selection of materials between timber frames and masonry are the availability of labour/contractors, speed of construction, material cost, cash flow and limited impact of compliance with energy efficiency.

4.2.2. Timber Frame vs. Masonry: Longevity and Consumer Confidence

Longevity was a concern for interviewees 1 and 2, both build predominately masonry homes and revealed that they consider the longevity of construction. Interestingly, interviewees, 1 and 2 are both housing associations, meaning that most of the built property is retained. As a result, longevity is important because the retained dwelling becomes an asset to the organisation. Aside from asset value, maintenance must be considered. If the dwellings are going to be retained for several years, the costs associated with upkeep may become a problem if material longevity is poor. Interviewee 2 comments on the masonry homes constructed by their organisation "*most homes providing the standard of workmanship are reasonable will not require a great deal of maintenance for 80 years or more*". Similarly, interviewee 1 highlights why they opt for masonry construction when considering longevity "*timber-framed homes are known to last far longer than the 15–25 year guarantee their exact life expectancy is not documented. We feel more secure with masonry construction*". It is apparent that interviewees 3, 4 and 5 have little interest in longevity but are constructs solely for sale on the open market. The result of this is the developer releases the asset without consideration for future costs associated with maintenance. Interviewee 5 highlights this feeling when commenting on longevity by stating "it is not something which concerns me".

In relation to consumer confidence, all but interviewee 2 made comments on offering a third-build guarantee. Build guarantees or structural warranties allow the homeowner to claim against the warranty provider for any covered defect within the policy cover period, generally between 8 and 10 years. The developers look at structural warranties as a way of reassuring purchasers of the build quality. This is highlighted by interviewee 5 when stating "*the structural warranty provides peace of mind for the purchasers, it almost acts as a safety net*". Interestingly interviewees 2, 3, 4 and 5 all alluded to the issues associated with early timber frame. It would, however, seem that the poor media associated with timber frames is no longer a threat to developers, perhaps in part due to the build warranties offered on new homes. Interviewee 3 whose organisation build predominately timber-framed homes was quick to dismiss any lack of consumer confidence when stating "*we have never experienced a problem with consumer confidence*". These views were echoed by interviewee P4 when stating "*I know during the 70s timber frame had a bad reputation amongst major house builders. Times have changed now; I strongly believe people have moved on*". The next section elaborates on these responses in relation to sustainability.

4.2.3. Timber Frame vs. Masonry: Insight into Sustainability

The interviewees were asked how their organisations are dealing with sustainability largely from an energy performance perspective. A common theme amongst the five interviewees is that sustainability compliance is not easy. To quote interviewee 3 when asked about suitability compliance "*truthfully, we find energy-related compliance very taxing*". It should be considered that interviewees 1 and 2, both of whom represent housing associations, have wholeheartedly embraced climate compliance. Interviewees 1 and 2 are not only improving existing build methods to comply but are looking to enhance policy expectations. Interviewee 1 highlighted this when stating "*we have been working closely with the Brick Development Association to improve the thermal performance of our builds to not only meet current guidelines but exceed*". Interestingly, both have commented on looking outside of their preferred construction method to improve the sustainability of their developments. It seems that MMC (modern methods of construction) is beginning to spark interest mainly due to the sustainable options it offers. Interviewee 2 comments on their organisation's view of MMC when stating "*we are investing heavily in the potential of MMC. We consider MMC to be at the forefront of suitable design*". This theory is reiterated by interviewee 1 when confirming "*we are actively embracing MMC and have run a number of pilot schemes*". Contrastingly the 3 developers (3, 4 and 5) that construct predominately for sales on the open market appeared to see energy-related compliance as a necessary component. This is linked both to material cost and time associated with meeting regulations. Interestingly, interviewee 4 who represents an organisation building predominately masonry homes highlighted the effect energy compliance is having on the construction of cavity walls and foundation widths. Interviewee 4 stated "wider cavity walls and more insulation requires deeper and wider footings which increase labour and material cost of constriction". The two smaller developers, interviewees 3 and 5 appear to tackle the issue by outsourcing energy compliance to the chosen timber frame suppliers. When questioned, interviewee 3 confirmed the reason for outsourcing "*we avoid any costly mistakes on site by ensuring the frames arrive fully insulated and compliant with current building regulations*". It is evident that interviewees 3 and 5, both operating smaller businesses, simply do not have the time or capacity to invest in energy-related compliance, whereas the three larger developers (1, 2 and 4) have increased capacity to overcome any difficulties associated with meeting regulations. This is highlighted by interviewee 4 when stating "*we now have a team committed solely to energy performance regulations*".

4.2.4. Timber Frame vs. Masonry: Five-Year View

The final question in the semi-structured interview process was aimed at obtaining a view of the developer's 5-year material construction plan, with the view of highlighting any likely changes in organisation build routes. Interviewees 1 and 2 alluded to showing interest in MMC, as covered in the previous section on sustainability. The developers consider MMC not just from an energy efficiency basis but by capitalising on other attributes offered by this emerging form of construction. Interviewee 1 provides a great insight into the organisation's view on MMC when stating "*it is likely to offer greater site accuracy and lower volumes of labour*". Although both interviewees 1 and 2 admit to showing interest in embracing MMC within their 5-year construction plans, both are not willing to accept a wholesale shift in the build process. There is further common ground, with both developers looking to substitute the limited volume of timber-framed homes currently produced in favour of MMC. This is highlighted by interviewee 2 when stating "*timber frame will be phased out initially in favour of MMC*". Both developers are willing to sacrifice timber frames to maintain masonry construction during a phased programme incorporating MMC.

Comparatively, developers 3, 4 and 5 are unlikely to embrace change in their current preferred build methods within the next 5 years. Interviewee 4 highlighted a reluctance to change when saying "*you have to understand construction moves slowly and as a company, we are hesitant to welcome change*". Interviewee 4 was questioned on whether MMC would be considered if the change was implemented. The response highlighted further awareness of MMC but a reluctance to accept its position within their 5-year plan. The two smaller developers (3 and 5) provided a clear response that they would not be willing to consider change within the next 5 years. Unsurprisingly, interviewee 3 mentioned the company would be price led when stating "the only reason for the change is a cost". The overriding feeling between interviewees 3 and 5 appeared to be why change a process that currently works and is profitable. This view is summarised by interviewee 5 who stated "*we will stick with what we know*".

4.2.5. Summary and Highlights

The data analysed from the semi-structure interviews showed that masonry can be recognised as the dominant material choice among larger developers. Cash flow associated with masonry seems to be a leading driver, with developers seeming to want to slow down construction to improve cash flow and meet the rate of end user occupancy. This is one of the most interesting findings. It appears the developers are actively slowing down new home production to benefit business cash flow. Comparatively, those committed to timber-framed construction appeared to be smaller developers. Cash flow was again the key driver, but from the perspective of speeding site completion and limiting bank borrowing. The increasing energy compliance associated with new homes seemed to push smaller developers towards timber-framed construction. The ease of in-house SAP calculations and fully insulated frames appeared to be a benefit during a period of regulation change. However, the two housing associations both suggested looking at MMC when questioned on suitability. The interest in MMC was not solely associated with energy efficiency but was linked to lower labour rates and increased site efficiency. Looking at the 5-year plan, it seems only the two housing associations will consider change, whilst the majority will continue to build in the same fashion. While developers may be aware of new and improving technology, they are not willing to embrace change. This again might help to highlight why the UK is falling considerably short of its 300,000 new homes a year target.

5. Discussion and Practical Implications

5.1. Timber Frame or Masonry: Can Decisions Be Backed Up?

The analysis of build costs associated with masonry and timber-framed construction, along with the semi-structured interviews, will assist in substantiating an informed opinion of the UK residential sector. The build cost analysis highlighted a clear cost-associated benefit with masonry construction with evidence of a 9.49% total saving. This appeared to be echoed by interviewees 1, 2 and 4. Interviewee 1 highlighted the developer's views when stating "*cost, is our biggest consideration*." Interviewee 1 continued to confirm that "*developers work on as little as 20% profits*", which is perhaps one of the most crucial segments of data. The review of material cost in Section 4.1 provided clear evidence that timber frame shell construction was the single largest contributor to cost difference between build routes. Timber frame shell construction came out 34% more than masonry during shell construction. Reviewing the semi-structured interviewees highlights this high-cost output is acting as a deterrent to larger developers. The high material cost associated with a relatively early phase of construction is taxing on developers' cash flow. Comparatively, masonry is less strenuous on cash flow. Interviewee 2 highlighted these views when stating "*timber-framed construction is heavy on cash flow, the frames are expensive and usually require 30–40% down payments*". The two smaller developers (3 and 5) both build predominately timber frame homes and appear to value the speed of construction and the associated faster cash flow offered by timber frames. However, reviewing the build cost data highlights only a marginal build time difference between the two material choices. Timber frame offered a 3.77% increase in build speed compared to masonry. It is difficult to imagine that interviewees 3 and 5 put such value on a 3.77% build time advantage when the overall build cost difference is 9.49%. It is perhaps not out of the question that the data used in the build cost analysis are more current than the developers' perceived timesaving. Essentially, if interviewees 3 and 5 have not ordered timber frames within the last 8–12 months due to finishing existing sites, they may be unaware of current material shortages, resulting in longer timber frame lead times. This may be linked to meeting the housing gap, which was indicated by Gompertz (2020), who indicated that it could take up to 15 years to close such a gap [12]. The smaller developers are, however, happy to accept higher build costs associated with timber frames. Interviewee 3 states "*we accept that the cost may be higher than brick and block construction*". However, for large housing developers, timber frames may not be the optimum choice due to supply shortages. This could perhaps explain why masonry was recognised as the dominant material choice amongst larger developers, which fits with the RICS view that masonry construction accounts for approximately 65% of the market [9]. This, although aligned with the view of three large developers, reaching the target of 300,000 homes per year [50], seems to be complex even with the choice of fast-paced material such as masonry. It is accepted that regardless of the preferred build route, energy-related compliance was challenging. Yet, the build cost analysis shows only a 5.9% cost difference associated with energy compliance. Clearly, the difficulty is not a matter of cost but more of understanding regulations and ensuring new builds are compliant. The mixed methods of research have helped to link the developer's thought process with accurate build cost data to provide a greater understanding of UK house building.

5.2. UK Residential Sector: Decisions for the Future

The report has highlighted several pushes and pull factors associated with both materials. The "15.4%" in the 6 months to March 2021 price inflation provides the perfect push factor for UK developers to continue to shy away from embracing timber frames [51]. As covered in Section 5, the UK is beholden to Europe, with "42%" of sawn timber imports coming from Sweden alone. The semi-structured interviews highlighted that UK developers' margins are too slim to embrace material price inflation and, as a result, the larger UK developers are currently priced out of the European timber market. Further investigation in MMC promoted by responses from interviewees 1 and 2 has highlighted a European influx in the UK house building market. Furniture conglomerate Ikea has merged with Skanska "one of the world's leading project development and construction groups" [52]. The RICS recognises that MMC has the potential to speed up delivery, improve productivity and modernise the sector [9]. This, however, would appear to differ from UK developers' view on building methods and perhaps highlights that the UK is slow in embracing European sustainable building methods. The carbon footprint of Boklok developments, as one of the housing developers, for instance, is less than half that of normal building projects [53]. Developments have already been completed in Bristol and Worthing, with further expansions planned.

It could perhaps be considered that UK Developers are somewhat stuck in a cycle of maximising profits, achieving the minimum climate compliance, and continuing with traditional construction methods. A quote from Interviewee 4 highlights this "As a developer, we are trying to maximise profits, we will ensure the properties are compliant but not push the boundaries because it will begin to affect profit margins". It is likely that this movement of European developers to the UK producing factory-finished homes is set to continue with the likes of Boklok actively pursuing the UK Market. The UK developers will have to be mindful of the continuing awareness of sustainability values if they are to maintain a stronghold against European building practices. An improved synergy between both European developers, such as Boklok, and UK developers building largely with traditional methods could be beneficial to the UK market, not only from a delivery but also from an environmental perspective. However, in the short term, it would appear that UK developers, unless based within the social sector, are largely dismissive of MMC despite its widespread European popularity. Therefore, to holistically recognise complexities in housing projects, it is essential for housing developers to draw more emphasis toward the supply chain through engaging key stakeholders to provide more informed decisions. With reference to findings from this study and recognising that cost forms a major concern to most housing developers, more of an emphasis on supply chain will support the more tangible recognition of costs associated throughout the whole lifecycle, and, more importantly, would maximise value integration [54] in the project. Key stakeholders include architects, quantity surveyors, building surveyors and even potential building occupants. Although many housing developers have begun to move toward Modular Units to boost the speed of building, they often do not undergo careful cost considerations, and mostly focus on speed of productivity to deliver the required units. Findings from this study, therefore, can support informing architects' designs, and, more importantly, motivate more integration of quantity surveyors to consider cost throughout the whole lifecycle. It is important to highlight that reaching Net Zero carbon houses will remain as one of the ultimate focuses in housing projects. To do so, it is essential that policies underlying Zero Carbon emissions to be governed, and for architects, developers and clients to tangibly include environmental measures as part of their housing scheme. Although this may impose more challenges at current times where the focus is to meet housing targets, it will support improved longevity and more sustainable infrastructure for the future.

6. Conclusions and Future Work

To sum up, this research has assisted in providing a comparative analysis of the application of timber frame and masonry construction in the UK residential sector: a comparative analysis of existing literature and new primary data covering both cost and material preference. This research has highlighted key drivers associated with the build route. The potential challenges faced by the materials and subsequent market direction have been showcased and analysed to provide an informed decision on the direction of the UK residential market. Reviewing the current literature and analysis of data, it is difficult to see masonry losing its dominance over the UK market within the next 5 years. However, this is not necessarily a positive for the UK residential sector. The UK housing crisis continues to grow due to the UK construction sector's inability to meet government targets of 300,000 new homes a year. Yet, this report has highlighted developers actively using masonry construction to slow down build rates to improve cash flow. Falling labour rates are perhaps the greatest threat to continued growth in UK masonry construction.

The future for timber-framed construction is complex. Timber frame was set to become a major contributor to the UK housing market following the boom years in the late 1970s and early 1980s. Yet, the suppression caused by bad publicity in 1983 prevented the market from continuing to flourish. The evidence provided from the semi-structured interviews suggests consumer confidence, once knocked by poor publicity, is no longer a threat. The timber frame market is facing vast price inflation due to timber shortages and European imports. As a result, the price of timber frame construction is considerably higher than masonry; the report highlights a cost difference of 9.49%. Such a price difference makes it difficult to persuade developers to embrace timber frame construction. Considering the tendency of smaller developers keen to reduce build times appears unflustered by the price fluctuation, but inflation has not gone unnoticed by larger developers. The suggestion is that MMC is likely to replace a small percentage of the timber frame for some larger developers within the next 5 years. The extent of MMC uptake is yet to be seen by UK developers. It is, however, evident that European developers are taking interest in the UK construction market and beginning to infiltrate with factory-produced homes. This study, therefore, informs the existing body of knowledge in terms of the importance of providing further insights into the supply chain within the context of housing projects. In doing so, this will support informing future research to MMC for housing projects. Therefore, it is inevitable for housing developers to integrate key stakeholders as part of the whole lifecycle, as this will support recognising major costs, and, more importantly, provide more informed decision making. Although one of the primary focuses is meeting housing targets in the UK, providing a sustained and integrative supply chain is essential to the success of housing projects. More importantly, it will support accommodating modern techniques such as MMC, and potentially other technologies such as 3D-printing.

Future studies should provide a supply chain centred approach while integrating key stakeholders to unfold further complexities about housing projects. Another recommendation from this study is to gain further insights into the architects' view of optimum housing designs, their accountancy toward sustainability and what complexities impact their decisions. Simultaneously, it is essential to explore the level of integrating quantity surveyors in housing projects, and determine the complexities associated with costs. The research also uncovered the emergence of MMC within two interviewees' 5-year construction plans. This did not form part of the scope of this report and certainly provides the opportunity for further research. Future studies can incorporate a wider range of housing developers, and also look into different types of houses across different regions in the UK. This will enable integrating other factors such as geographical, landscape and social factors.

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