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1. Introduction

The subject of this chapter is to describe the study and clarify the concept. The chapter begins with a summary of the study's background, followed by an overview of the contemporary building processes and problems confronting construction firms in the United Kingdom. It concludes with a discussion of the study's aims and objectives, presenting an overview of the study technique as well as the thesis structure.

1.1 Background of research

Energy efficiency in the building economy is currently a top priority for energy planning at the regional, national, and global levels. In industrialised nations, the construction industry ranks among the top consumers of energy.

The maintenance of indoor climate and environments in buildings (BICE) uses between 30-40% of the world's energy. The availability of primary energy resources, social & economic conditions, focus on energy requirements, application of energy rules on buildings, as well as the climate, all affect this proportion differently from one country to another (Omrany et al., 2016). According to recent studies, the United States consumes a total of 41% primary demands of energy for building temperature control, which is close to 40% in the European Union. Several BICE proportions are suggested in the writings for China's overall primary consumption of energy. In 2007, 31% of primary energy was consumed by China to meet its BICE demand, according to the International Energy Agency (IEA) (Soares et al., 2013).

Furthermore, 27.5% of the nation's overall energy consumption in 2012 was used to power buildings. Zhang and others utilized a life cycle approach to determine how much energy is used by Chinese structures. It was found that buildings accounted for about 43% of China's overall energy use. Similar to this, it is well known that India's BICE consumes 47% of the nation's energy (Seyrek Şık et al., 2022).

The US government similarly plans to cut ozone depleting substance emanations by 80% by 2050 as a response to "the 2 °C guardrail," which was laid out by the Copenhagen Environment Culmination. Furthermore, US government regulation plans to bring down the energy utilization of new structures by 70% by 2020. (Süer and İlerisoy, 2022).

One of the main methods for lowering BICE energy consumption is to improve the thermal and energy performance of the building envelope. This improvement can be achieved by putting into practice strategies for active, passive, or mixed energy management. In recent years, passive tactics have become more and more prevalent. Ingenious plans have been put forth by scientists to improve the energy efficiency of building exterior components. An extensive technical review and enhancements related to BICE efficiency are covered in this article for the building envelope's wall component. This study focuses exclusively on the tactics used by the wall component. Additionally, energy-saving wall designs that are innovative are exhibited. This study provides a better understanding of such innovative approaches and is acknowledged as novel solutions for forthcoming building exterior trends (Luo et al., 2019).

Rationale of Research

Amplifying efficiency and saving electricity in buildings have been linked with sustainability during current years. Several innovative materials have been developed to implement energy efficiency in the hunt for sustainability (da Cunha & de Aguiar, 2020). The depletion of natural resources, economic uncertainty, global warming and health issues have led to the movements of sustainable development across the world. The contribution of prevailing buildings in concern to sustainability must not be underestimated (Soares et al., 2013).

The UK has some of the least and oldest energy-efficient housing standard in Europe and much architecture manage to enhance the energy efficiency of prevailing buildings which comes with its own sets of opportunities and challenges. While there has been substantial research on sustainable practices in the construction industries, there exist few studies on the challenges and opportunities for the provision of energy-efficient and durable exterior wall systems. The study aims to fill that gap and address the practices and challenges for facilitating durable and energy-efficient wall systems in the UK.

Aim of Research

The main aim of this study is to identify the key challenges and opportunities for improving the provision of energy-efficient exterior wall systems in the UK construction industry.

Objectives of Research

- To identify the challenges for enhancing the provision of energy-durable and energy-efficient wall systems in the UK construction industry.
- To identify the opportunities for improving energy efficiency and durable exterior wall systems in the UK construction industry.
- To evaluate sustainability in the UK construction sector
- To assess the practices for facilitating energy-efficient and durable exterior wall systems in the UK construction sector.

Structure of Research

This research consists of 5 chapter. Each chapter will specify certain knowledge and information. The five chapters are divided according to nature of information it includes.

The first chapter will be introduction. This chapter will include the background information available on the topic, research objectives, research questions, research aim and structure of the research.

The second chapter will be literature review. This chapter critically analyzes the past literature available on wall systems and their implementations.

The third chapter will be methodology. Methodology will highlight all the tools, techniques, and methods adopted by the researcher to carry out the research and draw results.

Fourth chapter will be analysis and results. This chapter will analyse the results and conclusions drawn after conducting the methodology.

Fifth chapter will be last chapter of the research. This chapter will be conclusion. It will conclude the research and results. This chapter will also include recommendations regarding future researches.

LITERATURE REVIEW

Introduction

A catastrophe is on the horizon for the United Kingdom as the gap between energy utilisation and availability continues to widen. Along with the growing demand for energy in the country, which has increased by 12% since 1990, the country's greenhouse gas emissions from diesel have also skyrocketed (Yüksek and Karadayi, 2017). The process of establishing and maintaining control over all aspects of a project's lifecycle, from the initial conception to the final evaluation, including the establishment of a scope, schedule, and budget, is referred to as project management. This process takes place during the course of managing a project. During the building process, which includes the planning and construction of external walls, efficient project management is important for the success of the endeavour (Wang et al., 2018). These days, project managers place a much greater reliance on environmentally favourable construction methods such as passive walls.

The present energy crisis is being caused by a number of factors, including the deterioration of existing infrastructure, the reduction of oil and diesel supplies from the North Sea, and increasing rates of energy consumption (Assimakopoulos et al., 2020). Building energy consumption has therefore converted into an international emphasis which necessitates further development in the UK construction sector.

Sustainability in the UK construction sector

According to Mavi et al., (2023), the global construction industry contributes an overall 13% of the gross domestic product (GDP). Also, construction and building account for the energy consumption of about 36% of the entire global energy and 39% of overall CO_2 emissions. Therefore, it is not astonishing that sustainability is the current agenda within the construction industry among different associates such as the government, academic community, business organisations, practitioners etc.

Massive stone edifices covered on the outside by a glass covering are known as trombe walls. These walls have the ability to absorb heat from the sun during the day and then release it later in the day when the sun has set inside the building. Walls constructed using the double-skin method have two pieces of glass with an empty space in between each one. This separation provides protection, which in turn reduces the expenses of heating and ventilation. Green wall systems make use of vegetation as a means of fortification and air conditioning as an alternative to the conventional systems, which is capable of both collecting and dissipating heat, later utilised in the construction of the walls of a PCM-enhanced structure.

Throughout this process, there is a need to consider different social, environmental, economic factors and the overall impact. The construction industry of the UK has helped in developing infrastructure and the overall quality of the people, however the exploitation of the natural environment can't be ignored. Sustainability is not only about addressing environmental impact, in fact it is regarding the enhancement of the well-being of the surrounding community. (Murtagh, 2019) has highlighted that the regulation & legislation proposed by the government effectively within construction projects in the UK, consisting of well planned construction projects with a lesser impact on the existing environment & community can be considered a sustainable approach. 31 The three pillars of sustainability such as social, environmental and economic aspects are expected by every operating organisation in the UK.

There is a huge pressure on the existing construction industry to change its conventional approach to achieve sustainability, since the overall energy consumption in the building process is 50% and the Co2 emission also adds up to 50%. In addition, consumption of water is about 12-16%, creating a huge waste which is about 19% of the overall nation's waste materials. Therefore, there is a need to initiate sustainable construction right from engineering, planning, regulation, procurement etc. The above identified flaws can be addressed & mitigated at the same time to conserve the natural resources for the future generations and benefit from them accordingly.

As reported by (Natividade, Cruz and Silva, 2022) the operations & maintenance of buildings largely consume energy and emit carbon accordingly with a huge environmental impact. The existing buildings in the EU represent an energy usage of 40% and emit 36% of greenhouse gases. Despite multiple alternatives, the rate of consumption and emission is increasing tremendously in the UK. Therefore, to tackle these challenges energy-efficient infrastructure can be developed, considering a careful design and development of the structure. The above discussion can be supported and discussed by the findings of (Shoubi et al., 2015) who have considered energy-efficient buildings as an approach to deal with negative environmental impact.

For instance, the thermal aspect of the overall construction of buildings can be considered since it's the major portion that consumes energy. The rate of the overall 88 consumption of energy and emission of gases depends on the environmental circumstances and design of the buildings. Therefore, appropriate action is expected to enhance overall performance where thermal insulation can be used to minimise heating along with cooling loads. This will effectively help in lowering excessive emissions of harmful gases since it reduces overall energy consumption (Cabral and Blanchet, 2021).

The major consideration here is the heating and cooling based on the climatic circumstances, hence it becomes necessary to create constructive solutions that provide advantages in lowering overall energy consumption throughout the project lifecycle. The entire construction project is expected to plan and monitor thoroughly by project managers to encourage an effective and sustainable approach.

Role of External Wall systems in Addressing Energy Crisis

The role of external obstacles in the process of finding a solution to the energy challenge is an extremely important one. The majority of the building's energy is lost through its external walls, having inefficient walls leads to an increase in financial spending on utilities; pollution caused by greenhouse gases increases, creating a less enjoyable environment. As a direct result, the planning and building of external walls have taken on an increasingly important role in context to an environmental friendly architecture.

"Passive walls" are a cutting-edge method of constructing external walls that help cut down on electricity costs. These walls are constructed using organic materials and passive design principles, giving them the name "passive walls." Passive walls do not actively absorb or emit heat. Their function is to restrict the amount of heat transmitted through the wall system, which in turn reduces the need for heating, ventilation, and air conditioning (HVAC) systems within the building.

On the other hand, conventional external wall systems (masonry or concrete) have inadequate insulation values and high thermal mass, demanding a greater amount of electricity to operate heating and cooling equipment. According to studies, passive walls can reduce energy consumption by as much as 90% when compared to traditional external walls, making them a practical solution to the problem of excessive energy consumption. It is imperative that passive walls be incorporated into the planning and construction of structures given the severity of the present energy crisis.

Types of External Wall Systems

Buildings are among the largest consumers of energy and contributors to greenhouse gas emissions, while Exterior walls play an important role in reducing the energy requirements of buildings. The quantity of heat, light, and oxygen that is allowed to penetrate a structure from the outside is regulated by the building's exterior walls and roof. It is possible to cut down on the amount of energy needed to heat, chill, and illuminate a building by using walls that either surround the building, provide ventilation, or walls that do both of these things (Cabral and Blanchet, 2021).

1. ***Trombe Wall Systems***

The Trombe wall, which is also called Storage Wall or Solar Heating Wall (SHW), was invented by Edward S. Morse in 1881, refined by Felix Trombe and Jacques Michel in the 1960 Binggeli et al. It is a huge vertical construction made of stone, masonry, or concrete with high inertia and a black coloured layer placed for glazing. It captures solar rays, naturally convicting some heat energy into the structure via the solar chimney created by the windows on one side and the wall on the other. To boost stability through the ‘solar chimney,' two openings, each at the bottom and top of the glass frame are added. The heat-absorbing black wall, has two apertures to enable ventilation to the interior via thermosiphon. The stack effect (the main propelling force of natural airflow) is increased by entering solar energy through the window, further increasing air shifts between smokestack and interior (ji et al., 2013).

Effects of Trombe walls on BICE performance

Prior research has addressed different aspects of Trombe walls, such as heat storage characteristics, integrating Photo Voltaic system (PV) with them, cost analysis, and phase change materials (PCM). Boji et al. and Koyunbaba et al. conducted a research to analyse the performance of BIPV (Building Integrated Photovoltaic) Trombe wall integrated to the façade of a room in Izmir, Turkey. Results showed that the model was capable of increasing the building's thermal efficiency and enhancing the average daily electricity consumption. Krüger et al. analysed the heating/cooling potential of the system, and Briga-Sá et al. used a calculating methodology to analyse the energy performance of the wall based on ISO 13790: 2008 (E). The results showed that heating energy needs can be reduced by 16.36% and decreasing the impacts of Co2 emission.

2. ***Double skin façade wall systems***

Double-skin façade (DSF) refers to "a different type of envelope in which a second skin (usually transparent) is placed in front of a regular building façade" (Safer et al., 2005). It consists of a 'channel', a hollow area between the exterior & interior epidermis which is aired to reduce temperature problems in the summer and add to energy savings in the winter. The idea was first proposed in the early 1900s, made a little headway until the 1990s but has grown in popularity in recent years. DSF is a building façade with numerous glass panels that covers one or more floors. The space between the façade's layers can be impermeable or naturally/mechanically vented. The exterior layer is typically a single toughened sheet that is completely glazed. In most uses, the interior layer is a protective double-glazing but not necessarily completely opaque. The optimal breadth for the space between the two layers is between 200 mm and more than 2 m. The air tightened DSF improves building thermal protection while decreasing heat loss during the cold (Chan et al., 2009).

Effects of Double skin façade walls

Chan investigated the energy efficiency of a DSF applied to a normal Hong Kong workplace, while Xu et al. suggested a DSF for a two-storey domestic structure in Kitakyushu, Japan. Joe et al. quantified the effect of original DSF design variables such as window glass type and hollow depth on the energy usage of neighbouring conditioned zones. The results revealed that the variance in energy consumption happened when the glass type on the outside surface of the interior layer varied, and energy consumption dropped when the hollow depth of the DSF was reduced.

Charron et al. investigated the efficacy of DSF combined with PV and motorised shutters. The results revealed that putting the blind in the centre of the hollow can improve the efficiency of the viewing portion by 5% and optimising the performance of the façade contributing to an increase in energy efficiency of more than 60%. When compared to a triple-glazed façade with no air movement between the glazing's, Energy Plus projected a 3% decrease in ventilation and heating demands with DSF. According to recent research, DSF can be enhanced by varying optimal depth of space, the use of glass systems, and the merging of DSF and PV systems.

3. ***Green wall system***

Green walls, also known as "vertical gardens", "green vertical systems," "vertical greenery systems (VGSs)," or "Bio walls" (Manso and Gomes 2015). One out of ten roofs in German cities, regarded as a pioneer in the implementation of ecological technologies, and 70% of flat roofed central city structures in Swiss towns (Yuen et al., 2005). Green systems are becoming more popular in Asia (nations such as Japan, Hong Kong, Singapore. Green systems are viable methods for restoring metropolitan areas due to their great environmental benefits and healing effects. Vertically clothed urban structures with verdant plants aid in the incorporation of flora into the urban environment without filling horizontal areas such as roadways.

Effects of Green wall system

Wong et al. investigated how vertical green systems impact building energy and environment. Vegetation on structure surfaces increases thermal effectiveness. TAS software created a potential ten-storey structure with substantial walls, seven openings per floor, and a complete glass top. Vertical vegetation devices were compared to circumstances, measuring the interior mean radiation temperature and cooling energy burden. Plants reduced heat transfer through concrete walls in a fictitious tropical home. A 100% vertical plant coating can also reduce the mean radiation temperature of a glass façade structure.

During the lowering period, Eumorfopoulou et al. examined the thermal characteristics of naked walls and walls with plant façades in Greece. This research looked at dynamic thermal characteristics and temperature variation, also discovering that covering walls with vegetation enhanced both interior & exterior thermal efficiency.

4. External Wall Insulation

In colder climates, like the UK, home insulation is one such economic way to maintain indoor temperatures by minimising heat leakage from the building. This insulation has the ability to save 46% of energy consumption and cut CO2 emissions by 41%, substantially decreasing the harmful ecological effect of buildings. It has been proven that this insulation reduces the energy consumption needed for home heating. There are different types of insulation, including loft, hollow wall, and solid wall insulation. EWI is an instance of the latter, whereby an additional layer of an insulating medium is added to the external walls of a structure. House insulation provides the convenience benefit of requiring little to no maintenance adjustments. It differs from more active energy efficiency measures such as wind turbines and solar PV panels, that are expensive to acquire, install and need very specific operating procedures. Furthermore, there is minimal chance for tampering and risk of breakdown. (Sara Lilley et. al, 2017)

Sara Lilley et. al, 2017 – add reference to his

CASE STUDY.

In addition, the qualitative interview survey is supported by a case study that perfectly aligns with the participant's viewpoints. The following case study examines how two social housing providers have adopted modern construction techniques to combat the UK's energy crisis.

Two social house builders based in the Northeast of England are engaged in an industry-revolutionary effort to promote these high-efficiency building technologies, with the aim of establishing them as viable mainstream alternatives to conventional building techniques. Together, they provided External wall insulation for more than 800 homes for the **local council**. The objective of the study was to assess the efficacy of EWI in a sample of properties in terms of both tenant satisfaction and property performance. The research employed both quantitative and qualitative data collection techniques, such as tenant interviews, regular metre readings, and temperature recording. A variety of post-World War II designs, including 3-bedroom Wimpey No Fines (both mid & end-terrace and flat roof), Wimpey No Fines maisonette, 1 bedroom Wimpey No Fines bungalow, 3-bedroom Dorran, and 3-bedroom BSIF (British Steel Frame) were initially identified for consideration in the study.

In the end, 11 properties were included in the first phase, which went from November 2015 to December 2016, and 8 properties were included in the second phase, which ran from January 2016 to February 2016. This was due to alterations in the construction schedule and difficulties in contacting tenants. Prior to the installation of EWI, tenant interviews were conducted to determine their environmental knowledge, attitudes, and behaviours, as well as their energy consumption and well-being. Regular metre readings were also obtained. Eight to ten months after the installation of EWI, follow-up interviews were conducted to assess the impact of the insulation on tenant satisfaction and property performance. Temperature monitoring and thermal imaging with infrared thermography were used to evaluate property performance prior to and after the installation of EWI.

The study found that EWI was effective for enhancing property performance, with temperature recording and thermal imaging indicating substantial reductions in heat loss and energy consumption. Tenants reported an increase in comfort along with a decrease in condensation and moisture. The study also identified some difficulties associated with the installation process, such as disruption to tenants' daily routine.

ANALYSIS OF THE CASE STUDY.

Value management

In this section, we will discuss all the factors that contributed to the project's increased value. It is essential for a project manager to evaluate the likelihood of the project's value increasing relative to the costs incurred. Let's examine the factors that have contributed to the increase in the project's value, as demonstrated in the above case study.

1. ***Thermal efficiency is better:*** As a result of installation, External wall system contributed to the heating of house, particularly during the colder part of day. Additionally, it made heating less necessary, which results in lower energy costs.
2. ***Greater ease of use:*** External wall system made homes more agreeable by working on warm proficiency. It kept homes cooler in the summer and warmer in the winter.

3. ***Reduced utility costs:*** Homes used less energy to maintain a comfortable temperature when external wall system was used to reduce heat loss.
4. ***A more appealing appearance:*** There are many different kinds of insulation, which can be finished with a variety of coatings. This can make a building look better, making it look more modern and appealing.
5. ***A rise in air quality:*** External wall system was able to better seal homes by preventing heat loss, keeping pollutants and allergens out.
6. ***A rise in the property's value:*** By lowering energy costs, increasing thermal efficiency, and enhancing the building's appearance, External wall system can raise a property's value.

Project manager value analysis: In this case of the property in question, strategic interventions and improvements have increased its value significantly. In addition to optimizing the thermal efficiency of the building, upgrading and modernizing the building systems, improving energy efficiency, improving aesthetics, and increasing functionality and usability, the buildings will also save energy and utility costs in the long run, thus placing it in a better position to succeed in the market and provide its stakeholders with an excellent return on investment.

Stakeholder management

The purpose of this section is to illustrate how a project manager interacts with stakeholders in specific situations by focusing on stakeholder management efforts and highlighting client interactions. In this case study, we examine the contractor-client relationship and the survey conducted to determine the tenant's environmental behaviours. Additionally, the survey aimed to understand the impact of the construction project on the appearance, health and wellbeing of the tenants.

1. **Environmental behaviours**

When asked if their energy bills were too high or too low, the tenants responded in either direction. During phase 1, five renters felt that their energy expenses were either excessively high or very high.

A little more than half of tenants at phase 1 said that if they had access to more information on this, they could use less energy. Some tenants claimed to have already done this by monitoring the meter and their monthly bills, and that they had discovered it to be effective in lowering the amount of energy used. The remaining renters felt that they could not use any less, either because they already

used as little energy as possible or because they thought that doing so would compromise their personal comfort and health. Following the installation of External wall systems

The motivations of residents for household energy conservation were looked into. The majority of respondents agreed that both were critical, however tenants at both phases said that saving money was more essential to them than protecting the environment.

All of the renters who gave information claimed to have experienced reductions in their energy bills ranging from 16 to 56 percent since the installation of the External wall system. The average reduction was roughly one-third, or little less than 33%. Tenants stated that they have saved money after the External wall system was built.

2. **Factors influencing behaviour:**

   The survey also sought to identify the factors that influenced the behaviour of the tenants. At phase 1, only two tenants cited efficiency as a consideration when purchasing large elec trical appliances, while cost was the most frequently cited factor by five individuals. By phase 2, six individuals regarded efficacy as one of the most crucial factors. This demonstrates the potential impact of awareness campaigns and education initiatives on the promotion of energy-saving behaviours.

3. **Other Outcomes:**

   In phase 1, just four respondents indicated satisfaction with the appearance of their dwellings; in phase 2, every tenant did the same. All tenants gave affirmative answers when asked whether the External wall system had any impact on the appearance of their home or that of other houses in the neighborhood, characterizing both as "much better," "nicer," and "clean and tidy."
   In phase 2, seven out of eight renters felt that the installation of the external wall system had enhanced their health and wellbeing. This was closely related to the rise in warmth, which improved the mood and comfort of the occupants and benefited two renters with arthritis. I'm not afraid to turn on the heat since it makes the prospect of paying much simpler, said one individual who said that spending less on heating their home made them feel less stressed.
   Another respondent claimed that the neighbourhood's transformation had improved their mood: During the summer, when they gleam, the houses are cheerier to look at.

This suggests that tenants in our construction project are receptive to energy-saving measures and willing to adopt them over time. The findings also indicate that the regular interactions with the tenants allowed the contractor to understand and emphasis on their requirements. Thus as a project manager one should continue to engage with tenants and provide education initiatives to promote sustainable behaviours and ensure that the construction project meets their needs and expectations.

Project scheduling

In order to schedule a project effectively, one needs a thorough understanding of the construction process and project requirements as well as strong communication and collaboration skills. Providing a well-organized project schedule ensures on time within budget while minimizing risks and maximizing productivity. This section examines the connection between project scheduling and project management. As a construction project manager, you are responsible for organizing, arranging, and executing the tasks, resources, and timelines necessary for a construction project to be completed on time, within budget, and in the required quality.

In light of the case study for the installation of EWI in 800 housing units, I will propose a preconstruction schedule for 100 housing units that is scaled down. This entire schedule spans eleven months and includes surveying, acquiring installation samples, procuring funds, and manufacturing.

Performance of Passive Walls against Traditional External Walls Systems

As mentioned earlier, a building's energy is wasted through its external walls. If the external walls of the building are not well insulated and sealed, then the cost of heating & cooling the building will increase for both the owner of the building and the residents (Yüksek and Karadayi, 2017). Therefore, increasing the planning and building of external walls within the context of environmentally friendly passive architecture. Passive walls are an innovative method of constructing external walls, cutting down on energy use by using natural materials and design principles that are inactive (Natividade et al., 2022).

Passive walls perform their function by restricting the amount of heat that can be transmitted through the wall system of the building, which in turn reduces the need for heating, ventilation, & air conditioning (HVAC) systems within the building itself. Insulation is generally installed within the wall space of a building to retain warm air during winter and keep out hot air during summer (Kiani Mavi et al., 2021). Limestone and concrete, two popular materials for external walls, both have a substantial heat density but inadequate insulation values. Masonry has a higher heat density than concrete (Santamouris and Vasilakopoulou, 2021).

The demand for electricity is expected to rise, that exerts more effort on heating & ventilation system (Yüksek and Karadayi, 2017). Homeowners installing passive walls saw a significant reduction in their monthly electricity costs. This is a problem that has been demonstrated to be solvable. According to the findings of recent studies, passive wall constructions consume up to

90% less energy than traditional buildings (Wang et al., 2018). Passive walls have a longer lifespan than traditional ones, which require fewer repairs & improvements with reduced adverse effect on the environment.

Benefits and Barriers of Passive Walls

There are numerous positive results associated with passive walls, which are an alternative to conventional external walls that are better for the environment and use less energy (Yüksek and Karadayi, 2017). The reduction in the electricity costs (for heating & cooling the house) and lowering the overall effect on the environment is a significant benefit. In addition, passive walls make life easier for inhabitants of a building, contributing to the maintenance of a constant temperature & humidity level inside the building throughout the entire year (Santamouris and Vasilakopoulou, 2021).

Passive walls are constructed to last for decades without requiring complex maintenance, in addition to having a pleasant appearance from an ornamental standpoint. Finally, passive walls are constructed from biological materials that don't off-gas any harmful substances, which results in a more wholesome environment inside the building. However, the widespread implementation of inactive barriers is still hampered by a few challenges (Misopoulos et al., 2019). One of the most significant challenge is the initial installation cost associated with them. It is possible that the original cost of installing passive walls will be more expensive than the cost of conventional wall systems. In addition, the construction & installation of passive walls could necessitate the use of specialised expertise, which would result in an increase in the cost of the task (Saud et al., 2022).

Another issue is the lack of awareness. The consumers, contractors, and managers all have a limited understanding of what passive walls are and how they work. Due to the low level of interest in these wall systems, their price increases while their availability decreases. Lastly, the need for local acquisition and the limited availability of native materials may have an impact on the scalability of passive walls (Natividade et al., 2022). Passive walls get good scores across the board for being eco-friendly, to save energy, and the level of gratification provision to residents. However, in order to promote their ubiquitous use in the building construction industry, it's necessary to overcome barriers by the acceptance of such high cost, need for instruction, and limited supply of resources (Santamouris and Vasilakopoulou, 2021).

Opportunities for enhancing the energy-efficient external wall systems in the UK Construction Industry

A comparative study undertaken by (Chippagiri et al., 2021) engrossed the energy and economic examination of conventional and innovative construction. From the sustainability standpoint, the end merchandises were a bio-based resolution for its efficient influence on dense discarded administration. The created end product resulted in the preservation of a warm atmosphere within the prototype homes, which can be unchanging, as well as adaptable to various climate unpredictability.

Construction of these wall systems economically can be deliberated costly, due to expenses associated with the transport, moulds and manufacture that are of huge amounts for a sole component but can be alleviated when built in giant figures.

The construction of external obstacles that are both energy-efficient & environmental friendly is necessary in the UK. If the building's external is correctly sealed, it is possible to reduce half the money spent on heating & cooling of the building. This leads to reduced levels of energy utilisation plus emissions caused by carbon dioxide. Green building denotes both the construction & application of techniques are ecologically conscious, with resource-efficiency all through the life sequence of a building: design, planning, construction, renovation, upkeep and demolition.

The concept of 3R: "Reduce, Recycle and Reuse", is to minimise the use of non-renewable energy to minimise the impact on the atmosphere, save energy and to reuse building materials during the refurbishment of old buildings. Many nations like the UK have implemented practices of green buildings that play a crucial role in architectural development. It demonstrates that building services denote HVAC structures, encompassing lighting, water heating, control management and electrical systems. HVAC is a chief apprehension since individuals devote approximately 80% of their phase in buildings, systems of HVAC represent 51% and 47.7% of the energy expended in office/residential buildings correspondingly.

One such strategy to minimise the impact of HVAC is through smart controls & technologies. Utilising thermally effectual materials to enhance HVAC such as, thermally vigorous building schemes and radiant ceilings for flexible building solutions engages in energy-efficient HVAC systems (Natividade et al., 2022). Actions such as window opening, increases air contact that magnifies heat consumption and higher energy expenses. Further, the weather (such as humidity, air temperature, wind speed, solar energy) also influences the building enterprise and construction circumstances.

Al-Tamimi (2022) performed an optimisation evaluation on a prototype sample villa, undertaking the yearly energy reserves as the main function and strategy parameters were set as the thermal lining. The result demonstrated that the extruded polystyrene XPS is the most cost-effective lining among conservative lining resources. The optimal lining layers resulted in the overall savings of 37.7% in hot-humid and 29.8% in hot-dry climates. Enhancing the energy efficiency of prevailing public buildings depended on mechanical approaches such as air & lighting acclimatising systems & smart building management systems. That being said, elevating the efficacy of building through retrofit & ordinary systems is still more effective for both prevailing and new buildings.

The usage of CLT (Cross Laminated Timber) is extremely concerted in Europe which holds approximately 95% of the entire marketplace. The material was also noted to be highly sustainable & durable at the same time offering simple assembling. The material can be assembled by three coatings of wood panels being stuck upright against one another under great pressure. The precise lifespan of a CLT building is unidentified since no building with the material has been in practice for more than 40 years, but there are prevailing timber houses that have been in use for over 700 years and the age of timber is well researched. Traditional timber structures and current concrete frameworks have a computed epoch of 100 years. The only issue of CLT lifetime is the aging of the adhesive employed between the timber layers. The airtightness of the material is comparable to a conservative building material leading to a highly energy-efficient structure, making it a suitable construction material.

Challenges for enhancing the provision of energy-efficient external wall systems in the UK Construction Industry

The use of fossil fuels to generate electricity is one of the primary contributors to global warming & climate change, in order to address the current energy crisis, the UK government is committed to the objectives of the Paris Declaration on Climate Change that aims for carbon neutrality by 2050. Regarding the construction of green structures, there is a lack of robust policy and limited awareness at the present time. Energy costs are escalating daily, and the construction industry consume over 30% of all energy produced (Anaokar, 2020).

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In the United Kingdom, one of the most significant contributors to the country's overall emissions of greenhouse gases is the energy industry, which is responsible for approximately 25% of all emissions. The major challenges faced by the construction sector are namely: overpopulation, increased demand, climate change, greenhouse gas emissions, urban overheating, high fossil fuel consumption (electricity generation).

From the evaluation of the thermal comfort of the residents, peaks in energy demand, and periods of tenancy of the environment, it would be probable to recognise opportunities for minimising energy consumption. Some of the features which can impact thermal circumstances are building orientation, energy levels, set point, climate, apartment size and fiscal factors.

In a study undertaken by Yüksek and Karadayi (2017), the outline of the building is a substantial element impacting heat damage & expansion that is described through geometric variables such as the building height/depth/length, bossage, type of roof and gradient. Buildings have a great potential for energy efficacy through conscious initiatives and regulations to enhance the effectiveness of buildings in the UK. Accurate energy-shielded landscape scheme for energy conservation are reliant on a region. Up to 90% of an individual's time is spent indoor in developed nations and 69% of this indoor time is spent at home. As a consequence, buildings are accountable for over 40% of the energy usage in Europe and even more in the UK, thus energy efficiency has become pivotal.

The building features of UK's prevailing housing encompass less insulation in floors, roofs, walls and single-glazed windows. The schemes of fabric incentives are yet to attain the full assortment of social & private housing. Through this study, retrofit procedures might not be as efficient as predicted owing to lack of monitoring, and poor quality of building installations which might amplify the use of heating after being refurbished. Irrespective to that, retrofitting is considered to be a chief element in attaining energy efficiency with significant redeemable potentials in the residential industry.

As stated by Hodgkin and Sasse (2022) the price of energy will rise further and remain higher for a longer period of time. The UK is specifically exposed to these price upsurges due to its reliance on gas compared to other nations, using it for heating buildings, industry supply and producing electricity. This reliance has deep roots that encompass the availability of gas in the North Sea and struggles to diversify the energy utilised for heating leading to swerving energy expenses. The awareness of the potential of energy efficient enhancement remains low and is considered to be of low priority as compared to other home improvements.

Assessing the practices for facilitating durable exterior energy-efficient wall systems in UK

The increase amount of energy efficiency in homes can help alleviate fuel poverty and bring down the cost of energy in the country. The government policy on energy efficiency is increasing and it is essential for decarbonizing the economy, eradicating fuel poverty, cutting the cost of energy for households, ensuring reliable energy sources, reducing the need for additional power plants, and increasing the amount of output that businesses produce. According to Bournas (2018), prior to the economic and financial catastrophe, the development of new housing structures increased more rapidly than that of non-housing buildings.

Construction outputs continue to decline significantly in the construction industry. In addition, the overabundance of structures in some associate states has impeded the construction of new structures. In recent years, building envelope code requirements have increased substantially and continue to expand in scope. With each revision in the UK, the building envelope principles have substantially enhanced, with an increased emphasis on energy maintenance. This necessitates the development of novel materials with thermal lining to achieve the lowest possible thermal diffusion value. Installation standards and craftsmanship can have a substantial effect on thermal diffusion. If lining is improperly installed with chilly bridges & voids, thermal transmittance can be significantly higher than expected leading to convection, conduction, radiation and eventually heat loss.

To provide assurance of a successful implementation, the application of quality control techniques is required. Regular maintenance of exterior wall systems is required to ensure their sustained efficacy. Before your items are returned to you, they will be inspected, cleaned, and repaired. To maximise the wall system's durability & performance throughout its lifecycle, the building's proprietors should devise a maintenance schedule and adhere to it regularly. If the construction industry in the UK adopted best practises for the design, installation, and maintenance of exterior wall systems, energy efficiency & durability could be significantly enhanced, with a substantial environmental & financial. Moreover, this technique results in fewer accidents and less disruption to domestic residents during construction. As stated by

Assimakopoulos et al. (2020) green walls denote the vertical resolutions of building components signified by the occurrence of vegetation. The advantageous tools of a green wall are the shading impacts from the plants, the insulation attained by plants, the cooling attained due to the evapotranspiration tools from the vegetation and the impact of wind variation. External green wall systems are intended to decrease the amount of energy needed to heat and cool a structure.

The study has integrated the 4 C's risk management framework entailing 4 different stages of valuation, specific mechanical design, construction & handover (Hodgkin and Sasse, 2022). The risk organisation framework can be a beneficial mechanism to minimise the impact of unanticipated significances in retrofit, leading to scalable retrofit strategies. The lack of prescriptive roles and the disjointed landscape of the UK construction industry require retrofit risk management procedures and adherence to PAS 2035 for government-subsided retrofit projects (Alabid, 2022).

The layers of exterior wall can be pre-developed and implemented on the respective site directly. However, management of these exterior walls is difficult because of their complex nature and project managers are usually expected to select and make it implement them effectively with the appropriate method. For instance, the AHP method is one of the significant ones as it helps the project managers to implement exterior walls considering economic, environmental and social criteria. According to Mayhoub et al., (2021), the Analytic Hierarchy Process (AHP) is one of the most used and shared methods and it is known for its multi-criteria decision-making approach and assists in solving issues when it comes to prioritising criteria. The selection and implementation of exterior walls altogether assist in managing scaling issues and different other sensible aspects of construction projects. Therefore, the project managers in different construction projects in the UK are suggested to initiate for AHP method considering sustainability a core aspect of development.

Conclusion

The literature review demonstrates the use of energy-efficient and durable wall systems in the construction industry of the UK. The construction industry in the UK needs to increase the

availability of exterior wall systems that are both energy-efficient and durable in order to meet the demand for more sustainable buildings and to reduce the amount of energy that is consumed. It is important that the building's exterior wall systems be constructed to maximise energy efficiency and durability. These systems should be customised to the building's intended use and the environmental circumstances. In order to achieve this goal, it is essential to make use of high-quality construction materials and techniques, as well as to pay painstaking attention to soundproofing, airtightness, and the management of dampness. Solutions for exterior walls will only continue to be effective over time if they are implemented properly.
It is recommended that the implementation be carried out by experienced technicians who are conversant with the applicable standards and best practises. The issue of energy consumption is something that project managers should be aware of and consider addressing by incorporating passive walls and other environmentally conscientious building practises into their work. This ensures that the structure will be constructed in a manner that is environmentally friendly, makes effective use of energy, and is beneficial to the climate, all while adhering to the timeline and budget that have been established for the project.

Methodology

For the author to gather information related to the thesis defence case, a research strategy is a crucial instrument. (Saunders 2003). The study's processes, techniques, and the layout of the tools used to gather and show data are all covered in this chapter. This research investigated the effectiveness of passive exterior wall systems in influencing the UK's energy problem using the knowledge and data gathered through detailed literature analysis.

The combination of both qualitative and quantitative methodologies provides a comprehensive understanding of the research problem, as it allows for a deeper exploration of the experiences and perspectives of the participants, while also providing numerical data to support or refute the findings. This approach ensures that the research is not limited to one method and provides a more robust analysis (Babbie, 1973).

3.1 Setting and design of the study

In recent years, it has become increasingly clear how crucial and applicable qualitative research is to technology and engineering management. Additionally, it has been recognised that qualitative research has a strong potential for investigating deeper into the underlying causes of issues and problems that are objectively studied (Fellow and Liu, 2003).

Every technique has its limitations, but additional quantitative analysis may be able to provide a more detailed analysis of the limitations of qualitative research, that include viewpoints and notions (Naoum, 2002). Two research methods—a qualitative interview and a quantitative questionnaire survey—were used to confirm the results of the interviews. Creswell refers to this combination of two methods as the "mixed method approach" (Creswell 2003).

3.2 Data collection methods/procedures

Primary Data Collection: Swan Contractors Ltd.'s director and a project manager both of them were interviewed in order to gather the primary data for the study on passive external wall systems and their potential to help with the energy crisis and sustainability.

An online survey using Google forms was used to gather data on the subject in order to support these viewpoints.

To find a solution to the problem, data from a variety of professionals with interconnections to the current construction industry were gathered.

The use of passive external wall systems, as shown in the literature review section of the paper, will be illustrated through the use of a case study to show how it is achieving environmental objectives.

Secondary Data Gathering: In order to confirm the quality of the findings done and to offer a genuine justification for using methodology in carrying out the study, the methodological context taken from other dissertations is examined in this stage.

The secondary information includes the proposed characteristics of exterior wall systems. In order for the author to gather information pertinent to the case made in support of the thesis, a research methodology is a crucial tool (Saunders 2003). The study's methods, procedures, and instrumentation for data collection and presentation are all covered in this chapter.

The purpose of this study was to investigate the effectiveness of passive external wall systems and their adaptation for use in the UK construction industry using the knowledge and information gathered from the extensive literature review.

Ethical Consideration

Prior to taking the poll, permission was acquired from the interviewees. They were also told of the purpose of the study, the terms of their involvement, and the fact that declining to participate would not result in payment or other consequences.

The subjects experienced no negative impacts as a result of participating in the study. Furthermore, it was highly unlikely that the subjects would feel uncomfortable answering the questionnaire's queries. Opting out of the research was a choice given to participants. Sensitive information was removed in order to safeguard the participants' privacy, and any data associated with a specific person cannot be identified.

Limitations and possible solutions

Because of the limited time, it was difficult to interview more construction professionals, which reduced the number of respondents recruited. Additionally, getting expert feedback via interview survey took a lot of time, which made it difficult to stay within the study's time limit. Nevertheless, this restriction was removed by using closed-end web questionnaires and case studies to collect data, leading to a more dependable and quick data-gathering technique.

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Results & Analysis

Introduction

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This section includes comprehensive results and a study of the information gathered from both quantitative and qualitative questionnaires. The findings of the data collection reveal a wide variety of opinions and views about energy-efficient external walls in the UK and the function of wall systems in resolving the energy crisis issue. Tables of findings, case studies, and diagrams were used to analyse the outcomes of the current research.

Interview Survey

Interviews with the Director and the Senior Project Manager of Swan Contractors Ltd., a construction business with headquarters in London's Harrow, were performed after obtaining the participants' permission.

What factors do you think have majorly contributed to the energy crisis in the country? what methods/ practices would you suggest to tackle this? The primary objective of conducting these interviews are meant to extract information from people with in-depth understanding of the building industry and experience working in a rapid, small-scale and large scale development environment. This question will be asked of the subjects as part of the interview process in order to learn about the difficulties associated with the adoption of passive external wall systems in the UK and to get their thoughts on how they would deal with them, as well as to gain an understanding of what key elements a project manager would look into to deal with a similar situation.

Participant 1: The director

In addition to fragmenting and viewing it just as an experimental building technique, local governments and the government should review new building projects with the implementation of modern methods more rapidly. With the increase in population growth, industrialization, limited availability of fossil fuels and inadequate investment in renewable energy technologies, I recognize that the energy crisis has been caused by several similar factors. Having served as a director, I realize how important the construction industry is in addressing the energy crisis. As part of this scenario, it will also be important to work closely with clients to educate them about the benefits of energy-efficient external wall systems, as well as the importance of sustainability in the construction industry.

Based on his experience in the construction industry over the past 20 years, he has expressed that by employing energy-efficient technologies in building design and construction, such as, external wall systems, and smart building technologies, the construction industry has the potential to combat the energy crisis. In addition, he also stated that it can promote the adoption of renewable energy sources, such as solar panels and wind turbines, to reduce reliance on non-renewable resources and contribute to a more sustainable future.

Participant 2: The Senior Project Manager

Based on my understanding of the construction industry and the backdrop of how to handle the energy problem, I recognise that inadequate energy efficiency requirements for structures and equipment play a significant part in this issue. It is possible to decrease energy usage and carbon gas pollution by adding energy-efficient exterior wall systems, which will result in a reduced energy cost and a more sustainable future. Building rules and laws that require energy-efficient construction standards are essential for promoting the use of such wall systems. In addition, businesses that engage in energy-efficient technologies may be eligible for benefits such as tax rebates or grants to promote their usage. While the UK building industry works hard to achieve its own set of carbon-reduction goals, it must also contribute to raising knowledge of novel methods and teaching local governments about their advantages.

According to the project manager, new techniques such as passive exterior walls have encountered numerous challenges and repercussions in the UK house construction industry. Significant causes for this is that the technique used to construct these houses has not been properly publicised and there hasn't been enough support from the concerned bodies. The majority of developers today are ignorant of this technique due to an absence of knowledge about it, and he also stressed that there is too much red tape, and funding for infrastructure should be allowed to increase.

The following were the findings of this interview:

• The modern methods of wall systems indeed have the potential to support the process of achieving energy efficiency.

• Although modern technologies have a positive impact on lowering energy crisis, they cannot be executed or address the ongoing problem unless the government supports it.

• These innovative building methods are treated just as an experiment technique and are poorly publicized

Analysis:

After reviewing the comments and opinions of both participants regarding the potential impact of External walls on the energy crisis in the United Kingdom, it was evident that both participants were interested in and believed that these modern methods could provide a paradigm shift for the industry. This interaction provided a chance to acquire a better comprehension of how these passive barriers are generally perceived in the United Kingdom. Both Participant 1 and Participant 2 acknowledged the impact of factors such as population growth, urbanization, and insufficient investment in renewable energy infrastructure and technology on the UK's energy crisis. A consensus was also reached on the significance of employing energy-efficient technologies and methods in building design and construction, such as external wall systems and smart building technologies, in order to combat the crisis and advance sustainability.

Participant 1 emphasised the need for the construction industry to work closely with clients and stakeholders to educate them on the benefits of energy efficiency and sustainability, whereas Participant 2 emphasised the significance of building rules and laws that require energy-efficient construction standards and the potential benefits for businesses that implement energy-efficient technologies. In addition, Participant 2 expressed concern over the difficulties and lack of support for novel techniques, such as passive exterior walls, whereas Participant 1 emphasised the promotion of the use of renewable energy sources. Overall, both participants

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acknowledged the importance of the construction industry in resolving the energy crisis in the United Kingdom, but their approaches to achieving this objective differed significantly.

Questionnaire Survey

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Question 1: What is your role in the construction sector?

Objective: The question had the primary purpose to assess each person's role in the organization and their level of experience in their ability to talk on a particular topic.

Following is a table presenting the results of the questions.

Role of Individual	Number	Respondents Percentage
Architect		
Planner		
Site Managers		
Project managers		
Skilled Workers		
Quantity Surveyor		

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Question 2: How many years' experience do you have in the construction sector?

Objective: The purpose of the question was to find out how well people were familiar with the construction sector.

Role of Individual	Experience years on average
Architect	
Planner	
Site Managers	
Project managers	
Skilled Workers	

Quantity Surveyor	

Question 3: What do you think is the major problem uk is facing today?

Objective: This question aims to learn how industry participants feel about the continuing crisis that is having an impact on people's lives and how much significance they give to it.

Responses	Number of respondents	Respondents Percentage
Housing		
Energy		
Workforce		
Environmental Concerns		

The bar graph below illustrates that the majority of respondents firmly feel that the United Kingdom is now suffering an energy crisis, and their collective opinion suggests that the energy crisis is a severe danger to the nation. Furthermore, there is a substantial belief among the remaining respondents that housing shortages are an issue that must be addressed. Thus suggesting that it is vital for the construction sector to consider innovative contemporary approaches to assist address these issues and to advance from old methods.

Question 4: What is your take on energy costs in the recent years?

Objective: to find out if respondents have noticed a substantial rise in energy costs recently.

Responses	Number of respondents	Respondents Percentage
Declined		
Neutral		
Increased		
Highly Increased		

According to this graph, the majority of respondents believe that energy prices have recently risen dramatically. This finding is perfectly consistent with the difficulties outlined in the literature review, implying that it is time for the construction sector to focus on going green, regardless of

the extent of work being done, to take responsibility and begin taking efforts to reduce the current energy crisis.

Question 5: What do you think are the barriers of innovation in construction sector?

Objective: to determine whether respondents think that the UK's constructing business is being negatively impacted by the lack of information about innovative construction methods.

Responses	Number of respondents	Respondents Percentage
Complexity		
No fail mentality		
Lack of Awareness		
Seniority		

Again, the findings of the bar graph below co-relates to the findings of the literature review and the key findings of the face-to-face interview conducted. It demonstrates that the majority of respondents agree that a lack of awareness has had a significant negative impact on the availability of houses in the UK to date, implying that the young blood in the construction industry should be given opportunities to illustrate what can be accomplished with the latest technologies, thus educating the public to get rid of this issue.

Question 6: What factors, in your opinion, should be taken into account when managing a project that makes use of new approaches, such as energy-efficient exterior wall systems?

Objective: What elements, in your view, needs to be considered when managing a project which involves the use of innovative methods like energy-efficient external wall systems?

Question 7: Which of the following wall systems do you think can contribute towards solving the energy crisis?

Objective: find out if respondents think using energy-efficient exterior wall systems might assist the UK in overcoming its energy problem.

Responses	Number of respondents	Respondents Percentage
Green Walls		
Trombe Walls		
Double Skin facade		
External wall insulation		

Question 8: Is it practically possible to achieve the government's plan on carbon neutrality by 2050, with the given circumstances?

Objective: To determine whether respondents agree with the UK government's strategy to become carbon neutral by 2050 that using energy-efficient exterior wall systems promotes sustainability.

Responses	**Number of respondents**	**Respondents Percentage**
Strongly Agree		
Agree		
Neither agree/disagree		
Disagree		
Strongly disagree		

To achieve their goals, the UK Government and Local Authorities should invest in Modern Methods of Construction by acquiring innovative techniques, which are widely employed in countries such as Japan and China, as well as European nations such as Germany and Sweden, because they demonstrate significant efficiency in the construction industry without compromising sustainability. This policy will enable the industry to create sustainable and environmentally friendly greenhouses, thereby contributing to the elimination of the energy crisis.

This survey revealed that a minority of construction professionals were uncertain about the government's planning policies over the years, but the vast majority believe the government's carbon neutrality plan will be successful. The results are illustrated in the figure below.

Question 9: What are your thoughts about external wall systems having the potential to replace the current conventional walls?

Objective: To learn what respondents think about the possibility of replacing existing standard walls in construction firms with energy-efficient exterior wall systems.

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