CMA5004 ENVIRONMENTAL AND CONSTRUCTION TECHNOLOGY DESIGN

Table of Contents

Part 1

Construction Drawings

The suggested renovation uses locally available materials that are eco-friendly to minimize carbon and improve energy performance. The external walls, recycled work covered with cavity insulation to enhance thermal efficiency, timber beams, and cross-laminated timber panels are used in the floors and the roofs respectively, since they are renewable. Optimization of natural light and reduction of heat loss are performed by utilizing “high-performance”, “double-glazed aluminium windows”. Healthy indoor air quality is promoted by low-VOC paints, bamboo flooring, and recycled gypsum “plasterboard”. The nature of the chosen materials is to provide high durability, minimal maintenance, and adherence to the “UK Building Regulations Part L” in terms of energy saving and sustainable design of the homes.

Existing elevations & floors plan

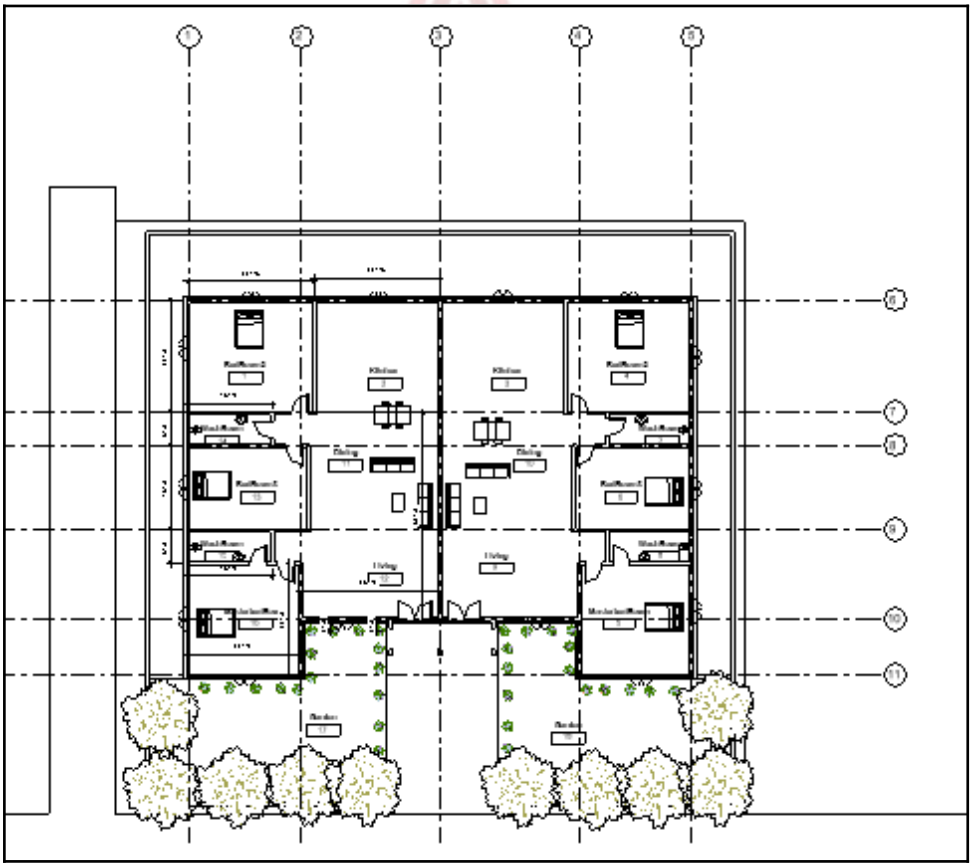


Figure 1: Floor

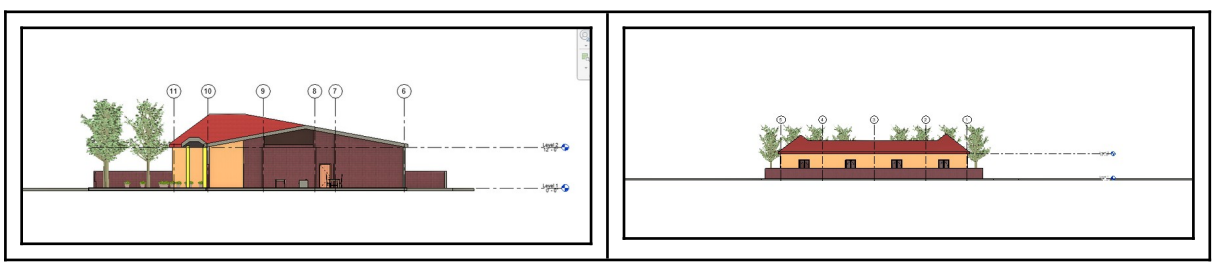
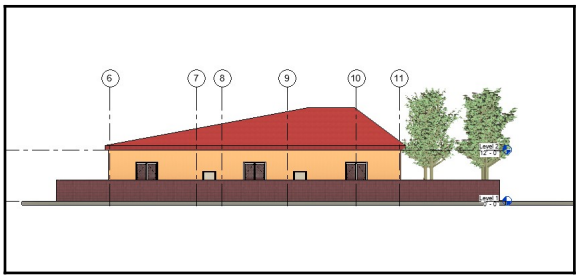


Figure 2: East elevation	**Figure 3: North elevation**
	
Figure 4: South elevation	**Figure 5: West elevation**

Proposed renovated elevations & floors plan

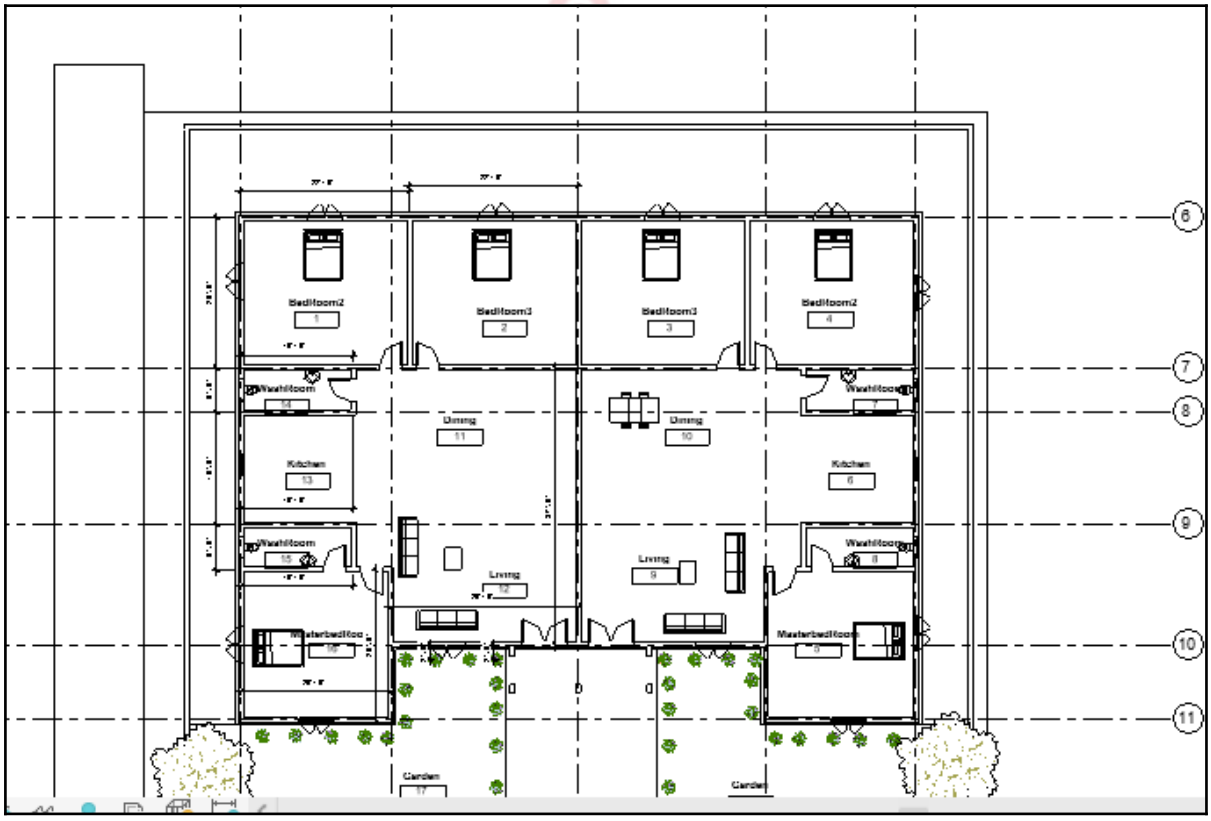
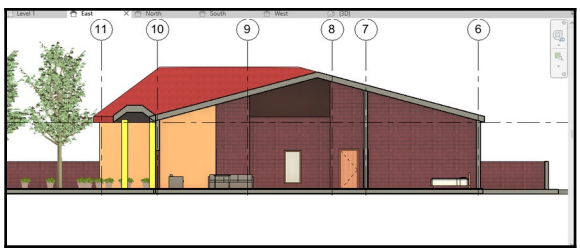


Figure 6: Floor



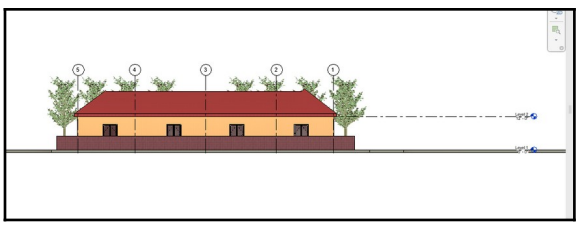
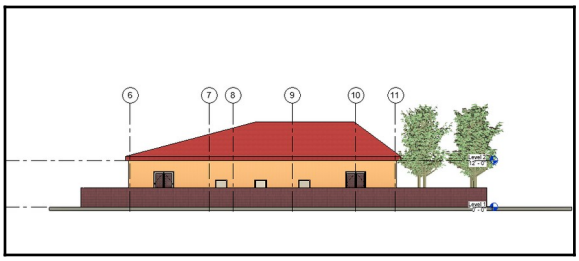


Figure 7: East elevation	Figure 8: North elevation
	
Figure 9: South elevation	**Figure 10: West elevation**

Site Plan location

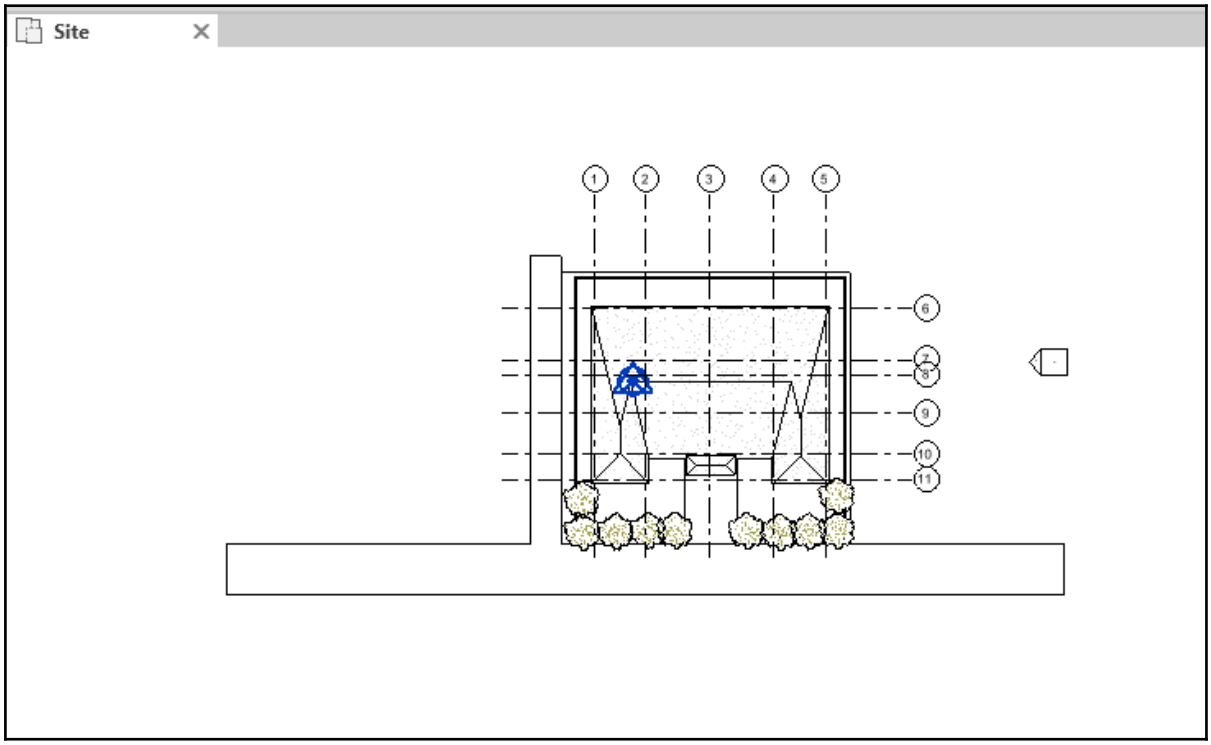


Figure 11: Existing site plan

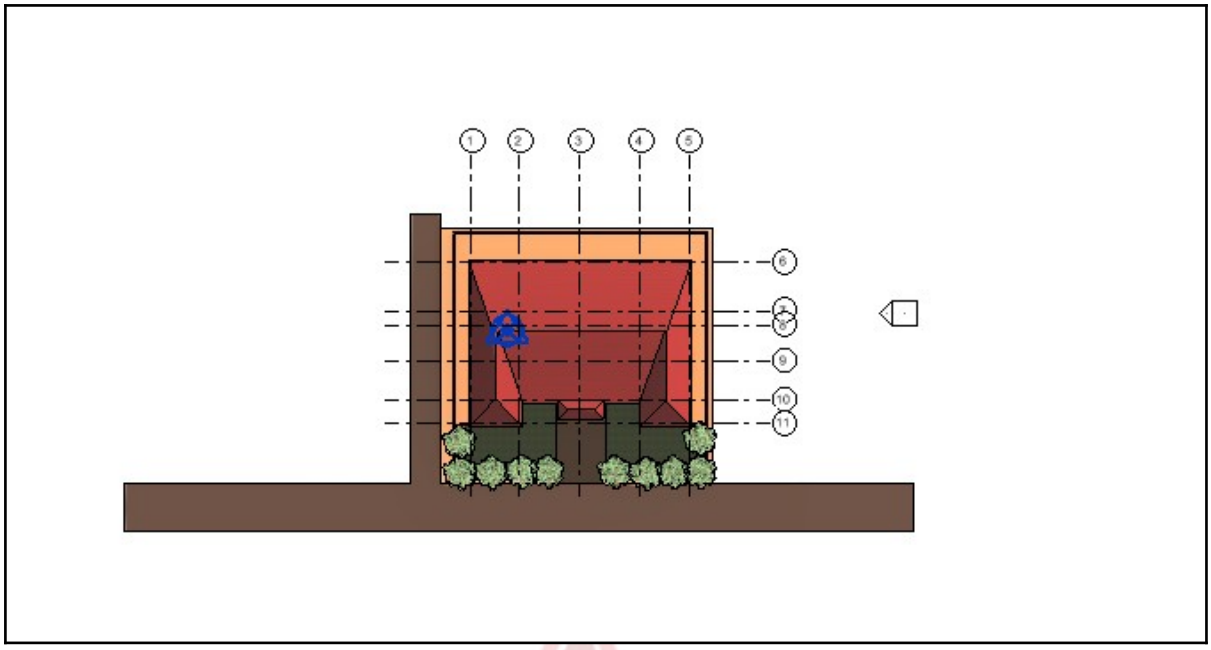


Figure 12: Proposed site plan

This part shows the construction drawings, such as the floor plan, elevation, and site plan of the detached house. Clients buy a house and then they renovate this according to their own design. They just modified the kitchen and one bedroom in this house as per their own plan. There are three bedrooms, two washrooms, and one kitchen on each side. The length of the bedroom is 20 feet, and width of the room is 20 feet, and the height of the house is 12 feet. Grid is used to understand the drawing position and it is drawn on the ground section. The garden is presented on both sides of the building for personal use with trees. For the proposed plan, the clients changed the plan using interchanging the bedroom and kitchen.

The kitchen is replaced by the bedroom, and the kitchen is totally open and connected to the living room. The entrance is connected with the living room, and the master bedroom is located in the front section of the house, and the other two bedrooms are located in the backside section of the house. The “master bedroom” has an attached washroom, and one washroom is open for all uses. The furniture was also modified according to the place, and reconstruction has been done. The elevation shows the side faces of the building to understand the building structure from the outside.

The given design will transform the “semi-detached house of the Smith family” to provide a better spatial functionality and comfort with a careful renovation. The redesign will reorganize the interior spaces through the exchange of one bedroom and the kitchen to make the kitchen-living room an open-plan, which is easy to interact with and allows natural light penetration. The design is focused on practicality, environmental sustainability, and the “UK Building Regulations” so that the home can be modern, energy-saving, and comfortable.

Part 2

A. Introduction

These renewals and expansions of residential properties have been of particular activity in the modern construction field, with more and more house extensions being turned to meet the standards of modern living and sustainable construction methods. The increased focus on energy efficiency, environmentally friendly materials, and better spatial planning has changed the way construction specialists view refurbishment projects. The information in this report includes the “design and construction” of the proposed extension and renovation of a semi-detached three-bedroom house. The project is focused on improving the internal living space by increasing the living area, number of bedrooms, as well as energy performance to suit a family of six.

The overall aim of this report is to show how the proposed design has incorporated “sustainable construction technologies, sound space planning, and compliance with UK Building Regulations and Permitted Development Rights”. The design rationale is explained (with special reference given to environmental responsibility, cost efficiency, and occupant comfort). The project applies “Building Information Modelling (BIM)” and digital design tools such as Revit to make sure that the project achieves a high level of visual and technical communication during the design and construction process.

Sustainability is also improved by ensuring that one chooses materials carefully in the form of recycled brickwork, cross-laminated timber, high-performance, and double-glazed aluminium windows, and low-VOC interior finishes. These materials were selected due to their minimal environmental effect, strength and adherence to the Building Regulations, which encourage energy-efficient design.

The report is divided into four primary parts. The former part shows the construction drawings comprising floor plans, elevations and site layouts. The second studies the superstructure and the structural elements. The third reviews the environmental and sustainability issues. The detailed outline and examination of the application of environmental and building technology principles have been effectively achieved in ensuring a concrete, sustainable and comfortable living environment.

B. The different elements of the superstructure.

Importance of Using Steel Beams in House Extensions

The steel beams are very essential in the extension of houses nowadays, particularly when building open-plan or a large structural opening of a house, where the weight-carrying walls will be eliminated. Their “high strength-to-weight ratio” makes them capable of covering a large distance without having support in between, allowing flexible and spacious interior designs. In residential constructions, steel beams are widely used, which are either “Rolled Steel Joists (RSJ) or Universal Beams (UBs)”, and are used to ensure that the structural loads are safely transferred to the foundations, whilst preserving stability and rigidity.

The construction with steel beams enables the easy incorporation of huge windows, sliding doors, and open kitchen-living rooms, and the increase of the natural light and the connection between the indoors and outdoors. They are also adaptable in design and have dimensional accuracy, and thus can be used with different construction materials such as timber, brick, or concrete. Moreover, steel is a sustainable structural material because of its durability, resistance to fire, and recyclability.

A suitable structural shape is a “hybrid reinforced concrete” beam which includes the benefits of FRP and steel rebar. In order to ensure the safety of hybrid reinforced beams, their dependability needs to be examined. The hybrid basalt FRP (BFRP)–steel-reinforced beam conducted a flexural performance test, the failure process was investigated, and numerical models were developed (Zhang *et al.* 2022). While the ductility of the FRP concrete beam is weak, its stiffness is low, and its cracks and stiffness are more than those of the reinforced concrete beam.

Strength, Flexibility, and Spanning Capability of Steel Beams

Steel beams are commonly known to be very powerful, flexible, and can extend long distances without necessarily being supported by an intermediate beam. Their tensile and compressive strengths are very high, and when they are subjected to large loads ensure the minimization of deflection, hence are good for the open-plan residential extensions that are intended to be used to have large spaces. As compared to timber or concrete, steel does not change its performance during stresses, such as which offers the same level of structural stability even when exposed to heavy architectural designs.

The common utilisation of steel beams in contemporary buildings is not a mistake. For skyscrapers, stadiums, transit hubs, and intricate infrastructure, steel beams offer an unparalleled foundation due to their distinct advantages in strength, durability, flexibility, and

sustainability. The superior ”strength-to-weight ratio of steel beams” is among its most evident benefits when used in construction. Steel has significantly more strength per unit of weight than materials such as concrete and wood, allowing for the creation of strong, thin buildings that are both structurally sound and visually stunning (mahsteel,2024).

Expanded beams are frequently utilised as the primary structural components in a variety of construction projects (Morkhade *et al*. 2022). Hot-rolled beams' open part is removed to create steel beams with open holes.

Role of Tension, Compression, and Cantilever Loads in Superstructure Stability

The designer needs to know all information during the “renovation and extension of the semi-detached home” of the Smiths, such as it is necessary to know tension, compression, and cantilever loads, to make the superstructure stable and safe in general. Tension is the force that exists in pulling structural elements of a material, like the lower flange of a steel beam, that tries to stretch the material. Compression works on the columns, load-bearing walls, or the upper flange of beams, compressing together material and transmitting the vertical loads in a way that will not pose any danger to the foundations. Structures that can sustain vertical loads, such as those forced on by gravity, must be designed and built with compression in view. Structural materials must be able to handle compressive stresses without breaking down or deforming under typical operating circumstances (construo,2025).

The steel beams placed over the open-plan kitchen-living space in this project are tension and compression resistant in order to hold the weight of the roof and upper floor. A balance of these forces is correct to avoid deflection, cracking, or structural deformation. A cantilever beam is a structural component that is set on one end and free on the other. They can also have cantilever loads when the projections of the roof are further than the support line, and the bending moments become critical and must be supported at the fixed end (strucalc,2024).

Use of Timber Frame Structures in Roofing Systems

Timber frame roofing systems are common in residential buildings because of their light weight and cheap construction. Timber rafters and timber beams used in the renovation of the Smiths' “semi-detached house” are used as the primary structure of the pitched roof, which is used to support the roof covering and also offer stability to the roof covering but at the same time, it still gives the house a traditional outlook. The strength-to-weight ratio of timber is high and can, with relative ease, support tiles, insulation, and weather conditions without unnecessary structural bulk.

There are two popular timber roof systems in domestic construction, including the cut roof system and trussed rafter system. The roof of the cut is constructed on site with separate rafters,

purlins, and ridge boards, which provides flexibility of design to extend or form irregular roofs. The trussed rafter's system involves the use of triangular units, which are pre-fabricated and then joined together using metal plates, which means that the system takes less time to install and also minimizes labour on the site.

The roof truss's wood components are connected by straight joint connections. The quantity of objects that can be examined for material qualities is restricted since ancient wood has significant historical significance (Wu *et al.* 2022). Wood also decreases quickly and loses some of its mechanical qualities over time. deterioration of the main hall's wood elements.

Types of Timber Frame Constructions and Key Structural Elements

"Timber frame construction" is a popular approach that is used in residential buildings due to its sustainability, fast assembly, and resistance to structural damage. Timber frame systems are of three major types, namely "platform framing, balloon framing, and post-and-beam framing", that characterize various aspects and approaches to construction.

The most prevalent platform framing in the UK housing sector is platform framing, which assumes that the storeys are constructed on top of the former floor deck, which provides a stable base on which the wall panels and roofing are built. This enables the installation of insulation and services easily to offer excellent thermal performance.

The post and beam method enhances the use of larger timber columns and beams, which are joined by metal or wooden pegs, thus forming an open interior structure with fewer load-bearing walls that are suitable in modern designs. Primary structural features in every system are studs, top and bottom plates, noggings, sheathing panels, and diagonal bracing to provide lateral stability.

Shear Walls and Cavity Walls in a Superstructure

Wall cavity and shear walls are critical structural integrity elements that contribute to the structural stability, robustness, and energy efficiency of a superstructure of a building. "Shear walls" are straight vertical elements that support against the lateral force, which could be the wind loads, and ensure that there is no structural deformation or structural failure. They are usually installed on the perimeter walls, stair cores, or gable ends of a building to give them rigidity and eliminate unreasonable sway.

Shear walls are components of structures that resist earthquakes. The shear walls of a shear wall construction are subject to the majority of seismic forces (Shida, 2024). Because of the shear wall's movement, there can be significant axial load changes in the piles supporting it.

"Cavity walls" are made of two leaves forming two layers, an outer brickwork leaf and an inner blockwork leaf, with an insulated cavity between. This design has superior thermal insulation,

water resistance, and acoustic performance. External walls are usually constructed with cavity walls to ensure that the internal walls are not damaged by damp vapor and also to comply with "Part L" of the "UK Building Regulations on energy efficiency".

Facing brick and lightweight concrete block will help to provide durability, low maintenance, and aesthetic continuity with the prevailing structure. Shear and cavity walls, when used together, give the building its strength, weather protection, and higher thermal comfort, which is essential in the construction of sustainable and structurally sound residential buildings.

C. Environmental and Sustainability

Environmental Impact and Sustainable Mitigation Measures

The house renovation project by the Smiths can have a few adverse effects on the environment, such as "noise pollution", "dust emissions", waste disposal, soil disturbance, and carbon emissions by construction machinery and transportation of construction materials.

The neighbourhood's residents can suffer from air pollution caused by the removal of construction waste (Gan, 2021). Excavation and demolition operations on the site can be harmful to the habitat of the local environment, and random dumping of waste materials can pollute the soil and water around the area. Energy consumption is high, and non-renewable materials are used in the project, which adds to the overall carbon footprint of the project.

Sustainable construction practices are adopted to counter the effects of these effects. The project is in accordance with the Environmental Protection Act 1990 and The Waste (England and Wales) Regulations 2011, which entail proper management of waste through recycling and reuse of waste materials, which include bricks, timber, and steel used as raw materials in construction (Woodard, 2021). In order to mitigate air and noise pollution, dust suppression systems, acoustic barriers, and low-emission construction equipment are used. This decreases environmental disruption using carbon-free local materials, prefabricated parts, and energy-efficient machinery.

The strategy of sustainable use of resources used in the project is determined by compliance with the Climate Change Act 2008 and the Clean Air Strategy 2019 (Averchenkova *et al.* 2021). Combining all these steps helps decrease greenhouse gas emissions, protect the local biodiversity, and make sure that the renovation is in line with the goals of national sustainability without worsening the construction efficiency and the welfare of the community.

Integration of Sustainable Materials in the Renovation and Extension

The renovation and extension of the semi-detached house belonging to the Smiths has been totally designed with sustainable materials to limit the adverse effects on the environment, as

well as to guarantee the material durability and high performance. The reclaimed bricks and recycled cavity insulation are used in the outer envelope, minimising embodied carbon and preventing landfill diversion. Floors and roof framing are done with cross-laminated timber (CLT) and C24-grade timber joists, which have a renewable source, high strength, and good thermal characteristics (Kurzinski, 2022). The manufacture and installation of cross-laminated timber (CLT), a common element in mass timber construction, has significantly increased during the past 20 years.

High-performance aluminium windows that are double-glazed are associated with greater energy efficiency and reduced heat loss, and maximization of natural daylight, as well as zinc roofing is associated with long-term durability, can be recycled and is resistant to corrosion. Interior finishes such as low-VOC paints, bamboo flooring, and recycled plasterboard encourage the well-being of the indoor air and sustainable living.

Each of the chosen materials has already been approved in accordance with Part L of the UK Building Regulations concerning energy conservation, and also, in accordance with the BS EN 15978 standards of environmental assessment. This resourceful approach makes the extension not only environmentally knowledgeable but also economical, as well as ensuring that the extension can offer sustainable structural and aesthetic services during its existence cycle.

Addressing the Client's Aspiration for an Environmentally Friendly, Low-Carbon Refurbishment

The desire by the client to ensure that the refurbishment is an "environmentally friendly refurbishment" with minimal or zero carbon footprint has been focal of both the design and construction process. The project follows a sustainable design philosophy, which incorporates "low-carbon materials", energy-saving systems, and green building methods.

Energy efficiency comes in the form of improved thermal insulation, airtight construction, and high-performance glazing that limit the amount of heat escaping and the use of mechanical heating. The proposed solutions that will be implemented in the building include a solar photovoltaic system on the roof to produce renewable energy and "LED lighting", and "energy-efficient appliances" that will "reduce electricity consumption". The open plan design will allow as much natural light and cross-ventilation as it is possible, and, therefore, artificial lighting and cooling will be minimized.

The waste minimization strategies used in the construction, which include the reuse of materials and segregation on the site, will be used to follow the guidelines provided in the "Waste and Resources Action Programme (WRAP) and BS 8895". The project site's waste management system helps in preventing and minimising the generation of waste (Tafesse,

2021). The UK Net Zero Carbon Building Standard also fits the project and contributes to long-term sustainability. The design incorporates passive design, renewable energy integration, and efficient use of materials, thus achieving the objective of the client who wanted to develop a low-impact, future-ready, and environmentally responsible home.

Key Principles of Low Energy, Passive Design and Healthy Buildings

The renovation project incorporates the most important concepts of low energy, passive design, and healthy building approaches to the desire of the client to have a home that is environmentally friendly and comfortable. Passive design is aimed at minimizing the energy demand based on the smart utilization of natural resources (Al-Tamimi, 2022). The house faces the sun, and the design allows it to maximize natural daylight and cross-ventilation, which reduces the necessity to use artificial lighting and mechanical cooling. Thermal comfort throughout the year is ensured by high-performance insulation, airtight building, and low U-value glazing, and thermal mass materials assist in stabilizing temperatures inside buildings through the absorption and release of heat over an extended period.

In order to provide a healthy living environment, the design uses low-VOC materials, natural finishes, and bamboo and timber floors to enhance indoor air quality and reduce harmful emissions. Proper moisture control and natural ventilation ensure that there is no condensation or growth of Molds, which ensures the occupants ' well-being. Visual contact with nature and the decrease of the stress level are provided through biophilic design components that include big windows leading to garden areas.

Legal Obligations and Compliance with Building Legislation

The refurbishment is planned according to the “UK Building Regulations” and other legal requirements that manage the safety, inclusivity, and sustainability. Part L has been followed in terms of energy conservation; the design has “high-performance insulation”, energy-efficient glazing, and LED lighting to conserve energy and minimize emissions of carbon emissions.

Part M (Access to and Use of Buildings) is completed by the project through the inclusion of level thresholds, expanded doorways, and accessible circulation areas to ensure that the home is accommodating to individuals with limited mobility (Vaughan, 2025). Part Q (Security -Dwellings) is fulfilled by using secure entry points, strong locking systems, and fitting of the windows with conforming fittings to prevent unauthorized access.

Part A has been utilized by the use of steel beams, reinforced foundation, and proper load-bearing walls to ensure stability and load-bearing capacity. Part B of fire safety is achieved with the help of fire-resistant materials, smoke detectors, and emergency exits.

Procedure for Acquiring Planning Permission and Appeal Process

The “planning permission” for this refurbishment project is based on the standard procedures provided by the “UK local planning authority (LPA)”. First, the designer will create detailed architectural drawings, such as site plans, elevations, and the proposed alterations, which must be checked against the local development plans and the “National Planning Policy Framework (NPPF)”. It is suggested that a pre-application meeting with the LPA should be held to verify possible problems and receive preliminary comments.

A formal planning application is made using the Planning portal, where all the necessary documentation is to be added, such as the design and access statement, environmental considerations, and a fee. The planning officer considers the application in line with planning policies before giving or rejecting permission.

D. Conclusion

The reformation and the expansion of the “semi-detached house of the Smith family” have offered essential ideas to the concepts of “Environmental and Construction Technology Design” in terms of the contemporary residential building. The combination of design innovation, sustainability, and statutory building regulation has been proven as an essential process in the construction business through this project. The proposal was set out to provide a functional, energy-efficient, environmentally responsible living structure which addresses the lifestyle and spatial needs of a family of six members whilst complying with the “UK Building Regulations and Permitted Development Rights”.

In terms of construction technology, the project enhanced the significance of structural integrity by properly utilizing “steel beams, timber frames, shear walls, and cavity wall systems” in order to make the project safe and durable. It was complemented by a good knowledge of tension, compression, and cantilever load distribution, which are fundamental in bringing about the stability of the superstructure. The commitment to reducing the embodied carbon and enhancing indoor air quality is shown environmentally through the use of sustainable flooring materials like recycled brick, cross-laminated timber, and bamboo flooring, as well as low-VOC paints.

The adaptability of “passive design techniques”, such as optimization of daylight, cross-ventilation, and maximization of insulation power, is indicative of the increasing focus on low-energy housing in the UK sustainability agenda. The importance of regulatory compliance emerges due to adherence to applicable building standards including Parts A, B, L, M, and Q in promoting the occupant safety, accessibility, and energy efficiency of buildings.

This project demonstrates the case that environmental-friendly design and high-technological construction tools go together to create modern, strong, and eco-friendly homes. These principles, as a professional in the construction business, are important in learning and implementing them to achieve the present-day objectives of the environment and help in making the future of residential architecture a high and responsible one.

This project provided the opportunity to understand how environmental and construction technologies relate and address issues important for buildings to be sustainable and energy-efficient. From this project, I gained experience in the application of the UK Building Regulations and the BIM tools of Revit for clear visualization and effective communication of design ideas. The renovation plan of this work allowed me to understand practically how to make use of eco-friendly materials, passive design strategies, and structural elements such as steel beams and timber frames. I also developed a more deep appreciation of how sustainability and modern design can exist and ensure comfort, safety, and environmental responsibility within residential construction projects.

E. Reference List

Al-Tamimi, N., 2022. Passive design strategies for energy efficient buildings in the Arabian desert. *Frontiers in Built Environment*, *7*, p.805603.

Available at: construo,2025,compression, Available at: https://construo.io/tags/compression#:~:text=In%20the%20context%20of%20construction,in%20their%20size%20or%20volume. [Available on: 3.11.2025]

Averchenkova, A., Fankhauser, S. and Finnegan, J.J., 2021. The impact of strategic climate legislation: evidence from expert interviews on the UK Climate Change Act. *Climate Policy*, *21*(2), pp.251-263.

Gan, S.J., 2021. *Impacts of construction materials and site activities to the neighbourhood environment* (Doctoral dissertation, Tunku Abdul Rahman University College).

Kurzinski, S., Crovella, P. and Kremer, P., 2022. Overview of cross-laminated timber (CLT) and timber structure standards across the world. *Mass Timber Construction Journal*, *5*(1), pp.1-13.

mahsteel,2024,Advantages of using of steel beams in construction, Available at: https://mahsteel.com/news/advantages-of-using-of-steel-beams-in-construction/, [Available on: 1.11.2025]

Morkhade, S.G., Gupta, L.M. and Martins, C.H., 2022. Effect of web post width on strength capacity of steel beams with web openings: experimental and analytical investigation. *Practice Periodical on Structural Design and Construction*, *27*(2), p.04022010.

Shida, Y. and Tamura, S., 2024. Superstructure-foundation interaction considering settlement during a large earthquake-Effects of shear walls on stress of piles. *Japanese Geotechnical Society Special Publication*, *10*(55), pp.2066-2071.

strucalc,2024,What is a Cantilever Beam?, Available at: https://strucalc.com/blog/learning/understanding-cantilever-beams/, [Available on: 1.11.2025]

Tafesse, S., 2021. Material waste minimization techniques in building construction projects. *Ethiopian Journal of Science and Technology*, *14*(1), pp.1-19.

Vaughan, P.J. and Bergin, D., 2025. Automating accessibility compliance in building design: a visual programming approach to part m of Irish building regulations using BIM.

Woodard, R., 2021. Waste management in small and medium enterprises (SMEs): compliance with duty of care and implications for the circular economy. *Journal of Cleaner Production*, *278*, p.123770.

Wu, C., Xue, J., Song, D. and Zhang, Y., 2022. Seismic performance evaluation of a roof structure of a historic Chinese timber frame building. *International Journal of Architectural Heritage*, *16*(10), pp.1474-1495.

Zhang, W., Liu, X., Huang, Y. and Tong, M.N., 2022. Reliability-based analysis of the flexural strength of concrete beams reinforced with hybrid BFRP and steel rebars. *Archives of Civil and Mechanical Engineering*, *22*(4), p.171.