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Introduction

Background

Approximately 45% of the UK total carbon emissions are a result of energy consumption in buildings [1]. Building Regulations are getting progressively more demanding and in 2008 the Climate Change Act sets the UK government target at 34% and 80% reductions in carbon emissions by 2020 and 2050 respectively based on 1990 levels [2]. e 24 million UK dwellings accounts for approximately 27% of the total carbon emissions [3] due to space heating for the provision of internal comfort conditions. It has been estimated that 70% of the UK housing stock will still be in use by 2050, and thus, there is a need for mass refurbishment to help achieve the UK government target by 2050, due to the fact that the majority of the existing stock of dwellings has been built with low energy performance [4]. In addition, all new homes in England will have to be net zero carbon by 2016. is has prompted further changes to UK Building Regulations between 2010 and 2016 calling for a 25% reduction in carbon emissions by 2010 and a further 44% reduction by 2013, leading to net zero carbon by 2016.

Building envelope

Turner and Townsend [5] have studied three di erent buildings and identi ed potential improvement strategies to reduce carbon emissions. ey have found that a 20% reduction in carbon emissions can be achieved for these buildings without raising the capital cost by more than 5%. e benchmark dwellings used in the Turner and Townsend report [5] have been adopted by others for use in further research [6,7]. is study will follow the same method and the benchmark dwelling derived from a study carried out by the Zero Carbon Hub [8] will be utilised. Zero Carbon Hub [8] has informed the strategy adopted

being a simplified tool but should fully capture the simple nature of a typical dwelling in the UK.

Costs of construction methods

When comparing costs of construction methods there are fluctuations in price associated with labour and equipment costs for each construction method, these fluctuations stem from issues such as faster build time for alternative/modern methods of construction resulting in lower labour costs and hire charges, these costs are considered by the National Audit Office [17]. They have highlighted areas where modern methods of construction can create increased costs that would not normally be encountered when using traditional methods such as loss of the factory production slot, suppliers failing to deliver the correct components or damage to critical prefabricated components. The cost of this study will be based on material costs alone similar to a study carried out by Wang

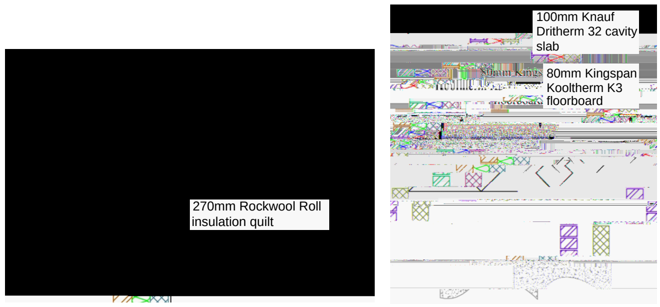


Figure 3: The Base Property: Wall/Roof/Floor construction details diagram.

to the Leicester area using the appropriate cost indices. Elemental cost gures have been selected from the analysis which best ts the speci cation of the base property. e costs per m² of oor/wall/roof/ window area were determined using Building Cost Information Service indices. e total cost is shown in Table 2.

1. Standard improvement 1: Standard methods of construction with insulation levels increased.

2. Standard improvement 2: Standard methods of construction with regular insulation substituted for an insulation with a better thermal performance.

3. Standard improvement 3: Standard methods of construction with cavity wall insulation replaced with Xtratherm full ll insulation.

4. Alternative method 1: Structural Insulated Panels (SIP) used in place of the standard roof and wall constructions.

5. Alternative method 2: Insulated Concrete Formwork (ICF) used in place of the standard wall construction.

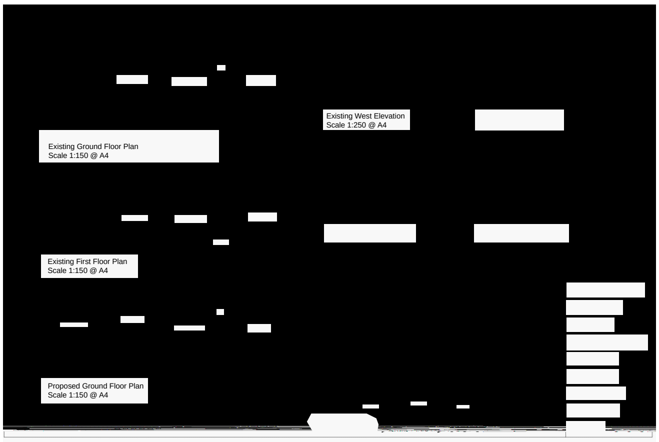
6. Alternative method 3: in joint solid blockwork walls with external insulation and oating oor used in place of the standard wall and oor constructions.

e case study

Standard construction methods

Standard improvement 2: e second set of improvements to the standard construction methods will be to substitute the type of insulation in each thermal element with a lower thermal conductivity

Figure 4: a) Rear elevation b) Existing outbuilding.



could be used as shown in Figure 10 which would reduce the U value of the wall to 0.065 W/m2K. e extra over costs for the alternative method 2.1 from the base property would be £15302.

in joint blockwork

in joint block work combines standard 'aircrete' building blocks with a thin joint of cement based adhesive which is fast to set and cuts the standard mortar joint of 10 mm down to just 3 mm. Due to the fast setting time of the thin joint adhesive the external walls of a building can be erected faster, the thermal performance of the wall is increased because thermal bridges created by mortar joints are reduced and the system of blockwork is familiar to tradesmen so no further training is required. e system can be used in any standard block work application; this study will look at the solid external wall construction. Figure 11 shows the build up of the external wall with insulation applied externally and a render nish. For this construction method the thin joint blockwork walls have been combined with a oating oor comprising 150 mm polystyrene insulation over the concrete slab nished with an 18 mm tongue and grooved chipboard as shown in Figure 11.

Table 8 shows the construction details of the alternative method 3 together with extra cost involved. For the purpose of the SAP calculation an air tightness of 4 m3/hr/m^2 was assumed as recorded in other case studies.

Existing terraced dwelling with a new single storey extension

e physical characteristics of this solid-wall dwelling (Figure 5) were entered into the NHER so ware to produce SAP ratings and details of carbon emissions. e results for di erent scenarios are summarised in Table 9. e speci cation and costs of the proposed insulation systems are shown in Table 10.

Table 9 shows that the overall thermal performance of the dwelling is not notably improved if the existing dwelling is not refurbished and the impact of the new extension on the reduction of carbon emissions per m^2 would be only 5.2%, but the overall carbon emissions of the dwelling were increased by 8.6%. Although the extra costs of the new extension would be approximately £11778, but it seems that the building control would only be concerned with new extension in terms of its thermal performance and little attention made to the main part of the dwelling. Table 9 shows that by reducing the U-value of the existing external walls and roof to 0.35 W/m^2K and 0.2 W/m^2K respectively the percentage reduction in carbon emissions would be 21.7%. Such reduction could be achieved with extra costs of £1026 (4.7% over the extension cost) for the case of an internal wall insulation system, or £1211 (5.5%) if external wall insulation system was applied (Table 10).

ese results show that any attempt to construct a new extension to an existing solid-wall dwelling needs to consider refurbishing the existing part to enhance the overall energy e ciency. ese results, as applied to construction of a new extension, suggest that a 21.7% reduction in carbon emissions can be achieved with approximately 4.7%

e impact of building envelope types on thermal performance and costs

All base property details (Figure 2 and Table 2) such as orientation, window sizes, heating speci cation, element U-Values etc were entered into the NHER so ware to produce SAP ratings and details of carbon emissions for the base property. e results are summarised in Table 11.

Citation: Taki

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References

1. Department of Energy and Climate Change (2010) Digest of United Kingdom Energy Statistics.
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