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Sustainability Assessment of Modern Methods for Constructing Irish Residential Buildings

Background

To transition Ireland to a low carbon, climate resilient and environmentally sustainable economy by 2050, the Irish Government considers mitigating the environmental impact of the Irish built environment and agriculture sectors [1], in addition to becoming a global leader in the bio-economy [2], as important objectives in this transition. During this transition to 2050, Ireland is forecast to increase its production of wood materials from 3.2 million cubic meters each year to 8 million by 2035 [2]. Additionally, the population of Ireland is expected to increase by around one million people to almost 5.7 million people by 2040 requiring at least an additional half a million new homes [3].

Bricks, blocks and concrete have been the main material choices for the superstructure of residential buildings in Ireland since the pre-1900s [4]. Timber frame houses have become more common in Ireland since the 1990s [4]. Light weight steel frame houses and insulating concrete formwork frame houses are starting to become a more common superstructure option for Irish housing [5], [6]. The aim of this research is to establish which of four modern methods for constructing Irish residential buildings is the more sustainable from an economic, environmental and social perspective.

Case Study Description

The Irish case study building is based on a theoretical semi-detached house. Semi-detached houses are the second most common housing typology in Ireland [7]. The case study building is constructed using four modern methods for constructing Irish residential buildings: concrete cavity wall frame, timber frame, light weight steel frame and insulated concrete formwork frame (Figure 1).



Figure 1: Theoretical semi-detached case study building and the four modern methods for constructing Irish residential buildings to be examined: concrete cavity wall frame, timber frame, light weight steel frame and insulated concrete formwork frame.

Results

Three of the four modern methods for constructing an Irish residential semi-detached house have been preliminarily evaluated [8] from a “cradle to gate” life cycle environmental and total construction cost perspective (see Table 1). When global warming potential emissions and the abiotic depletion potential for fossil resources are evaluated, which are two of the most commonly considered environmental impacts, the timber frame construction is the best performer. The increased use of wood in timber frame construction means that its carbon footprint is reduced by the CO₂ absorbed in trees during their growth.

Table 1: Environmental and economic impact of a steel frame, timber frame and concrete cavity wall frame semi-detached house [8]

Indicator	Concrete Cavity Wall Frame	Timber Frame	Steel Frame	Units
GWP	-26.472	-108.225	53.470	kg CO ₂ eq/m ²
ODP	1.80E-06	1.66E-06	5.48E-06	kg CFC11 eq/m ²
AP	0.333	0.322	0.237	kg SO ₂ eq/m ²
EP	0.055	0.056	0.024	kg PO ₄ ³⁻ eq/m ²
ADPE	8.84E-04	1.48E-05	7.35E-03	kg Sb eq/m ²
ADPF	763.060	693.681	814.165	MJ/m ²
WC	0.933	0.877	0.542	m ³ water/m ²
Waste	14.258	9.049	10.522	kg/m ²
Construction Cost	1,105	1,107	1,097	€/m ²

This analysis does not consider what happens to the construction materials at the end of their life cycles. Any timber used can be taken to a biomass plant and burned to produce energy. This advantage of energy production is offset by the CO₂ and other greenhouse gases that would be released. As the timber frame construction contains the most timber products, the results of the end of life cycle process would have the biggest global warming potential increase the most. However, the abiotic depletion potential for fossil resources would decrease when the energy created in biomass plants is considered. The steel frame construction has an advantage at the end of its life cycle, in that it can be fully reused or recycled. If it were to be put straight back into the construction industry, the environmental impacts would be lessened as the need for steel production from raw material would be lower. Concrete blocks can be recycled after use but are often ‘downcycled’ for use as fill material. Thus, offsetting the material with a lower environmental impact than the original block itself.

All three technologies for constructing a semi-detached house in Ireland has similar costs. This is only the case for when comparing the steel frame as a modular build to the timber frame as a panel build. If the methods were both panel builds, then the timber frame would be the least expensive method.

The four construction methods to be examined in this research will be evaluated from an environmental, economic and social perspective similar to research that has been carried out on Irish nZEB residential buildings [9], [10]

Findings and Recommendations

To be added after further social and economic indicator analysis.

References

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