A COMPARISON OF THE EMBODIED ENERGY AND EMBODIED CARBON OF A TIMBER VISITOR CENTRE IN IRELAND WITH ITS CONCRETE EQUIVALENT

Desmond Dolan¹, Dr. Annette Harte²

ABSTRACT: Climate change is widely accepted as the greatest environmental challenge facing the world today. Increases in the emission of greenhouse gases (GHGs), especially CO₂, to the atmosphere is a major contributor to climate change. As buildings account for 36% of EU CO₂ emissions the use of sustainable construction materials such as wood has a major role to play in reducing our CO₂ emissions. Research is presently underway to accurately quantify and compare the total environmental impacts associated with the construction of a timber office block in Ireland to a similar office block constructed primarily from concrete using Life Cycle Assessment (LCA), an environmental assessment tool. Preliminary results indicate that the embodied energy and embodied carbon associated with the construction of the timber office block are 2,911 GJ and 287.9 T CO₂e respectively which are to be compared to the concrete equivalent structure. Should carbon sequestration be included the total cradle to gate carbon released was calculated to have a negative net value of -110.9 T CO₂e highlighting the fact that both carbon neutral and carbon negative construction are possible in Ireland.

KEYWORDS: Embodied Carbon, Embodied Energy, Life Cycle Assessment, Construction Wood Products

1 INTRODUCTION

Buildings account for 36% of EU CO₂ emissions which is a major contributor to climate change globally. To counteract this, a major push is needed towards constructing more environmentally friendly buildings. To date a lot of emphasis has been placed in examining the energy used and associated carbon released throughout the operational phase of residential, office and industrial buildings. However, since major improvements have been made in both materials and construction techniques for thermal insulation of the building envelope, its contribution to the overall environmental impact of the building is becoming less and less significant.

In line with EU policy, it is becoming accepted that a life-cycle approach to product development and construction must be adopted. This allows the total environmental impacts associated with these products to be quantified.

Therefore, the embodied energy (EE) and embodied carbon (EC) of the construction materials used are becoming increasingly important. The EE and EC of each material refers to the total energy consumed and carbon released from all processes associated with that product over its life cycle from the extraction of the raw materials through to the manufacturing, transportation and maintenance of that material. This research aims to investigate the total environmental impacts associated with the construction and maintenance of a timber office block and compare the results to a similar concrete office block using an environmental assessment technique known as life Cycle Assessment or LCA.

2 BACKGROUND

2.1 LIFE CYCLE ASSESSMENT

LCA began in the early 1960s and has since evolved into an internationally accepted analytical method for quantifying the total environmental impacts generated by a product at each stage of its life cycle. In 2006, the International Organisation for Standardisation (ISO) published guidelines on how to conduct an LCA, the ISO 14000 series [1]. The environmental impacts assessed, include energy and material usage, emissions to air and water as well as solid waste generated at each stage. LCA considers materials over the course of their entire lives, from extraction through manufacturing, transportation, installation, use, maintenance, and disposal or recycling.
2.2 CONSTRUCTION WOOD PRODUCTS

Wood is unique among construction materials as it is a truly renewable resource when grown in sustainably managed forests. One key aspect that is often overlooked when considering wood is the fact that CO\textsubscript{2} is absorbed from the atmosphere as it grows and this sequestered carbon is then stored in the wood throughout its life. Assuming oven dried wood is approximately 50% carbon by mass, every 1kg of dry wood used can store up to 1.83kg of CO\textsubscript{2} equivalents demonstrating the potential to produce carbon negative construction products and ultimately carbon negative buildings. These environmentally beneficial aspects can be taken into account when analyzing timber buildings using LCA.

2.3 ICE DATABASE

In order to conduct an LCA of a timber building the environmental indicators for each of the construction products used must be available. One of the issues in analyzing wood products using LCA is that these values can vary significantly from country to country due to differences in local climate and in forestry, sawmilling, product manufacture, and construction practices. For the purpose of this project the ICE database is used in conjunction with the design plans to quantify the total embodied energy and carbon of the timber office block considered. The ICE database is an inventory of embodied energy and carbon data for buildings materials which has been compiled to include data from almost 1900 energy and carbon records from around the world [2].

3 PRELIMINARY RESULTS

The timber office block examined is the Tayto Park Visitor Centre which is located at an amusement park on the east coast of Ireland. The two story structure is home to a kitchen, restaurant, shops, meeting rooms and an exhibition space. The structure covers approximately 1700m\textsuperscript{2} of floor space and was completed in 2011 with a designed life span of 100 years. The structure is built almost entirely using Sitka Spruce, however, oak and larch were also used in places. It demonstrates the best practice in timber building technology therefore, providing a perfect candidate to highlight the potential benefits of timber construction. Using LCA the total environmental impacts associated with the structure are analysed. This includes the associated EE and EC from the extraction, production, transportation and maintenance of each of the raw materials. A concrete building of similar dimensions, lifespan and thermal properties are comparable to those measured in the existing timber office block. This will allow the relative impact of the EE and EC of the timber structure be precisely compared to its concrete equivalent.

4 CONCLUSIONS

Based on the quantity of wood used throughout the timber office block the structure stores almost 398.8 T CO\textsubscript{2}e. This figure is considerably greater than the total EC produced therefore a total net value of 110.9 T CO\textsubscript{2}e was calculated to be taken out of the atmosphere due to the construction of this structure.

Work is currently being conducted to analyse a similar concrete structure. The concrete equivalent structure has been designed to ensure the function, lifespan, dimensions and thermal properties are comparable to those measured in the existing timber office block. This will allow the relative impact of the EE and EC of the timber structure be precisely compared to its concrete equivalent.

ACKNOWLEDGEMENT

The first author would like to acknowledge the financial support of both, Coillte and the Irish Research Council to this project.

REFERENCES