Quantifying the Environmental Impact of Railway Bridges Using Life Cycle Assessment: A Case Study

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Abstract

As emission regulations in the EU are becoming stricter, the reduction of greenhouse gas emissions from the construction industry has become a pressing need. As part of the efforts related to this issue, it has been found that Environmental Life Cycle Analysis (LCA) approaches are required to optimize the design, construction, operation, and maintenance of buildings and infrastructure assets. In this paper, The Institution of Structural Engineers guidance on how to calculate the embodied carbon in structures is used as LCA model and evaluated in a case study. The guidance divides the structure´s life cycle into five stages (A1-A3: Product, A4-A5: Construction process, B1-B7: Use, C1-C4: End of live and D: Benefits and loads beyond the system boundary) and the environmental impact is measured in terms of carbon dioxide equivalent emissions (kgCo2e) or global warming potential (GWP). The model was applied to an existing reinforced concrete trough bridge, which is a structure type commonly used in Swedish railways. Results show that that the model was effective and simple for investigating the environmental impact of the studied structure.

Keywords: Life cycle analysis; Reinforced concrete; Railway Bridge, Embodied carbon, Global warming potential.

1 Introduction

Anthropogenic emissions of CO_2 and other greenhouse gases (GHGs) cause global warming. After the Paris Agreement, Governments of 190 countries have decided to keep global warming well below 2°C above pre-industrial levels [1]. In addition, the EU is aiming to reach net-zero carbon emissions by 2050 [2], although some countries are setting their own national targets. For instance, the national target of Sweden is to become carbon neutral by the year 2045 [3]. These efforts are aimed to guarantee sustainable environment for this and future generations [4], [5]. As buildings and construction presently account for about 40% of energy-related CO_2 emissions [4], deep changes are needed in the design, construction, use, and reuse of structures and infrastructure to reach those goals. This might not only lead to reducing the global warming impact of the construction industry but to significant economic benefits through a more efficient construction practice and use of buildings. These savings could influence 42% of total energy consumption, 35% of greenhouse gas emissions (GHG), 50% of the raw materials extracted in some regions, and save up to 30% of water in certain regions according to the Roadmap to a Resource Efficient Europe [3].

The European Commission concluded that Life Cycle Assessment (LCA) is currently the best tool for evaluating the environmental effects of a building during its life cycle [6]. In recent years, Nordic countries (i.e., Denmark, Finland, Norway, and Sweden) have shown increased interest in employing LCA for environmental performance in the building sector [6]. The need of LCA to enhance the possibilities of mitigation environmental impacts has also been pointed out by several researchers in fields different than construction industry [7], [8].