DESIGN OPTIMISATION OF A STEEL BRIDGE BRACKET

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Steel brackets have a renowned potential of being used in bridge constructions as a load-bearing element. Due to the higher consumption of steel in bridge constructions, the emission of Carbon Dioxide (CO_2) gas is increased when manufacturing steel components. CO_2 is one of the main greenhouse gases prompting the increase in global warming. Moreover, excessive material usage in bracket manufacturing will lead to expensive constructions and increased embodied energy consumption. Another concern is that, though the material usage is to be reduced, the strength, stiffness and stability of the structure should be preserved. Hence, engineers have identified that structural optimisation is the best solution to address this global problem, and they have been practising structural optimisation principles on the structural components recently to achieve sustainability during the service life. In other words, their ultimate target is to apply sustainable concepts to the construction principles. Although many researchers have studied various structural optimisation tools and presented novel designs, applications of those designs in the construction industry are still limited due to the complex geometries of the optimised designs. Nevertheless, the advantages of optimised designs are more powerful than the manufacturing challenges. The recent developments in additive manufacturing extend higher flexibility and efficiency to the fabrication of these structures by overcoming the manufacturing challenges. However. nowadays, these novel and eco-friendly techniques are getting more attention all over the world because of their merits in the ever-evolving field of Civil Engineering.

To circumvent the above-mentioned challenges, this research demonstrates a novel approach for producing an optimum and sustainable steel bracket for a pedestrian bridge construction. Among several structural optimisation methods, topology optimisation is used as the tool of choice in this work, which has a proven record of arriving at the highest stiffness to weight ratio. This study uses an existing steel bridge bracket in Castleford Foot Bridge, England as a study case. The bracket is optimised under several volume fractions and ultimately, the optimum design is selected based on both simulation results and practical considerations. According to the results, the optimised model with a 30% volume constraint is selected as the optimum design which leads to the manufacturing of cost-effective and sustainable structure. Considering the manufacturing possibilities, the optimised model from the finite element software is converted into a manufacturable parametric Computer-Aided Design (CAD) model using the Rhinoceros software package for further post-processing and analysis. The modified CAD model is re-analysed using finite element software and its structural performance is verified. It is shown that a considerable amount of material could be saved without sacrificing the strength and stiffness requirement of the bridge bracket. Similarly, further optimisation could be performed in terms of the shape of the geometry which is identified as a potential future work that stems from this study.

Keywords: Topology optimisation, Steel brackets, Structural optimisation, Sustainable designs, Computer-Aided Design

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