Bridge Design Project Report

CIV102: Structures and Materials

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Abstract

This research project investigated the design, computational modeling, and experimental validation of a lightweight Matboard bridge subjected to a moving train load. A Python-based structural analysis tool was developed to evaluate candidate bridge geometries by computing internal force distributions, bending and shear stresses, and factors of safety for multiple failure modes, including flexural yielding, shear failure, plate buckling, torsional instability, and adhesive joint failure. Designs were iteratively optimized over seven major revisions using both computational output and hand calculations grounded in beam theory and thin plate buckling theory. The bridge was designed for a 1200 mm span and evaluated under a moving three-car train load. Load Case 1 consisted of a total train weight of 400 N distributed across six axles. Load Case 2 introduced a progressively increasing load protocol, with asymmetric car loading in which the locomotive was approximately 1.35–1.38 times heavier than freight cars depending on pass number, and freight car weights increased monotonically between passes. The final design was predicted to sustain a maximum load of 1048 N under Load Case 2 before failure. Experimental testing using the moving train apparatus resulted in a measured failure load of 640 N. The discrepancy between predicted and observed performance indicates limitations in idealized structural assumptions and sensitivity to construction tolerances, particularly at adhesive joints and localized buckling regions.