F26.50 Software Development for Design of Tie-Strut Systems Using Topology Optimization

Overview

This project aims to develop an advanced software platform for the conceptual and detailed design of structural systems using tie-strut modeling and topology optimization. Strut-and-tie models (STM) are widely used in civil and structural engineering for designing reinforced concrete elements and other structural forms that rely on discrete load paths. Relying on the physical interpretation and stress paths in a structure, this method depends on user intuition and experience. On the other hand, topology optimization (TO) answers the fundamental engineering question: how to place material within a prescribed design domain to obtain the best structural performance? Therefore, TO provides a systematic way to achieve the design of STM models. The goal is to provide engineers, architects, and researchers with a user-friendly computational tool that bridges the gap between intuitive modeling using the STM model and automated, optimization-driven structural layout generation using TO. This tool would be particularly valuable in the design of bridges, deep beams, shear walls, and other structural elements where complex force paths are present. It would also serve as an educational tool for teaching structural optimization and the fundamentals of strut-and-tie modeling.

What the student will DO and LEARN

The student will gain comprehensive experience in developing software with a graphical user interface (GUI) and applications in structural design. Specifically, the student will:

1. Implement a GUI-based, flexible, stress-based topology optimization tool using the Julia programming language.

2. Provide user controls to guide the optimizer toward discrete truss-like configurations, including volume constraints, stress-state filters, and manufacturability constraints.

3. Enable interactive visualization of the evolving structure, with clear distinctions between ties, struts, and voids.

Additional benefits

The student will regularly present their progress during research group meetings and prepare a poster or presentation at the end of this project for the UGRAD symposium.

Additional qualifications

Some experience with coding.

Time commitment

6 hrs/week for 30 weeks