Summer 8-12-2021

Topology Optimization Of 2D Structures With Multiple Displacement Constraints

Patricio Uarac Pinto

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Author: Patricio Uarac Pinto

Supervisor: ChrissaLee Butler/Michelle Sands

Abstract

The use of topology optimization in the design process in Civil Engineering can lead to innovative building shapes that not only fulfill structural requirements but also open new opportunities for arquitectonics.

Introduction

- Topology Optimization (TO) is a mathematical method that search the best material distribution under defined constraints (Tovar, 2015).

(Hemmerling and Nether, 2014)

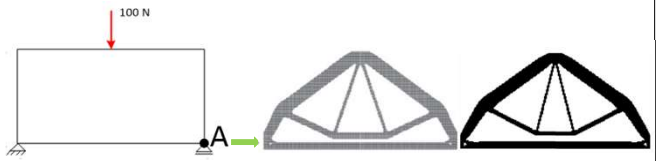
Figure 1: Example of a chair optimized

- There are two main lain of thought: discrete optimization (binary, 0 or 1) and continuum optimization (like a line).
- Huang and Xie (2009) proposed a combined method taking the strengths from both lain of thought.
- As objective function we use the minimization of the elastic energy (Pedersen, 2001) which is the same of maximization of the stiffness.
- As constraints we use displacement at different point and the total volume of the structure.

The application of multiple displacement constraints to a volume constrained structural optimization algorithm leads to maximum stiffness structures that satisfy all constraints simultaneously.

Model Calibration

To study new applications of OT, first made a MATLAB® code capable of duplicate the results of Huang and Xie (2010) for problems with one load case (red arrow) and one constraint (green arrow), in this case a beam.



Model (Huang and Xie, 2010) Huang and Xie (2010)

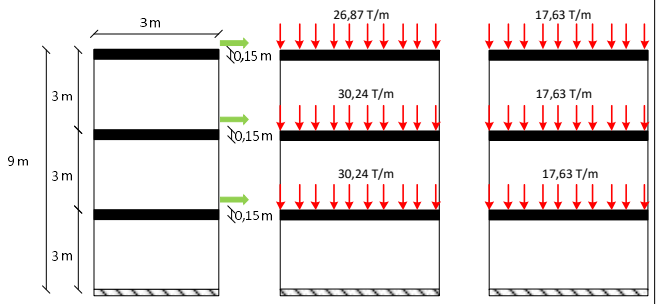
Figure 2: Simply supported beam

Results

We propose the analysis of a shear wall (element capable to resist lateral loads like wind or earthquake and vertical loads).

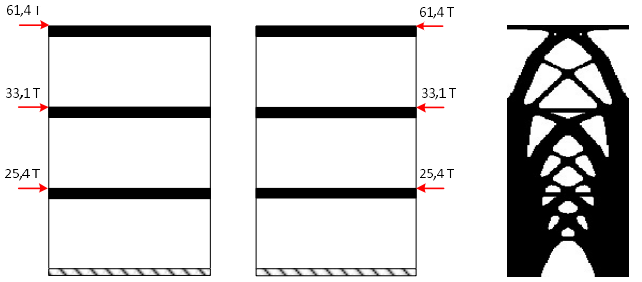
The domain have an optimizable zone (white zone between slabs) and a non-optimizable zone (black strips, slabs).

The loads and displacement are defined so they fulfill the Chilean codes.



Model Dead load (self weight) Live load (people)

Figure 3.a: Model of a three story building



Positive earthquake load Negative earthquake load Optimized structure

Figure 3.b: Model of a three story building

The next question that arise is: Is it possible to build such structures?

(Ohmori, 2008)

Figure 4: Akutawaga Westside Proyect

Conclusion

We can apply TO methods to Civil Engineering problems that leads to structures of maximum stiffness that also satisfy all constraint simultaneously.

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