MECA0027-1
Structural and multidisciplinary optimization
Academic year 2025-2026

Computer work 2: Topology optimization

1 Objectives

The goal of this second computer work is to familiarize the student with topology optimization and the use of an industrial software (NX-Topol) to perform it. To do so, it is asked to solve the problem of optimizing the material distribution in the case of the MBB-beam, depicted in Fig. 1, such that its compliance is minimized under the constraint of a material volume under 35% of the design domain volume. Note that the beam is made of AISI steel 1005. You have to take into account both forces, although they don't act simultaneously.

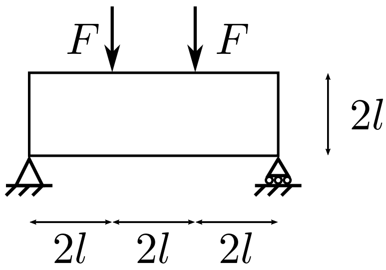

Figure 1: MBB-beam.

2 Analysis

It is requested to investigate the influence of the numerical parameters in such design domain and to explain where these parameters come into play in the optimization process

Part 1

To do so, start first to study the effect of the filter size and the finite element discretization:

1. Solve the optimization problem with different discretizations, *i.e.* meshes, keeping the ratio of elements n_x/n_y constant;

2. Solve the optimization problem with different filter radius;

3. Compare the results and comment about the role of the filter (its goal, how it works, ...) with respect to the discretization. Three different values of filter radius and three different meshes have to be tested, thus accounting for nine results to be analyzed.

Then, for a given discretization and filter radius that you choose based on your previous results, one has to evaluate the effect of the penalization parameter:

1. Solve the optimization problem with different penalization parameters, for example, $p = 1$, $p = 1.5$, $p = 3$, $p = 4$ and $p = 8$. Compare results and comment: how does it work ? Why do you obtain these results ? And is there any physical interpretation for those values?

2. Solve the optimization problem using a continuation procedure. Here, the penalization parameter is gradually increased during the optimization problem. For example, start with $p = 1$ and after 30 iterations increase the value by 0.5 up to reach a value of p that you judge appropriate for your analyses. Plot the convergence curve and comment about its shape and the iteration number where the lowest objective value is reached.

3. Compare the results obtained with and without the continuation procedure. Which is the procedure that gives the best result? Why?

Finally, change the aspect ratio of the design space. What is its influence on the optimized beam?

Part 2

The boundary conditions and loading must be slightly changed to match the configuration depicted in Fig. 2. For that case, study the impact of the optimization solver: SPOT against GCM V2. What can you observe and why?

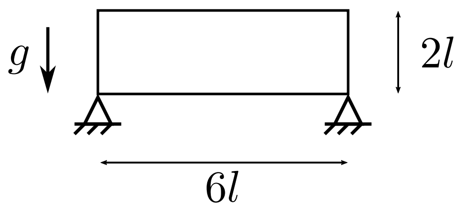

Figure 2: MBB-beam under its own weight.

3 Organization and grading

This work is to be performed in group of 2 students, the same as for the first computer work. Each group must submit a compressed zip file named "student1_student2". The zip file should contain:

- A short **report** (max 15 pages) detailing the analysis, saved as a .pdf file named "student1_student2.pdf"

- A folder named "Part_1" containing **only** all the .prt, .fem and .sim files created for part 1 of the project. However, do not include the solution files generated by NX

- A folder named "Part_2" containing **only** all the .prt, .fem and .sim files created for part 2 of the project, again without solution files.

The deadline for submission is December 19, 2025. The documents should be sent by email to louis.dehaybe@uliege.be. If the zip is too large to be sent by email, you can use methods such as wetransfer.

The final grade will take into account the quality of the report (content, design, figures, text, tables etc.), the results (implementation of the methods) and **most of all, the analyses**.