

# Assignment in Structural Optimization, 2017

Division of Solid Mechanics

The task is to implement and analyze different optimization methods. The theory related to the methods and the results should be presented in a well structured report. The methods should be implemented in Matlab where use can be made of suitable subroutines included in the CALFEM toolbox. The developed computer code should be attached as an appendix in the report.

## Problem description

In order to test the implementation, an optimization of a simple problem should be performed. The compliance of a beam should be minimized. Geometry and boundary conditions are illustrated in Fig. 1. The material of the beam is linear elastic, homogeneous and isotropic.

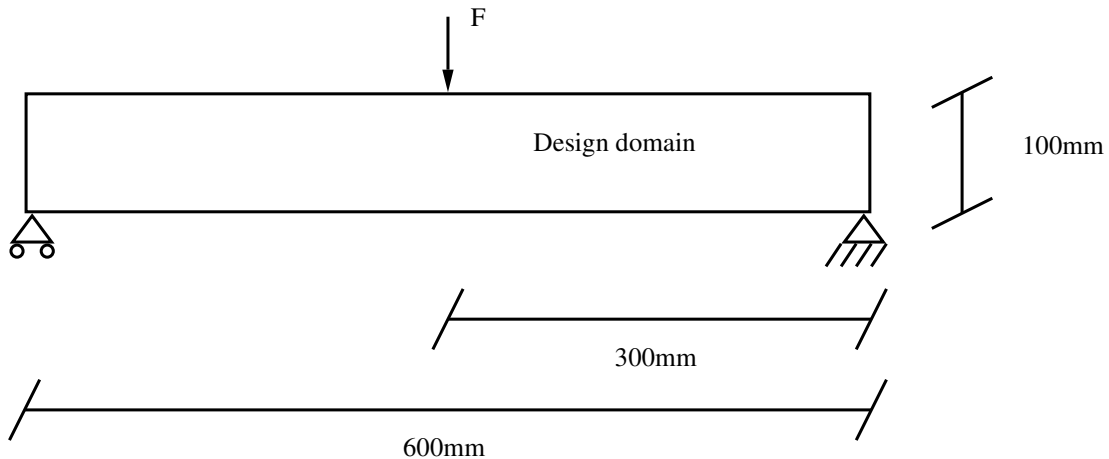


Figure 1: Illustration of geometry and boundary conditions

## Problem formulation

The optimization methods that should be considered are:

### Size optimization

- In this task you should design a load carrying structure using a truss design. The geometry for the truss structure is given in the file `geomS0.mat` which can be downloaded from the course homepage. The maximum allowable cross-section diameter of the circular bars is  $d_{max} = 20mm$  and the maximum allowed volume of the structure is  $V_{max} = 2000mm^3$ . Solve the problem for a range of  $d_{min}$  values and initial values.

## Topology optimization

The following tasks should be solved for two finite element discretizations, `MBCoarseMesh.mat` and `MBBFineMesh.mat`, both available on the course homepage.

- b) Use the SIMP algorithm to derive an optimal design. You should investigate the two discretizations and different initial values. The maximum allowed volume of the structure is  $V_{max} = 0.4V_{box}$  where  $V_{box}$  is the volume defined by Fig. 1 together with an eligible thickness.
- c) Include a filter in the SIMP algorithm. The two following type of filters should be implemented, separately:
  - a *density filter*,
  - the Helmholtz' PDE based filter.

The theory describing density filters can be found in e.g. [2], and the theory describing the PDE filter can be found in Lazarov and Sigmund [1]. Examine the influence of different length scale parameters,  $r$ . Routines related to the density field are available on the course homepage. Plane stress should be used.

## Procedure

The analysis is to be performed in CALFEM. A well structured concise report of your findings should be returned to the Div. of Solid Mechanics no later than **2017-03-13 16.00**. The results should be presented in the form of illustrative graphs and tables. Note that it should be possible to generate the results from the information provided in the report, i.e. numerical parameters used should be clearly stated in the report. MATLAB/CALFEM files (appendix) should be well structured and carefully commented. The reader of the report is assumed to have the same knowledge level as the author before taking the structural optimization course. It is possible to obtain up to 30 points. The task should be solved in groups of *two* (or *individually*). Keep the report as concise as possible. It is strongly recommended that you keep the report well below 10 pages excluding the appendix containing the code.

## Submission

You should submit your report in **PDF** to `FHLN01@solid.lth.se`. In addition to your report you should also attach your m-files. Moreover, a **paper** version should be handed in to the division of Solid Mechanics.

## References

- [1] B. S. Lazarov and O. Sigmund. Filters in topology optimization based on helmholz-type differential equations. *International journal for numerical methods in engineering*, 86:765–781, 2010.
- [2] Ole Sigmund. Morphology-based black and white filters for topology optimization. *Structural and Multidisciplinary Optimization*, 33(4):401–424, 2007.