Assignment in Structural Optimization, 2015

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 report should contain a description of the problem, the solution procedure that is needed as well as the results from the calculations in form of illustrative figures and tables. The program codes should be well commented and included in an Appendix. When writing the text it can be assumed that the reader has basic knowledge of Solid Mechanics, but it has been a while since he/she dealt with this type of analysis. After reading the report, the reader should be able to obtain all the relevant results just by reading through the report, i.e. without using the included program.

Problem description

Two problems will be solved in the project, one related to a truss optimization using bar elements and another to a clamp structure using continuum elements.

Shape and size optimization of truss structure

Consider the truss structure given below.

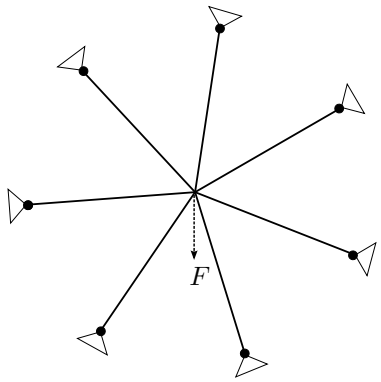

Figure 1: Truss-structure

In this task you should design a load carrying structure using the initial truss design in Fig. 1. The structure should be made as stiff as possible by minimizing the compliance $C = \boldsymbol{F}^T \boldsymbol{u}$ where the maximum allowed volume of the structure must be less than $V_0 = 0.15$ m^3.The material of the bar is linear elastic, homogeneous and isotropic. The geometry for the truss structure is given in the file `geomSO1.mat` which can be downloaded from the course homepage. This problem is divided into two parts.

a) Size optimization. Assume the central node in Fig. 2 is fixed at position $(x, y) = (0, 0)$. The cross section areas of the bars should be optimized. The maximum allowable cross-section

area of the bars are $A_{max} = 0.05$ m^2. Perform a CONLIN approximation and solve the problem for a range of A_{min} values.

b) Size and shape optimization. The central node is now allowed to slide in the horizontal direction. Optimize the structure with respect to the horizontal coordinate and the cross section areas of the bars. You may use SLP, CONLIN or MMA or a mix thereof to solve the problem. As in all tasks it is important that the report clearly describes the strategy you have choosen. The position of the central node is allowed to move 0.7m in the horizontal direction.

Topology optimization of a pressing tool

Consider the structure below. The geometry and a mesh generating m-file is available on the course-home page.

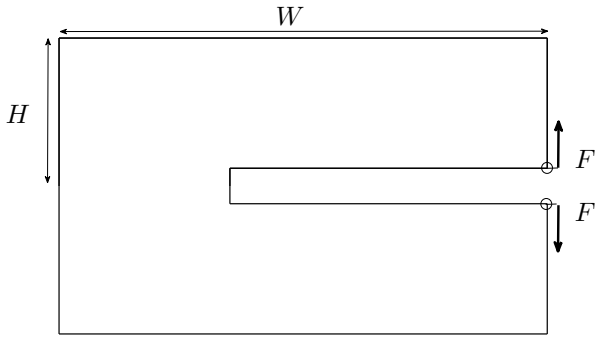

Figure 2: Continuum structure

The optimization methods that should be considered are:

c) Use the SIMP algorithm to derive an optimal design. You should investigate different discretizations and different initial values. The maximum allowed volume of the structure after the symmetry condition has been considered is $V_{max} = 0.5HWt$, where H and W are the width and height given in Fig. 2, and t is an eligible thickness. Solve the problem for different meshes.

d) Include a filter to the SIMP algorithm by introducing Helmholz PDE into the formulation. The theory describing the filter can be found in Lazarov and Sigmund [2010]. Solve the problem for different meshes and different length scale parameters. Routines related to the density field is available on the course-webpage.

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 **2014-03-16 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. 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 12 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

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.