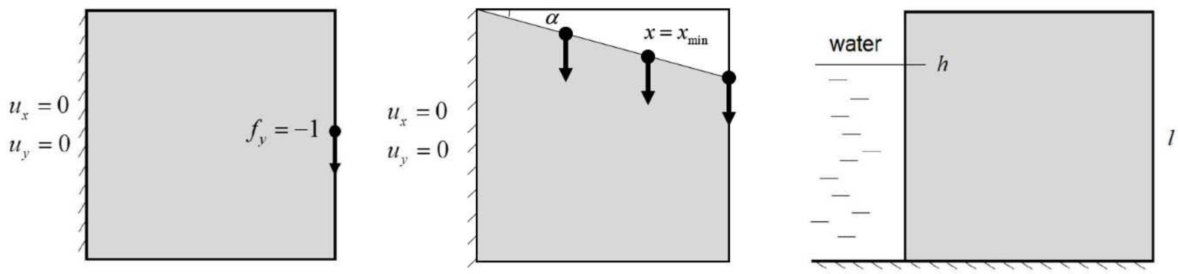
Topology optimization Assignment (1.0EC)

I. Ostanin, 12.02.2021.

1. **(1 point)** Get acquainted with the topology optimization code provided (the code top88.m). Use the paper [1] as the guidance.

Change the loads and boundary conditions in order to solve the problem depicted on Fig. 1 (A).



A B C

D

Fig. 1 (A) Problem 1, (B) Problem 2, (C)Problem 3, (D) Examples of designs of roof supports used in architecture of houses.

See how the solution depends on filtering radius, penalization factor, volume fraction, mech resolution. Check if the resulting solution depends on the initial guess, both in case of small penalization (p=1) and large penalization (p=3).

2. **(1 point)** Write the code that uploads a monochrome image of a given size in *.bmp format as the distribution of density, determines the volume fraction and computes the stored elastic strain energy for a prescribed boundary value problem, provided input image size and penalization factor as the arguments: solver(nelx, nely, p). In MS Paint or other graphics editor sketch you best guess of engineering design providing the maximum stiffness of the structure in the problem 1. Using your new code, determine the volume fraction and the value of strain energy. Run the optimization code with the same BVP, penalization factor and volume fraction. Compare the results.

3. **(4 points)** Using previously designed tools, try to design an optimal roof support (see the problem description on Fig. 1(B) and sample designs on Fig. 1(D)). The elements above the roof level are of zero density and do not participate in the optimization process (see [1] for the details on how to implement such a constraint in the code). For the remaining elements, use volume fraction *f* of 0.5 as an optimization

constraint. We assume the load from the roof is distributed evenly among N equispaced support points (On the Fig 1(B) N=3). Try to perform the optimization for few values of N, including N = 1 (tip-loaded beam) and N is equal to number of elements along x (uniformly distributed load). Try to perform the topology design procedure for the roof inclination angles $\alpha = 15^O$ and $\alpha = 30^O$.

Based on these studies, propose your design of a roof support. For your design, use $\alpha = 15^O$. You are free to chose N as you like. Try to make your design not only functional/manufacturable but aestatically looking as well. Compute exact values of volume fraction and compliance for your design, perform topology optimization with the same N, α, f and penalization factor p=3. How close is your design to optimal one in terms of compliance?

Summarize all the assumptions made when designing the roof-supporting beam. Which of those assumptions may be not true in the real sutiation?

4. **(2 points)** Try to design a dam (Fig. 1(C)), given that the density of the material of a dam is negligible compared to density of the water. Compute solutions for few different water levels.

5*. **(2 points)** Modify your code to account for the structure's self-weight, linked to the material density. With your new code, try to solve the problem of a dam again, assuming that the density of material of a dam is twice the density of water. (***Note:*** *This is actually a research problem. The tricky part is that the presence of body force that depends on the density distribution* ***is changing the BVP****, that serves as the optimization constraint, on the fly, therefore the straigtforward SIMP/OC approach may not work well. In case of divergence of the algorithm, try to suggest possible workarounds.*)

References:

[1] E. Andreassen, A. Clausen, M. Schevenels, B. S. Lazarov and O. Sigmund. Efficient topology optimization in MATLAB using 88 lines of code. Struct Multidisc Optim, Volume 43, Issue 1, p.1 - 16, 2011.