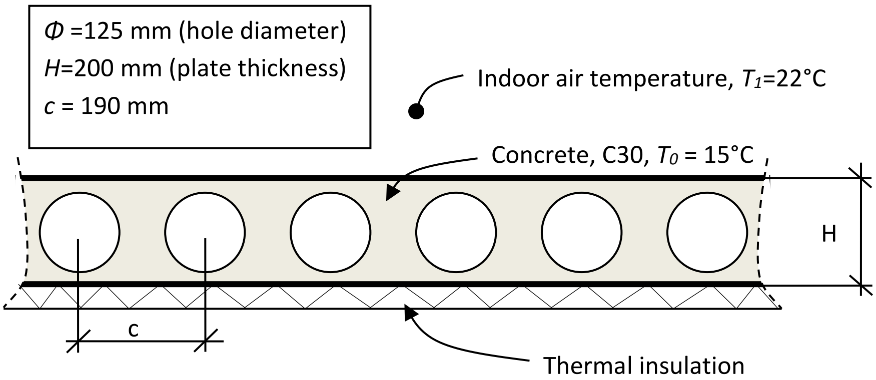
Hand-in assignment 3 - Transient Heat Flow

Problem description

A hollow-core concrete floor slab according to the figure below is situated in a residential building. The cavities in the floor are intended to be used for heating by letting hot air flow inside some of them. The floor is made from concrete of strength class C30 and its initial temperature is T_0=15°C. The indoor temperature T_1=22°C and there will be *convection* along the indoor boundary. Inside the cavities, the convection can be neglected. The thermal insulation below the floor may be regarded such as heat not is flowing across the lower boundary.



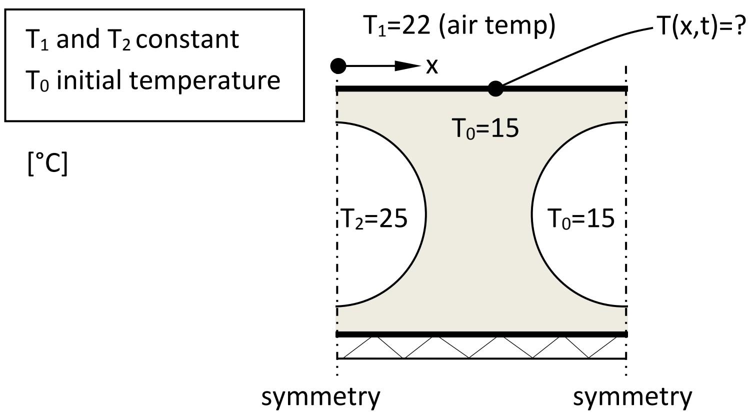
Task

To determine if this solution for heating the room is a good solution, the heat transfer within the floor slab must be determined. To judge the comfort and effectiveness of the floor it is of special importance to determine:

- *the temperature distribution along the top surface and its variation with time*
- *the total heat flow (power) into the room*

It is assumed that only every other cavity need to be supplied with hot air at T_2=25°C. The remaining cavities are then filled with air with an *initial* temperature of T_0=15°C.

Note that symmetry properties can be utilized (see below). Convection (on the top concrete surface) can be modelled either by introducing a fictitious convective layer or by following the approach of section 10.1.2 in [1]. Make sure that the discretisations introduced, *i.e.* element size *and* the size of the time step, are reasonable so as to obtain a solution of adequate accuracy. Also, how long time do you have to run to reach steady-state?



Report

The results of your work will be presented in a written report. Use the below structure of the report and make sure it includes:

1. Problem description and objectives.
2. Basic theory used. Include especially, on approximately two pages, the theory of the transient heat flow *element* you have used and the time integration procedure.
3. Model description: All assumptions made in the modelling - Finite element mesh used, time stepping parameters chosen and assumptions regarding geometry, materials, loads and boundary conditions.
4. Results. This section ***must*** include:
    - Investigation on ***influence of time stepping parameters*** (α and *dt* of *step1*-command in CALFEM) on the solution.
    - ***Colour plots of the temperature distribution*** at appropriate times. (For example at *t*=1, 4, 8 and 16 hours (4 filled contour plots)).
    - Plots of the ***temperature distribution along the top concrete surface*** at appropriate times. (For example, *T(x)* at *t*=1, 4, 8 and 16 hours (*i.e.* 4 curves in *one* figure)).
    - A plot of the ***total power supplied per square meter of floor area as a function of time***.
5. Discussion of your results.
6. Appendix: Commented Calfem .m-file(s).

The report will be judged and graded as described in the course programme, which also states the deadline. See also handed out material "Note on report writing".

References

[1] Ottosen, N.S., Petersson, H.: Introduction to the Finite Element Method, Prentice Hall 1992.