Assignment A - Residential Block, Thermal strains

A residential block with a concrete structure is to be built. The concrete structure consists of walls, pillars, and of two slab floors with identical geometry. The lower concrete slab is shown in Figure 1.

The computer code CALFEM is available for the calculations. Also comments concerning the modelling of the structure, the loads, the material and the boundary conditions should in an appropriate amount be added.

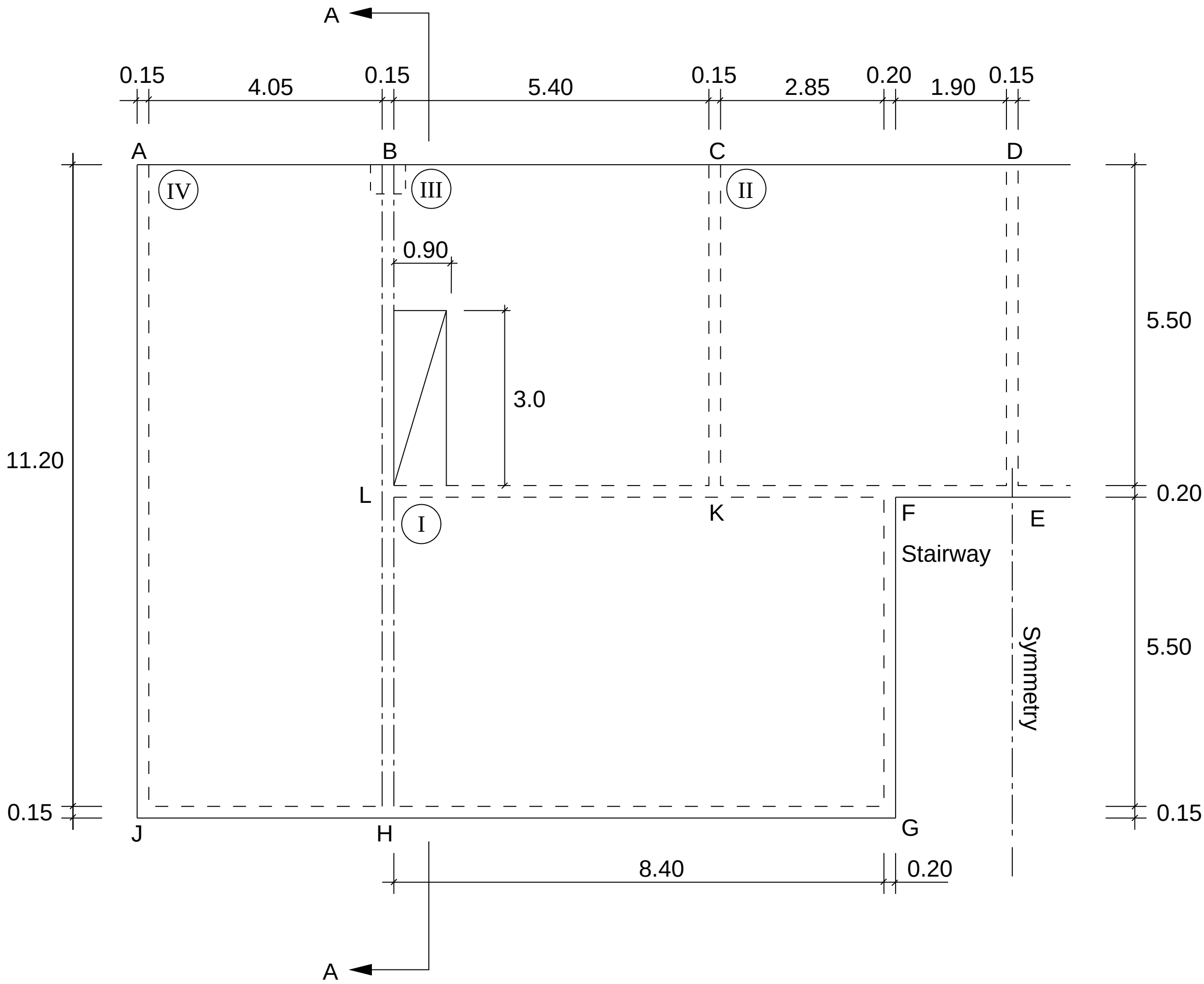

Figure 1: Drawing of the lower concrete slab.

Structural modelling

The residential block has two slab floors with identical geometry which are located straight above each other. The slabs have a free edge along A-D, and can be considered as simply supported at the remaining supports except at the stairway. At the stairway the plates are casted together with the 200 mm thick stairway wall. There is a 0.9×3.0 m^2 large hole in part III of the slab as shown in the figure. The plate is 150 mm thick.

	Load	Partial coefficient
Selfweight	4.9 kN/m^2	1.20
Imposed load	2.0 kN/m^2	1.50

Part III of the plate is loaded by a concentrated load P=4 kN at the non-supported corner of the hole.

Material modelling

The structure is to be constructed of concrete C20/25.

Task

In addition to the loads described above, the additional stresses due to thermal induced strains in the plate is to be calculated. An initial temperature of 15 °C is assumed when the concrete is hardened. The temperature then increases to 25 °C on the top surface and decreases to 5 °C at the bottom surface of the slab. Assume a linear temperature variation through the thickness of the plate.

Determine the deformations and the risk of cracking for the plate.

The computer code CALFEM is used for plate calculations.

Computer codes and documentation

The report of this Assignment A as well as the later handed out Assignment B must be written in separate reports. The computer code CALFEM and the meshing module can be downloaded from the course homepage at the following adress.
http://www.byggmek.lth.se

Hints

Thermal strains

In state of plane stress, the thermal strains may be written as (see eq.(13.30) in the book)

$$\boldsymbol{\epsilon}_0 = \alpha \Delta T \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} \tag{1}$$

where $\Delta T = T(z) - T_0$ and α is the thermal expansion coefficient. $T(z)$ is the thermal variation through the thickness.

Moments in plates (see eq.(18.20))

$$\mathbf{M} = \int_{-t/2}^{t/2} \boldsymbol{\sigma} z dz \tag{2}$$

The stresses may, according to Hooke's law, be written as (see eq.(18.15))

$$\boldsymbol{\sigma} = \mathbf{D}\boldsymbol{\epsilon} - \mathbf{D}\boldsymbol{\epsilon}_0. \tag{3}$$

and the strains may be written as (see eq.(18.16))

$$\boldsymbol{\epsilon} = -z\boldsymbol{\kappa} \tag{4}$$

Stiffness matrix

The element stiffness matrix may be written as

$$\mathbf{K}^e = \int_A \mathbf{B}^{e^T} \mathbf{M} dA. \tag{5}$$

By inserting the moment, $\mathbf{M}$, defined above, the initial strain vector $\mathbf{f}_0$ may be derived.

Finite element formulation

The finite element formulation may now be written as

$$\mathbf{K}^e \mathbf{a}^e = \mathbf{f}_b^e + \mathbf{f}_l^e + \mathbf{f}_0^e. \tag{6}$$

In CALFEM

$\mathbf{f}_0^e$ may be assembled into the global $\mathbf{f}$ vector by use of a vector assembling command:

$[\mathbf{f}]$ =vec_assem$(Edof(i,:), \mathbf{f}, \mathbf{f}_0)$