MEC-E1005

MODELLING IN APPLIED MECHANICS 2023

Weeks 17-18 PERIODIC STRUCTURE DISPLACEMENT

PERIODIC STRUCTURE

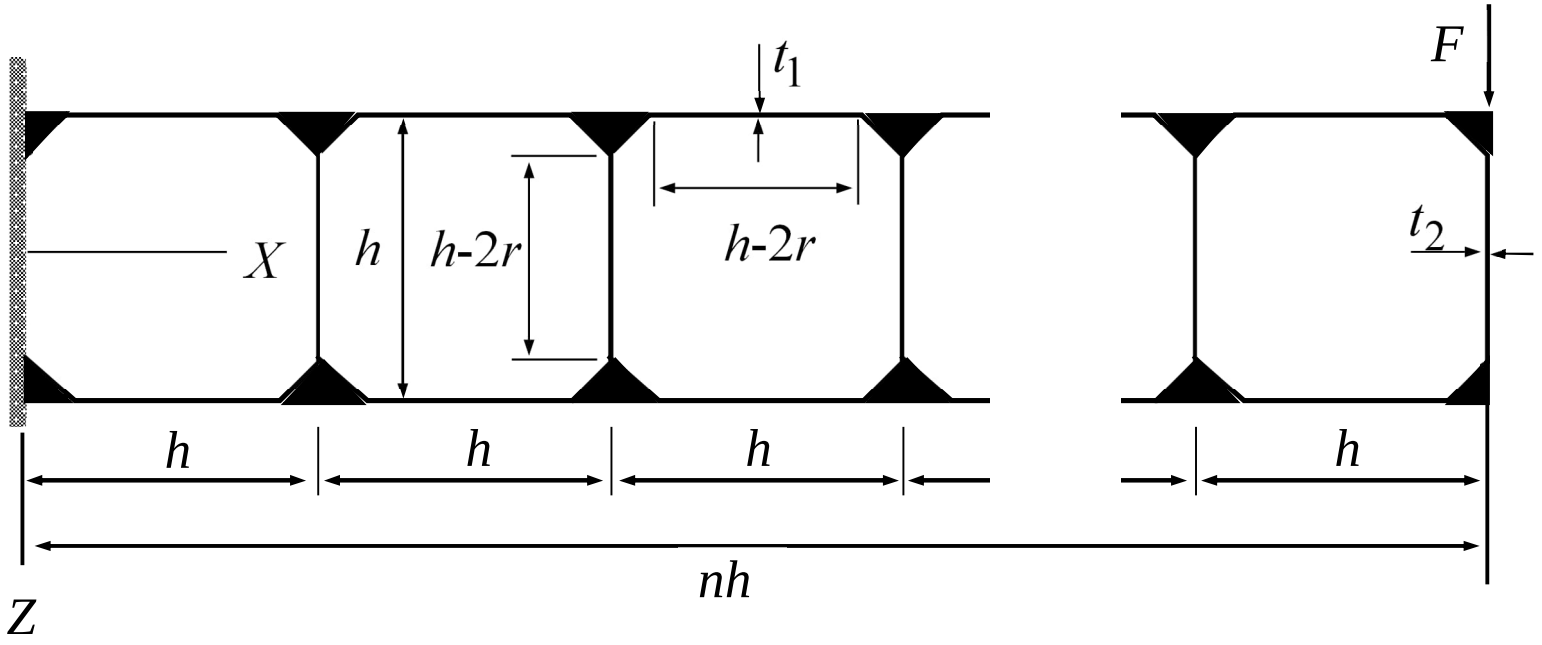
ASSIGNMENT

A structure is considered as periodic if one may identify a part which repeats itself in one or several directions. Regularity in that sense can be used to simplify, e.g., displacement analysis with variable number of parts.

The aim is to find the effect of geometrical and material parameters to the displacement-load relationship of a periodic steel structure of the type shown in the figure. The left end is attached to a wall. The right end is loaded by a point force. The starting point is a generic expression predicted by dimension analysis. First, a simplified model is used for a more specific relationship. After that, analysis by FEM is used to study the effects of details. Finally, the displacement-force relationship is compared with an experimental one.

IDEALIZATION AND PARAMETERIZATION

In the idealization, *n* identical parts are connected by welds of triangular shape. The left end is rigidly connected to a wall and load is acting at the right end.



DIMENSION ANALYSIS

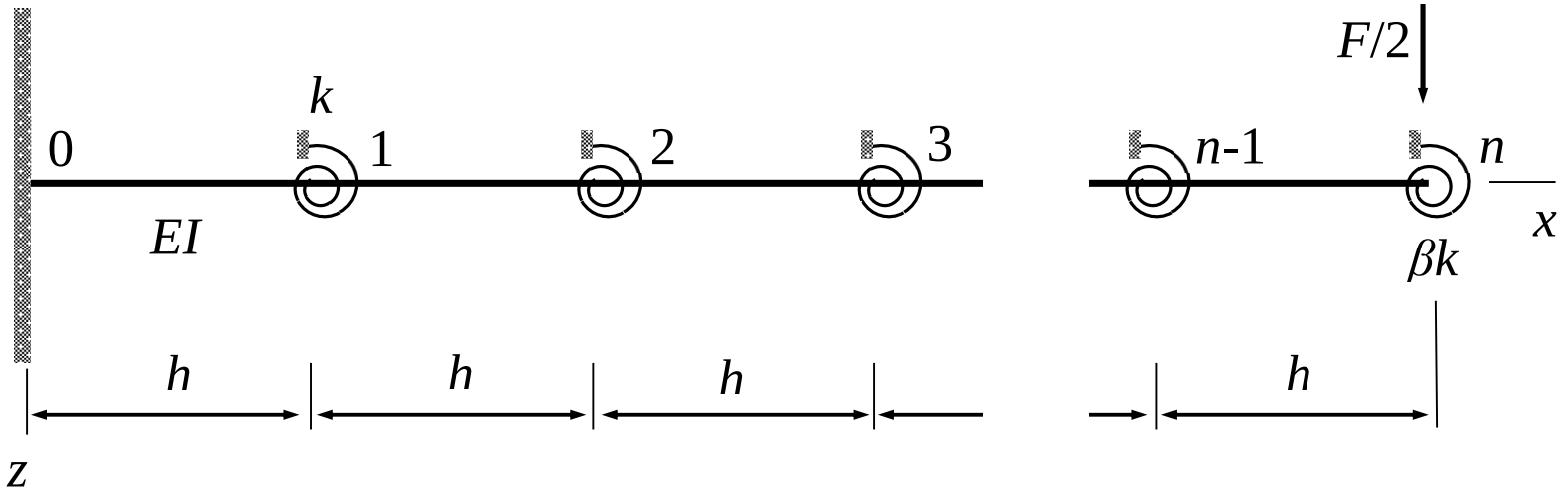
Assuming that the effect of the axial deformation of the material is negligible compared to that of bending, dimension analysis, based on quantities E, I_1, I_2, h, r, F, and w, gives the relationship

$$\frac{w}{h} = \frac{Fh^2}{EI_1}\alpha\left(\frac{r}{h}, \frac{I_2}{I_1}, n\right), \tag{1}$$

in which the form of the right-hand side requires a more detailed analysis. The indices in the second moments refer to the two different thicknesses of the material. Equation (1) assumes linearity between displacement and load, vanishing displacement with zero loading, and that the straight parts behave essentially as Bernoulli beams in bending.

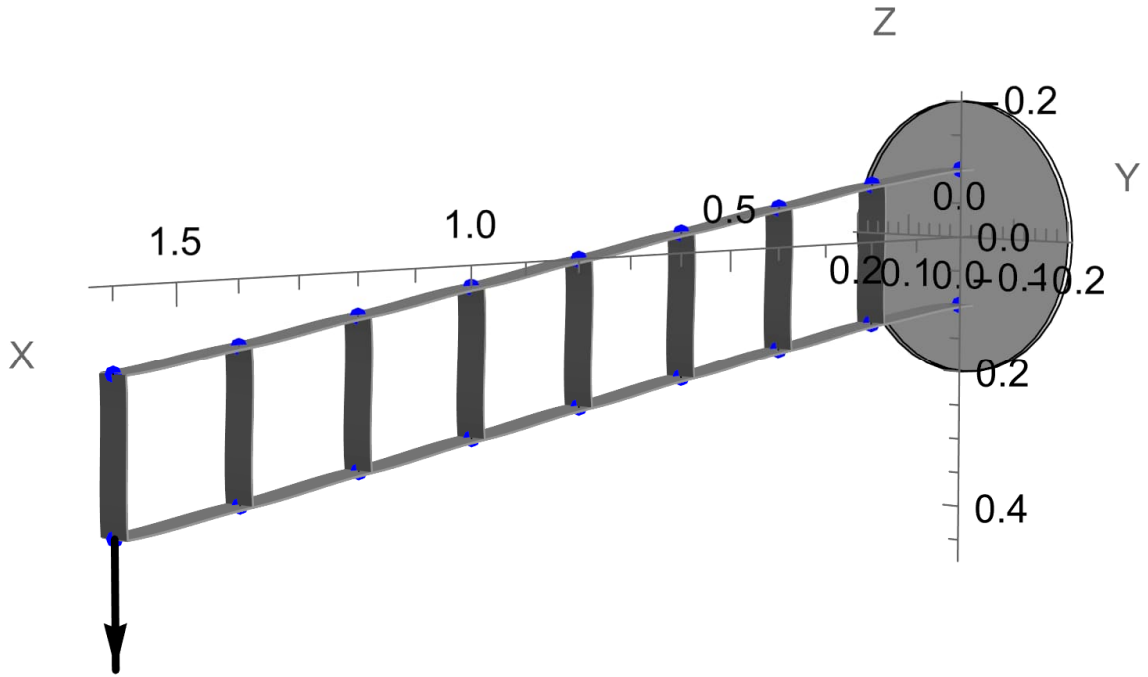
SIMPLIFIED ANALYSIS

Simplification assumes that $r/h = 0$ and $I_2/I_1 = 1$. As the end points of the vertical parts translate downwards but not sideways, the vertical parts just increase the bending stiffness of the upper and lower horizontal parts which deform in the same manner. Therefore, one may consider an inextensible Bernoulli beam shown.



FINITE ELEMENT ANALYSIS

Finite element analysis with solid, plate or beam elements give the force-displacement relationship without (too many) simplifying assumptions. However, analysis requires numerical values for all the problem parameters.



EXPERIMENT

The set-up is located in Puumiehenkuja 5L (Konemiehentie side of the building). The hall is open for measurements during the office hours (09:00-16:00) from Thu of week 17 to Thu of week 18.

Place a mass on the loading tray and record the displacement shown on the laptop display. Gather enough mass-displacement data to find the displacement-force relationship reliably. For example, you may repeat a measurement with certain loading several times to reduce the effect of random error by averaging etc. Do not overload the structure.