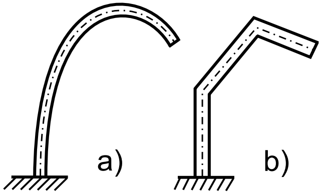
14. Curved and angular open beams

a) **A curved beam** is a beam the centreline of which is a continuous and smooth curve.

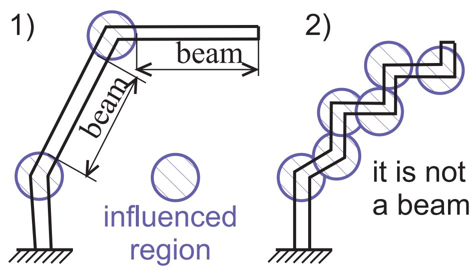
b) **An angular beam** is a body having the character of a beam the centreline of which is a continuous but not smooth curve (the centreline is smooth only per parts - it consists of several smooth parts being either straight or curved). An angular beam has a finite number of turning points (points where the centreline is not smooth) in the surroundings of which the bar assumptions are not accomplished; therefore the surroundings of these turning points cannot be solved using the simple theory of elasticity of bars.



bar assumptions
Example 203
Example 623
Problem 619
Problem 620

If we want to analyse an angular beam, then

1. we make use of Saint-Venant's principle and we solve only parts in a sufficient distance from the turning points using the theory of elasticity of beams,



Saint-Venant's principle

2. we are able to analyse only such angular beams at which the sum of the parts of centreline influenced by turning points is small in comparison with the length of the centreline,

3. we assume that the turning point is rigid, i.e. the angle of both parts of the centreline in the turning point remains constant and this part of the beam rotates as a rigid body. This assumption is correct that time if the beam in the surroundings of the turning point is stiffened sufficiently in comparison with its smooth parts. The stiffening is usually necessary from the viewpoint of limit states because the stress state in the surroundings of the turning point cannot be solved by an analytical solution. In some cases it is possible to determine the stress in the turning point vicinity by use of the stress concentration factor, similarly to notches.

concentration factor

4. as the near surroundings of the turning point does not deform (the turning point rotates as a rigid whole), the strain energy is calculated only for the smooth parts of the beam, which is valid if the assumptions of the paragraphs 2 and 3 are met.

The solution algorithm is the same for curved as well as angular beams. We resemble only some notes:

1. The centreline is generally curvilinear which means that there is ds instead of dx in the term behind the integration symbol at quantities calculated by integration (deformation parameters).
2. If the centreline contains turning points and locations where the curvature of the beam changes (transitions from straight to curvilinear parts), the deformation parameters are calculated by integration per the individual parts.
3. We must decide whether the beam can be solved as slightly curved. In the opposite case, the beam should be solved using the analytical theory of curved beams (which is not presented within the framework of this course) or using the finite element method (FEM).
4. If there is a critical location in the turning point, we solve stresses in a section **near** this point at the left or right hand side, because we are not able to solve them in the very turning point.
5. At curved and angular beams, simple loadings (simple tension, flection, shear or torsion) occur only in some special cases. The loading is mostly combined, but flection is often dominant at in-plane slender beams.
6. At statically indeterminate beams, the partial free body isolation is mostly realized by isolation of the supports with the frame. If using Castigliano's theorem, it is always necessary to express the support resultants (which occur in the relations for strain energy containing inner resultants) from the static equilibrium equations as functions of that of the resultant, with respect to which the strain energy is to be differentiated.

algorithm
Problem 606
Problem 609
Problem 605
Problem 611
Problem 612
Example 626
Problem 603
S-Venant's principle
loading
flection
Castigliano's theorem
Example 613
Example 614
Problem 610
Problem 615