AS3020*: Assignment 4

Module 4: Bending of Beam-Like Structures

Posted on 14-Sep-2024; Due at 11.59PM on 25-Sep-2024

General Instructions

1. Write this honor code and sign your name against it in the first page of your submission. Evaluation will not be done unless this is present in the submission.

   Upon my honor I state that I have received no unauthorized support and can attest that the submission reflects my understanding of the subject matter.

2. Discussions among students is permitted for this assignment. But ensure that your submission is your own. Do not write anything that you do not understand.

1 Answer Briefly.

1. Suppose the length of a beam ℓ is $\mathcal{O}(1)$ ("of the order of magnitude of $1\,m$), it's sectional dimensions X_2, X_3 are $\mathcal{O}(\varepsilon)$ (some $\varepsilon \ll 1$). These are mathematically denoted by $\ell \sim \mathcal{O}(1)$, $X_2, X_3 \sim \mathcal{O}(\varepsilon)$.

   Using the above notation, write down the order of magnitude of

   (a) The area of the cross section, A;

   (b) The second moment of area of the cross section, I_{ij}; and

   (c) An arbitrary area-moment $M^{(n)}_{i_1 i_2 \ldots i_n} = \int_A \prod_{k=1}^{n} X_{i_k} dA$ ($i_k \in \{2,3\}$, $k \in [1,n]$).

2. Classify the off-diagonal second moment of area ($I_{23} = \int_A X_2 X_3 dA \neq 0$) written about the area-centroid as positive, negative, or zero for the thin-walled sections shown in fig. 1. Assume constant thickness t. Make any other geometrically simplifying assumptions as appropriate.

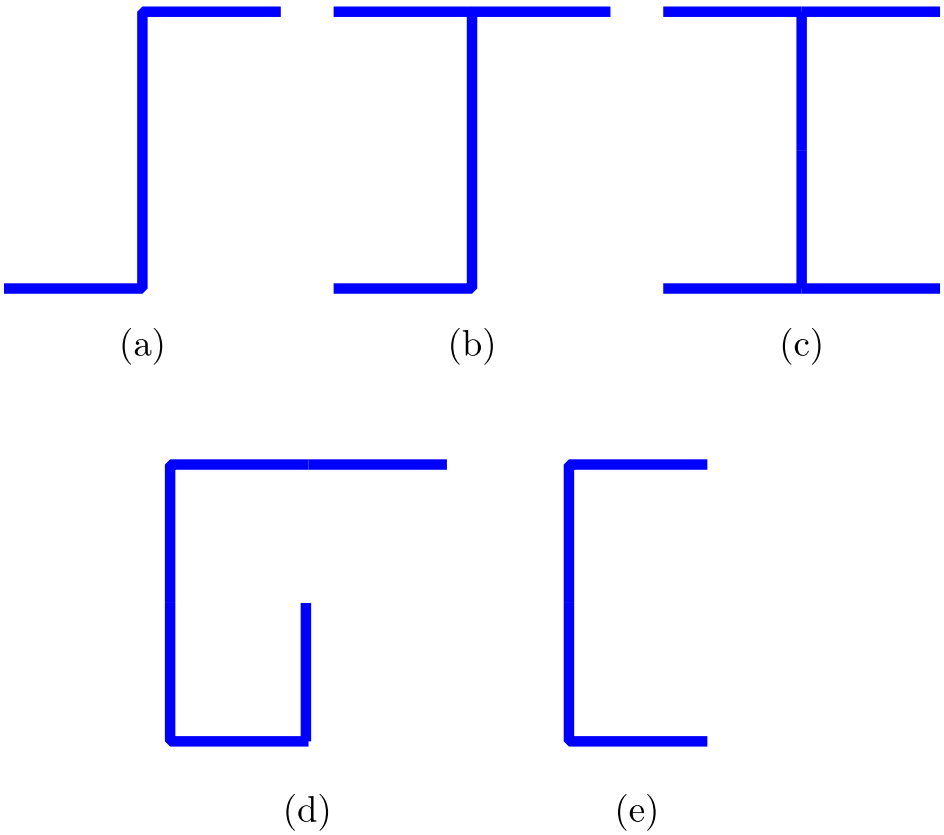

Figure 1: Sections for Question 2

2 Answer in Detail

1. Consider a square section with side a and thickness t as shown in fig. 2. Answer the following:

   (a) Suppose that the resultant shear is along the $\underline{e}_3$ direction only. Compute the shear flow. Provide a schematic representation.

   (b) Where is the shear center of the section located? Why?

   (c) Compute the average shear flow in each face (AB, BC, CD, and DA). Indicate them as vectors with components along $\underline{e}_2$ and $\underline{e}_3$.

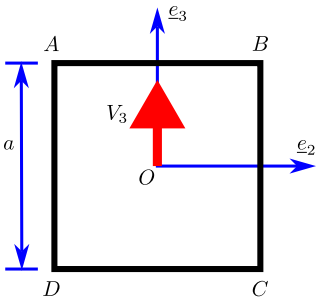

Figure 2: Box section geometry for Q2.1.

2. Suppose that it is desired to reduce the thickness of the sheet metals involved in the above section significantly (such that the new thickness is nearly zero), and booms are to be introduced at the vertices of the box section as shown in fig. 3. Answer the following:

   (a) What must be the area of the booms such that bending stiffness is the same as the case with finite thickness?

   (b) Compare the zeroth moments of area from the box section and the idealized section. Which is greater? Write down one implication in a single sentence.

   (c) What is the shear flow in the members for the same resultant ($V_3\underline{e}_3$) as in Q1? Provide a schematic representation.

   (d) Is the shear flow in the idealized members higher or lower than the average quantities estimated for the original case? Discuss implications of this within two sentences.

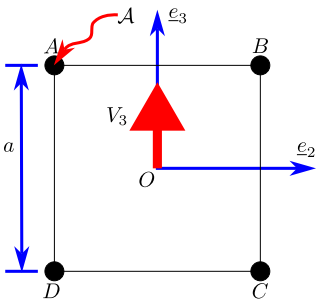

Figure 3: Idealized box section geometry for Q2.2.