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NUMERICAL AND EXPERIMENTAL ANALYSIS OF LARGE DEFLECTIONS OF CANTILEVER BEAMS UNDER A COMBINED LOAD

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Slender structural components, such as beams and columns, constitute basic parts of many structures. In this work the problem of deflection of a flexible cantilever beam of linear elastic material subjected to an external vertical concentrated load at the free end and an uniformly distributed load is analyzed. Under the action of these external loads, the beam deflects into a curve called the elastic curve or elastica. If the thickness of the cantilever is small compared to its length, the theory of elastica adequately describes the large, non-linear displacements due to the external loads. In this study, we assume that the beam is non-extensible and the strains remain small. We also assume that Bernoulli-Euler's hypothesis is valid and that the plane-sections do not change their shape or area. Governing equation is derived by using the shearing force instead of the bending moment because the shearing force formulation possesses some computational advantages over the bending moment formulation in the case of large deflected member. The problem involves geometrical non-linearity and the governing equation is a non-linear differential equation, which requires numerical solutions to determine the large deflection for a given loading. A iterative procedure to convert the two-point boundary value problem into an initial value problem is followed and solved the non-linear differential equations utilizing a fourh-order Runge-Kutta integration scheme. The values of the end slopes and the non-dimensional tip deflection parameters of uniform cantilever beam under a concentrated load at the free end obtained with this method are compared with the values obtained by using the elliptical integral method and the agreement between these is good. The developed algorithm is used to numerically evaluate the system. The Young's modulus of the beam material is obtained by using the experimental measurements of the tip deflections for various loads. To do this, we fit the experimental results of the vertical displacement at the free end to the numerically calculated values for different values of the Young's modulus by minimizing the sum of the mean square root. Finally, we compare the numerical results with the experimental ones obtained in the laboratory.

TOPICS + KEYWORDS: Non-linear mechanics, Cantilever beams, Large deflections, Geometrical non-linearity, Computational physics.