This article deals with numerical calculations of thin-walled composite laminate beams with closed cross-section subjected to pure bending. Thin-walled beams with square cross-section made of eight-layer GFRP laminate have been taken into consideration. An FEM model has been prepared using four-node multi-layered shell elements governed by first-order shear deformation theory. Linear buckling analysis and nonlinear static analysis including large displacements have been performed. A Newton–Rapson algorithm has been employed. The FEM calculations have been conducted using Ansys® software. Three following layer arrangement were considered: $[45/-45/0/0]_S$, $[45/-45/45/0]_S$ and $[45/-45/45/0/0/-45/45/-45]_T$. The influence of number of load steps and geometrical initial imperfection on course of equilibrium paths has been checked. The results of calculations have been compared with experimentally performed four-point bending tests. Comparing results of tests and numerical calculations, it was observed that, in some cases, the deflection of beams does not correspond to the bifurcation buckling mode but corresponds to the lowest buckling load; the geometrical imperfection that corresponds to the higher buckling mode should be taken into consideration to obtain similar postbuckling equilibrium paths from tests and FEM calculations. As is well known, the buckling load and failure load for real structures depend on course of equilibrium paths. Taking above considerations into account, the author of this article tries to show some problems in obtaining numerical calculations results that are similar to experimental tests.