A newly developed framework is presented for structural design and analysis of long slender beam-like structures, e.g., wind turbine blades. The framework is based on the BEam Cross section Analysis Software – BECAS – a finite element based cross section analysis tool. BECAS is used for the generation of beam finite element models which correctly account for effects stemming from material anisotropy and inhomogeneity in cross sections of arbitrary geometry. These type of modelling approach allows for an accurate yet computationally inexpensive representation of a general class of three dimensional beam-like structures. Preliminary results are presented where the devised framework is used for stiffness and strength analysis of wind turbine blades, material and structural topology optimization of wind turbine blade cross sections, and evaluation of strain energy release rate in fractured beams. The results show a good agreement with solutions from three-dimensional solid finite element models but require only a fraction of the computation time.