AnalySwift™

Efficient High-Fidelity Modeling of Composites—A New Approach

EFFICIENT. ACCURATE. VERSATILE.

VABS™

OVERVIEW

VABS is the only tool capable of rigorously modeling three-dimensional (3D) slender solids (commonly called beams) with complex microstructures and is becoming the tool of choice for the wind turbine and helicopter industries after 20 years' development. Researchers and engineers worldwide are actively using VABS, which is the standard tool for design and analysis of composite slender structures such as wind turbine blades, helicopter rotor blades, high aspect ratio wings, composite bridges, and other slender structural components. The unique technology underlying VABS renders it the first truly efficient high-fidelity modeling tool for composite beams, saving users many orders of magnitude in computing time relative to 3D FEA (finite element analyses), without a loss of accuracy. The advantages of VABS over other technologies have been clearly demonstrated by virtue of its generality, accuracy, and efficiency.

UNIQUE TECHNOLOGY

VABS (Variational Asymptotic Beam Sectional Analysis) implements the various beam theories based on the concept of simplifying the original nonlinear 3D analysis of slender structures into a one-dimensional (1D) nonlinear beam analysis using a powerful mathematical method, the variational asymptotic method. VABS is designed to model structures for which one dimension is much larger than the other two (i.e., a beam-like body), even if the structures are made of composite materials and have a complex internal structure. VABS takes a finite element mesh of the cross section including all the details of geometry and material as inputs to calculate the sectional properties including structural properties and inertial properties. These properties are needed for the 1D beam analysis to predict the global behavior of the slender structure. The 3D pointwise displacement/strain/stress distribution within the structure can also be recovered based on the global behavior of the 1D beam analysis.

KEY BENEFITS

+ Unprecedented competitiveness as the only available technology to rigorously model real structures such as composite blades

+ Drastically reduced design cycle and time to market by helping you save many orders of magnitude in engineering design and analysis time

+ The best compromise between accuracy and efficiency, an effective alternative for computation-intensive 3D FEA

+ An enabling technology for nonlinear aeroelastic analysis of highly flexible structures

APPLICATIONS

+ Wind turbine blades
+ Helicopter rotor blades
+ Gas turbine blades
+ High aspect ratio wings
+ Wing section design
+ Composite bridges
+ Other general composite/smart structures:
  - Beams
  - Shafts
  - Rods
  - Columns
  - Bars

MATERIALS

VABS is not restricted by materials. The structure can be made of an arbitrary number of general materials including:

+ Fiber reinforced composites
+ Woven composites
+ Braided composites
+ Conventional materials
+ Foam materials and others

EFFICIENT HIGH–FIDELITY

Enabled by VABS, analysis can be done as efficiently and simply as conventional beam analysis, without losing accuracy compared to more complex and time-consuming 3D FEA. With VABS, it is now possible to confidently design and analyze real structures with complex microstructures due to this unique efficient high-fidelity feature of VABS. For example, structures as complex as real composite rotor blades with hundreds of layers can be easily handled by a laptop computer.

VERSATILE

VABS is implemented using the finite element techniques with a general element library that includes all the typical 2D elements such as 3, 4, 5, 6-noded triangular elements and 4, 5, 6, 7, 8, 9-noded quadrilateral elements. Users are free to choose the type of elements, and different types of elements can be mixed within one mesh, if necessary. This flexibility allows VABS to model beams of any shape.

VABS can deal with arbitrary layups. Users can provide one parameter for the layup orientation and one parameter for the ply orientation to uniquely specify the material system in the global coordinate system. Nine parameters can be used for the ply orientation if a ply is highly curved and the ply angle is not uniform within an element.

VABS does not require the beam reference line to be the locus of cross-sectional area centroids. VABS can calculate the centroid for any arbitrary cross section, and users can choose their own reference line for the convenience of the 1D global beam analysis.

VABS can deal with isotropic materials, orthotropic materials, and general anisotropic materials.

VABS can be quickly and conveniently integrated with other environments such as computer-aided design environments, multidisciplinary optimization environments, or commercial finite element packages.

ADDITIONAL FEATURES AND BENEFITS:

1. Shape of the cross-section: Truly arbitrary geometries accommodated. Modeling of realistic rotor blades is only possible through VABS. No need of oversimplified approximation for real structures.

2. Material properties: VABS has no restrictions on material properties and can handle any material including isotropic, orthotropic, or general anisotropic materials.

3. Multiphysical capability: VABS can analyze structures under the coupled effects of thermal, mechanical, and electromagnetic fields.

4. Various engineering beam models: Generalized Euler-Bernoulli model, generalized Timoshenko model to account for transverse shear, generalized Vlasov model for composite beams with significant restrained warping effects. No ad-hoc assumptions such as plane sections remaining plane and normal to the beam axis are invoked.

5. Modeling of Initially curved /twisted /oblique beams: The structure can be initially twisted or curved and/or have a naturally oblique cross-section.

6. Recovery of field variables: Possible to accurately recover 3D stresses, strains, and displacements from 1D displacements and sectional resultants.

7. Free companion 1D beam analysis: GEBT, also developed by Prof. Yu as a companion code for VABS, is a general-purpose 1D nonlinear beam analysis code. It is based on the geometrically exact beam theory and can be used for static, dynamic, eigenvalue analysis.

8. Trapeze effect: Carries out a nonlinear sectional analysis to incorporate the trapeze effect for beams under large centrifugal forces which effects the torsional rigidity.

9. Overall benefits: Very high levels of accuracy—comparable to 3D nonlinear FEA yet with the efficiency of simple 1D beam analysis. Possible to design/analyze complex structures which is not possible using 3D FEA within available computing resources.

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Analy Swift ™