Kite as a Beam Modelling Approach: Assessment by Finite Element Analysis

C. Duport, A. Maison, A. Nême, J.-B. Leroux, K. Roncin, C. Jochum, Y. Parlier

3D non-linear lifting line model [1]

- Prandtl lifting line theory adapted to wings with variable dihedral and sweep angles. Finite wing and its wake represented by a set of horseshoe vortices of different strengths $F$.
- Inclusion of the non-linearity of the lift coefficient.
- Iterative solution:
  - Computation of the induced velocities with the Biot-Savart law.
  - Computation of the circulation from the equivalent local lift calculated from the Kutta formula and from the polar of the section.

Kite as a Beam model [2]

- Kite considered as an assembly of elementary cells.
- Cell composed of:
  - Portion of the inflatable leading edge: modelled as a beam with two half inflatable battens: modelled as beams.
  - Corresponding canopy: modelled as a shell.
- Each elementary cell is replaced by an equivalent beam.

Comparison of the 3D non-linear lifting line method with 3D RANSE results (Star-CCM+®) [3]

- Semi-circular kite of radius 1.0m with a NACA2412 section.
- Non-linear swept law.
- Linear twist law: from 0° at root to 5° at tips.
- Non-linear chord law from 1.0m at root to 0.1m at tips.
- Computation time:
  - Lifting line: 0.5s with a standard PC.
  - Star-CCM+: 4hmin with 8 cores.

Comparison of the Kite as a Beam model with a Finite Element model [4]

- Fluid-Structure Interaction (FSI) on a 50m² kite at 10° of incidence with an apparent wind of 25m/s and 75m of tether length. The anchor point of the tethers is a fixed point and the tethers and bridles system are represented by truss elements.
- Comparison between the Kite as a Beam model coupled with the 3D non-linear lifting line method and the Finite Element model coupled with a linear lifting line. The results of the two lifting line are slightly different.
- Computation time: few minutes for the KaB FSI, few hours for the FE FSI.

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References: