Turbine Blade Design

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Key design objective: If the tip deflects too much under a combination of normal aero induced loads and max wind load conditions, it will come into contact with the wind turbine tower.

Key performance parameter (KPP): Maximum blade tip deflection, Dmax, based on maximum anticipated wind induced load is 2 meters.

CHAMPS ontology used as is if possible or extended to include design objective and key performance parameter and design scenario.

Model parameters:

- blade width, w (m) (in the case of the I-Beam, this is the flange width. In the case of the box beam, the model will be extended to include box beam wall thickness, tbb (m).
- blade thickness, t (m)
- blade length, L (m)
- evenly distributed wind loads - Q2 (N/m). The value for this will be determined after literature review.
- evenly distributed aero-induced loads - Q1 (N/m) The value for this will be determined after literature review.

Design constraints:

- Allowable blade cross-section shapes: I-beam, hollow-box, rectangular (used to determine moment of inertia, I, for an area)
- The maximum distributed wind loads are constant, Q (value tbd)
- Allowable blade length range is 90 m to 110 m
- Allowable width: no constraint
- Allowable thickness: no constraint
- Wind loads are normal to the plane created by the blade length and blade width
- The elastic modulus is constant in the lengthwise direction.
- The cross-section shape does not change over the length of the blade.
- Evenly distributed wind loads start at 30% blade length and extend to 90% blade length.
- Only assume cyclic load conditions due to wind loads. Weight induced loads will not be considered.
- Maximum wind loads will occur once per day.
- ---need to calculate the number of anticipated cycles over a 40 year lifetime; the cycles used for design be a factor of three greater (e.g. cycles over a 120 year lifetime) --

CHAMPS ontology used as is if possible or extended to include all elements of the design constraints.

Approach:
As a first order approximation, treat the blade as a simple cantilevered beam. The tip is free and the root is fixed.

Allow the user to select Elastic Modulus values only based on the values available in the SNLMSU database. (using SPARQL).

Select various values for L (within limits: SPIN rule), w, t, cross-sectional shapes. Recall Q1 and Q2 will be constant at this point in the design. Develop a matrix of L, w, t, and cross-section shapes and vary parameters until max tip deflection has been determined for each established set of design parameters.

Since each elastic modulus value in the SNLMSU database corresponds to a composite material (reinforcement fiber, matrix), this identifies candidate materials that may satisfy the blade design.

Calculate weight based on design dimensions and weight information in the SNLMSU database for each of the candidate materials.

Determine max strain 1 meter from fixed beam location.

Select design with the lowest material weight and retrieve fatigue data (SPARQL) for that material (strain vs cycles to failure). Using the max strain, determine if the material meets the durability requirements.