Finite element analysis of wind turbine tower with a tapered cross-section using various finite element models

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Abstract

In this paper, we present the finite element analysis results for a wind turbine tower using three different finite element models. A typical three-bladed upwind onshore wind turbine, with rated power production of 2 MW, is chosen as a reference case study. Tapered cross-section of the wind turbine tower has been incorporated in the inner product while estimating the stiffness matrix of the finite element model. Linear static analysis is carried out for a typical aero thrust load applied at the tip of the tower. The finite element results are benchmarked using 3-D linear and quadratic brick and shell elements using ANSYS. It is shown here that Euler-Bernoulli beam model predicts the response of the wind turbine tower quite accurately. The beam model is computationally more efficient compared to shell and solid element models without compromising the accuracy of the results.

Keywords: Finite element analysis, shell element, Euler-Bernoulli beam element, wind turbine tower.

1 Introduction

Wind turbine has become a fast-growing source of energy because of it's characteristic of being reliable and emission free. The increasing demand on clean energy is witnessed throughout the years, according to the global wind statistics in 2001, the global cumulative wind capacity installed was 23.9 GW whereas, in 2016 it increased up to 486.8 GW. In Kuwait, Shagaya renewable energy park was constructed to obtain clean energy to cover the energy demand. The Wind farm has a total gross capacity of 10 MW and consist of 5 wind turbines [1]. The towers have a circular tapered cross section varying along the length. They are subjected to different wind speeds throughout the year noting that Kuwait has a harsh dessert environment.

The technical characteristics of the Shagaya wind turbines are presented in Table 1.