POST-CRACKING BEHAVIOUR OF A WIND TURBINE CONCRETE TOWER

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The paper deals with the dynamic performance of a simply reinforced concrete tower built using prefabricated elements. The main uncertainty of this strategy stems from the possible cracking of the concrete and its implications on the stiffness, natural frequency and dynamic amplification of the tower.

In 2006 an 80 m high prototype was built, supporting a 1.5 MW wind generator, carefully instrumented and test loaded to 80% of its design capacity. The prototype and installed instrumentation remained in operation for 3 years. Detailed calculations were carried out of the cracking induced in the concrete and its effects on the natural frequency of the tower, as a function of wind speed and orientation; the results were compared with the monitoring data.

It is concluded that numerical modelling with Abaqus allowed good predictions and interpretations of the observed response of the tower. Also, simply reinforced concrete is shown to be a good option for high towers; if the structure is well designed, the natural frequency will not migrate to a point where its proximity to the forcing frequency will lead to unacceptable levels of the dynamic amplification.

Keywords: wind turbine, concrete, cracking, natural frequency

1. Introduction

The last few years have witnessed a strong development in wind power generation, perhaps particularly in countries like Spain but also at a global scale. The general tendency has been towards greater tower heights, rotor diameters and rated powers. The majority of the existing wind turbines are supported on steel towers, which are shop fabricated in three segments, transported to site and assembled locally. However, beyond a certain size, this strategy must be abandoned because the dimensions of the tower segments no longer satisfy the limitations imposed by land transportation. Though in principle the tower could be decomposed in more than three parts, its reliability and durability can be expected to decrease as the number of connections increases.

A possible alternative is to use concrete instead of steel for building all or part of the tower. The concrete could be pre-stressed or simply reinforced, prefabricated or cast in situ. The use of simply reinforced concrete for this role may generate some concerns, on the grounds that its progressive cracking could reduce the tower stiffness, thereby bringing its resonant frequency closer to that of the excitation and hence increasing the dynamic amplification of the response.

The present paper deals with a reinforced concrete tower, built using prefabricated elements that are assembled in situ without any pre-stressing; the tower is 80 m high and supports an AW-77 wind turbine capable for 1.5 MW. A prototype was built, carefully instrumented and subjected to a

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