Cracks analysis in onshore wind turbine foundations

Tomás RIPA ALONSO
Partner. Civil Engineer
LRA Infrastructures Consulting
Madrid, SPAIN
tomasripa@lraingenieria.es

Tomás Ripa received his civil engineering degree from the Technical University of Madrid, Spain. Apart from managing LRA Infrastructures Consulting, T.Ripa is Senior Lecturer at Technical University of Madrid.

Enrique GONZÁLEZ DUEÑAS
Civil Engineer
LRA Infrastructures Consulting
Madrid, SPAIN
enriquegonzalez@lraingenieria.es

Enrique González received his civil engineering degree from Technical University of Madrid with a year abroad at Imperial College London. Soon after graduation, E. González joined the structures department at LRA Infrastructures Consulting.

Summary

Wind turbine foundations are load extremely eccentrically and the loading is usually highly dynamic. Over the last years, an observable fact is arising in some wind farms: a set of discrete and clearly visible radial and circumferential cracks appear at regular intervals around the embedded steel tower. Fortunately, if these cracks are detected at an early stage they do not reduce the structural integrity of the foundation. However, if water makes its way through the cracks it can reach the reinforcement, which in addition to dynamic loads and fatigue, can make the matters worse and compromise the serviceability of the structure.

Based on the crack patterns recorded in the field and with the aid of a simulated finite element model using contact elements, the origin and nature of the cracks were identified. Furthermore, stresses in the foundation have been obtained in order to be controlled. These stresses do not exceed the ultimate strength of concrete but cracks finally appear due to cycle loading.

In this paper, the structural behaviour of the foundation is analyzed based on the cracks observed at the site and interpreting a FE model.

Keywords: Wind turbines, foundation, cracks, finite elements, repair, forensic engineering.

1. Introduction

The element designed for resisting the loads of a wind turbine and carrying them to the soil is the wind turbine foundation. Wind turbines transmit to the base a reduced vertical force, an horizontal load that is not relevant and an extreme bending moment. Apart from wind farms access roads, foundations represent the main civil engineering activity when erecting a wind farm.

Damages in the foundations are found when maintaining specific kinds of foundations in certain wind turbine farms. Due to their frequent presence, damages analysed in this document are those that occur mainly in wind turbines with an embedded steel ring inserted in the foundation. The damages appear as radial and circumferential cracks in the pedestal, near the steel tower mast.

Due to dynamic nature of loading, these cracks are not static. They grow as the number of load cycles increase and fatigue alters concrete properties. Depending on the structural mechanism of the foundation, these cracks may affect the integrity of the structure in different ways. Although cracks will not cause structure to collapse, they will create gaps in the concrete and originate oscillations in the steel tower, requiring very expensive repairs.

This paper summarises all possible types of foundations in wind turbine designs. After that, cracks are shown to illustrate the pathology. Finally, structural origin of these cracks is analysed with the aid of a Finite Element program.

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