Bridge construction using decommissioned wind turbine blades as a poverty alleviation centric technology: possibilities and implementation example

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Abstract

Wind energy is the second most popular renewable energy source (RES) in the world after solar energy. The most important problem of using wind energy is the recycling of turbine rotor blades, which are made of FRP composites. Thanks to their shape and mechanical parameters wind turbine blades can be used in construction industry i.e. as bridge girders. Reused in this way, as a component of cheap house or bridge wind turbine blades can contribute in poverty alleviation. The paper presents the example of reusing wind turbine blade as a footbridge main girder. The design, numerical simulations as well as static and fatigue tests with the use of a distributed fibre optic sensors to assess the behaviour of the structure under load are described. Successful examination in the laboratory led to the first Polish implementation of a footbridge made of reused wind turbine blades. The main conclusions from this project and plans of the research team for future development of hybrid wind turbine blade - concrete bridge girder are also presented in the paper.

Keywords: decommissioned wind turbine blade, recycling, FRP, footbridge, structural and material testing.

1 Introduction

In 2021 about 6000 turbines were decommissioned worldwide due to the expiration of 20 years of service [1]. Currently 3800 composite blades are removed annually in Europe [2], but already in 2023 about 14000 blades are envisaged to remove and recycle [3]. The annual composite wastes are expected to grow about 12% per year until around 2026, and then 41% per year until 2034, reaching 28.1 million tonnes of blade material [2]. Based on a predicted moderate growth scenario from the Global Wind Energy Council for future global wind power installations, a total of 16.8 million tonnes of composite materials will need to be decommissioned by 2030 and 39.8 million tonnes by 2050 [4]. According to [5], a total of 43 million tons of blade waste will be accumulated worldwide by 2050, 25% of them in Europe. Considering market growth scenario, the annual decommissioning of wind turbine blades is expected to reach 2 million tonnes by 2050 [5].

Structural recycling is a promising alternative end-of-life (EoL) solution for composite wind turbine blades. The process reuses the blades as large parts or construction elements. Structural recycling of blades prolongs the material lifetime, preserves the structural integrity of the composite, and needs relatively little reprocessing effort [6-8]. When decommissioned, blades may still have enough residual capacity to be structurally recycled. In the study [9] the effect of service life on wind turbine blades was investigated by comparing the actual state and performance of blades after 20 years to

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