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台灣風力機塔之抗颱風易損性分析

Analysis of Fragility for Typhoon-resistance of Wind Turbine Tower in Taiwan

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摘要

台灣處於西太平洋盛行颱風之端，每年颱風侵襲台灣約為 3~4 次，濱海地區或離岸容易受颱風災害，一旦發生破壞都是相當嚴重。然而目前風力機塔在臺灣並無設計規範可依循，因此本文將發展風力機塔之易損性以達到抗颱風安全評估為主要目的。在颱風盛行地區，風力規範之線彈性方法不能掌控風敏結構破壞機制，亦不能有效估計風敏結構在颱風作用下的工作性能。非線性靜力分析法，可以估計風敏結構之非線性變形，結果比線彈性法更接近實際。本研究採用非線性靜力側推分析得到抵抗之能耐容量，進一步根據迴歸台灣颱風頻譜推導風力機塔陣風反應因子，並引入一次矩可靠度值，最後以實際案例，利用分析得到各易損曲線圖可獲得不同設計風速(或傾倒力、位移)相對之失效機率，研究結果如下：(1) 易損性評估可採建議之迴歸風頻譜進行台灣颱風順風力需求(Demand)；(2) 機率式抗風評估較傳統單點式確定性評估安全可靠；(3) IEC 61400-1 規範並不能完全適合台灣，建議風力機塔之抗颱風能耐(Capacity)應提高至 IEC 1A 等級規範 1.69 倍。

關鍵詞：抗颱風安全；風頻譜；非線性靜力側推分析；易損性。

Abstract

Due to the probability of typhoon occurrence is about 3~4 per year strike in the Taiwan, therefore induced many severe damage of wind-turbine towers (WTTs) in the onshore or offshore area. However, WTTs does not have the standard design codes to follow up to today in Taiwan. Therefore, the purpose of the study is developed for the procedures of analysis fragility to meet the requirements for the typhoon-resistant safety evaluation of WTTs. Increased with new material, higher with slender of vertical structures, the elastic linear method cannot control the failure mechanism for the wind code at prone-typhoon area. Also it cannot control the performance function under typhoon strike. However, the nonlinear static analysis can estimate the nonlinear deformation and the results are more than the elastic linear method accurately. Based on the gust response factor (GRF) method of the wind spectrum of regression in Taiwan for considering the dynamic wind force of wind-turbine towers, the feasibility of the application of Nonlinear Pushover Analysis (NPA) method to obtain the demand and capacity of the typhoon-resistance safety evaluation is investigated. Furthermore, the probability of fragility analysis is carried out using the First-Order Reliability Method (FORM). There are three major results in this study: (1) the proposal formulation of wind speed power spectrum in Taiwan is suggested; (2) Wind Probabilistic Risk Assessment method is more reliable than the Certainty Method of Point Estimation; (3) the IEC-61400-1 code not suits to conduct the WTTs design in the Taiwan region, the capacity of typhoon-resistance should be upgraded to 1.69 times of IEA 1A hub load.

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