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System reliability assessment of an offshore wind turbine jacket by using adaptive Kriging and composite active learning approaches

C. Ren[1], Y. Aoues[2], D. Lemosse[3] and E. Souza De Cursi[4]

[1] Normandie Univ, INSA Rouen Normandie-LMN, France, chao.ren@insa-rouen.fr
[2] Normandie Univ, INSA Rouen Normandie-LMN, France, younes.aoues@insa-rouen.fr
[3] Normandie Univ, INSA Rouen Normandie-LMN, France, didier.lemosse@insa-rouen.fr
[4] Normandie Univ, INSA Rouen Normandie-LMN, France, eduardo.souza@insa-rouen.fr

Abstract:

Steel jackets become the main support structures of larger wind turbines in deep waters. Reliability assessment of these structures becomes important task to consider parameters uncertainties [1]. However, advanced modeling of the jacket structure to consider joint flexibility of the joints and stress concentration makes the reliability analysis of the jacket more complicated. Traditional reliability methods, as FORM/SORM and crude Monte Carlo simulations, are not suitable for complex and computationally expensive numerical models, such those required for offshore wind turbine jacket. Today, the reliability analysis of complex engineering problems is generally conducted by using surrogate models.

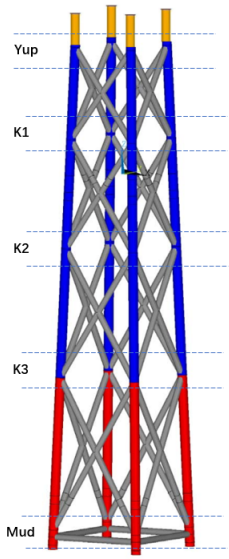

Figure 1: Joint zone classification

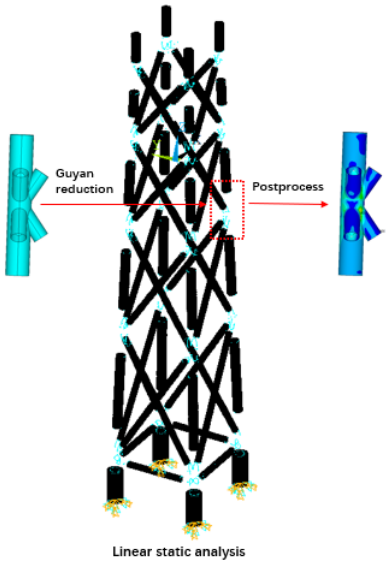

Figure 2: Von-Mises stress of K2 joint in super-element model

The failure of the jacket structure is rarely devoted to one failure mode. Furthermore, the system reliability analysis consists of consider several failure modes or component limit states. In this work, A jacket model is developed to consider joint flexibility by using

superelement. All the joints are originally modeled with shell elements and then reduced to superelements by the substructuring method. The stress concentration of the joints in the jacket model is then studied. Moreover, given the increase of extreme weather conditions in the recent decade, an extreme design load case of the offshore wind turbine is also considered, and the ultimate limit state is taken into account in the reliability analysis.

To reduce the computational burden of Crude Monte Carlo simulations for reliability assessment, the system reliability analysis is based on adaptive Kriging surrogate model with active learning approaches. Many active learning approaches [2, 3] have been developed for system reliability assessment. In this work, a composite active learning function is proposed to the adaptive Kriging surrogate model. The proposed method is applied to conduct the system reliability analysis of the jacket structure. Finally, the probability of failure of the jacket is estimated by considering the local stress concentration of joints. A comparison to the probability of failure estimated by using traditional beam modeling shows the interest and the efficiency of the surrogate-based active learning approaches for evaluating the reliability of the jacket by using advanced modelling.

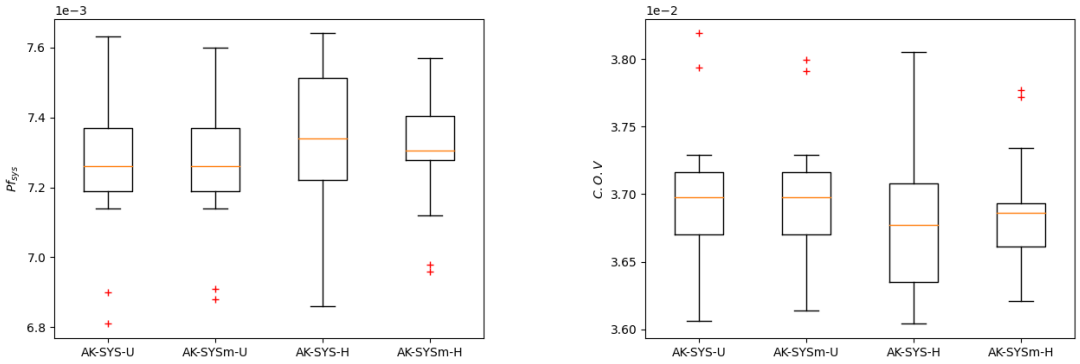

Figure 3: Boxplots of the probability of failure and coefficient of variation.

Keywords: *Offshore jacket structure, System reliability assessment, Active Learning function, Krigning, Monte Carlo simulations*

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