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Efficient fatigue testing of jacket nodes

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Abstract

The design of the structure of offshore wind turbines is pre-dominantly fatigue driven, welded joints being often critical. Any improvement in the fatigue resistance of the structure would result in decreasing the mass and the cost of the structure. However, any improvement needs to be demonstrated experimentally. In the present investigation, a fast test method for fatigue testing of tubular joints of jackets has been developed. It was investigated by numerical simulation if it would be possible to excite the node of a jacket close to its resonance frequency. After some iteration, a suitable geometry was found, based on an X-node. The test method was then demonstrated on a X-node with braces of OD219mm WT 5.59mm welded to a leg of OD368mm WT 25mm and 500mm length. The geometry was modified in order to obtain similar stiffness in OPB and IPB. It was then possible to obtain similar resonance frequencies for the OPB and IPB. The behaviour of the system was also computed by the finite element method, giving a good agreement of local measured strains and computed values.

Methods

Final element computations were performed with Abaqus 6.11. Experimental investigation were performed with the resonant bending system of the University of Ghent.

Objectives

Reduce the weight of jackets structures by 10% by assessing that welding methods achieving better fatigue performance exist.

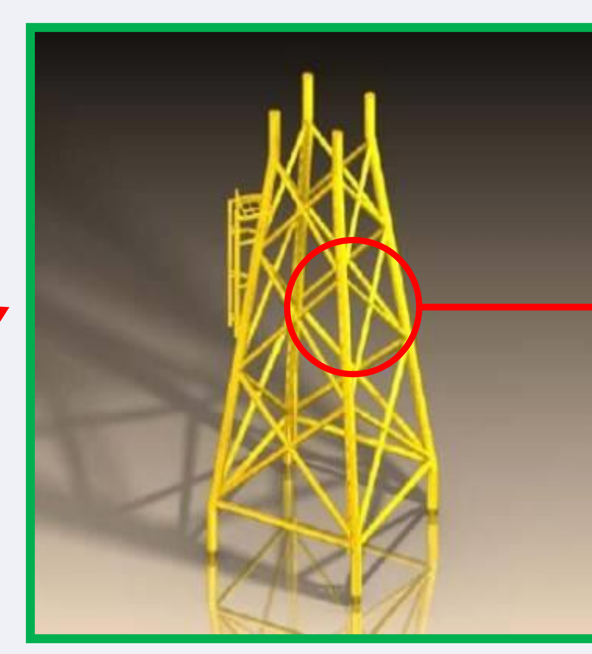
For this purpose, find a technique to be able to test very fast a tubular joints at full scale

Determine the weak points of a weld over the full circumference

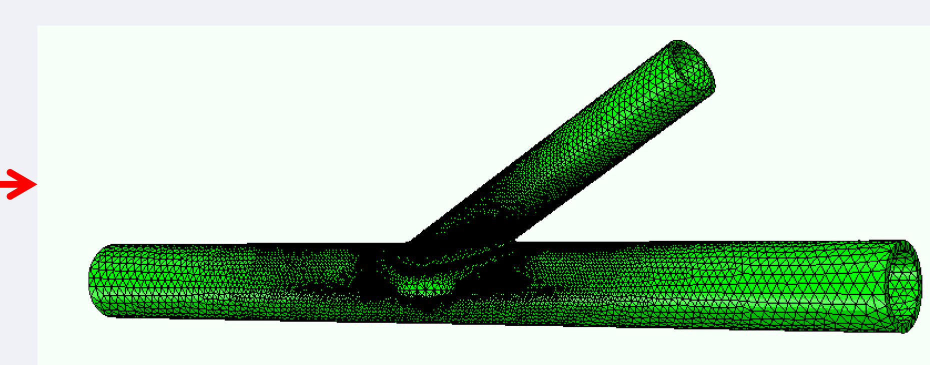
Principles

Wind farm of x wind turbines

Jacket foundation



Y-Node



Loads (Wind, Generator, Waves…)

Damage accumulation (Miner's rule)

Geometry (stress concentration factors)

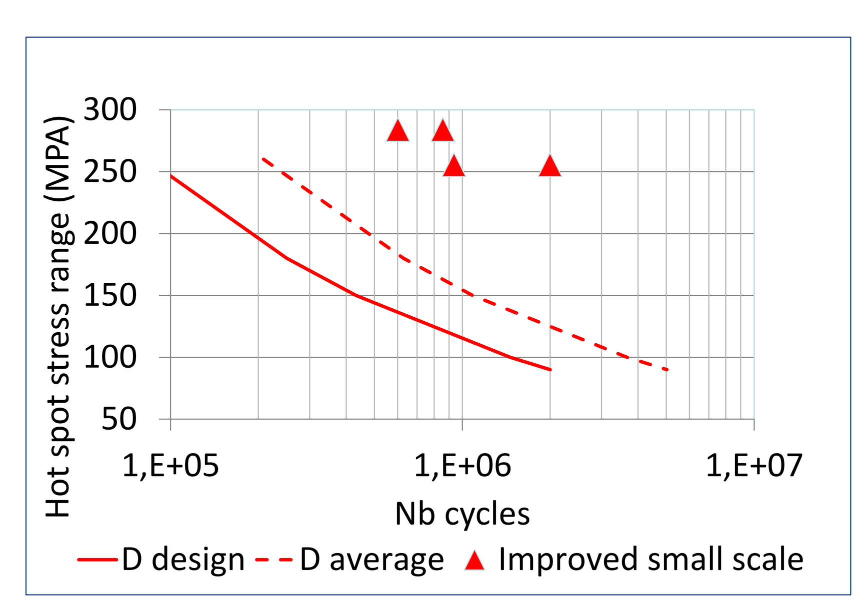
Design

Weight

Fabrication cost

Any improvement reduces cost

S-N Curve

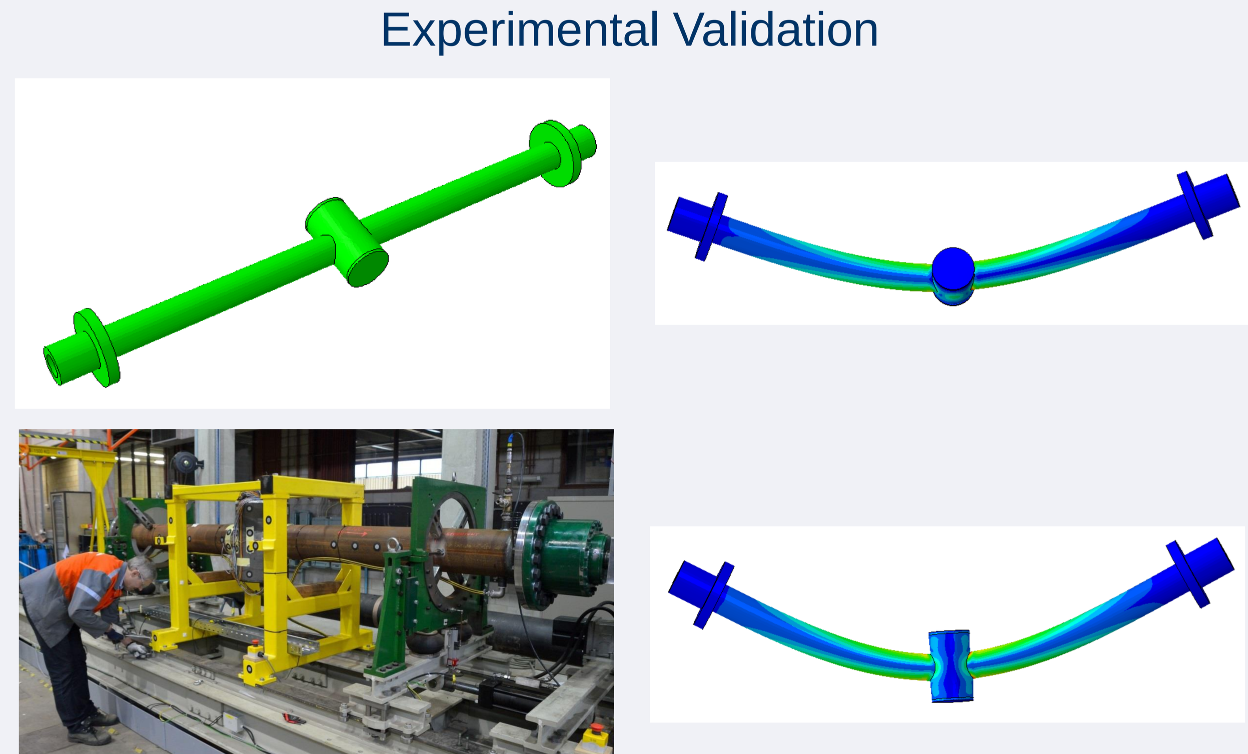


Possible improvement?

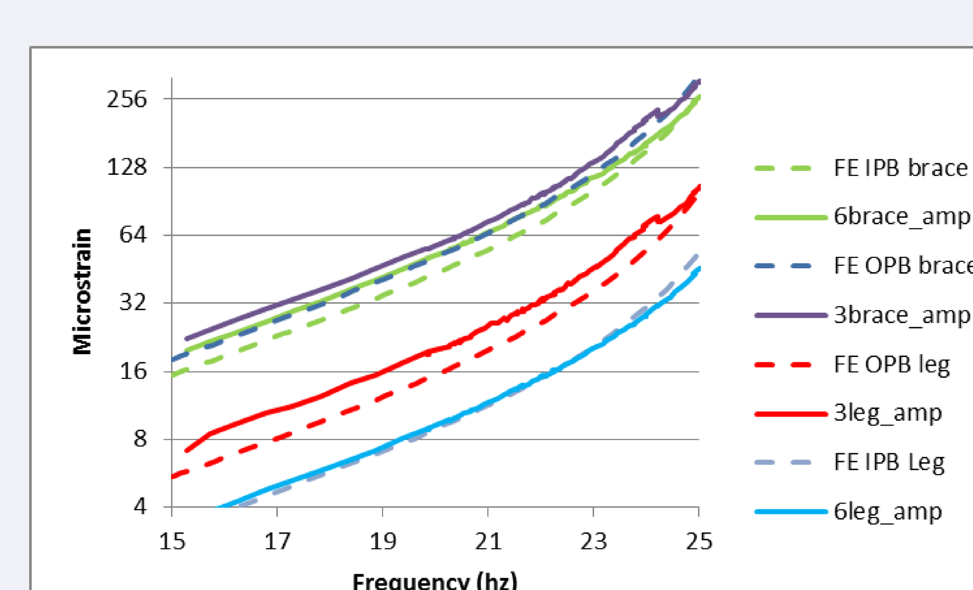
Need of large scale demonstration

Eigenfrequency computations showed that, by choosing the adequate parameters, it is possible to achieve a resonance frequency between 20 and 40 hz for X-node. Furthermore, the resonance frequencies of the in-plane bending and out-of-plane bending modes are close to each other (differences of less than 1hz) and the position of the resonance nodes are also almost identical. Based on these findings, a patented fatigue testing method was developed, based on the excitation of an X-node with an eccentric mass.

Experimental Validation



Comparison with finite element



Conclusions

If the S-N curve applied for the design of a jacket structure is improved, it will be possible to reduce the weight and the cost of the structure. Preliminary results show that it is possible. For the large scale validation, a new testing technique was developed based on the excitation of an X-Node close to the resonance frequency. Experiments on a node with bracings of OD 220mm demonstrated the possibility to achieve test frequency of 20hz, targeting achieving 10 million cycles in one week.

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