"Fatigue life evaluation of offshore wind turbines considering scour and passive structural control" (Manuscript number: wes-2023-149)

In this work, the influence of scour and tuned-mass dampers (TMD) on the fatigue life offshore wind turbines is investigated. Furthermore, a new approach to determine optimal parameters for the design of the TMD is proposed, which considers time-variable scour depths.

As the fatigue life is of major importance for the design of offshore wind turbines and scour and TMD both influence the fatigue life significantly, the topic is relevant for the readers of the WES journal. Moreover, most of the paper is nicely written and the argumentation is mainly clear. Nonetheless, there are several points that must be clarified or corrected.

Points to be clarified/corrected:

1) In industry, quite frequently scour protection systems are used nowadays. Hence, the topic of scour might become less relevant. It would be nice if you could briefly discuss scour protection in your introduction.
2) L. 77: I think that the statement "This study can provide a guidance for the fatigue life evaluation […]" is exaggerating, as you use a simplified fatigue life analysis and there is other work really focusing on this topic. With the second part on TMD, I totally agree, as this is the core of your work.
3) Fig. 1: In the caption of the Fig. 1, you write "scour effect" and yes, it is shown in the figure. However, it is not marked. I think it would help to mark it.
4) L. 87: What do you mean by "three-dimensional beam"? It is just a standard Euler-Bernoulli or Timoshenko beam?
5) L. 88-91: You use only a few beam elements. Is the number sufficient? Have you conducted a convergence study? Please, show it.
6) L. 83-94: Perhaps, a figure showing the FE model would help to see where the loads are applied, the TMD is positioned etc.
7) Equation 1 and 2: Are C_T and c_T the same (same for K_T and k_T)?
8) L. 102: Is u_s actually the displacement vector of the tower top? Isn't it the displacement vector of all nodes of the main structure?
9) L. 109-124: If I understand it correctly, you do not use a wind turbine controller when calculating the wind load from the turbulent wind field. This is a significant simplification. I do not know how important this simplification is in this context, but it might be relevant. At least, you have to discuss this simplification.
10) Section 2.3: You discuss that you use the more complex ABAQUS model and not simplified p-y curves for the derivation of your stiffness matrix. This is totally fine. However, the soil stiffness is load dependent. The load dependency is even represented by the p-y curves, but not by your stiffness matrix. You definitely have to discuss the load dependence of the soil stiffness.
11) Eq. 6: I think it should be $\mathbf{\Psi}^T M \mathbf{\Psi} \ddot{\alpha} + \mathbf{\Psi}^T C \mathbf{\Psi} \dot{\alpha} + \mathbf{\Psi}^T K \mathbf{\Psi} \alpha = \mathbf{\Psi}^T F$ and not $\mathbf{\Psi}^T M \mathbf{\Psi} \ddot{u} + \mathbf{\Psi}^T C \mathbf{\Psi} \dot{u} + \mathbf{\Psi}^T K \mathbf{\Psi} u = \mathbf{\Psi}^T F$ as the transformation is $\mathbf{\Psi} \alpha = u.$
12) Eq. 8 is not sufficiently clear. For example, x and y are not explained. Furthermore, the element shape functions are neither given nor explained. It is not stated that the shape functions refer to the original FE model, i.e., the model before applying the modal reduction.
13) L. 243: "t is the thickness at which cracks may grow"; are you sure that this statement is correct? Isn't t the actual thickness of the pile?
14) Table 3: A SCF is given. However, you never state how you use it.
15) L. 251: N_c is obtained by the rainflow counting? I think N_c has to be defined before the rainflow counting can start, as it is the number of bins, the rainflow counting sorts the cycles into. Which value do you use for N_c?

16) L. 272-274: I would be careful when stating that the fore-aft mode is the most important one. For large monopile and significant wind-wave-misalignments, side-to-side modes can be more critical with respect to fatigue, as the aerodynamic damping is lower in side-to-side direction.

17) L. 275-276: If the TMD is in the tower, is it still rotating, when the RNA is yawed? Otherwise, I wonder how the TMD can always be aligned with the fore-aft direction.

18) L. 290: Why did you choose 1% for the mass ratio and not any other value?

19) Section 3.2: Perhaps, it would help to give a short example demonstrating how c_T and k_T change if the eigenfrequency drops to, for example, 0.26 Hz due to scour.

20) Figure 6: Is the equivalent stiffness matrix actually "added" to the 4DOF model? I thought that it is added to the MATLAB FE model.

21) Figure 6: The parts on "Divided by 0.1D" and "Scour depth plus 0.1D" are completely unclear at this stage. They become a bit clearer later on, but I think some explanation or at least a reference to a later section is needed here. Otherwise, the reader is lost.

22) L. 309: Here, you state that the mass ratio is a variable. Before, you just select a value, i.e., 1%, for it. Later, you do both. This is quite confusing when you read the paper for the first time. Perhaps, it would help to elaborate a bit more on it it (see comment 17 as well).

23) L. 313: You state that you use Fmincon. First of all, Fmincon is just a MATLAB routine. What is actually interesting is which optimization algorithm is used. If I remember correctly, Fmincon uses a local optimization algorithm. Is this sufficient? Have you looked at the objective space and it is rather smooth without local minima? Otherwise, a global optimization algorithm might be more appropriate.

24) L. 318: You state that you model operational and parked conditions. What is the difference between these two in your simplified model without a controller? Are only the wind loads different or do you also change the inertia of the RNA etc.? In reality, even the first fore-aft bending eigenfrequencies of the entire turbine are slightly different in operational and parked conditions.

25) Table 4: V_w, T_z, H_s and P_{state} are not explained.

26) L. 317-319: You state that you have 22 environmental states for operational and parked situations. However, only in line 401, you start to explain that you run six 10-min simulations for each condition. This should already be stated here. Furthermore, two questions are unanswered in my opinion: 1) What is the total number of simulations? Is it $2 \times 22 \times 6$ (operating/parked x environmental states x seeds)? 2) Do you remove some time at the beginning of each simulation to remove initial transients? If yes, how much?

27) L. 338-339: What are the values for d_{50}, ρ_s and ρ_w you use?

28) Fig. 6: Perhaps, it would be nice if you add two other graphs to this figure for the TMD (ABAQUS + MATLAB) or at least one for MATLAB if you do not have the TMD implemented in ABAQUS.

29) L. 371: Is this case an operating or a parked case?

30) L. 379: You state that the effect is more prominent for other operating conditions. First, I think that is it especially more prominent for parked conditions with less aerodynamic damping. And second, please show a case, where the effect is more prominent. You can just add a second figure.

31) Fig. 7: I can hardly read this figure in greyscale. Please, enlarge it and think about clearly different line styles (and perhaps also thicker lines).

32) Fig. 7: In the caption, you write "four operating conditions". I think it should be "four load cases".

33) Section 4.4: You visually compare time series and spectra for the 4DOF and the FE model. This is a good starting point. However, frequently, you cannot see the differences leading to different fatigue lifetimes in these plots immediately. Hence, it would be good if you could also calculate the damage value D_k (Eq. 10) for this time series and the two models. This would be an objective comparison.

34) L. 434 and 445: How does these two values (50% and 62%) fit together?

35) L. 461: You use your "standard" value of 1% as a boundary value for the optimization. This is not a good approach, as it excludes all values below the "standard" value. Please, either repeat your optimization with another boundary value or justify your choice.

36) Table 6: I think that it would help if you name the first row "Initial (LC 5)". This would make things much clearer.

37) L. 471: You state that your results indicate that "considering time-varying scour depth" is beneficial. However, you cannot know this from your results, as you directly compare "fixed" TMD parameters with optimized ones which consider time-varying scour depth. What you do not compare are optimized TMD parameters for the maximum scour depth. I can imagine that these are quite similar to the ones you have determined for the time-varying scour depth. Hence, perhaps, the benefit is just due to the optimization. Therefore, you should either include TMD parameters that are optimized for the maximum scour depth in your analysis, or you should it least discuss this aspect here.

38) Conclusions: You should clearly state your major simplifications, e.g., simplified lifetime calculation with just 22 environmental states, no controller, TMD only in fore-aft direction etc.

<u>Typos etc.:</u>

1) As you can see in the following, there are some typos and inconsistencies. As I have definitely not found all of them, I recommend a thorough proof reading.

2) Please, check your citation style, e.g., in line 43, it should be "Sørensen and Ibsen, 2013". The other names are given names.

3) L. 49 and others: "damage" and not "damages". There is no plural of "damage" in the context of structural engineering.

4) L. 83: "An FE model" and not "A FE model"

5) L. 83: "a monopile-supported OWT" and not "an monopile-supported OWT"

6) Table 1: "Rated wind speed" not "Rated wind Speed"

7) L. 129: "in Shirzadeh et al. (2013)" and not "in Ref. (Shirzadeh et al., 2013)"

8) Table 2: "kN/m³" and not "kN/m3"

9) L. 227: Remove "the" before "Eq. (6)

10) L. 287 "and ξ_{opt} is the" not "and is the"

11) L. 296: "885 Ns/m" and not "885 $N \cdot s/m$"

12) L. 333: Remove "was used"

13) L. 406: I think it should be "where the maximum stress is reached".

14) L. 484: Where is the "on the one hand"? You just use "on the other hand.

15) L. 578: "Patil" not "patil".

16) L. 594: See typo comment 2.

17) L. 628 "van der Tempel, J. (2006)" and not „Tempel, J. van der. (2006)"