

QUESTIONS AND ANSWERS

Webinar: Sesam and Bladed - Efficient coupled analyses

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1. [Is this superelement approach applicable to floating wind turbines as well, where you have to couple the motions of the floating substructure with that of turbine?](#)

Sesam and Bladed can be used for floating wind turbines, but not using superelements. The superelement approach is applicable to fixed structures only. Floating structures need feedback of the platform's position and motions each time step and therefore require an integrated approach.

2. [In terms of time, what would be the difference of running one complete load loop in integrated analysis versus the 3 shorter loops in the superelement analysis?](#)

This is an interesting question, and we don't have any quantitative answer to this at the moment (we are planning to do some proper comparisons on this in the coming months). However, for integrated analysis we would expect some possible time savings, since the structural analysis step is only performed by Bladed, while for superelement analysis the structural analysis is reproduced in Sesam for the jacket. In the integrated approach, the wave loads are calculated in Bladed, whereas in the superelement approach they are calculated in Sesam; this is just moving the calculation from one software to the other, which shouldn't affect the simulation time much.

3. [Have you done any verification of shell TP vs simplified beam TP?](#)

Both are possible in Sesam, and in general it should be equally valid for the global response of the model. Of course, when using beam elements, the user should make sure that those properly represent the shell structure. The benefit of using beam elements is that they can be taken into Bladed in an integrated approach (and via the superelement approach), while shells can be used through the superelement. Obviously, shell models will take more time to analyse than beam elements, since they will include more degrees of freedom.

4. [In the superelement approach, is the soil spring always elastic?](#)

Yes, in superelement analysis, the springs need to be linear.

5. [Can we model non-linear foundations like suction bucket or gravity base in Sesam?](#)

Suctions buckets can be included by including external mass, stiffness and damping matrices for these, which can be included into the model. Gravity base is usually based on concrete models. Sesam is based on linear elastic materials such as steel, so strictly speaking, gravity base structures cannot be analysed in Sesam. That being said, we know that Sesam is being used for this purpose and users are finding workarounds to the limitations for this.

6. For the superelement method step 4, how do you ensure that the structure has the correct natural frequencies if the tower and turbine is not included in the analysis when the load time series from Bladed is included? I assume you would risk not to capture the correct dynamic amplifications around the natural frequencies of the structure.

The superelement is a reduced version of the original jacket. Whether the original jacket or the superelement is linked to the wind turbine in Bladed should not matter as both should give similar results. If not, then it means that the superelement was not properly converged (i.e. does not contain enough degrees of freedom). Hence, as long as the superelement is converged, then the results in Bladed should be valid. In Sesam (step 4) the interface loads from Bladed are added onto the jacket again together with the original wave loading. These interface loads are based on the dynamic response of the complete system in Bladed and will therefore contain the correct dynamic response of the wind turbine onto the jacket. This was confirmed by our verification study where we compared the integrated versus the superelement approach.

7. When generating superelement in Sesam, how are turbine and tower considered in Sesam? Do we need to consider the flexibility of turbine and tower?

Please see the above answer.

8. Is there a user manual available?

Yes, Sesam and Bladed both come with extensive user and theory manuals.

9. Could you outline how your tools and services can be utilized? Will you e.g. act as consultants on designs or method studies?

Both Bladed and Sesam are commercially available software. DNV GL also offers consultancy services for further assistance with your projects.

10. For now is it only possible to define a single interface node? Is it possible to set interface between jacket with pile?

Correct, at the moment it is common to use a single interface node, since the jacket and tower only have a single beam node in common. In principle, the method could be extended to include multiple interface nodes (as is e.g. already possible in a superelement analysis in Sesam when using multiple Sesam superelement models).

11. In the presentation, to generate SEs, mainly K, M, and F are written. Why isn't damping matrix dealt with in detail?

This is a simplification in the slides. You are correct that a damping matrix is part of the superelement matrices too and this is sent to Bladed as well.

12. Do you have any plan to extend the program for seismic loading including liquefaction?

Seismic loading is already possible in various ways in Bladed and Sesam. However, liquefaction is currently not part of the plans, as this goes more into the solid modelling of the soil. More detailed analysis tools would be required for this.

13. In step 4, the analysis of the jacket structure with interface forces applied. Do you recommend to performed static or dynamic analysis? If dynamic, how is it ensured that the dynamic in the structure is captured correctly when the turbine is not included in the dynamic analysis?

Dynamic should be the way to go, unless the structure does not show any dynamic behavior and a static analysis can be justified. The dynamics are captured through the interface loads originating from the complete system in Bladed.

14. Are you planning to offer 'everything' in one tool (as seen from the users point of view)?

For now, the two tools are well-interfaced. Creating a single user interface/workflow is something that we are considering.

15. At the current stage on our project we are doing a spectral calculation for wave fatigue and combining with damage equivalent loads on the turbine. Just to confirm - is 'Fatigue Manager' only for time-history fatigue analysis? We are currently using Sesam Manager for the spectral wave fatigue calculation.

Sesam's Fatigue Manager is based on time history analysis. However, Sesam can indeed also be used for the type of analysis that you are currently performing already.

16. Have you compared the damage and lifetime results from both integrated and superelement approach for an example project?

Our verification study includes some information on this, by comparing the integrated versus the superelement approach (although not including damage and lifetime results, but only loads, displacements, velocities and accelerations). However, a more detailed study would be required to give a real comparison of results here, which is something that we are hoping to kick off in the near future.

17. Can you say something on how the 56x56 M, K get integrated into Bladed at the tower bottom node which has 6 DOFs? how is that done in practice?

Only 6 DOFs of the matrices are linked to the interface node. The remaining DOFs (in this example 50) will improve the dynamic response of the superelement.

18. Have you compared jacket natural frequency results between Bladed and Sesam?

Yes, this is compared in our verification study. The results are near-identical.

19. Q: Is there no dynamic wave response in the second run?

Correct, in a superelement approach the wave response is calculated ahead of time. This is a simplification, but for jackets the difference is understood to be relatively small.

20. Q: What are the limits of the superelement model? Would it be false in case of large deflections?

The original jacket model in Sesam as well as the superelement are linear. As long as the superelement is converged (spectrally and spatially) for reference cases (i.e. a very large displacement load), then the superelement should be equally valid as the original model.

However, to fully capture non-linear structural response due to large deflections and the hydro-elastic coupling, an integrated model in Bladed could be used.

21. Q: Why mass and stiffness matrix of super element was 56 by 56 matrix?

The 56 degrees of freedom are made up of 6 degrees of freedom at the interface node, and an additional 50 internal mode shapes of the original model that were added to the superelement to improve its dynamic response. In this example, 50 mode shapes were added to reach spectral and spatial convergence of the superelement, but the number to use will depend on the model.

22. Q: Is this superelement creation based on Guyan's reduction or Craig-Bampton's method?

Craig-Bampton is used in Sesam.

23. Q: Does the super element approach account for the non-linear soil pile interaction and how is this accounted for?

The superelement contains equivalent linearized spring matrices of the original non-linear pile soil system. These have been linearized for some reference load case(s). The user can define these load cases after which Sesam will automatically linearize the non-linear pile soil system into equivalent linear spring matrices.

24. In the first superelement analysis, are just wave loads included, or both wind and wave loads?

In a superelement analysis, wave loads will be created in Sesam at first. These are then sent with the superelement model to Bladed and will there be combined with the wind loads. A structural analysis is then performed on the model with wave and wind loading. Afterwards, the interface loads are sent back to Sesam and combined with the original wave loading for a structural analysis to find the internal jacket loads.

25. Can we add appurtenances (ladders, boat landings, etc) in Sesam?

Yes, you can model these in Sesam if desired.

26. Can earthquakes be included in the superelement through acceleration time series of the foundation?

It is possible in both Sesam and Bladed to use seismic acceleration time series on the foundation. However, we have not implemented this into the superelement interface yet.

27. How detailed is your joint's model? Local joint flexibility, SCFs?

The joint model in Sesam can indeed include local joint flexibilities. Besides that, SCFs are computed in the fatigue analysis automatically.

28. While generating SEs, how is the wind turbine gravity dealt with?

This is computed by Bladed and then included onto the jacket in Sesam through the interface loads.

29. Is the constrained wave approach which is specified in IEC61400-3 available on jacket to evaluate wave load?

Yes, the constrained wave approach is available in both Bladed and Sesam.

30. What is the cost of a single license (of Bladed and Sesam)?

Please contact our Sales department for this.

31. Replacing the piles/soil with stiffness matrices is a simplification, would it be possible to keep the piles and attached springs in the model?

Yes, instead of using equivalent linearized spring matrices, it is possible to include piles and attach springs to this in the model.

32. How do the verification results look for an ESS case?

The verification study so far only looked into a limited number of load cases, not including extreme sea states. We have planned a follow-up study which will look into a larger number of load case types.

33. Why are 6 DOFs not enough for super element and dynamic DOF should be added? Why dynamic DOFs are not covered within that 6 DOF?

The original jacket model may contain e.g. 1500 DOFs. Reducing this to 6 DOFs will without doubt lose information. The dynamics are therefore not properly represented anymore. By adding in

internal mode shapes of the original model, the dynamic response of the superelement can be improved. Note that the interface mode shapes can be calculated using only the finite element stiffness matrix, so they are often called "static modes". The dynamic response is enhanced by including further Eigen modes, that depend on the finite element mass and stiffness matrices.

34. For the Jackets, the relative motions are small and hence super-element is advantageous. How can this be used for Monopile design as well?

In principle, the technique can be employed for any type of support structure. However, for a monopile, usually the structure is directly modelled instead due to its simplicity.

35. Are GeniE and Bladed adequate for running a full static and dynamic analysis or are other Sesam modules like Prepost, Postresp and Presel still required?

Prepost, Postresp and Presel are not required for time domain analysis of fixed offshore wind turbine support structures using Sesam and Bladed. The Sesam modules required are GeniE, Wajac, Splice, Sestra, Framework, Fatigue Manager and (optionally) Xtract.

36. Can Sesam be used to model support structures other than Jackets?

Yes, Sesam supports most types of offshore structures.

37. Have you implemented direct expansion?

No, as this is not necessary using our current approach.

38. Can Sesam incorporate p-y curve of soil?

Yes, both Sesam and Bladed can include the non-linear p-y curves. Sesam can also include t-z and q-z curves.

39. Is the fatigue module shown in Sesam available for integrated approach using just Bladed as well?

For the integrated design approach the same post-processing functionalities in Sesam can be used as for the superelement approach.

40. In the integrated approach the Sesam model is imported into Bladed and I assume the jacket is represented as beam substitute. What does it mean if more detailed TPs are modelled in Sesam? Have you carried out a verification in this case?

In an integrated model, the full jacket model can be included into Bladed, as long as the jacket is modelled with beams. Transition pieces can be included using equivalent beam models. The user should in that case create an equivalent beam model of the transition piece. This is a common approach.

41. How was the wind field generated for the time-domain analysis?

The wind field is generated by Bladed.

42. What is the difference of the soil linearization, i.e. linearized SE vs. non-linear soil?

Obviously there may be some differences. However, as long as the springs are linearized for a certain reference case that is valid for the design load cases, then the approach is valid. Typically, a different set of springs will be used for FLS and for ULS.