MODAL SPACE - IN OUR OWN LITTLE WORLD

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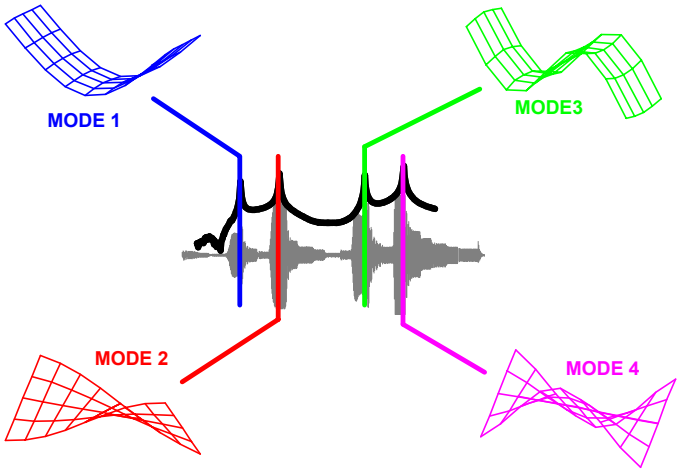
We talked about the number of points needed for a modal test before.
Someone told me that the entire shape may not need to be completely defined.
Let's discuss this and explain this further.

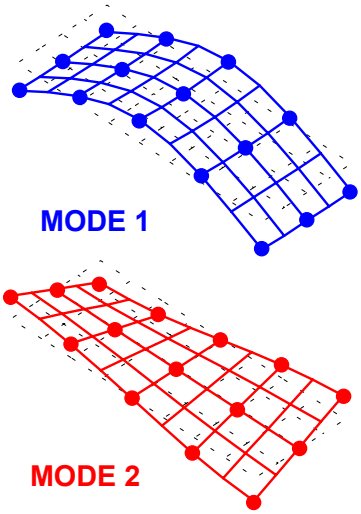
The last discussion we had regarding the total number of points for an experimental modal test was directed towards the adequate description for the mode shape. But in order to define a good dynamic model, the requirement can be different. Let's first restate what was identified earlier regarding the mode shape definition and then proceed on to identify the points needed to identify a good dynamic model.

Let's start with a simple structure that we have discussed before. The simple plate structure.



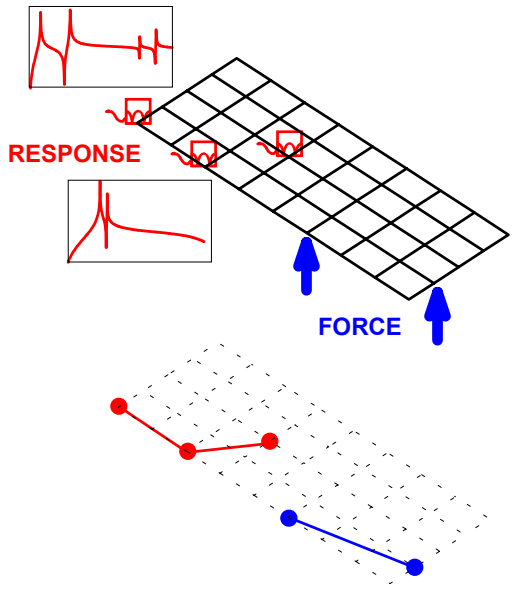
For this plate, there are many possible measurement locations that can be used to describe the dynamic characteristics of the structure. If the experimental modal analysis is being conducted to correlate with a finite element model, then it is necessary to have a reasonable number of well distributed measurement dofs in order to have sufficient spatial distribution for comparison to the model. It is also important in order to visualize the shape.

So let's consider a finite element model that has 45 node points with 32 plate elements. Let's also consider an experimental modal test with 15 evenly distributed measurement locations. A comparison of the finite element node points and experimental measurement points to describe the plate are shown for the first two free-free flexible modes of the plate.



For this comparison, there is a sufficient distribution of points such that the modes can be uniquely defined for the correlation of the finite element model and experimental modal model. If the model is to be correlated using the Modal Assurance Criteria and using Pseudo Orthogonality Checks, then there is sufficient information to perform a valid analysis. However, a response model may not need the same distribution of points.

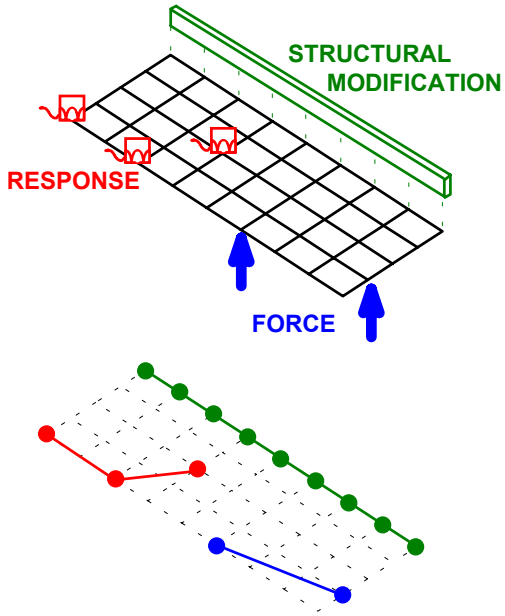
Consider a structure where there are two separate points where forces are applied to the system. Also consider that there are only three points on the structure where critical response needs to be measured. This is pictured below with the input forces in blue and response measurements in red.



The point-to-point frequency response function describes the characteristic output response due to a unit sinusoidal input force. This is computed for a particular input-output measurement on the structure. A particular frequency response measurement has no relationship to other measurements on the structure. If only one frequency response function is of concern, it doesn't matter whether two, three or one hundred additional measurements are made - the individual frequency response measurement for a particular input-output measurement does not get better or worse as additional measurements are added.
(This is not true of the finite element approach where adding additional nodes and elements generally has a direct effect on the results.)

If the only requirement is to determine what the dynamic response of the system is due to the applied forces, then the only points that are required for the experimental modal model are the three red points and two blue points pictured. These points completely describe the response of the system at these points. Of course, the points shown may not adequately describe the deformation sufficiently to determine exactly how the load is distributed through the system - but this limited set of points is sufficient to define the dynamic model.

Now let's continue on and consider that the system may need to be modified with structural changes to the system. The figure below depicts the structure with a rib stiffener modification that could possibly be proposed to modify the structure. In order to perform any of these structural dynamic modifications, a set of points associated with all of the dofs used for the structural change need to be included. These are shown in green in the figure.



So these two models show a completely different set of measurement dofs that are needed for each of the different models described. For the response model and structural dynamic modification model, a significantly different set of dofs are needed in order to develop the proper dynamic model to describe the system.

So ..... the set of required points can be stated as follows.
In order to have an adequate dynamic model, there must be points to describe

1. all dofs where forces are applied to the system
2. all dofs where response needs to be measured
3. all dofs where structural modifications are considered

Any additional dofs included in the model are included for your viewing pleasure only!!! Additional points are included in the experimental modal test for you to better visualize the characteristic shapes of the system (or for correlation of a model if that is the purpose of the test). This minimum set of dofs is all that is required to develop an appropriate dynamic model.

Now I hope you have a better understanding of how many points are needed for a modal test - it varies depending on the ultimate use of the dynamic model. If you have any other questions about modal analysis, just ask me.