

MODAL SPACE - IN OUR OWN LITTLE WORLD

by Pete Avitabile

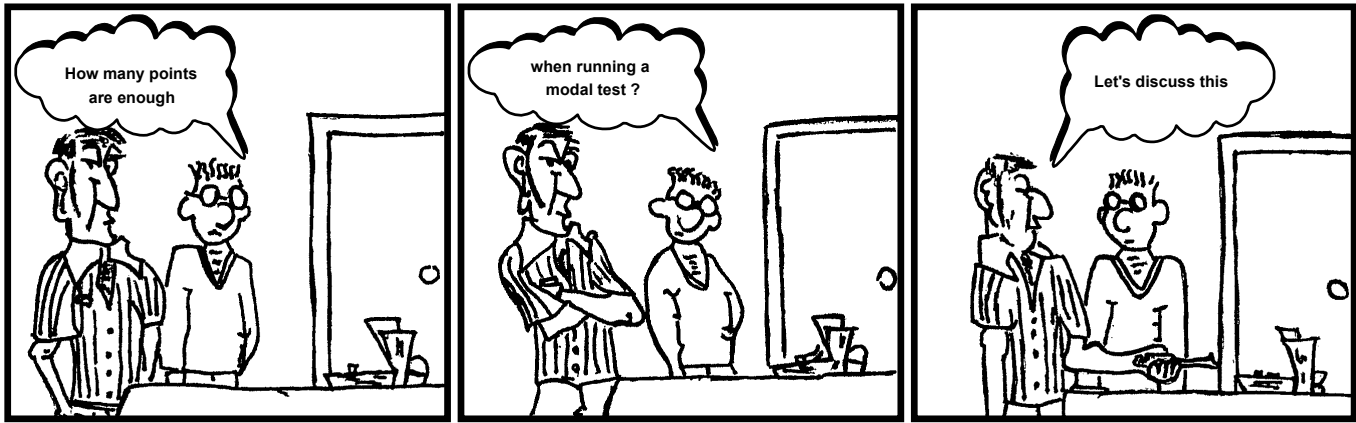
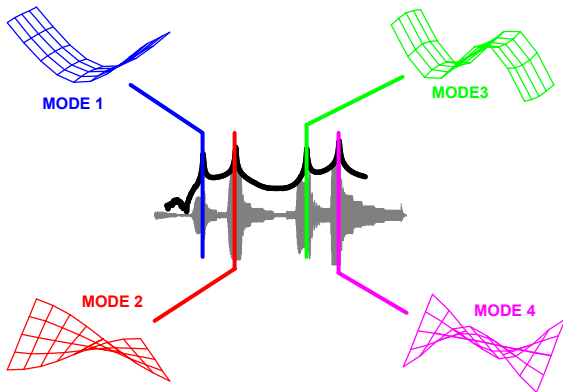


Illustration by Mike Avitabile

How many points are enough when running a modal test? Let's discuss this

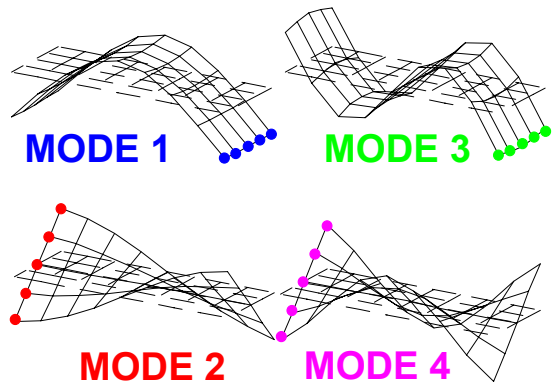
I expected that eventually you would get around to asking me that question. Its another one that I get asked all the time. Basically the simplest answer is that you need to measure a sufficient number of points so that you can uniquely describe the mode shape. This answer may not be completely obvious. We need to talk about this a little more.

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

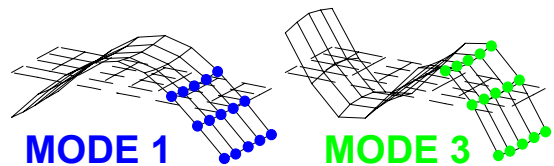


Now from the mode shapes shown we can see that there are sufficient number of points to describe the mode shape for each mode. But there are a total of 45 measurement locations on this plate.

Now let's consider only 5 points along one edge of the plate to illustrate some important points. If I look at mode 1 and mode 3, I quickly realize that there are not enough points to adequately describe the differences between the two modes. And also considering mode 2 and mode 4, the same conclusion can be drawn.



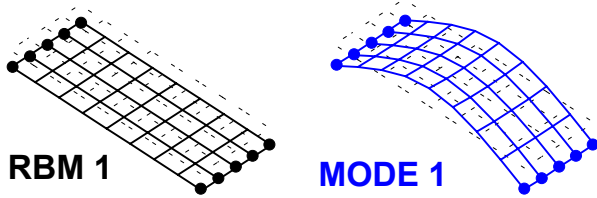
But I think we would all realize that only 5 points will not be sufficient to adequately describe the mode shape. Would it be possible to measure the mode reasonably well with only 15 measurement points? Well, most likely - but it is heavily dependent on *where* the 15 points are located. Let's consider 15 points - but I am going to pick the points to illustrate a point.



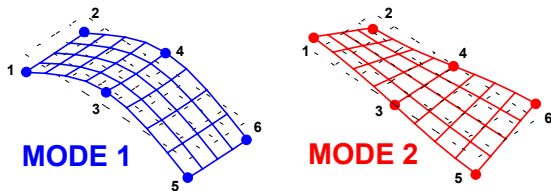
If I look at these 15 points then it is very hard to distinguish between mode 1 and mode 3. For all practical purposes, the mode shapes look almost exactly the same.

Now let's consider that we only took measurements along the front and back edges of the plate. You would be very hard

pressed to tell the difference between the first rigid body mode and the first flexural mode.

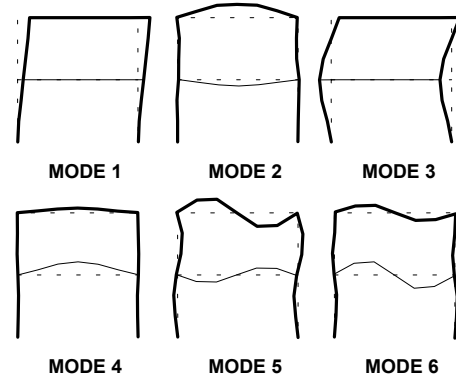


So from all of these simple examples above, it becomes obvious that we need a distribution of points located *appropriately* such that each mode shape can be uniquely distinguished. If I am only interested in characterizing mode 1 and mode 2, then possibly I could get a fairly good description with only 6 points as shown but fewer points than that would be difficult especially if we needed to distinguish the flexible modes from the rigid body modes.

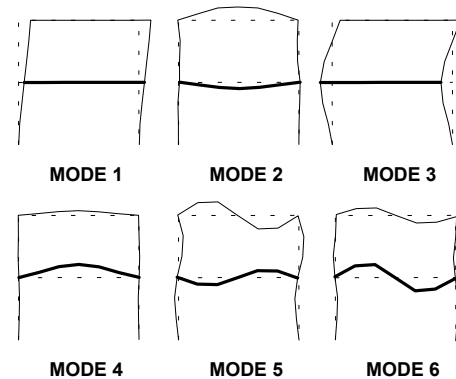


Now let's consider another example - the simple frame shown. Suppose that the only surfaces that are accessible are the three exterior surfaces. If I only collected measurements on those surfaces and did not have any measurements on the interior surface, then the description of the mode shapes may not be sufficient to uniquely describe the mode shapes. Just consider mode 2 and mode 4. In one mode, the two cross beams are out of phase with each other and for the other mode they are in phase with each other. The same is true for mode 5 and mode 6. If there are no measurements available on the interior surface then it is very difficult to distinguish the mode shapes for these modes. This is a common testing problem that occurs in many modal tests. Too few points are used to describe the mode shape due to inaccessibility of all the significant modally active portions of the structure.

Another common problem encountered in performing a modal test is the reluctance to measure adjacent portions of a structure. A typical comment that will be made is that we are only interested in a portion of a structure that we have responsibility for. We are not interested in the rest of the structure because it doesn't fall under our jurisdiction. To illustrate the problem with this statement we can also use the simple frame again.



But this time measurements and modal data are only collected for the interior surface of the structure. We can quickly see that some of the mode shape information is strongly controlled by the exterior of the structure. If we don't measure enough information to fully describe the mode shape, then it may be very difficult to determine what the cause of the problem is when we blindly limit the data we look at.



A good example of this brings to mind a recent modal test on a troublesome torsional vibration shaker system. The folks interested in solving their problem were only interested in the fixture and test article that came under their responsibility. Their impression of the shaker system and supporting structure was that they really didn't care what the outside world was doing. But in fact, the rest of the structure was actually responsible for the trouble that they were experiencing. The local response on the fixture and test article was largely due to some major global modes of the system. Without measuring this information, you would not have sufficient data to correct or understand the problem.

Now I hope you have a better understanding of how many points are needed for a modal test - a sufficient number to uniquely identify the mode. If you have any other questions about modal analysis, just ask me.