ACOUSTICS AND RADIATION COUPLING OF MODES WITH SUBMERGED STRUCTURES

Question:
Is it true that the vibration modes of submerged structures couple?

Answer:
There are only two types of submerged structures for which it is true that the modes do not more or less couple, these are a sphere or an infinite long cylinder. For all other structures, the pressure generated by a the motion of the mode will be more or less out of phase with the pressure that is generated. This is what makes the modes couple and create new modes of motion. This is called radiation coupling of modes and is described in literature such as “Sound, Structures, and Their Interaction” by Miguel C Juger and David Feit (ISBN 0-262-10034-7) , also see http://mitpress.mit.edu/catalog/item/default.asp?ttype=2&tid=10430 .

If you consider the results you get with the element “FLUID30” in ANSYS™, you will see that ANSYS generates pure Real part solutions. The reason is that FLUID30 is based on the fundamental acoustic wave equation (FLUID30), where the assumption is that the motion of a mode is in phase with the pressure generated. This is OK for acoustics in air and the two submerged examples mentioned above. If the air flow velocity increases or the geometry for the submerged structure changes the approximation does not hold. This is also, why the FLUID30 type acoustic theory does not help you solve aeroelastic problems. For these types of problems you need to treat the pressure as a non-conservative load, which is not the case in ANSYS or any other acoustic tools.

The area of aeroelasticity of fluid-structure interaction in general is a complex subject and there are many misunderstandings among engineers. It’s important to understand the basics of the theory you are using.