DEFINITION OF COORDINATE SYSTEMS FOR PROGRAM VIVA

PART OF THE VIVA MANUAL

M.S. Triantafyllou
MIT Testing Tank Facility
Cambridge, Massachusetts 02139 USA

OUTLINE

We outline the coordinate sytem used and the current decomposition needed to run the three-dimensional VIVA version.

1 COORDINATE SYSTEM USED

The global orthogonal system (OXYZ) has the origin O fixed at the bottom end of the riser. Usually this is the touchdown point, but in some rare occasions, when springs model the riser/soil interaction, it can be an arbitrary point of the riser lying on the floor.

The X axis is pointing vertically upwards. The Z and Y axes can be arbitrary in principle, but, following the way the program was written originally, the Z axis is the one pointing "downstream". This has absolute meaning only when the current is unidirectional; then the Z component is nonzero, while the Y component is zero.

When the riser is inclined, we specify a local coordinate system (xyz) at each point of the riser. The direction x is tangential to the local riser configuration (when the riser is vertical x coincides with X). The y and z coordinates are defined according to the case considered. When the riser is vertical y coincides with Y and z with Z.

2 CURRENT DECOMPOSITION

The program requires two current components to be specified at each point. We distinguish three cases of increasing complexity:

2.1 Vertical, straight-rigid riser

For this case the system xyz coincides with the system XYZ; hence specify the current along two perpendicular horizontal directions, one along the Y-axis and the other along the Z-axis. It is advisable to consider the z-direction as the "downstream" direction and the y-direction as the "transverse" direction, although in principle it does not make any difference.

The simplest case is for a unidirectional current. Then you specify the nonzero current velocity along the z-axis, and set the y component equal to zero.

2.2 Curved riser, static configuration co-planar (two-dimensional)

When the riser is curved but the static configuration is contained within a plane, then one must specify the velocity components in a plane perpendicular to the local riser axis.

There are still three cases to distinguish:

1. The static configuration is contained within the x-z plane. Then the y component of the velocity remains the same as the Y component of the current, while the z-component of the current is equal to the Z-component times the cosine of the inclination angle (zero inclination angle means vertical riser).

2. The static configuration is contained within the x-y plane. Then the z component of the velocity remains the same as the Z component of the current, while the y-component is equal to the Y-component times the cosine of the inclination angle (zero inclination angle means vertical riser).

3. The static configuration is coplanar but not contained neither in the x-y plane nor the x-z plane. Rotate the coordinate system so you fall under case (1) or (2) above.

In summary, we consider the riser curvature to lie entirely within either the XY plane or the XZ plane.

2.3 Curved riser, static configuration three-dimensional

The program is not strictly valid for this case, because the decomposition of the riser response into two perpendicular planes, even within the linear regime, is not valid. One may argue that the coupling terms are small and proceed with providing again the velocity components along perpendicular directions.

Now we define at each point of the riser a plane perpendicular to the local riser centerline configuration (as shown in Figure 2). The x axis is tangent to the riser configuration and

two Euler angles are needed for its precise definition. To avoid having to deal with internal calculations with Euler angles, we ask the user to specify the current velocity components along the local y and z directions. The z direction is defined as the intersection of the XZ plane and the normal plane to the riser. The y direction is defined as perpendicualr to the axis z, contained within the normal plane. The system must be right-handed, so the choice of y is determined by the consideration that if the riser is vertical y must coincide with Y.