Summary of fluid-structure-interaction and coupled analysis capabilities
Summary of fluid-structure-interaction and coupled analysis capabilities relating to

- Hydrodynamic diffraction/radiation
  - AQWA

- Structural Mechanics
  - ASAS (offshore-specific vertical application)
  - ANSYS Mechanical (generic implicit FEA)

- Viscous Computational Fluid Dynamics
  - CFX
  - FLUENT
Content

• Three capabilities
  – AQWA data transfer into ASAS and ANSYS Mechanical
    • Forces
  – Rigid-body six degree of freedom calculations in ANSYS CFD
  – ANSYS CFD data transfer into ANSYS Mechanical
    • One-way and two-way
AQWA Loading calculation

- AQWA performs loading calculations on two types of body:
  - Small Diameter Tubular
  - General Shell/Solid
- AQWA reads the ASAS model then writes the loadings into the analysis deck

2.3 Incident Diffracted and Radiated Wave Forces

Incident, diffracted and radiated wave forces on the structure are calculated by AQWA-LINE for selected wave periods and directions. These forces may be thought of as relating to a unit wave amplitude, although they are actually forces per unit wave amplitude and relate to infinitesimal waves. The incident wave forces are sometimes referred to as Freudent-Krylov forces. The radiated wave forces are zero for a fixed structure. AQWA-LINE stores the incident, diffracted and radiated components of the pressures on the individual facets in a backing file. Real and imaginary components of pressure are retained. The way AQWA-WAVE handles these pressures depends on the type of ASAS model being loaded. "tube" means models of shell-solid models.

For tube beam models, groups of AQWA facets (specified by element group numbers) may be associated with a given node or element in the ASAS model. This data is provided in the AQWA-WAVE data file. In addition to the group number, the user must also specify which quadrant or half of a symmetric model is to be used. Provision is also made for defining the assembled component to which the element or node belongs.

The program will evaluate the incident and diffracted wave forces for each facet in the AQWA group at the requested wave height, period, direction and phase (see Section 2.2). It will then sum these forces about the node or element centroids requested. Summed forces at a node will be applied as ASAS Nodal Loads. Forces on an element will be applied as distributed loads. Elements and nodes that do not have AQWA groups assigned to them will not be loaded.

For solid shell elements, a special load case (load case 1000) must be present in the ASAS data for any component that has an external wetted surface. Components with no load case 1000 will be assumed to be wholly internal, or above the water surface. This load case should be an ASAS face pressure or unit load case, defining the wetted faces of all wetted elements. (Note: The actual load values are unimportant, only the face data is used by AQWA-WAVE.)

AQWA-WAVE evaluates pressures for the requested wave height, period, direction and phase, in accordance with Section 2.2, for each node on the wetted surface of each element that appears in load case 1000. Elements in the ASAS model generally will not correspond to facets in the AQWA model and some method is clearly needed to obtain these pressures at the ASAS nodes. The method currently adopted is to locate the ASAS node on the AQWA mesh and then interpolate the pressure.

2.4 Morison Loads

AQWA-LINE does not evaluate drag forces on submerged components. AQWA-WAVE therefore allows Morison forces on such components to be calculated and added to the incident and diffracted wave forces from AQWA-LINE.

Two types of component are considered here:

1. Relatively large diameter tubular components simulated using facets in AQWA-LINE, but for which drag forces are considered important (e.g. GBS shafts).
2. Smaller diameter tubular members subject to drag and inertia loads (e.g. conductor framing on GBS).

Although provision is made for modelling the inertia loads on such tubes in AQWA-LINE, this is not the recommended modelling for AQWA-WAVE, and the tubular members do not need to be modelled in AQWA-LINE.

When evaluating Morison loads on such components of the structure, several factors need to be considered:

- The incident flow is expected to be modified by the presence of the main structure due to diffracted wave forces. The particle velocities and accelerations on which the Morison forces are based need to consider this effect.
- The local water surface during the passage of a wave is also expected to be modified due to the presence of the structure, thus affecting the extent of structure subjected to wave loading. A "caisson effect" (overall increase in water height) and a "rise up" on vertical members cutting the surface are expected.
- The effects of current velocity on drag should be considered. Current velocities should also be modified to allow for the presence of the structure.
- Although linear wave theory is considered sufficient for evaluating incident and diffracted wave effects, this is often not sufficient for drag loads near the water surface where the particle velocities and water surface elevation can often be in excess of that predicted by simple Airy theory. Some consideration should be given to the effects of higher order wave theory.
Case Study: Vuyk Engineering Rotterdam

• Requirement for stability and structural studies for range of lifting conditions and sea-states
AQWA usage

- Stability Studies
  Varying loads, sea-states etc.

- Global Structural Analysis
  using forces developed in AQWA
  applied to beam model

- Local Stress Analysis
  using internal loads
  developed in the global analysis

Courtesy of Vuyk Engineering Rotterdam
Case Study: Vuyk Engineering Rotterdam

- AQWA analysis provides hydrodynamic pressure loads on hull
- Combination of still-water and wave-load sets feed structural fatigue assessment
AQWA Load transfer in Workbench

ANSYS Workbench aims to facilitate data transfer between applications.
ANSYS CFD FSI and couplings

- ANSYS CFD
  - Provides inbuilt 6 degree-of-freedom rigid body solver
ANSYS CFD FSI and couplings

- ANSYS CFD
  - Coupled to ANSYS Mechanical
    - One-way
      - Passing of pressure
    - Two-way
      - Dynamic transfer of CFD results to ANSYS Mechanical and displacements back to CFD

Steady-state one-way transfer

Transient two-way transfer
Seminar summary and close

• Today we wished to show a range of software tools that allow specific types of simulation to be performed of relevance to marine, offshore and wave/tidal renewable energy industries
  – Hydrodynamic diffraction/radiation
  – Structural Mechanics
  – Viscous Computational Fluid Dynamics
  – Fluid-structure-interaction
• I hope the seminar has been informative and interesting
• Before we conclude today’s seminar, we have time for any further questions....