

## ANSYS AQWA

### Proven Technology for Design and Analysis of Mobile Offshore Structures

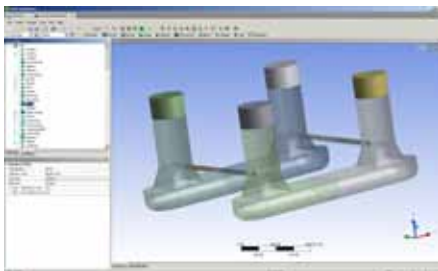
ANSYS® AQWA™ software is an engineering analysis suite of tools for the investigation of the effects of wave, wind and current on floating and fixed offshore and marine structures, including spars, floating production storage and offloading (FPSO) systems, semi-submersibles, tension leg platforms (TLPs), ships, renewable energy systems and breakwater design. Projects today require that structure design and analysis be performed efficiently in terms of time and cost. The powerful range of modeling and analysis capabilities enables the rapid assessment of many design alternatives, in particular early in a project, significantly reducing overall project costs and timescales.

Three ANSYS AQWA value-based packages are available to meet typical analysis requirements: ANSYS AQWA Diffraction, ANSYS AQWA Suite and ANSYS AQWA Suite with Coupled Cable Dynamics.

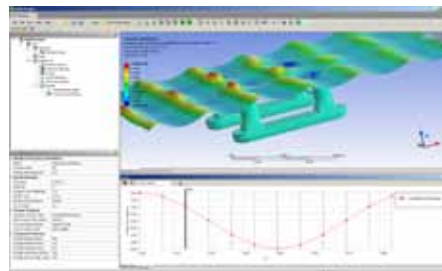
Included with all of the ANSYS AQWA packages is the Hydrodynamic Diffraction analysis system, representing the first phase of the integration of ANSYS AQWA technology into the ANSYS® Workbench™ platform. This provides direct links to ANSYS® DesignModeler™ software, external CAD geometry import, geometric parameterization and integrated meshing technologies. In addition, the ANSYS AQWA Suite of products include the Hydrodynamic Time Response analysis system, which is now exposed in the ANSYS Workbench platform.

### ANSYS AQWA Diffraction for Multi-body Diffraction Analysis

The ANSYS AQWA Diffraction product provides an integrated environment for developing the primary hydrodynamic parameters required for undertaking complex motions and response analyses. Three-dimensional linear radiation and diffraction analysis may be undertaken with multiple bodies, taking full account of hydrodynamic interaction effects that occur between bodies. While primarily designed for floating structures, fixed bodies such as breakwaters or gravity-based structures may be included in the models. Computation of the second-order wave forces via the full quadratic transfer function matrices permits use over a wide range of



Geometry in ANSYS DesignModeler software



Model imported into ANSYS AQWA Diffraction software, meshed and analyzed

## ANSYS AQWA Diffraction Product Features

### Wave Diffraction and Radiation

- 3-D panel method
- Multi-body wave diffraction and radiation
- Forward speed
- Full quadratic transfer function (QTF) calculation for slow drift effects
- Simulation of mooring and physical connections through user-defined stiffness matrix

## ANSYS AQWA Suite Product Features

### Analysis Options

- Static and dynamic stability
- Mean equilibrium position for multi-body assemblies
- Frequency-domain solution of significant and extreme linear response due to first-order wave and second-order, slowly varying drift effects
- Time-domain simulation of extreme wave conditions including nonlinear hydrodynamic effects resulting from the variable wetted surface
- Time domain simulation of slow drift motions due to irregular seas
- Coupled tension leg platform (TLP) tendon analysis, including stress and fatigue
- Computation and utilization of full quadratic transfer function (QTF) matrices for slow drift effects, including both sum and difference frequency components
- Panel, slender tube or mixed models facilitated
- Fully coupled cable dynamic feature enabling mooring line drag and inertial characteristics to be included in the vessel motions analysis

# ANSYS AQWA Suite Product Features

## Environmental Loading

- Constant wind and current
- Regular and irregular (spectral) waves
- Wave surface time history
- Wind time history
- Current profile
- Wind spectrum

## Mooring Capabilities

- Linear elastic lines
- Intermediate pulleys
- Linear drum winches
- General nonlinear polynomial
- Multi-segment composite catenary
- Nonlinear composite catenary
- Thrusters
- Constant force lines
- Fixed or floating fenders
- Intermediate buoys and clump weights
- Line break facility
- Quasi-static or dynamic catenaries

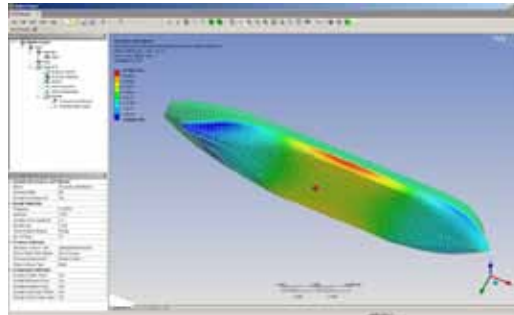
## Articulations

- Physical connections between two or more vessels or to ground
  - Fully fixed
  - Hinged
  - Universal joint
  - Ball joint
- Connections can include stiffness, damping and friction

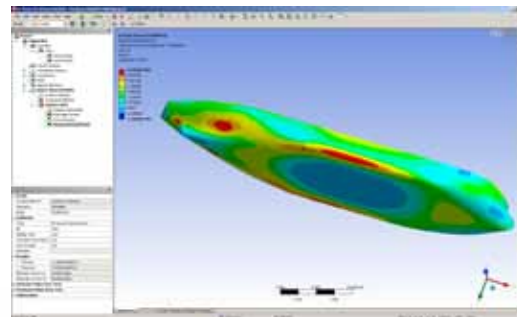
water depths. User-defined stiffness matrix definition enables mooring and connection systems to be included in the diffraction analysis where these significantly impact the motions response of the structures.

## ANSYS AQWA Diffraction and Hull Design

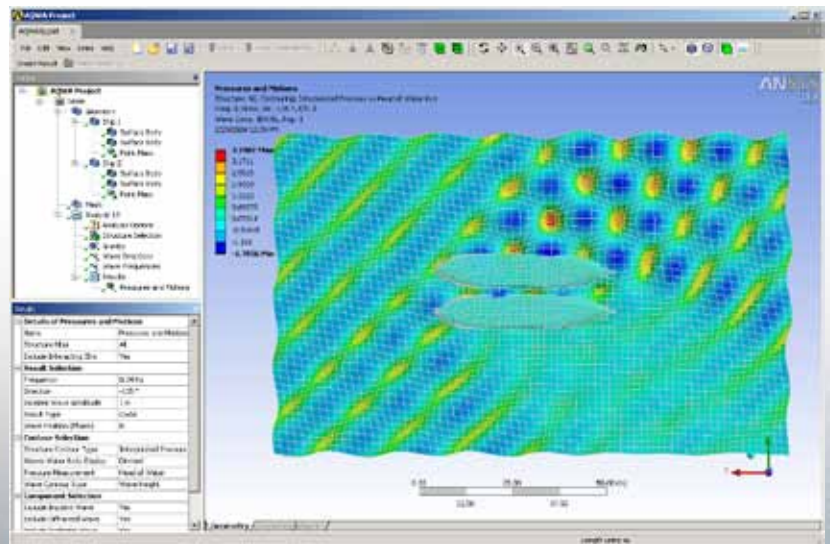
ANSYS AQWA Diffraction software can also generate pressure and inertial loading for use in a structural analysis as part of the vessel hull design process. The results from a diffraction analysis can be mapped onto an ANSYS structural mechanics product or ANSYS ASAS finite element model for further structural assessment and detailed design. Since the mapping function automatically accounts for mesh differences between the hydrodynamic and finite element models they do not have to be topologically identical.



Hull pressure plot in ANSYS AQWA Diffraction software



Stress results in ANSYS Mechanical software after pressure mapping



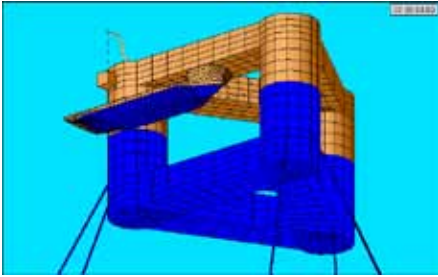
Wave surface elevation plot showing interference between adjacent vessels

## ANSYS AQWA Suite Multi-body Global Hydrodynamic Analysis

The ANSYS AQWA Suite includes the AQWA Diffraction package plus comprehensive dynamic analysis capabilities for undertaking global performance assessments. The generic nature of the program enables the hydrodynamic simulation of all types of offshore and marine structures including spars; floating production, storage and offloading (FPSO) vessels; semi-submersibles and ships. Specialized tether elements permit idealization of tension leg platforms while inclusion of bending stiffness in the mooring definition enables improved modeling of rigid and flexible risers.

## Frequency- and Time-Domain Options

The ANSYS AQWA Suite provides the flexibility to undertake simulations in either frequency or time domains, thus combining the speed of frequency-domain solutions for screening and initial studies with rigorous and more general time-domain capabilities. Slow-drift effects and extreme-wave conditions may be investigated within the time domain, and damage conditions, such as line breakage, may be included to investigate any transient effects that may occur.



Lifting operations

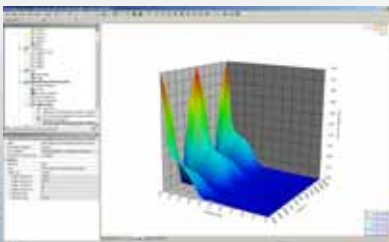


Renewable energy applications

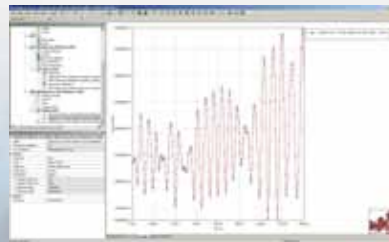
## Results Interpretation

ANSYS AQWA software provides extensive tools for results interpretation and manipulation, allowing many common and more advanced processing requirements to be undertaken directly within the software and enabling a rapid assessment of extensive results data, including:

- Statistical interpretation of time-series data — such as vessel motions and mooring tensions — to obtain mean, peak and significant values along with probability density, Rayleigh and Weibull Peak distributions
- Time-history filters and processors providing rapid access to fundamental data such as frequency components and critical damping
- Algebraic functions and combinations of results that provide a framework for user-defined results interpretation, such as square root sum of squares (SRSS) of horizontal motions for station keeping



3-D plot of response amplitude operators against frequency and direction



Time history plot of mooring line tension

## ANSYS AQWA Suite Product Features

### Special Features

- General external force time history
- User-defined external dynamic link library enabling general forces to be added to a time-domain solution; for example, in the simulation of dynamic positioning or power extraction systems
- User-defined external dynamic link library enabling general load generation; for dynamic positioning systems, for example
- Ability to directly access and retrieve ANSYS AQWA results using Excel®
- High-order Morison elements to permit dropped-object simulation and dramatically simplified modeling

## ANSYS AQWA Suite with Coupled Cable Dynamics Product Features

### Coupled Cable Dynamics

- Frequency domain
- Time domain
- Fully coupled
- Stand alone
- Composite cables



# ANSYS AQWA Product General Capabilities

## Modeling

- ANSYS Workbench interface providing access to import of geometries from ANSYS DesignModeler software or external CAD systems
- Integrated meshing
- Automatic generation of ship models from line plans (offsets)
- Interface to ANSYS structural mechanics products via ANSYS Mechanical APDL command utility to export ANSYS AQWA data from ANSYS geometric models
- Pressure and inertial load mapping to ANSYS Mechanical and ANSYS ASAS simulation products

## Visualization

- Model display for mesh checking including zoom, pan, rotation controls together with facilities to cut or exclude segments
- Extensive facilities for view manipulation, including:
  - Moorings and their components
  - Physical connections (articulations)
  - Hull pressures
- Animation sequence generation for time history motions analysis
- Animation of wave height profiles for air gap/wave on deck studies
- Display of diffracted wave surface
- Powerful graphing functions (2-D and 3-D)

## Capabilities Chart

The table below shows the ANSYS AQWA capabilities for a given product package.

	ANSYS AQWA Diffraction	ANSYS AQWA Suite	ANSYS AQWA Suite with Cable Dynamics
Model generation	✓	✓	✓
Hydrostatics	✓	✓	✓
Radiation/diffraction	✓	✓	✓
Load mapping to FEA	✓	✓	✓
Static position analysis (with moorings)		✓	✓
Dynamic motions analysis in frequency domain		✓	✓
Dynamic motions analysis in time domain		✓	✓
Quasi-static mooring model		✓	✓
Dynamic mooring models (includes drag and inertial effects)			✓

The ANSYS AQWA portfolio of software solutions is part of the comprehensive range of applications from ANSYS that collectively satisfy the demanding engineering and design requirements of the offshore industry. Other software packages include ANSYS® ASAS™ software for advanced structural assessment of all types of fixed and floating structures. The ANSYS AQWA product portfolio is supported by the ANSYS Mechanical structural analysis tool, and ANSYS® CFX® and ANSYS® FLUENT® fluid analysis packages. ANSYS offers the most complete range of solutions for the offshore industry, from front-end engineering and design (FEED) studies through global analysis, to component design. Solutions are available for contractors, consultants, fabricators, certification authorities, operators and equipment manufacturers.

## The ANSYS Advantage

With the unequalled depth and unparalleled breadth of ANSYS engineering simulation solutions, companies are transforming their leading edge design concepts into innovative products and processes that work. Today, almost all of the top 100 industrial companies on the “FORTUNE Global 500” invest in engineering simulation as a key strategy to win in a globally competitive environment. They choose ANSYS as their simulation partner, deploying the world’s most comprehensive multiphysics solutions to solve their complex engineering challenges. The engineered scalability of solutions from ANSYS delivers the flexibility customers need, within an architecture that is adaptable to the processes and design systems of their choice. No wonder the world’s most successful companies turn to ANSYS — with a track record of 40 years as the industry leader — for the best in engineering simulation.

# ANSYS®

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