



## Key Components

### Modeling

- Precede Graphical Modeler
- Datagen Intelligent Editor
- Gap Elements
- Superelements

### Loads

- Seastate Wave, Wind, Current
- Buoyancy, Mud flow
- Gravity, Inertial
- Skid, Moving

### Analysis

- SACS IV Solver
- Large Deflection (LDF)
- PSI Pile/Structure Analysis
- Liquefaction
- Wind Turbine Analysis
- Dynpac Modal Analysis
- Collapse

### Design

- Combine Solution Files
- Post Offshore Code Design
- Concrete design
- Postvue Graphical Redesign
- Joint Can
- Interactive Fatigue
- Dynamic Fatigue
- Wave Fatigue

# SACS®

## Design and Analysis Software for Offshore Structures

SACS is an integrated finite element structural analysis suite of applications that uniquely provides for the structural analysis and design of offshore structures, including oil and gas platforms, wind farms, and topsides of FPSOs and floating platforms. Nearly 40 years of focus on these specialized requirements have made SACS the analysis mainstay for most of the world's offshore engineers. Virtually all of the world's energy companies specify SACS software for use by their engineering firms across the lifecycle of offshore platforms. Three options of the SACS software suites are available: Offshore Structure Enterprise for comprehensive capabilities required for typical offshore jackets, wharfs, and dolphin structures; Offshore Structure Advanced for static topside and deck analysis; and Offshore Structure for static structural analysis.

### Offshore Structure Enterprise:

The Offshore Structure Enterprise suite contains capabilities required for typical offshore jackets, wharfs, and dolphin structures. It includes the interactive graphics modeler with advanced 3D capabilities, SACS IV solver and interactive graphics 3D post processor, Seastate, Joint Can, Pile, Combine, Gap, Tow, and LDF large deflection. The suite also includes automatic model generation, beam and finite element capability, steel code check and redesign, environmental load generation, tubular connection check, single pile/soil interaction, inertia and moving load generation, tension/compression nonlinear elements with initial gap, load case combination, linear large deflection analysis, and full output report and plotting capabilities. The package also contains the multi-core analysis capability, allowing the user to conduct multiple analysis of the same type in parallel, saving hours of runtime.

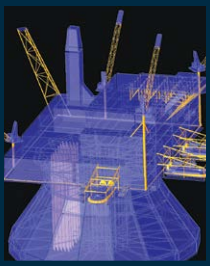
### Offshore Structure Advanced:

The Offshore Structure Advanced suite contains capabilities required for typical topside and deck analysis. It includes the

interactive graphics modeler with advanced 3D capabilities, SACS IV solver and interactive graphics 3D post-processor, topsides wind loading, Combine, Gap, Tow, and LDF large deflection. The package also includes automatic model generation, beam and finite element capability, steel code check and redesign, wind and gravity load generation, inertia and moving load generation, tension/compression nonlinear elements with initial gap, load case combination, linear large deflection analysis, and full output report and plotting capabilities.

### Offshore Structure:

The Offshore Structure suite contains capabilities required for static structural analysis. It includes the interactive graphics modeler with advanced 3D capabilities, SACS IV solver and interactive graphics 3D post-processor, Combine, Gap, Tow, and LDF large deflection. The package also includes automatic model generation, beam and finite element capability, steel code check and redesign, inertia and moving load generation, tension/compression nonlinear elements with initial gap, load case combination, linear large deflection analysis, and full output report and plotting capabilities.



The following add-on modules extend the functionality of any of the three Offshore Structure suites. Some of these add-on modules are combined with the Offshore Structure Enterprise suite to provide the Wind Turbine Package.

## **Pile Structure Design: Soil/Pile/Structure Interaction Analysis**

This non-linear add-on package permits non-linear soil/pile/structure interaction analysis of fixed offshore structures with multiple fixed supports using the PSI program modules. It requires the use of the Offshore Structure, Offshore Structure Advanced, or Offshore Structure Enterprise package.

## **Collapse: Plastic Non-Linear Add-On**

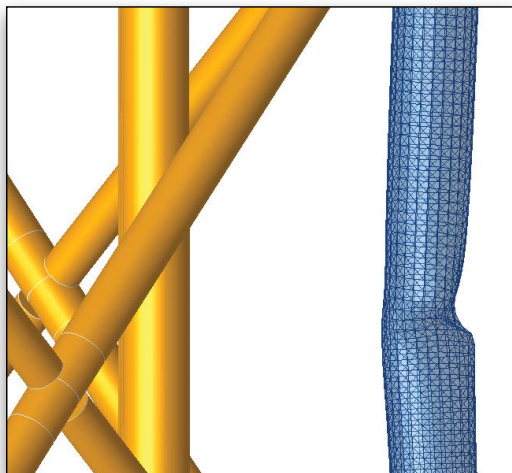
This add-on package performs advanced plastic analysis including pushover, ship impact, and blast non-linear analysis. It requires the use of the Offshore Structure, Offshore Structure Advanced, or Offshore Structure Enterprise package.

## **Fatigue Advanced – Dynamic Response: Fatigue Package with Dynamic Response**

This Advanced Dynamic Fatigue package contains the modules required to determine the wind fatigue damage of a dynamic system. This package contains DYNPAC, Fatigue, Interactive Fatigue, and Dynamic Response. It requires the use of the Offshore Structure, Offshore Structure Advanced, or Offshore Structure Enterprise package.

## **Fatigue Advanced – Wave Response: Fatigue Package with Wave Response**

This Advanced Dynamic Fatigue package contains the modules required to determine the fatigue damage of a dynamic system subject to wave loads. This package contains DYNPAC, Fatigue, Interactive Fatigue, and Wave Response. It requires the use of the Offshore Structure, Offshore Structure Advanced, or Offshore Structure Enterprise package.



*Ship impact analysis.*

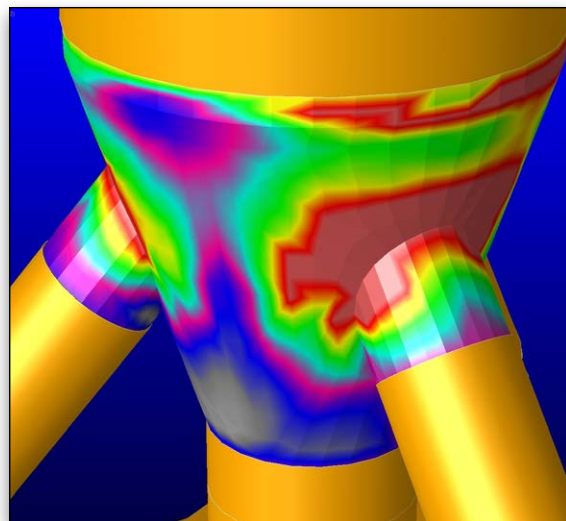
## **Fatigue Enterprise: Fatigue Package with Wave Response and Dynamic Response**

This Advanced Dynamic Fatigue package contains the modules required to perform any dynamic deterministic, time history, or

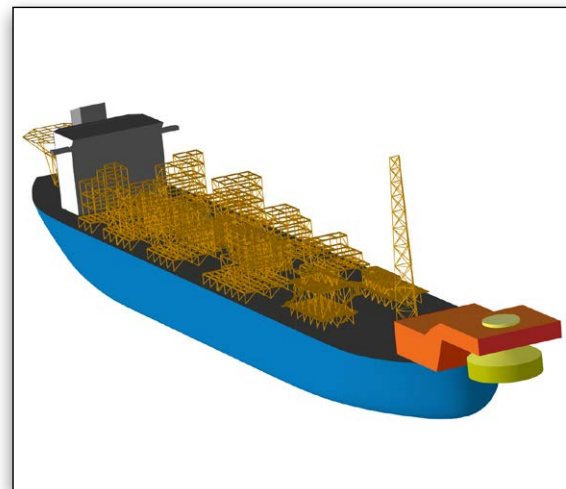
spectral fatigue analysis. This package contains DYNPAC, Fatigue, Interactive Fatigue, Dynamic Response, and Wave Response. It requires the use of the Offshore Structure, Offshore Structure Advanced, or Offshore Structure Enterprise package.

## **Wind: Wind Turbine Package**

The Wind Turbine package is comprised of the following packages necessary for wind turbine platform design: Offshore Structure Enterprise, Pile Structure Design, Collapse, and Fatigue Enterprise. The package also contains the SACS interfaces to the GH Bladed and FAST wind turbine aero-elastic modules. Full automation including multi-core analysis capability is included for efficient analysis of a large number of time history simulations.



*Parametric study for the fatigue design of a wind turbine transition piece.*



*Data interchange with MOSES for FPSO topsides analysis.*

The following software modules extend the functionality of any of the three Offshore Structure suites and are either included within those packages or available as add-on modules. Please consult your Bentley representative for product specifics relative to your needs.

### SACS Executive:

#### Common Interface to Program Suite

- Controls and connects all elements of the SACS system
- Launches all SACS interactive programs
- Executes all batch program analyses
- Allows access to all SACS system configuration settings, including system file location and security key settings
- Includes command line help and power buttons for the most commonly executed tasks
- Specifies analysis options without changing data input file
- Generates SQLite database for reporting in Excel and other programs
- Integrated with ProjectWise for sharing of all projects files across multiple sites

### Precede:

#### Interactive Full Screen Graphics Modeler

- Model generation capabilities include geometry, material and section properties, and loading
- Automatic input error detection
- Maintains data backup
- Beam and/or finite element modeling including plate and shell elements
- Automatic offshore jacket and deck generation
- User defined input units
- Cartesian, cylindrical, or spherical mesh generation
- Automatic weight or load generation including gravity, pressure, and skid mounted equipment loads
- Seastate data generation capabilities
- Extensive plotting and reporting capabilities
- Code check parameter generation including K-factors and compression flange unbraced lengths

- Allows SACS model files to be converted into 3D SAT file format compatible with AutoCAD, and other CAD systems
- Physical member support capabilities
- Professional and other ACIS-enabled CAD packages
- Supports full 3D geometry and section properties
- Allows SACS model files to be ported directly to a PDMS macro file, which creates the 3D model in PDMS
- Supports PDMS section libraries in addition to creating PDMS sections for sections defined in the SACS model
- Logging functionality
- ISM Export to ProSteel and other steel detailing systems
- Integrated with ProjectWise for sharing of all projects files across multiple sites

### Data Generator:

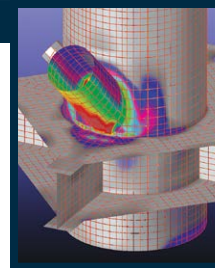
#### Interactive Data Generation for all Programs

- Intelligent full screen editor that labels and highlights data fields and provides help for data input
- Form-filling data input available as well as full screen mode
- Automatic data checking
- Integrated with ProjectWise for sharing of all projects files across multiple sites

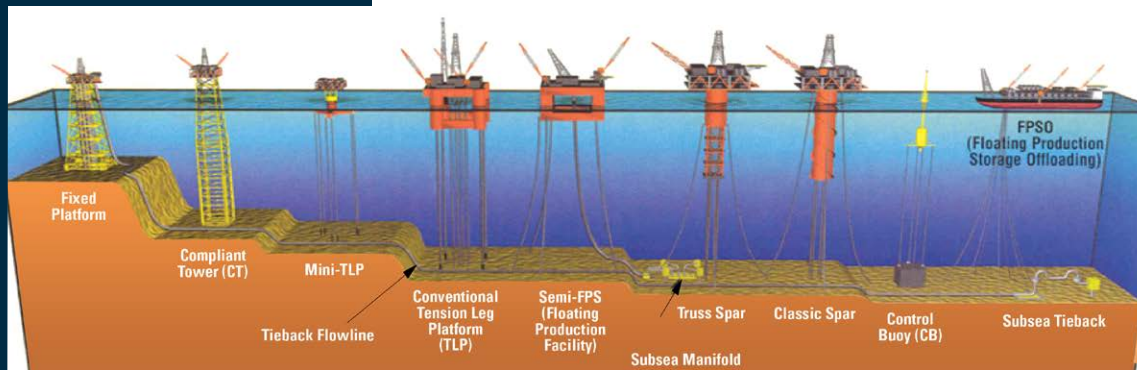
### Seastate:

#### Environmental Loads Generator

- Ability to view plot files on screen
- Sends viewed plots to printer/plotter
- Supports HP-GL, Postscript, DXF, Windows devices
- Metafile (WMF), and SACS NPF plot file
- Allows plot size, character size, margins, formats, etc.
- Ability to modify chart settings



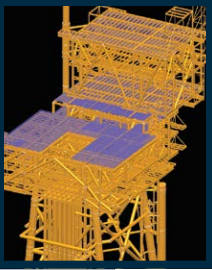
## Offshore System Types



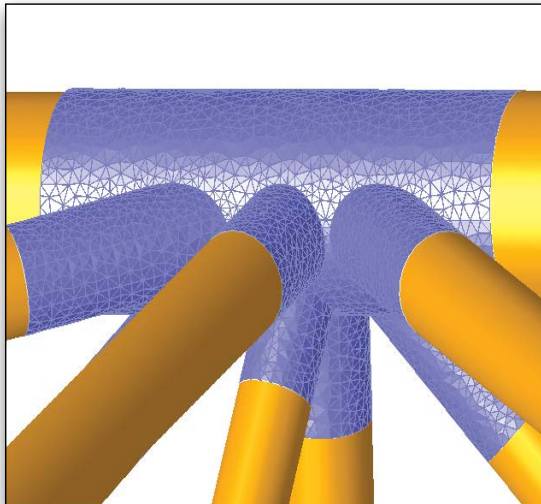
## SACS has applications for all types of offshore structures and vessels

1. Fixed platforms
2. Compliant tower
3. Tension leg platforms
4. Semi-submersibles
5. FPSOs





- Full implementation of API 21<sup>st</sup> edition
- Supports five wave theories
- Current included or excluded
- Generates load due to wind, gravity, buoyancy, and mud flow
- Marine growth, flooded, and non-flooded members
- RAO and acceleration loading including non-structural weights
- Moving loads generation
- Diameter, Reynolds number, and wake encounter effects dependent drag and inertia coefficients
- Weight load cases
- Forces on non-structural bodies
- Deterministic and random wave modeling for dynamic response
- Member hydrodynamic modeling for static and dynamic analysis



*Automatic joint meshing.*

## **SACS IV Solver:** **Static Beam and Finite Element Analysis**

- Beam elements including tubulars, tees, wide flanges, channels, angles, cones, plate and box girders, stiffened cylinders, and boxes
- Solid and plate elements (isotropic and stiffened)
- Discrete Kirchoff Theory (DKT) thin-plates
- Isoparametric 6-, 8-, and 9-node shell elements
- Library of AISC, U.K., European, German, Chinese, and Japanese cross sections, as well as user-defined libraries
- Member, plate and shell local and global offsets
- Beam and finite element thermal loads
- Elastic supports defined in global or reference joint coordinate system

- Specified support joint displacements
- Unlimited load cases
- P-delta effects
- Master/slave DOF

## **Post:** **Beam and Finite Element Code Check and Redesign**

- Beam and plate element code check and redesign
- API (including 21<sup>st</sup> edition), AISC, LRFD, Norsok, Eurocode 3, Canadian, DNV, British Standards, and Danish DS449 code check
- Plate panel checks in accordance to DNV-RP-C201
- Creates updated model with redesigned elements
- Modify code check parameters
- Load combination capabilities
- Supports codes from 1977 to present
- Detailed and summary reports
- Hydrostatic collapse analysis
- Span (multi-member effects)
- ISO 19902

## **Joint Can:** **Tubular Joint Code Check and Redesign**

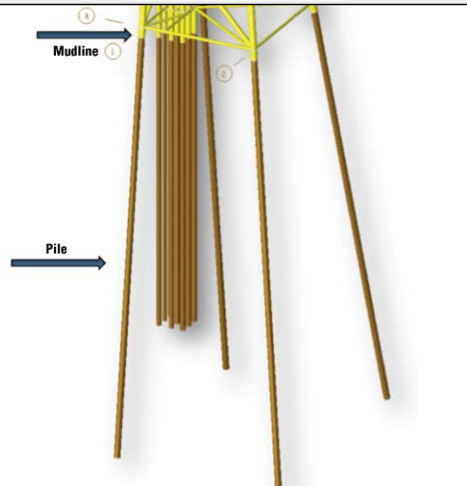
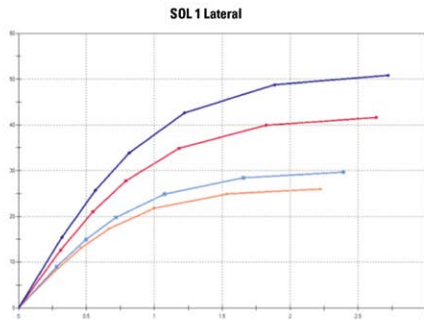
- Present and past codes including latest API 21<sup>st</sup> edition, supplement 2, and LRFD, Norsok, DS449, and Canadian
- API earthquake and simplified fatigue analysis
- ISO 19902
- Connection strength (50 percent) check
- Overlapping joints analyzed
- Minimum and extreme seismic analysis

## **Postvue:** **Interactive Graphics Post Processor**

- Interactive member and tubular joint code check and redesign, with the option to print code check details for latest AISC, ASD and LRFD, API, ISO 19902 codes
- Display shear and bending moment diagrams
- Display rendered deflected shapes for static and dynamic analyses
- Animate deflected and modal shapes
- Color plate stress contour plots
- Code check and redesign by individual or group of elements

**PSI:**

- API P-Y / T-Z Soil
- API Adhesion Soil
- User Defined P-Y / T-Z Soil
- User Defined Adhesion Soil



- Supports same codes as post module
- Extensive reporting and plotting capabilities
- Color-coded results and unity check plots
- Creates updated input model file for re-analysis
- Labels UC ratio, stresses, and internal forces on elements

**Concrete:****Reinforced Concrete Code Check and Redesign**

- Rectangular, Circular, Tee, and L cross sections
- Beam, bi-axial beam-column, slab, and wall elements supported
- Multiple reinforcement patterns can be specified
- Code check per ACI 318-89 (Revised 1992)
- Shear reinforcement check and redesign
- Reinforcement development length check
- Deflection and creep calculation
- Second order/P-delta analysis capabilities

**Fatigue:****Fatigue Life Evaluation and Redesign**

- Spectral, time history, and deterministic fatigue analysis
- Cyclic stress range calculation procedures include wave search, curve fit, and interpolation
- SCF calculations recommended by API (including 21<sup>st</sup> ed. supplements), HSE, DNV, DS449 and Norsok Codes
- Automatic redesign
- API (including 21<sup>st</sup> ed. supplements), AWS, HSE, and Norsok thickness dependent recommended S-N curves
- Multiple run damage accumulation
- Pierson-Moskowitz, JONSWAP, Ochi-Hubble double peak, simplified double peak, and user-defined spectra

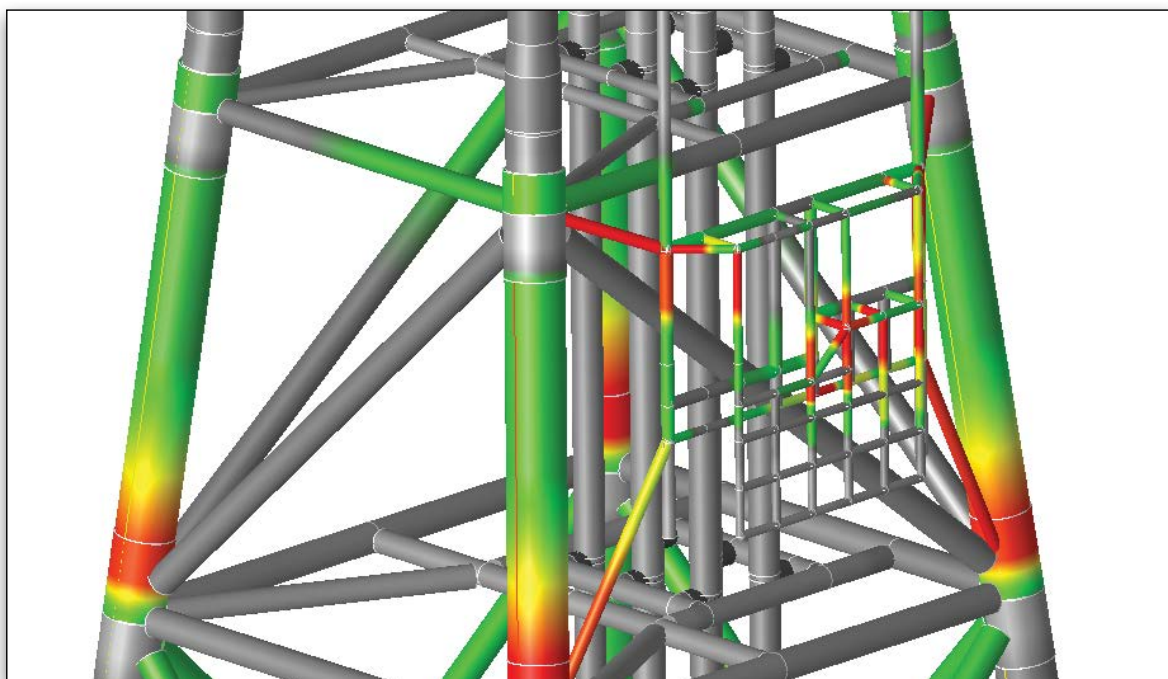
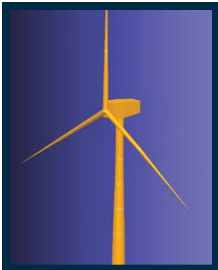
- Automated or user-specified connection details
- Pile fatigue analysis
- Creates wave spectra from scatter diagram
- Uses Paris equation to predict crack growth rate due to cyclic stresses
- Load path dependent joint classifications
- Includes wave spreading effects
- Reservoir (rain flow) cycle counting method
- ISO 19902

**Interactive Fatigue:****Interactive Fatigue Life Evaluation**

- Shows the 3D view of the connection and allows braces to be selected with the mouse
- Reads connection defaults when joint and/or brace is/are selected, thus eliminating the need to calculate and display SCFs before viewing capacity or modifying properties
- Recognizes all SCF and S-N options available in the batch program
- Allows SCF theory to be changed for any type connection, including in-line connections and connections with user defined SCFs
- Reports have been expanded and reworked to make them easier to read
- Reports and plots can be displayed on the screen and/or saved to a file
- Automatic redesign

**GAP:****Non-linear Analysis With One-way Elements**

- Accurate simulation of load out or transportation analysis using one-way elements
- Tension or compression gap elements with initial gap
- General non-linear elements
- Friction element



*Non-linear elasto-plastic deformations.*

#### **PSI:**

##### **Non-linear Soil, Pile, and Structure Interaction**

- Beam column effects included
- Non-uniform piles
- P-Y and T-Z curves, axial adhesion and springs
- API P-Y, T-Z, skin friction and adhesion data generated from soil properties per API
- Full structural analysis and pile code check API, LRFD, Norsok, HSE, DS449, Canadian, and DNV
- Offset P-Y & T-Z curves for mudslides
- Full plotting and graphical representation of soil data and results, including stresses, P-Y, T-Z curves
- Soil liquefaction effects

#### **Pile:**

##### **Isolated 3D Pile Analysis**

- Beam column and pile batter effects included
- Uses PSI soil data
- Optional pile head springs
- Specify force at or below pile head
- Specify pile head displacements
- Specified pile head forces or displacements
- Automatic generation of linear equivalent pile stubs for dynamic or static analysis
- Soil liquefaction effects
- Same plotting and code check features as PSI

#### **Superelement:**

##### **Automated Substructure Creation and Application**

- Unlimited number of superelements
- Up to 1,000 interface joints per superelement
- Translation and rotation of superelements
- User defined stiffness matrices
- Full stress recovery
- Superelements can contain other superelements
- Translation and rotation of superelements

#### **Combine:**

##### **Common Solution File Utility**

- Combines dynamic and static results from one or multiple solution files
- Combines results from analyses having different member, plates, etc.
- Superimposes mode shapes
- "Worst-case" combination of dead loads with earthquake response
- Determine extreme wave loads from input spectra

#### **Large Deflection (LDF):**

##### **Large Deflection Analysis**

- Iterative solution for geometric
- Solves plate membrane problems
- Accounts for P-delta effects nonlinearities

**Collapse:****Non-linear Collapse Analysis**

- Linear and non-linear material behavior
- Non-linear springs
- Sequential load stacking capability
- Activate and deactivate elements
- Joint flexibility options
- Impact analysis with automatic unloading, built-in DNV ship indentation curves and energy absorption functionality
- Load cases may contain loading and/or specified displacements
- Includes geometric nonlinearities
- Plastic members and finite elements
- Includes piles with non-linear soils and plasticity
- Soil liquefaction effects
- Plastic DKT plates

**Dynpac:****Dynamic Characteristics**

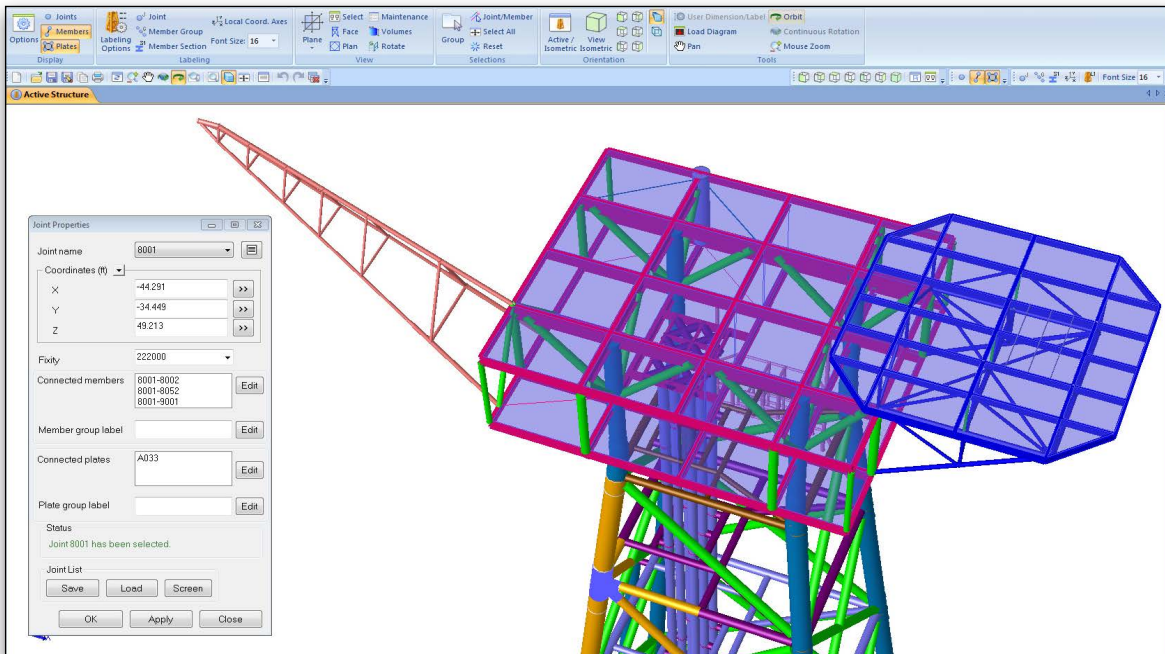
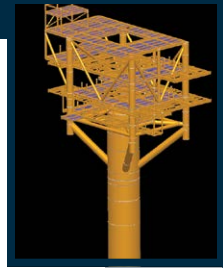
- Householder-Givens solution
- Guyan reduction of non-essential degrees of freedom
- Lumped or consistent structural mass generation
- Automatic virtual mass generation
- Complete seastate hydrodynamic modeling
- User input distributed and concentrated mass
- Non-structural weight modeling
- Full 6 DOF modes available for forced response analysis

**Wave Response:****Dynamic Wave Response**

- Deterministic and random waves
- Pierson-Moskowitz, Jonswap, Ochi-Hubble, and user wave spectra
- Harris, Von Karmon, and Kaimal wind spectra
- Fluid-structure relative velocity and acceleration accounted for "Modal Acceleration" and non-linear fluid damping
- Closed form steady state response in the frequency domain
- Equivalent static load output for accurate stress recovery
- Zero crossing and RMS responses
- Time history analysis of wave and wind and time history load
- Buoyancy dynamic loads included
- Stress, internal load, base shear, and overturning moment transfer function plots available
- Full coupling with Fatigue program
- Elastic dynamic response of floating structures including stingers
- Input and output Power Spectral Densities with Probability Distributions
- Special features for wind turbine analysis

**Dynamic Response:****General Dynamic Response and Earthquake Analysis**

- Frequency domain analysis
- Time history, response spectrum or PSD-based driven input
- Time history and harmonic-force driven input
- SRSS, CQC and peak modal combinations
- API response spectra library and user input spectra



*Precede graphical modeler aids modelling of jackets and complex topside.*



## System Requirements

### Processor:

Core 2 processor or better

### Operating System:

Windows 7 or Windows 8

### RAM:

Minimum 2 GB of RAM

### Hard Disk:

Minimum 2 GB of free hard disk space

### Display:

Graphics card supporting Open GL

128 MB RAM or greater video card with 1280x1024 or higher video resolution

**Find out about Bentley at: [www.Bentley.com/Offshore](http://www.Bentley.com/Offshore)**

### Contact Bentley

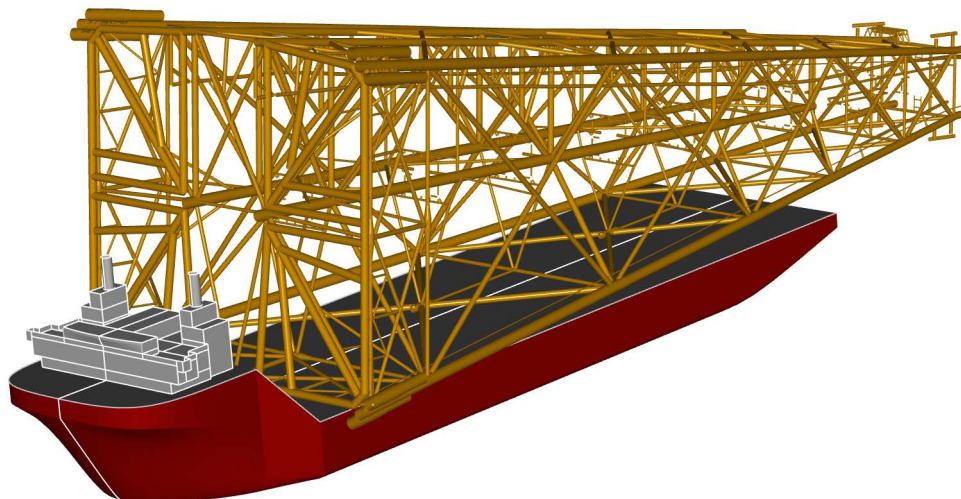
1-800-BENTLEY (1-800-236-8539)  
Outside the US +1 610-458-5000

### Global Office Listings

[www.bentley.com/contact](http://www.bentley.com/contact)

## Tow Structural Analysis

- *Combine multiple common solution files*
- *Static analysis with non-linear GAP elements*
- *Seafastener design*



- Wind spectral loading capability
- Structural and fluid damping
- Vibration analysis with multiple input points with user specified frequencies and phasing
- General periodic forces decomposed by Fourier analysis
- Ice dynamics analysis
- Engine/compressor vibration analysis
- Response spectrum output at any joint
- Equivalent static load and incremental load output resulting from earthquake, ship impact, dropped object and blast analysis. This loading can be used for subsequent linear static analysis or for non-linear collapse analysis
- Ship impact analysis
- Dropped object analysis

### Tow:

#### Transportation Inertia Load Generator

- Input motion for six degrees of freedom
- Output location for selected points
- Automatic weight calculation
- User input member and joint weights
- Generates distributed member and plate loads
- Converts user defined loads into inertias

### MTO:

#### Material Take-Off, Weight Control, and Cost Estimation

- Member lengths including cuts
- Steel tonnage and CG location
- Material list, cost estimate, and weight control reports
- Weld volume requirements and cost
- Required protective anodes and cost
- Surface area calculations by elevation
- Anode calculation in accordance to NACE SP0176-2007 (formerly RP0176-2003) and DNV-RP-B401

**SACS**

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Sustaining Infrastructure