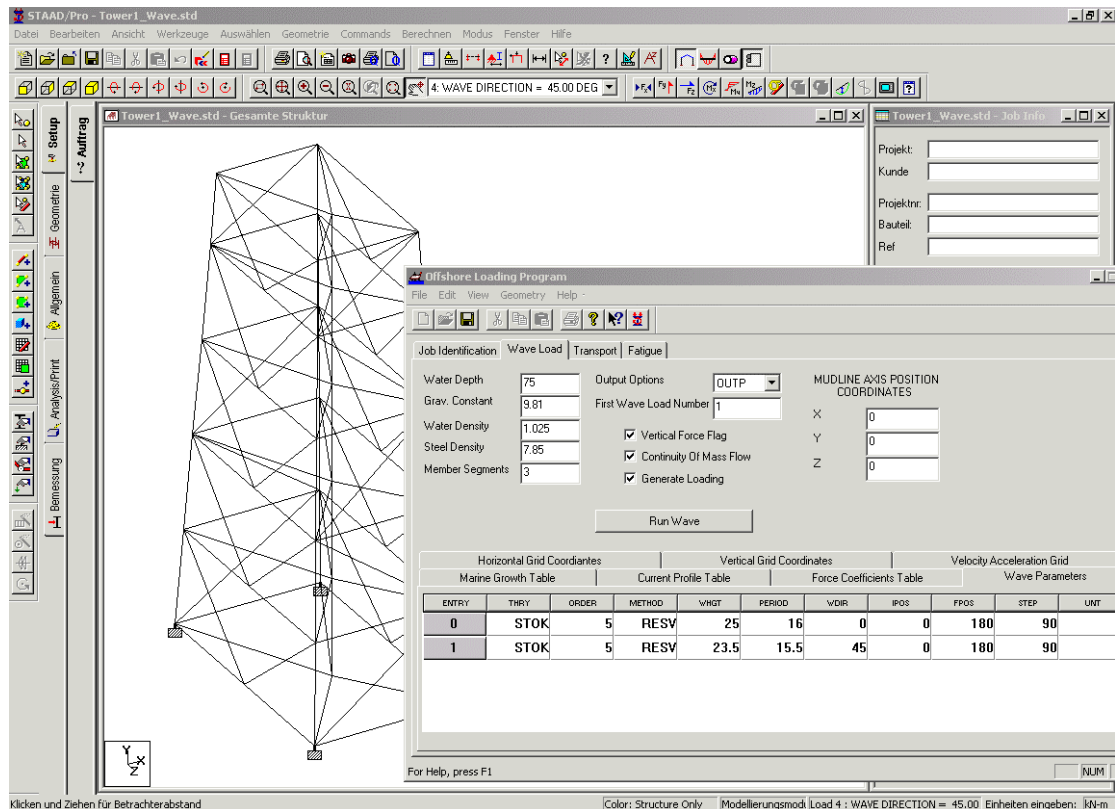


Offshore Loading System for Windows (for use with STAADIII & STAAD/Pro)



Introduction

The Offshore Loading System consists of a suite or pre and post processor programs to the STAAD-III Structural Analysis and Design Program. The suite is made up of three modules :-

- WAVELOAD is a program for generating wave loads on structures using either STREAM function, STOKES 5th Order Theory, AIRY theory, or a user defined grid wave. The program generates a STAAD loading file for the stiffness analysis.
- FATIGUE is a deterministic fatigue program for calculating fatigue lives of tubular joints.
- TRANSPORT is a motions program for calculating the inertia forces on a structure, and generates the STAAD-III loading file for the stiffness analysis.

WAVELOAD – Wave forces on 3D Space Structures

The program computes the wave loading intensities due to wave and/or current effects along the submerged portion of the structural members and appurtenances below the wave surface profile, relative to the local X, Y, Z,. co-ordinated and the global X, Y, Z,. co-ordinates. The wave loadings are summed at the joints for each member using simple beam theory from which the total structure base shear and overturning moments are calculated.

The wave can be stepped through the structure in any specified direction over a range subdivided into equal intervals using either phase angles or length units. The interval is specified by giving start and finish positions of the wave crest relative to the structure mudline axis system and a step interval.

The wave force coefficients, drag and added mass, can be specified independently for each member or using member range. The coefficients are relative to the member local co-ordinate system.

Marine growth and current velocity profiles are specified relative to the mean water level and are described as a discrete set of data points. The magnitude of the current at other elevations is determined by direct interpolation or extrapolation of the data. Alternatively, current flow continuity can be selected. The marine growth is only applied to the members within the profile range that is specified.

The program computes the wave surface profile, wave celerity and wave length.

The wave loading intensity along the members is assumed to be linear varying over a segment length. The accuracy is controlled by user by specifying the appropriate number of segments along the members or by using the auto-segmentation option.

The program generates a STAAD-III loading file comprising of: equivalent simple beam joint loads for buoyancy; wave loading intensities on structural members, and joint loads for wave loading on appurtenances. The structures deadweight can be generated by STAAD-III. Other output files include the structure base force summaries. There is an option in the program to neglect the overturning moments at the base that are caused by the vertical forces. This allows the vertical wave force effects to be quantified.

The wave forces are calculated from Morison's equation using either Stream Functions, Stokes 5th Order, or Airy linear theory, to compute the particle velocities and accelerations, or a user defined Grid of velocities and accelerations.

FATIGUE – Deterministic Fatigue analysis of 3D Tubular Space frames

The FATIG program computes the fatigue lives of tubular joints at the chord-side and stub-side positions of the stub to chord weld connections, and at the stub-brace weld connection. The cyclic member end forces have to be generated by STAAD-III and the WAVE program before FATIG can be run.

The analysis is based on a log-linear wave exceedance curve, bi-linear S-N curve, and either a single reference wave height with an assumed stress function relationship through the wave height; for each wave approach direction to the structure.

The stress concentration factors can either be generated by the program, or input manually.

The analysis can consider up to 16 wave approach directions to the structure. In each wave direction the reference wave height is stepped through the structure in equal

increments using the program WAVE to generate the member loadings, which are input to the structural analysis program STAAD-III to generate the member end forces.

The maximum number of wave positions within the wave length is ten. The cyclic stress range is determined from quadratic curve fitting through the 2 maxima and the 3 minima points. Alternatively, three wave positions at phase 0, 90 & 180 degrees apart may be used to generate the member end force data. For this condition the fatigue program will fit a sinusoidal function through the data to determine the cyclic stress range for the wave height. This method is not so accurate as the curve fitting approach, especially for those members in the wave zone, and members that cut the wave surface profile.

A number of waves can be passed through the structure to obtain the stress range versus wave height relationship for each wave direction, or the cyclic stress range versus wave height relationship can be obtained from a single reference wave height in each wave direction. For the single reference wave height method it is assumed to be that the stress range, S , is equal to the constant, a , times the wave height, H , raised to the power constant, b . From the stress range, S_r , associated with the reference wave height, H_r , the constant, a , is computed by assuming a value for the power constant, b , is of the order of 1.4 for jacket structures. This operation uniquely defines the cyclic stress range relationship to be used for the fatigue damage calculation.

The program will evaluate the fatigue lives at up to 16 points around the tubular and output the minimum life of the chord, stub, and brace.

The wave exceedance curve data is log-linear based on a one year return period, i.e. the wave height will only be exceeded once in one year.

The program includes the D. En S-N curves B, C, D, E, F, F2, G, W, and T curves and the facility to declare a user defined S-N curve. The S-N curve is log-bi-linear, and is defined by the S-N curve constant $\text{LOG}_{10}(A)$, the allowable cycles at the intersection of the first and second parts of the S-N curve at NO cycles, (normally $1E7$ cycles), and slope of each part.

The fatigue damage calculation is based on Miners cumulative damage rule. Using Miners rule, and the above relationships for wave exceedance, S-N curve, and cyclic stress range versus wave height, a closed form solution is obtained for fatigue damage.

TRANSPORT - Motion/Transport Analysis

The TRANS program can calculate the inertia forces due to motion accelerations, consisting of any combination of the 3-translational and 3-rotational degrees of freedom. The inertia loads can either be lumped at the nodes, or distributed along the members. The program generates a complete STAAD-III input file consisting of basic load cases for the inertia loadings on the structure, together with the STAAD-III commands necessary to perform analysis, output displacements, reactions and member end forces.

Motion loads can be generated in all six degrees of freedom, DOF, and combined, to form basic STAAD-III load cases. The DOF motions in a load case can be added or subtracted by specifying a directional load factor, e.g. -1.2, 1.0 etc., a factor greater than 1.0 would signify a correction factor being applied to the generated load. If gravity tilt loads are to be generated then the global Y axis must be set vertically upwards. Also, in respect of vessel motions, a suitable axis convention would be to set the global Y axis vertical with the global X axis in the direction of the vessel longitudinal axis. This convention gives the following correspondence between each DOF in terms of ship motions as follows:-

DOF	Ship Motion
DX	Surge
DY	Heave
DZ	Sway
RX	Roll
RY	Yaw
RZ	Pitch

Thus, for example, using directional load factors it is possible to form load cases comprising of heave + roll, or heave - roll and heave + pitch, or heave - pitch, to determine the maximum member forces at all positions within a structure.

STAAD-III Design module for the API code

GENERAL DESCRIPTION

The implementation of the API design code into STAAD-III includes a comprehensive code check for all members with the option of automatic selection of the optimum member size if required. When the general member design has been completed, punching shear at the joints can be checked.

PUNCHING SHEAR CHECK

For tubular members, punching shear may be checked in accordance with the American Petroleum Institute (API) RP2A - 18th Edition Section 4. The following joint types can be specified.

K (overlap)

K (gap)

T & Y

CROSS

CROSS (with diagrams)

AUTOMATIC

Automatic selection of the chord and brace members can be performed by STAAD. The punching shear check is carried out on the joint treating it as a T & Y joint. Where a punching shear check is carried out the geometry data used in the check can be written to an external file. This file can also be used for inputting data to represent *can/stub* geometry or to specify chords that could not be identified automatically.

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