

What is new in CAPWAP® 2014

CAPWAP model changes/additions

Time Increment/wave speed variations

This feature is especially important for analyzing cast-in-situ and other concrete piles. It allows modeling piles that experience micro cracking during driving or testing, which may cause the wave speed to be noticeably lower when the stress wave becomes tensile after the first L/c time. Tension slacks could be used on previous versions to model that effect; however, multiple tension slacks were needed for distributed micro cracks, and that usually led to rather rough computed pile top curves. In addition, tension slack modeling is a lengthy process and the right combination of segment number, slack size and slack efficiency values can only be determined in a tedious trial and error procedure. To allow better modelling in those cases, the user can now specify different time increments at specified times. The new Variable Time Increment input dialog shows timing information, which can be used to determine reasonable modified wave speed starting times.

Extra toe model extensions

It is now possible to enter the areas (for unit resistance calculations), the damping options (0=viscous, 1=Smith, 2=Smith/viscous) and toe gaps for each of the two extra toes. The analysis was modified to consider different toe gaps for the three toe soil models. The unit toe resistance for the extra toes is now included in the Final Summary table (provided that the area of the extra toes have been entered – in this case, those areas are displayed at the end of the Pile Profile output).

Pile stiffness of static load-set curve computation

The user can now choose to have the added impedance included in the pile stiffness computation for the load-set curve.

Toe Impedance

The program now uses the toe impedance with an adjustment for the toe plug to calculate the **BT** radiation dashpot value for the toe.

Major changes and additions

Calculated pile model volume information

The bottom of the Pile Profile input page, the Impedance Input screen and the Pile Segment property table of the Pile Model input now show the total pile volume and volume ratio relative to the pile profile volume (the profile volume is based on the input cross sectional area and length values). The total volume and the volume ratio consider the added impedance values. This information is helpful for the analysis of cast-in-situ piles for which the construction volume is known.

The user can also choose to show this information at the end of the Pile Model table in the output.

Auto Impedance adjustment

Three menu commands have been added for automatic calculation of added impedance values. The options are as follows:

- **Automatic with fixed limits on all segments** - automatically calculates added impedance values for all segments with predefined limits on maximum number of

iterations (100) and total impedance (between 90% and 200% of the pile profile impedance);

- **Single iteration on selected segments** - automatically adjusts added impedance values for selected segments by one half of the suggested impedance change values;
- **Automatic adjustment on selected segments with user specified conditions** – performs automatic impedance adjustments on a selected range of segments, allowing the user to specify:
 - Maximum number of iterations
 - Lower and upper impedance change limits
 - A construction volume to match

Saving trial analyses

In addition to the automatically saved Best Match, the user now has the option to save a selected trial and to select a trial analysis to display as a 3rd curve. Icons were added to allow adding the current trial to the match plot, so it will be shown as a 3rd curve on subsequent analyses. The trials selected for saving will never be deleted from the list.

Tapered Pile Profile Generator and Concrete Filled Composite Pile Profile Generator

The diameter of a solid tapered pile section (like a timber pile, or a concrete-filled Taper Tube™ or Monotube®), usually varies linearly, but the cross sectional area and thus the impedance vary with the square of the diameter and depth. In that case, entering only the top and bottom cross sectional areas is not accurate enough to calculate the area of the pile model segments. Thus, an input tool was added to the Pile Model to help create a pile profile based on the top and bottom values of the tapered section and on the cross section areas at multiple equally spaced locations along the pile.

An additional option calculates the pile profile values for a straight or tapered circular concrete-filled pipe section.

Improvements to automatic procedures for signal matching

Automatic Toe (AT): The **AT** method is now working like the Automatic Quantity adjustment method, **AQ**. It searches for the best set of toe-related parameters ST/JT, QT, TG, CT, PL, Rtoe and RU. Neither Rs nor any other non-toe related quantity is affected.

Auto Resistance-Damping Exchange (ARD): An **AQ on Standard Parameters** is now performed at the end of an **ARD**.

Quick Resistance-Damping Exchange (QARD): An **AQ on Standard Parameters** procedure is now performed at the end of a **QARD**.

Auto CAPWAP® (AC): An **AQ on Standard Parameters** and a **QARD** are performed at the end of an **AC**.

iCAP®

CAPWAP now also allows you to perform signal matching using the iCAP automatic procedure. This allows for example using iCAP with non-uniform piles, reproducing field results, performing conventional CAPWAP on previously iCAP-analyzed data, etc.

New Output: Comprehensive CAPWAP Report Page

A new CAPWAP report page can now be included in the standard output. This page includes:

- The Measured Force/Velocity plot
- The Match plot

- CAPWAP® simulated Static Load-Set curve
- Vs. Depth plots include
 - CAPWAP unit resistance distribution and a pile profile
 - Plots of SPT N-values, unconfined compressive strength and soil type description, when entered by the user. New tabs are provided in the Job Information screen for entering this information.
 - Custom input quantity when entered by user
- Summary information such as project, pile number, etc. as per Job Information
- CAPWAP results of capacity and stresses
- Blow count information, i.e., the driving log as entered in the PDA file. The user can also edit/input the drive log in CAPWAP.

Pile model wave speed output

The pile model table in the numerical output now shows:

- The wave speed for pile top (WS),
- The pile model elastic wave speed, based on the pile profile properties,
- The overall wave speed as per Pile Model (PM) input

Static Load-Set Graph with additional offset criteria

Different options are now available for offset display:

- Davisson/ASSHTO (same as CAPWAP 2006):
- Davisson: $PL/AE + 0.15" + D/120$
- User defined: $D/Divisor$; user enters Divisor

CAPWAP Summary Plot Output enhancements

- In the CAPWAP standard output, the force match plot can now be replaced by the wave match plot.
- Optional $2L/c$ vertical gridlines were added below the Measured Force/Velocity plot to emphasize the alignment with resistance/pile force plot.
- The resistance distribution can be shown either with units of (kPa)/(ksf)/(tons/m²) or (kN/m)/(kips/ft)/(tons/m) (Note: "tons" are metric tons).
- A numerical summary was added on the right lower corner of the Summary Plot.
- Ticks and lines were added to the resistance/pile force plot to indicate the separation of toe resistance (i.e., end bearing, EB) and shaft friction (SF).

Output of gage-related information

The ID, calibration factors and replay factors of the active gages are shown in the Match Summary and Annotation tables.

Output of CASE Method results

- J(RX) values up to 2.0 are shown (were limited to 0.9 before)
- RP values (obsolete) can now be suppressed from output
- Added Toe Stiffness, defined as toe resistance / quake. This is labeled as KEB, but can be customized.

Other changes to output

- The total shaft plug is shown in the CAPWAP Summary Results table.
- The static and dynamic resistance at toe vs. time can now be plotted
- An option to hide the toe load-set curve was added.

- For load-set curve, the option, “Dyn. Toe Displacement, Ideal Toe Resistance” was removed
- For load-set curve, the label "Inactivated capacity included" is displayed if users allow for inactivated resistance in the analysis and not all of the capacity is activated
- The exact damping type (Viscous, Smith or Smith-viscous) is always shown in the Result Table
- An optional editable disclaimer page can be added to the printed output
- Warning messages (translatable) are added to the output if MQ is too large

New MQ-related status indicators

Additional MQ- related status indicators were created to encourage the user to achieve a better match:

-  Best Match achieved so far, and $MQ \leq 3$
-  Good, $MQ \leq 3$
-  Fair, $3 < MQ \leq 5$
-  So so, $5 < MQ \leq 10$
-  Poor, $MQ > 10$ or if capacity not activated

Pile model segment property table

This table has been expanded to show both wave speed (WS) as an additional column and the segment property units below the heading.

New time-saving and convenience features

Data quality check for data review

To simplify the analysis and data checking without having to go back to the PDA program, a dialog box was added to show individual force/velocity traces, calibration factors, replay factors and included sensors.

Simplification of extra toe information input

- For toes 2 and 3, it is now possible to enter the ultimate resistance, quake, damping and the depth below gages where those extra toes are located directly in the **Main Input** and **Resistance** input forms.
- The original extra toe input dialog boxes now feature two tabs for accessing the two toe inputs directly.

Improvements of resistance input

- Checks to avoid negative skin friction when distributing unresolved resistance;
- When **Toe Hold** is selected, the color of the Rs field changes and a warning “Shaft resistance may change after resolving the difference” will appear;
- When **Shaft Hold** is selected, the color of toe related inputs change and a warning “Toe resistance may change after resolving the difference” will appear.

Simplification of segment selection

The segment range can still be selected by manually entering the values on the upper and lower segments, but the following two additional methods were added:

- Click the starting cell, then use shft+up/down arrow key to move to the last cell;
- Click the starting cell and shft+click on the ending cell to select a range.

This feature is useful for operations performed on selected segments such as interpolation and auto impedance change.

Additional interpolation option for segment inputs

In most segment related input forms (pile and soil), you can now right click to bring up a floating menu item named Interpolation Input, which allows entering the start segment number and value, the end segment number and value and the segment increment. This makes it possible to input, for example, the same TS (tension slack) value for every other segment.

Improved information and handling of overall and elastic wave speed

If the overall wave speed is different from the elastic one after the pile profile is changed, the wave speed defaults to the elastic wave speed. If the original overall wave speed was different than the original elastic one, the user is asked to confirm if the overall wave speed should be changed. Note that the pile profile screen now shows the elastic wave speed at the bottom.

Easy change of bottom area

The bottom area can now be changed in the Pile Model screen, without having to go back to the PDA program.

Shaft plug input – PS

If all shaft plug values are zero, entering a value for PS in either the **Main Input** or **Overall Parameters** screens will cause the new PS values to be assigned to all shaft segments starting from ground level rather than from the first pile segment.

Additional function key assignments

- F7 - Resistance-Damping Exchange (RD)
- Ctrl+F9 - Auto Quantity Improvement (AQ-Std)
- F9 - AQ on Selected Parameter
- F10 - Auto search for improved Match Quality using Resistance-Damping Exchange
- F11 - Auto Search Procedure against friction (FR)
- F12 - Back to main input (MI)

Non-uniform model warnings

To help quickly identify if and what kind of model parameters are non-uniform along the pile or which kind of unusual model parameters have been set, the following 6 warning indicators were added on the right side of the top status bar:

- "QS" for non-uniform skin quakes
- "DA" for any added damping
- "DM" for any damping multiplier not equal to 1.0
- "C_S" for any non-zero compression slack
- "T_S" for any non-zero tension slack
- "Plg" for any shaft plug greater than zero (note that this would also be indicated by a non-zero PS value)
- "Z" for any non-zero added impedance

Custom decimals and unit labels

The following options were added to allow the user to change the precision (number of decimal digits) of various individual input/output values:

- The input screen and output tables precisions of Case and Smith damping (JS/JT, SS/ST), quakes and plug. The quake output format also controls Dy and Dx in the load-set plot.
- The input screen precisions of CS, CT, UN, LS and LT.
- The output table precisions of compression stresses and tension stresses; different precisions can be set for different materials (steel, concrete and timber)
- The precisions of Extrema Table output results of compression force, tension force, energy and velocity.

In addition, for small pile toe areas ($< 0.4 \text{ m}^2$) the program now automatically changes the units in the Pile Profile table; in those cases, the program uses cm^2 or in^2 instead of m^2 or ft^2

Other additions and improvements

- Automatically saves the CAPWAP® result (cww) file with a default name when starting an analysis, in the same folder as the PDA file. If a file with the same name already exists in the folder, the program prompts the user for a different name.
- Hovering the cursor over a curve on the analysis screen shows the record time and signal magnitude.
- A warning was added for cases in which a negative added damping would reduce the damping at a segment to less than $\frac{1}{2}$ of the proportional value from JS/SS.
- The program now issues a warning and prohibits input of a negative damping multiplier
- An icon  was added to turn on/off display of the static load-set in the analysis screen
- Improved automatic abscissa scaling of wave-up match plot
- The search animation has been changed, and can now be replaced by any movie clip with uncompressed avi format.
- The user can now directly save the output to pdf using a built-in converter.
- For RSA:
 - TG is set to zero when changing from non RSA to RSA;
 - If TG is manually changed after a RSA is performed, a warning of “out of range” appears;
 - Since $\text{UN} = 0$ is meaningless to RSA, a warning appears if UN is 0 when RSA is turned on;
 - After an RSA is performed, if UN is changed to less than 0.2 it is shown as out of range.
- Improvement of input forms rotation sequence ()
 - Input forms, Main Input, Overall Parameters, Resistance and Impedance are always included;
 - The other forms will be included only if changes have been made.
- Set/blow is now shown in the load-set graph
- Saving the results after using the **Input->import Force and Velocity** feature will no longer overwrite the previous solution.