# GRLWEAP 14 Update List

(Enhancements, Improvements, and Significant Differences from GRLWEAP 2010)

## Program Name and Versions

Since 1976, 13 different versions of WEAP and GRLWEAP existed. The version released in 2021 was therefore named GRLWEAP 14 (GW14). The program comes in two sub versions: **Professional** and **Offshore** and is licensed with a software lock only. Including all features from **Professional** version, the latter adds extra features that are particularly helpful for those working on large diameter pipe piles installed nearshore or offshore, and need more customized features. However, this version may also offer advantages for those involved in pile driving with free riding leads or be beneficial to those concerned about fatigue stresses imposed by pile driving and /or soil resistance fatigue during continuous pile driving.

Its additional features and improvements are listed in this section. Features that require the **Offshore** license are shown in *Italic Font.* At end of this document, the features summarized are only available to **Offshore** version.

## Hammer database

Both hammer database and the maintenance program have been updated to allow to expand the hammer database to include more information, and to make the creation and management much easier:

- The hammer maintenance program has been greatly improved with following new features:
    - Allows user to create own hammer database files and keep the files at any location defined by user.
    - Allows to open multiple hammer database files and moving and duplicating hammer records among user generated database files.
    - Easier to add, remove and edit hammer data.
    - Added checking of hammer data to prevent obvious errors when inputting hammer data;
    - Prevents user from inadvertently modifying the PDI hammer data files.
- Hammer database file has been updated to include more information:
    - Total hammer weight has been added which will be used to generate default assembly weights; total hammer weight may differ from assembly plus ram weight and will be considered in the initial balance check.
    - For each hammer entry, a field of Note is added for additional information related to the hammer.
    - For each hammer database file, a field of Note is added for additional information related to the database file.

## Geotechnical Static Analysis Tools

- SA: if friction angle ϕ is entered for gravel, sand and cohesionless silt, the resistance computations now are performed based on Fellenius (2014) and new limits have been applied for consistency with other methods.
- Added **FHWA/Driven** method, including Nordlund and Tomlinson static analysis methods for granular and cohesive soils, respectively.
- *Added **API2** method based on API 2007 specifications; the previous method (referred to as API) was retained. While helping user to meet the specification requirement, this method also added extra features to make the use easy. **API2** Includes:*
  - *A soil type based method similar to the API method of GRLWEAP 2010 with updated soil type groups defined by API 2007.*
  - *The CPT based methods highly recommended by API 2007 for sand, which includes:*
    - *The Simplified ICP-05 method,*
    - *The Offshore UWA-05 method,*
    - *The Fugro-05 method and,*
    - *The NGI-05 method.*
  - *If CPT data is available for CPT based method, this method allows users to classify soil by customizing the classification default by the program based on Robertson et al. (1986).*
- *Added an **A&H**–method for soil resistance distribution and/or soil fatigue analysis, which requires CPT data as input:*
  - *The **Alm** and **Hamre** (A&H) **Friction Fatigue** Method now also calculates the initial unit resistance values, shape factors and the ratio of residual to initial resistance which is called setup factor in **GRLWEAP** language.*
  - *Users can customize the **A&H** calculated unit resistance values or which works with an externally prepared set of unit resistance values for which the **A&H** proposed shape and setup factors are then computed by GW14.*
  - ***A&H** may be used as a static analysis method to compute the initial resistance values as soil resistance distribution which requires CPT data.*
- *Slightly modified the **GRLWEAP Friction Fatigue** method (single shape factor).*
- Improved input of soil layer and data interpolation, allowing for large or only single soil layers without loss of accuracy. (Previous versions had a suggested maximum soil layer input thickness of 5m. Now the program uses a default computational soil segment length ≤ 0.5 m).
- Added an option for improved treatment of end bearing at soil layer interfaces considering soil strength values above and below the pile toe location.

## Pile/Soil Model

- Added a Pile Builder for non-uniform piles, an improved and more versatile pile profile input and pile model building routine.
- Added Export and Import options of user generated pile profiles.
- Added sheet pile profiles and additional H-pile types to the pile data base.
- *The added Pile Builder allows for building a pile with multiple add-ons and if this is the method to input a pile with multiple add-ons, the temporary lengths and corresponding temporary pile*

*profiles for driveability analysis will include the cut-off to more accurately model driving each add-on.*

- Eliminated limit of the number of computational pile model segments (previously 498) for potentially improved calculation accuracy of long piles.
- Expanded for unlimited lines of soil data input (previous limit 100) and unlimited number of soil segments.

## Input

- Extended and improved the input wizard to include all necessary input parameters, both for easier operation and reduced likelihood of erroneous data input;
- Added for the same data set multiple hammers inputs for both bearing graph *and driveability analyses; in this way driveability analyses (impact hammers only at this time) can simulate the situation where first a smaller hammer is used and once driving gets harder driving is done with a more powerful unit.*
- Allows user to import hammer data to the list in the program from different files and locations. Users then can apply filters to the list to help selecting hammers from the list to be included in the analysis.
- Allows for input of individual hammer driving systems for multiple hammer analysis.
- Added "Quick Review" feature to display analysis result summary during input generation.
- Simplified 2-toe and 2-pile input.
- Organized seldom used parameters such as hammer and pile damping, coefficients of restitution and round-out parameters in ways which are easier to understand and find for the user.
- The graphic prestation has been improved such as:
  - On the main input graphics, double click on each graphic model component opens corresponding input window;
  - The soil description appears in the graphic display of the main screen if built-in Geotechnical Static Analysis Tools (not customized) have been used for soil resistance input.

## Program Flow

- For each individual driveability depth analysis, if anyone of the built-in Geotechnical Static Analysis Tools is used (not customized) then the soil resistance input is generated individually as if each analysis depth were the final installation depth. In this way methods that considered driven depth as a parameter for unit resistance calculation (this means however, that the display of unit resistance only pertains to the final driving depth – see also output) can be used more accurately.
- Streamlined the input-analysis-output process for user friendliness and faster program operation.
- Completely revised program flow allowing for removal of temporary files for data transfer from input to analysis and output components.
- Reorganized for immediate analysis and output upon input.
- Removed limit (previously 100) on analysis depth values for expanded driveability analysis capabilities.

- Increased the default minimum analysis time for each individual analysis from 50 to 100 ms to avoid potentially not including late record stress extrema (particularly tension stress for low resistances).
- Improved analysis time increment check routine to compare mass against the stiffness both above and below each individual segment of the hammer-driving system –pile model. Since this check also consider soil resistance, the time increment used in the analysis may be different for different resistance distributions.

## Output

- Integrated the output program component with the input and analysis segments for increased speed and reduced potential for system related malfunctions.
- Enabled data sharing (copy/paste) with other applications such as Excel for all output features;
- Expanded standard report styles to cover most result combinations.
- *Provided for user created report styles including graphical and numerical contents.*
- Integrated Variables vs Time into summary output showing three graphs simultaneously with each graph allowing for individual customizing.
- Added a shaft resistance distribution graph (SRD) showing both LTSR and SRD unit shaft resistance.
- *Added for friction fatigue unit shaft resistance distributions a graph (FF) for all analyzed analysis depths.*
- Improved user friendliness and reliability of printing of reports or saving to PDFfiles.

## Features only available in the Offshore Version:

- Soil **Friction Fatigue** resistance distribution calculation is based on the assumption that the shaft resistance near the pile does not immediately lose resistance while the resistance some distance above the toe reaches fully reduced values. There are two available options as follows:
    - **GRLWEAP Friction Fatigue** method
    - Alm and Hamre (**A&H**) Friction Fatigue Method
- Additional Geotechnical Static Analysis Tools:
    - **API2** method is based on API 2007 specifications with added extra features to make the use easy.
    - Alm and Hamre (**A&H**) Method used to compute the initial resistance values as soil resistance distribution which require CPT data.
- **Multiple Pile Add-ons** input provided by **Pile Builder** is similar to Pipe Pile Builder in the previous version. It allows for a consideration of the cut-off and stabbing guide. In this case, the graphical representation of the model shows the stabbing guides instead of the solid area plot features (multiple add-on) and the temporary lengths and corresponding temporary pile profiles for driveability analysis will include the cut-off to more accurately model driving each add-on.
- **Multiple impact hammer** input and sequential analysis for a driveability analysis.
- Allow users to create **report styles** including graphical and numerical contents.
- Added for friction fatigue unit shaft resistance distributions a graph (FF) for all analyzed analysis depths.
- **Alternate hammer location** at any point along the pile. The related inputs are hammer location, hammer cushion stiffness and helmet stiffness.

- **Static bending analysis** for inclined pile driving; related additional input included: center of hammer gravity, hammer total weight, jacket height and water depth; the latter two inputs are also shown on the model plot. The output replaces the tension stresses with the combined static bending and dynamic compression stresses.
- **Tables for pile material Fatigue Analysis** are now an output based on a so-called single blow approach. The tables include for each segment maximum compressive and tensile stresses multiplied with the number of their occurrences (from average blow count).
- Consideration of the **Soil Plug Weight** in the static equilibrium analysis which considers the help that the soil weight can add to pile driveability.