VDisp – Soil Settlement Analysis Software

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Introduction

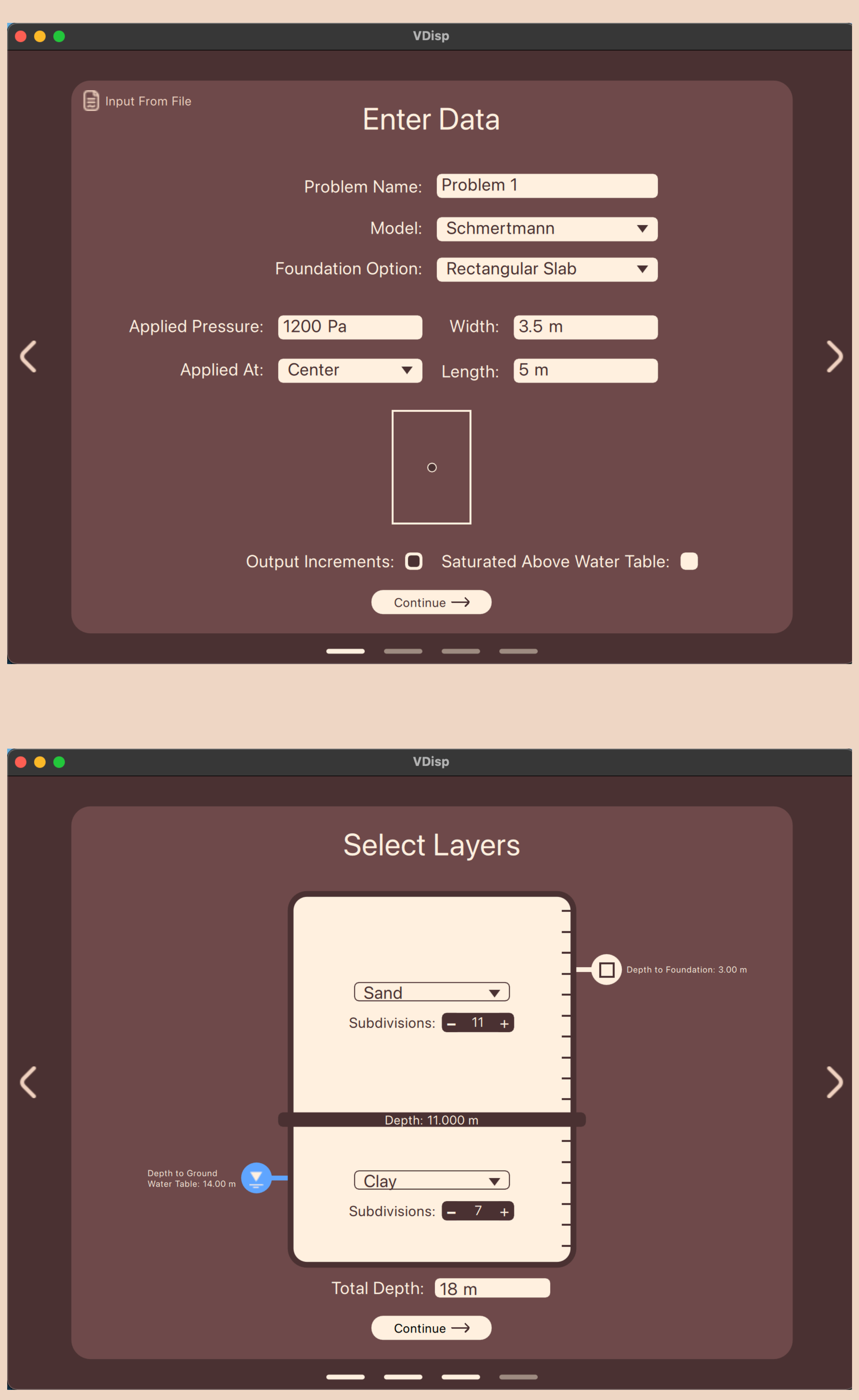
- **VDisp** is an open-source software that performs one-dimensional soil settlement analysis.
- It is based on a legacy FORTRAN software called "**VDispl**". This software comes from the 1994 publication "Settlement Analysis".
- Both **VDisp** and **VDispl** are abbreviations for **Vertical Displacement**.
- **VDisp** was developed using the Julia programming language and Qt/QML for the UI.
- **VDisp** is aimed to be a tool to aid undergraduate Civil Engineering students in their studies of Geotechnical Engineering by allowing them to quickly see the effects of different inputs on the outcome and aiding their understanding of the output through visualizations.

What is Geotechnical Engineering

- Geotechnical Engineering is the study of soil behavior under load force or soil-water interactions.
- Soil settlement analysis is a set of complex calculations performed by experienced Geotechnical Engineers.

How to Use VDisp

- **VDisp** was designed to provide a simple UI for users to input values into, while also having its own input file format allowing more experienced users to quickly enter many values.
- The input consists of 4 stages in which the user specifies the foundation data, material properties, layer sizes, and model calculation-specific data respectively.



*Different Input Stages of **VDisp***

Calculations

- The first step in all **VDisp** calculations is calculating the **effective stress**, **σ**', of each layer using the following formulas:

$$\sigma = \sigma' + u_w$$
$$\sigma = \gamma_{sat} z$$
$$u_w = \gamma_w z$$

- The next step in all **VDisp** calculations is calculating the added stress from the foundation, **σ**, of each layer using the following formula called the **Boussinesq Equation**:

$$\sigma = \frac{q}{2\pi}\left(\tan^{-1}\left(\frac{ab}{zC}\right) + \frac{abz}{C}\left(\frac{1}{A^2} + \frac{1}{B^2}\right)\right)$$
$$A^2 = a^2 + z^2$$
$$B^2 = b^2 + z^2$$
$$C = \sqrt{a^2 + b^2 + z^2}$$

- Next, if user selects Consolidation/Swell method, the following calculations are made for each layer, j, which are used to determine total consolidation, ρ_c:

$$\Delta e_j = C_c \log_{10}\frac{\sigma'_{fj}}{\sigma'_{oj}}, \text{if } \sigma'_{fj} < \sigma'_{pj}$$

$$\Delta e_j = C_r \log_{10}\frac{\sigma'_{pj}}{\sigma'_{oj}} + C_c \log_{10}\frac{\sigma'_{fj}}{\sigma'_{pj}}, \text{if } \sigma'_{fj} \geq \sigma'_{pj}$$

$$\rho_{cj} = \frac{\Delta e_j}{1 + e_{oj}} H_j$$

$$\rho_c = \sum_{j=1}^{n} \rho_{cj}$$

- Else, if user selects the Schmertmann (or Schmertmann Elastic) method, the following calculations are made for each layer, j, which are used to determine the total settlement, ρ:

$$E_{si} = \begin{cases} 2.5 q_{ci} \text{ if rectangular footing} \\ 3.5 q_{ci} \text{ if long strip footing} \end{cases}$$

$$I_{zp} = 0.5 + 0.1\sqrt{\frac{\Delta p}{\sigma'_{izp}}}$$

$$I_{iz} = \begin{cases} 0, \text{if } z > 2w \\ \frac{4}{3} I_{zp} - \frac{I_{zp} z}{1.5w}, \text{if } z > 0.5w \\ 0.1 + \frac{(I_{zp} - 0.1)z}{0.5w} \end{cases}$$

$$C_1 = 1 - \frac{0.5\sigma'_{od}}{\Delta p}$$

$$C_t = 1 + 0.2\log_{10}\frac{t}{0.1}$$

$$\rho = C_1 C_t \Delta p \Delta z \sum_{i=1}^{n} \frac{I_{iz}}{E_{si}}$$

- The Boussinesq equation shown is the Boussinesq equation for the stress at a point under a *corner* of a rectangular load. The **2:1 Method** is used if calculations must be made at a point under the *center* of a rectangular load.
- E_{si} calculations are not made in *Schmertmann Elastic* mode since elastic moduli are already given as input.

Output

- **VDisp** outputs the results of the calculations via tables and graphs within the GUI interface while also allowing users to save the data to a file for future reference.
- The tables show *incremental* values for settlement (Schmertmann) or heave (Consolidation/Swell)
- The graphs, as per the convention, show *cumulative* values for settlement (Schmertmann) or heave (Consolidation/Swell).
- The depth values (y-axis) are shown inverted in order to depict the layers as they would appear in the ground. This is also a conventional approach to graphing these outputs.

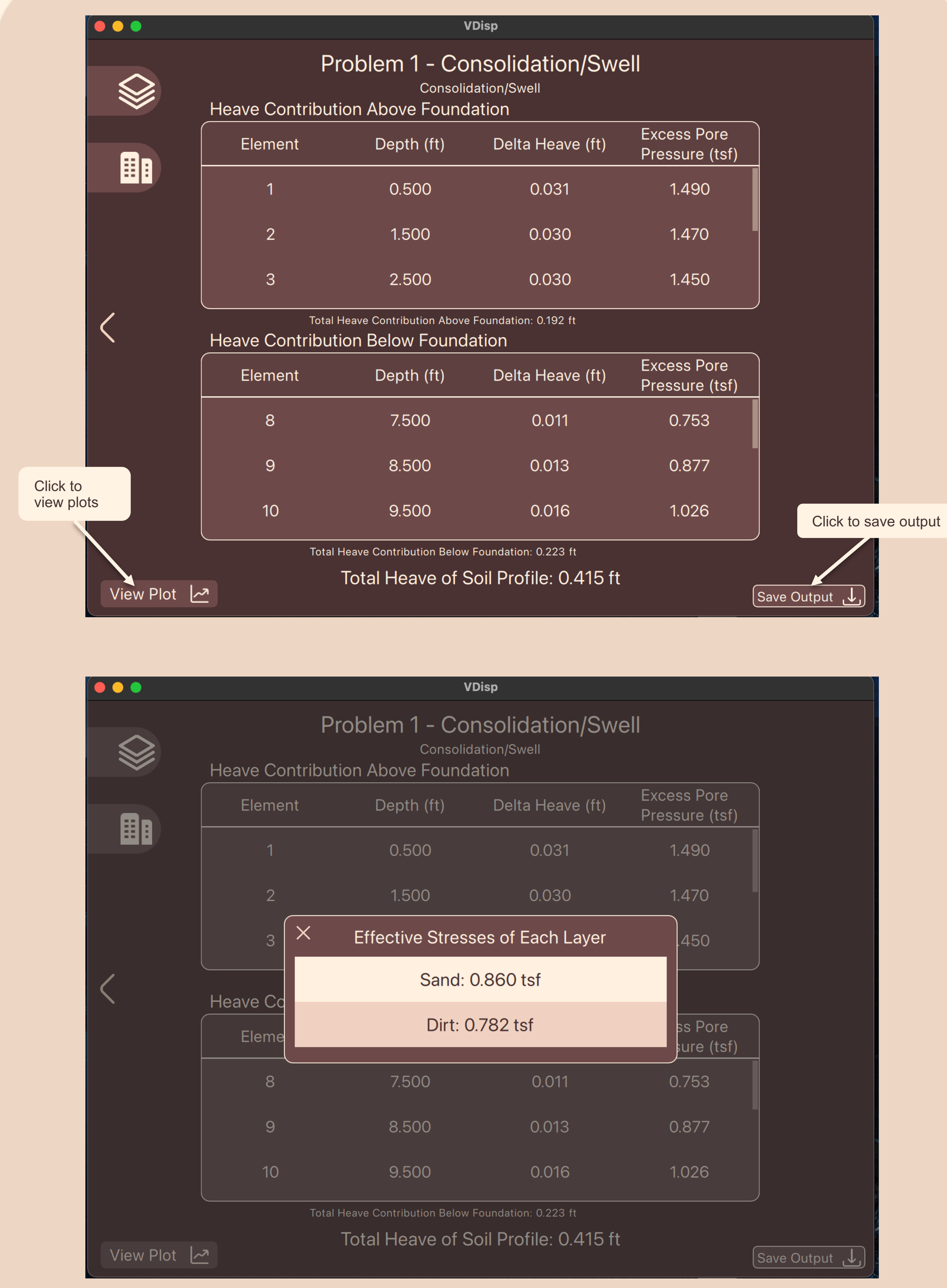
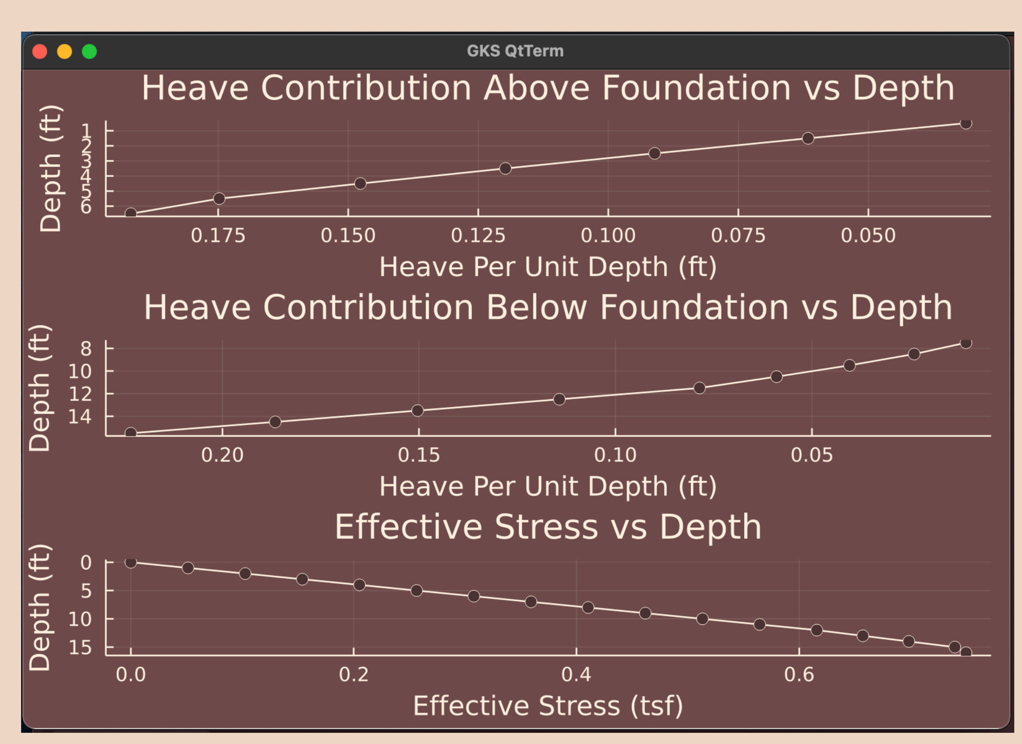


*Table outputs of **VDisp***



*Graph output of **VDisp***

References

- "Settlement Analysis," 30-Sep-1990. [Online]. Available: https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-1-1904.pdf. [Accessed: 07-Aug-2022].
- "Geotechnical Engineering," Wikipedia, 05-Aug-2022. [Online]. Available: https://en.wikipedia.org/wiki/Geotechnical_engineering. [Accessed: 07-Aug-2022].

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