



Lessons from the Slide Rule and the Design of *Settle*^{3D}

"Our object in developing the HP-35 was to give you a high precision portable electronic slide rule. We thought you'd like to have something only fictional heroes like James Bond, Walter Mitty or Dick Tracy are supposed to own." 1972 "HP-35 User Manual"

Few symbols of engineering evoke nostalgia and memories as powerful and vivid as the venerable slide rule. The slide rule was an indispensable tool in the universe of scientific and engineering computations for over three hundred years. For modern engineering graduates though, it is at best a curiosity of a previous age, a peculiar device that belongs in museums. No need to blame them. After all, computers and electronic calculators have deposited the slide rule.

The slide rule, a quite simple mechanical device, however offers important lessons that are as relevant today as they were in the 1600s. To more fully harness the power of today's computing resources, we applied these lessons in our development of our latest software, *Settle*^{3D}, for geotechnical settlement analysis. In this article, we explore these lessons and show how they relate to the solution of settlement problems. But first a little bit of history.

A Short History of the Slide Rule

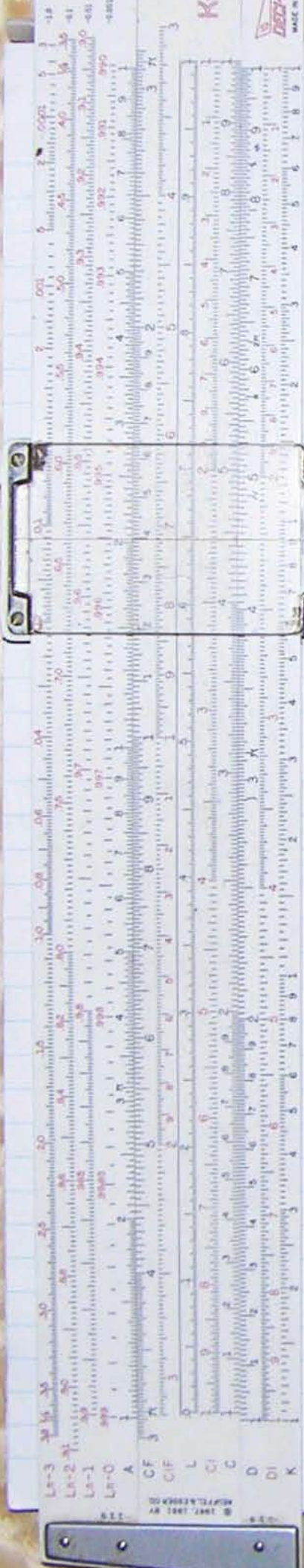
The history of the slide rule begins with the publication of logarithmic tables by John Napier in 1614. These tables liberated astronomers and mathematicians from tedious calculations, allowing them to focus more on analyzing problems. As scholars used these tables, some realized that logarithms could form the basis of mechanical devices for performing automatic calculations.

William Oughtred was an English mathematician who was also an ordained

minister. In his spare time, he worked on developing an automatic mechanical calculating device based on Napier's logarithm ideas. In 1621 he introduced the slide rule to the world. He had managed to perfect this device. With the slide rule users could perform arithmetic and many other types of calculations, with the exception of addition and subtraction. Over the years, specialized versions were created for mechanics, navigation, reinforced concrete, chemistry and other scientific and engineering fields.

In the pre-computer era the slide rule reigned supreme in engineering, mathematics and science. Engineers and scientists used all of its 10 inches (the most popular size) to design electronic devices, awe-inspiring buildings and bridges, automobiles and aircrafts, and space rockets. Undoubtedly, it played a key role in achieving one of mankind's most outstanding accomplishments – placing a man on the moon.

Experts associate the falling of the slide rule into obsolescence to the creation of Hewlett-Packard's HP-35 calculator in 1972. In the book by G. Harry Stine entitled "The Untold Story of the Computer Revolution - Bits, Bytes, Bauds, and Brains," the HP-32 is described as "the one single product that forever changed the whole image of the computer industry." Once the affordable electronic calculator was born, engineers, scientists, other professionals and students quickly drifted to the new, much more powerful technology. It did not take too long for the slide rule to slide (pun intended) into oblivion.



Three Fundamental Advantages of Slide Rule Use

The beauty and power of the slide rule lay in its simplicity and ease of use. It was relatively fast (in its time), compact, affordable, and yet able to compute a wide variety of complex mathematical operations.

Secondly, the slide rule had great educational qualities and was enjoyable to use. It helped users to think but without requiring them to focus too much on the details of mathematical operations.

Thirdly, the slide rule was perfect for solving problems for which reasonable answers were good enough, i.e. for problems which did not require too much precision (the slide rule could give answers to the third significant digit). Typically, problems that fall into this class are not completely described by existing scientific and mathematical laws. Calculations for these cases always produce answers that are not quite correct. Since the answers differ from reality by some margin, what then is the point in pursuing many significant digits?

This latter attribute of the slide rule helped engineers to minimize the allure of "false precision." False precision arises in situations where numerical results are presented such that they suggest better precision than there actually is.

Lessons for Settlement Software Development


In creating our new settlement analysis program, *Settle^{3D}*, we decided to incorporate the timeless advantages described above. First, we would give geotechnical engineers a simple, affordable, yet versatile, tool that would help them think

their way through the different aspects of settlement behaviour of geotechnical structures and the factors that affect behaviour. We also strived to make the tool enjoyable to use.

Rocscience attained the first goal by building the program upon the simple, time-tested, settlement calculation approaches widely familiar to geotechnical engineers. Next, great care was taken in designing the interface to ensure that the software was very easy to use. The most commonly-used functions and operations are readily visible on the interface in the form of menu options and toolbar icons. Icons and buttons were chosen to convey correct messages as to their use. They are also organized in ways that are natural to the processes and logic of settlement analysis.

Significant effort went into making sure that computational algorithms in *Settle^{3D}* were optimized for speed. As well it was ensured that the effects of actions taken by users were readily visible. This valuable feedback (interactivity) helps users to quickly establish whether or not actions they have taken are appropriate. The program is also priced to make it accessible to most firms.

The careful design of *Settle^{3D}*'s interface goes a long way to help engineers enjoy use of the software. The intuitive layout naturally speaks on how things must be done in the program. As a result, users do not have to wonder whether they will remember how to use the software when they need it, even after long periods of not modelling with *Settle^{3D}*.



Geotechnical engineers, more than any other engineering specialists, work with very limited data on materials that have complicated behaviours, and can have highly variable properties over short distances. We are required to make important decisions and develop designs with relatively low factors of safety, based on this limited information. As such, we rely on simplified approaches and approximations that allow us to enhance our engineering judgment.

Rarely do settlement values calculated by geotechnical engineers agree with

actual measurements by error margins of $\pm 25\%$ or less. The reasons for this are many, but we shall discuss one. In addition to dealing with materials that exhibit wide ranging behaviours, geotechnical engineers are forced to extrapolate field properties and behaviour from simplified and imprecise tests on small samples, or on correlations to index properties. We therefore cannot expect our calculation results to be more precise than our input data. To help engineers avoid the fallacy of false precision, *Settle^{3D}* by default reports settlements only to the nearest millimetre.

Important Ways of Aiding Settlement Analysis

Settle^{3D} does not harbour lofty dreams of being held in the same esteem as the venerable slide rule. It only seeks to build upon the timeless benefits offered by the slide rule, the most fundamental of which is "a simple, yet versatile, computational tool for tackling wide-ranging challenging problems."

Incorporation of the three important lessons from slide rule usage into the development of *Settle^{3D}* will help the program to be as useful to settlement analysis as the slide rule was to engineering in general. It is our belief this new software tool will aid engineering design and analysis of settlement in several important ways. *Settle^{3D}* will help users to:

- ◆ Organize their thoughts regarding available data and their interrelationships
- ◆ Test different concepts and ideas for their reasonableness and impact on settlements
- ◆ Formulate design alternatives and assess whether they meet set goals and constraints
- ◆ Raise appropriate questions, identify inconsistencies and gaps in information and design alternatives
- ◆ Construct arguments to support design choices and conclusions, and
- ◆ Present results in ways that can be easily understood by clients and other interested parties.

We hope that *Settle^{3D}* will foster the kind of creative genius and innovative thinking that the slide rule stimulated in generations of engineers.

Notes:

For those who care, there is an international society, the Oughtred Society, which states its raison d'être as dedication to the history and collection of slide rules and other calculating instruments.

Specifications and capabilities of *Settle^{3D}* can be found at the following links:

[Settle^{3D} Coming Soon](#) (from RocNews Spring 2007)

[Settle^{3D} Product Sheet](#)