

# Phase<sup>2</sup> v.6.01: Why An Update?



Did you know that Cam Clay is not a type of clay, but rather a theoretical soil model named after River Cam, which flows through Cambridge University in England?

Modifications to the input dialog and computational engine for the Cam Clay and Modified Cam Clay material models are some of the additions to the Phase<sup>2</sup> 6.01 update.

# Phase<sup>2</sup> Version 6.01: Why An Update?

*Rocscience aspires to become the globe's leading provider of geotechnical software solutions. And the company has decided the best way to accomplish this end is to place the interests of our customers first.*

This means providing top quality software that allows users to solve real-world problems. This means providing customers with exceptional service that ensures every dollar spent on our software is money well spent. Our free software updates are fundamental to this pursuit of excellence. The recent update to *Phase<sup>2</sup>* version 6.0 highlights our commitments to you.

Typically the enhanced features implemented in our software updates require time resources that range from a few days to a few weeks. Most of these improvements are new capabilities that people are asking for. On rare occasions updates are dictated by the correction of software bugs. We do everything possible to ensure every feature works as

intended. We plan carefully early in the development cycle. We pay great attention to programming details, testing extensively. Despite all these efforts, however, errors do happen. In such cases, we ensure customers receive what they paid for by fixing any bugs and quickly offer the improved solutions as free updates.

Although the enhancements in software updates tend to be relatively easy to implement, make no mistake about them: they offer valuable new capabilities. This point is well illustrated in the latest update to *Phase<sup>2</sup>* version 6, which we will describe next.

---

*"To desire is to obtain; to aspire is to achieve."*

— by James Allen

## Modified Cam Clay / Cam Clay Material Model

### Update 6.01 to *Phase<sup>2</sup>*

The improvements in the newest update to *Phase<sup>2</sup>* can be classified under four areas. In no particular order they are:

1. Modifications to the input dialog and computational engine for the Cam Clay and Modified Cam Clay material models
2. New Project Setting features for Shear Strength Reduction (SSR) analysis that simplify analysis for the novice but offer greater flexibility to the experienced
3. Innovative pressurized joint functionality, which allows for more realistic modelling of water pressures on tunnel linings in soil and weak rock, and
4. More realistic, automatic means for assigning tractions to liners and structural interfaces.

The Cam Clay and Modified Cam Clay constitutive relationships are among the earliest critical state models for realistically describing the behaviour of soft soils. As a result, they constitute the most widely applied stress-strain relationships in the non-linear finite element modelling of practical geotechnical problems.

Based on a client's question on the specification of input properties for these materials, Rocscience modified the input data dialogs for the materials. The new dialogs better capture the alternative ways in which geotechnical engineers specify properties for critical state models.

The new *Phase<sup>2</sup>* update offers users the flexibility to specify initial stress conditions for a Cam Clay and Modified Cam Clay material either through a preconsolidation pressure or through an overconsolidation ratio. Users can also choose to enter either the specific volume of the normal compression line at unit pressure,  $N$ , or the specific volume of the Critical State

---

*Rocscience  
modified the  
input data  
dialogs for the  
materials based  
on a client's  
question.*

Line at unit pressure,  $\Gamma$ , for these materials. The ability to choose between these alternatives makes life easier for soft soil engineers.

The Cam Clay and Modified Cam Clay formulations require designation of either a constant shear modulus or a constant Poisson's ratio for a material, but not both. The new dialog in the latest *Phase<sup>2</sup>* update eliminates any confusion regarding specification of either of these elastic parameters.

Lastly, the update implements a more robust and efficient approach for integrating these constitutive models over finite strain increments. It also comes with a verification example that demonstrates the correctness of the Modified Cam Clay algorithm in *Phase<sup>2</sup>* through comparisons with closed-form solutions.

## Project Settings for SSR Analysis

SSR analysis of slopes has become a hit with *Phase<sup>2</sup>* users. It has been adopted into geotechnical practice at a much faster pace than any one anticipated. To make it even easier and faster for

users to obtain factor of safety results, Rocscience software developers enhanced the Project Settings dialog for such analyses.

In the new update, the default settings for SSR analysis include an option to automatically select a convergence criterion, tolerance value, and maximum number of iterations appropriate to a slope model. A study by Rocscience engineering staff determined that an energy stopping criterion, which sums the squares of energies calculated at element nodes, worked better over a wide range of slope problems.

### *A Comparison of Finite Element Slope Stability Analysis with Conventional Limit-Equilibrium Investigation*

The study also revealed that different convergence parameters were required for the analysis of unsupported and supported slopes.

With the automatic option checked in the Project Settings dialog, the *Phase<sup>2</sup>* update automatically selects convergence parameters well suited to the model. Since the nature of finite element analysis is such

---

*Making life easier for soft soil engineers.*

that automatically selected convergence parameters do not always produce the best answers under all modelling conditions, the update allows users to easily change these parameters or experiment with them.

Update 6.01 of *Phase<sup>2</sup>* can also speed up factor of safety calculations without sacrificing accuracy. It achieves this by reducing the number of iterations once *Phase<sup>2</sup>* determines that the solution for a model is not converging during a load step. In non-linear finite element analysis loads are applied in steps. If during a load step the solution error does not fall below the specified tolerance level within the maximum number of iterations, *Phase<sup>2</sup>* automatically halves the maximum number of iterations for subsequent load steps.

Since SSR analysis determines factor of safety based on the onset of solution non-convergence, this acceleration procedure does not impact accuracy at all. Its only drawback is that, on the SSR convergence plot, it visually diminishes the transition from stable solutions to unstable results.

## Realistic Specification of Water Pressures Acting on Tunnel Liner in Soil

The effects of water pressures acting on tunnel linings can be accounted for in *Phase<sup>2</sup>* through use of structural interface or composite liner elements. Each of these element types comprises a set of adjacent joints and beams. Water pressures are modelled by specifying internal pressures in the joints. Prior to this update, the internal pressure in a joint was applied to the elements (these could be solid elements representing soil or rock or beam elements representing liners) on either side of the joint.

A few users rightly drew Rocscience's attention to the fact that although the assumption was reasonable for the linings of tunnels in rock masses, it was unrepresentative of behaviour in soil. In soils (which are porous media), the influence of water pressures is already accounted for through the principle of effective stress. As such it should not be reapplied to soil as tractions.

---

*Speed up factor of safety calculations without sacrificing accuracy.*

Consequently, in the new update to *Phase<sup>2</sup>*, Rocscience programmers implemented an option to apply joint water pressures only to an adjacent liner and not to surrounding soil material.

## Application of Traction to Liners

Whenever tractions are specified to act on liner or structural interface elements, the latest *Phase<sup>2</sup>* update applies the loads directly to these elements. Previously such tractions were applied to the solid elements immediately adjacent to liners or structural elements, which in some cases led to behaviour inconsistent with real-world observations.

## Concluding Remarks

One of the greatest benefits of software to users is the level of professional support that comes with a purchase. Quality technical support and software updates generate large cost and time savings to customers, and enhance user experience and confidence. We recognize this and therefore measure our success and progress from the perspective of value for the

customer, each customer. We take great pride in providing tools that satisfy their needs, and updates are one among the best vehicles to deliver value to them.

*Phase<sup>2</sup>* 6.01 is a timely response to client needs. And there are other examples. When users of Dips requested for a time-saving feature, which would allow dxf files to be imported, Rocscience obliged with an update. When slope stability engineers requested for a B-bar option that would allow them to account for short-term (transient) changes in pore pressure due to rapidly applied loads, or to simulate the effects of rapid drawdown on stability we responded with a *Slide* update.

We consider each user an invaluable partner in the pursuit of engineering software excellence. Since we have innovative partners who are never going to run out of new ideas, we will continue to release software updates that reflect your feedback.