

# Alive Engineering Education

Transforming and Innovating  
Engineering Education

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CHAPTER 46 

**Regression Analysis Applied to  
Soil Mechanics**

Everaldo Bonaldo<sup>\*</sup>, Fernando Júnior Resende Mascarenhas<sup>♦</sup>, Leopoldo  
Grajeda<sup>^</sup> and Juliana Torres de Oliveira Bonaldo<sup>▼</sup>

<sup>\*</sup>Pontífica Universidade Católica de Minas Gerais, Belo Horizonte, Brazil

E-mail: bonaldo@pucminas@hotmail.com

<sup>♦</sup>Pontífica Universidade Católica de Minas Gerais, Belo Horizonte, Brazil

E-mail: fer.jr.resende@hotmail.com

<sup>^</sup>Pontífica Universidade Católica de Minas Gerais, Belo Horizonte, Brazil

E-mail: leopoldo@grajeda.com.br

† Pontífica Universidade Católica de Minas Gerais, Belo Horizonte, Brazil

E-mail: jultoli@gmail.com.br

**Abstract:** The present dissertation aims to demonstrate the results from the scientific initiation project that proposes the use of MS-Excel to determine the coefficients of the soil shear equation: cohesion and the angle of internal friction. This project has two main objectives. First, the development of a computational analytical method with the use of computational techniques of regression analysis in MS-Excel to determine the equation of shear strength. Second, this project was attended by four students from the second term (first year) of Civil Engineering of PUC Minas, in Brazil, under the supervision of a student of the last year and three professors of PUC Minas. These four students only had previous knowledge of the basic disciplines, without knowledge about Mechanic of Materials and Soil Mechanics, which are primordial for the project's development. The interdisciplinary that has occurred between the disciplines of Soil Mechanics, Laboratory and Field Tests, Mechanic of Materials, Calculus, Analytical Geometry and Linear Algebra was detected with the accomplishment of this work. It was observed that the values obtained using MS-Excel are reliable, and using MS-Excel solved the difficulties of precision found in the determination of the cohesion and the angle of internal friction.

Hence, it is possible to conclude that the automation of the procedure behaved in a very effective way, and it can be clearly applied and used by students and professors. In addition, such computational analytical method proved to be viable and indicated option to gain time savings and optimization of works, since the program proved to be highly efficient and reliable in obtaining the shear equation, meeting the expectations and the objectives established by the project.

**Keywords:** Computational Tool, Equation of Shear Strength, Excel, Linear Regression, Soil Mechanics.

## 46.1 Background

The breakdown of soils is an important matter concerned with soil mechanics, with an emphasis on Geotechnical Engineering. The soil rupture occurs by shearing, since the soil has very low tensile strength and high compressive strength<sup>1</sup>. Thus, “when it refers to soil resistance, it is implicitly its shear strength”<sup>1</sup>.

The determination of the shear boundary strength of soils has a direct impact on several real Engineering problems, such as: “the shear strength of soils is a fundamental issue in the problem involving limit equilibrium

analysis such as the load bearing of foundations, stability of slopes, dams and embankments, and buoyancy of earth in containment structures”<sup>2</sup>.

Based on this, using the knowledge of Soil Mechanics, Laboratory and Field Tests, Mechanic of Materials, Calculus, Analytical Geometry and Linear Algebra and Programming, this project aims to develop a computational analytical method with the computational implementation of regression analysis techniques in MS -Excel to determine the shear strength equation that can be used by both students and teachers. Moreover, it proposes to create interdisciplinary ties, arousing in the participating students the interest in subjects that they will still study, as well as they arouse the taste for participating in scientific initiation projects.

## 46.2 Purpose/Hypothesis

In classrooms, in the subjects of Laboratory and Field Tests, Soil Mechanics and Foundations, the graphical determination of shear strength of soil is made using the Mohr-Coulomb Circles, and the rupture envelopes are made using graph paper, ruler, square and compass. Such methodology used in the teaching-learning process has its limitations and problems at the time of execution. As an example, the professor, when presenting the graphic solution, finds difficulty “when there is a need to re-present some design steps for a

differentiated approach for some students”<sup>2</sup>.

In addition, students should be very precise when designing Mohr’s envelopes, since this practice in classrooms has shown that if the drawing is done in a not appropriate way, no matter how small the error, it generates large changes in the parameters extracted from it. Therefore, the use of computational resources is of great value in determining the Mohr-Coulomb envelope and the shear strength equation. According to Ventri and Neto, cited by Fakhey and Alves (2006), the Engineering student’s expectation when entering the course is “to find and utilize current and modern resources within the teaching-learning process, since these generations are accustomed to the use of Computing in all its day-to-day activities”<sup>3</sup>.

## 46.3 Design/Method

In order to determine the coefficients of the soil shear equation: cohesion and the angle of internal friction using MS-Excel, the participant students were headed by three professors and by one student as teacher assistant.

In order to reduce the errors mentioned in the previous session and to allow both students and teachers to have a new tool for determination of the shear breaking equation by the Mohr-Coulomb criterion, an Excel programming was developed that fulfills such Function. Basically, the user has to type the

maximum and minimum tensions of the analysed soils and click at the bottom “Iniciar”, as shown in Figure 46.1, and the MS-Excel will give the searched results.

|    | F           | G           | H           | I                                    | J                | K       |
|----|-------------|-------------|-------------|--------------------------------------|------------------|---------|
| 1  |             |             |             |                                      |                  |         |
| 2  |             |             |             | Somatório dos Quadrados da Distância | Ângulo de Atrito | Coesão  |
| 3  | 1.250028064 | 2.80645E-05 | 7.87614E-10 | 1.32614E-09                          | 0.35354694       | 0.53037 |
| 4  | 1.750019955 | 1.99551E-05 | 3.98207E-10 |                                      |                  |         |
| 5  | 2.250011846 | 1.18458E-05 | 1.40322E-10 |                                      |                  |         |
| 6  |             |             |             |                                      |                  |         |
| 7  |             |             |             |                                      |                  |         |
| 8  |             |             |             |                                      |                  |         |
| 9  |             |             |             |                                      |                  |         |
| 10 |             |             |             |                                      |                  |         |
| 11 |             |             |             |                                      |                  |         |
| 12 |             |             |             |                                      |                  |         |
| 13 |             |             |             |                                      |                  |         |
| 14 |             |             |             |                                      |                  |         |

Figure 46.1 – Obtaining the searched results.

## 46.4 Results

Demonstrating the efficiency of the proposed computational analytical method, a huge number of tests were done using known values and comparing the Excel results with those obtained through manually process. Thus, this carried out tests confirmed that the results given by MS-Excel are very precise.



Table 46.1 demonstrates one of those tests in which the results obtained manually by four students were compared with the one obtained using MS-Excel. The coefficients of the soil shear equation: cohesion and the angle of internal friction are shown.

Table 46.1 – Comparing results obtained manually and using MS-Excel.

| Method           | Cohesion | Angle of internal friction |
|------------------|----------|----------------------------|
| Student 01       | 0.52     | 19.80                      |
| Student 02       | 0.52     | 19.79                      |
| Student 03       | 0.59     | 10.75                      |
| Student 03       | 0.60     | 12.40                      |
| MS-Excel         | 0.53037  | 19.47                      |
| Reference Values | 0.53037  | 19.47                      |

## 46.5 Conclusions

With the accomplishment of this work, it is evident the interdisciplinary that occurred between the courses of Soil Mechanics, Laboratory and Field Tests, Mechanic of Materials, Calculus, Analytical Geometry and Linear Algebra for the participating students.

Hence, it is concluded that the automation of the procedure behaved in a very effective way, and can be clearly applied and used by students and teachers. In addition, the developed computational analytical method with

the use of computational techniques of regression analysis in MS-Excel proved to be viable and indicated option to obtain time savings and optimization of works, since the program proved to be highly efficient and reliable in obtaining the shear equation, meeting the expectations and the objectives established by the project.

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