Software for Containment Structures Solutions

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ABSTRACT
Much of what has been studied and is still being investigated around the world is motivated by the chance to reduce impacts caused by the effects of landslides, landslides and landslides when massive soil becomes unstable. The present work presents a software capable of assisting in the design of containment structures, where the main objective is to make the daily life of designers and students more agile and efficient, as regards the time spent in the calculation steps for the design and design. in the generation of boards with the necessary drawings for the execution of the generated solutions. For the development of the tool were considered the parameters of the deterministic method, the NBR 11682 - Slope Stability and the Brazilian Manual of Geosynthetics for the determination of safety coefficients for rigid and flexible solutions, respectively. The development of the tool has shown that besides being an excellent project aid option, it enables the development of important skills and competencies for civil engineers.

RESUMO
Muito do que já foi estudado e ainda é investigado, é motivado pela chance de reduzir os impactos causados pelos efeitos de deslizamentos, quando maciços de solo se tornam instáveis. O presente trabalho apresenta um software capaz de auxiliar no dimensionamento de estruturas de contenção, onde o principal objetivo é tornar mais ágil e eficiente, para projetistas e estudantes, o processo de cálculo para o dimensionamento e a geração de pranchas com os desenhos necessários para a execução das soluções geradas. Para o desenvolvimento da ferramenta foram considerados os parâmetros do método determinístico, a NBR 11682 – Estabilidade de Encostas e o Manual Brasileiro de Geossintéticos para a determinação dos coeficientes de segurança para as soluções rígidas e flexíveis, respectivamente. O desenvolvimento da ferramenta mostrou que além de ser uma excelente opção para auxílio em projetos, possibilita o aperfeiçoamento de habilidades e competências importantes para engenheiros civis.

1. INTRODUCTION

Slopes also known as hills, slopes or ramps can be classified as natural or artificial. Its most notable feature is the fact that they have sloping surfaces, forming an angle with the horizontal, containing soil and rock.

The slopes hide a great destructive power, due to the possibility of mass movement when they become unstable. The occurrence of mass movements is owing to some alteration (natural or anthropic) in one or more parameters that are associated with the stable behavior of the massif. The main parameters are slope, height, predominant soil type in the massif, presence of water and slope cover type.

A survey conducted by DNIT - National Department of Transport Infrastructure estimated that in 2007 approximately R $ 92.0 million were spent on slope recovery works, slope stabilization, erosion elimination. This amount corresponds to 33.5% of total spending on emergency works on federal highways (DNIT, 2009 apud MATTOS, 2009).

Stability analyzes should be done in risk areas to prevent disasters. For these analyzes deterministic or probabilistic methods may be employed. The first one is widely used, and the use of the parameters is fixed, even knowing that the parameters present considerable variability. Still on the deterministic method, it is based on a safety coefficient that is related to the level of safety against damage to human, material and environmental lives. The second one measures the inaccuracy due to the variability of the parameters of the massif, making it possible to obtain a reliability index and a probability of ruin. (APAZA; BARROS, 2014).

To ensure the stability of the massif, a computational tool has been developed to assist engineers and students in the design and presentation of structures capable of ensuring safety for human lives, as well as nearby material goods.

2. METHODOLOGY

The computational tool can scale and generate boards for rigid and flexible landfill solutions.

2.1 Rigid Structure Solution

The gravity wall was the solution adopted as a rigid structure; whose main feature is to combat the active buoyancy of the soil acting on the upstream face ("pushing" the wall) with its weight. The buoyancy theory adopted was that of Coulomb, proposed in 1776. The main point of the considered theory is the buoyancy acting only on the upstream face, that is, the weight of the structure receives no contribution from the vertical portion of the thrust (Rankine theory), and can be considered a sizing detail that is in favor of safety.

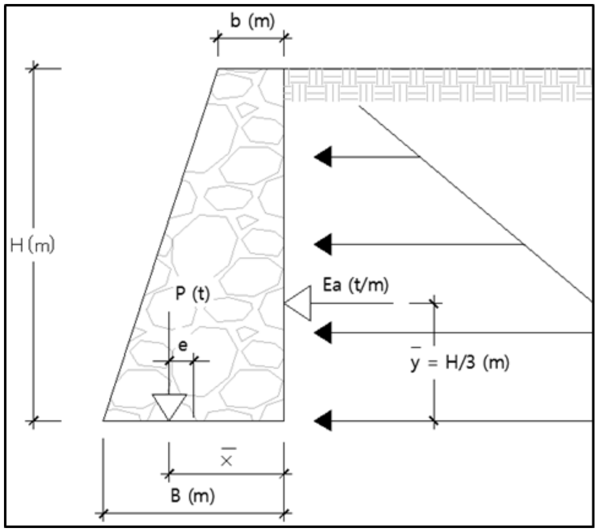

Figure 1. Gravity Wall and Efforts

The geotechnical parameters required for sizing are: Specific Weight of the Wall; cohesion; Angle of friction; Specific Soil Weight; Coefficient of friction; Height of the wall; Allowable Ground Tension.

The sizing of the structure is made to avoid dislocations, rotations and rupture of the foundation. Following are the coefficients adopted for each case: Safety coefficient against tipping (prevents tipping around the downstream base) = 2.0; Safety coefficient against base slip = 1.5.

In addition to the containment structure, a good drainage system is essential as it will reduce the active buoyancy caused by excess upstream water. The system should preferably consist of a draining mattress connected to geotextile-lined pipes (so that there is no upstream to downstream soil displacement). In addition, base and top channels prevent damage and extend frame life.

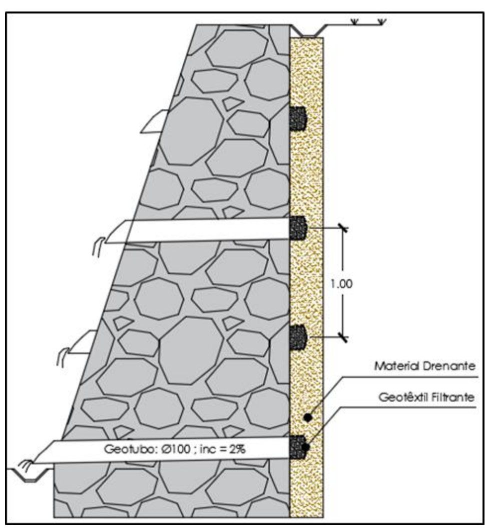

Figure 2. Gravity Wall Drainage Elements

2.2 Flexible Structure Solution

As a second solution option, the software features geosynthetics soil reinforcement sizing, according to the Brazilian Geosynthetics Manual.

Man has been seeking throughout history to improve soil performance by adding alternative materials. Some reports show that plants that had tough fibers were mixed with the soil to increase their strength and durability. In the present day the previously used vegetables have been replaced by industrialized materials called geosynthetics.

Around 1950, shortly after the end of World War II, the first geosynthetics appeared in the United States with application in hydraulic works, where their function was primarily erosion control. Over the next ten years other geosynthetics with separation and reinforcement functions emerged and were first used in Europe. According to Ehrlich and Becker (2009) in the 70s there were the first experiences with the application of geotextiles in slopes, but it was not until 1986 that the first rational project with the use of reinforced soil occurred. Since then there has been a growing investment and new products have been manufactured for numerous applications such as slopes containment and reinforcement, dams, paving, drainage, landfills and so on.

With the advancement of technology and the countless researches with the use of geosynthetics, it is possible to affirm that the insertion of geosynthetics in walls and slopes guarantees a better soil behavior, since they better distribute stresses and deformations, which may have higher heights, be more steep and often be built with poorer soils, ie soils that do not have good geotechnical parameters.

The necessary parameters for sizing geosynthetic reinforced soils suggested by the Brazilian Manual of Geosynthetics are as follows:

- Height of the wall;
- Face Tilt;
- Specific Landfill Weight;
- Design Friction Angle;
- Friction Angle Peak Reduction Factor;
- Safety Factor for Individual Mechanical Breakdown of Reinforcement Layers;
- Type of geosynthetic;
- Soil / Geosynthetic Interaction Coefficient;
- Geosynthetic resistance.

In addition to these input parameters, Jewell's Abacuses (1991) are required for the determination of reinforcement lengths (Lr). The three abacuses correspond to the coefficient of buoyancy, internal stability and slippage along the base.

As suggested for the gravity wall, this solution should also have an internally and superficially efficient drainage system in addition to the base and top guards.

3. APP IDENTITY

The Software was developed on a conventional computer running Microsoft's Windows 10 operating system, using the programming language on the Visual Studio Express 2013 platform, which is a tool that enables the development of software that can be used to solve everyday engineering problems, simply and allows the creation of a graphical user interface.

The tool was developed applying technical knowledge of programming and engineering through object-oriented language, which allows the use of code already created, reducing the number of lines and development time.

The name was adopted considering that the term "Geo" referring to the word geotechnics and that the application was developed in Visual Basic, hence the second term "Basic". Therefore, the software is called GeoBasic - Geotechnical Solutions, a name that is easy to remember and spread.

3.1 Calculation and data entry model

The software can be used for both gravity wall sizing and geosynthetic reinforced (geogrid). During the development we opted for simple calculation models, since this is an early version of the program.

For the design of the retaining wall, the calculation model employed is a non-sloping ground mass with no external loads acting on the embankment, as shown in the figure below.

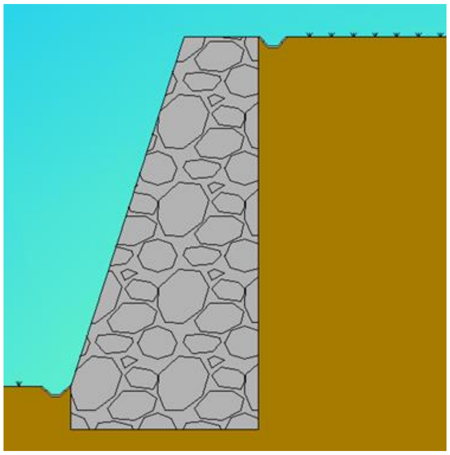
Figure 3. Gravity Wall Calculation Model

If the user chooses to design with an alternative material, he can use the second available option which consists of geosynthetic reinforced soil design (geogrids).

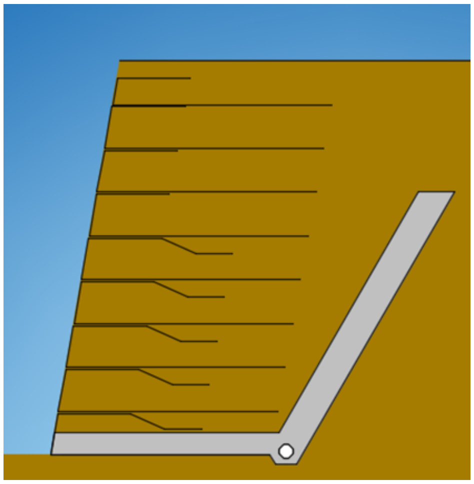
Figure 4. Reinforced Soil Calculation Model

In addition to helping to spread this new technology, the software in its upcoming updates may be cost-effective, as the external conditions for the problem are the same as those for the gravity wall.

The following figures show the graphical interface with the input data entered for the gravity wall and geosynthetic reinforcement cases. On the left is a field where input data will be entered and processed in the structure dimension. After sizing, the user is automatically presented with a scale scheme of the structure for greater interaction and clarity in receiving the results.

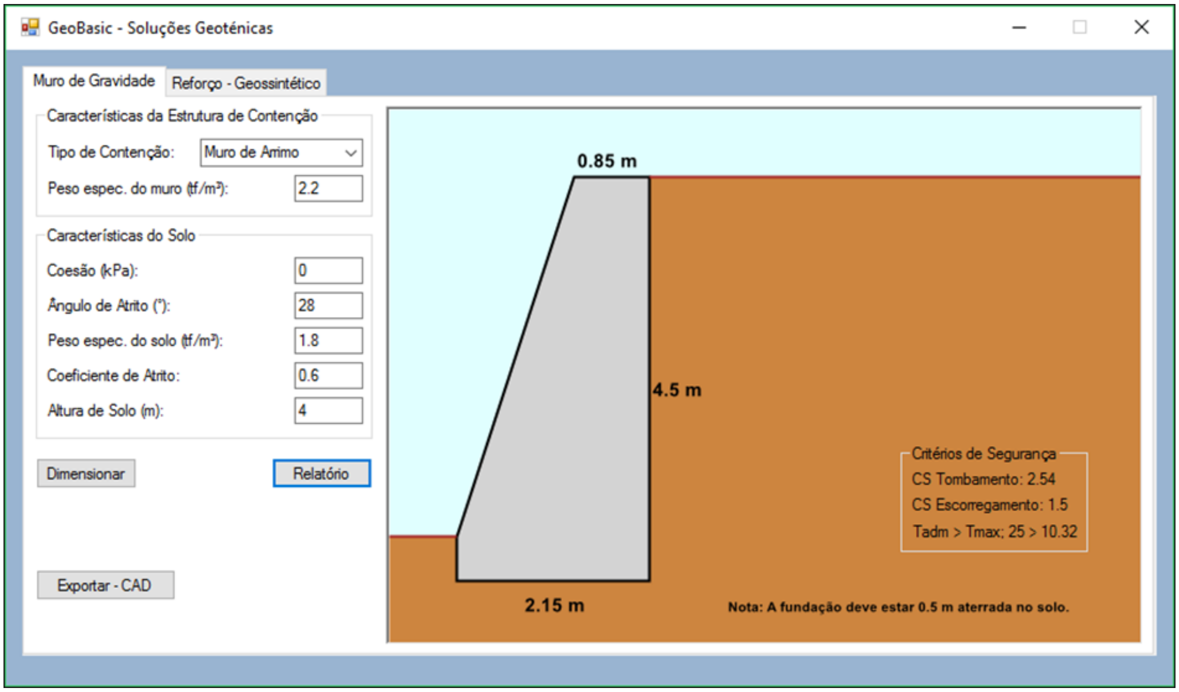

Figure 5. Graphical Interface (Input and Output) for Gravity Wall

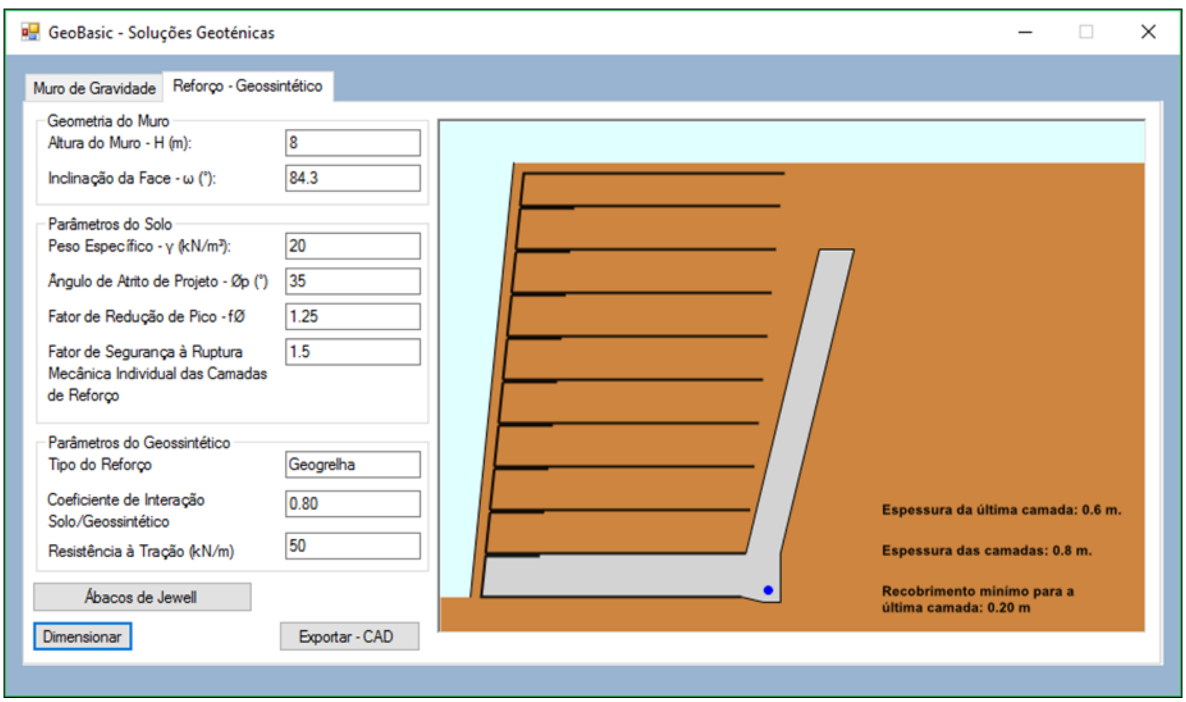

Figure 6. Graphical Interface (Input and Output) for Reinforced Soil

For both solutions the input is made simple and intuitive, adding the geotechnical parameters and data related to the slope geometry.

3.2 Flowchart and calculation routines

The following flowchart is a graphical representation of the logical steps taken to scale each solution selected by the user.

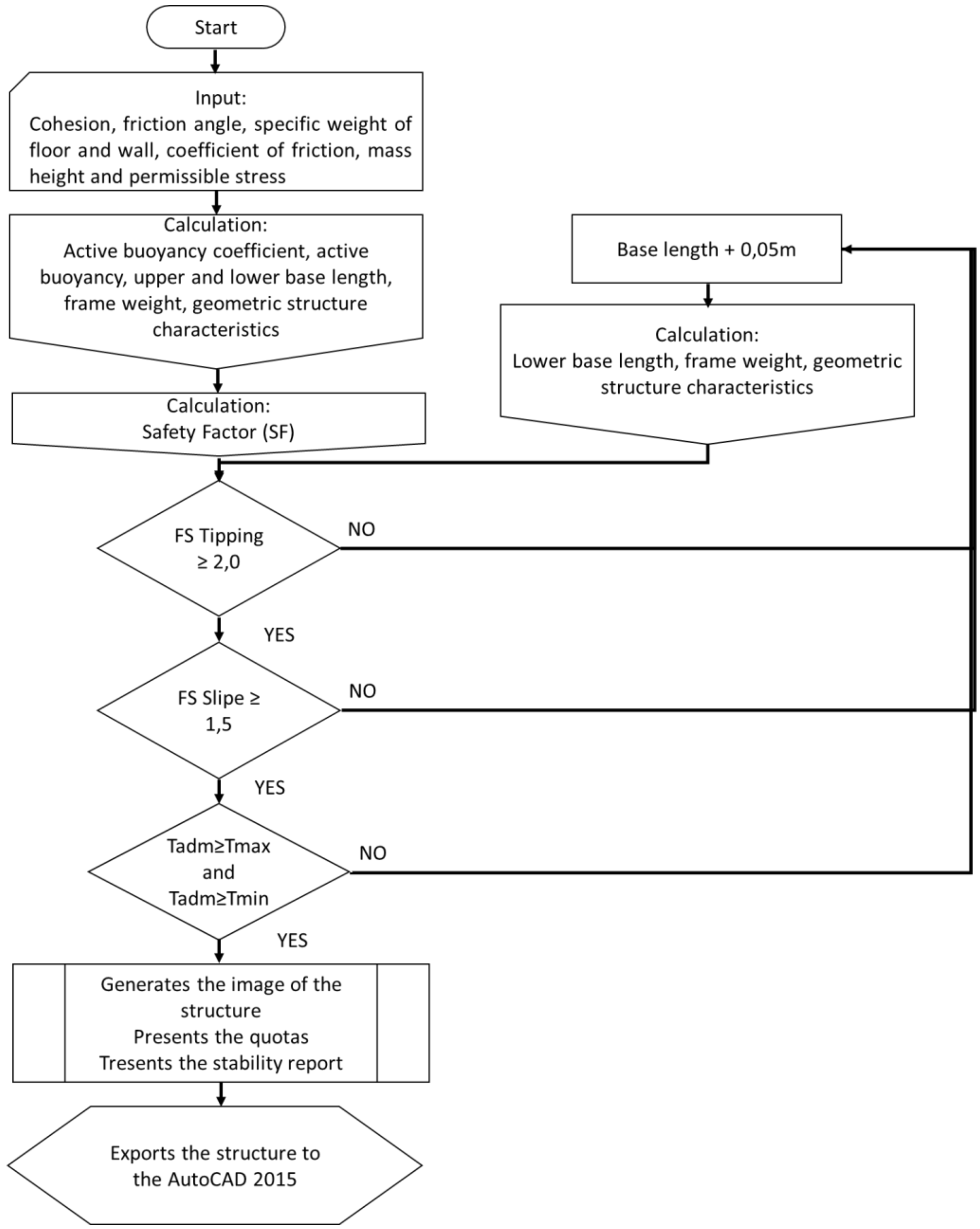

Figure 7. Flowchart - Gravity Wall

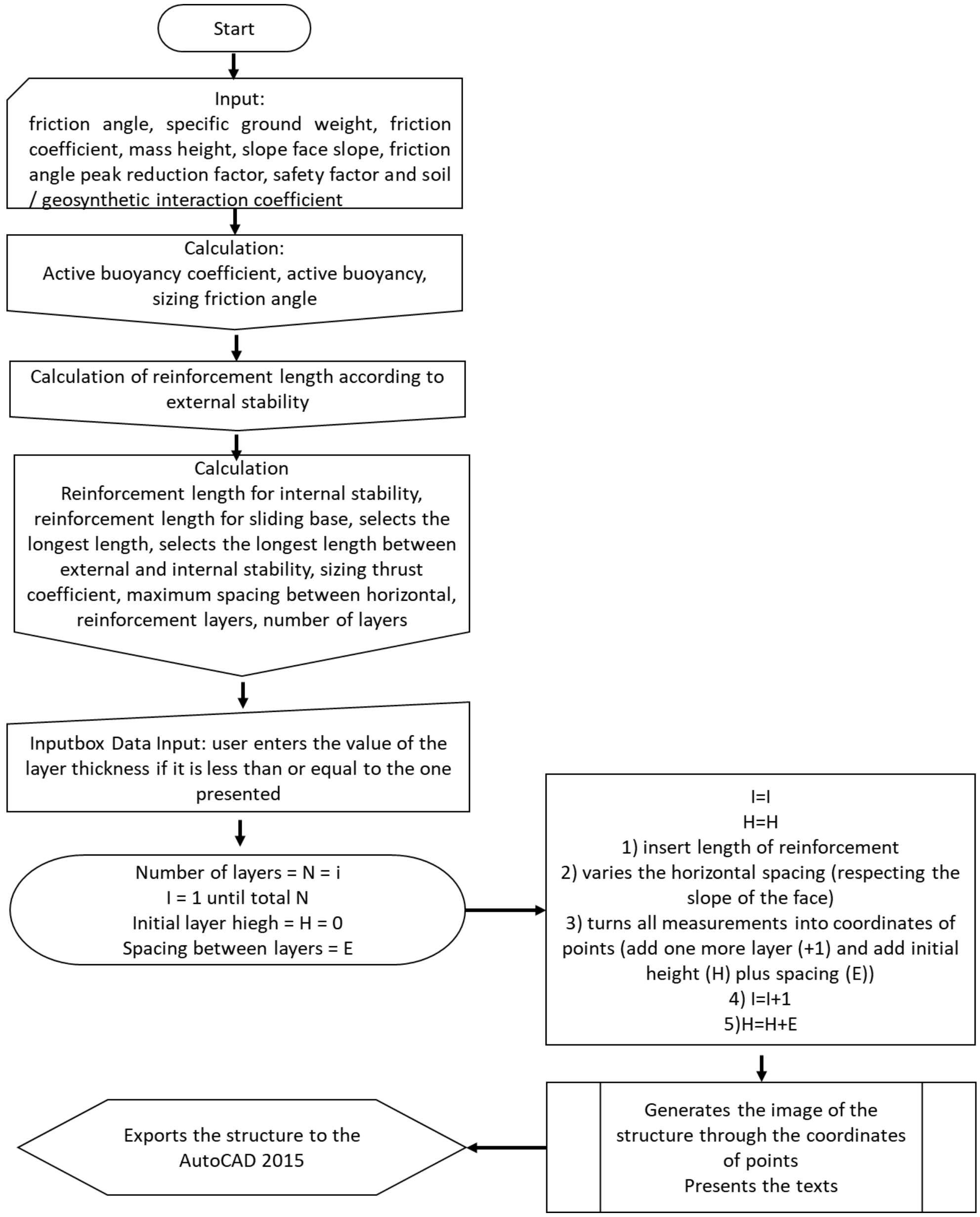

Figure 8. Flowchart – Reinforced soil

4. RESULTS

The figures have two important points of the program, the first is related input and the second to output, this is the most important, because it is at this stage that the results of the dimensioning are presented, the sketching of the scaled structure in the program interface itself and the main, the option to export the scaling results to AutoCAD, automating and eliminating the time spent with the plank drawings needed to execute the structure.

5. CONCLUSION

Considering that the usability of the application can be considered easy and the interface provides easy learning and interpretation of the results, it is expected that the program will be a tool that can assist in the development of containment structures projects inside and outside the classrooms since all objectives have been achieved.

This early version of the software, although simple and quite educational, has a great potential for updating. Future upgrades may contain new options in rigid and flexible solutions, new calculation routines that consider overload values and groundwater presence. In addition, it is possible to insert routines that generate a complete budget of the chosen solution, making it possible to perform a feasibility analysis.

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