International Journal of Materials Science and Applications
2025, Vol. 14, No. 5, pp. 239-251
https://doi.org/10.11648/j.ijmsa.20251405.16

Research Article

Correlation Between the Factors of Safety from Slide 2D and Plaxis 2D Software

Brige Dublin Boussa Elenga[1,*], Severin Jean Maixent Loubouth[1], Adolphe Kempena[2], Sorel Dzaba-Dzoualou[1], Louis Ahouet[1,3,4]

[1]Department of Civil Engineering, Marien Ngouabi University, Brazzaville, Congo
[2]Department of Geology, Marien Ngouabi University, Brazzaville, Congo
[3]Department of Civil Engineering, Denis Sassou Nguesso University, Brazzaville, Congo
[4]Control Office for Building and Public Works, Brazzaville, Congo

Abstract

This study conducted a rigorous comparative analysis of the Slide 2D (based on the Limit Equilibrium Method, LEM) and Plaxis 2D (based on the Finite Element Method, FEM) software packages to evaluate slope stability and validate methodological consistency in geotechnical engineering. The main objective was to determine whether a correlation exists between the Safety Factors (FS) calculated by these two tools, which possess distinct theoretical foundations. A series of typical slope cases, varying in geometry and soil properties, was modeled in both software environments. Statistical analysis revealed a remarkably significant correlation, with a coefficient of approximately 0.999, between the Safety Factors provided by the two tools. This strong relationship allowed for the establishment of a simple linear conversion equation that can be used to estimate the FS from Plaxis 2D based on the value obtained from Slide 2D. This equation confirms that, despite their fundamental differences, both tools yield comparable and reliable stability assessments under standard conditions. In conclusion, the ability to translate and validate results from one software to the other offers engineers and researchers greater confidence in the use and verification of landslide risk assessment results. Nevertheless, the crucial recommendation remains: it is imperative to choose the appropriate tool based on the intrinsic complexity of the geotechnical problem (presence of excessive deformations, staged construction analysis) and the specific parameters requiring modeling, with the FEM remaining the preferred option for the most complex or non-linear analyses.

Keywords

Correlation, Slope Stability, Factor of Safety, Plaxis 2D, Slide 2D

1. Introduction

Landslides constitute one of the most formidable and destructive natural disasters globally. Their consequences are often dramatic, resulting in a considerable number of annual human losses and significant material damage affecting infrastructure and homes. These mass movements, which primarily occur on slopes or embankments, result from a com-

*Corresponding author: dublinbrige@gmail.com (Brige Dublin Boussa Elenga)

Received: 1 October 2025; **Accepted:** 16 October 2025; **Published:** 31 October 2025

Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

plex interaction of factors. They can be natural in origin, including the geological and geomechanical properties of the terrain, the slope morphology, the intensity of precipitation, and the hydraulic action of water on the soil [1, 2]. Simultaneously, anthropogenic activities, such as excavations, embankments, surcharges, or modifications to hydrological regimes, also contribute significantly to slope instability [3].

Facing the increasing scale of these risks, exacerbated by climate change and the urbanization of risk-prone areas, the geotechnical community has been committed for several decades to a process of deepening the understanding and prediction of these phenomena. A fundamental objective of this process is the precise determination of the Factor of Safety (Fs), a crucial indicator used to assess the degree of slope stability [4]. Historically, this evaluation relied on manual or graphical methods, but the advent of computing has revolutionized analytical capabilities. Numerous numerical modeling software packages have thus emerged, offering powerful tools to simulate the behavior of soil masses and calculate their stability.

Among the most widely used and recognized tools in the field, Plaxis 2D is a Finite Element Method (FEM) program developed since 1983, renowned for its analysis of soil deformation and stability, and particularly suited for complex modeling and soil-structure interactions [5, 6]. Concurrently, software based on the Limit Equilibrium Methods (LEM), such as Slide 2D by Rocscience, and other integrated solutions like GeoStudio (which includes modules such as SLOPE/W for limit equilibrium), have become benchmarks for their simple interface and efficiency in slope stability analyses [7]. Each of these software packages relies on distinct theoretical assumptions and calculation algorithms, potentially influencing the results obtained.

This plurality of modeling tools raises a fundamental question for practitioners: Do these software packages, despite their different theoretical bases (Finite Element vs. Limit Equilibrium), apprehend and model the landslide phenomenon equivalently? Are the Factors of Safety they provide directly comparable, or do they present significant divergences depending on the geometric configurations and soil properties? Although various comparative studies have been conducted in the scientific literature to evaluate the performance of different slope stability software or different calculation methods [8-15], a systematic and in-depth analysis focused specifically on the correlation of Factors of Safety between Slide 2D and Plaxis 2D for typical cases remains essential.

It is precisely within this context that the present article is positioned. It proposes to perform a rigorous comparative analysis of the models and results obtained by Slide 2D and Plaxis 2D for a series of typical slope stability cases. The ultimate objective is to establish, if possible, the link and correlation that might exist between the Factors of Safety calculated by these two software packages. This approach aims to provide users with valuable information for a more informed and reliable application of these tools in their geotechnical studies, thereby contributing to a better risk assessment and the design of more robust stabilization solutions.

2. Materials and Methods

The procedure adopted for conducting this work is presented as follows:

2.1. Selection of Case Studies

To ensure the representativeness and generalizability of the conclusions, twelve (12) case studies were examined. Among these twelve cases, six (06) concern slopes with a homogeneous layer, specifically composed of silty sand. The other six (06) cases concern slopes with heterogeneous layers composed of two types of rock: argillite in the upper part and marl in the lower part.

For each case, a precise geometry (length and slope angle) is defined.

2.2. Geotechnical Properties of Materials

2.2.1. Case of Slopes with a Homogeneous Layer

Table 1*. Geotechnical properties of the homogeneous soil.*

Property	Unit	Soil
Material Model		Mohr-Coulomb
Drainage condition		Drained
Unit weight (Unsaturated)	kN/m^3	18
Unit weight (Saturated)	kN/m^3	20

Property	Unit	Soil
Young's Modulus	kN/m^2	3
Poisson's Ratio		0
Cohesion	kN/m^2 ou Kpa	5
Angle of internal friction	°	30
Dilation angle	°	0

2.2.2. Case of Slopes with Heterogeneous Layers

Table 2. Geotechnical properties of the heterogeneous soil.

Property	Unit	Soil 1 (Upper layer)	Soil 2 (Lower layer)
Material Model		Mohr-Coulomb	Mohr-Coulomb
Drainage condition		Drained	Drained
Unit weight (Unsaturated)	kN/m^3	16.7	17.2
Unit weight (Saturated)	kN/m^3	18.55	18.42
Young's Modulus	kN/m^2	21000	21000
Poisson's Ratio		0.4	0.42
Cohesion	kN/m^2 ou Kpa	37	37
Angle of internal friction	Degr é	12	12
Dilation angle	Degr é	0	0

2.3. Software Modeling

Each case study was modeled independently in Slide 2D and Plaxis 2D.

2.3.1. Modeling with Slide 2D Version 6.0

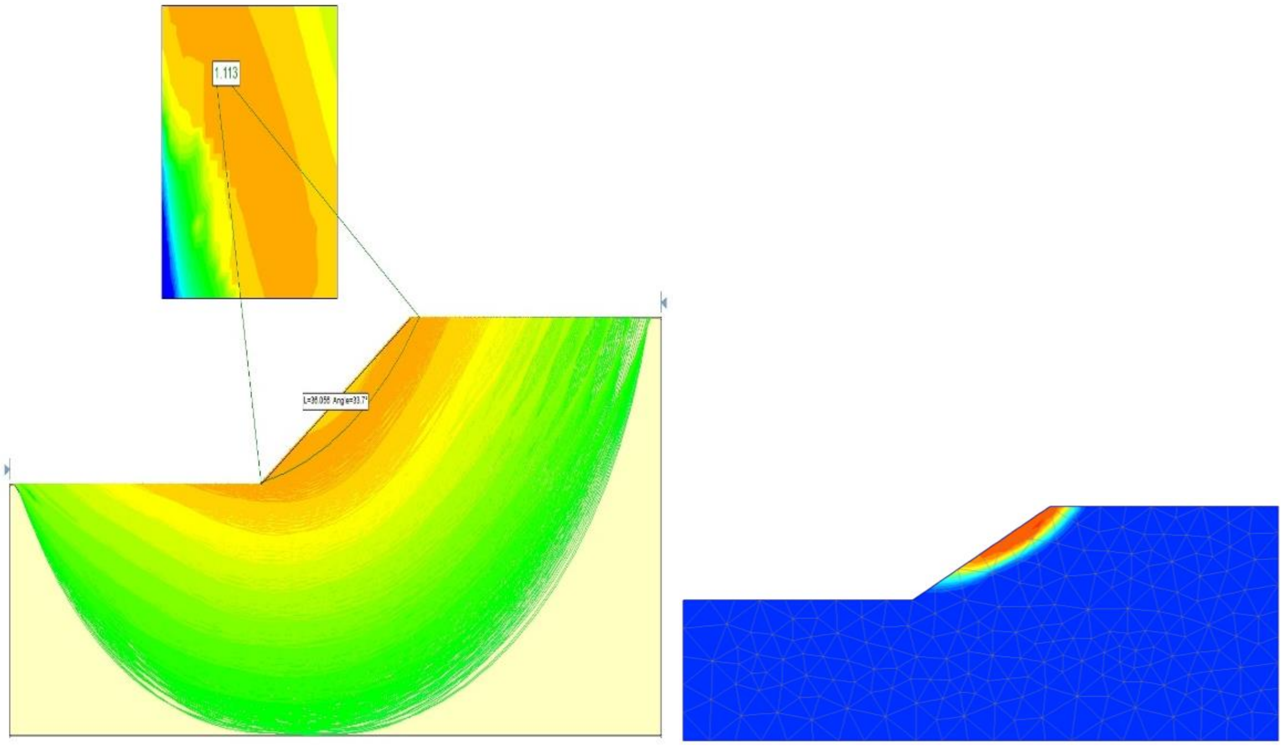
For each case study, modeling with Slide 2D was performed by first defining the slope geometry. Subsequently, the properties were assigned to the different materials present in the slope. Finally, a stability analysis was executed to determine the slope's Factor of Safety (Fs). The Fs was determined for each Limit Equilibrium Method (LEM), specifically the Simplified Bishop, Simplified Janbu, and Fellenius methods.

2.3.2. Modeling with Plaxis 2D Version 8.2

For each case study, modeling with Plaxis 2D initially involved precisely defining the slope geometry, including the different soil layers and existing structures. Next, the geotechnical parameters of each material (such as Young's Modulus, cohesion c, and friction angle ϕ) were assigned to the corresponding zones. After generating a Finite Element mesh, the stability analysis was performed using the Strength Reduction Method (SRM). This technique determines the Factor of Safety (Fs) by progressively reducing the shear strength parameters until failure is reached. The Fs is then calculated as the ratio of the available shear strength to the shear strength required to cause soil failure.

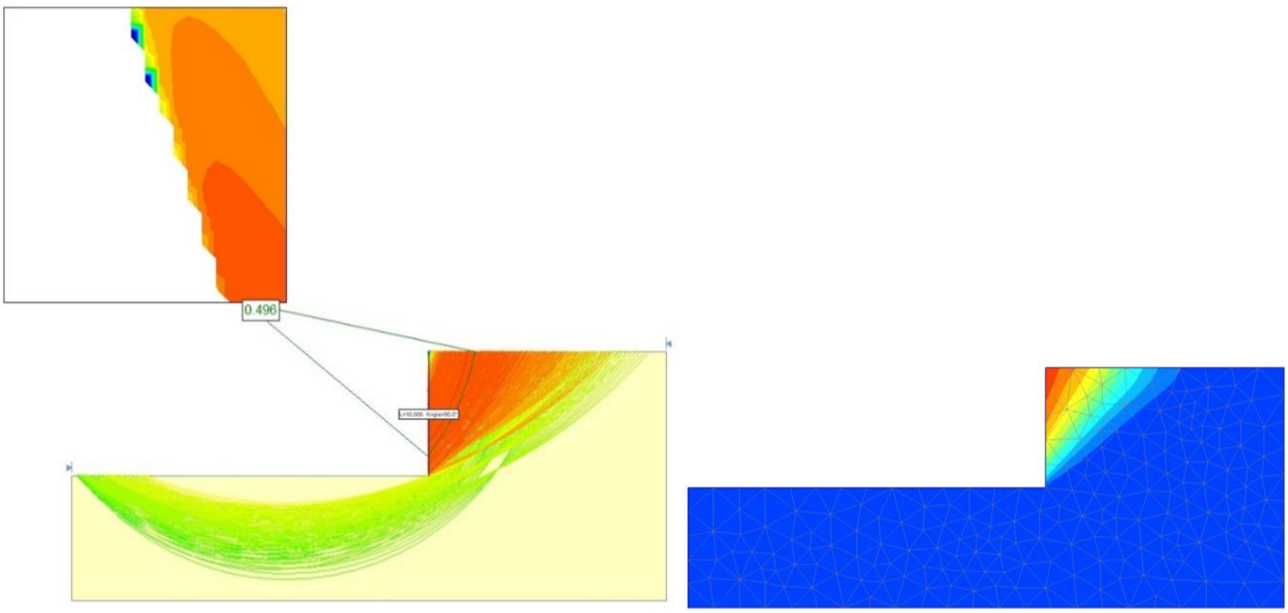
3. Results and Discussion

3.1. Homogeneous Slopes



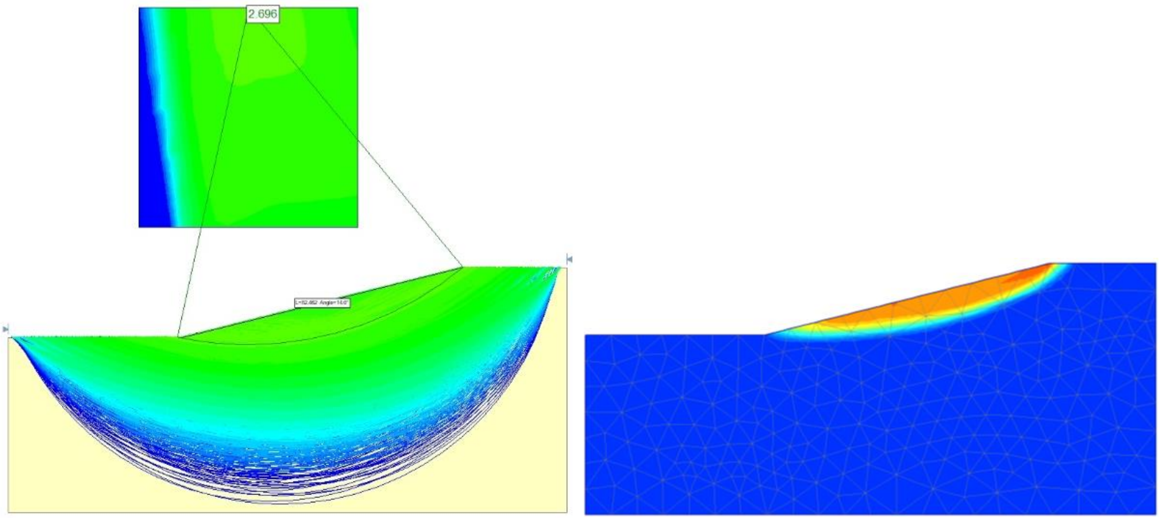
(A) (B)

Figure 1. *Modeling of Case 1 with Slide 2D (A) and Plaxis 2D (B) for homogeneous soil slope.*



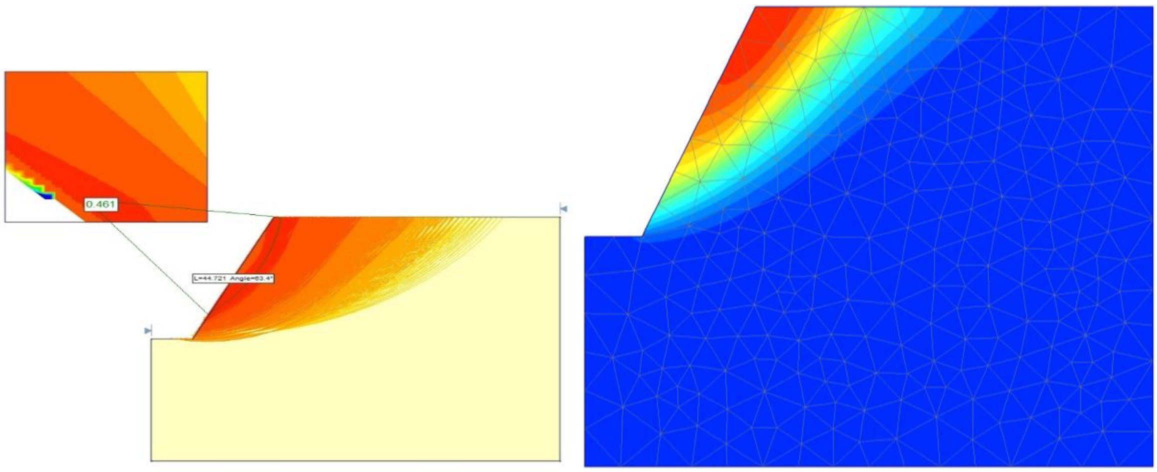
(A) (B)

Figure 2. *Modeling of case 2 with Slide 2D (A) and Plaxis 2D (B) for homogeneous soil slope.*



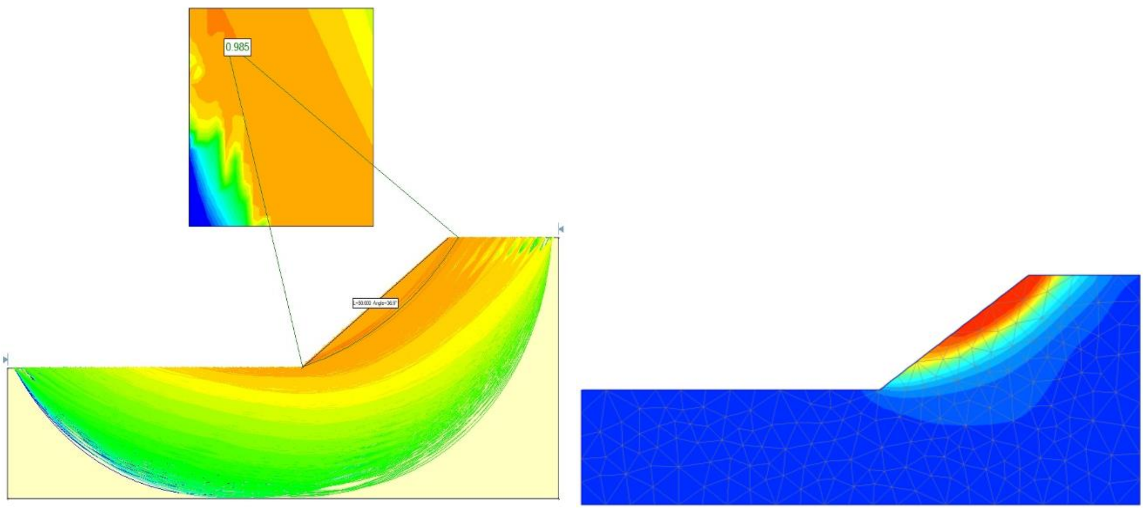
(A) (B)

Figure 3. *Modeling of case 3 with Slide 2D (A) and Plaxis 2D (B) for homogeneous soil slope.*



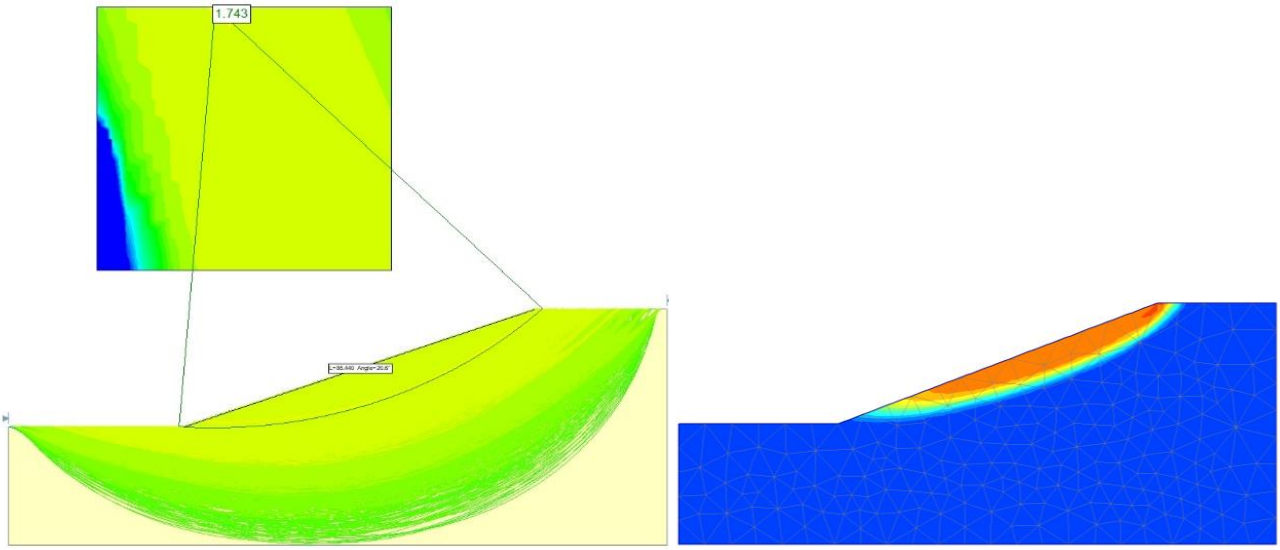
(A) (B)

Figure 4. *Modeling of case 4 with Slide 2D (A) and Plaxis 2D (B) for homogeneous soil slope.*



(A) (B)

Figure 5. *Modeling of case 5 with Slide 2D (A) and Plaxis 2D (B) for homogeneous soil slope.*



(A) (B)

Figure 6. *Modeling of case 6 with Slide 2D (A) and Plaxis 2D (B) for homogeneous soil slope.*

Figures 1, 2, 3, 4, 5, and 6 illustrate the various modeling approaches for homogeneous soil slopes with varying geometries, performed comparatively using the Slide 2D and Plaxis 2D software. As can be observed, the failure surfaces identified by each software for each case are sensibly identical; that is, these rupture surfaces are located almost at the same positions. These results lead to the conclusion that these two software packages, even while employing different approaches for calculating the factor of safety, analyze the critical failure surfaces in the same manner. This was also highlighted by Yu *et al.* [16], who showed that the critical failure surfaces determined by the Finite Element Method are very close to those determined by the Limit Equilibrium Method.

Table 3. *Factors of safety for different Homogeneous soil slope cases.*

Case series	Slope (°)	Slope length (m)	Factor of Safety with Slide 2D			Factor of Safety with Plaxis 2D
			Simplified Bishop	Simplified Janbu	Felenius	
Case 1	36.06	33.70	1.151	1.108	1.113	1.143
Case 2	10	90	0.488	0.498	0.496	0.259
Case 3	82.46	14	2.696	2.586	2.593	2.651
Case 4	44.2	63.40	0.489	0.460	0.461	0.320
Case 5	50	36.90	0.985	0.951	0.953	0.918
Case 6	85.44	20.60	1.805	1.739	1.743	1.734

Table 3 above reports the factors of safety (Fs) for the different homogeneous soil slope cases analyzed using the Slide 2D and Plaxis 2D software. It is observed that, regardless of the software used, certain cases exhibit unstable slopes due to their Factors of Safety being less than 1.0. This notably includes Cases 2, 4, and 5. Conversely, Cases 1, 3, and 6 present stable slopes given that their Fs values are greater than 1.0. Furthermore, the Factors of Safety calculated with Slide 2D are, for the majority of cases, higher than those obtained with Plaxis 2D. This observation was also made by Kempena *et al.* [17].

The Table 4 below presents the absolute differences between the Factors of Safety (Fs) from Slide 2D and Plaxis 2D. It is noted that these differences are small for the majority of cases, with an average of 0.098 using the Simplified Bishop method, 0.086 with the Simplified Janbu method, and 0.085 with the Fellenius method. These results suggest that the two software packages, Slide 2D and Plaxis 2D, can be used to evaluate slope stability with good accuracy. However, these discrepancies between the Factors of Safety can be attributed to inherent differences in the calculation methods, namely the Limit Equilibrium Method (LEM) utilized by Slide 2D and the Finite Element Method (FEM) utilized by Plaxis 2D.

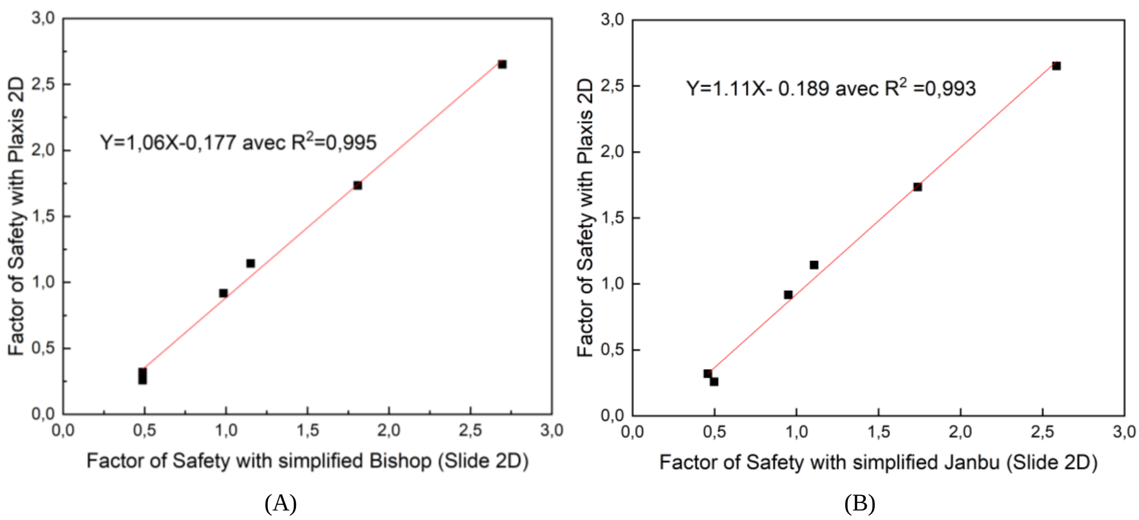
Table 4. *Absolute differences between factors of Safety from Slide 2D and Plaxis 2D: Homogeneous Slopes.*

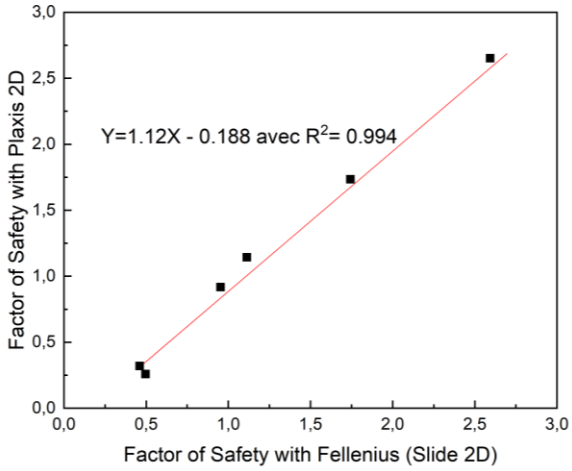
Case series	Absolute difference between Fs (Bishop) and Fs (Plaxis)	Absolute difference between Fs (Jandu) and Fs (Plaxis)	Absolute difference between Fs (Fellenius) and Fs (Plaxis)
Case 1	0.008	0.035	0.030
Case 2	0.229	0.239	0.237
Case 3	0.045	0.065	0.058
Case 4	0.169	0.140	0.141
Case 5	0.067	0.033	0.035
Case 6	0.075	0.005	0.009

Table 5. *Correlation coefficient, Relationship and Coefficient of determination between factors of safety from Slide 2D and Plaxis 2D: Homogeneous Slopes.*

	Correlation coefficient	Relationship	Coefficient of determination
Simplified Bishop - Plaxis	0.999	Y=1.06X - 0.177	0.995
Simplified Janbu - Plaxis	0.999	Y=1.11X - 0.189	0.993
Fellenius - Plaxis	0.999	Y=1.12X - 0.188	0.994

Table 5 reports the values for the correlation coefficient, the coefficient of determination and the linear relationship between the Factors of Safety (Fs) calculated by the two software packages. It emerges that the correlation coefficients between the Fs values from Slide 2D and Plaxis 2D are all equal to 0.999. These positive values imply that as the Fs from Slide 2D increases, the Fs from Plaxis 2D also increases, and vice versa. Being extremely close to 1.0, they indicate a very strong linear relationship between the two software results. This relationship is described by the mathematical equations mentioned in Table 5, where X represents the Factor of Safety from Slide 2D and Y represents the Factor of Safety from Plaxis 2D. These equations follow a first-degree polynomial law, as illustrated in Figure 7 below.



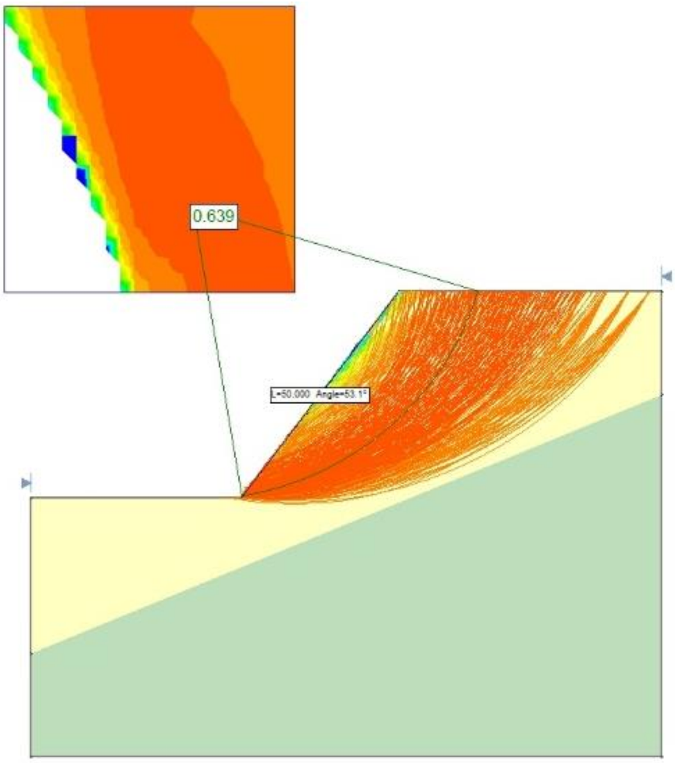


(C)

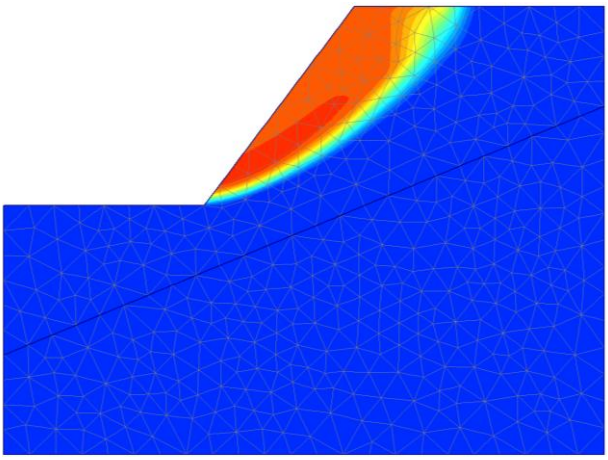
Figure 7. *Evolution of the Safety Factor from Plaxis 2D with that of simplified Bishop (A), simplified Janbu (B) and Fellenius (C) for slopes in homogeneous soil.*

Furthermore, among the methods used by Slide 2D to determine the Factor of Safety, the Simplified Bishop method correlates best with the Plaxis 2D result, as its coefficient of determination is the highest at 0.995.

3.2. Heteregeneous Slopes

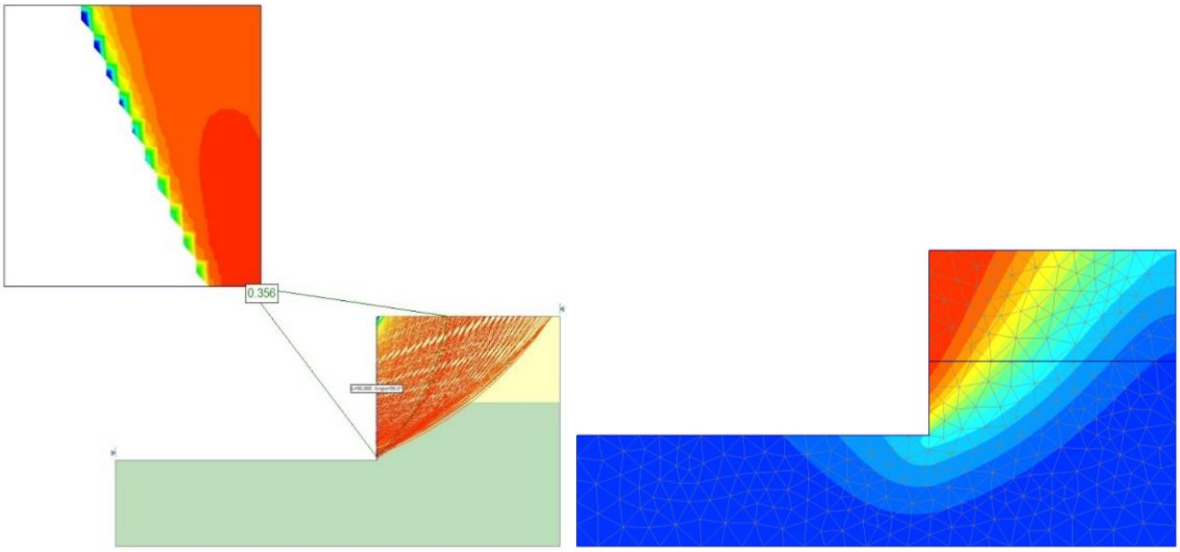


(A)



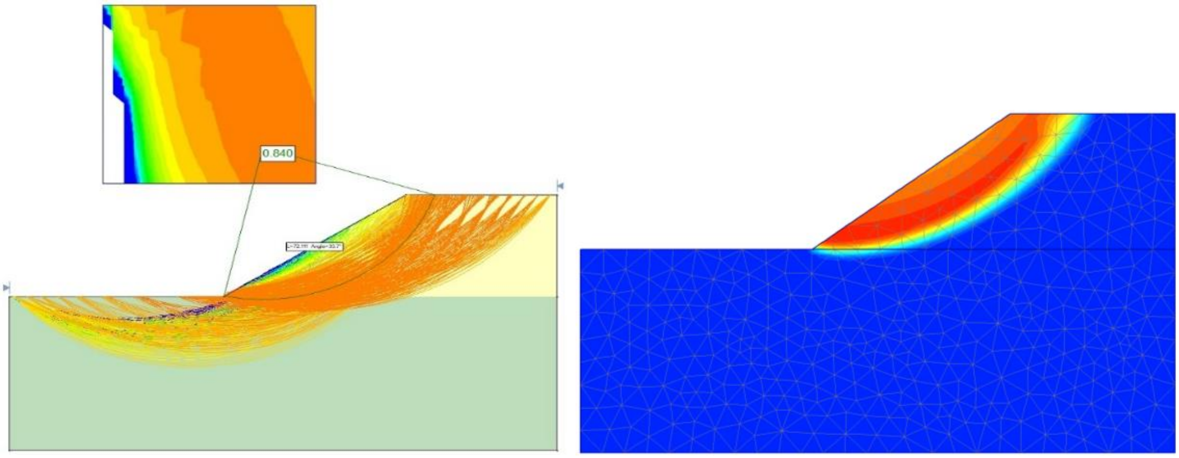
(B)

Figure 8. *Modeling of case 7 with Slide 2D (A) and Plaxis 2D (A) for hetergeneous soils slopes.*



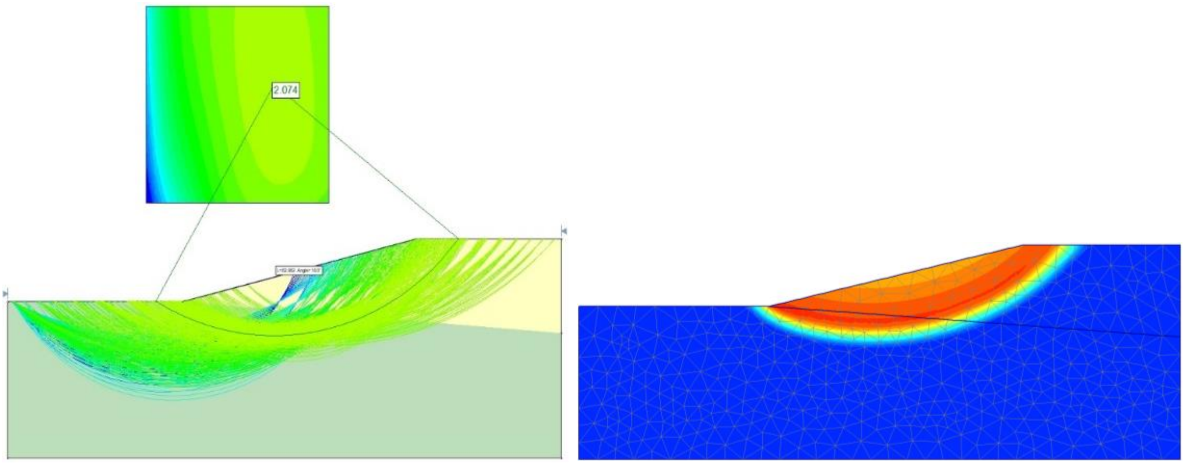
(A) (B)

Figure 9. *Modeling of case 8 with Slide 2D (A) and Plaxis 2D (B) for hetergeneous soils slopes.*



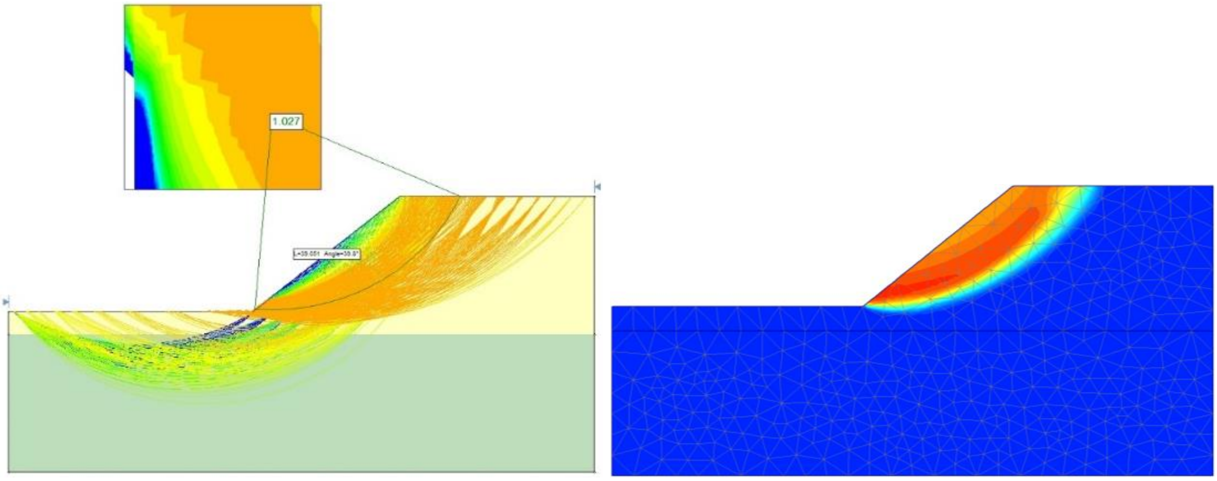
(A) (B)

Figure 10. *Modeling of case 9 with Slide 2D (A) and Plaxis 2D (B) for hetergeneous soils slopes.*



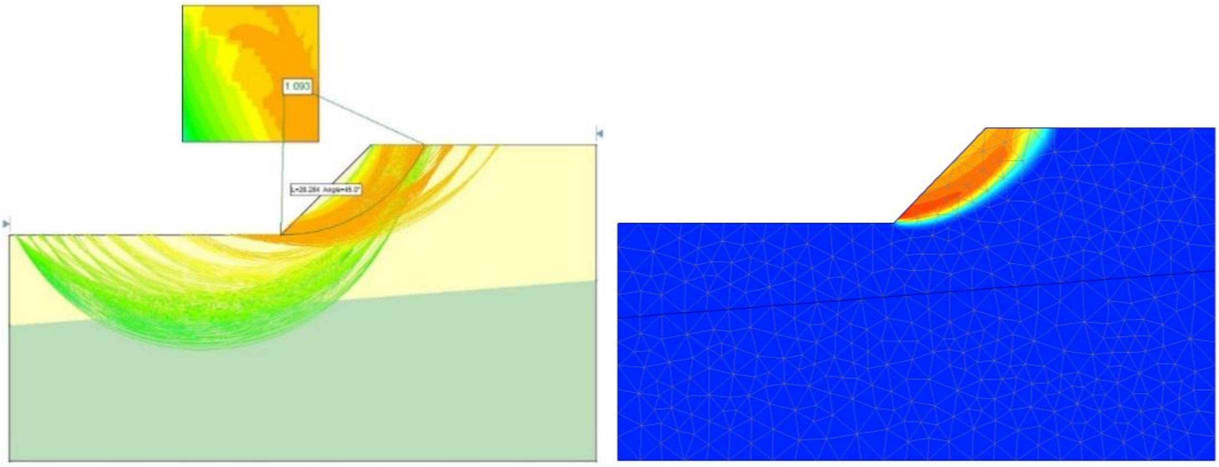
(A) (B)

Figure 11. *Modeling of case 10 with Slide 2D (A) and Plaxis 2D (B) for hetergeneous soils slopes.*



(A) (B)

Figure 12. *Modeling of case 11 with Slide 2D (A) and Plaxis 2D (B) for hetergeneous soils slopes.*



(A) (B)

Figure 13. *Modeling of case 12 with Slide 2D (A) and Plaxis 2D (B) for hetergeneous soils slopes.*

Figures 8 to 13 above illustrate different modeling approaches for heterogeneous soil slopes with varying geometries, performed comparatively using the Slide 2D and Plaxis 2D software. It is observed that the location of the failure surfaces is almost identical for all six (06) cases studied. These results lead to the conclusion that these two software packages, although employing different approaches for calculating the factor of safety—the Limit Equilibrium Method (LEM) for Slide 2D and the Finite Element Method (FEM) for Plaxis 2D—analyze the critical failure surfaces in the same manner. This finding aligns with scientific literature, particularly the work of A. Khalkhali *et al.* [18], who emphasized that the rupture zones localized in the PLAXIS model that have entered the plastic phase show considerable proportionality with the probable wedge of the slip surface obtained by the Radius & Grid technique used in the SLOPE/W software.

Table 6. *Factors of Safety for different heterogeneous soil slope cases.*

Cas series	Slope (°)	Slope length (m)	Factor of Safety with Slide 6.0			Factor of Safety with Plaxis 2D
			Simplified Bishop	Simplified Janbu	Felenius	
Case 7	53.1	50	0.639	0.629	0.627	0.604
Case 8	90	50	0.334	0.371	0.356	0.077

Cas series	Slope (°)	Slope length (m)	Factor of Safety with Slide 6.0			Factor of Safety with Plaxis 2D
			Simplified Bishop	Simplified Janbu	Felenius	
Case 9	33.7	72.11	0.885	0.821	0.840	0.856
Case 10	14	82.46	2.074	1.868	1.939	2.055
Case 11	39.8	39.05	1.027	0.978	0.987	0.993
Case 12	45	28.28	1.093	1.069	1.071	1.054

Table 6 above reports the Factors of Safety (Fs) for the different heterogeneous soil slope cases calculated using the Slide 2D and Plaxis 2D software. The results obtained show that, regardless of the software, Cases 1, 2, 3, and 5 exhibit unstable slopes because their Factors of Safety are systematically below 1.0. Conversely, Cases 4 and 6 present stable slopes given that their Fs values are greater than 1.0. These conclusions are consistent with the findings of Hammouri *et al.* [19], who demonstrated that, although based on different principles, the Finite Element Method (FEM) and Limit Equilibrium Method (LEM) can produce coherent results for slope stability analysis, especially when the soil parameters and slope geometry are well defined.

Table 7. *Absolute differences between Factors of Safety from Slide 2D and Plaxis 2D in heterogeneous slope cases.*

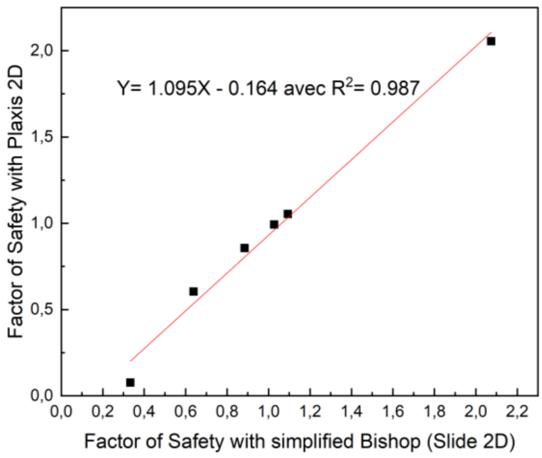
Case series	Absolute difference between Fs (Bishop) and Fs (Plaxis)	Absolute difference between Fs (Janbu) and Fs (Plaxis)	Absolute difference between Fs (Fellenius) and Fs (Plaxis)
Case 7	0.035	0.025	0.023
Case 8	0.257	0.294	0.279
Case 9	0.029	0.035	0.016
Case 10	0.019	0.187	0.116
Case 11	0.034	0.015	0.006
Case 12	0.039	0.015	0.017

The analysis of the discrepancies between the Factors of Safety (Fs) calculated by Slide 2D and Plaxis 2D, as documented in Table 7 above, reveals encouraging results. These discrepancies, while present, remain small, with average absolute differences of 0.098 for the Simplified Bishop method, 0.086 for the Simplified Janbu method, and 0.085 for the Fellenius method. These results suggest that both software packages can be used to evaluate slope stability with good accuracy. The differences observed in the Factors of Safety are attributable to the distinct theoretical foundations of the software, namely the Limit Equilibrium Method (LEM) used by Slide 2D and the Finite Element Method (FEM) used by Plaxis 2D.

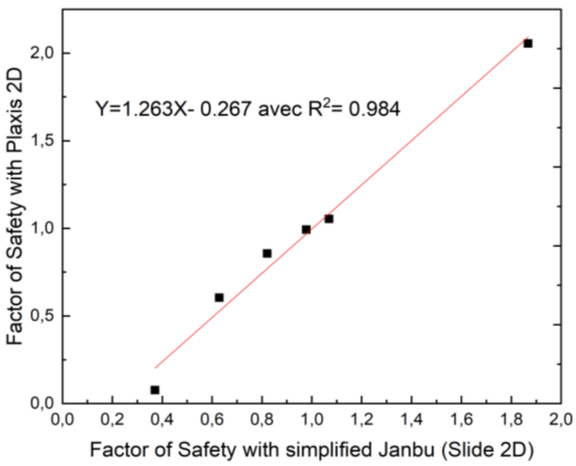
Table 8. *Correlation Coefficient, Relationship, and Coefficient of Determination Between Factors of Safety from Slide 2D and Plaxis 2D: Heterogeneous Slopes.*

	Correlation coefficient	Relationship	Coefficient of determination
Simplified Bishop -Plaxis	0.994	Y= 1.095X - 0.164	0.987
Simplified Janbu -Plaxis	0.993	Y=1.263X - 0.267	0.985
Fellenius-Plaxis	0.993	Y=1.97X - 0.221	0.986

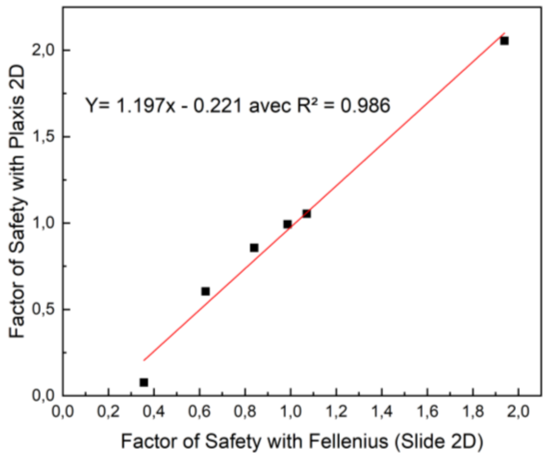
The results presented in Table 8 demonstrate a strong correlation between the Factors of Safety (Fs) calculated by the Slide 2D and Plaxis 2D software, with a correlation coefficient of 0.994 between the Simplified Bishop method and Plaxis. This value, being very close to 1.0, indicates a near-perfect linear relationship: an increase in the Factor of Safety from Slide 2D is accompanied by an increase in Plaxis 2D, and vice versa. This relationship is described by first-degree polynomial equations (linear equations), as illustrated in Figure 14. Furthermore, the Simplified Bishop method in Slide 2D shows an optimal correlation with the Plaxis 2D results, as evidenced by its coefficient of determination of 0.987, which is the highest among all the compared methods.



(A)



(B)



(C)

Figure 14. *Evolution of the Safety Factor from Plaxis 2D with that of simplified Bishop (A), simplified Janbu (B) and Fellenius (C) for slopes in heterogeneous soils.*

4. Conclusion

The main objective of this study was to establish the existence of a correlation between the Factors of Safety (Fs) calculated by the Slide 2D and Plaxis 2D software packages. To achieve this, a rigorous comparative analysis was conducted on a series of typical cases, including both homogeneous and heterogeneous soil slopes, relying on the Limit Equilibrium Method (LEM) for the former and the Finite Element Method (FEM) for the latter. The following key findings emerged:

1) The critical failure surfaces located in Plaxis 2D were found to be nearly identical to those determined by Slide 2D.
2) An exceptionally strong correlation was established, with a correlation coefficient (R) reaching 0.999 for homogeneous cases. This discovery is crucial, as it confirms that, despite their distinct theoretical foundations, these two numerical approaches lead to slope stability assessments that are not only comparable but also high-

ly consistent.

3) A major contribution of this research is the establishment of a linear equation that allows the Factor of Safety from Plaxis 2D to be estimated based on the value obtained with Slide 2D. This conversion capability reinforces the confidence of engineers and researchers in using these tools, as it validates their respective results.
4) The Simplified Bishop method used in Slide 2D proved to be the most highly correlated with the results from Plaxis 2D.

Ultimately, the study demonstrates that Limit Equilibrium Methods, such as those used by Slide 2D, can serve as a reliable tool for initial estimations, with the assurance that the results are in agreement with the more complex Finite Element analyses. However, the final choice of the tool must remain guided by the complexity of the geotechnical problem and the specific parameters requiring modeling.

Abbreviations

FS	Factor of Security
FEM	Finite Element Method
LEM	Limit Equilibrium Methods

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Fourie & Beer, Landslide Risk Management: An introduction, CRC Press, 2013.

[2] J. N. N. Manuel, «Numerical analysis of slope failure in granitic soil slopes. Main types of instability and remediation measures, Tese para obtenção do Grau de Doutor em Engenharia Civil», p. 254, Universidade da Beira Interior, Covilhã, Portugal, 2015.

[3] Kjekstad & Highland, «Economic and social impacts of landslide», *Springer*, pp. 539-546, 2009.

[4] R. Larsson, G. Sallfors, P. E. Bengtsson, C. Alen, U. Bergdahl and L. Eriksson, Skjuvhallfasthet-utvärdering I Kohesionsjord, Geotechnical Institute and Chalmers University of Technology, 2007.

[5] Brinkgreve & Swolfs, Plaxis 2D version 2010: Reference Manual, 2010.

[6] H. M. Shiferaw, «Study on the infuence of slope height and angle on the factor of safety and shape of failure of slopes based on strength reduction method of analysis», *Journal of Basic and Applied Sciences*, vol. 10, n°11, pp. 31, 2021.

[7] Roscience Inc., Slid 6.0 User Manual, 2017.

[8] Luc Leroy, Michel Kenmoe, Tchognia Nkuissi, Sylvain Lawou, and Innoua Mohamadou1 «Comparative Analysis of the Slope Stability Using Slide and Plaxis 2D Software: A Case Study of Tombel Pozzolan Quarry (South-West Cameroon)», *Applied and Environmental Soil Science*, 20 pages, 2024.

[9] Duncan J. M & Wright S. G, «Soil Strength and Slope Stability, Wiley & Sons», 2005.

[10] D. V. Grifths and P. A. Lane, «Slope stability analysis by fnite elements», *Géotechnique*, vol. 49, n°13, pp. 387-403, 1999.

[11] Y. Mao, L. Chen, Y. A. Nanehkaran, M. Azarafzan, R. Derakhshani, «Fuzzy-based intelligent model for rapid rock slope stability analysis using Qslope», vol. 15, n°%116, pp. 2949, 2023.

[12] A. V. Deliveris and I. E. Zevgolis, «Numerical Modelling of Slope Stability in Open Pit lignite Mines: A Comparative Study», *Bulletin of the Geological Society of Greece*, 2016.

[13] A. Azadi, A. Esmatkhah Irani, M. Azarafza, M. Hajialilue Bonab, F. B. Sarand, and R. Derakhshani, «Coupled numerical and analytical stability analysis charts for an earthfll dam under rapid drawdown conditions», *Applied Sciences*, vol. 12, n°19, pp. p. 4550, 2022.

[14] M. Azarafza, H. Akgün, M. R. Feizi-Derakhshi, «Discontinuous rock slope stability analysis under blocky structural sliding by fuzzy key-block analysis method», *Heliyon*, vol. 6, n°15, 2020.

[15] Y. A. Nanehkaran, Z. Licai, J. Chengyong «Comparative analysis for slope stability by using machine learning methods», *Applied Sciences*, vol. 13, pp. 1555, 2023.

[16] Yu H, Salgado R, Sloan W, Kim J, «Limit analysis versus equilibrium for slope stability», *Geotech Geoenviron Eng ASCE*, vol. 124, n°11, pp. 1-11, 1998.

[17] A. kempena, W. N Noël, O. O Harmel, M. U Urbain, A. O Gonçalaves, R. G Lacaba, B. Florent, «Comparative Study of Slope Soils Analysis by Using Limit Equilibbirum and Finite Element Methods», *International Journal of Geosciences*, vol. 13, pp. 1089-1102, 2002.

[18] A. B Khalkhali and M. K Koochaksaraei, «Evaluation of Limit Equilibrium and Finite Element Methods in Slope Stability Analysis - Case Study of Zaremroud Landslide, Iran», *Computational Engineering and Physical Modeling*, pp. 01-15, 2019.

[19] N. A Hammouri, A. H. Malkawi, M. Yamin «Stability analysis of slopes using the finite element method and limiting equilibrium approach», *Bulletin of Engineering Geology and the Environment*, pp. 471-478, 2008.