iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** IX **Month of publication:** September 2017

DOI: http://doi.org/10.22214/ijraset.2017.9127

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue IX, September 2017- Available at www.ijraset.com

Two-Dimensional Slope Stability Analysis by Plaxis-2d

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Abstract: The use of the finite elements in calculations of stability has to overcome the weakness of the traditional methods. An analysis of stability was applied to a slope, of complex geometry, composed of alternating sandstone and marls using finite elements and limit equilibrium methods. Various calculations carried out illustrate perfectly benefits that can be gained from modeling the behavior by the finite elements method. In the finite elements analysis, the shape of deformations localization in the slope is nearly circular and confirms the shape of the failure line which constitutes the basic assumption of the analytical methods [1]. In this paper the value of Factor of safety is taken constant and compared for various types of soil with varying slope, but for constant two-dimensional model. The major limitations of this method are found from this comparative study.
Keywords: Slope stability, Finite element method, Drained condition.

I. INTRODUCTION

For slope stability analysis, the limit equilibrium method (LEM) is widely used by engineers and researchers and this is a traditional and well established method. Although the LEM does not consider the stress–strain relation of soil, it can provide an estimate of the factor of safety of a slope without the knowledge of the initial conditions with the result that the LEM is favored by many engineers. The LEM is well known to be a statically indeterminate problem and assumptions on the distributions of internal forces are required for the solution of the factor of safety. The variational approach to determine the factor of safety proposed by Baker and Garber [2] does not require the assumption on the internal force distribution but is tedious to use even for a single failure surface. In this present study we are using finite element method with the value of Factor of safety is taken as 1, there slope angle and other important soil parameters are variable here. But the different boundary conditions are taken same here which is required.

For different set of slope stability analysis Mohr's-Coulomb material model is followed here specially. The importance of the various parameters and their applicability under several special cases are considered in the following sections. Many different proposals have been suggested in the past and detailed discussions on various methods for locating the critical failure surface have been provided by Cheng [3]. While most of these methods can work for normal problems.

II. STABILITY ANALYSIS FOR HOMOGENEOUS SOIL SLOPE

Firstly, a homogeneous soil slope with slope height 5m, Top:20m, Right=50m. [Common for all data set]. Here the Cohesive strength(C) varies and the friction angle(ϕ) are variable. The density, elastic modulus, Poisson's ratio and along with the other parameters are kept constant for all the variable data set respectively in all the stage of analysis here.

A. Material sets for soil interfaces

GENERAL PARAMETERS	
Material set	Common for all variable sets
Material model	Mohr's-Coulomb model
Material type	Drained condition

B. Soil Property Under Study

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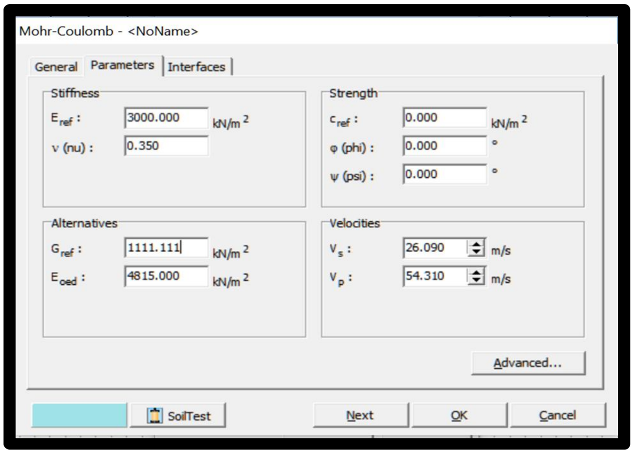
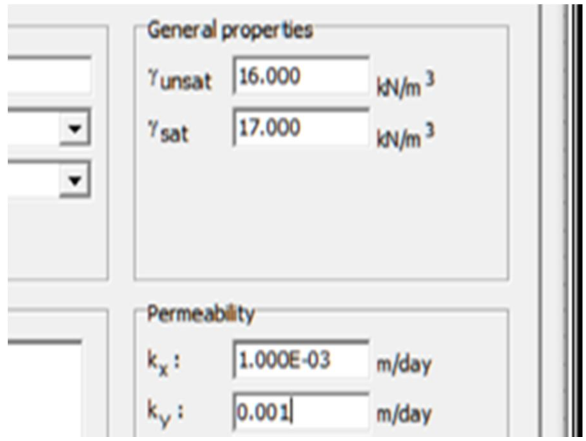
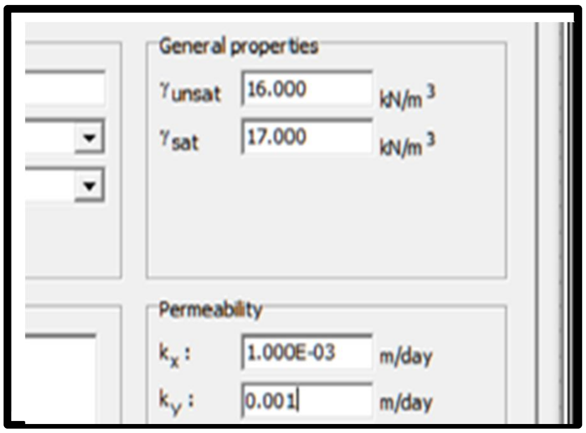
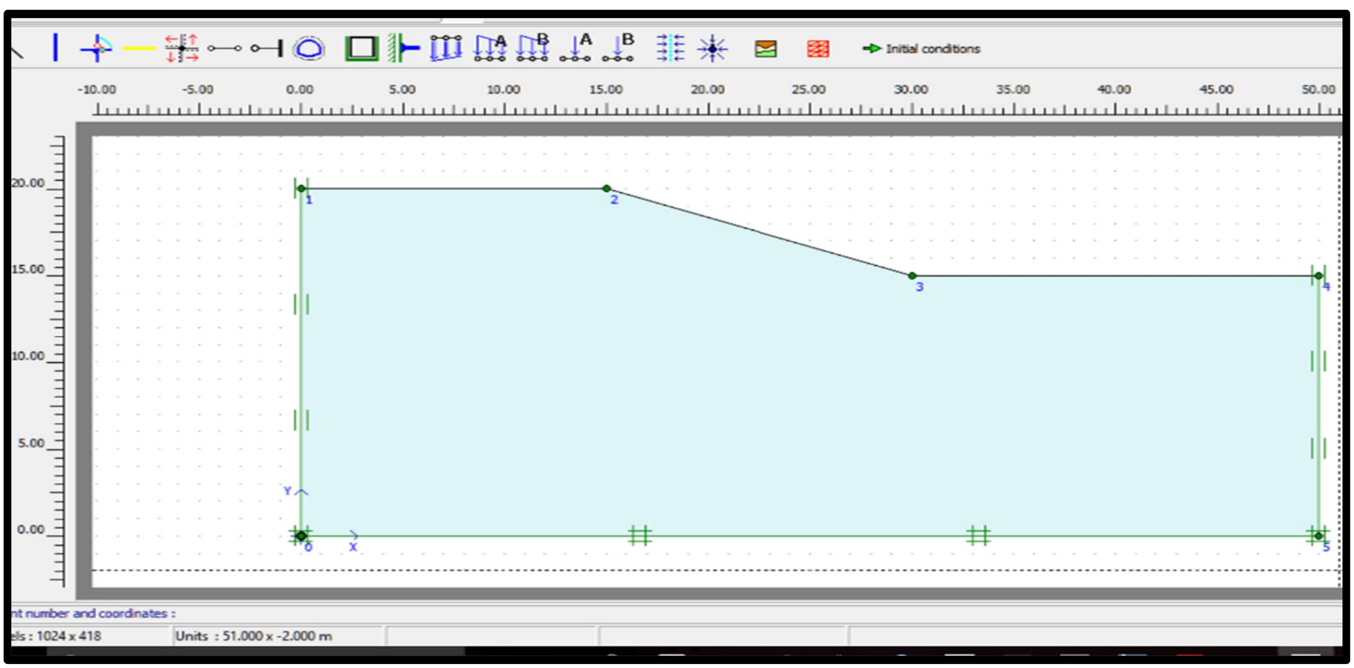






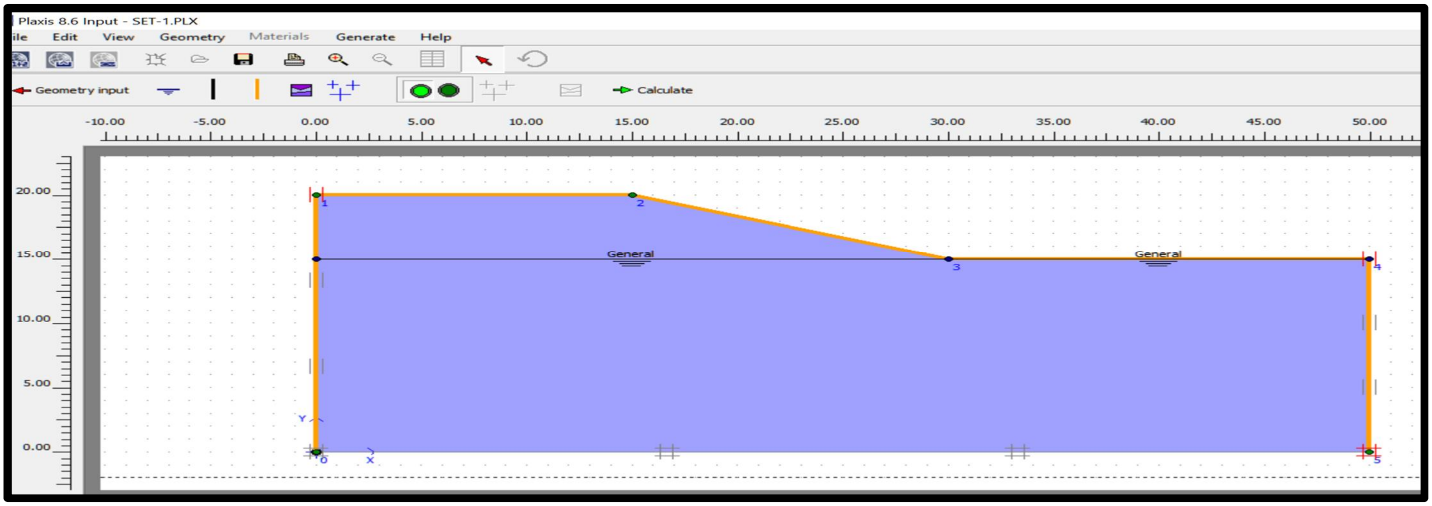
So, here are the above mentioned soil properties which are constant for all variable data set now we are going to introduce here the constant geometry of slope and the boundary conditions as well.

C. Soil Geometry Under Study



[Figure-1]

Here in This figure -1 it shows the actual geometric configuration of taken slope model for analysis by Plaxis,it is the first step by providing geometric parameters of given slope model.



[Figure-2]

Here in this above model it specifies the initial condition by providing Phreatic level, closed consolidation boundary, closed flow boundary etc. constant for all variable data set.

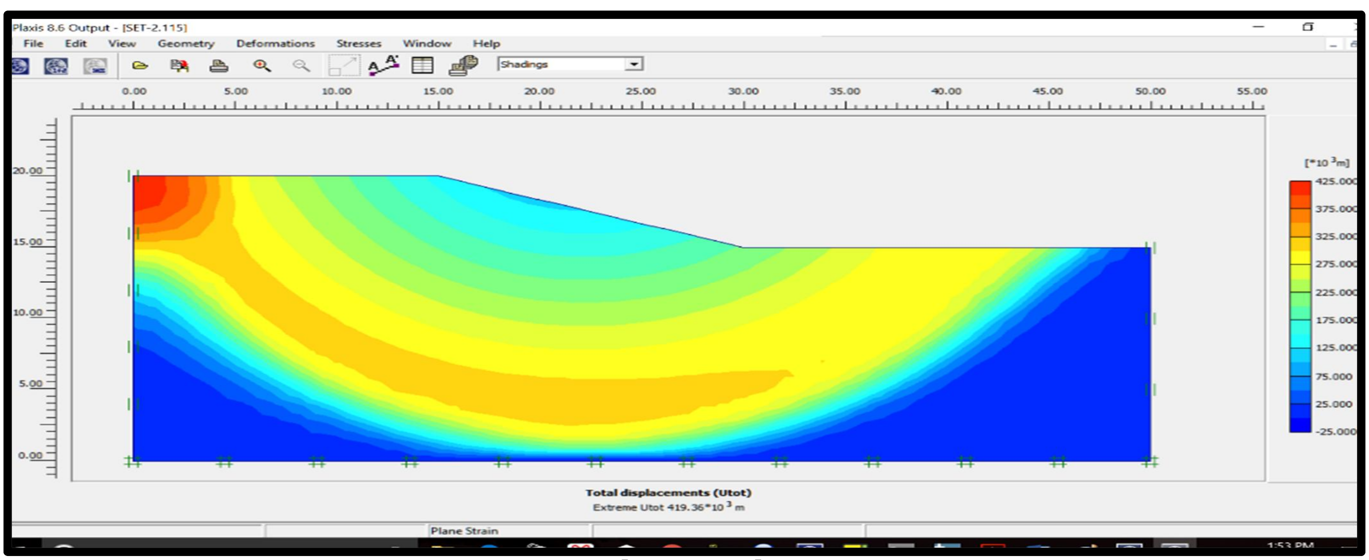
III. COMPARATIVE RESULTS AND ANALYSIS OF DIFFERENT VARIABLE DATA SET:

A. For purely Cohesive soil

Where the cohesion values are variable and value of angle of friction is(ϕ=0) are as follows:

DATA	C-VALUE	φ VALUE
SET-1	10	0
SET-2	20	0
SET-3	30	0
SET-4	40	0

Now here we are going to compare set no.2 and set no.4 data for purely cohesive soil



[Figure no-3]

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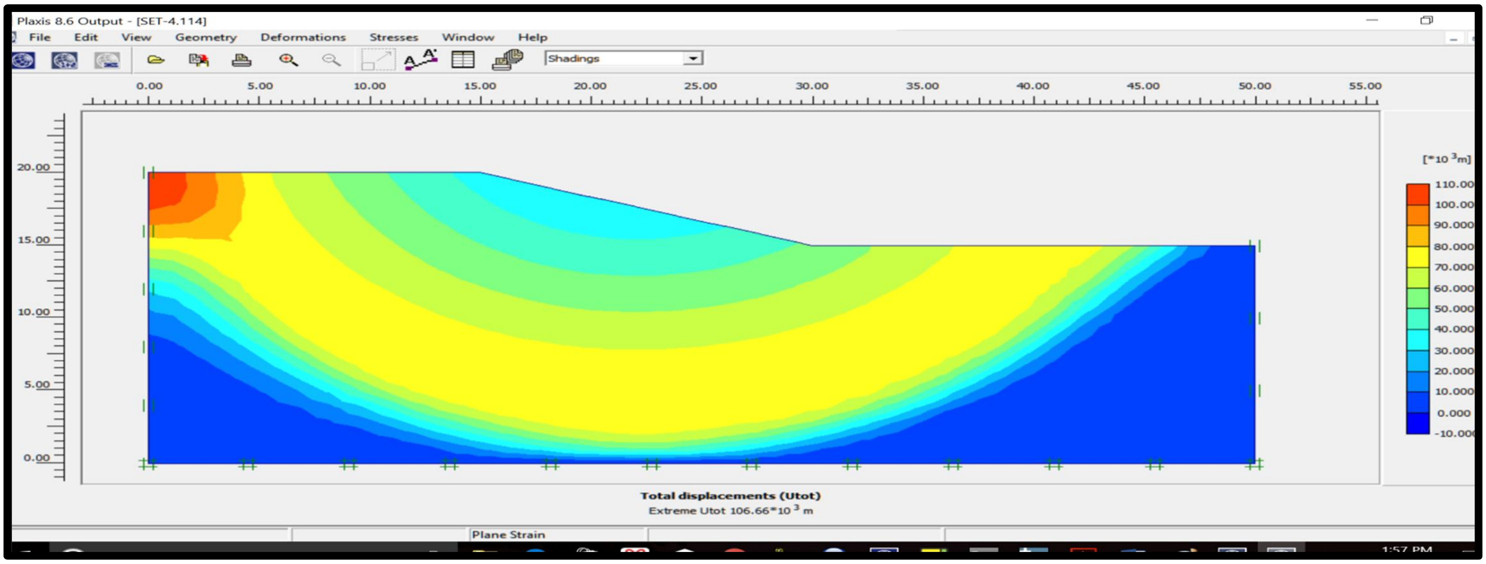
[Total displacement comparison with C=20kPa and ϕ=0, where total displacement=ExtremeUtot419.36*10^3m]



[Figure no-4]

[Total displacement comparison with C=40kPa and ϕ=0, where total displacement=ExtremeUtot106.66*10^3m]

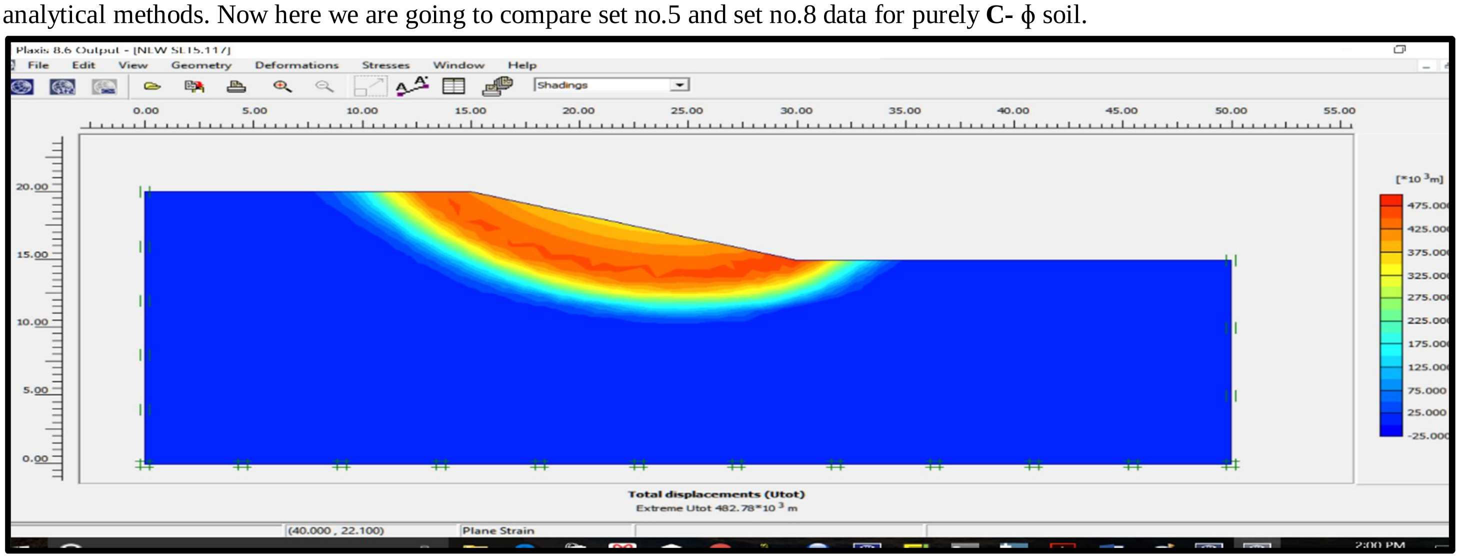
So from here in this analysis we can able to conclude that the more the cohesive value increased for purely cohesive soil the lesser is the total displacement take place for homogeneous soil slope.

B. For purely C- ϕ soil

Where the cohesion values are taken as =5(constant) and value of angle of friction are variable, as follows:

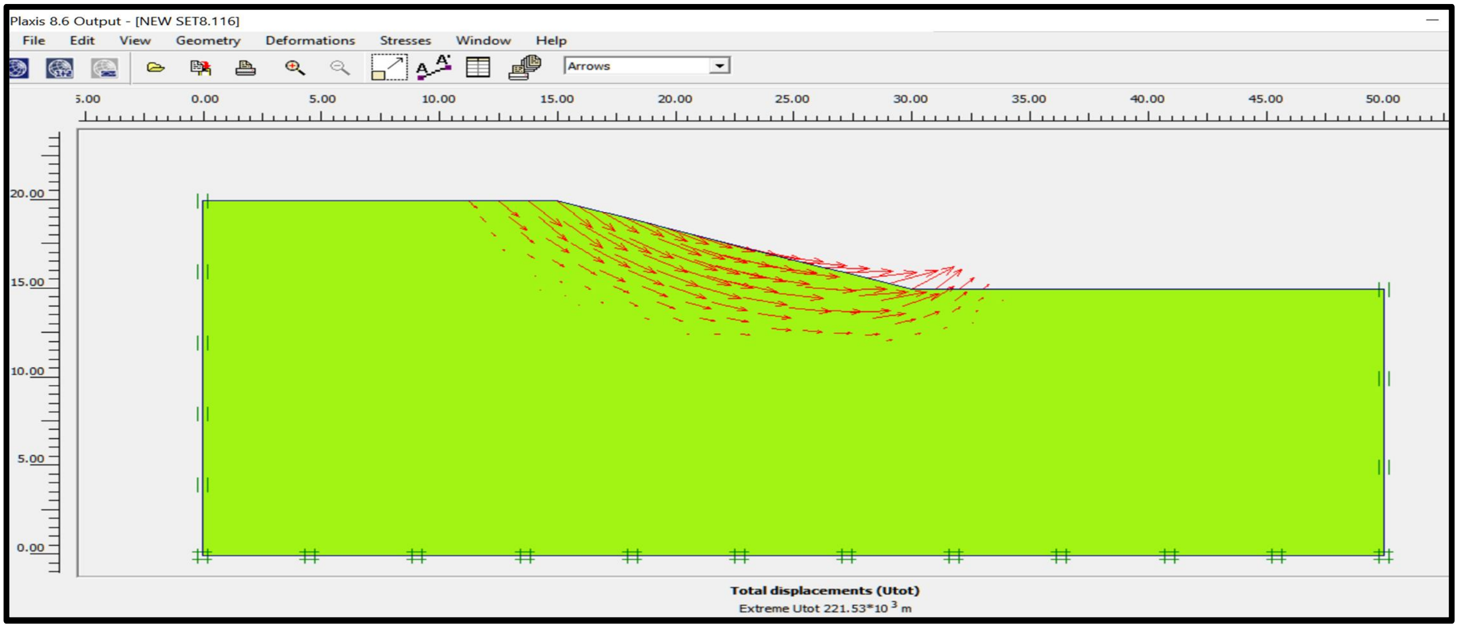
DATA	C-VALUE	φ VALUE
SET-5	5	10
SET-6	5	20
SET-7	5	30
SET-8	5	40

The total displacements figure highlights the limit be- tween the zone where there is no displacement (zero value) and the zones where displacements occur (non null values). We note the circular form of this limit which points out the slip surface adopted by the analytical methods. Now here we are going to compare set no.5 and set no.8 data for purely **C- ϕ** soil.



[Figure no-5]

[Total displacement comparison with C=5kPa and ϕ=10, where total displacement=ExtremeUtot482.78*10^3m]



[Figure no-6]

[Total displacement comparison with C=5kPa and ϕ=40, where total displacement=ExtremeUtot221.53*10^{3}m]

So from here in this analysis we can able to conclude that for the constant cohesive value with the variable value of angle of friction for purely C- ϕ soil, the greater is the ϕ value the lesser is the total displacement take place for homogeneous soil slope.

C. For purely Cohesion less soil

Where the cohesion values are zero(constant) and values of angle of friction are variable are as follows:

DATA	C-VALUE	φ VALUE
SET-9	0	10
SET-10	0	20
SET-11	0	30
SET-12	0	40

Here from this analysis we can able to state that this set value has a faulty result which shows the soil layer is collapsed when the value of c is zero.so set 9 to set-12 has the same results. So from here we can conclude that without giving a minimum value of cohesion this set of programme cannot run and doesn't give the experimental results.

IV. COMPARATIVE OUTPUT OF ALL DATA SET:

PARAMETERS	SET1	SET2	SET3	SET4
1.EXTREME TOTAL DISPLACEMENT	1.11x10^{3}m	419.36x10^{3}m	217.87x10^{3}m	106.66X10^{3}m
2.TOTAL DISPLACEMENT	1.11x10^{3}m	419.36x10^{3}m	217.87x10^{3}m	106.66X10^{3}m
3.HORIZONTAL DISPLACEMENTS	819.15x10^{3}m	314.25x10^{3}m	163.31x10^{3}m	79.48x10^{3}m
4.VERTICAL DISPLACEMENTS	1.11x10^{3}m	419.36x10^{3}m	217.87x10^{3}m	106.66X10^{3}m
5.TOTAL STRAIN	33.40x10^{3}%	13.56x10^{6}%	6.76x10^{6}%	3.10x10^{6}%
6.EXTREME EFFECTIVE	-197.37 KN/m^2	-199.99KN/m^2	-199.75 KN/m^2	-201.00 KN/m^2

PRINCIPLE STRESS				
7.EXTREME TOTAL PRINCIPAL STRESS	-343.93 KN/m^2	-340.53KN/m^2	-347.15 KN/m^2	-347.67 KN/m^2
8.HORIZONTAL EFFECTIVE STRESS	-202.36 KN/m^2	-208.11 KN/m^2	-208.01 KN/m^2	-208.68 KN/m^2
9.VERTICAL EFFECTIVE STRESS	-187.71 KN/m^2	-189.54 KN/m^2	-189.61 KN/m^2	-189.63 KN/m^2
10.HORIZONTAL TOTAL STRESS	-352.36 KN/m^2	-358.10 KN/m^2	-358.00 KN/m^2	-358.66 KN/m^2
11. VERTICAL TOTAL STRAIN	-337.71 KN/m^2	-339.53 KN/m^2	-339.60 KN/m^2	-339.62 KN/m^2

PARAMETERS	SET5	SET6	SET7	SET8
1.EXTREME TOTAL DISPLACEMENT	482.78x10^{3}m	289.58x10^{3}m	402.40x10^{3}m	221.53X10^{3}m
2.TOTAL DISPLACEMENT	482.78x10^{3}m	289.58x10^{3}m	402.40x10^{3}m	221.53X10^{3}m
3.HORIZONTAL DISPLACEMENTS	458.17x10^{3}m	280.61x10^{3}m	389.29x10^{3}m	212.39x10^{3}m
4.VERTICAL DISPLACEMENTS	347.58x10^{3}m	198.55x10^{3}m	284.47x10^{3}m	156.60X10^{3}m
5.TOTAL STRAIN	-12.52x10^6%	9.72x10^6%	12.74x10^6%	-7.16x10^6%
6.EXTREME EFFECTIVE PRINCIPLE STRESS	-248.47 KN/m^2	-228.45KN/m^2	-323.91 KN/m^2	-252.43KN/m^2
7.EXTREME TOTAL PRINCIPAL STRESS	-360.06KN/m^2	-329.85KN/m^2	-390.53 KN/m^2	-332.67 KN/m^2
8.HORIZONTAL EFFECTIVE STRESS	-173.84 KN/m^2	-140.20KN/m^2	-164.69 KN/m^2	-177.67 KN/m^2
9.VERTICAL EFFECTIVE STRESS	-179.73 KN/m^2	-183.57 KN/m^2	-229.53 KN/m^2	-228.82 KN/m^2
10.HORIZONTAL TOTAL STRESS	-300.01 KN/m^2	-270.96 KN/m^2	-262.03 KN/m^2	-260.00 KN/m^2
11. VERTICAL TOTAL STRAIN	-329.73 KN/m^2	-333.56KN/m^2	-335.02 KN/m^2	-337.11 KN/m^2

V. DISCUSSION AND CONCLUSION

The analysis and design of failing slopes requires an in-depth understanding of the failure mechanism in order to choose the right slope stability analysis method. The present study made it possible to compare on a real geometrical model the computation result that the behavior law stress-strain which is lacking to the limit equilibrium methods is integrated into the finite elements methods.

From here we can conclude that by mentioning the different comparative outcome parameters from this analysis that higher the cohesion and angle of friction value higher the stability apparently in preliminary aspects. From the above defined outcome results we have been seen that different stresses values are increasing with the increase of angle of friction value or some time decreasing also. But another important thing we can conclude here from this slope stability analysis by Plaxis-2D that is without giving a minimum value of cohesion this set of programme cannot run and doesn't give the experimental results.

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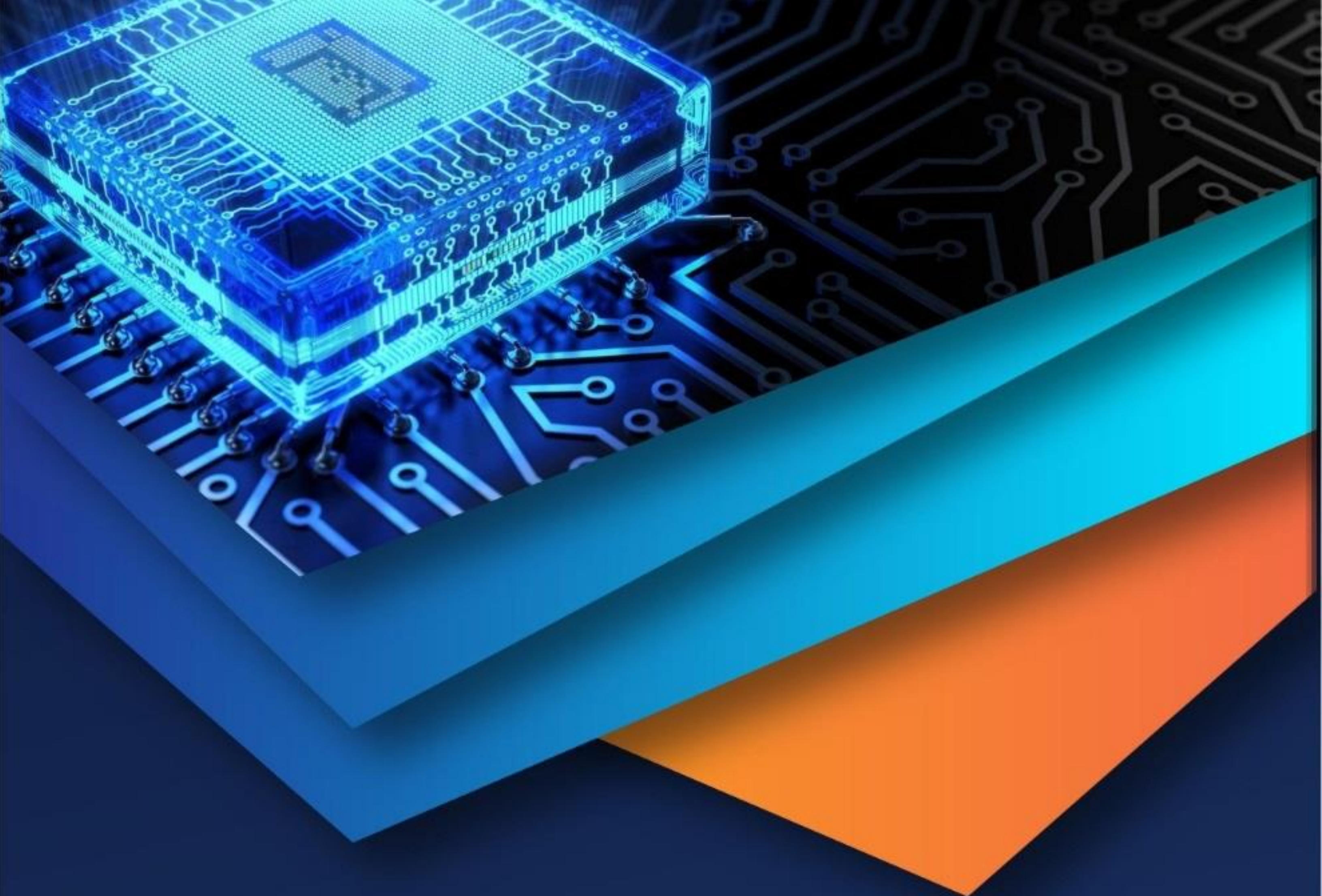

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