SLOPE STABILITY AND FACTOR OF SAFETY ANALYSIS ON DIFFERENT REGION OF SOIL BY USING GEO STUDIO SLOPE/W SOFTWARE

MAJOR II REPORT

SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS

FOR THE AWARD OF DEGREE OF

MASTERS OF TECHNOLOGY

IN

GEOTECHNICAL ENGINEERING

SUBMITTED BY

VISHAL RATHORE

(2K18/GTE/17)

Under the Supervision of

Prof. ANIL KUMAR SAHU

DEPARTMENT OF CIVIL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

DELHI 110042

AUGUST 2020

CIVIL ENGINEERING DEPARTMENT

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana Road, Delhi-110042

CANDIDATE'S DECLARATION

I, **VISHAL RATHORE,2K18/GTE/17** student of M tech (GEOTECHNICAL ENGINEERING),hereby declare that the dissertation entitled "**SLOPE STABILITY AND FACTOR OF SAFETY ANALYSIS ON DIFFERENT REGION OF SOIL BY USING GEO STUDIO SLOPE/W SOFTWARE**" which is submitted by me to department of Civil Engineering ,Delhi Technological University, Delhi In Partial fulfillment of the requirement of the award of the degree of Master Of Technology , is original and not copied from any source without proper citation .This work has not previously formed the basis for the award of any Degree, Diploma Associate ship, Fellowship or other similar title or recognition.

Place: New Delhi **(VISHALRATHORE)**

Date: August , 2020

CIVIL ENGINEERING DEPARTMENT

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana Road, Delhi-110042

CERTIFICATE

I hereby certify that the dissertation entitled "**SLOPE STABILITY AND FACTOR OF SAFETY ANALYSIS ON DIFFERENT REGION OF SOIL BY USING GEO STUDIO SLOPE/W SOFTWARE**" which is submitted by (**VISHALRATHORE ,2K18/GTE/17)** to department of Civil Engineering, Delhi Technological University, Delhi In Partial fulfillment of the requirement of the award of the degree of Master Of Technology, is record of the project work carried by the Student under my supervision . To the best of my knowledge this work has no been submitted in part or full for any Degree to this University or elsewhere.

Place: Delhi
Date: AUGUST 2020

(ANIL KUMAR SAHU)
PRPFESSOR SUPERVISOR
DEPARTMENT OF CIVIL ENGG
DTU DELHI 11004

ACKNOWLEDGEMENT

I thank my parents and God almighty for bestowing their blessings and grace in completion of minor project 2.

I express my sincere thanks to the respective V.C. of DTU and respective HOD of Civil Engineering Department and to the University Management. As I write this acknowledgement , I must clarify that this is not just a formal acknowledgement but also a sincere note of thanks and regards from my side . I feel a deep sense of gratitude and affection for those who associated with the project and without whose co-operation and guidance this project could not have been conducted properly.

Words fail me to express my regards towards my project guide, **Prof. A.K. Sahu**, Department of Civil Engineering ,Delhi Technological University , Delhi for giving me an opportunity to work under his guidance , which really instilled in me the requisite confidence.

I also express my deep gratitude to all the Faculty members of Department of Civil Engineering .

Last but not the least , I would like to thank my family and friends who stimulated me to bring this work to a successful close.

VISHAL RATHORE
2K18/GTE/17
DTU DELHI 110042

Table of contents

List of Tables and Figures

Tables

Figures

LIST OF ABBREVIATION

MDD : Maximum Dry Density

C : Cohesion

Φ : Internal friction angle

C_c : Coefficient of compression

C_u : Coefficient of Uniformity

D_{10} : Size of grain at which 10% finer by weight (Effective Particle size)

D_{30} : Size of grain at which 30% finer by weight

D_{60} : Size of grain at which 60% finer by weight

F.O.S : Factor of safety

ABSTRACT

The one of the main trouble in the industry of construction is on account of topography nature and the weather conditions is Slope stability . Excavations, hill roads, railway lines, embankments, earth dams, open-cut mines, reservoirs and coastal slope stability these type of applications can come under the consideration of slope engineering. One of the frequent disaster is Slope failure which can generate great loss in property and life. The project namely "Slope Stability and Factor of safety analysis" gives analysis of Four region soil (Himalaya, Jammu and Punjab and on DTU, Delhi) using Geo Studio Slope/w software. The analysis for stability of earth structures can be get from a general software tool Slope/W which is design and develop accordingly. The main essential thing that must be taking care of in the slope stability is in order to undergo the mountainous region project. The study is focus on slope stability analysis for Himachal Jammu and Punjab State and Delhi soil slope using Slope/w. Slope failure has become one of the most frequent geological disaster along the road network in the hilly terrain of Himalayan Jammu , Punjab and Delhi regions that lead to huge loss of life, property and above all the environment. The process of slope stability is very important to defence of the slopes from failure and minimize the likelihood of failure of slopes. By helping Geo Studio(Slope/w) software, the factor of safety and slope stability slope stability will be analyzed.

1. INTRODUCTION

India 2020 population is estimated about 1.38 billion people at mid year according to UN data . The population of india is approx 17.7% of the total population of the world . India ranks second in the list of countries which is by the number of population. The density of population in India is 464per square kilometer . As the population growth, we will need more land which mean that more civil engineering project work will be carried out in mountainous or hilly regions. In order to undergo the hilly region project, Slope stability is the most important thing that must be taking care of.

Due to the nature of the topography and weather conditions, Slope stability issue becomes one of the main problems in construction industry. Excavations, hill roads, railway lines, embankments, earth dams, open-cut mines, reservoirs and coastal slope stability these type of applications can come under the consideration of slope engineering. The most frequent natural disaster that can lead to great loss in property and life is acknowledged as Slope Failure. The stability of slope depends more on the driving force and resisting force because the driving force is greater than the resisting force which actually causes slope failures.

The main purpose of this study is to analyze slope stability by using Geo Studio Slope/w software. The stability analysis of earth structures can be obtained from a general software tool Slope/W which is design and develop accordingly. The sliding stability of a gravity retaining wall can be access by Slope/W, and for find out active earth forces on the wall. The stability of a wedge of soil that has been reinforced with a structural component such as a soil nail, geo-fabric, a pre-stressed anchor or some other material can ne analyzed by slope/W. By inserting the data to the software the software will analyze data in order to get slope stability. The data of the slope, which used in analyzing the slope stability using Slope/w, For Himachal , Jammu and Punjab soil was obtained from the research paper (vivek et al. 2015)“Slope stability Analysis” which was published in IJCEM (International journal core engineering and management) Volume 2, Issue 3, June 2015. Data used for DTU soil, analyzed in DTU laboratory itself.

1.1. Objective of the study

The analysis on slope stability using Geo Studio Slope/w software has two specific objectives which are:

1. To produce slope stability analysis for Himachal, Jammu, Punjab and DTU, Delhi soil slope using Slope/w.

2. To determine the factor of safety of slope stability of Himachal, Jammu, Punjab and DTU, Delhi soil slope using Slope/w.

2. Literature Reviews

This literature review of the project consists of titles such as research work , parameter and result of different research works on change in various attributes of Slope Stability.

Ravi Chandra , Bahnali Ghosh , S. B. Prasad , August 2016, "Stability Analysis of Slopes and Seismic Analysis of Earthen Dams using GeoStudio" Evaluation of Slope Stability and Seismic Analysis of Earthen Dams for different conditions by using the software slope/W .In this report under recorded earthquake the behavior of Earthen Dams analysed by using Finite Element Based Geostudio Qwake/W .Geotechnical software simulation were concerned on the effect of water pressure and the seismic response of earthdams to a recorded earthquake. At the three conditions first,middleand end times of the earthquake ,the earthquake behavior of the dams during the earthquake loading obtained as the results of the Numerical Analysis.

Shanmugapriya Dewdree and Siti Norafida Jusoh , 2019, "Slope stability analysis under different soil nailing parameters using the SLOPE/W software" For determining the most appropriate value for stabilization of soil slope using software Slope/W ,Soil nailing system was studied in terms of inclination of soil nailing . The best factor of safety found at (60°,50° and 40° respectively) with the horizontal . Soil nailing FOS varies very minute where the soil nails varies (5°-20°) respectively.

D. Durga Naga Laxmi Devi and R. Anbalagan , 2017 , "Study on Slope Stability of Earthen Dams by using Geostudio Software" By using the Slope/W and Seep/W software tools of Geostudio for sudden drawdown conditions and Steady State Seepage , FOS analysed . Seepage analysis and study stage seepage are essential for homogenous earthendams on downstreamside , Providing of drain on the Downstream side increases the FOS.

Imran Arshad and Muhammad Muneer , 2017, 'Numerical Analysis of Seepage and Slope Stability in an Earthen Dam by using Geo slope software" Bishap, Janbu , Ordinary Method of Slice and Morgenstern Price method these four analysis used for finding out the slope stability. It revealed that both side (Upstreamside and Downstreamside) of the dam section has a direct effect of FOS.

Michael Peter Serra , oct 2013 , University of Southern Queensland , Fculty of Engineering Science (Geotechnical Stability Analysis using student versions of FLAC, PLAXIS and SLOPE/W) By using FLAC and Plaxis , mesh can be generated in Finite Difference(FD) and Finite Element(FE) , gives best results . In FLAC student version it allows only coarse mess so it gives less accurate FOS compare to PLAXIS and SLOPE/W. Each software has its own limitations and benefits , user uses the software according to their model requirements.

Sarper Demirdogen , oct.2018, "Numerical Analysis of Leakage through Defective Geomembrane Liners in Embankment Dams" In this report a 2D numerical analysis conducted by using Seep/W for evaluating the leakage through geomembrane liner within an earthen dam. This study gives the appropriate idea which gives better understanding of how the parameters of geomembrane will affect the FOS of the downstream slope.

Marwah Qaddoori and Marwah Kamil Hussein , November 2019 , "Slope Stability Prediction of Homogeneous Earth dam caused by fluid particles seeps by using artificial neural networks" C, Φ,ϒ are used as input parameter of dam and find out the FOS by using entry and exit method , Here time series method used for analysis . Slip surfaces eliminated in Upstream and Downstream side of the dam to find out the FOS.

Ahnad Amirul Bin Mohd Zaki, july 2015, "Comparison of factor of safety using different method of analysis for slope stability" Margenstern Price , Jonbu, Ordinary and Bishop methods used in Slope/W and FOS analysed for each case . FOS of each type with the help of Slop/W calculated and compared with conventional analysis.

Yue Yan and Yahui Zhang , 2014 , "Impact of Balasting Vibration on Soil Slope Stability" Studies the stress-strain relationship of soil mass for finding out FOS in natural conditions as well as with vibration of blasting for finding out the most endangered slidy surfaces . The deformation , Stability and stress field of slope summarize the varying pattern of slope stability under the vibration of blasting.

Amin Pourkhosravani ,January 2011, "A review of current method for slope stability evaluation" In this report author discuss the different method of analysis of slope stability (Limit Equilibrium, Numerical Analysis method) L.E method has less accuracy than other methods . The method of analysis can be based on two things :Location of slope and probable slip surface.

Guangjin Wang et al. ,2011, " Research on slope stability analysis of super high dumping site based on cellular automation" The most important characteristics of super high jumping site is the size grading of particle . FLAC 3D software was used to analyze the stability of slope for various pilling up pattern slope based on the model. On site survey data obtained for granular size distribution and geological data. A model generated with the properties of particle size grading.

Digvijay et al. , 2017, "An overview on methods for slope stability analysis" For different soil type and slope condition the FOS find out with the principle of L.E. and F.EM. . The various factor of safety and various parameters used by the author and reviewed and disscuss . Ass s suggestion , same mathematical tools are suggested for analysis of slope.

Yu Zhoa and Zhi-Yi tong , 2014, "Slope Stability analysis using slice wise factor of safety" , In this report it is taken that the interslice force ratio is equal between the two slices and the slice weight is also taken into account for eccentric moment. Equilibrium forces and moments and the forces of interslice taken into consideration for calculating the FOS.

Xu ejun Zhou et al, 2018 , "Analysis of Slope stability with Imprecise soil properties using Uncertain sets" Due to variation of mineral composition and stress behavior of the soil. The uncertainity starts from the starting errors on account of sampling disturbance and human activities . The Unit weight, C and Φ expresses the uncertain sets of methodology.

An-Juili et al. , August 2018, "Seismic slope stability evaluation considering Rock Mass Disturbance varying in the slope" . In this analysis Finite Element and Limit Equilibrium approach is used for Seismic slope stability behavior . Same investigation performs for

Earthquake and Check out the Slope Failure During Earthquake , The generalized Hoek –Brown Failure Criterion is taken into account.

Yongtao Zhang , 2015, "The study methods and the New Progress of slope Stability" Two type of methods used (Limit Equilibrium and Numerical Analysis) most disadvantages introduce the 3D dynamic stability of slope on the research. It can concluded through that software . it is not exactly explained that all the very accurate results but it gives the mature and effective results.

Shuren Wang et al. , January 2019 , "Stability of step shaped Dump. Slope and reinforcement –Optimization analysis of Anti-Slide Piles" , By using FLAC 3D Software a three Dimentional numerical calculation done. Software made of dumping slope constructed and by the loading process the step shaped dumping slope analyzed,

Aizhang Lu, Ning Zhang , May 2015, "Analytical method of calculating slope stability by elasticity theory and limit equilibrium method" By explicit expressions Hmax can be calculated with the help of ϒ and Φ . By Non linear equation of ϒ, C and Φ , Φmax can be calculated.

Chunyuan Liu et al. , June 2018, "Analysis of Road Embankment slope stability" For different height and slopes different method of slope stability solved.

Katsahiki Arai and Keijchi Jagyo, March 1985, "Determination of Non circular slip surface giving the minimum factor of safety in slope stability analysis" Different shapes of slip surfaces like slice has been taken into consideration, each method have its own surface of slip here in this report non circular slip surface taken into consideration which gives the least value of FOS.

2.1. Type of Slope

Topography, Characteristics of soils and geography are the various factors which taken into account for analyzing the slope stability .Type of the soil is one of the main factor for analyzing any information. Infinite slope and Finite slope are the two types of slopes . and according to Murthy 2003 , Slopes has been also classified as natural slope and man made slope.

2.1.1. Infinite slope

A parallel surface considers from the surface of the original slope for too long slope failure. According to the balance of forces acting on slices "abcd" in figure, infinite slope stability analysis can made. Equation for FOS for infinite slope surface is show as:

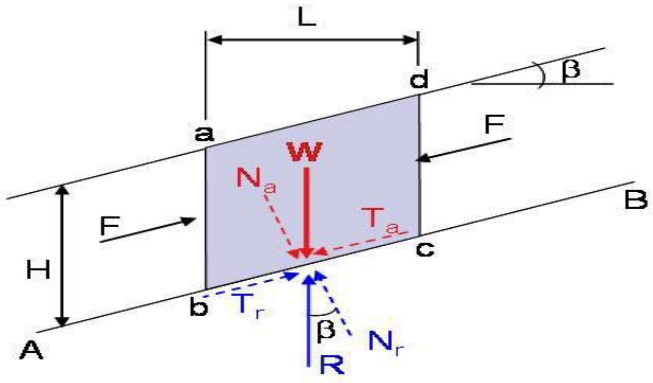

Figure1.1 : Analysis of infinite slope
Source: Winniyarti , 2010

FOS= $c/(\Upsilon H \cos^2\beta \tan\beta)+(\tan\Phi/\tan\beta)$

Where

FOS = factor of safety
c' = effective cohesion of soil (kN/ m^2)
γ = unit weight of soil (kN/m^3)
W = weight slice (= $\gamma \times$ slices area (kN/m)
α = inclination of slip surface (degree)
ϕ' = effective friction angle of the soil
β = inclination angle of slope.

If ground water level is below the plane of failure so c'=0

FOS= 9=$(\tan\Phi/\tan\beta$

2.1.2. Finite slope

The slopes generally considered as finite slope when the critical height approaches the height of slopes. The general shape of the surface of potential failure have to take into consideration for the analysis of finite slope. According to Culmann (1875) slope failures usually occurs on the curved failure surface. According to Swedish , Geotechnical commission recommended that actual failure surface may be to be circularly cylindrical . After this assumption in most of the stability analysis of slopes slopes is considered as arc of a circle.

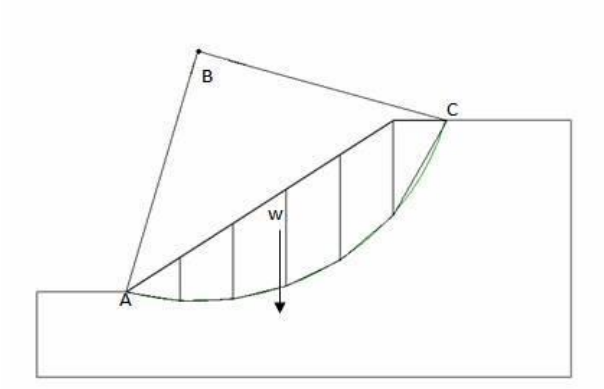

Figure1.2 : Circular slip surface

Source: Winniyarti , 2010

2.1.3. Natural Slopes

In hilly areas natural slopes can be obtain, in hill areas formation processes take a long time without disturbance process. The movement of the earth's core and earthquake may influenced th slope formation. This type of slopes are strong and stable as long as no human activities suh as mining and logging that effect the stability of slope .

2.1.4.Man-made slope

Man cut the slope or embankment for providing ground level to facilitate construction , mam made slopes are those slopes which are generated for desired construction . the stability of these type of slopes monitored time to time to prevent landslides. Itt can be classified into two categories :

1: Cut Slopes

2: Fill Slopes

1. Cut Slopes

Cut slope is one of the type of man –made slope which is generated for the construction of roads and other infrastructures. By changing the height and angle the geometry of the slope construction influenced . Each country has its own guidelines for construction of cut slopes.

2. Fill slopes

Fill slope is one of the type of man made slope, It can be generated by reclamation of land from other areas.This type of slope can be seen easily in Highway construction.Each country has its ownguidelins for construction of fill slope.

2.2. Types of slope failure

In response to gravitational stresses the movement of rock debris and and soil can lead to the slope failure.The several types of the failures are obtained through the study of ground movement.

1. Topples
2. Flowage
3. Sliding
4. Lateral spread

1. Topple

About a point or axis below the centre of gravity of the displaced mass, Topples is the forward rotation out of the slope of rock mass or soil mass. It is sometimes driven by gravity exerted by material upslope tf the displaced mass and sometimes by water or ice in cracks in the soil mass. These type of slope failures occurs due to human activity such as cutting slopes , quarrying which are not in prescribed standards .

Figure1.3 : Topple

Source : Idaho Geological Survey , 2008

2.Flowage

The main mechanism for this process is depends on the water content .When the material is in the liquid state, flow can be defined as unconsolidated material. In this type of slope failure the several categories are:

1. Debris flow

2. Mudflow

Debris flow :

The combination of rock, loose soil, organic matter, air and water mobilize as slurry in the form of rapid mass movement that flows down slope. Debris flow is due to intense surface water flow, On account of heavy rain of rapid snowmelt erodes and mobilizes loose soils or rock on steep slopes.

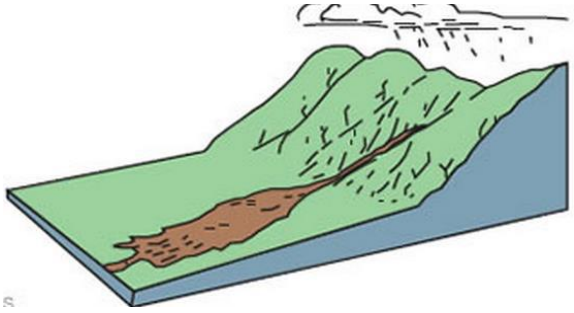

Figure1.4: Debris flow

Source : Idaho Geological Survey , 2008.

2. Mudflow :

Those type of materials that are wet enough to flow rapidly and contains atleast 50% sand , silt and clay size particles comes in the mud flow .Those countries have high heavy rainfall mudflow is one of the main kind of slope failure that occurs frequently. Mudflows and the Debris flow are referred as “mudslides”.

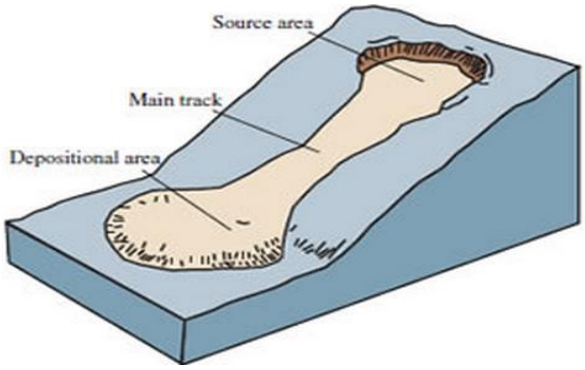

Figure1.5 : Mudflow

Source : Idaho Geological Survey , 2008.

3. Sliding

It can be defined as Continuous and uniform movements in a smooth surface, It can be classified as:

1. Translational slide

2. Rotational slide

1. Translational slide :

In the translational slide landslides occurs when the slide downwards and outwards translationally . When the base is stronger than the upper layer slip plane influenced . landslides of this type contains a greater failure. This is due to the fault plane , which extends for some distance and it is very difficult for expected failure.

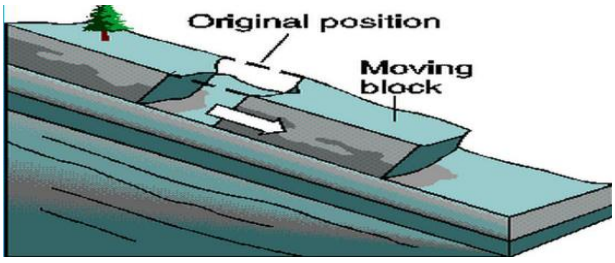

Figure1.6 : Translational Slide

Source : Idaho Geological Survey , 2008.

2. Rotational Slide

It is also known as slump , It is described as the sliding of the material along the curved surface. due to the erosion at the base of the slope this slide occurs. It slides downward or outwards that gives the backward tilt to the slipping mass.

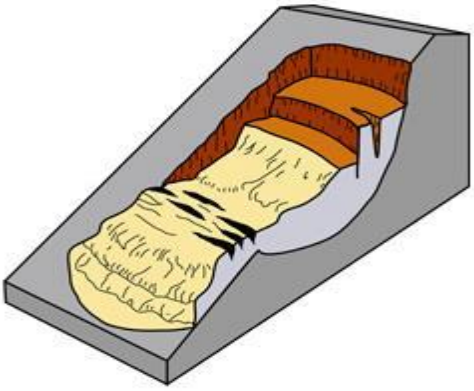

Figure1.7 : Rotational slide

Source ;Idaho Geological Survey , 2008.

4. Lateral spread:

This type of the slope failure occurs at a very wavy or gentle slope. By shear or tensile fractures lateral extension accompanied . By rapid movement of the soil failure occurs, such as by the earthquake effect. Lateral spreading in fine grained materials on low slopes is progressive, the failure starts in a small area and spreads rapidly.

Figure1.8 : Lateral spread

Source : Idaho Geological Survey , 2008.

3.Methodology

In this report we have taken soil sample of Himachal, Jammu, Punjab and DTU, Delhi region and study of slope stability done with the help of geotechnical software code Slope/w (Geo-slope). By using the limit equilibrium within the Morgenstern–Price method, Bishop, Janbu and Ordinary Method along with Mohr-Coulomb expression Factor of safety determined. We have taken laboratory test results on soil to get the Cohesion, Unit weight and Phi value of all Four sample of soil. **The Lab results for Himachal, Jammu and Punjab soil ontained from the research paper "Slope stability Analysis" which was published in IJCEM (International journal core engineering and management) Volume 2, Issue 3, June 2015**. For DTU, Delhi soil sample the following laboratory test has been conducted in the DTU laboratory:

- Modified Proctor Test (IS 2720(1986) Part-13)
- Direct Shear Test (IS 2720(1983) Part-8)
- Sieve Analysis (IS 2720(1985) Part-4)

3.1. Software Package and the respective method Used

GEO-SLOPE International Ltd. , Slope/W 2018 R2 version 9.1.1.16749 (Student License), Operative system Microsoft windows 7 used for performing the analysis.

A software tool Slope/W uses Limit Equilibrium method for computing the FOS OF earth slopes and rock slopes. The uses should know about the geotechnical principles which involved in the analysis and the final judgment is necessary to ensure that actual soil properties are used to find the FOS. ϒ(Unit weight), C(Cohesion) and Φ(Internal friction angle) of soil requires for this analysis.

3.1.1. Limit Equilibrium Method (LE)

The most widely used approach is Limit Equilibrium for solving geotechnical engineering problems like slope stability failures . The limit Equilibrium method requires criteria of Mohr coulomb where the material failure is on account of the combination of the maximum normal stress and maximum shear stress With the help of the soil properties Limit Equilibrium works . The working principle of Mohr column criteria is slope stability by comparison of the forces causing failure against resisting forces .With the help of static equilibrium equation FOS can be analyzed. The basic assumption of the failure is that failure occurs by sliding of mass or block along the slip surface.

3.1.2. Morgenstern-Price Method

This method was generated by N.R. Morgenstern, E. Spencer, which consider not only the normal and tangential equilibrium but also the moment equilibrium for each slice in circular and non-circular slip surfaces. It is solved for the factor of safety using the summation of forces

tangential and normal to the base of a slice and the summation of moments about the center of the base of each slice. The equations were written for a slice of infinitesimal thickness. The Combination of Moment and Force equilibrium and a modified numerical technique of Newton-Raphson was used to solve for the factor of safety satisfying force and moment equilibrium. The requirement of solution an self made assumption regarding the direction of the resultant of the interslice shear and normal forces.

4.Results and Discussion

Modified Proctor test , Direct Shear test and Sieve analysis perform on all the three types of soil , MDD obtained from Modified Proctor test, and by plotting the curve between Normal stress and Shear stress in Direct shear test Φ and C value obtained , And with the help of sieve analysis obtained the classification of soil sample and Cu and Cc. Here in this report we are taking the data from the research paper "Slope stability Analysis" which was published in International Journal of Core Engineering & management (IJCEM) Volume 2, Issue 3, June 2015.

4.1.1. Laboratory Test Results of Himachal Soil (Vivek et al. 2015)

MDD = 2.13g/cm^3 =19.31kN/m^3 (By modified Proctor test)

Value Of ϕ = 48° and C= 0.0514 N/mm^2 =51.4 kPa (By Direct Shear test)

Well Graded Soil D10 = 0.081 D30 = 0.18 D60 = 0.52 CU = 0.642 % Gravel = 8.4 % Fines = 8.8 CC = 0.77 % Sand = 82.8% Unified Classification of Soil: SW (By sieve analysis)

4.1.2. Laboratory Test Results of Jammu Soil (Vivek et al. 2015)

MDD = 1.85g/cm^3 = 16.77kN/m^3 (By modified Proctor test)

Value Of ϕ = 64.66° Value Of C= 0.0319 N/mm2 =31.9 kPa (By Direct Shear test)

Well Graded Soil D10 = 0.18 D30 = 0.45 D60 = 1.39 CU = 7.72 % Gravel = 3.2 % Fines = 0.4 CC = 0.81 % Sand = 96.4% Unified Classification of Soil: SW (By sieve analysis)

4.1.3. Laboratory Test Result of Punjab Soil (Vivek et al. 2015)

MDD = 1.86g/cm^3 =18.24kN/m^3 (By modified Proctor test)

Value Of ϕ = 36.86° Value Of C= 0.053 N/mm2 =53 kPa (By Direct Shear test)

Well Graded Soil D10 = 0.081 D30 = 0.18 D60 = 0.52 CU = 0.642 % Gravel = 8.4 % Fines = 8.8 CC = 0.77 % Sand = 82.8 Unified Classification of Soil: SW (By sieve analysis)

4.1.4 Laboratory Test Result of DTU, Delhi Soil (By Lab tests conducted in DTU Lab)

MDD = 1.69g/cm^3 =16.57kN/m^3 (By modified Proctor test)

Value Of ϕ = 41.78° Value Of C= 0.004 N/mm2 =4.05 kPa (By Direct Shear test)

Well Graded Soil D10 = 0.15 D30 = 0.21 D60 = 0.4 CU = 2.67 CC = 0.735

Unified Classification of Soil: SP (By sieve analysis)

4.2. Slope/W analysis

4.2.1. Slope/W analysis of Himachal Soil with Morgenstern-Price Method

File Information

File Version: 9.01
Revision Number: 1
Date: 05/03/2020
Time: 05:24:15 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W HIMACHAL SOIL.gsz
Directory: C:\Users\Sys\Documents\
Last Solved Date: 05/03/2020
Last Solved Time: 05:24:18 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE/W Analysis on Himachal soil

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
Side Function
Interslice force function option: Half-Sine
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 9.807 kN/m³
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 m
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 2,000
Tolerable difference in F of S: 0.01
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Piezometric Line 1

Table1.1: Coordinates

X(m)	Y(m)
0	10
22.8	6

Materials

Soil layer

Model: Mohr-Coulomb
Unit Weight: 19.31 kN/m³
Cohesion': 51.4 kPa
Phi': 48 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Table1.2: Region

	Materials	Points	Area
Region 1	Soil layer	1,2,3,4,5,6	316 m^2

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.96, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Range
Right-Zone Left Coordinate: (32.82, 4) m
Right-Zone Right Coordinate: (33, 4) m
Right-Zone Increment: 8
Radius Increments: 4

Table1.3: Points

	X(m)	Y(m)
Point 1	0	14
Point 2	10	14
Point 3	26	4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 4) m

Slip Results

Slip Surfaces Analysed: 180 of 225 converged

Current Slip Surface

Slip Surface: 183
Factor of Safety: 4.552
Volume: 150.40423 m³
Weight: 2,904.3056 kN
Resisting Moment: 107,789.91 kN·m
Activating Moment: 23,679.525 kN·m
Resisting Force: 3,709.4992 kN
Activating Force: 815.09665 kN
Slip Rank: 1 of 225 slip surfaces
Exit: (32.82, 4) m
Entry: (1, 14) m
Radius: 25.782497 m
Center: (22.804997, 27.75788) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength (kPa)	Suction Strength (kPa)	Base Material
Slice 1	1.498052	13.267647	-34.623251	-1.5532061	-1.7250101	51.4	0	Soil layer
Slice 2	2.4941561	11.897488	-22.899923	19.816231	22.008154	51.4	0	Soil layer
Slice 3	3.4902601	10.695871	-12.82949	38.667619	42.944742	51.4	0	Soil layer

Slice 4	4.4863642	9.6288006	-4.0785547	55.629565	61.782891	51.4	0	Soil layer
Slice 5	5.4859746	8.6704509	3.6001247	71.733872	75.670193	51.4	0	Soil layer
Slice 6	6.4890913	7.8052209	10.359546	87.034706	85.156392	51.4	0	Soil layer
Slice 7	7.4922081	7.0246489	16.288727	101.14264	94.239823	51.4	0	Soil layer
Slice 8	8.4953249	6.3194378	21.478843	114.34903	103.14279	51.4	0	Soil layer
Slice 9	9.4984416	5.6823329	26.001042	126.87369	112.03043	51.4	0	Soil layer
Slice 10	10.533333	5.0912612	30.017124	133.86605	115.33591	51.4	0	Soil layer
Slice 11	11.6	4.5450715	33.538378	135.12763	112.8263	51.4	0	Soil layer
Slice 12	12.666667	4.0594642	36.465501	135.57175	110.06864	51.4	0	Soil layer
Slice 13	13.733333	3.6307704	38.834473	135.18124	107.00393	51.4	0	Soil layer
Slice 14	14.8	3.2559949	40.674668	133.90785	103.54594	51.4	0	Soil layer
Slice 15	15.866667	2.9326899	42.010093	131.67801	99.586315	51.4	0	Soil layer
Slice 16	16.933333	2.6588619	42.860296	128.3987	95.000027	51.4	0	Soil layer
Slice 17	18	2.4329027	43.241049	123.96396	89.651869	51.4	0	Soil layer
Slice 18	19.066667	2.2535375	43.164856	118.26228	83.404134	51.4	0	Soil layer
Slice 19	20.133333	2.1197866	42.641323	111.18513	76.125611	51.4	0	Soil layer
Slice 20	21.2	2.0309372	41.677441	102.63631	67.701687	51.4	0	Soil layer
Slice 21	22.266667	1.9865241	40.277772	92.541772	58.045052	51.4	0	Soil layer
Slice 22	23.333333	1.9863172	39.362187	84.72652	50.382196	51.4	0	Soil layer
Slice 23	24.4	2.0303154	38.930697	79.150649	44.668782	51.4	0	Soil layer
Slice 24	25.466667	2.1187467	38.063451	71.835004	37.507109	51.4	0	Soil layer
Slice 25	26.568333	2.2579896	36.697896	63.859635	30.166167	51.4	0	Soil layer
Slice 26	27.705	2.4519122	34.796097	59.909744	27.89153	51.4	0	Soil layer
Slice 27	28.841667	2.6988692	32.37419	54.461784	24.530758	51.4	0	Soil layer
Slice 28	29.978333	3.0004513	29.416574	47.575021	20.166999	51.4	0	Soil layer
Slice 29	31.115	3.3586889	25.903338	39.347048	14.930752	51.4	0	Soil layer
Slice 30	32.251667	3.7761274	21.809519	29.905045	8.9909924	51.4	0	Soil layer

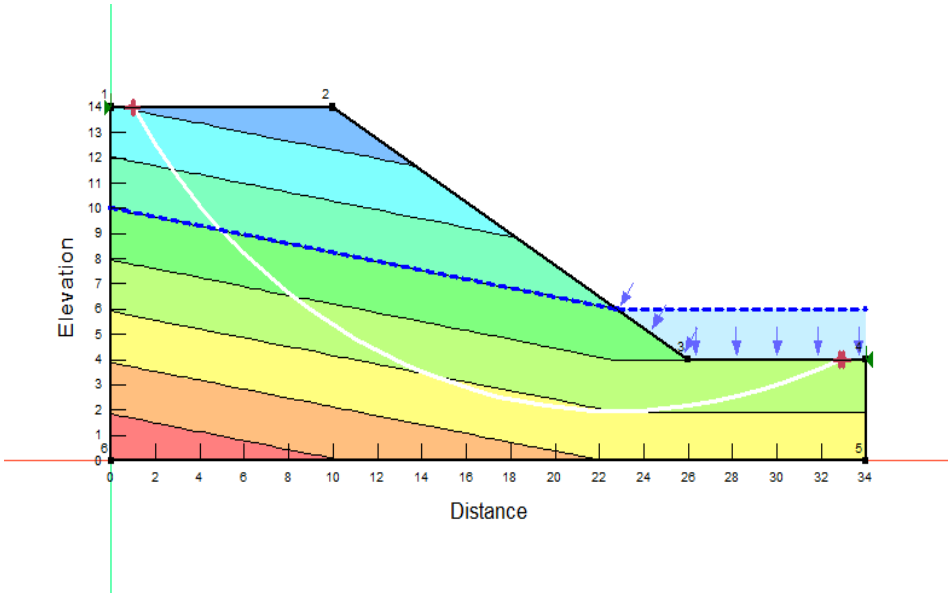

Figure2.1: Pore Pressure through Piezometric line (Himachal region sample Slope/W Analysis with Morgenstern-Price method)

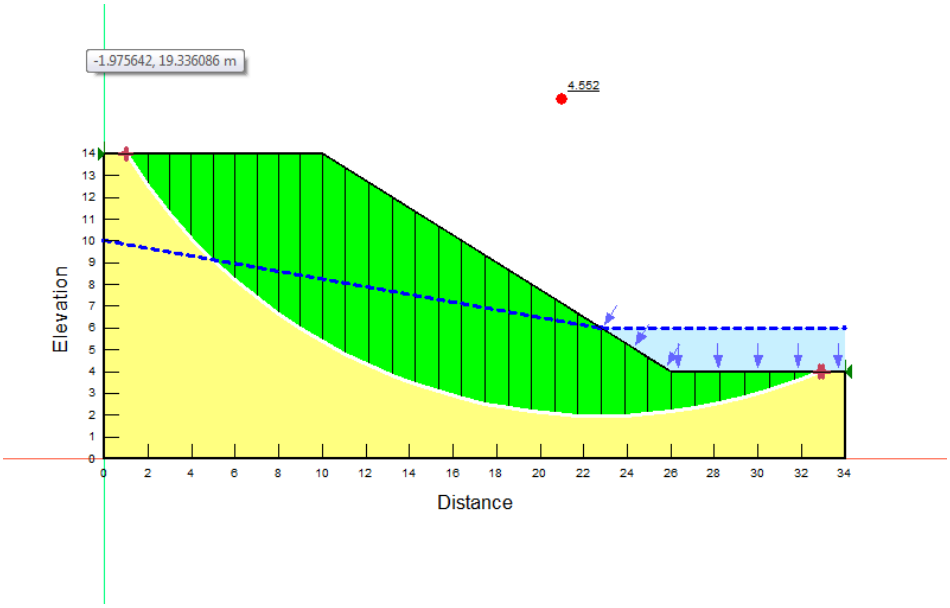

Figure2.2: Factor of safety and slip surface results of Morgenstern-Price analysis computed by SLOPE/W

4.2.2. Slope/W analysis on Himachal soil with Bishop Method

File Information

File Version: 9.01
Revision Number: 2
Date: 06/21/2020
Time: 02:15:30 AM
Tool Version: 9.1.1.16749
File Name: SLOPE W HIMACHAL BISHOP.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope Himachal soil Content\
Last Solved Date: 06/21/2020
Last Solved Time: 02:15:34 AM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE W HIMACHAL SOIL BISHOP

Kind: SLOPE/W
Method: Bishop
Settings
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: Yes
Use Staged Rapid Drawdown: No
Unit Weight of Water: 9.807 kN/m³
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 m
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 30
Tolerable difference in F of S: 0.01

Materials

Soil Layer

Model: Mohr-Coulomb
Unit Weight: 19.31 kN/m³
Cohesion': 51.4 kPa
Phi': 48 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.96, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Range
Right-Zone Left Coordinate: (32.82, 4) m
Right-Zone Right Coordinate: (33, 4) m
Right-Zone Increment: 4

Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 4) m

Slip Results

Slip Surfaces Analysed: 100 of 125 converged

Current Slip Surface

Slip Surface: 103
Factor of Safety: 4.575
Volume: 150.40423 m³
Weight: 2,904.3056 kN
Resisting Moment: 108,326.24 kN·m
Activating Moment: 23,679.525 kN·m
Slip Rank: 1 of 125 slip surfaces
Exit: (32.82, 4) m
Entry: (1, 14) m
Radius: 25.782497 m
Center: (22.804997, 27.75788) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength(kPa)	Suction Strength (kPa)	Base Material
Slice 1	1.498052	13.267647	-33.589413	-1.7470058	-1.9402465	51.4	0	Soil Layer
Slice 2	2.4941561	11.897488	-22.216139	20.003657	22.216312	51.4	0	Soil Layer
Slice 3	3.4902601	10.695871	-12.446405	40.081511	44.515027	51.4	0	Soil Layer
Slice 4	4.4863642	9.6288006	-3.9567704	58.67548	65.165723	51.4	0	Soil Layer
Slice 5	5.4859746	8.6704509	3.4926262	76.624252	81.220899	51.4	0	Soil Layer
Slice 6	6.4890913	7.8052209	10.050213	93.818148	93.033717	51.4	0	Soil Layer
Slice 7	7.4922081	7.0246489	15.802351	109.59302	104.16509	51.4	0	Soil Layer
Slice 8	8.4953249	6.3194378	20.837492	124.09361	114.67753	51.4	0	Soil Layer
Slice 9	9.4984416	5.6823329	25.22466	137.43426	124.62139	51.4	0	Soil Layer
Slice 10	10.533333	5.0912612	29.120823	144.37187	127.99926	51.4	0	Soil Layer
Slice 11	11.6	4.5450715	32.536934	144.70664	124.57707	51.4	0	Soil Layer
Slice 12	12.666667	4.0594642	35.376654	143.71844	120.32574	51.4	0	Soil Layer
Slice 13	13.733333	3.6307704	37.674889	141.4808	115.28815	51.4	0	Soil Layer
Slice 14	14.8	3.2559949	39.460137	138.05246	109.49787	51.4	0	Soil Layer
Slice 15	15.866667	2.9326899	40.755686	133.47999	102.98077	51.4	0	Soil Layer
Slice 16	16.933333	2.6588619	41.580502	127.79973	95.75615	51.4	0	Soil Layer

Slice 17	18	2.4329027	41.949886	121.0391	87.837476	51.4	0	Soil Layer
Slice 18	19.066667	2.2535375	41.875968	113.21766	79.232978	51.4	0	Soil Layer
Slice 19	20.133333	2.1197866	41.368068	104.34769	69.945951	51.4	0	Soil Layer
Slice 20	21.2	2.0309372	40.432967	94.434626	59.974918	51.4	0	Soil Layer
Slice 21	22.266667	1.9865241	39.075092	83.477274	49.31362	51.4	0	Soil Layer
Slice 22	23.333333	1.9863172	39.362187	74.742749	39.294095	51.4	0	Soil Layer
Slice 23	24.4	2.0303154	38.930697	68.289409	32.606153	51.4	0	Soil Layer
Slice 24	25.466667	2.1187467	38.063451	60.84834	25.305183	51.4	0	Soil Layer
Slice 25	26.568333	2.2579896	36.697896	55.585831	20.977177	51.4	0	Soil Layer
Slice 26	27.705	2.4519122	34.796097	52.514352	19.678116	51.4	0	Soil Layer
Slice 27	28.841667	2.6988692	32.37419	48.379484	17.77568	51.4	0	Soil Layer
Slice 28	29.978333	3.0004513	29.416574	43.133248	15.23391	51.4	0	Soil Layer
Slice 29	31.115	3.3586889	25.903338	36.715791	12.008446	51.4	0	Soil Layer
Slice 30	32.251667	3.7761274	21.809519	29.052616	8.044275	51.4	0	Soil Layer

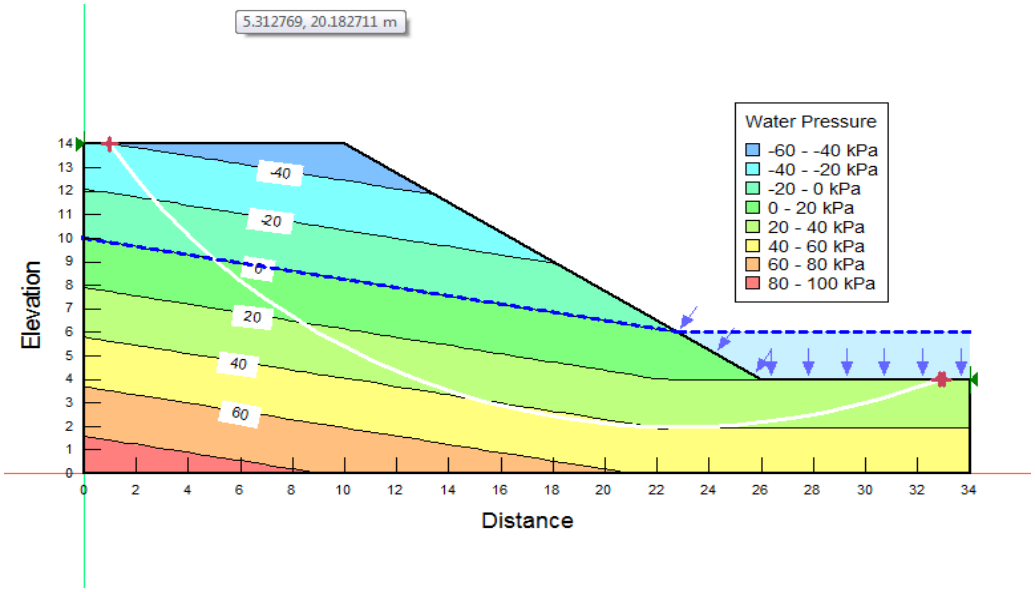

Figure2.3: Pore Pressure through Piezometric line (Himachal region sample Slope/W Analysis with Bishop method)

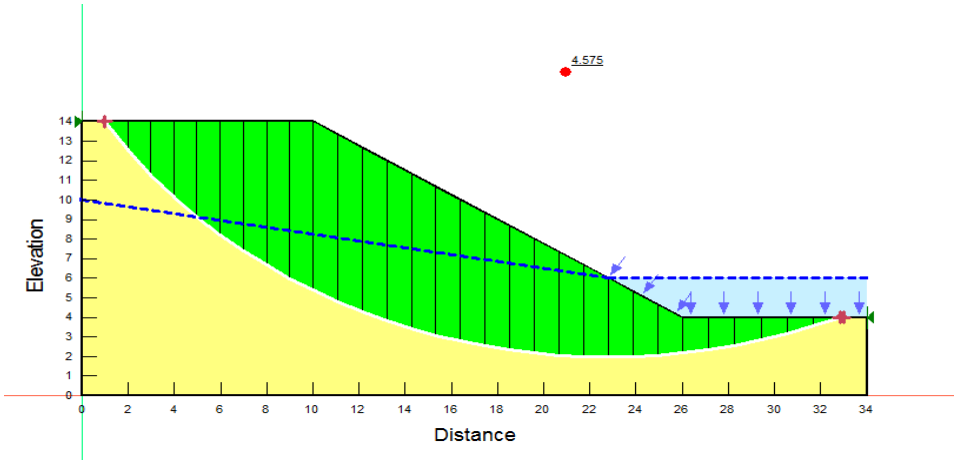

Figure2.4: Factor of safety and slip surface results of Bishop analysis computed by SLOPE/W

4.2.3. Slope/W analysis of Himachal soil with Janbu Method

File Information

File Version: 9.01
Revision Number: 1
Date: 06/21/2020
Time: 02:04:50 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W HIMACHAL JANBU.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope Himachal soil Content\
Last Solved Date: 06/21/2020
Last Solved Time: 02:04:56 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

Slope w Himachal Janbu

Kind: SLOPE/W
Method: Janbu
Settings
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: Yes
Use Staged Rapid Drawdown: No

Unit Weight of Water: 9.807 kN/m³

Slip Surface

Direction of movement: Left to Right

Use Passive Mode: No

Slip Surface Option: Entry and Exit

Critical slip surfaces saved: 1

Optimize Critical Slip Surface Location: No

Tension Crack Option: (none)

Distribution

F of S Calculation Option: Constant

Advanced

Geometry Settings

Minimum Slip Surface Depth: 0.1 m

Number of Slices: 30

Factor of Safety Convergence Settings

Maximum Number of Iterations: 100

Tolerable difference in F of S: 0.001

Materials

Soil Layer

Model: Mohr-Coulomb

Unit Weight: 19.31 kN/m³

Cohesion': 51.4 kPa

Phi': 48 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range

Left-Zone Left Coordinate: (0.96, 14) m

Left-Zone Right Coordinate: (1, 14) m

Left-Zone Increment: 4

Right Type: Range

Right-Zone Left Coordinate: (32.82, 4) m

Right-Zone Right Coordinate: (33, 4) m

Right-Zone Increment: 4

Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m

Right Coordinate: (34, 4) m

Slip Results

Slip Surfaces Analysed: 100 of 125 converged

Current Slip Surface

Slip Surface: 104
Factor of Safety: 4.173
Volume: 216.60687 m³
Weight: 4,182.6786 kN
Resisting Force: 4,407.511 kN
Activating Force: 1,056.2541 kN
Slip Rank: 1 of 125 slip surfaces
Exit: (32.82, 4) m
Entry: (1, 14) m
Radius: 20.107733 m
Center: (20.277944, 19.716799) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength (kPa)	Suction Strength(kPa)	Base Material
Slice 1	1.4929643	12.683382	-28.022126	-4.3665404	-4.8495344	51.4	0	Soil Layer
Slice 2	2.478893	10.422693	-8.159217	30.134049	33.467252	51.4	0	Soil Layer
Slice 3	3.4738675	8.7120593	6.4552692	61.09895	60.687955	51.4	0	Soil Layer
Slice 4	4.4778879	7.306374	18.15333	89.426633	79.157022	51.4	0	Soil Layer
Slice 5	5.4819083	6.1209262	27.756015	113.81761	95.581089	51.4	0	Soil Layer
Slice 6	6.4859286	5.1008895	35.784952	135.24428	110.46077	51.4	0	Soil Layer
Slice 7	7.489949	4.2131018	42.555649	154.29852	124.10303	51.4	0	Soil Layer
Slice 8	8.4939694	3.4356803	48.276303	171.3732	136.71295	51.4	0	Soil Layer
Slice 9	9.4979898	2.7533171	53.092558	186.74473	148.43577	51.4	0	Soil Layer
Slice 10	10.527685	2.1415547	57.19425	195.384	153.47526	51.4	0	Soil Layer
Slice 11	11.583054	1.5956165	60.626824	197.08914	151.55675	51.4	0	Soil Layer
Slice 12	12.638424	1.1255865	63.337196	197.07674	148.53281	51.4	0	Soil Layer
Slice 13	13.693793	0.72580218	65.379238	195.47265	144.48337	51.4	0	Soil Layer
Slice 14	14.749163	0.3918861	66.794599	192.37185	139.46767	51.4	0	Soil Layer
Slice 15	15.804533	0.12045879	67.615431	187.84524	133.52872	51.4	0	Soil Layer
Slice 16	16.871199	0	66.981068	187.41321	133.75345	51.4	0	Soil Layer
Slice 17	17.949163	0	65.181782	174.40354	121.30305	51.4	0	Soil Layer
Slice 18	19.027127	0	63.382497	161.39386	108.85265	51.4	0	Soil Layer
Slice 19	20.105091	0	61.583211	148.38419	96.402252	51.4	0	Soil Layer
Slice 20	21.183054	0	59.783926	135.37451	83.951852	51.4	0	Soil Layer
Slice 21	22.261018	0	57.984641	122.36484	71.501453	51.4	0	Soil Layer
Slice 22	23.511836	0	58.842	111.63214	58.62939	51.4	0	Soil Layer
Slice 23	24.667754	0.099372651	57.867452	108.62645	56.373576	51.4	0	Soil Layer
Slice 24	25.555918	0.31957981	55.707881	99.869414	49.046352	51.4	0	Soil Layer
Slice 25	26.568333	0.62769591	52.686186	92.262197	43.953613	51.4	0	Soil Layer
Slice 26	27.705	1.0409942	48.63297	85.558072	41.00948	51.4	0	Soil Layer

Slice 27	28.841667	1.5346943	43.791253	77.208382	37.113482	51.4	0	Soil Layer
Slice 28	29.978333	2.1155981	38.094329	67.033751	32.140484	51.4	0	Soil Layer
Slice 29	31.115	2.7927418	31.453581	54.788976	25.916581	51.4	0	Soil Layer
Slice 30	32.251667	3.5783326	23.749292	40.127956	18.190349	51.4	0	Soil Layer

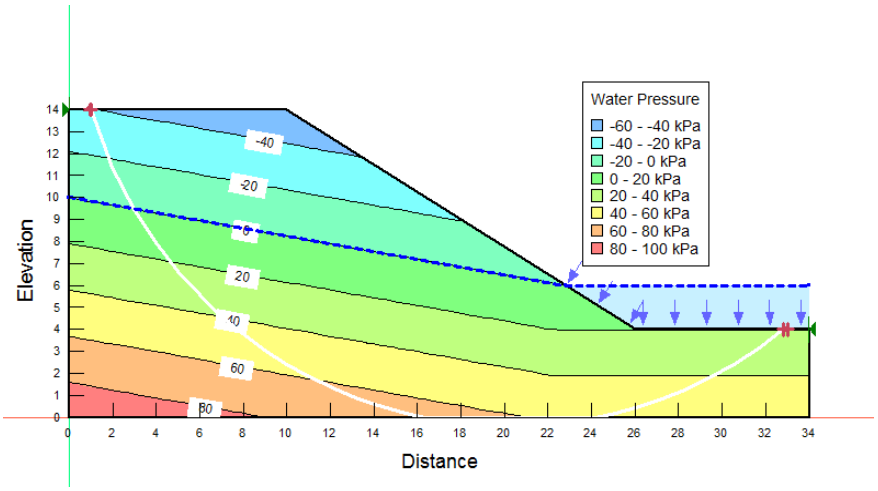

Figure2.5 : Pore Pressure through Piezometric line (Himalayan region sample Slope/W Analysis with Janbu method)

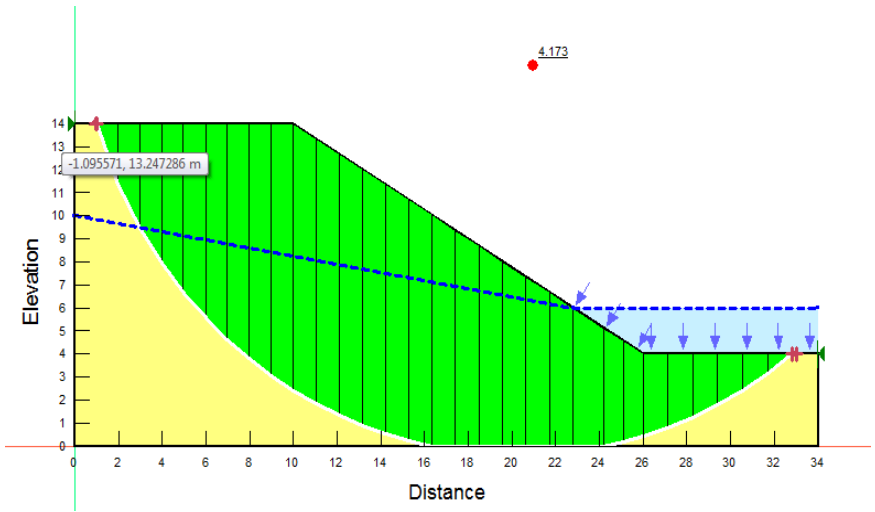

Figure2.6: Factor of safety and slip surface results of Janbu analysis computed by SLOPE/W

4.2.4. Slope/W analysis of Himachal soil by Ordinary method

File Information

File Version: 9.01
Revision Number: 1
Date: 06/21/2020
Time: 02:45:06 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W HIMACHAL Ordinary.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope Himachal soil Content\
Last Solved Date: 06/21/2020
Last Solved Time: 02:45:08 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

Slope w himachal Ordinary

Kind: SLOPE/W
Method: Ordinary
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 9.807 kN/m³

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 m
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001

Materials

New Material

Model: Mohr-Coulomb
Unit Weight: 19.31 kN/m³
Cohesion': 51.4 kPa
Phi': 48 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.96, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Range
Right-Zone Left Coordinate: (32.82, 4) m
Right-Zone Right Coordinate: (33, 4) m
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 4) m

Slip Results

Slip Surfaces Analysed: 100 of 125 converged

Current Slip Surface

Slip Surface: 104
Factor of Safety: 4.246
Volume: 216.60687 m³
Weight: 4,182.6786 kN
Resisting Moment: 95,053.864 kN·m
Activating Moment: 22,387.531 kN·m
Slip Rank: 1 of 125 slip surfaces
Exit: (32.82, 4) m
Entry: (1, 14) m
Radius: 20.107733 m
Center: (20.277944, 19.716799) m

Slip Slices

	X (m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength (kPa)	Suction Strength (kPa)	Base Material
Slice 1	1.4929643	12.683382	-28.022126	3.1259131	3.4716782	51.4	0	New Material
Slice 2	2.478893	10.422693	-8.159217	14.799522	16.436534	51.4	0	New Material
Slice 3	3.4738675	8.7120593	6.4552692	35.165932	31.886422	51.4	0	New Material
Slice 4	4.4778879	7.306374	18.15333	60.544314	47.079957	51.4	0	New Material
Slice 5	5.4819083	6.1209262	27.756015	84.701762	63.244659	51.4	0	New Material
Slice 6	6.4859286	5.1008895	35.784952	107.75603	79.931978	51.4	0	New Material
Slice 7	7.489949	4.2131018	42.555649	129.69766	96.781013	51.4	0	New Material
Slice 8	8.4939694	3.4356803	48.276303	150.46464	113.49165	51.4	0	New Material
Slice 9	9.4979898	2.7533171	53.092558	169.97303	129.80892	51.4	0	New Material
Slice 10	10.527685	2.1415547	57.19425	183.68708	140.48453	51.4	0	New Material
Slice 11	11.583054	1.5956165	60.626824	190.51863	144.25947	51.4	0	New Material
Slice 12	12.638424	1.1255865	63.337196	194.59822	145.78014	51.4	0	New Material
Slice 13	13.693793	0.72580218	65.379238	196.0399	145.11336	51.4	0	New Material
Slice 14	14.749163	0.3918861	66.794599	194.96532	142.34801	51.4	0	New Material
Slice 15	15.804533	0.12045879	67.615431	191.50453	137.59278	51.4	0	New Material
Slice 16	16.871199	0	66.981068	187.41321	133.75345	51.4	0	New Material
Slice 17	17.949163	0	65.181782	174.40354	121.30305	51.4	0	New Material
Slice 18	19.027127	0	63.382497	161.39386	108.85265	51.4	0	New Material
Slice 19	20.105091	0	61.583211	148.38419	96.402252	51.4	0	New Material
Slice 20	21.183054	0	59.783926	135.37451	83.951852	51.4	0	New Material
Slice 21	22.261018	0	57.984641	122.36484	71.501453	51.4	0	New Material
Slice 22	23.511836	0	58.842	111.63214	58.62939	51.4	0	New Material
Slice 23	24.667754	0.099372651	57.867452	99.178153	45.880181	51.4	0	New Material
Slice 24	25.555918	0.31957981	55.707881	88.053011	35.922907	51.4	0	New Material
Slice 25	26.568333	0.62769591	52.686186	81.594122	32.105515	51.4	0	New Material
Slice 26	27.705	1.0409942	48.63297	72.91254	26.965194	51.4	0	New Material
Slice 27	28.841667	1.5346943	43.791253	62.965474	21.295129	51.4	0	New Material
Slice 28	29.978333	2.1155981	38.094329	51.829853	15.254844	51.4	0	New Material
Slice 29	31.115	2.7927418	31.453581	39.589997	9.0364049	51.4	0	New Material
Slice 30	32.251667	3.5783326	23.749292	26.333738	2.8703173	51.4	0	New Material

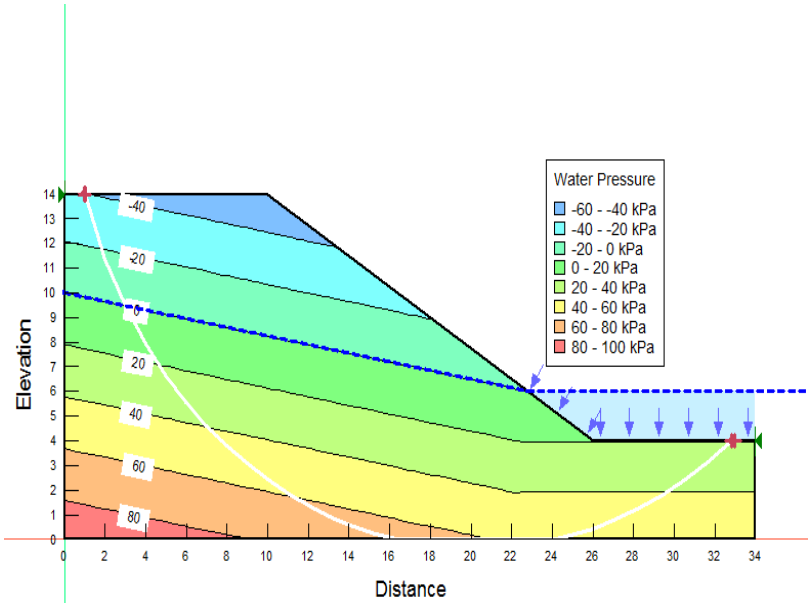

Figure2.7: Pore Pressure through Peizometric line (Himalayan region sample Slope/W Analysis with Ordinary method)

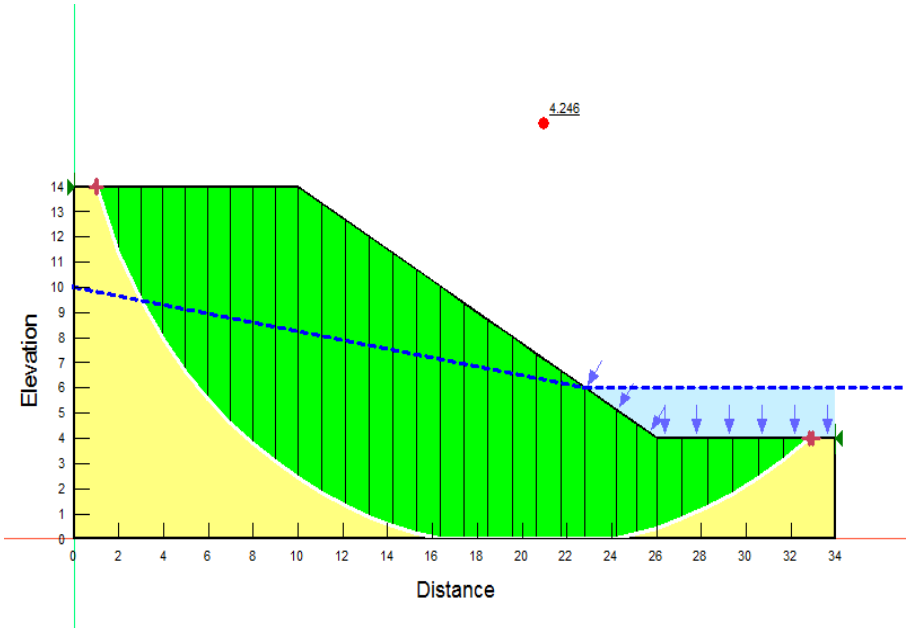

Figure2.8: Factor of safety and slip surface results of Ordinary analysis computed by SLOPE/W

4.3.1. Slope/W analysis on Jammu soil with Morgenstern-Price Method

File Information

File Version: 9.01
Revision Number: 2
Date: 05/03/2020
Time: 04:16:05 PM
Tool Version: 9.1.1.16749
File Name: SWWEP W ON JAMMU SOIL.gsz
Directory: C:\Users\Sys\Documents\
Last Solved Date: 05/03/2020
Last Solved Time: 04:17:56 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE/W Analysis on Jammu soil

Description: Analysis on Jammu soil
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 9.807 kN/m³

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 m

Table2.1:Coordinate

X(m)	Y(m)
0	10
22.44444	7

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 2,000
Tolerable difference in F of S: 0.01
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Soil layer

Model: Mohr-Coulomb
Unit Weight: 16.77 kN/m³
Cohesion': 31.9 kPa
Phi': 64.6 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Table2.2: Region

	Material	Points	Area (m^2)
Region 1	Soil Layer	1,2,3,4,5,6	332

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 8
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 8
Radius Increments: 4

Table 2.3:Points

	X(m)	Y(m)
Point 1	0	14
Point 2	10	14
Point 3	26	5

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 36 of 45 converged

Current Slip Surface

Slip Surface: 43

Factor of Safety: 6.624
Volume: 152.26374 m³
Weight: 2,553.4628 kN
Resisting Moment: 118,289.4 kN·m
Activating Moment: 17,853.486 kN·m
Resisting Force: 4,207.003 kN
Activating Force: 635.28952 kN
Slip Rank: 1 of 45 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 25.087975 m
Center: (22.087975, 27.590578) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength (kPa)	Suction Strength(kPa)	Base Material
Slice 1	1.4829263	13.303515	-34.341449	3.269557	6.8856711	31.9	0	Soil layer
Slice 2	2.4487788	11.998745	-22.811645	19.206161	40.448082	31.9	0	Soil layer
Slice 3	3.4146313	10.851723	-12.828867	33.648906	70.864431	31.9	0	Soil layer
Slice 4	4.3804838	9.8314627	-4.0892532	46.922591	98.818747	31.9	0	Soil layer
Slice 5	5.3770691	8.8909103	3.8283835	60.341249	119.01582	31.9	0	Soil layer
Slice 6	6.4043871	8.0202362	11.020438	73.717411	132.03952	31.9	0	Soil layer
Slice 7	7.431705	7.2386843	17.338472	86.017695	144.63811	31.9	0	Soil layer
Slice 8	8.459023	6.5362728	22.880376	97.500744	157.15013	31.9	0	Soil layer
Slice 9	9.486341	5.9052746	27.721928	108.36226	169.82814	31.9	0	Soil layer
Slice 10	10.518519	5.3372041	31.93998	114.74446	174.38582	31.9	0	Soil layer
Slice 11	11.555556	4.8277086	35.577216	116.4667	170.35285	31.9	0	Soil layer
Slice 12	12.592593	4.375704	38.650639	117.47305	165.99961	31.9	0	Soil layer
Slice 13	13.62963	3.9778794	41.192719	117.7592	161.24863	31.9	0	Soil layer
Slice 14	14.666666	3.631529	43.229991	117.29538	155.98134	31.9	0	Soil layer
Slice 15	15.703703	3.3344427	44.78413	116.03044	150.04437	31.9	0	Soil layer
Slice 16	16.740741	3.0848251	45.872744	113.89605	143.25674	31.9	0	Soil layer
Slice 17	17.777777	2.8812344	46.509972	110.81133	135.41835	31.9	0	Soil layer
Slice 18	18.814815	2.7225381	46.70692	106.68821	126.32031	31.9	0	Soil layer
Slice 19	19.851851	2.6078791	46.471995	101.43761	115.75733	31.9	0	Soil layer
Slice 20	20.888889	2.5366517	45.811136	94.976429	103.54187	31.9	0	Soil layer
Slice 21	21.925926	2.5084853	44.727978	87.234997	89.519574	31.9	0	Soil layer
Slice 22	23.037037	2.527575	43.861072	81.343497	78.937804	31.9	0	Soil layer
Slice 23	24.222222	2.6006246	43.144674	77.050117	71.404696	31.9	0	Soil layer
Slice 24	25.407407	2.7303598	41.872361	70.870994	61.070978	31.9	0	Soil layer
Slice 25	26.5	2.8988272	40.220202	63.686468	49.41984	31.9	0	Soil layer
Slice 26	27.5	3.0986552	38.260489	60.120722	46.037543	31.9	0	Soil layer
Slice 27	28.5	3.341352	35.880361	55.468362	41.252235	31.9	0	Soil layer
Slice 28	29.5	3.6282227	33.06702	49.754789	35.14436	31.9	0	Soil layer

Slice 29	30.5	3.9608794	29.804656	43.02823	27.848782	31.9	0	Soil layer
Slice 30	31.5	4.3412916	26.073953	35.356144	19.548249	31.9	0	Soil layer
Slice 31	32.5	4.7718535	21.851433	26.819758	10.463269	31.9	0	Soil layer

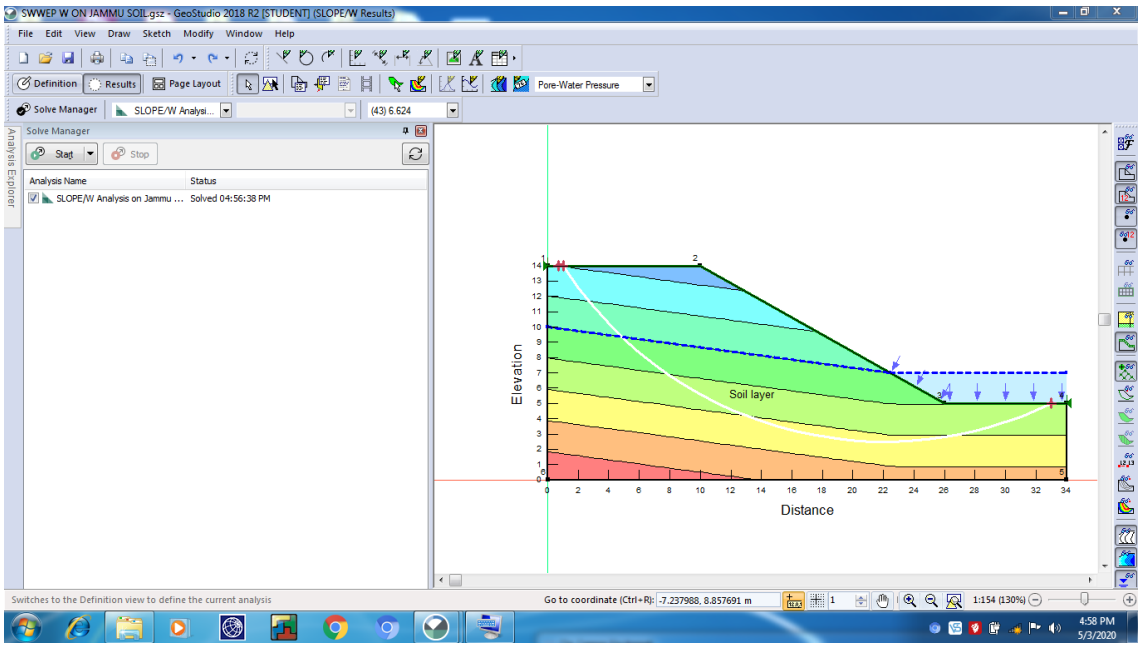

Figure3.1: Slope/W Analysis (Jammu Region Soil)

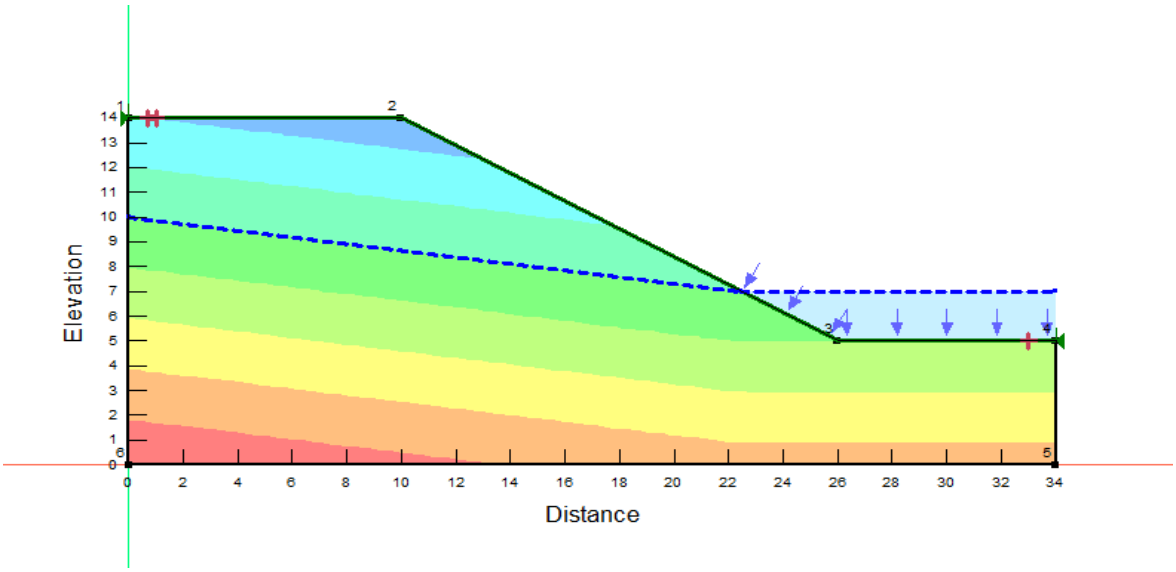

Figure3.2: Pore Pressure From Piezometric line (Jammu Region Sample Slope/W Analysis with Morgenstern–Price Method)

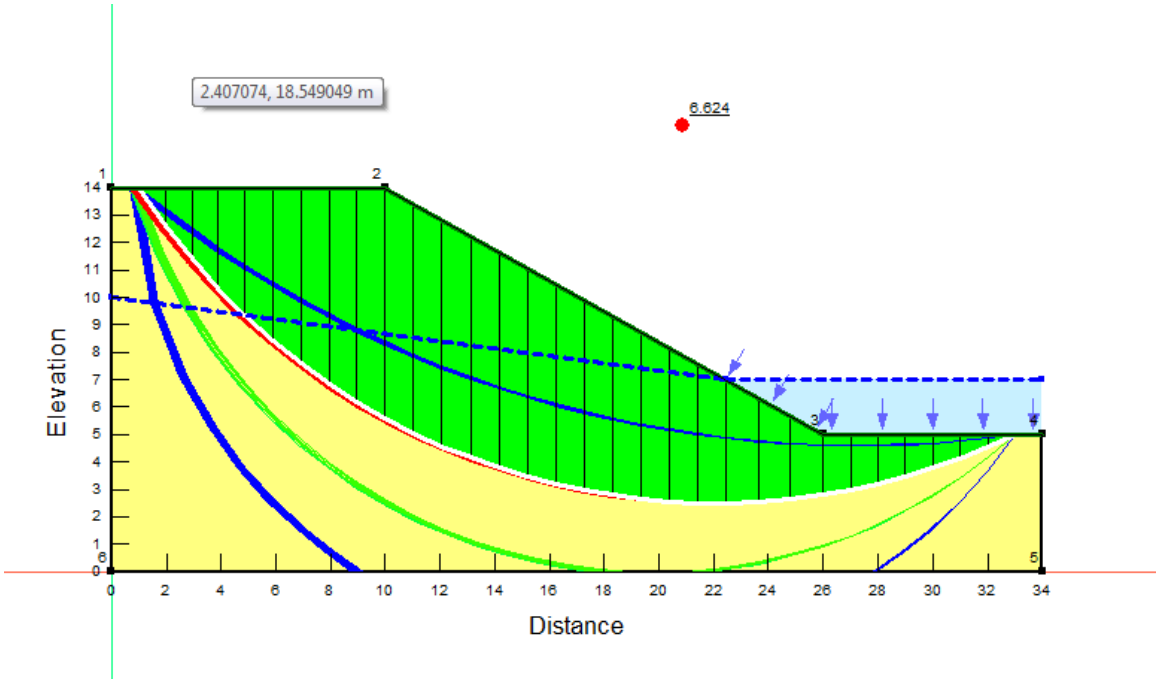

Figure3.3: Factor of safety and slip surface results of Morgenstern-Price analysis computed by SLOPE/W

4.3.2. Slope/W analysis of Jammu soil with Bishop Method

File Information

File Version: 9.01
Revision Number: 1
Date: 06/21/2020
Time: 03:28:50 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W JAMMU SOIL BISHOP.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope Jammu soil content\
Last Solved Date: 06/21/2020
Last Solved Time: 03:28:52 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE W JAMMU SOIL BISHOP

Kind: SLOPE/W
Method: Bishop
Settings
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: Yes
Use Staged Rapid Drawdown: No
Unit Weight of Water: 9.807 kN/m³
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 m
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 2,000
Tolerable difference in F of S: 0.01

Materials

Soil layer

Model: Mohr-Coulomb
Unit Weight: 16.77 kN/m³
Cohesion': 31.9 kPa
Phi': 64.6 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 8
Right Type: Point
Right Coordinate: (33, 5) m

Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 36 of 45 converged

Current Slip Surface

Slip Surface: 43
Factor of Safety: 6.644
Volume: 152.26374 m³
Weight: 2,553.4628 kN
Resisting Moment: 118,612.49 kN·m
Activating Moment: 17,853.486 kN·m
Slip Rank: 1 of 45 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 25.087975 m
Center: (22.087975, 27.590578) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength (kPa)	Cohesive Strength (kPa)	Suction Strength (kPa)	Base Material
Slice 1	1.4829265	13.303515	-33.738677	3.2672189	6.880747	31.9	0	Soil layer
Slice 2	2.4487794	11.998745	-22.411246	19.669122	41.423076	31.9	0	Soil layer
Slice 3	3.4146323	10.851721	-12.603689	35.055648	73.827023	31.9	0	Soil layer
Slice 4	4.3804852	9.8314613	-4.0174768	49.490282	104.22629	31.9	0	Soil layer
Slice 5	5.3770705	8.890909	3.7611832	64.263974	127.41858	31.9	0	Soil layer
Slice 6	6.4043882	8.0202353	10.826994	79.102653	143.7882	31.9	0	Soil layer
Slice 7	7.4317058	7.2386837	17.034126	92.676067	159.30156	31.9	0	Soil layer
Slice 8	8.4590235	6.5362725	22.478752	105.11545	174.03248	31.9	0	Soil layer
Slice 9	9.4863412	5.9052745	27.235319	116.52371	188.0409	31.9	0	Soil layer
Slice 10	10.518517	5.337205	31.379324	122.82839	192.59128	31.9	0	Soil layer
Slice 11	11.55555	4.8277111	34.952705	123.88965	187.30077	31.9	0	Soil layer
Slice 12	12.592583	4.3757077	37.972173	123.85315	180.86491	31.9	0	Soil layer
Slice 13	13.629617	3.9778839	40.469627	122.7741	173.33282	31.9	0	Soil layer
Slice 14	14.66665	3.6315341	42.471137	120.69624	164.74168	31.9	0	Soil layer
Slice 15	15.703683	3.334448	43.997997	117.6536	155.11848	31.9	0	Soil layer
Slice 16	16.740717	3.0848302	45.067507	113.67227	144.4813	31.9	0	Soil layer
Slice 17	17.77775	2.8812391	45.693556	108.77065	132.84005	31.9	0	Soil layer
Slice 18	18.814783	2.7225422	45.887056	102.96077	120.19696	31.9	0	Soil layer

Slice 19	19.851817	2.6078822	45.656266	96.248416	106.54682	31.9	0	Soil layer
Slice 20	20.88885	2.5366535	45.007021	88.633343	91.876822	31.9	0	Soil layer
Slice 21	21.925883	2.5084855	43.94289	80.109303	76.166284	31.9	0	Soil layer
Slice 22	23.037015	2.5275747	43.861075	73.215461	61.820193	31.9	0	Soil layer
Slice 23	24.222222	2.6006247	43.144674	67.893884	52.121716	31.9	0	Soil layer
Slice 24	25.407407	2.7303598	41.872361	61.466321	41.264784	31.9	0	Soil layer
Slice 25	26.5 m	2.8988272	40.220202	56.637302	34.574332	31.9	0	Soil layer
Slice 26	27.5	3.0986552	38.260489	53.636112	32.380986	31.9	0	Soil layer
Slice 27	28.5	3.341352	35.880361	49.870116	29.462357	31.9	0	Soil layer
Slice 28	29.5	3.6282227	33.06702	45.301728	25.766235	31.9	0	Soil layer
Slice 29	30.5	3.9608794	29.804656	39.884974	21.229101	31.9	0	Soil layer
Slice 30	31.5	4.3412916	26.073953	33.563498	15.772945	31.9	0	Soil layer
Slice 31	32.5	4.7718535	21.851433	26.267795	9.3008366	31.9	0	Soil layer

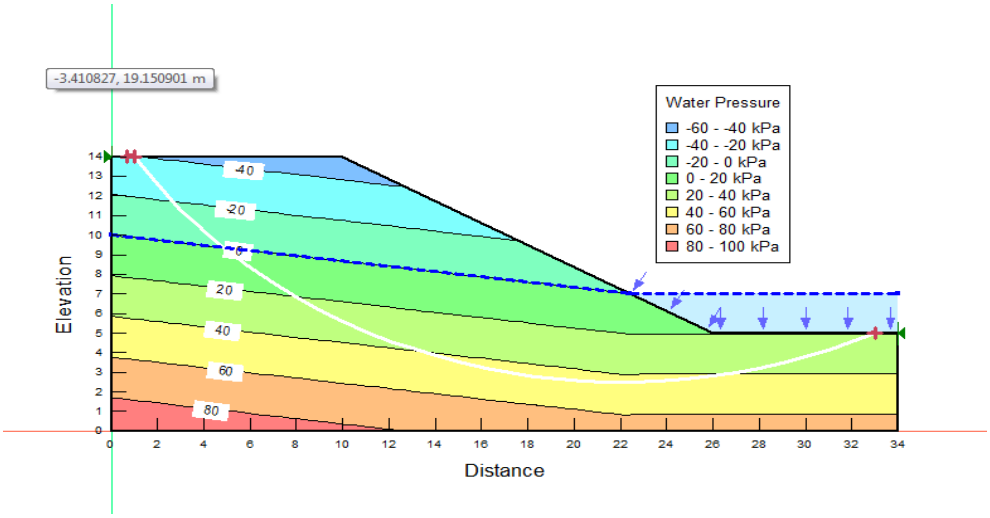

Figure3.4 : Pore Pressure From Piezometric line (Jammu Region Sample Slope/W Analysis with Bishop Method)

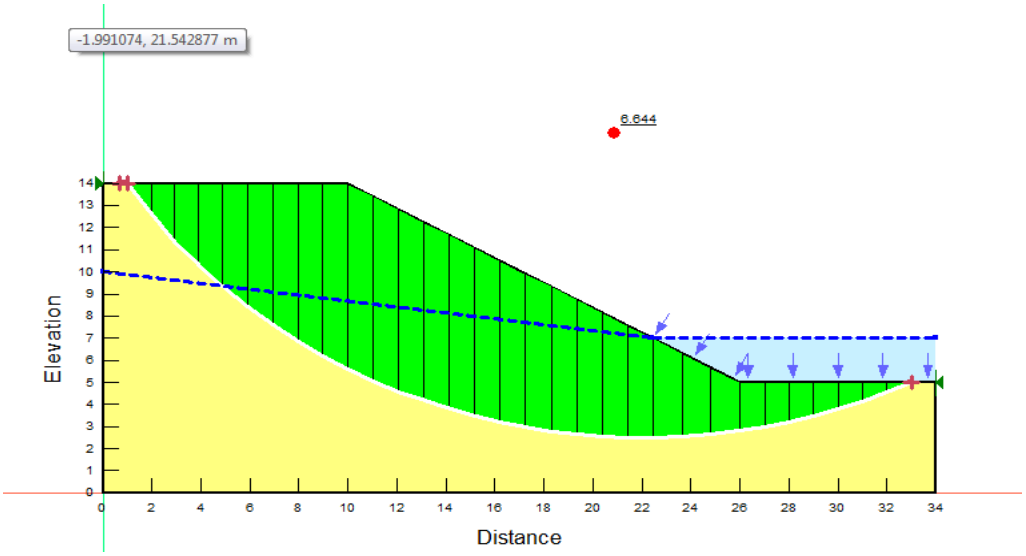

Figure3.5 : Factor of safety and slip surface results of Bishop analysis computed by SLOPE/W

4.3.3. Slope/W analysis of Jammu soil with Janbu Method

File Information

File Version: 9.01
Revision Number: 1
Date: 06/21/2020
Time: 05:44:59 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W JAMMU SOIL JANBU.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope Jammu soil content\
Last Solved Date: 06/21/2020
Last Solved Time: 05:45:02 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE W JAMMU SOIL JANBU

Kind: SLOPE/W
Method: Janbu
Settings
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: Yes

Use Staged Rapid Drawdown: No
Unit Weight of Water: 9.807 kN/m³
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 m
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 2,000
Tolerable difference in F of S: 0.01

Materials

SOIL LAYER

Model: Mohr-Coulomb
Unit Weight: 16.77 kN/m³
Cohesion': 31.9 kPa
Phi': 64.6 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 24
Factor of Safety: 6.146
Volume: 222.64535 m³
Weight: 3,733.7625 kN
Resisting Force: 5,211.6342 kN
Activating Force: 847.9557 kN
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 19.695433 m
Center: (19.860951, 19.672269) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength (kPa)	Suction Strength(kPa)	Base Material
Slice 1	1.4827338	12.723295	-28.148091	4.0378123	8.5036129	31.9	0	SOIL LAYER
Slice 2	2.4482014	10.527416	-8.2344483	29.274749	61.652479	31.9	0	SOIL LAYER
Slice 3	3.4358683	8.8424331	6.7281822	54.052213	99.664178	31.9	0	SOIL LAYER
Slice 4	4.4457348	7.4402892	18.937111	77.989846	124.36477	31.9	0	SOIL LAYER
Slice 5	5.4556012	6.2615695	28.993377	98.601895	146.5952	31.9	0	SOIL LAYER
Slice 6	6.4654676	5.2501951	37.437295	116.70791	166.94353	31.9	0	SOIL LAYER
Slice 7	7.475334	4.372447	44.593741	132.80581	185.77418	31.9	0	SOIL LAYER
Slice 8	8.4852004	3.6061675	50.676203	147.22586	203.33311	31.9	0	SOIL LAYER
Slice 9	9.4950668	2.9359079	55.833525	160.20043	219.79619	31.9	0	SOIL LAYER
Slice 10	10.556625	2.3246277	60.356019	167.99678	226.69091	31.9	0	SOIL LAYER
Slice 11	11.669876	1.7713842	64.252767	170.32965	223.3974	31.9	0	SOIL LAYER
Slice 12	12.783126	1.302221	67.339412	171.01342	218.33695	31.9	0	SOIL LAYER
Slice 13	13.896377	0.91079783	69.677042	170.16408	211.62521	31.9	0	SOIL LAYER
Slice 14	15.009627	0.59230863	71.311964	167.86623	203.34281	31.9	0	SOIL LAYER
Slice 15	16.122877	0.34313347	72.279055	164.17967	193.54225	31.9	0	SOIL LAYER
Slice 16	17.236128	0.1606069	72.603995	159.14364	182.25206	31.9	0	SOIL LAYER
Slice 17	18.349378	0.04286321	72.304761	152.77932	169.47903	31.9	0	SOIL LAYER
Slice 18	19.383477	0	71.385998	146.26449	157.69373	31.9	0	SOIL LAYER
Slice 19	20.338424	0	70.156187	137.25635	141.31262	31.9	0	SOIL LAYER
Slice 20	21.223023	0.02822915	68.744989	130.25836	129.54686	31.9	0	SOIL LAYER
Slice 21	22.037274	0.10173232	66.988179	122.20389	116.28402	31.9	0	SOIL LAYER
Slice 22	23.037015	0.24388432	66.257226	114.52882	101.65974	31.9	0	SOIL LAYER
Slice 23	24.222222	0.47539134	63.986837	106.97694	90.53695	31.9	0	SOIL LAYER

Slice 24	25.407407	0.78403287	60.95999	97.870707	77.73379	31.9	0	SOIL LAYER
Slice 25	26.5	1.137139	57.497077	90.271191	69.022122	31.9	0	SOIL LAYER
Slice 26	27.5	1.5267266	53.676393	84.484888 k	64.88254	31.9	0	SOIL LAYER
Slice 27	28.5	1.9813871	49.217537	77.497049	59.556515	31.9	0	SOIL LAYER
Slice 28	29.5	2.5063145	44.069574	69.17127	52.864049	31.9	0	SOIL LAYER
Slice 29	30.5	3.108224	38.166647	59.322701	44.554545	31.9	0	SOIL LAYER
Slice 30	31.5	3.7959261	31.422353	47.6922	34.264219	31.9	0	SOIL LAYER
Slice 31	32.5	4.5812397	23.720783	33.898778	21.434809	31.9	0	SOIL LAYER

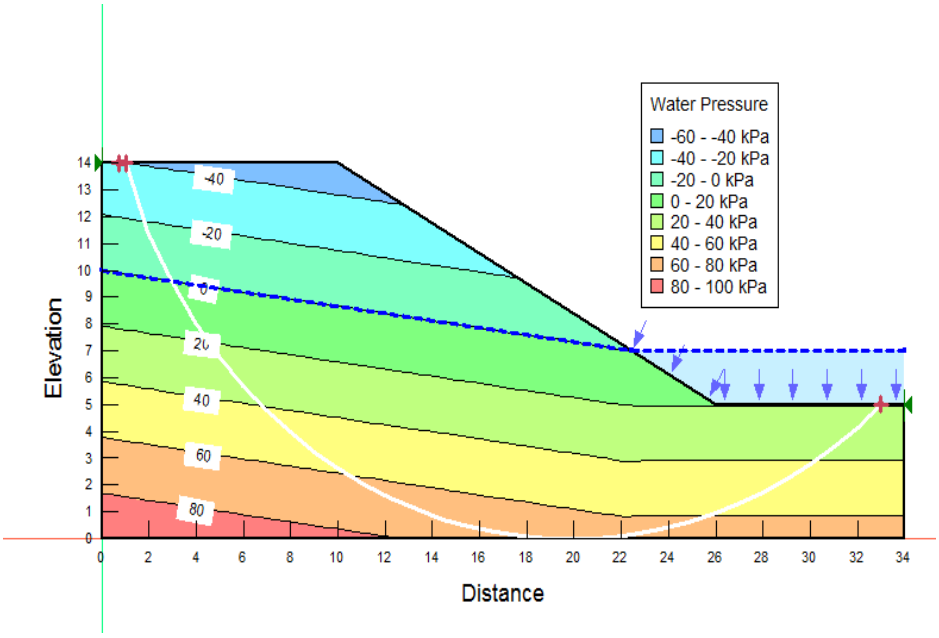

Figure3.6: Pore Pressure From Piezometric line (Jammu Region Sample Slope/W Analysis with Janbu Method)

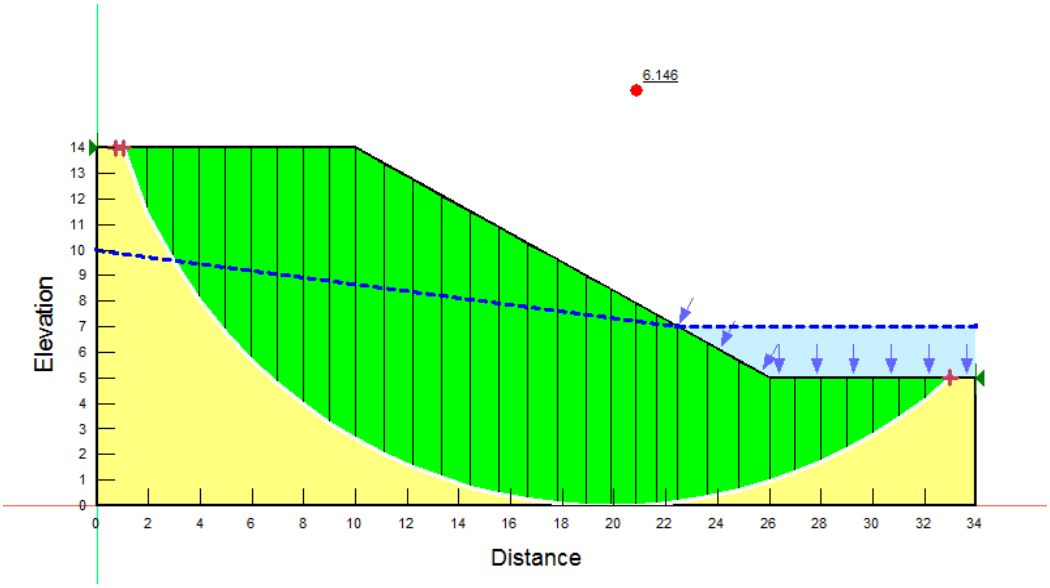

Figure3.7: Factor of safety and slip surface results of Janbu analysis computed by SLOPE/W

4.3.4. Slope/W analysis of Jammu soil with Ordinary Method

File Information

File Version: 9.01
Revision Number: 1
Date: 06/21/2020
Time: 05:58:16 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W JAMMU SOIL ORDINARY.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope Jammu soil content\
Last Solved Date: 06/21/2020
Last Solved Time: 05:58:18 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE W JAMMU SOIL ORDINARY

Kind: SLOPE/W
Method: Ordinary
Settings
PWP Conditions from: Piezometric Line

Apply Phreatic Correction: Yes
Use Staged Rapid Drawdown: No
Unit Weight of Water: 9.807 kN/m³
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 m
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 2,000
Tolerable difference in F of S: 0.01

Materials

SOIL LAYER

Model: Mohr-Coulomb
Unit Weight: 16.77 kN/m³
Cohesion': 31.9 kPa
Phi': 64.6 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 24
Factor of Safety: 6.149
Volume: 222.64535 m³
Weight: 3,733.7625 kN
Resisting Moment: 106,100.49 kN·m
Activating Moment: 17,254.774 kN·m
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 19.695433 m
Center: (19.860951, 19.672269) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Stregth(kPa)	Suction Strength(kPa)	Base Material
Slice 1	1.4827338	12.723295	-28.148091	2.678086	5.6400359	31.	0	SOIL LAYER
Slice 2	2.4482014	10.527416	-8.2344483	12.58974	26.51393	31.9	0	SOIL LAYER
Slice 3	3.4358683	8.8424331	6.7281822	30.897469	50.900399	31.9	0	SOIL LAYER
Slice 4	4.4457348	7.4402892	18.937111	54.123408	74.102169	31.9	0	SOIL LAYER
Slice 5	5.4556012	6.2615695	28.993377	75.784323	98.541502	31.9	0	SOIL LAYER
Slice 6	6.4654676	5.2501951	37.437295	96.113816	123.57247	31.9	0	SOIL LAYER
Slice 7	7.475334	4.372447	44.593741	115.18997	148.67532	31.9	0	SOIL LAYER
Slice 8	8.4852004	3.6061675	50.676203	133.02113	173.41801	31.9	0	SOIL LAYER
Slice 9	9.4950668	2.9359079	55.833525	149.58194	197.4337	31.9	0	SOIL LAYER
Slice 10	10.556625	2.3246277	60.356019	161.46084	212.92625	31.9	0	SOIL LAYER
Slice 11	11.669876	1.7713842	64.252767	167.66864	217.79333	31.9	0	SOIL LAYER
Slice 12	12.783126	1.302221	67.339412	171.26105	218.85847	31.9	0	SOIL LAYER
Slice 13	13.896377	0.91079783	69.677042	172.37152	216.27406	31.9	0	SOIL LAYER
Slice 14	15.009627	0.59230863	71.311964	171.13691	210.23084	31.9	0	SOIL LAYER
Slice 15	16.122877	0.34313347	72.279055	167.69908	200.95411	31.9	0	SOIL LAYER
Slice 16	17.236128	0.1606069	72.603995	162.20578	188.70093	31.9	0	SOIL LAYER
Slice 17	18.349378	0.04286321	72.304761	154.8112	173.75817	31.9	0	SOIL LAYER
Slice 18	19.383477	0	71.385998	146.26449	157.69373	31.9	0	SOIL LAYER
Slice 19	20.338424	0	70.156187	137.25635	141.31262	31.9	0	SOIL LAYER
Slice 20	21.223023	0.028229151	68.744989	128.1528	125.11255	31.9	0	SOIL LAYER
Slice 21	22.037274	0.10173232	66.988179	118.88308	109.29042	31.9	0	SOIL LAYER
Slice 22	23.037015	0.24388432	66.257226	109.52233	91.116099	31.9	0	SOIL LAYER
Slice 23	24.222222	0.47539134	63.986837	99.374917	74.527123	31.9	0	SOIL LAYER
Slice 24	25.407407	0.78403287	60.95999	87.636689	56.180999	31.9	0	SOIL LAYER
Slice 25	26.5	1.137139	57.497077	81.335723	50.204072	31.9	0	SOIL LAYER
Slice 26	27.5	1.5267266	53.676393	74.219864	43.26445	31.9	0	SOIL LAYER

Slice 27	28.5	1.9813871	49.217537	66.188969	35.741753	31.9	0	SOIL LAYER
Slice 28	29.5	2. 5063145	44.069574	57.270708	27.801523	31.9	0	SOIL LAYER
Slice 29	30.5	3.108224	38.166647	47.491959	19.639062	31.9	0	SOIL LAYER
Slice 30	31.5	3.7959261	31.422353	36.875534	11.484373	31.9	0	SOIL LAYER
Slice 31	32.5	4.5812397	23.720783	25.434523	3.6091292	31.9	0	SOIL LAYER

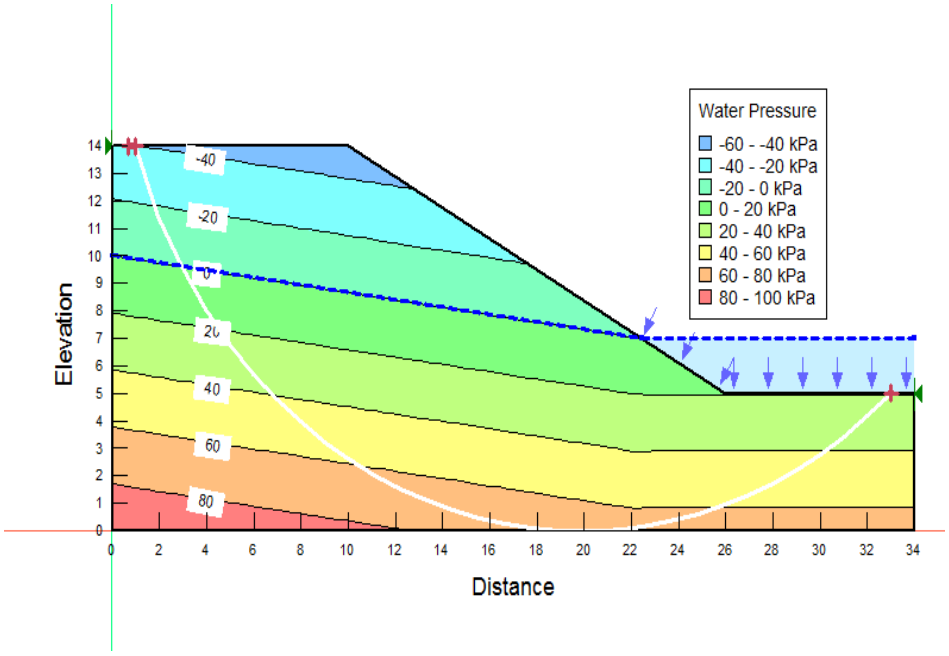

Figure3.8: Pore Pressure From Piezometric line (Jammu Region Sample Slope/W Analysis with Ordinary Method)

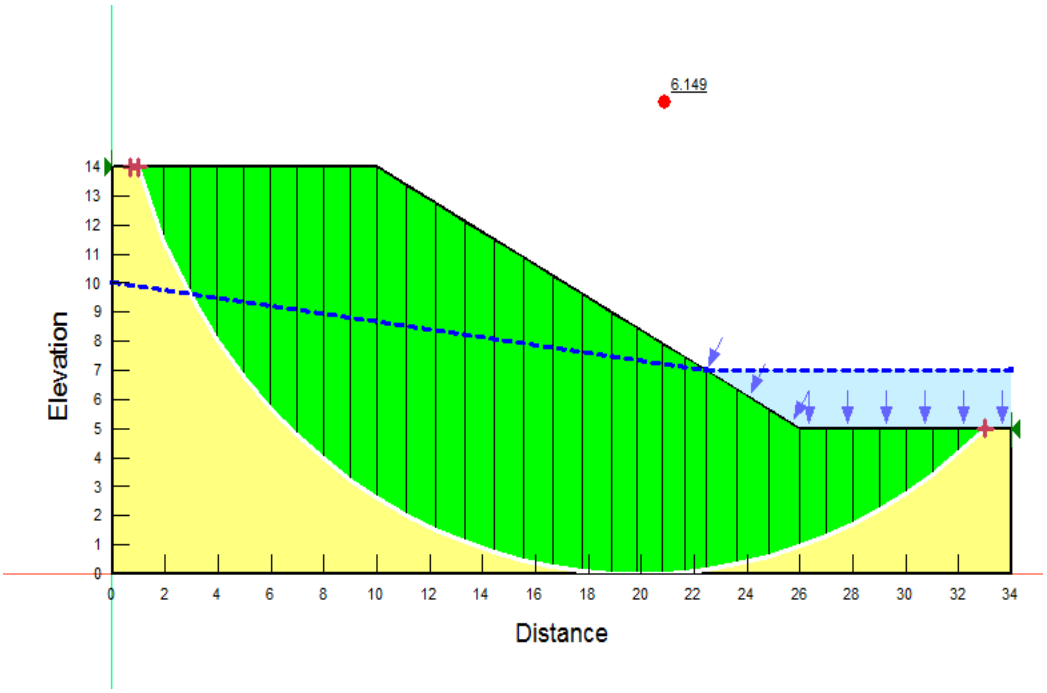

Figure3.9: Factor of safety and slip surface results of Ordinary analysis computed by SLOPE/W

4.4.1. Slope/W Analysis of Punjab Soil with Morgenstern-Price Method

File Information

File Version: 9.01
Revision Number: 1
Date: 05/03/2020
Time: 06:12:38 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W PUNJAB SOIL.gsz
Directory: C:\Users\Sys\Desktop\PROJECT\GEOSLOPE Jammu soil content\
Last Solved Date: 05/03/2020
Last Solved Time: 06:12:40 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE/W Analysis Punjab soil

Kind: SLOPE/W

Method: Morgenstern-Price
Settings
Side Function
Interslice force function option: Half-Sine
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 9.807 kN/m³
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 m
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 2,000
Tolerable difference in F of S: 0.01
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Piezometric Line 1

Table3.1:Co ordinates

X(m)	Y(m)
0	10
22.4444	7

Materials

Soil Layer

Model: Mohr-Coulomb
Unit Weight: 18.24 kN/m³
Cohesion': 53 kPa
Phi': 36.86 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Table 3.2: Region

	Material	Points	Area (m^2)
Region 1	Soil Layer	1,2,3,4,5,6	327.5

Table3.3 : Points

	X(m)	Y(m)
Point 1	0	14
Point 2	9	14
Point 3	26	5

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m

Left-Zone Increment: 4
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 24
Factor of Safety: 4.309
Volume: 218.13941 m³
Weight: 3,978.8628 kN
Resisting Moment: 79,816.887 kN·m
Activating Moment: 18,514.155 kN·m
Resisting Force: 3,407.927 kN
Activating Force: 791.22266 kN
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 19.695433 m
Center: (19.860951, 19.672269) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength (kPa)	Suction Strength (kPa)	Base Material
Slice 1	1.4827337	12.723296	-28.650983	-5.9959873	-4.4953723	53	0	Soil Layer
Slice 2	2.448201	10.527416	-8.3815647	29.361563	22.013248	53	0	Soil Layer
Slice 3	3.4366901	8.8413051	6.8583811	58.245411	38.526404	53	0	Soil Layer
Slice 4	4.448201	7.4372561	19.301963	83.276994	47.964007	53	0	Soil Layer
Slice 5	5.4597119	6.2572085	29.548764	104.13839	55.922088	53	0	Soil Layer
Slice 6	6.4712228	5.2448932	38.150615	122.20151	63.01549	53	0	Soil Layer
Slice 7	7.4827337	4.3664939	45.439151	138.28675	69.610638	53	0	Soil Layer
Slice 8	8.4942446	3.5997968	51.632224	152.92595	75.942961	53	0	Soil Layer
Slice 9	9.5503335	2.9037302	57.074188	162.4802	79.026062	53	0	Soil Layer

Slice 10	10.651001	2.274017	61.806991	166.90659	78.796336	53	0	Soil Layer
Slice 11	11.751668	1.7339062	65.661062	170.1956	78.372692	53	0	Soil Layer
Slice 12	12.852335	1.2754603	68.714246	172.42573	77.755624	53	0	Soil Layer
Slice 13	13.953002	0.89266864	71.025489	173.61224	76.912376	53	0	Soil Layer
Slice 14	15.053669	0.58096045	72.639616	173.72067	75.783508	53	0	Soil Layer
Slice 15	16.154336	0.33688431	73.590476	172.67698	74.288135	53	0	Soil Layer
Slice 16	17.255003	0.15789328	73.903046	170.37615	72.32879	53	0	Soil Layer
Slice 17	18.35567	0.042200896	73.594846	166.69036	69.796512	53	0	Soil Layer
Slice 18	19.383477	0	72.661423	163.10021	67.804679	53	0	Soil Layer
Slice 19	20.338424	0	71.409643	154.56429	62.343544	53	0	Soil Layer
Slice 20	21.481533	0.054988094	69.371945	147.33055	58.447913	53	0	Soil Layer
Slice 21	22.295804	0.12849391	67.583697	140.78341	54.880029	53	0	Soil Layer
Slice 22	23.037033	0.24388668	66.257203	137.0837	53.100754	53	0	Soil Layer
Slice 23	24.22222	0.47539086	63.986842	129.87869	49.401099	53	0	Soil Layer
Slice 24	25.407407	0.78403268	60.959991	120.13589	44.365952	53	0	Soil Layer
Slice 25	26.5	1.137139	57.497077	110.04396	39.395978	53	0	Soil Layer
Slice 26	27.5	1.5267266	53.676393	102.87576	36.88625	53	0	Soil Layer
Slice 27	28.5	1.9813871	49.217537	93.966656	33.549762	53	0	Soil Layer
Slice 28	29.5	2.5063145	44.069574	83.304288	29.415447	53	0	Soil Layer
Slice 29	30.5	3.108224	38.166647	70.896462	24.538528	53	0	Soil Layer
Slice 30	31.5	3.7959261	31.422353	56.765437	19.000474	53	0	Soil Layer
Slice 31	32.5	4.5812397	23.720783	40.939339	12.90927	53	0	Soil Layer

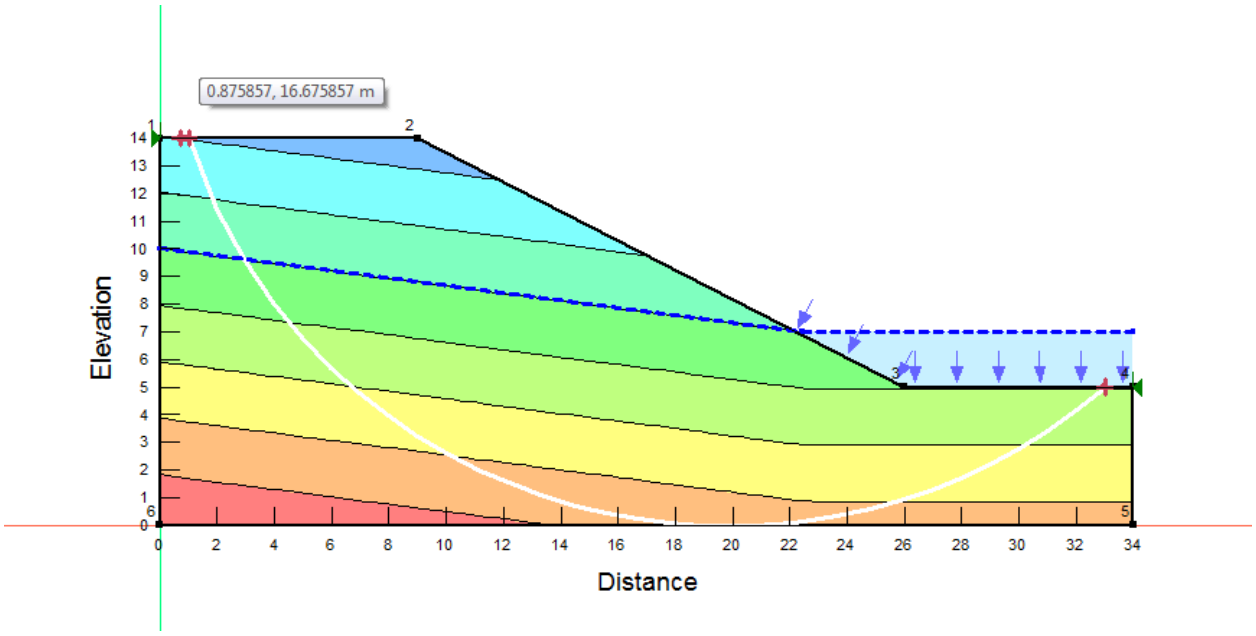

Figure4.1 : Pore Pressure from Piezometric line (Slope/W analysis Punjab region soil with Morgenstern-Price Method)

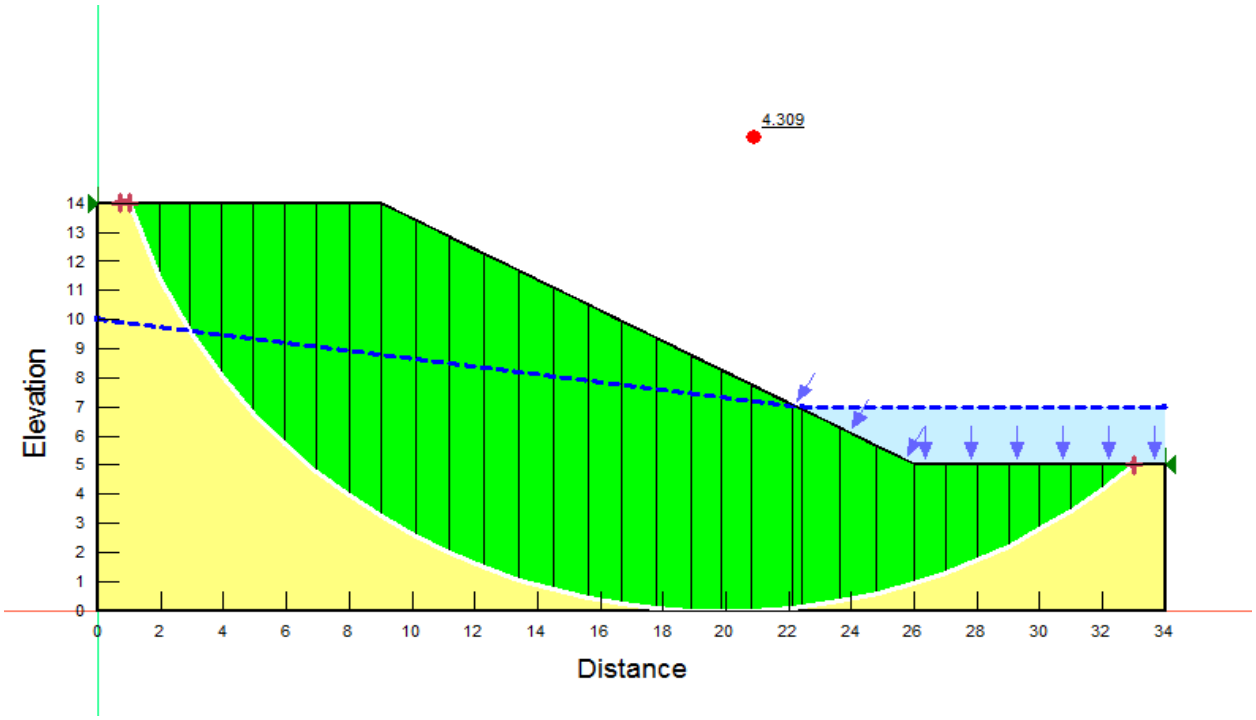

Figure4.2 : Factor of safety and slip surface results of Morgenstern Price analysis (Punjab Region Soil)

4.4.2. Slope/W analysis for Punjab soil with Bishop Method

File Information

File Version: 9.01
Revision Number: 1
Date: 06/21/2020
Time: 06:17:13 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W PUNJAB SOIL BISHOP.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope Punjab soil content\
Last Solved Date: 06/21/2020
Last Solved Time: 06:17:15 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE W PUNJAB SOIL BISHOP

Kind: SLOPE/W

Method: Bishop
Settings
PWP Conditions from: Piezometric Line
Apply Phreatic Correction: Yes
Use Staged Rapid Drawdown: No
Unit Weight of Water: 9.807 kN/m³
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 m
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 2,000
Tolerable difference in F of S: 0.01

Materials

New Material

Model: Mohr-Coulomb
Unit Weight: 18.24 kN/m³
Cohesion': 53 kPa
Phi': 36.86 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 24
Factor of Safety: 4.295
Volume: 222.64535 m³
Weight: 4,061.0512 kN
Resisting Moment: 81,272.977 kN·m
Activating Moment: 18,922.23 kN·m
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 19.695433 m
Center: (19.860951, 19.672269) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength (kPa)	Suction Strength (kPa)	Base Material
Slice 1	1.4827338	12.723295	-28.148091	-6.3922564	-4.7924672	53	0 kPa	New Material
Slice 2	2.4482014	10.527416	-8.2344483	29.908625	22.423397	53	0 kPa	New Material
Slice 3	3.4358683	8.8424331	6.7281822	60.997289	40.687184	53	0 kPa	New Material
Slice 4	4.4457348	7.4402892	18.937111	88.746494	52.338197	53	0 kPa	New Material
Slice 5	5.4556012	6.2615695	28.993377	112.28205	62.444023	53	0 kPa	New Material
Slice 6	6.4654676	5.2501951	37.437295	132.69534	71.417828	53	0 kPa	New Material
Slice 7	7.475334	4.372447	44.593741	150.63673	79.503621	53	0 kPa	New Material
Slice 8	8.4852004	3.6061675	50.676203	166.53095	86.85979	53	0 kPa	New Material
Slice 9	9.4950668	2.9359079	55.833525	180.67299	93.595905	53	0 kPa	New Material
Slice 10	10.556625	2.3246277	60.356019	188.62387	96.166268	53	0 kPa	New Material
Slice 11	11.669876	1.7713842	64.252767	190.21246	94.435776	53	0 kPa	New Material
Slice 12	12.783126	1.302221	67.339412	190.04767	91.998078	53	0 kPa	New Material
Slice 13	13.896377	0.91079783	69.677042	188.26789	88.911132	53	0 kPa	New Material
Slice 14	15.009627	0.59230863	71.311964	184.97657	85.217781	53	0 kPa	New Material
Slice 15	16.122877	0.34313347	72.279055	180.25031	80.949303	53	0 kPa	New Material
Slice 16	17.236128	0.1606069	72.603995	174.14413	76.127698	53	0 kPa	New Material
Slice 17	18.349378	0.04286321	72.304761	166.69493	70.767152	53	0 kPa	New Material
Slice 18	19.383477	0	71.385998	159.08553	65.750977	53	0 kPa	New Material
Slice 19	20.338424	0	70.156187	149.28777	59.327328	53	0 kPa	New Material
Slice 20	21.223023	0.02822915	68.744989	141.43195	54.495603	53	0 kPa	New Material
Slice 21	22.037274	0.10173232	66.988179	132.6483	49.227371	53	0 kPa	New Material

Slice 22	23.037015	0.24388432	66.257226	124.0875	43.357101	53	0 kPa	New Material
Slice 23	24.222222	0.47539134	63.986837	115.41806	38.559539	53	0 kPa	New Material
Slice 24	25.407407	0.78403287	60.95999	105.21518	33.17945	53	0 kPa	New Material
Slice 25	26.5	1.137139	57.49707	96.958646	29.585526	53	0 kPa	New Material
Slice 26	27.5	1.5267266	53.676393	90.895098	27.903985	53	0 kPa	New Material
Slice 27	28.5	1.9813871	49.217537	83.631384	25.801098	53	0 kPa	New Material
Slice 28	29.5	2.5063145	44.069574	75.064163	23.237577	53	0 kPa	New Material
Slice 29	30.5	3.108224	38.166647	65.059026	20.162026	53	0 kPa	New Material
Slice 30	31.5	3.7959261	31.422353	53.437941	16.50575	53	0 kPa	New Material
Slice31	32.5	4.5812397	23.720783	39.958724	12.174073	53	0 kPa	New Material

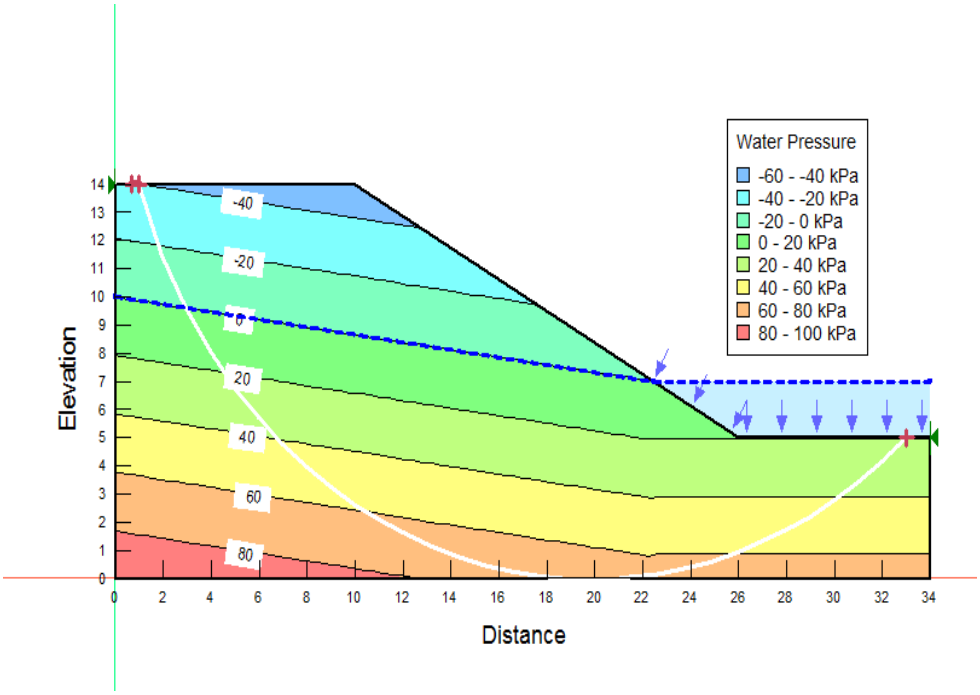

Figure4.3 : Pore Pressure from Piezometric line (Slope/W analysis Punjab region soil with Bishop Method)

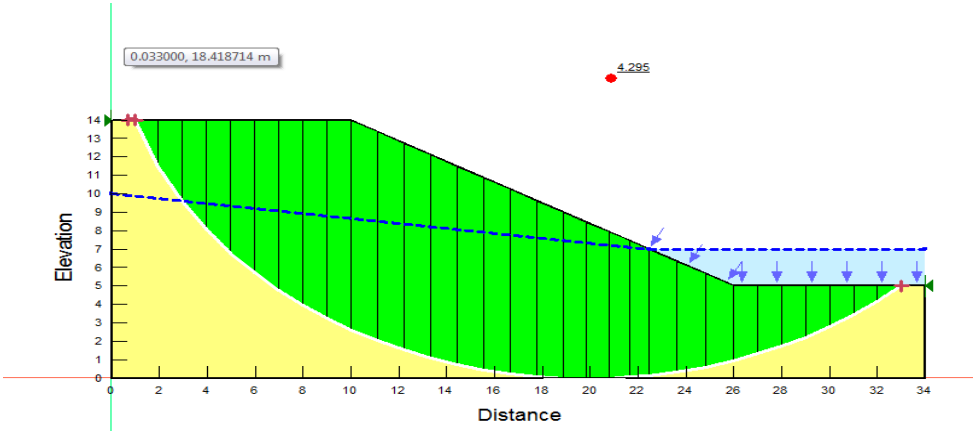

Figure4.4 : Factor of safety and slip surface results of Bishop analysis (Punjab Region Soil)

4.4.3. Slope/W analysis of Punjab soil with Janbu method

File Information

File Version: 9.01
Revision Number: 2
Date: 06/21/2020
Time: 06:46:43 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W PUNJAB JANBU SOIL.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope Punjab soil content\
Last Solved Date: 06/22/2020
Last Solved Time: 08:24:13 PM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE W PUNJAB JANBU

Kind: SLOPE/W
Method: Janbu
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 9.807 kN/m³

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 m
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 2,000
  - Tolerable difference in F of S: 0.01

Materials

New Material

Model: Mohr-Coulomb
Unit Weight: 18.24 kN/m³
Cohesion': 53 kPa
Phi': 36.86 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 24
Factor of Safety: 3.854
Volume: 222.64535 m³
Weight: 4,061.0512 kN
Resisting Force: 3,446.4976 kN
Activating Force: 894.37729 kN
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 19.695433 m
Center: (19.860951, 19.672269) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength (kPa)	Suction Strength (kPa)	Base Material
Slice 1	1.4827338	12.723295	-28.148091	-8.6732878	-6.5026251	53	0	New Material
Slice 2	2.4482014	10.527416	-8.2344483	27.068777	20.294277	53	0	New Material
Slice 3	3.4358683	8.8424331	6.7281822	58.023825	38.457889	53	0	New Material
Slice 4	4.4457348	7.4402892	18.937111	85.85704	50.171886	53	0	New Material
Slice 5	5.4556012	6.2615695	28.993377	109.50201	60.359748	53	0	New Material
Slice 6	6.4654676	5.2501951	37.437295	130.0425	69.428911	53	0	New Material
Slice 7	7.475334	4.372447	44.593741	148.1249	77.620425	53	0	New Material
Slice 8	8.4852004	3.6061675	50.676203	164.17169	85.090987	53	0	New Material
Slice 9	9.4950668	2.9359079	55.833525	178.47651	91.949143	53	0	New Material
Slice 10	10.556625	2.3246277	60.356019	186.66011	94.693979	53	0	New Material
Slice 11	11.669876	1.7713842	64.252767	188.53319	93.17678	53	0	New Material
Slice 12	12.783126	1.302221	67.339412	188.63885	90.941845	53	0	New Material
Slice 13	13.896377	0.91079783	69.677042	187.11612	88.04761	53	0	New Material
Slice 14	15.009627	0.59230863	71.311964	184.06878	84.537179	53	0	New Material
Slice 15	16.122877	0.34313347	72.279055	179.57352	80.441894	53	0	New Material
Slice 16	17.236128	0.1606069	72.603995	173.68522	75.783638	53	0	New Material
Slice 17	18.349378	0.04286321	72.304761	166.44036	70.576296	53	0	New Material
Slice 18	19.383477	0	71.385998	159.08553	65.750977	53	0	New Material
Slice 19	20.338424	0	70.156187	149.28777	59.327328	53	0	New Material
Slice 20	21.223023	0.02822915	68.744989	141.63679	54.649176	53	0	New Material
Slice 21	22.037274	0.10173232	66.988179	132.96332	49.463554	53	0	New Material
Slice 22	23.037015	0.24388432	66.257226	124.5286	43.687807	53	0	New Material
Slice 23	24.222222	0.47539134	63.986837	116.00812	39.001921	53	0	New Material
Slice 24	25.407407	0.78403287	60.95999	105.94289	33.725036	53	0	New Material
Slice 25	26.5	1.137139	57.497077	97.820784	30.231897	53	0	New Material
Slice 26	27.5	1.5267266	53.676393	91.900994	28.658135	53	0	New Material
Slice 27	28.5	1.9813871	49.217537	84.784347	26.665509	53	0	New Material
Slice 28	29.5	2.5063145	44.069574	76.367333	24.214603	53	0	New Material
Slice 29	30.5	3.108224	38.166647	66.515263	21.253811	53	0	New Material
Slice 30	31.5	3.7959261	31.422353	55.049594	17.714055	53	0	New Material
Slice 31	32.5	4.5812397	23.720783	41.72715	13.499916	53	0	New Material

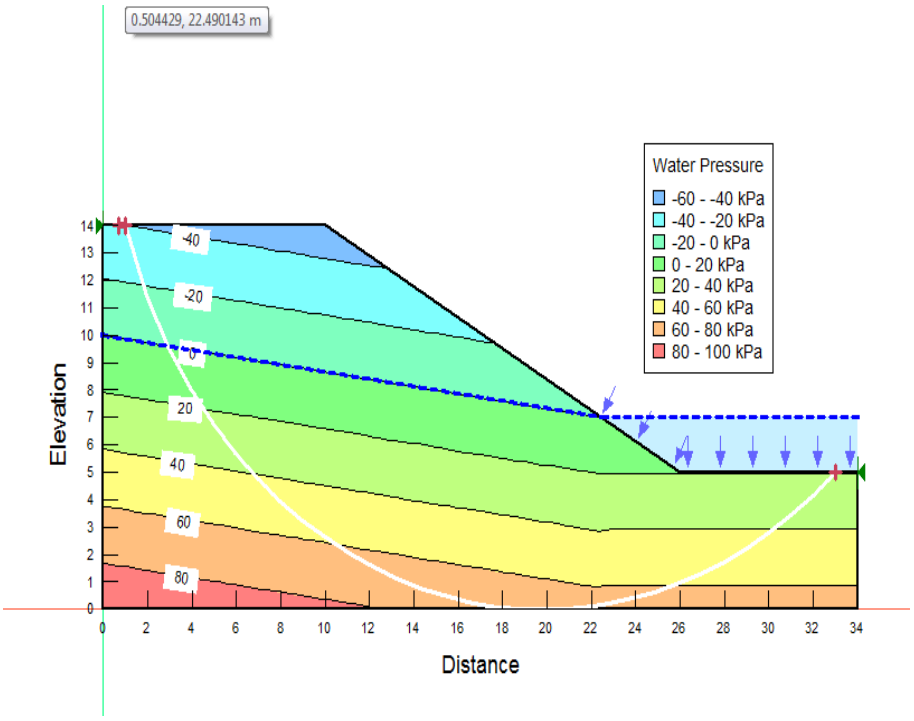

Figure4.5 : Pore Pressure through Piezometric line (Slope/W analysis on Punjab soil with Janbu Method)

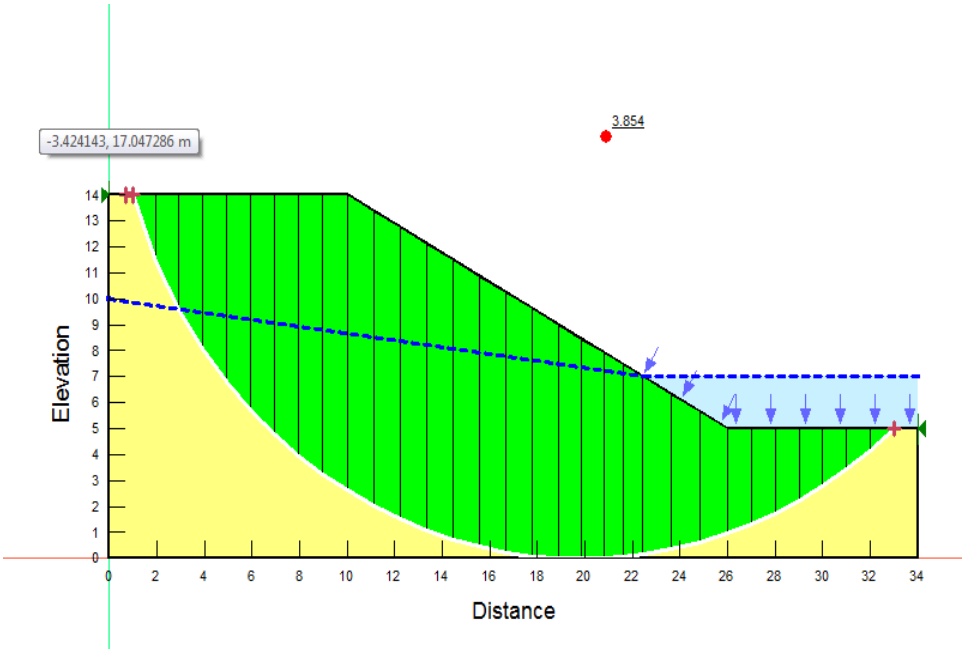

Figure4.6 : Factor of safety and slip surface results from Janbu analysis on Punjab soil

4.4.4.Slope/W analysis on Punjab soil with Ordinary method

File Information

File Version: 9.01
Revision Number: 2
Date: 06/21/2020
Time: 10:44:38 PM
Tool Version: 9.1.1.16749
File Name: SLOPE W PUNJAB SOIL ORDINARY.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope Punjab soil content\

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE W PUNJAB ORDINARY SOIL

Kind: SLOPE/W
Method: Ordinary
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 9.807 kN/m³

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 m
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 2,000
  - Tolerable difference in F of S: 0.01

Materials

SOIL LAYER

Model: Mohr-Coulomb
Unit Weight: 18.24 kN/m³
Cohesion': 53 kPa
Phi': 36.86 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 24
Factor of Safety: 3.936
Volume: 222.64535 m³
Weight: 4,061.0512 kN
Resisting Moment: 74,479.334 kN·m
Activating Moment: 18,922.23 kN·m
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 19.695433 m
Center: (19.860951, 19.672269) m

Slip Slices

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength (kPa)	Suction Strength (kPa)	Base Material
Slice 1	1.4827338	12.723295	-28.148091	2.9128377	2.1838421	53	0	SOIL LAYER
Slice 2	2.4482014	10.527416	-8.2344483	13.693313	10.266289	53	0	SOIL LAYER
Slice 3	3.4358683	8.8424331	6.7281822	33.1947	19.842798	53	0	SOIL LAYER
Slice 4	4.4457348	7.4402892	18.937111	57.849073	29.17347	53	0	SOIL LAYER
Slice 5	5.4556012	6.2615695	28.993377	81.065822	39.04028	53	0	SOIL LAYER
Slice 6	6.4654676	5.2501951	37.437295	103.01895	49.168542	53	0	SOIL LAYER
Slice 7	7.475334	4.372447	44.593741	123.73961	59.338042	53	0	SOIL LAYER
Slice 8	8.4852004	3.6061675	50.676203	143.19794	69.366333	53	0	SOIL LAYER
Slice 9	9.4950668	2.9359079	55.833525	161.33685	79.099018	53	0	SOIL LAYER
Slice 10	10.556625	2.3246277	60.356019	174.43201	85.526203	53	0	SOIL LAYER
Slice 11	11.669876	1.7713842	64.252767	181.3908	87.821913	53	0	SOIL LAYER
Slice 12	12.783126	1.302221	67.339412	185.51021	88.596206	53	0	SOIL LAYER
Slice 13	13.896377	0.91079783	69.677042	186.92036	87.90085	53	0	SOIL LAYER
Slice 14	15.009627	0.59230863	71.311964	185.75859	85.804085	53	0	SOIL LAYER
Slice 15	16.122877	0.34313347	72.279055	182.17059	82.388992	53	0	SOIL LAYER
Slice 16	17.236128	0.1606069	72.603995	176.31105	77.752303	53	0	SOIL LAYER
Slice 17	18.349378	0.04286321	72.304761	168.34406 k	72.003552	53	0	SOIL LAYER
Slice 18	19.383477	0	71.385998	159.08553	65.750977	53	0	SOIL LAYER
Slice 19	20.338424	0	70.156187	149.28777	59.327328	53	0	SOIL LAYER
Slice 20	21.223023	0.028229151	68.744989	139.35739	52.940247	53	0	SOIL LAYER
Slice 21	22.037274	0.10173232	66.988179	129.23223	46.666243	53	0	SOIL LAYER
Slice 22	23.037015	0.24388432	66.257226	118.71809	39.331489	53	0	SOIL LAYER
Slice 23	24.222222	0.47539134	63.986837	107.0975Pa	32.321363	53	0	SOIL LAYER
Slice 24	25.407407	0.78403287	60.95999	93.793289	24.616114	53	0	SOIL LAYER
Slice 25	26.5	1.137139	57.497077	86.36844	21.64573	53	0	SOIL LAYER
Slice 26	27.5	1.5267266	53.676393	78.556917	18.653679	53	0	SOIL LAYER
Slice 27	28.5	1.9813871	49.217537	69.771908	15.410231	53	0	SOIL LAYER
Slice 28	29.5	2.5063145	44.069574	60.057677	11.986762	53	0	SOIL LAYER
Slice 29	30.5	3.108224	38.166647	49.460681	8.4674773	53	0	SOIL LAYER
Slice 30	31.5	3.7959261	31.422353	38.026787	4.9515435	53	0	SOIL LAYER
Slice 31	32.5	4.5812397	23.720783	25.796321	1.5560937	53	0	SOIL LAYER

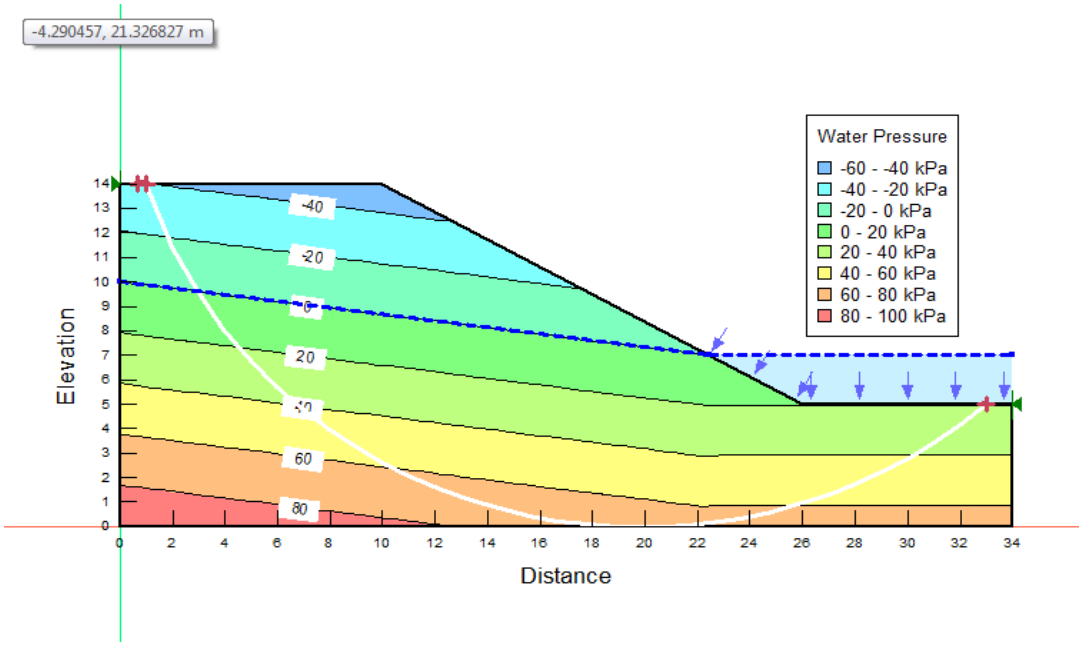

Figure4.7:Pore pressure through piezometric line (Punjab region sample slope/W with Ordinary method)

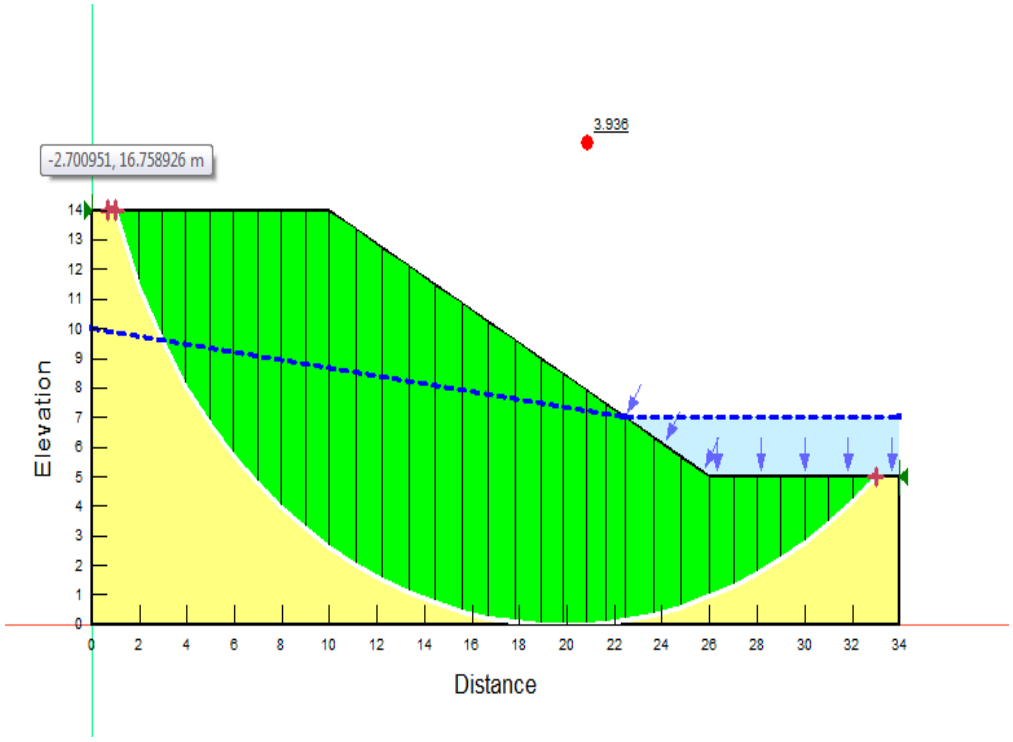

Figure4.8: Factor of safety and slip surface of Punjab soil with Ordinary Method

4.5.1 Slope/W analysis on DTU soil with Morgenstern-Price Method

File Information

File Version: 9.01
Revision Number: 2
Date: 06/25/2020
Time: 12:24:11 AM
Tool Version: 9.1.1.16749
File Name: SLOPE W DTU MORGENSTERN PRICE.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope DTU soil Content\
Last Solved Date: 06/25/2020
Last Solved Time: 12:25:04 AM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

Slope w on DTU Morgenstern price

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 9.807 kN/m³

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 m
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 2,000

Tolerable difference in F of S: 0.01

Solution Settings

Search Method: Root Finder

Tolerable difference between starting and converged F of S: 3

Maximum iterations to calculate converged lambda: 20

Max Absolute Lambda: 2

Materials

Soil Layer

Model: Mohr-Coulomb

Unit Weight: 16.57 kN/m³

Cohesion': 4.05 kPa

Phi': 41.78 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range

Left-Zone Left Coordinate: (0.7, 14) m

Left-Zone Right Coordinate: (1, 14) m

Left-Zone Increment: 4

Right Type: Point

Right Coordinate: (33, 5) m

Right-Zone Increment: 8

Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m

Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 23

Factor of Safety: 2.319

Volume: 152.26374 m³

Weight: 2,523.0101 kN

Resisting Moment: 40,887.946 kN·m

Activating Moment: 17,622.202 kN·m

Resisting Force: 1,456.9997 kN
Activating Force: 628.44511 kN
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 25.087975 m
Center: (22.087975, 27.590578) m

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	1.4829265	13.303515	-33.738677	5.7321118	5.1215001	4.05	0	Soil Layer
Slice 2	2.4487794	11.998745	-22.411246	20.224143	18.069772	4.05	0	Soil Layer
Slice 3	3.4146323	10.851721	-12.603689	33.549517	29.975664	4.05	0	Soil Layer
Slice 4	4.3804852	9.8314613	-4.0174768	45.954697	41.059386	4.05	0	Soil Layer
Slice 5	5.3770705	8.890909	3.7611832	58.773545	49.152185	4.05	0	Soil Layer
Slice 6	6.4043882	8.0202353	10.826994	71.746781	54.430324	4.05	0	Soil Layer
Slice 7	7.4317058	7.2386837	17.034126	83.733562	59.594296	4.05	0	Soil Layer
Slice 8	8.4590235	6.5362725	22.478752	94.985716	64.78318	4.05	0	Soil Layer
Slice 9	9.4863412	5.9052745	27.235319	105.69583	70.102529	4.05	0	Soil Layer
Slice 10	10.518517	5.337205	31.379324	112.1289	72.147752	4.05	0	Soil Layer
Slice 11	11.55555	4.8277111	34.952705	114.05933	70.679817	4.05	0	Soil Layer
Slice 12	12.592583	4.3757077	37.972173	115.28798	69.079759	4.05	0	Soil Layer
Slice 13	13.629617	3.9778839	40.469627	115.80665	67.311769	4.05	0	Soil Layer
Slice 14	14.66665	3.6315341	42.471137	115.58017	65.321114	4.05	0	Soil Layer
Slice 15	15.703683	3.334448	43.997997	114.55019	63.036643	4.05	0	Soil Layer
Slice 16	16.740717	3.0848302	45.067507	112.63935	60.373772	4.05	0	Soil Layer
Slice 17	17.77775	2.8812391	45.693556	109.75615	57.238345	4.05	0	Soil Layer
Slice 18	18.814783	2.7225422	45.887056	105.80099	53.531615	4.05	0	Soil Layer
Slice 19	19.851817	2.6078822	45.656266	100.67336	49.156413	4.05	0	Soil Layer
Slice 20	20.88885	2.5366535	45.007021	94.280185	44.024354	4.05	0	Soil Layer
Slice 21	21.925883	2.5084855	43.942892	86.544712	38.063673	4.05	0	Soil Layer
Slice 22	23.037015	2.5275747	43.861075	80.622249	32.8452	4.05	0	Soil Layer
Slice 23	24.222222	2.6006247	43.144674	76.428562	29.738331	4.05	0	Soil Layer
Slice 24	25.407407	2.7303598	41.872361	70.265513	25.368579	4.05	0	Soil Layer
Slice 25	26.5	2.8988272	40.220202	62.774052	20.151307	4.05	0	Soil Layer
Slice 26	27.5	3.0986552	38.260489	59.125957	18.64278	4.05	0	Soil Layer
Slice 27	28.5	3.341352	35.880361	54.36405	16.514719	4.05	0	Soil Layer
Slice 28	29.5	3.6282227	33.06702	48.51894	13.805909	4.05	0	Soil Layer
Slice 29	30.5	3.9608794	29.804656	41.648066	10.581794	4.05	0	Soil Layer
Slice 30	31.5	4.3412916	26.073953	33.831636	6.9312981	4.05	0	Soil Layer
Slice 31	32.5	4.7718535	21.851433	25.16621	2.9616712	4.05	0	Soil Layer

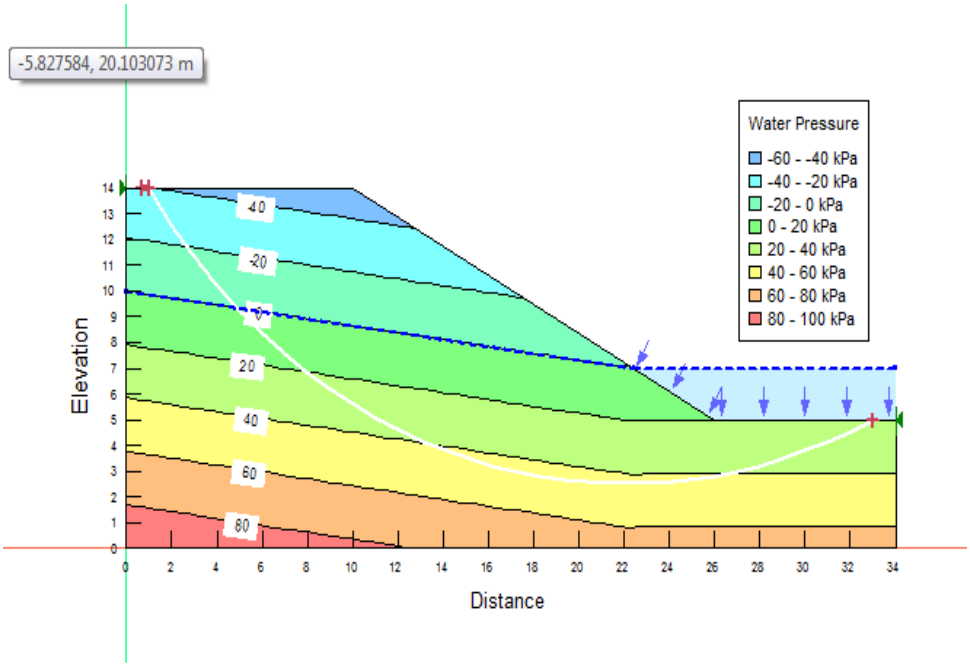

Figure5.1:Pore pressure through piezometric line (DTU region sample slope/W with Morgenstern-Price method)

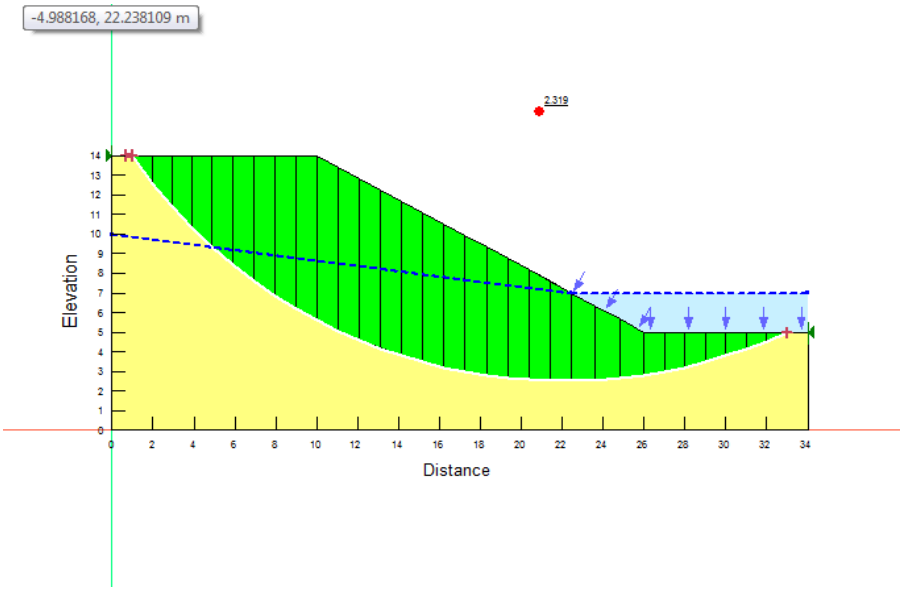

Figure5.2 : Factor of safety and slip surface results from Morgenstern-Price analysis on DTU soil

4.5.2 Slope/W analysis on DTU soil with Bishop Method

File Information

File Version: 9.01
Revision Number: 1
Date: 06/25/2020
Time: 12:33:57 AM
Tool Version: 9.1.1.16749
File Name: SLOPE W DTU BISHOP.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope DTU soil Content\
Last Solved Date: 06/25/2020
Last Solved Time: 12:34:02 AM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE W DTU BISHOP METHOD

Kind: SLOPE/W
Method: Bishop
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 9.807 kN/m³

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 m
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 2,000
  - Tolerable difference in F of S: 0.01

Materials

SOIL LAYER

Model: Mohr-Coulomb
Unit Weight: 16.57 kN/m³
Cohesion': 4.05 kPa
Phi': 41.78 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 23
Factor of Safety: 2.309
Volume: 152.26374 m³
Weight: 2,523.0101 kN
Resisting Moment: 40,682.896 kN·m
Activating Moment: 17,622.202 kN·m
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 25.087975 m
Center: (22.087975, 27.590578) m

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	1.4829265	13.303515	-33.738677	5.7863362	5.1699483	4.05	0	SOIL LAYER
Slice 2	2.4487794	11.998745	-22.411246	20.815509	18.598143	4.05	0	SOIL LAYER
Slice 3	3.4146323	10.851721	-12.603689	35.080217	31.343306	4.05	0	SOIL LAYER
Slice 4	4.3804852	9.8314613	-4.0174768	48.591532	43.415332	4.05	0	SOIL LAYER
Slice 5	5.3770705	8.890909	3.7611832	62.719332	52.677648	4.05	0	SOIL LAYER
Slice 6	6.4043882	8.0202353	10.826994	77.133957	59.243632	4.05	0	SOIL LAYER
Slice 7	7.4317058	7.2386837	17.034126	90.356431	65.511666	4.05	0	SOIL LAYER
Slice 8	8.4590235	6.5362725	22.478752	102.50862	71.50471	4.05	0	SOIL LAYER
Slice 9	9.4863412	5.9052745	27.235319	113.68632	77.241834	4.05	0	SOIL LAYER
Slice 10	10.518517	5.337205	31.379324	119.98649	79.168311	4.05	0	SOIL LAYER
Slice 11	11.55555	4.8277111	34.952705	121.23814	77.093904	4.05	0	SOIL LAYER
Slice 12	12.592583	4.3757077	37.972173	121.39911	74.539908	4.05	0	SOIL LAYER
Slice 13	13.629617	3.9778839	40.469627	120.52085	71.52379	4.05	0	SOIL LAYER
Slice 14	14.66665	3.6315341	42.471137	118.64356	68.05818	4.05	0	SOIL LAYER
Slice 15	15.703683	3.334448	43.997997	115.79798	64.151506	4.05	0	SOIL LAYER
Slice 16	16.740717	3.0848302	45.067507	112.00658	59.80841	4.05	0	SOIL LAYER
Slice 17	17.77775	2.8812391	45.693556	107.28451	55.029997	4.05	0	SOIL LAYER
Slice 18	18.814783	2.7225422	45.887056	101.64008	49.813948	4.05	0	SOIL LAYER
Slice 19	19.851817	2.6078822	45.656266	95.075094	44.1545	4.05	0	SOIL LAYER
Slice 20	20.88885	2.5366535	45.007021	87.58493	38.042309	4.05	0	SOIL LAYER
Slice 21	21.925883	2.5084855	43.942892	79.158387	31.464174	4.05	0	SOIL LAYER
Slice 22	23.037015	2.5275747	43.861075	72.337128	25.442649	4.05	0	SOIL LAYER
Slice 23	24.222222	2.6006247	43.144674	67.074547	21.38075	4.05	0	SOIL LAYER
Slice 24	25.407407	2.7303598	41.872361	60.68136	16.805376	4.05	0	SOIL LAYER
Slice 25	26.5	2.8988272	40.220202	55.821488	13.939364	4.05	0	SOIL LAYER
Slice 26	27.5	3.0986552	38.260489	52.744049	12.940703	4.05	0	SOIL LAYER
Slice 27	28.5	3.341352	35.880361	48.891501	11.625132	4.05	0	SOIL LAYER
Slice 28	29.5	3.6282227	33.06702	44.220432	9.9652983	4.05	0	SOIL LAYER
Slice 29	30.5	3.9608794	29.804656	38.677484	7.927652	4.05	0	SOIL LAYER
Slice 30	31.5	4.3412916	26.073953	32.196727	5.4705473	4.05	0	SOIL LAYER
Slice 31	32.5	4.7718535	21.851433	24.695971	2.5415246	4.05	0	SOIL LAYER

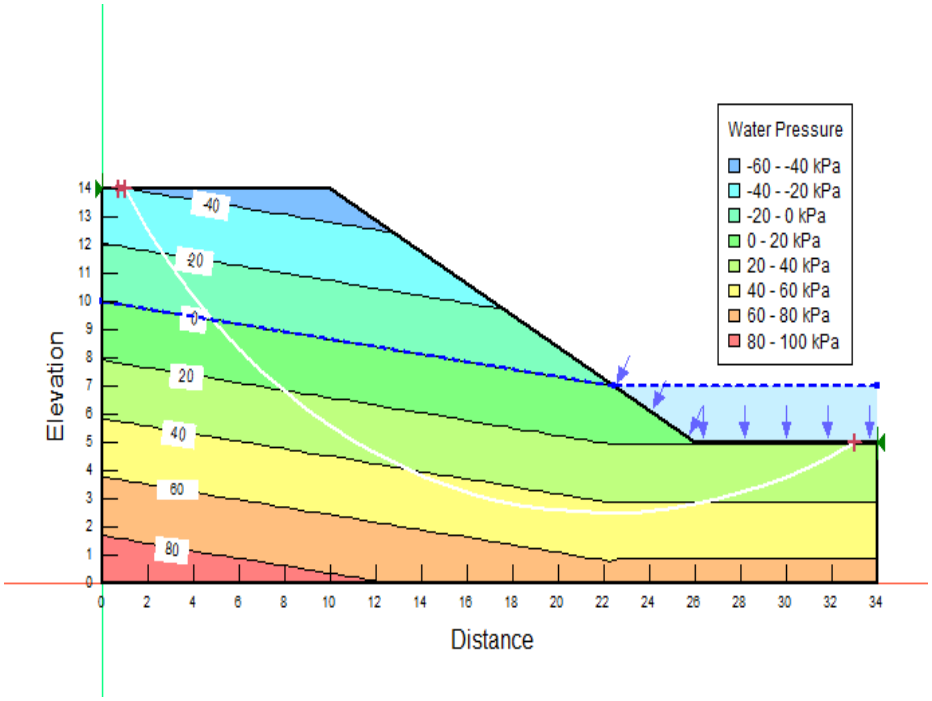

Figure5.3:Pore pressure through piezometric line (DTU region sample slope/W with Bishop method)

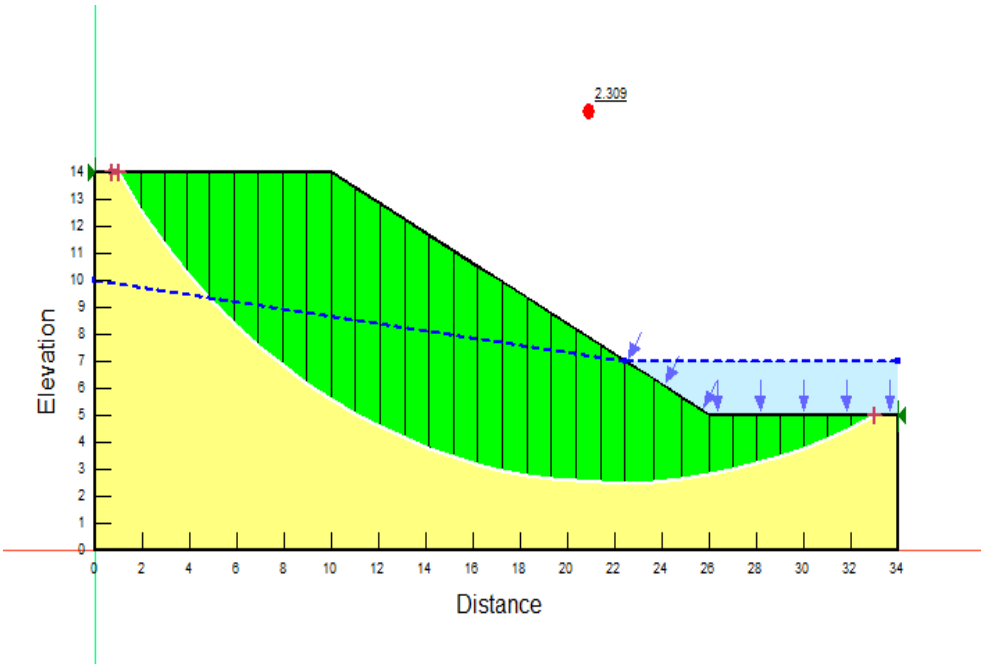

Figure5.4 : Factor of safety and slip surface results from Bishop analysis on DTU soil

4.5.3 Slope/W analysis on DTU soil with Janbu Method

File Information

File Version: 9.01
Revision Number: 1
Date: 06/25/2020
Time: 12:41:00 AM
Tool Version: 9.1.1.16749
File Name: SLOPE W DTU JANBU.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope DTU soil Content\
Last Solved Date: 06/25/2020
Last Solved Time: 12:41:02 AM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

SLOPE W DTU JANBU

Kind: SLOPE/W
Method: Janbu
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 9.807 kN/m³

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 m
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 2,000
  - Tolerable difference in F of S: 0.01

Materials

SOIL LAYER

Model: Mohr-Coulomb
Unit Weight: 16.57 kN/m³
Cohesion': 4.05 kPa
Phi': 41.78 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 23
Factor of Safety: 2.138
Volume: 152.26374 m³
Weight: 2,523.0101 kN
Resisting Force: 1,425.5128 kN
Activating Force: 666.6162 kN
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 25.087975 m
Center: (22.087975, 27.590578) m

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	1.4829265	13.303515	-33.738677	5.5017939	4.9157168	4.05	0	SOIL LAYER
Slice 2	2.4487794	11.998745	-22.411246	20.17457	18.025479	4.05	0	SOIL LAYER
Slice 3	3.4146323	10.851721	-12.603689	34.156735	30.518198	4.05	0	SOIL LAYER
Slice 4	4.3804852	9.8314613	-4.0174768	47.445949	42.391782	4.05	0	SOIL LAYER
Slice 5	5.3770705	8.890909	3.7611832	61.453664	51.546805	4.05	0	SOIL LAYER
Slice 6	6.4043882	8.0202353	10.826994	75.831038	58.079506	4.05	0	SOIL LAYER
Slice 7	7.4317058	7.2386837	17.034126	89.03612	64.332001	4.05	0	SOIL LAYER
Slice 8	8.4590235	6.5362725	22.478752	101.18873	70.325419	4.05	0	SOIL LAYER
Slice 9	9.4863412	5.9052745	27.235319	112.38311	76.077447	4.05	0	SOIL LAYER
Slice 10	10.518517	5.337205	31.379324	118.76788	78.079513	4.05	0	SOIL LAYER
Slice 11	11.55555	4.8277111	34.952705	120.15947	76.130141	4.05	0	SOIL LAYER
Slice 12	12.592583	4.3757077	37.972173	120.45793	73.698982	4.05	0	SOIL LAYER
Slice 13	13.629617	3.9778839	40.469627	119.7136	70.802527	4.05	0	SOIL LAYER
Slice 14	14.66665	3.6315341	42.471137	117.96561	67.45244	4.05	0	SOIL LAYER
Slice 15	15.703683	3.334448	43.997997	115.24357	63.656159	4.05	0	SOIL LAYER
Slice 16	16.740717	3.0848302	45.067507	111.56883	59.417284	4.05	0	SOIL LAYER
Slice 17	17.77775	2.8812391	45.693556	106.95523	54.735795	4.05	0	SOIL LAYER
Slice 18	18.814783	2.7225422	45.887056	101.40972	49.608128	4.05	0	SOIL LAYER
Slice 19	19.851817	2.6078822	45.656266	94.932525	44.027119	4.05	0	SOIL LAYER
Slice 20	20.88885	2.5366535	45.007021	87.517228	37.981818	4.05	0	SOIL LAYER
Slice 21	21.925883	2.5084855	43.942892	79.150542	31.457164	4.05	0	SOIL LAYER
Slice 22	23.037015	2.5275747	43.861075	72.376022	25.4774	4.05	0	SOIL LAYER
Slice 23	24.222222	2.6006247	43.144674	67.151744	21.449723	4.05	0	SOIL LAYER
Slice 24	25.407407	2.7303598	41.872361	60.782442	16.89569	4.05	0	SOIL LAYER
Slice 25	26.5	2.8988272	40.220202	55.940545	14.045738	4.05	0	SOIL LAYER
Slice 26	27.5	3.0986552	38.260489	52.885811	13.067364	4.05	0	SOIL LAYER
Slice 27	28.5	3.341352	35.880361	49.051193	11.767813	4.05	0	SOIL LAYER
Slice 28	29.5	3.6282227	33.06702	44.391051	10.117742	4.05	0	SOIL LAYER
Slice 29	30.5	3.9608794	29.804656	38.849137	8.0810204	4.05	0	SOIL LAYER
Slice 30	31.5	4.3412916	26.073953	32.35569	5.6125766	4.05	0	SOIL LAYER
Slice 31	32.5	4.7718535	21.851433	24.82331	2.6552983	4.05	0	SOIL LAYE

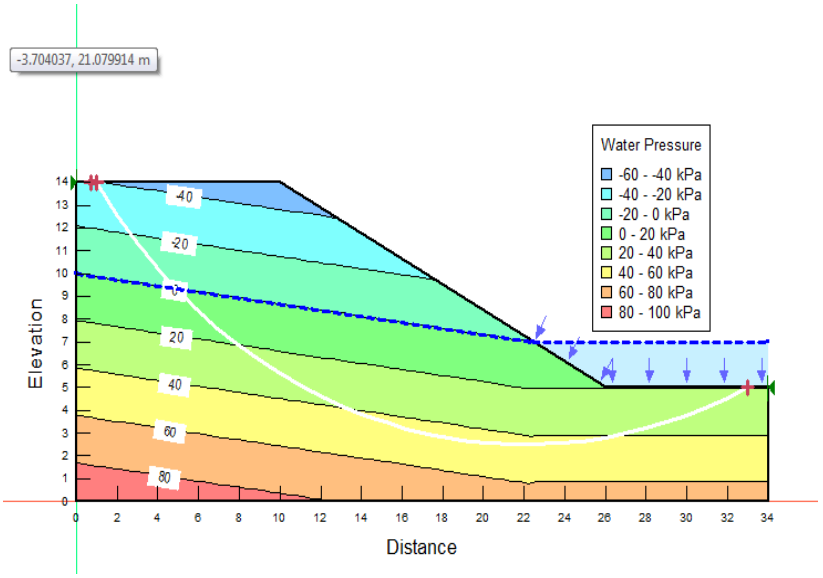

Figure5.5:Pore pressure through piezometric line (DTU region sample slope/W with Janbu method)

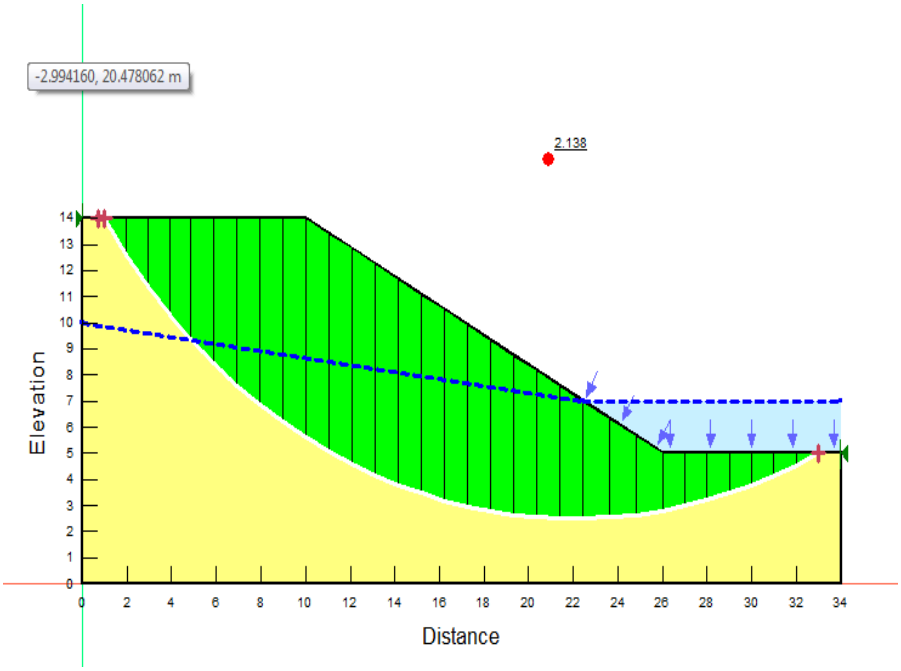

Figure5.6 : Factor of safety and slip surface results from Janbu analysis on DTU soil

4.5.4 Slope/W analysis on DTU soil with Ordinary Method

File Information

File Version: 9.01
Revision Number: 1
Date: 06/25/2020
Time: 12:46:28 AM
Tool Version: 9.1.1.16749
File Name: SLOPE W DTU ORDINARY.gsz
Directory: C:\Users\Sys\Desktop\Major project content\Geoslope DTU soil Content\
Last Solved Date: 06/25/2020
Last Solved Time: 12:46:32 AM

Project Settings

Unit System: International System of Units (SI)

Analysis Settings

Slope Stability

Kind: SLOPE/W
Method: Ordinary
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 9.807 kN/m³

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 m
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 2,000
  - Tolerable difference in F of S: 0.01

Materials

SOIL LAYER

Model: Mohr-Coulomb
Unit Weight: 16.57 kN/m³
Cohesion': 4.05 kPa
Phi': 41.78 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.7, 14) m
Left-Zone Right Coordinate: (1, 14) m
Left-Zone Increment: 4
Right Type: Point
Right Coordinate: (33, 5) m
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 14) m
Right Coordinate: (34, 5) m

Slip Results

Slip Surfaces Analysed: 20 of 25 converged

Current Slip Surface

Slip Surface: 23
Factor of Safety: 2.140
Volume: 152.26374 m³
Weight: 2,523.0101 kN
Resisting Moment: 37,711.895 kN·m
Activating Moment: 17,622.202 kN·m
Slip Rank: 1 of 25 slip surfaces
Exit: (33, 5) m
Entry: (1, 14) m
Radius: 25.087975 m
Centr: (22.087975, 27.590578) m

Slip Slice

	X(m)	Y(m)	PWP(kPa)	Base Normal Stress(kPa)	Frictional Strength(kPa)	Cohesive Strength(kPa)	Suction Strength(kpA)	Base Material
Slice 1	1.4829265	13.303515	-33.738677	3.7470095	3.3478604	4.05	0	SOIL LAYER
Slice 2	2.4487794	11.998745	-22.411246	12.820489	11.45479	4.05	0	SOIL LAYER
Slice 3	3.4146323	10.851721	-12.603689	23.242205	20.766336	4.05	0	SOIL LAYER
Slice 4	4.3804852	9.8314613	-4.0174768	34.636888	30.947203	4.05	0	SOIL LAYER
Slice 5	5.3770705	8.890909	3.7611832	48.738512	40.186131	4.05	0	SOIL LAYER
Slice 6	6.4043882	8.0202353	10.826994	64.56943	48.017537	4.05	0	SOIL LAYER
Slice 7	7.4317058	7.2386837	17.034126	79.592097	55.894	4.05	0	SOIL LAYER
Slice 8	8.4590235	6.5362725	22.478752	93.7918	63.716445	4.05	0	SOIL LAYER
Slice 9	9.4863412	5.9052745	27.235319	107.14472	71.39707	4.05	0	SOIL LAYER
Slice 10	10.518517	5.337205	31.379324	115.87189	75.492016	4.05	0	SOIL LAYER
Slice 11	11.55555	4.8277111	34.952705	119.40539	75.456381	4.05	0	SOIL LAYER
Slice 12	12.592583	4.3757077	37.972173	121.35943	74.504448	4.05	0	SOIL LAYER
Slice 13	13.629617	3.9778839	40.469627	121.80015	72.666814	4.05	0	SOIL LAYER
Slice 14	14.66665	3.6315341	42.471137	120.79461	69.980088	4.05	0	SOIL LAYER
Slice 15	15.703683	3.334448	43.997997	118.41125	66.486405	4.05	0	SOIL LAYER
Slice 16	16.740717	3.0848302	45.067507	114.72029	62.233036	4.05	0	SOIL LAYER
Slice 17	17.77775	2.8812391	45.693556	109.79391	57.272083	4.05	0	SOIL LAYER
Slice 18	18.814783	2.7225422	45.887056	103.7065	51.660239	4.05	0	SOIL LAYER
Slice 19	19.851817	2.6078822	45.656266	96.534679	45.458604	4.05	0	SOIL LAYER
Slice 20	20.88885	2.5366535	45.007021	88.357458	38.732544	4.05	0	SOIL LAYER
Slice 21	21.925883	2.5084855	43.942892	79.256234	31.551597	4.05	0	SOIL LAYER
Slice 22	23.037015	2.5275747	43.861075	71.744232	24.912911	4.05	0	SOIL LAYER
Slice 23	24.222222	2.6006247	43.144674	65.500462	19.974344	4.05	0	SOIL LAYER
Slice 24	25.407407	2.7303598	41.872361	57.961792	14.375508	4.05	0	SOIL LAYER
Slice 25	26.5	2.8988272	40.220202	53.990767	12.303659	4.05	0	SOIL LAYER
Slice 26	27.5	3.0986552	38.260489	50.520639	10.954141	4.05	0	SOIL LAYER
Slice 27	28.5	3.341352	35.880361	46.364741	9.3675342	4.05	0	SOIL LAYER
Slice 28	29.5	3.6282227	33.06702	41.53422	7.5652339	4.05	0	SOIL LAYER
Slice 29	30.5	3.9608794	29.804656	36.041788	5.5727227	4.05	0	SOIL LAYER
Slice 30	31.5	4.3412916	26.073953	29.901508	3.4198257	4.05	0	SOIL LAYER
Slice 31	32.5	4.7718535	21.851433	23.128499	1.1410265	4.05	0	SOIL LAYER

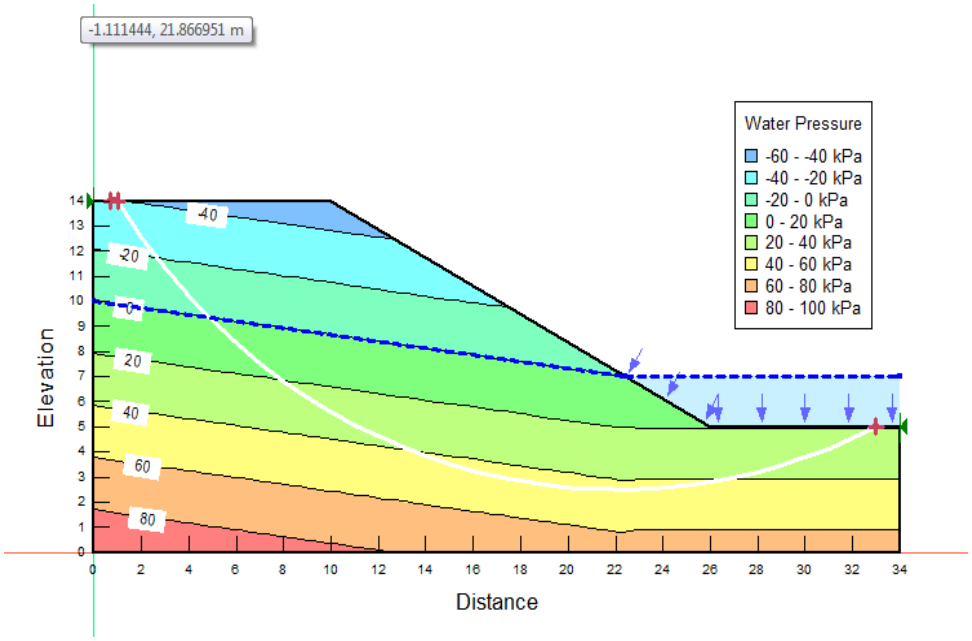

Figure5.7:Pore pressure through piezometric line (DTU region sample slope/W with Ordinary method)

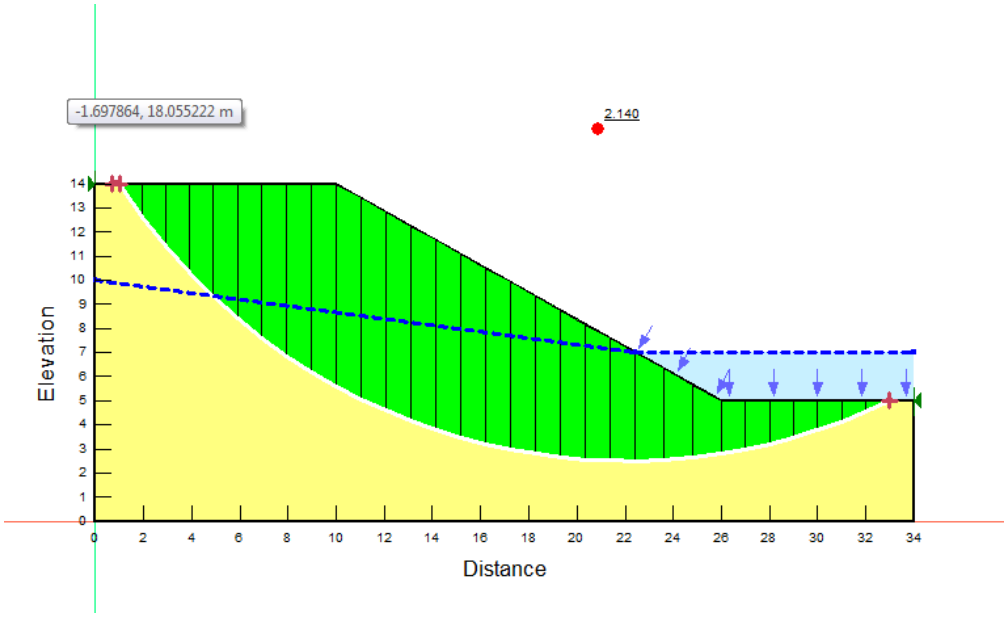

Figure5.8 : Factor of safety and slip surface results from Ordinary analysis on DTU soil

In Discussion for Morgenstern-Price method contains inter-slice forces and satisfy all equation of statics. The other methods(Bishop, Janbu and Ordinary) ignores inter-slice shear force for determining FOS of the slopes. Bishop assumes that normal or horizontal force explains the inter-slice forces. In Ordinary method that results in a linear factor of safety equation. In Ordinary method inter-slices force can be neglected due to they are parallel to base of each slice. In Janbu method a correction factor is used due to the effect of forces of the inter slice factor so this method gives the least stability to the structure . Bishop Method is very suitable for circular slip surfaces and Morgenstern price method is suitable for any type of Slip surface and Janbu is suitable for Shallow and Elongated slip surfaces.For circular slip surface Bishop method is best so it gives the maximum FOS And stability to the structure in the present study only.We can come to conclusion that DTU soil has lowest C value which gives the Lowest FOS according to the software Slope/W.

5. CONCLUSION

Table 4.1 : FOS obtained for different soil with different method

	Punjab Soil	Jammu soil	Himachal soil	DTU Soil
Φ	36.86°	64.6°	48°	41.78°
FOS(Margenstern Price)	4.309	6.624	4.552	2.319
Bishop	4.395	6.644	4.575	2.309
Janbu	3.854	6.146	4.173	2.138
Ordinary	3.936	6.149	4.246	2.140

- The results obtained from the software for F.O.S of safety of slope stability increases with the increase in Internal friction angle except in DTU soil, Due to its very less C value DTU soil has least FOS also.
- The FOS for Bishop method is obtained highest and for Janbu method obtained lowest.
- According to the theory of F.O.S here F.O.S >1.5 , so all the structures will be safe.

- All the detailed forces on each slice, failure mechanism, variety of the parameters distribution on the slip surfaces with respect to F.O.S. can be analyzed with the help of Geotechnical engineering software Slope/W (Geo-studio).

- Morgenstern-Price Method consider not only the normal and tangential equilibrium but also the moment equilibrium for each slice in circular and non-circular slip surfaces. It is solved for the factor of safety using the summation of forces tangential and normal to the base of a slice and the summation of moments about the center of the base of each slice.

- For calculating the F.O.S. of earth and rock slopes Slope/W software gives good results. Simple to simple and complex to complex problems can be solved for different slip shapes , Pore water pressure conditions, loading conditions and soil properties by using this software. For heterogeneous soil types ,complex stratigraphic and geometry of slip surface , variable pore water pressure conditions slope/W can take into consideration using limit equilibrium.

- After Performing all the method analysis on Slope/W software we come to conclution that Bishop method gives highest FOS then Morgenstern-Price method then Ordinary method then Janbu method gives the least value of FOS.

Rerences

- Ahmad Amiral Bin Mohd Zaki. “Comparison of Factor of safety using different method of analysis for slope stability” , University Malaysia Pahang , July, 2015.

- Akhtar M and Islam A . “Numerical Analysis of the Effects of Soil Nail and Slope Stability” . International journal of computer applications 141 (8), 12-15, 2016.

- An Jui Li et al. . “Seismic Slope stability Evaluation Considering Rock mass Disturbance Varying in the Slope” , KSCE Journal of Civil Engineering,2019.

- Amin Pourkhosravani et al. . “A Review of Current Methods for Slope Stability Evaluation” , Electronic Journal of Geotechnical Engineering , Vol. 16, 2011.

- Arshad I, Baber, M.M.. “Finite element analysis of seepage through an Earthen Dam by using Geo slope software” . Int. J Res. 619-634,2014.

- Dr. S.P.Tatewar , Laxman N.Pawade. “Analysis of Earth Dam by Geostudio software” . International Journal of Civil Engineering and Technology (Vol-3),2000

- D. Durga and R. Anbalagan., “Study on Slope Stability of Earthen Dams by using Geostudio Software” , International Journal of Advance Research , Ideas and Innovations in Technology, Vol.3 , ISSN 2454-132X, 2017.

- Digvijay et al. . “An Overview on Methods for slope stability analysis” , International Journal of Engineering Research and Technology (IJERT), ISSN :2278-0181, Vol. 3 , March 2017.

- Guangjin Wang et al. . “Research on slope stability analysis of super high jumping site based on cellular automation” , SREE Conference on Engineering Modellling and Simulation, Elsevier, 1877-7058, 2011.

- Gui Lei, Yin Kun-long, Zhai yue. “Landslide Stability Analysis Based on and Strength Reduction Technique” , Safety and Environmental Engineering 2011(6), 9-13.

- H Hasani , J Mamizadeh and H Karimim . “Stability of Slope Analysis in Earthen Dams using GeoStudio”. Department of Civil Engineering Payame Noor University , Iran,1998.

- J.M.Ducana, b and S.G. Wrighta. “The accuracy of equilibrium methods of slope stability”, Engineering Geology Volume 16, Isues 1-2,july 1980, Pages 5-17.

- Morgenstern,N.R.,and Price, V.E.(1965). “The analysis of the stability general slipsurfaces.II “, J.Geotech. ,1, 79-93.

- Osuji,S.O., Adegbemileke, S.A.. “Phratic line and Pore Pressure Stresses in Zoned Rockfill Dam” . Asian j. Sci. Tech. 1447-1454, 2015.

- P. Gopal . “Delvari Slope Stability and Seepage analysis of earthen dam by Geo studio” International journal of Engineering Science and Innovative technology (Vol -2 , issue-3),2001.

- Rouaiguia A and Dahim M . “Numerical Modeling of Slope Stability Analysis” , International journal of Engineering Science and Innovative Technology, 533-543, 2013.

- Shanmugapriya Dewedree and Siti Norafida Jusoh. , “Slope stability analysis under different soil nailing parameters using the Slope/W software” , Journal of Physics 1174 , 2017.

- Vivek, Mandeep Multanin, Pooja. “Slope Stability Analysis” , International journal of core civil engineering and management (IJCEM), volume 2,issue3,june 2015.

- Yanjie Zhou. “Three Dimentional Limit Equilibrium Stability Analysis on Juting landslide of Baoji-Chengdu Railway”. Railway investigation and Surveying , pp5-60, 2011.

- Yue Yan and Yahui Zhang ., “Impact of Blasting Vibration on Soil Slope Stability” , EJGE , Vol 19 , Bund 5 , 2014.

- Zhaolei Wang, Jun Zhang. “Stability analysis of a prestressed anchor cable composite soil nailing wall basic on Geostudio” Industrial Construction Vol-41, Supplement, p2011,437-440.