

ANALYSIS AND DESIGN OF SPREAD AND PILE FOUNDATIONS USING GEO5

A MAIN PROJECT REPORT SUBMITTED IN PARTIAL
FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

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CERTIFICATE

This is to certify that the project report entitled "ANALYSIS AND DESIGN OF SPREAD AND PILE FOUNDATIONS USING GEO5" that is being submitted by

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In partial fulfilment of the requirement for the award of B.Tech in Civil Engineering in the **RAJEEV GANDHI MEMORIAL COLLEGE OF ENGINEERING AND TECHNOLOGY**, Nandyal (Affiliated to J.N.T University, Anantapur) is a bona fide record of confide work carried out by her under our guidance and supervision. The results embodied in this technical report have not been submitted to any other university or institute for the award of any Degree.

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Professor and HOD

Examiner:

Date:

Dedicated to my beloved parents, and teachers who have worked hard throughout my education.

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Abstract

The foundation is the major component of any structure, which transfer the loads of superstructure to the sub soil safely. The foundation should prevent the settlement failures, for this the foundation of any structure should be designed according to the soil characteristics of ground and loads from the super structure. Generally, foundations are classified different categories, in the present study spread and pile foundations are considered for the analysis. In this analysis by using Geo5 software we can calculate bearing capacity of the foundation and also predict the foundation is how much safe. This analysis performed by considering the various influencing factors such as soil profiles, super structure loads, water table etc.

Keywords : Foundation, Spread foundation, Pile foundation, GEO5 Software

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1.2.1 Shallow Foundations

A Foundation in which the depth of the foundation is less than or equal to the width of the foundation , it is called shallow foundation. Shallow foundations are classified as

- i) Spread footing
- ii) Strap footing
- iii) Strip Footing
- iv) Combined footing
- v) Mat or Raft Foundation etc.

i) Spread Footing

Spread footings are those whose base is wider than a typical load-bearing wall foundations. The wider base of this footing type spreads the weight from the building structure over more area and provides better stability. Spread footings and wall footings are used for individual columns, walls and bridge piers where the bearing soil layer is within 3m (10 feet) from the ground surface. Soil bearing capacity must be sufficient to support the weight of the structure over the base area of the structure.

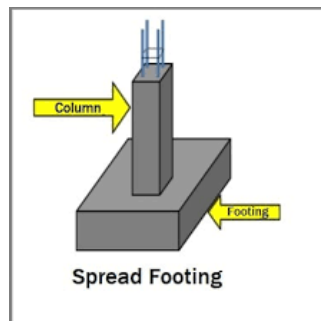


Figure 1.2: Spread Footing

ii) Strap Footing

A 'strap footing' comprises two or more footings connected by a beam called 'strap'. This is also called a 'cantilever footing' or 'pump-handle foundation'. This may be required when the footing of an exterior column cannot extend into an adjoining private property.

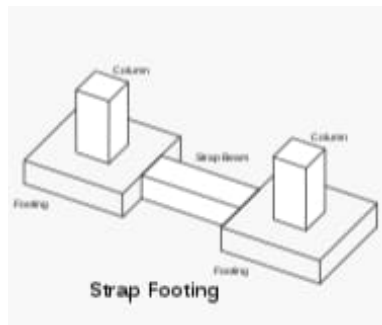


Figure 1.3: Strap Footing

iii) Strip Footing

A wall footing or strip footing is a continuous strip of concrete that serves to spread the weight of a load-bearing wall across an area of soil. It is the component of a shallow foundation. It is provided along the length of wall.

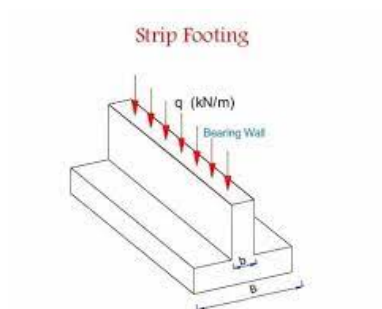


Figure 1.4: Strip Footing

iv) Combined Footing

A combined footing supports two or more columns in a row when the areas required for individual footings are such that they come very near each other. They are also preferred in situations of limited space on one side owing to the existence of the boundary line of private property. The plan shape of the footing may be rectangular or trapezoidal; the footing will then be called 'rectangular combined footing' or 'trapezoidal combined footing'.

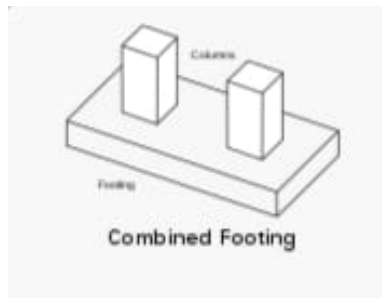


Figure 1.5: Combined Footing

v) Raft or Mat Foundation

A raft or mat foundation is a large footing, usually supporting walls as well as several columns in two or more rows. This is adopted when individual column footings would tend to be too close or tend to further, this is considered suitable when differential settlements arising out of footings on weak soils are to be minimised.

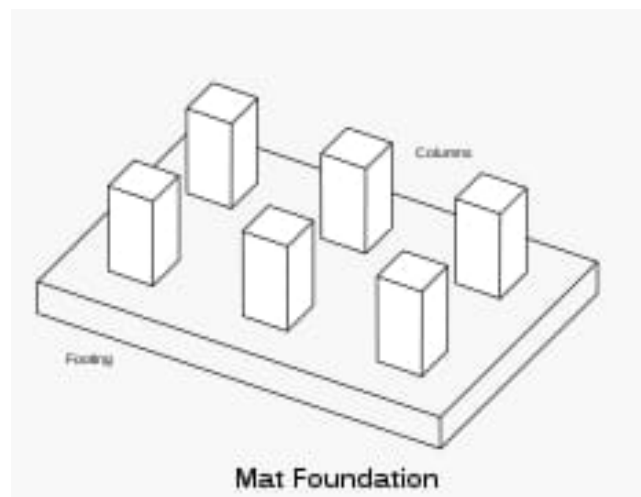


Figure 1.6: Mat Footing

1.2.2 Deep Foundations

A Foundation in which the depth of the foundation is greater than the width of the foundation, it is called deep foundation. Generally deep foundations are constructed at greater depths. The deep foundations are classified as

- i) Pile Foundations
- ii) Well Foundations
- iii) Pier Foundations etc.

i) Pile Foundation

A Pile foundation, a kind of deep foundation, can be defined as a slender column or long cylinder made of materials such as concrete or steel which are used to support the structure and transfer the load at desired depth either by end bearing or skin friction. Pile foundations are deep foundations. They are formed by long, slender, columnar elements typically made from steel or reinforced concrete, or sometimes timber. A foundation is described as 'piled' when its depth is more than three times its breadth.

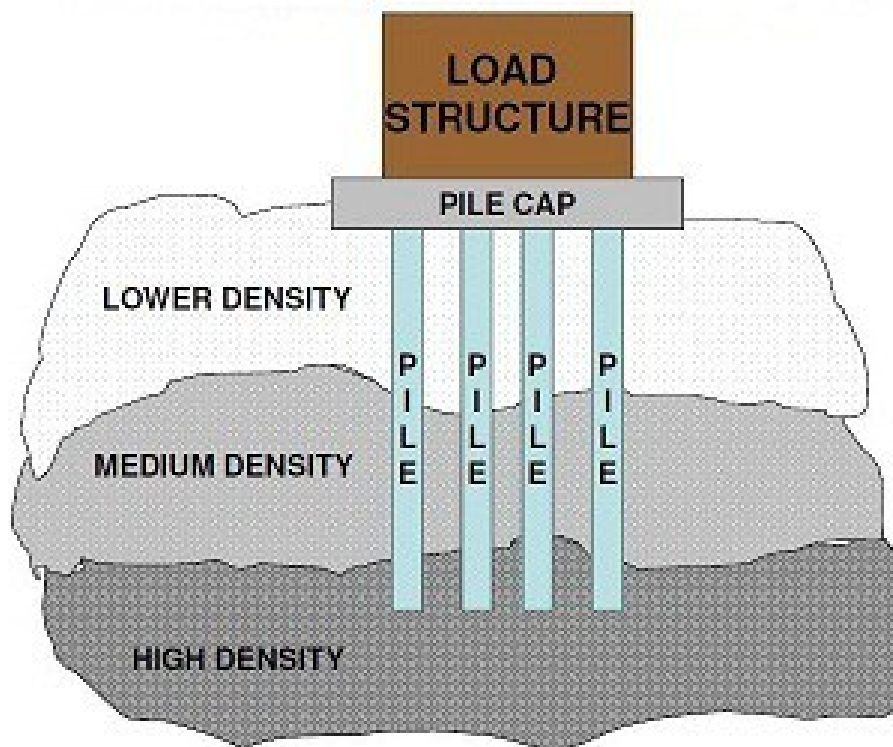


Figure 1.7: Pile foundation

ii) Well or Cassion Foundation

Well foundation is a type of deep foundation which is generally provided below the water level for bridges. Cassions or well have been in use for foundations of bridges and other structures since Roman and Mughal periods. The term 'cassion' is derived from the French word *caisse* which means box or chest. Hence cassion means a box like structure, round or rectangular, which is sunk from the surface of either land or water to some desired depth.

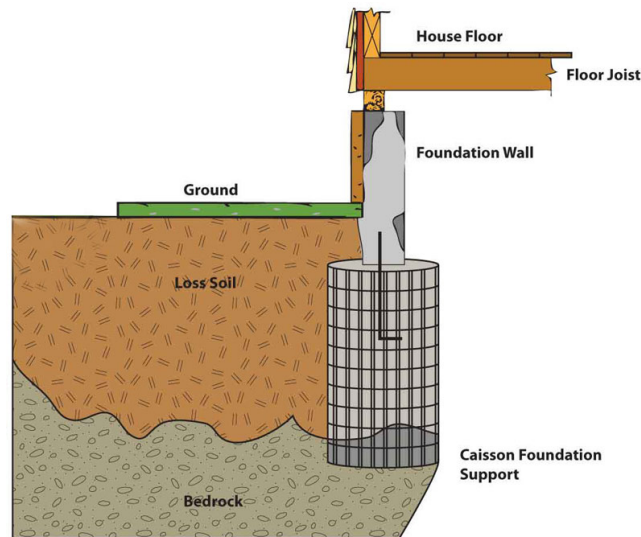


Figure 1.8: Well foundation

iii) Pier Foundation

A pier foundation is a series of vertical pillars or piles that transfer the building load to the soil. Beams are then built on top of these columns. They lift the house off the ground and are very popular in coastal regions where rising tides are a problem. Pier foundations work well in sites where it might be challenging to build a traditional foundation, such as around trees or vast root systems. Other reasons pier foundations are used:

1. When decomposed rocks are close to the surface, and there is
2. firmer soil just below them.
3. When there is a lot of stiff clay in the soil that offers resistance.
4. When a home is built from log or timber.
5. When the homes need to be built on a slope.
6. When the soil has a low water-bearing capacity.

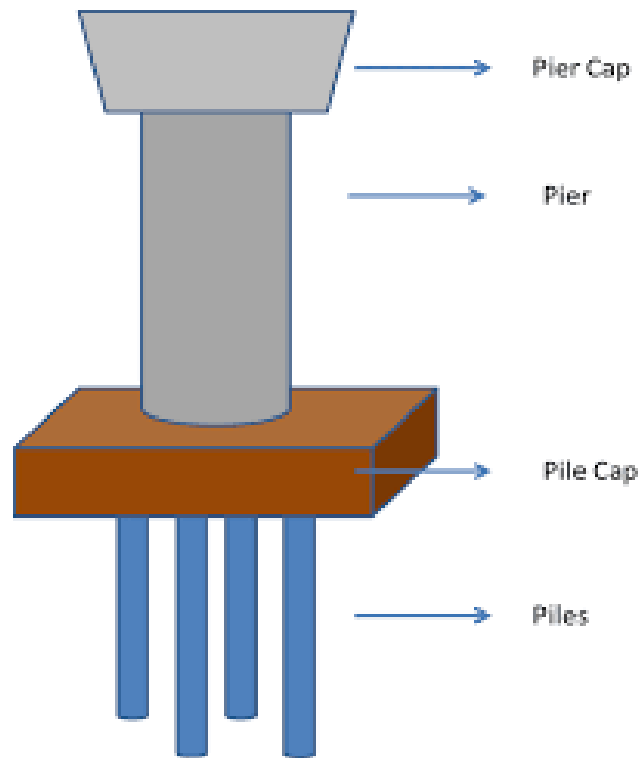


Figure 1.9: Peir foundation

1.3 Importance of Foundation

Foundations are mostly fails due to settlements and improper design. To avoid these failures it is necessary to analyse the foundation before the construction. There are plenty of numerical methods and software's are available for the analysis and design of foundations like plaxis, GEO5, Abacus, slope/w etc. These numerical methods will focus on the structural stability and safety factor of the foundations. In the present study the foundation is to be designed based on the soil profile, real world ground conditions of soil profile. It will be achieved through the GEO5 software because GEO 5 is an effective method to design of foundation according to the real world conditions which will increase the structural stability.



Figure 1.10: Differential Settlement of Foundation

1.4 GEO 5 Software

GEO5 is an intuitive software suite providing a solution for the majority of geological and geotechnical tasks. From geological site investigation, subbase model creation up to a wide range of analyses such as slope stability, deep excavation, and foundation designs. It is owned by fine software solutions. GEO 5 is an effective method to to design of foundation according to the real world conditions which will increase the structural stability.



Figure 1.11: GEO 5 Software

From the last decade for analysis and design of foundation for any structure , there are many Numerical methods (software's) developed like, Plaxis, Geo studio, Abacus, Anssis, GEO5 etc... In the present study to Analysis and design of selected foundations GEO 5 software is used. GEO5 software is a very intuitive and easy-to-use tool. users mostly do not need any extensive tutorial before using programs - they can work confidently with it within a few minutes. But you can use variety of training and documentation resources though whenever needed. Basic geotechnical approaches implemented in the GEO5 programs are applicable all over the world. Nevertheless, most countries adopt their own standards and conventions. GEO5 offers a unique way of applying standards which significantly simplifies the work of a designer and at the same time allows for complying with all required approaches.



Figure 1.12: Design tools offered by GEO5

Chapter 2

Literature Review

The following literature has been collected for the present study and the summary of each is presented below

In the year 2021 Nayan M R, has performed the analysis of foundations using Geo5. In this analysis, shallow foundation is considered. The analysis is to estimate and calculate the factor of safety using GEO5 student version Software. A vertical and horizontal bearing capacity analysis is performed by the program. Design of foundation includes four types of foundation. Analysis of foundation include different cases like with and without earthquake, with and without surcharge. Main objective of analysis is to design and calculate the dimensions and stability of spread footing foundation and to find the value of factor of safety using GEO5 program. In this analysis he observed that how four different types of foundations might increase their bearing capability. In comparison to other types of footing, the results demonstrate that bearing capacity increases greatly in the circular spread footing and decreases in the strip footing.

Khalid Waleed Hadi (2018), has studied by the calculation of vertical settlement values for Shallow foundation in sandy soil under the influence of different vertical loads. Settlement and bearing capacity values of shallow foundations for various soil conditions and load conditions were observed using different empirical methods.

N Dudek (2019), has performed a Pile group settlement analysis on the basis of Static Load Test. The results obtained are highly dependent on the input data, especially on characteristics describing soil subgrade stiffness and properties of the foundation soil. Main objective of analysis is to design and calculate the dimensions and stability of pile foundation and to find the value of factor of safety.

Parth Akbari and Hardik Patel in the year 2020 has conducted a case study on analysis and design of pile foundations. In this analysis he considered the different types of soils such as clays with different consistency, sand with different density having different angle of internal friction with layers of sand and clay. It also includes different pile cap parameters such as shape (Triangular, square rectangular), length, spacing of piles in groups and pattern of the pile group. From the analysis he concluded that the deflection of a laterally loaded pile is found to increase when stress–displacement response of soil strata is higher.

In the year 2015 Tiraawat Boonyantee has performed the analysis of pile foundation in Bangkok. This study was made on thirty-six static load tests on instrumented piles, which were larger and longer than ones in the past. Parameters for the determination of bearing capacity and settlement were back analysed and compared with previous analysis. In this study, empirical relations of practical interest and their assumed conditions were reviewed. Necessary design parameters were reassessed.

2.1 Objectives

Based on the considered literature, the following objectives are drawn for the present study.

1. To perform analysis and design of both shallow (spread) and deep (pile) foundation using GEO5 software.

Chapter 3

Material Used

In this chapter the properties of materials and methodology considered for the study are discussed.

The collected soil sample was tested in RGM campus for the present study. The shear parameters of soil are determined. The test results are presented below



Figure 3.1: Direct Shear Test

Table 3.1: Soil properties

Soil Type	Cohesion (KPa)	Angle of internal friction (°)	Unit weight (KN/m³)
1.Silty Gravel	2	35	19
2.Clayey sand	5	30	16.1
3.Clay	20	13	17.3

3.1 Methodology

The following methodology has been adopted for the present study to achieve the mentioned objective.

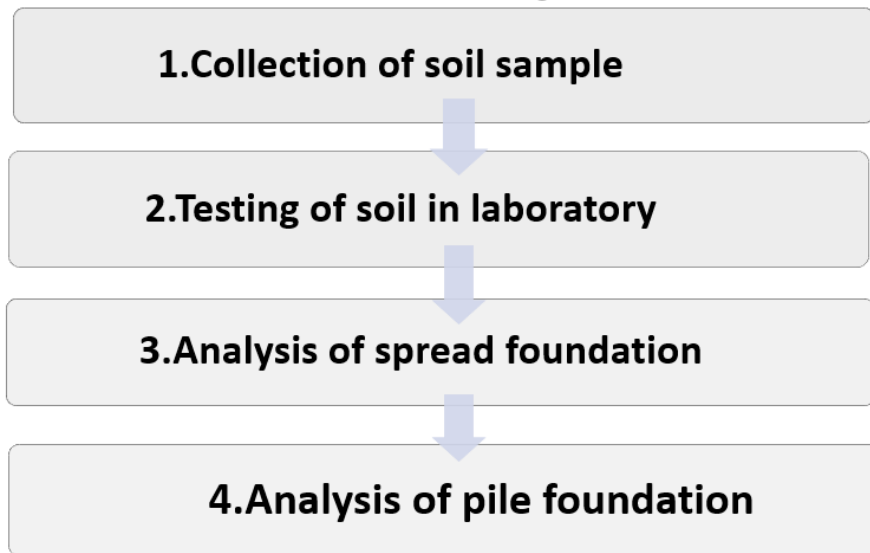


Figure 3.2: Methodology

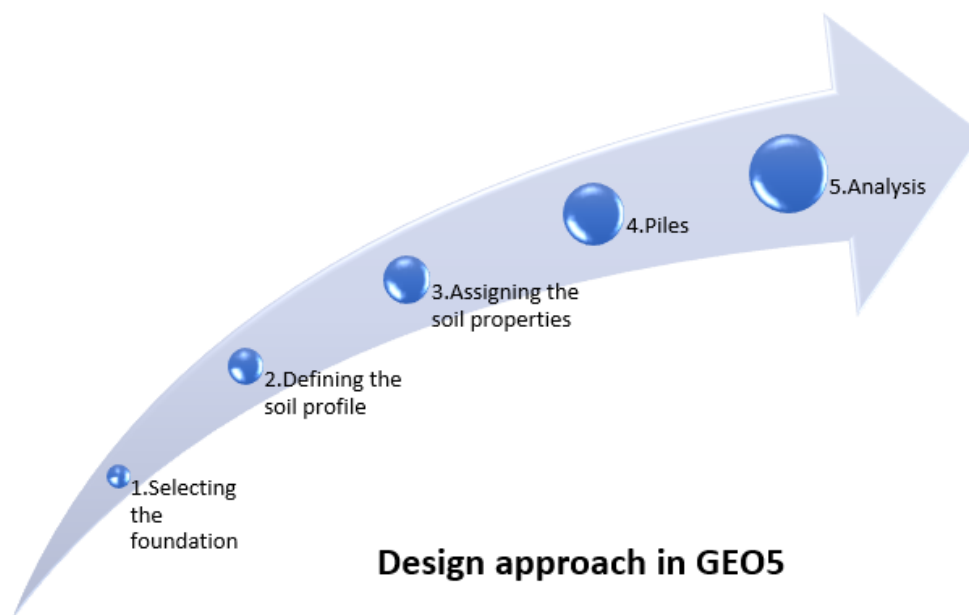


Figure 3.3: Design Approach in GEO5

Chapter 4

Analysis and Design in GEO5

In this chapter, step by step procedure for analysis of spread foundations and pile foundation Using geo5 software has been discussed.

4.1 Spread Foundation

4.1.1 User Interface

The user interface of the spread foundation consists of different tool bars. The tool bars are provided at the top left corner and top right corners which will be used for the analysis. The different tool bars of the user interface are settings, soil profile, assigning, water table, geometry, Material. The user interface of spread foundation is shown below

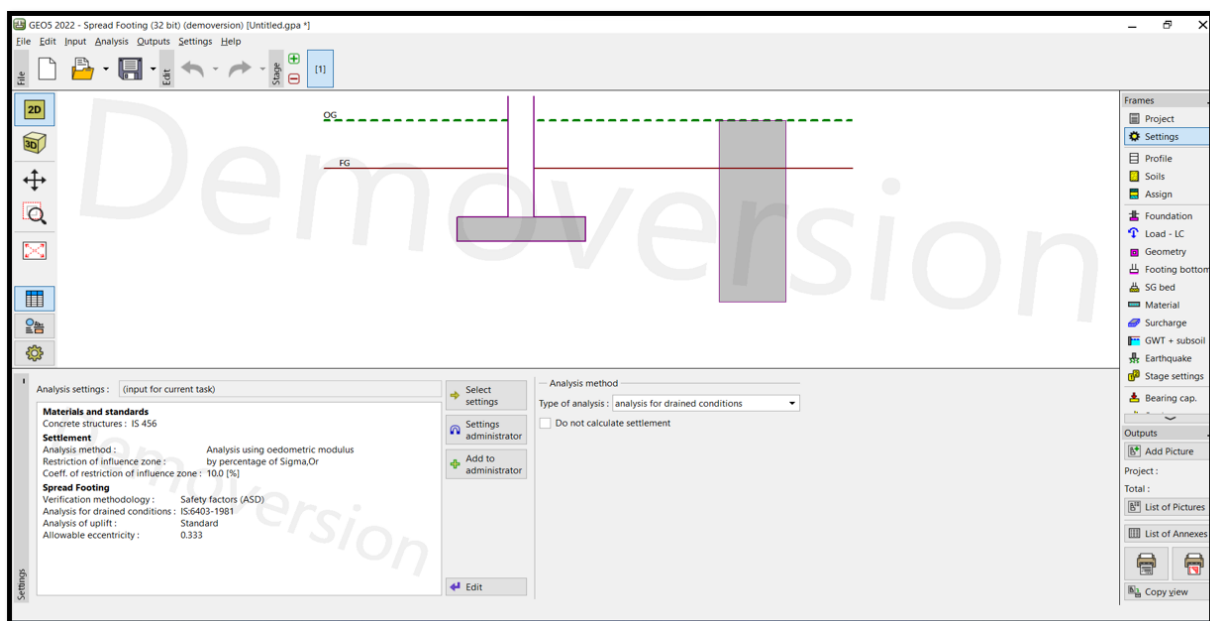


Figure 4.1: User interface of spread foundation

4.1.2 Assigning of Soil Profile

The soil profile in the ground is to be added by using the "profile" tool bar. The soil profiles in the grounds is to be added by clicking on add and then a dialogue box will be displayed on user interface. In the dialogue box the soil profile properties are to be entered. The entered soil properties are to be assigned by using assign tool bar and the dialogue box will be closed.

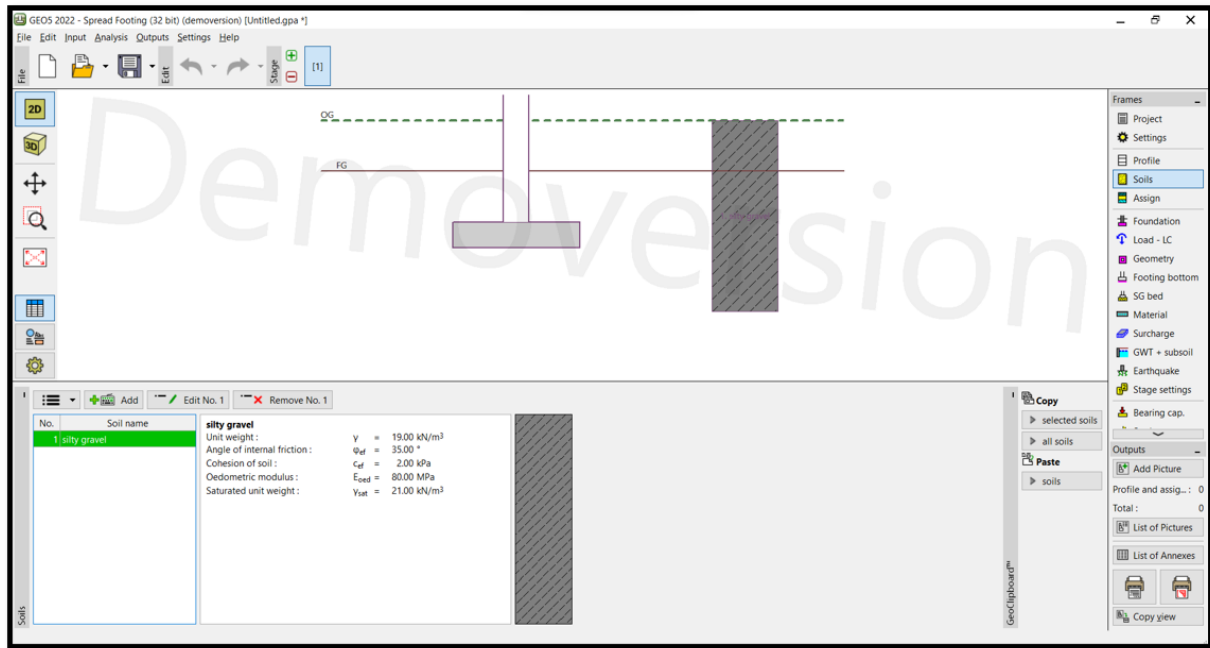


Figure 4.2: Soil Profile

4.1.3 Material Properties

The foundation materials like concrete and steel are assigned in this step. The material tool bar is used to assign these material properties. The characteristic compressive strength of concrete, yield strength of steel, transverse reinforcement, longitudinal reinforcement are to be given as the input for the further analysis.

1. M20 grade concrete is used for foundation.
2. Fe 415 steel is used for the longitudinal and transverse reinforcement.

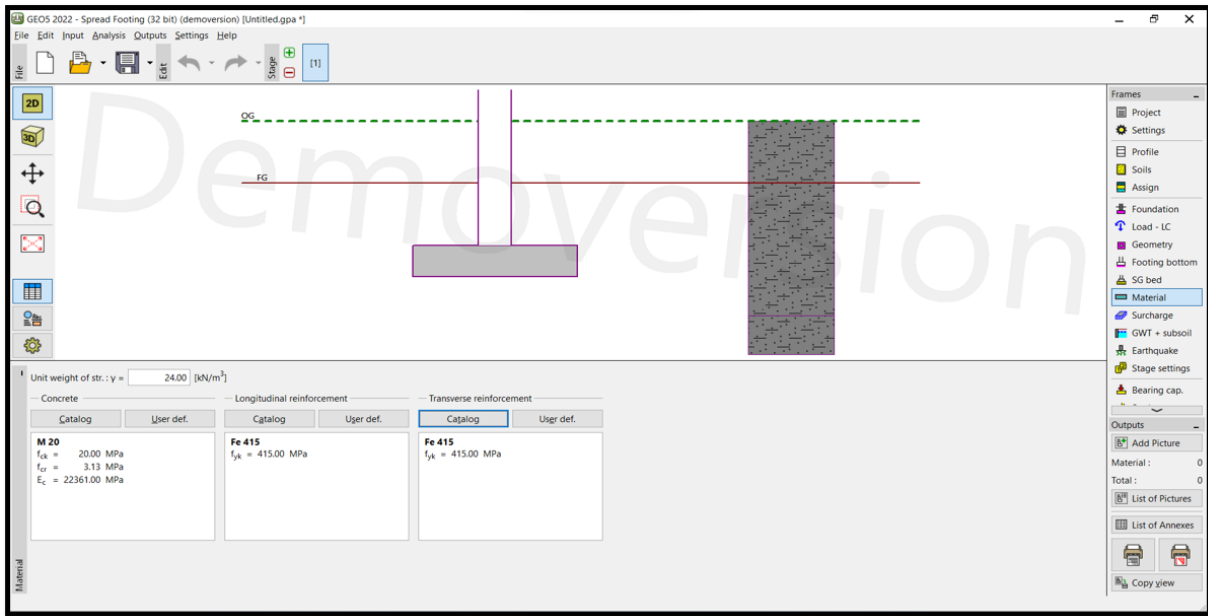


Figure 4.3: Material properties

4.1.4 Location of Ground Water Table

The ground water table is located at a depth of 50 meters from the ground surface. It can be assigned in GEO5 software using GWT tool which can be provided at the bottom right corner of the GEO5 user interface.

As the depth of the ground water table is 50 meters far from the depth of the spread footing, so there will be no effect of ground water table on the spread footing.

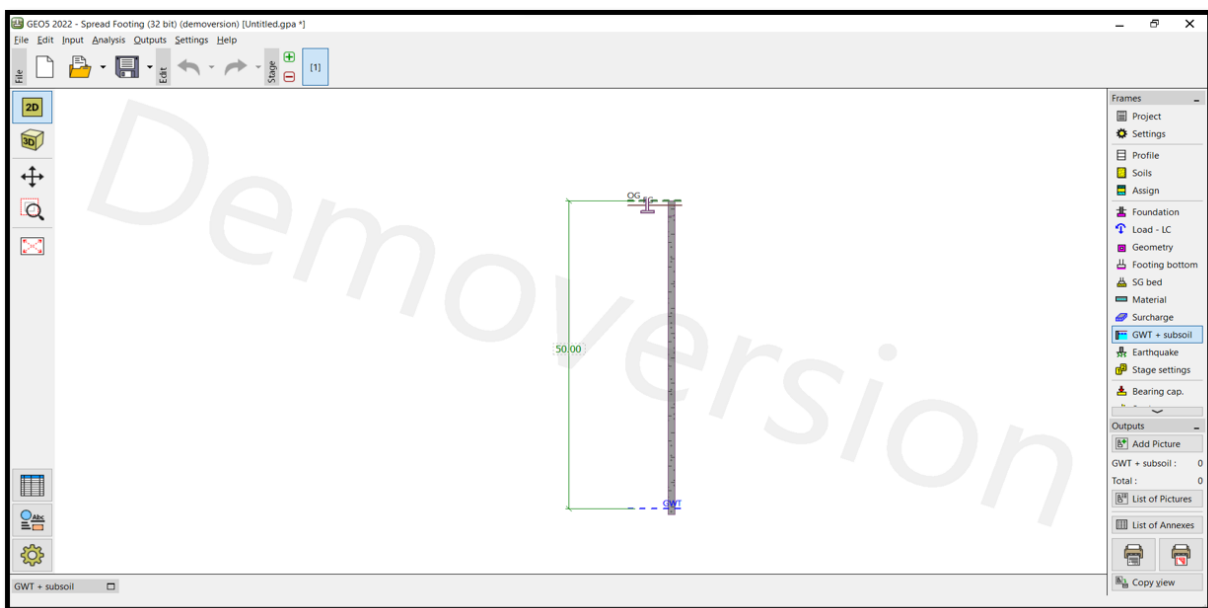


Figure 4.4: Depth of ground water table

4.1.5 Depth of Spread Foundation

The depth of the spread foundation as per the soil characteristics will be recommended by the GEO5 software. In case the recommended dimensions by the software are not satisfactory, it is possible to design manually. The depth of the spread footing from the ground level is 2 meters and the thickness of the spread footing is 0.4 meters.

The foundation tool bar is used to display all these dimensions of the spread footing and to enter manually a dialogue box will be displayed on the top corner of the GEO5 user interface.

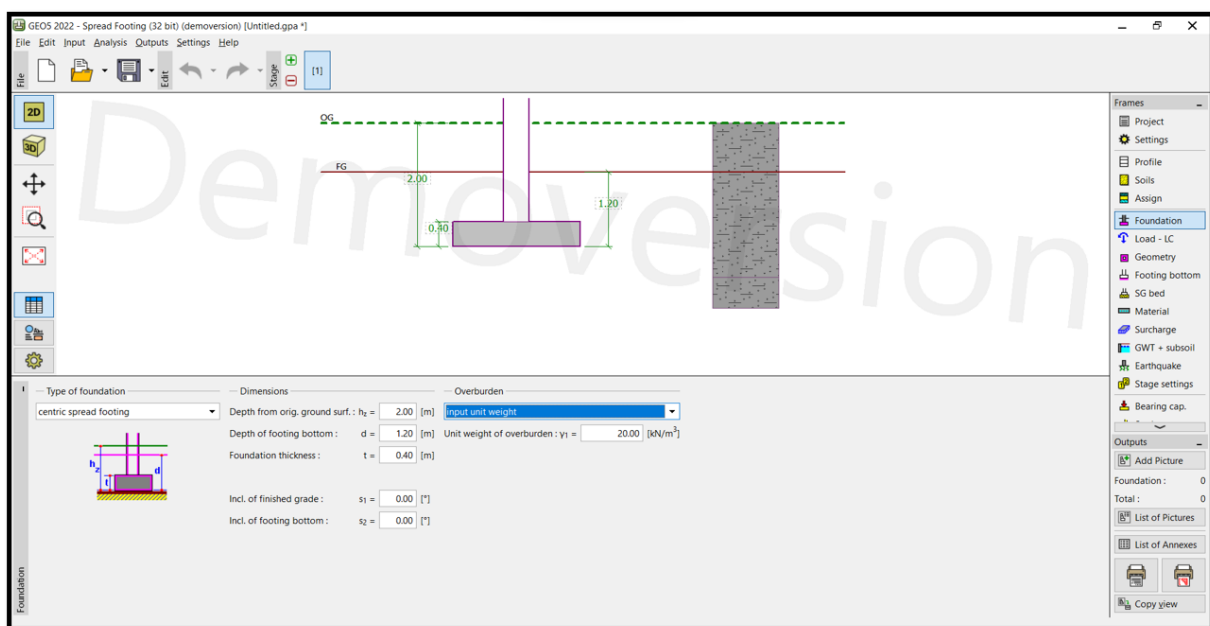


Figure 4.5: Depth of spread foundation

4.1.6 3-D View of Spread Foundation

The next step in the analysis is to display a three-dimensional view of the spread foundation in the ground. GEO5 offers the users to display all structural tools in the three-dimensional view and more. It will help in the settlement analysis. This is an extra feature offered by the GEO5 software to make the task easy for the users. The 3D tool bar is displayed on the top left corner of the GEO user interface, double-click on the tool bar will display the three-dimensional view of the spread footing.

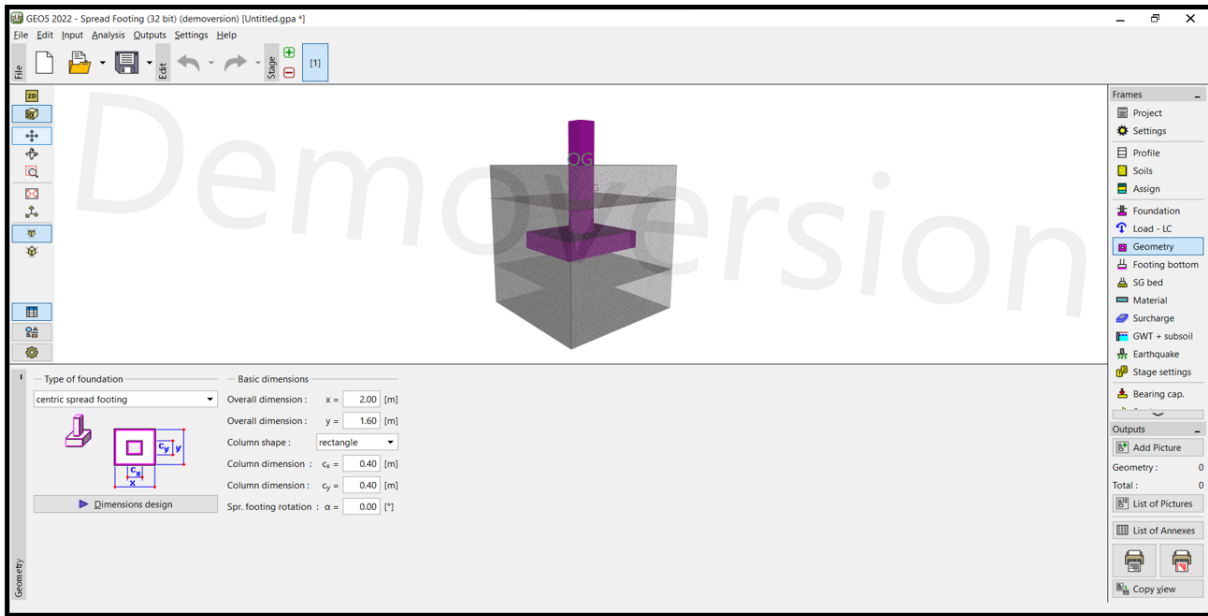


Figure 4.6: 3-D Dimensional View of spread foundation

4.1.7 Bearing Capacity

In this step the bearing capacity of the spread foundation can be determined by performing the analysis. The bearing capacity of the foundation should be satisfactory and when the capacity of the foundation is not satisfactory then the spread foundation is not suitable for that soil profile. Then other kind of foundations may be opted for the analysis.

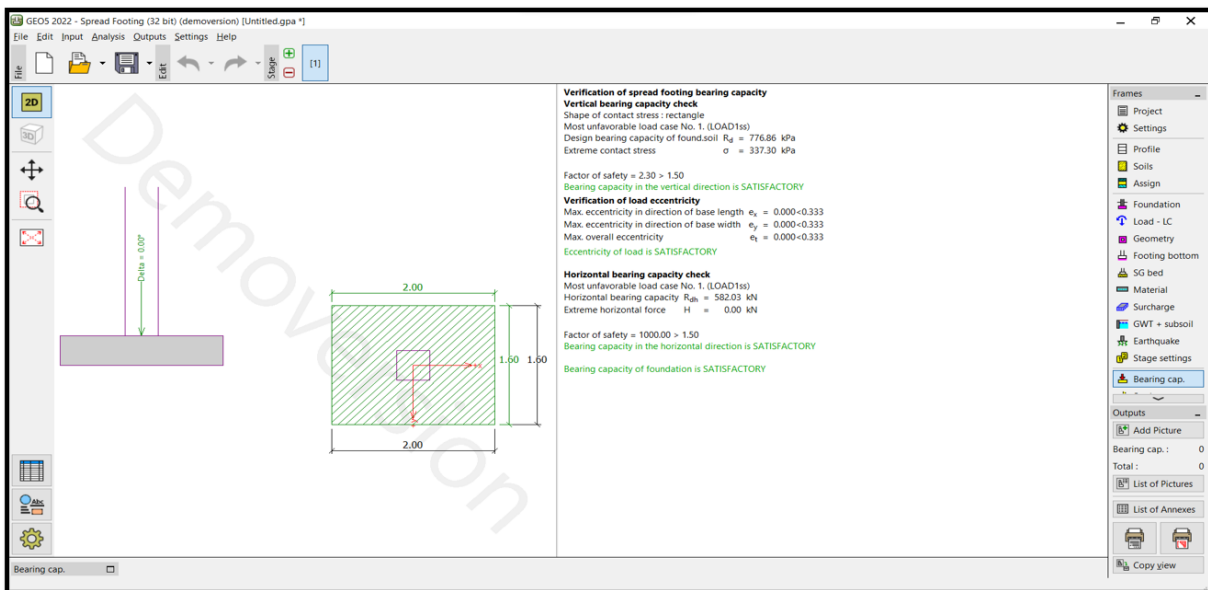


Figure 4.7: Bearing Capacity

4.1.8 Foundation Details

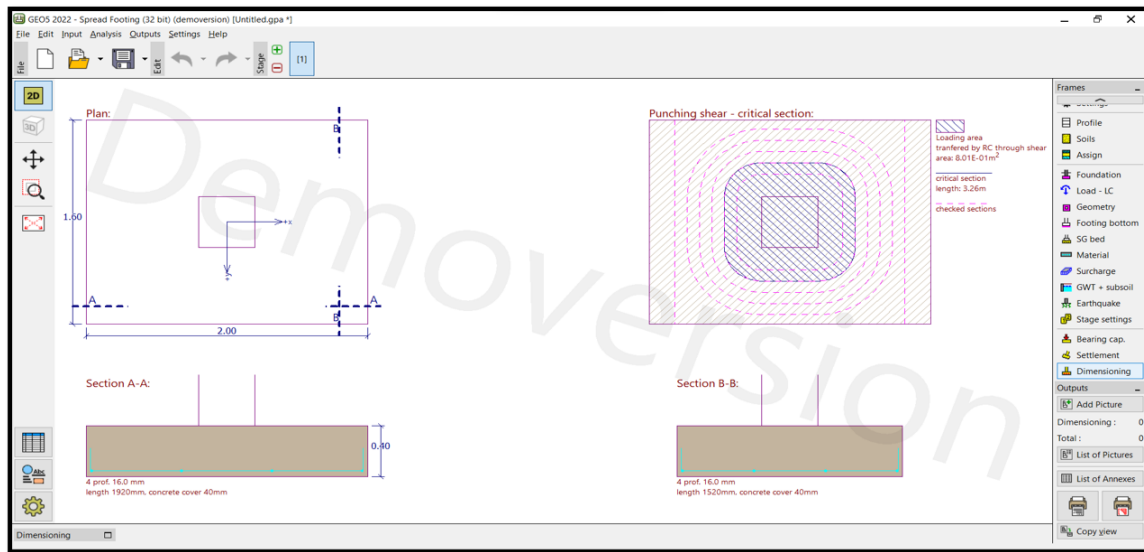


Figure 4.8: Foundation Drawings

4.2 Pile Foundation

4.2.1 Selection of Indian Standard

Before starting the pile foundation analysis in GEO5, In the project settings Indian standard is to be selected for the analysis. There are various country standards are also provided. From the drop down box indian standard is to be selected.

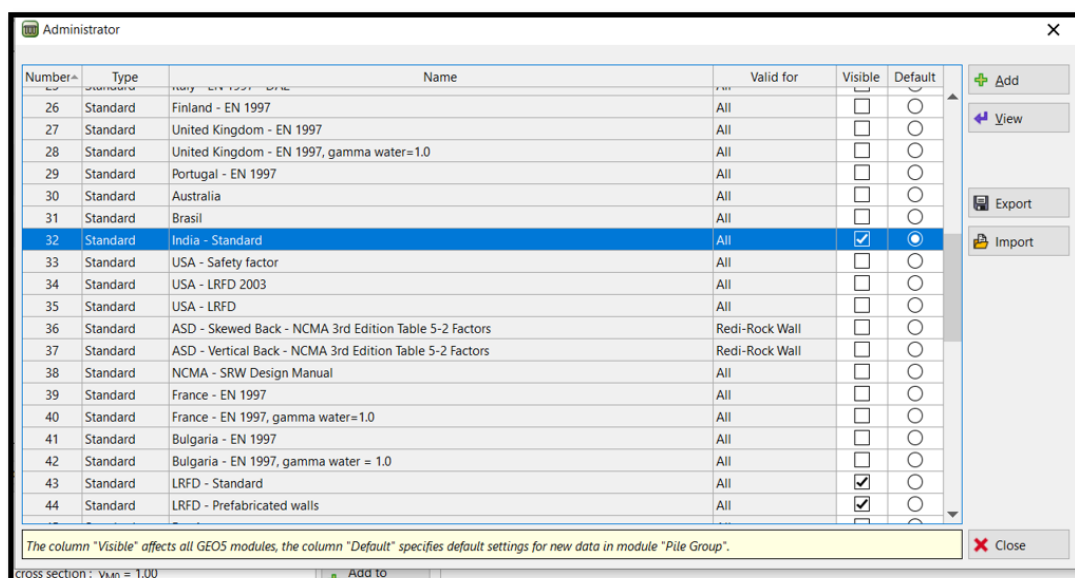


Figure 4.9: Selection of Indian Standard

4.2.2 Assigning of Soil Profile

The soil profile in the ground is to be added by using the "profile" tool bar. The soil profiles in the grounds is to be added by clicking on add and then a dialogue box will be displayed on user interface. In the dialogue box the soil profile properties are to be entered. The entered soil properties are to be assigned by using assign tool bar and the dialogue box will be closed.

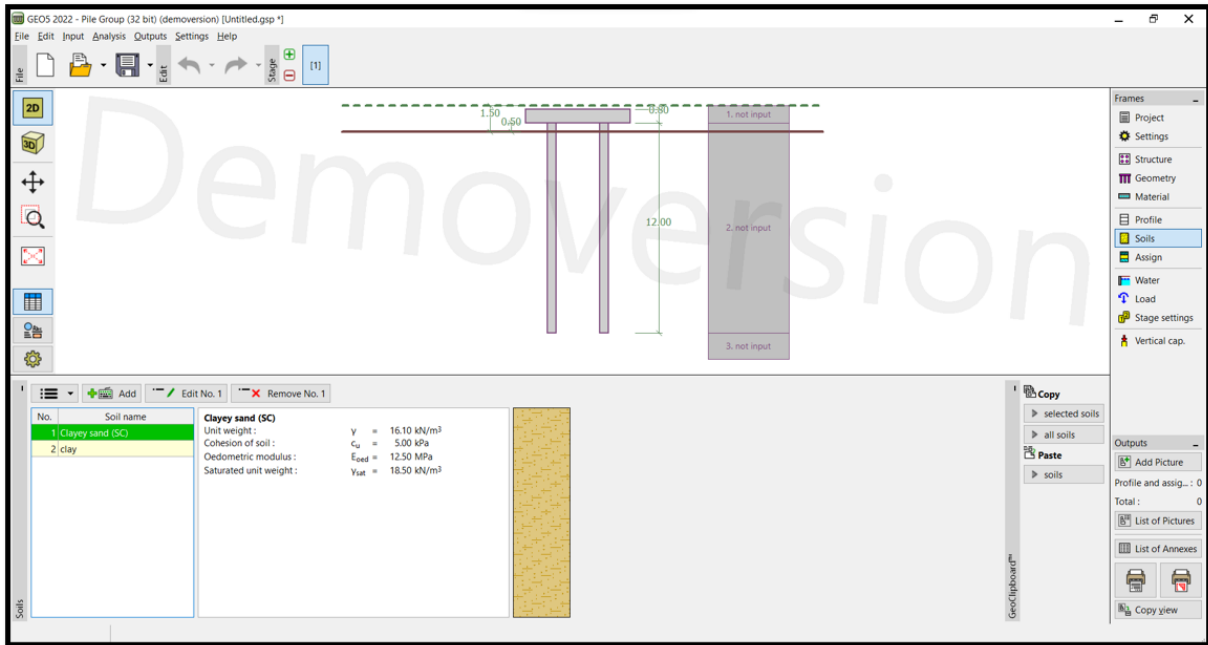


Figure 4.10: Soil profile

4.2.3 Pile Cap

The pile cap is an important part of the analysis. The dimensions of the pile cap are recommended by the software at this stage. Then, in the "Geometry" frame, we will define the depth from the ground surface, the pile head, offset, the pile cap thickness, and the lengths of all piles in the group. All the individual piles in the group have equal diameters and lengths.

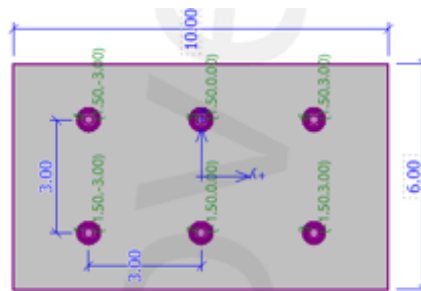


Figure 4.11: Pile Cap

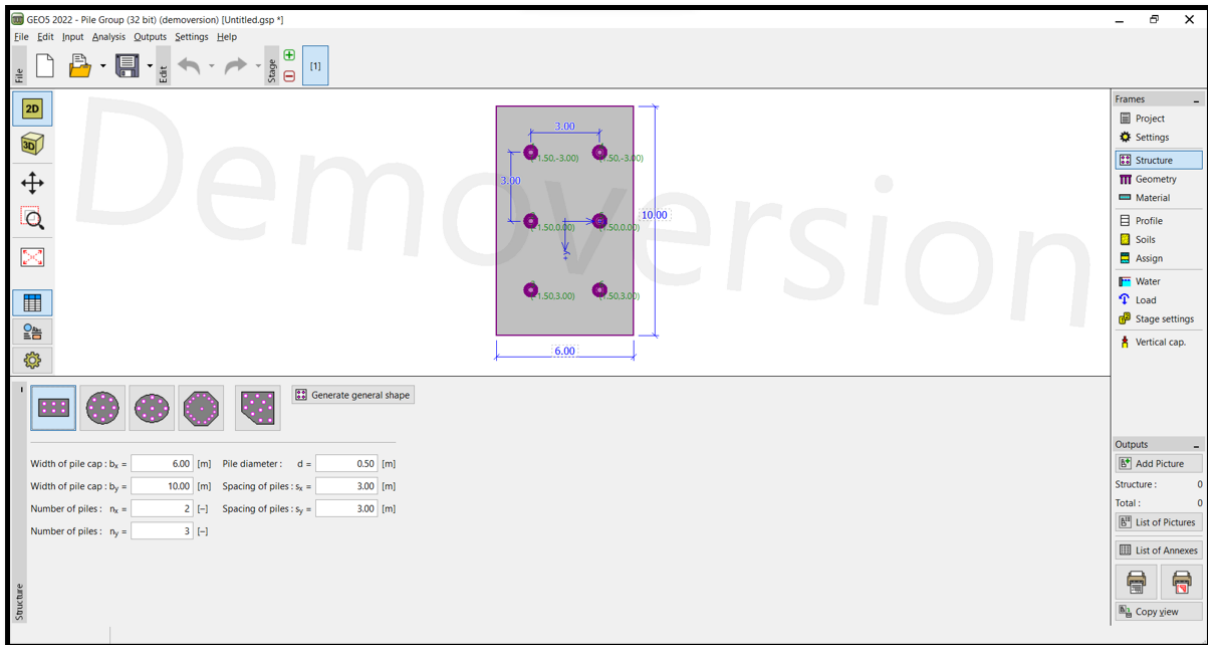


Figure 4.12: Pile Cap

4.2.4 Assigning Soil Profile

The soil profile in the ground is to be added by using the "profile" tool bar. The clayey sand and clay soil properties are assigned to the profile. To identify them easily colors are assigned for each soil. In the dialogue box the soil profile properties are to be entered. The entered soil properties are to be assigned by using assign tool bar and the dialogue box will be closed. Then further moved in the analysis.

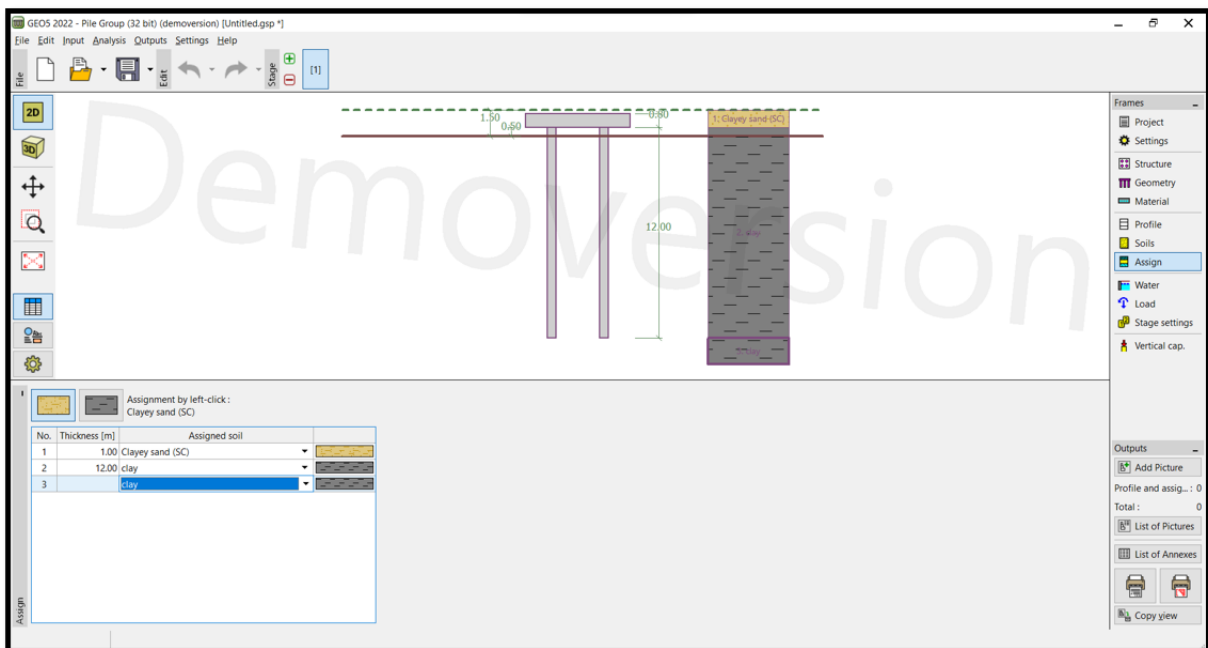


Figure 4.13: Assigning the soil profile

4.2.5 Material Properties

The foundation materials like concrete and steel are assigned in this step. The material tool bar is used to assign these material properties. The characteristic compressive strength of concrete, yield strength of steel, transverse reinforcement, longitudinal reinforcement are to be given as the input for the further analysis.

1. M20 grade concrete is used for foundation.
2. Fe 500 steel is used for the longitudinal and transverse reinforcement.

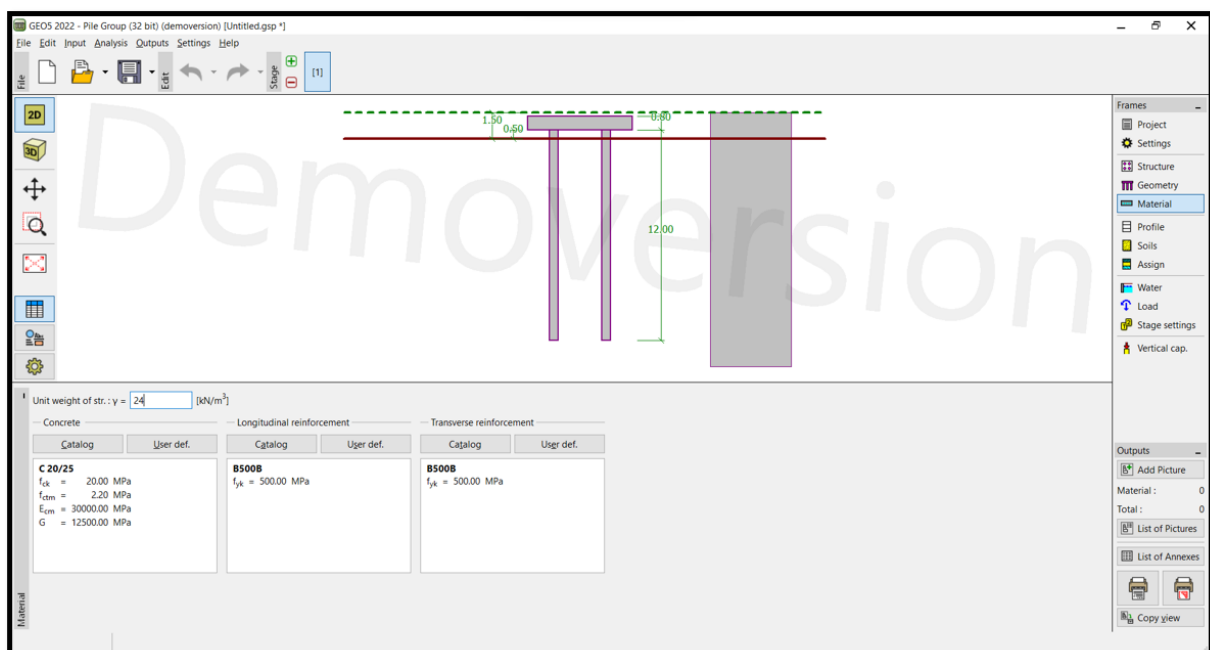


Figure 4.14: Material Properties

4.2.6 Bearing Capacity

In this step the bearing capacity of the spread foundation can be determined by performing the analysis. The bearing capacity of the foundation should be satisfactory and when the capacity of the foundation is not satisfactory then the spread foundation is not suitable for that soil profile. Then other kind of foundations may be opted for the analysis.

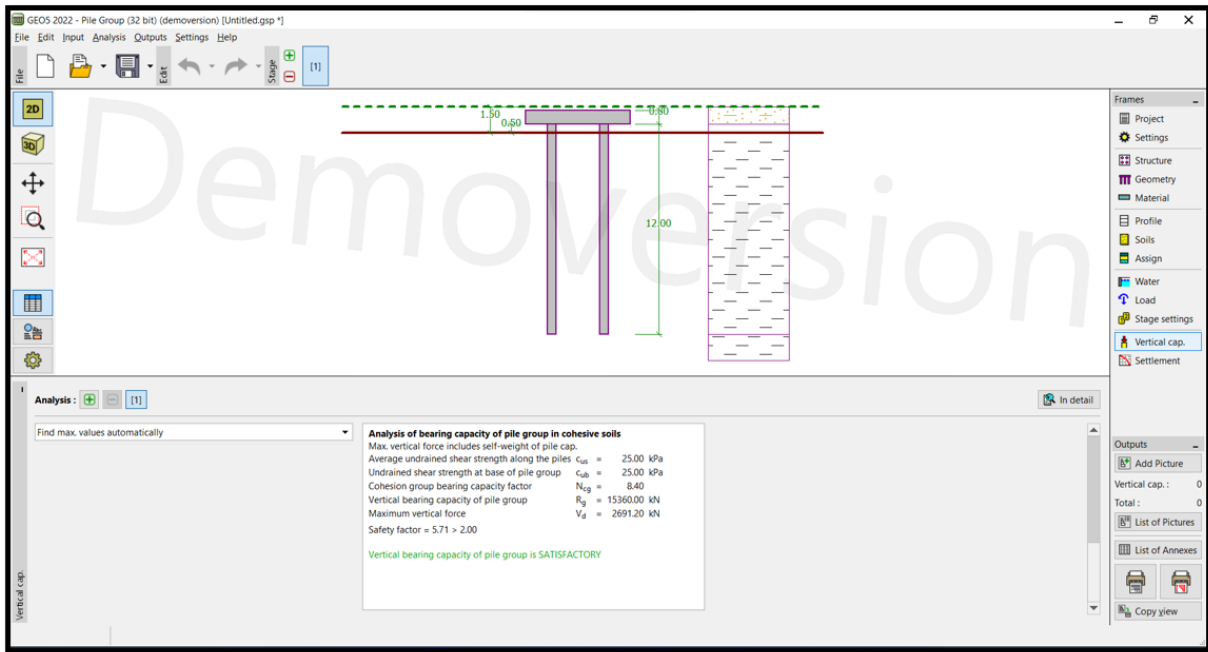


Figure 4.15: Bearing Capacity

Chapter 5

Results and Discussions

In this chapter the foundation analysis results of both shallow and deep foundation from the GEO5 software are discussed.

5.1 Spread Foundation

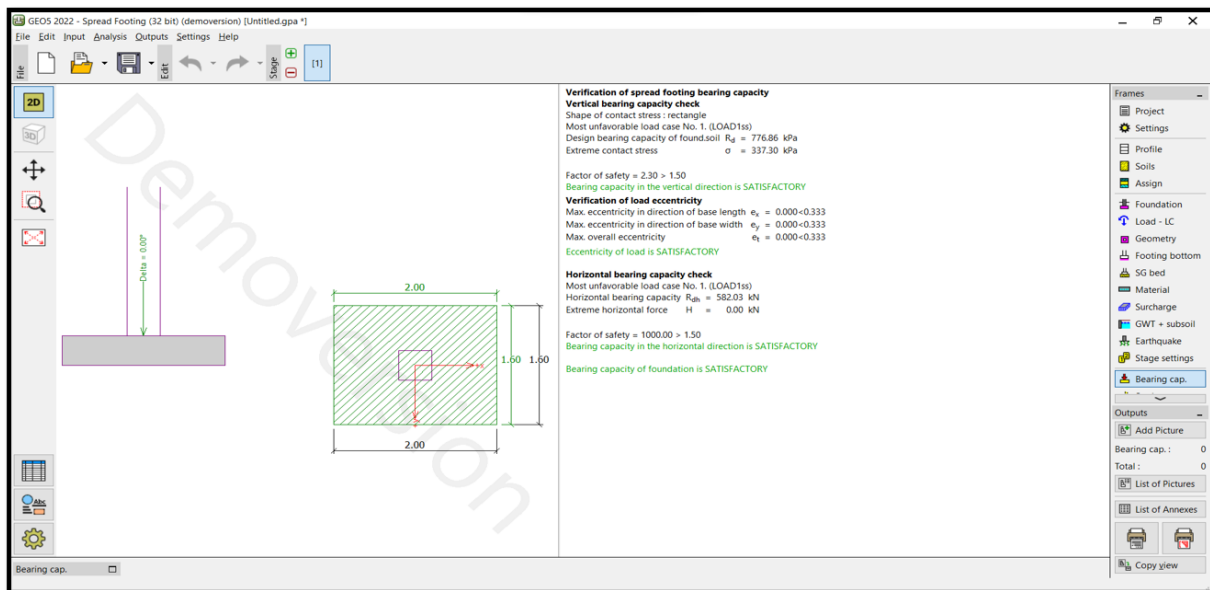


Figure 5.1: Bearing Capacity

1. Design bearing capacity = 776.86 KPa
2. Structural dimensions
 - Length = 2m
 - Width = 1.6m
 - Depth = 0.4m

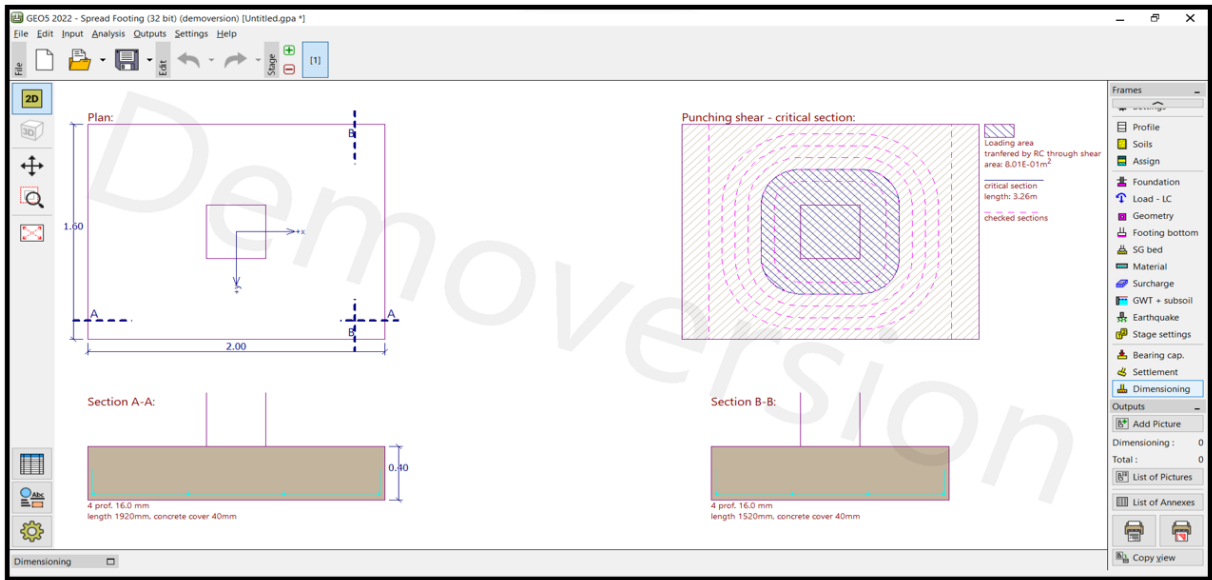


Figure 5.2: Foundation Drawings

5.2 Pile Foundation

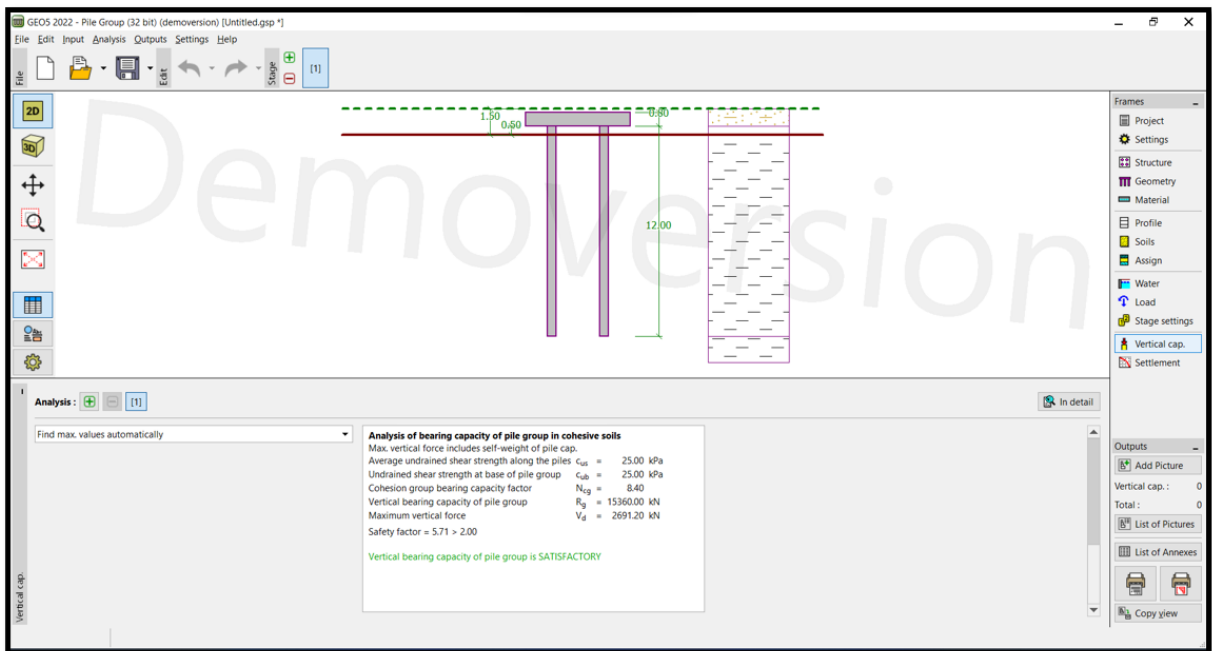


Figure 5.3: Pile foundation bearing capacity

1. Design bearing capacity = 15360 KN
2. Structural dimensions
 - Length = 12m
 - Diameter = 0.5m

Chapter 6

Conclusions

Using GEO5 the analysis and design of foundations (spread and pile) have performed and concluded that both foundations (spread and pile) are safe. The pile foundation offers greater bearing capacity even in clayey soil. It is also concluded that GEO5 is an effective method for foundation analysis however it also have some drawbacks.

References

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