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# An Exploratory Study on the Feasibility of Partial Utilization of Industrial Slag into Concrete Mix.

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***Abstract***— **The analysis of slope stability in river side areas has received widely attention now days because of its practical importance. To provide steepest slops which are stable and safe various investigations are ongoing. Stability is determined by the balance of shear stress and shear strength. If the forces available to resist movement are greater than the forces driving movement, the slope is considered stable. A factor of safety is calculated by dividing the forces resisting movement by the forces driving movement. A previously stable slope may be initially affected by preparatory factors, making the slope conditionally unstable. The field of slope stability encompasses static and dynamic stability of slopes of earth and rock-fill dams, slopes of embankments, excavated slopes, and natural slopes in the river side area of soil and soft rock. Various methods are available for slope stability analysis. This paper aims an overview on various methods of slope stability on the basis of assumptions, Factor of safety calculation, soil conditions, soil types, applicability of output of the method with its limitations. This paper also aims to focus some new mathematical tools which can be applicable for sustainable urban development of India..**

***Index Terms***— **Soil slope, Numerical analysis, Plaxis 2D.**

## I. INTRODUCTION

Slope stability is a crucial aspect of geotechnical engineering and construction. It refers to the ability of a slope or hillside to resist movement or failure. Understanding the factors that influence slope stability is essential for ensuring the safety and durability of structures built on or near slopes. Slope stability refers to the ability of a slope or hillside to resist movement or failure. Slope stability indicates the condition of slopes that either withstand or undergo movement. Slope stability analysis is a static or dynamic, analytical, or numerical method for assessing slope stability and understanding the causes of a slope failure or the factors that trigger a slope movement. Stability analysis answers a problem demanding force and/or moment equilibrium. The ratio between the shear strength and the shear stress expressed as a safety factor defines the slope stability. *(Abbas, J. M. (2014)*

*Infinite Slopes:*

If a slope represents boundary surface of a semi-infinite soil mass and the soil properties for all identical depths

*Finite Slopes:*

If the slope is of limited extent, it is called as finite slope.

*1.2. Objectives of present study:*

• To evaluate factor of safety of slope by analytical method and using software. (PLAXIS 2D)

• To suggest possible remedial measures of identify problems

## II. METHODS USED:

*2.1. Limit Equilibrium*:

a. Analytical technique- Methods of slices

•Swedish slip circle method of analysis

•Friction Circle Method

•Taylors stability number

*2.1.1 Swedish Slip Circle Method*:

The Swedish Slip Circle Method is a widely used method for analyzing slope stability in geotechnical engineering. It is based on the concept of the slip circle, which is a circular failure plane within a soil mass that tends to occur when the soil mass is on the verge of sliding. *(Bell, J. M. (1968).*

*2.1.2 Friction Circle Method:*

The friction circle method is a commonly used technique for analyzing the stability of slopes in geotechnical engineering. It is based on the concept of the Mohr-Coulomb failure criterion, which states that the shear stress needed to cause failure in a material is a function of the normal stress acting on the plane of failure and the friction angle of the material. The method involves constructing a Mohr's circle to represent the state of stress at a critical point on the slope. The circle is defined by the normal stress (σ) and the shear stress (τ) acting on the failure plane. By analyzing the circle, the factor of safety (FS) can be calculated, which is a measure of the stability of the slope. The friction circle method provides a simple and intuitive way to analyze slope stability by considering the interaction between normal and shear stresses. It has been widely used in geotechnical engineering practice and has been applied to various slope stability problems in both natural and man-made slopes.

*(Bell, J. M. (1968).*

*2.1.3. Taylors stability Number*:

If the slope angle β, height of embankment$H$ , the effective unit weight of material y, angle of Internal friction φ ', and unit cohesion $c'$ are known, the factor of safety may be determined. In order to make unnecessary the more or less tedious stability determinations, Taylor (1937) conceived the idea of analysing the stability of a large number of slopes through a wide range of slope angles φ' and angles of internal friction, and then representing the results by an abstract number which he called the "stability number". This number is designated as N*s*. The expression used is

$$Ns = \frac{c'}{F_c\, \gamma H}$$

From this the factor of safety with respect to cohesion may be expressed as

$$F_s = \frac{c'}{N_c\, \gamma H}$$

Taylor published his results in the form of curves which give the relationship between *Ns* and The slope angles β for various values of φ' as shown in Fig 6-A. These curves are for circles passing through the toe, although for values of β less than 53°, it has been found that the most dangerous circle passes below the toe. However, these curves may be used without serious error for slopes down to β = 14°. The stability numbers are obtained for factors of safety with respect to cohesion by keeping the factor of safety with respect to friction ($F_\emptyset$ ) equal to unity. In slopes encountered in practical problems, the depth to which the rupture circle may extend is usually limited by ledge or other underlying strong material as shown in Fig 7-B. The stability number *Ns* for the case when φ'= 0 is greatly dependent on the position of the ledge. The depth at which the ledge or strong material occurs may be expressed in terms of a depth factor $n_d$ which is defined as,

$$n_d = \frac{D}{H}$$

Where, $D$ = depth of ledge below the top of the embankment, $H$ = height of slope above the toe. For various values of $n_d$ and for the φ'= 0 case the chart in Fig 7-B. gives the stability number $N_s$for various values of slope angle β. In this case the rupture circle may pass through the toe or below the toe. The distance x of the rupture circle from the toe at the toe level may be expressed by a distance factor, $n_x$which is defined as,

$$n_x = \frac{x}{H}$$

The chart shows in fig 7-B the relationship between $n_d$ and$n_x$. If there is a ledge or other stronger material at the elevation of the toe, the depth factor $n_d$ for this case is unity.

*(Bell, J. M. (1968).*

## III. SOFTWARE USED:

*3.1 Software Used (Plaxis-2D):*

Plaxis 2D is a finite element analysis software used for determining the factor of safety of soil structures. It is commonly used in geotechnical engineering to analyze the stability of soil structures such as embankments, retaining walls, foundations, tunnels, and slopes.

Plaxis 2D uses the finite element method to model the behavior of soil and structures under various loading conditions. The software allows engineers to input soil properties, boundary conditions, and loading scenarios to create a virtual model of the structure. The software then calculates the stresses, strains, and displacements within the soil structure, allowing engineers to assess the stability and safety of the structure.

Factors of safety are commonly used in geotechnical engineering to assess the stability of soil structures. The factor of safety is calculated by dividing the maximum resistance of the soil structure by the maximum applied load. A factor of safety greater than 1 indicates that the structure is stable and can support the applied loads, while a factor of safety less than 1 indicates that the structure may be at risk of failure.

Plaxis 2D provides engineers with the tools and analysis capabilities to determine the factor of safety of soil structures accurately. The software uses advanced algorithms and numerical methods to simulate the complex behavior of soil and structures under various loading conditions. Engineers can use the results from Plaxis 2D to assess and optimize the design of soil structures for safety and stability. (*Albataineh, N. (2006).*

*3.2 Direct Shear Test:*

Direct shear test is an experimental procedure conducted in geotechnical engineering practice and research that aims to determine shear strength of soil.

| Sr. No | Shear Disp (mm) | Vertical Disp (mm) | Shear Force (KN) | Shear stress ($Kg/cm^2$) |
|---|---|---|---|---|
| 1 | 0.25 | 0.01 | 2.65 | 7.54 |
| 2 | 0.50 | 0 | 3.24 | 9.25 |
| 3 | 0.75 | 0.01 | 3.38 | 9.69 |
| 4 | 1.00 | 0.01 | 3.82 | 11 |
| 5 | 1.25 | 0.01 | 3.97 | 11.48 |
| 6 | 1.50 | 0.01 | 4.27 | 12.4 |
| 7 | 1.75 | 0.01 | 4.27 | 12.46 |
| 8 | 2.0 | 0.01 | 4.56 | 13.36 |
| 9 | 2.25 | 0.01 | 4.71 | 13.86 |
| 10 | 2.5 | 0.01 | 4.86 | 14.36 |
| 11 | 2.75 | 0.01 | 5.15 | 15.29 |
| 12 | 3 | 0.01 | 5 | 14.91 |
| 13 | 3.25 | 0.01 | 5.44 | 16.29 |
| 14 | 3.5 | 0.01 | 5.59 | 16.81 |
| 15 | 3.75 | 0 | 5.44 | 16.44 |
| 16 | 4 | 0 | 5.59 | 16.96 |
| 17 | 4.25 | 0.01 | 5.74 | 17.5 |
| 18 | 4.5 | 0.01 | 5.74 | 17.58 |
| 19 | 4.75 | 0.01 | 5.89 | 18.12 |
| 20 | 5.00 | 0.01 | 6.03 | 18.63 |

Table No.I: Sample I (0.5 Load)

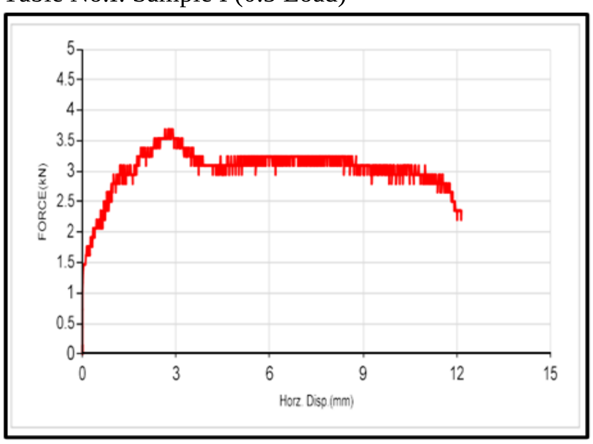


Fig.1. Force vs Displacement Graph sample I

| Sr. No | Shear Disp (mm) | Vertical Disp (mm) | Shear Force (KN) | Shear stress ($Kg/cm^2$) |
|---|---|---|---|---|
| 1 | 0.25 | 0.03 | 2.2 | 6.26 |
| 2 | 0.50 | 0.06 | 2.5 | 7.14 |
| 3 | 0.75 | 0.11 | 2.65 | 7.6 |
| 4 | 1.00 | 0.11 | 2.35 | 6.77 |
| 5 | 1.25 | 0.11 | 2.79 | 8.07 |
| 6 | 1.50 | 0.11 | 2.65 | 7.7 |
| 7 | 1.75 | 0.11 | 3.09 | 9.02 |
| 8 | 2.0 | 0.11 | 3.38 | 9.9 |
| 9 | 2.25 | 0.11 | 3.38 | 10.83 |
| 10 | 2.5 | 0.17 | 3.68 | 10.88 |
| 11 | 2.75 | 0.18 | 4.12 | 12.23 |
| 12 | 3 | 0.17 | 4.27 | 12.73 |
| 13 | 3.25 | 0.19 | 4.41 | 13.21 |
| 14 | 3.5 | 0.19 | 4.71 | 14.17 |
| 15 | 3.75 | 0.19 | 4.86 | 14.68 |
| 16 | 4 | 0.19 | 5 | 15.17 |
| 17 | 4.25 | 0.19 | 5 | 15.24 |
| 18 | 4.5 | 0.19 | 5.3 | 16.23 |
| 19 | 4.75 | 0.19 | 5.3 | 16.3 |
| 20 | 5.00 | 0.19 | 5.3 | 16.38 |

| Sr. No | Shear Disp (mm) | Vertical Disp (mm) | Shear Force (KN) | Shear stress ($Kg/cm^2$) |
|---|---|---|---|---|
| 1 | 0.25 | 0.36 | 1.76 | 5.01 |
| 2 | 0.50 | 0.36 | 2.20 | 6.28 |
| 3 | 0.75 | 0.37 | 2.50 | 7.17 |
| 4 | 1.00 | 0.37 | 2.94 | 8.47 |
| 5 | 1.25 | 0.37 | 3.09 | 8.94 |
| 6 | 1.50 | 0.36 | 3.09 | 8.98 |
| 7 | 1.75 | 0.37 | 3.24 | 9.45 |
| 8 | 2.0 | 0.37 | 3.38 | 9.9 |
| 9 | 2.25 | 0.37 | 3.38 | 9.95 |
| 10 | 2.5 | 0.37 | 3.53 | 10.43 |
| 11 | 2.75 | 0.37 | 3.68 | 10.92 |
| 12 | 3 | 0.37 | 3.53 | 10.52 |
| 13 | 3.25 | 0.37 | 3.24 | 9.7 |
| 14 | 3.5 | 0.37 | 3.38 | 10.17 |
| 15 | 3.75 | 0.37 | 3.09 | 9.34 |
| 16 | 4 | 0.37 | 3.09 | 9.38 |
| 17 | 4.25 | 0.37 | 3.09 | 9.42 |
| 18 | 4.5 | 0.37 | 2.94 | 9 |
| 19 | 4.75 | 0.37 | 3.09 | 9.51 |
| 20 | 5.00 | 0.37 | 3.09 | 9.55 |

Table No.II: Sample II (1 Load)

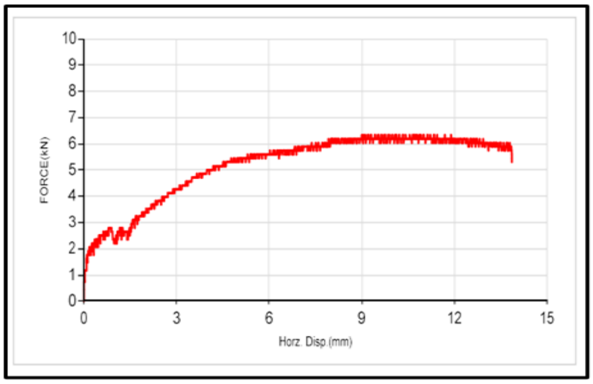


Fig.2 Force vs Displacement Graph sample II

Table No.III: Sample III (1.5 Load)

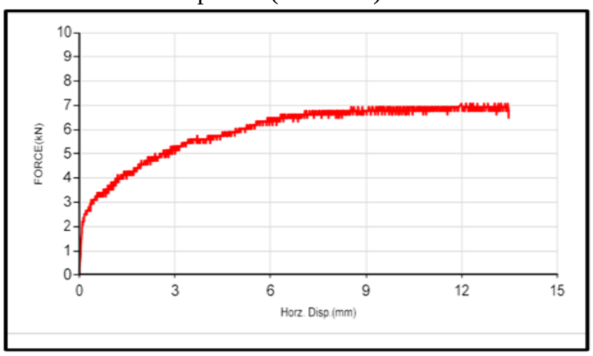


Fig.3 Force vs Displacement Graph sample III

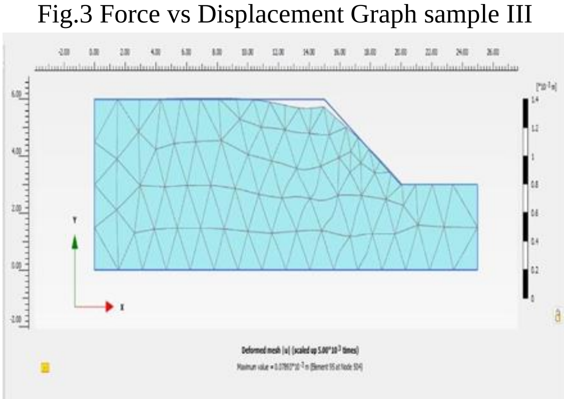

Fig.4 Deformation Mesh by PLAXIS 2D

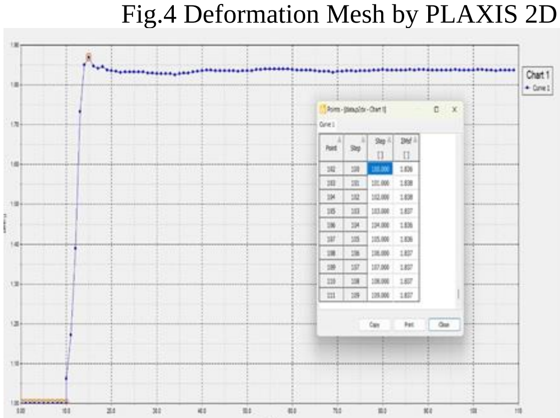

Fig.5 Factor of safety (FOS) of soil

## IV CONCLUSION

1. *From this Research and analysis we can find out the Factor of safety which indicates the soil cohesion capacity.*
2. *The analysis highlights the dynamic relation between factors such as soil composition, hydrological conditions, and topographical features, which significantly influence slope stability.*
3. *This analysis helps to neutralize the unstable slope in riverside areas.*
4. *Integrating advanced geotechnical modeling and monitoring technologies can enhance our understanding of slope dynamics and improve early warning systems for potential slope failures.*
5. *The project concludes is to Reduce and prevent Loss of soil and ensuring the stability also resilience of river side areas.*

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