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INSTABILITY SURVEY OF BASALTIC SOIL SLOPES IN MAHARASHTRA, INDIA

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ABSTRACT

Mahabaleshwar regarded as a destination for tourist and is situated in Maharashtra, India's most beautiful and important tourist finish point, suffering frequent slope owing to heavy rain and complex geologic circumstances. The area's litho component is Deccan Trap Basalt, most notable consecutive basaltic flows to Tertiary during late Cretaceous era. The area is extremely susceptible to temperature, different degrees of alteration, soil formation, and presence of bole beds in between two successive basaltic flows. In this region, soil formation cycle is one of most significant reasons for slope disappointment. These deformed soils create instability on slopes, and eventually aggregate into collapses on the slope. During arena studies, petrographic analysis alongside X-ray deflection, five kinds of soils were discovered which show changes in composition and color variations. Geo mechanical characteristics viz. five kinds of soil samples were tested for bulk density, particle size inspection, Atterberg limit, uniaxial compressive power, cohesiveness in addition to internal friction angle; using help of numerical software Slide 6.0, the impacts of various soils on slope stability were shown based on limit equilibrium process.

KEYWORDS: *Basaltic Soil, Soil Formation, Types of Soils, Weathering.*

1. INTRODUCTION

Highways in addition to roads in steep terrain are efficient methods of local transit besides linking from one location to the next. Highway planning in hilly regions is a real tough task. The impact of geo materials and organic heterogeneities includes on grade constancy. In general, a slope disappointment starts from mixes of effects such as mechanical discontinuities (circumstances besides orientations), withstanding besides geo material modifications, poor zone changes, litho logical disturbances, slope settings, heavy rains and considerably more. Geo material weathering and modification promotes litho logical disturbances and also aids in soil formation which adversely impacts stability of slopes. In addition, unanticipated highway projects in these ranges frequently present a major danger to human life, properties in addition resources, while an inventive field evaluation and suitable slope design will prevent loss of life, properties moreover potential unknown coincidences[1].

There are several conventional and numerical techniques used for determining safety factor (FoS) viz. Method of limiting equilibrium (LEM), system of finite elements (FEM), process of finite difference (FDM) and system of different elements (DEM). The current methods involve primarily kinematic analysis and ways of decreasing the equilibrium. LEM is the usual technique used on a daily basis for evaluating loose dirt etc., whereas translation or rotational motions occur when there is a clear failure. The conventional analyzes are performed to incorporate a set of shear asset parameters at failure either using a FoS or, via back-analysis. Over the past three decades, various methods for performing the two-dimensional (2-D) LEM of parts were suggested. Such techniques are (1) method by Fellenius, (2) fundamental method by Bishop, (3) simplified method by Janbu and (4) method by Spencer[2].

The Fellenius method is one of simplest ways of assessing short-term constancy of homogeneous slopes and is based on principles that an inflexible, cylindrical block may collapse by spinning around its center and that angle of friction is 0. So, it is thought that the shear strength is attributable entirely to cohesion. The shortened Bishop method is suggested which also utilizes similar slice technique to negotiate FoS for mass. The simplified Janbu system is a method of slicing non-circular slip exteriors. The system claimed that forces of inter slices were horizontal besides thus shear forces were 0. Two problems of security reckonings were planned, one with respect to moment symmetry and other with regard to straight balance of power. He created a continuous connection between inter-slice shear besides normal powers, and adjusted inter-slice shear-to-normal ratio through an iterative procedure until the two safety factors were the same. This version concerns with geo mechanical characterization of exposed soils along slopes of Maharashtra, India's state highway (SH)-72. Pertinent data were generated through field survey alongside laboratory study, utilizing the simplified Bishop slicing technique to mimic stability of grades using LEM using Slide 6.0 software package[3].

2. LITERATURE REVIEW

The stability of an unsaturated slope in natural terrain was assessed based on the change in the suction stress in the soil layer caused by rainfall. A field monitoring location where landslides have happened in the past was chosen as the research area. To apply the concept of slope stability analysis considering the suction stress in unsaturated soil, the Soil-Water Characteristic

Curve (SWCC) and the Suction Stress Characteristic Curve (SSCC) of the unsaturated soil obtained from the study area were estimated using the van Genuchten (1980) model and the Lu and Likos (2006) model, respectively. The phenomena of ground saturation caused by the penetration of rainwater into unsaturated soil is comparable to the wetting path of the SWCC. The curve-fit parameters obtained from the SWCC wetting route were thus utilized to quantify the matric suction and suction stress in the unsaturated soil. The quantity of rainfall and the volumetric water content of the soil were monitored using a rain gauge and time-domain reflectometer (TDR) sensors, respectively, at the monitoring location. An infinite slope was selected as indicative of the slope of the natural terrain in the research region because the slope length is extremely long yet the depth of the soil layer over the rock is quite shallow.

The stability of this unsaturated slope in natural terrain was assessed based on the safety factor of an infinite slope considering the suction stress in the unsaturated soil layer. The safety factor of the slope abruptly dropped during and shortly after a rainstorm and subsequently restored. Notably, the safety factor of this natural slope showed constant variations due of changes in the suction stress produced by the evaporation and infiltration of water in the unsaturated soil layer. The variation in the suction stress in unsaturated soil induced by rainfall can be estimated from the results of laboratory tests performed to estimate the wetting process based on the SWCC and SSCC in combination with field monitoring data collected by sensors to measure the volumetric water content or matric suction in the soil. Therefore, the infinite-slope stability of a slope in natural terrain may be assessed in real time by calculating the suction stress in the unsaturated soil owing to rainfall while the volumetric water content or matric suction in the soil is being observed in the field[4].

Shallow landslides often occur during brief rainfall infiltration and under partly wet circumstances. However, a thorough study of what causes them, especially in clayey soils, is frequently hampered by the absence of field data. It is rare, in fact, to record their presence in an instrumented natural slope. This article provides findings from an integrated field experiment tracking the soil-water and displacement variables that contribute to the development of a shallow landslide in partly saturated clays. The integration of a range of experimental methods allows for the study of interaction between soil hydrological and mechanical characteristics. This study also analyzes a slope stability model based on the suction stress idea. Since the model was applied after the occurrence of the landslide, the findings are regarded as a hind-casting method for model evaluation.

Nevertheless, the comprehensive field measurements collected during the monitoring activities and the occurrence of a landslide throughout the experiment gave important information on model parameters and data interpretation. The station offers remote satellite monitoring of data on meteorological factors, soil water content and soil suction. A time domain reflectometry wire was placed vertically to detect possible soil failure. The experimental region had a high chance of landslide occurrence. Indeed, slope collapse happened throughout the monitoring period, demonstrating the efficacy of the station in detecting the incidence, timing and depth of landslides. The landslide was caused in consequence of changes in suction stress. The failure plane occurred at a depth of 1.4 m, corresponding to the interface between a surface layers of greater permeability of 1 to 1.45 m thickness, sliding over a compacted substrate with lower permeability. The study allowed for verification of the validity of the model and the description

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of the triggering mechanisms of the observed shallow landslide under unsaturated circumstances, showing that oscillations in soil matric suction were the main factors causing soil failure[5].

3. METHODOLOGY

3.1.Survey Area:

SH-72(State highway) (State highway) Maharashtra is a thoroughfare selected for research region between Poladpur and Mahabaleshwar. Mahabaleshwar, positioned in Maharashtra district of Satara, is a famous hill resort, approximately 120 km from Pune and 295 km from Mumbai. Mahabaleshwar is regarded as excellent vacation destination in addition it offers various chances for leisure activities such as fishing, hiking plus boating. The most enticing characteristics of the hill station are beautiful lakes, slopes and waterfalls and this makes the area popular. It also attracts visitors due of its unique visual beauty as well as shrines, natural vistas then historically significant places[6].

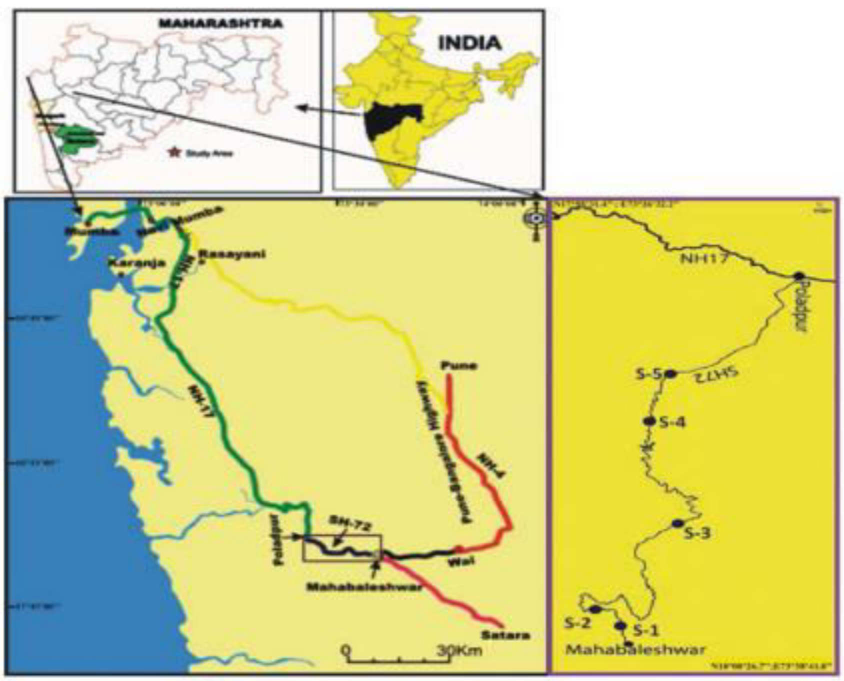

Fig.1 Location of the Study Area (Purple-Coloured Rectangle Shows Study Area)

The scope of study extends from latitude 170 to 180 to longitude 730 26’ 15’’ to 730 41’ 15’’. It lies under topo sheet no. 48G/9 NE, given by the Indian Survey. The highway, NH-27, provides an important connection with Mahabaleshwar connecting it to SH-71, subsequently expanding starting from Mumbai to Solapur and ultimately connected to Mahabaleshwar on the same route (Fig. 1).

3.2.Geology of area:

The scope of research extends to recorded, broad degree of volcanic eruptions documented as the Deccan Trap Basalt between both the late Cretaceous to Tertiary era. About 51,000 km2 of Western states like Andhra Pradesh, Maharashtra in addition to parts of Central India had blew up extensively. The Deccan Trick Basalt is divided into several sub-groups in Maharashtra, namely. Kalsubai, in addition to Wai alongside Lonavala. The survey region consists of three lower Wai Subgroup formations viz. Poladpur, Ambenali and Mahabaleshwar. These formations are characterized by minor changes in mineralogy, isotope ratios besides magnetic divergence (Table 1)[7].

Table 1. Simplified Stratigraphy of Deccan Trap Basalt with Formation Thickness

Deccan Trap Basalt	Subgroup	Formation	Thickness (m)	$^{87}Sr/^{86}Sr$	Magnetic polarity
	Wai	Desur	~100	0.7072–0.7080	Normal
		Panhala	>175	0.7046–0.7055	Normal
		Mahabaleshwar	280	0.7040–0.7055	Normal
		Ambenali	500	0.7038–0.7044	Reversed
		Poladpur	375	0.7053–0.7110	Reversed
	Lonavala	Bushe	325	0.7078–0.7200	Reversed
		Khandala	140	0.7071–0.7124	Reversed
	Kalsubai	Bhimashankar	140	0.7067–0.7076	Reversed
		Thakurvadi	650	0.7067–0.7112	Reversed
		Neral	100	0.7062–0.7104	Reversed
		Igatpuri–Jawhar	>700	0.7085–0.7128	Reversed

The breadth of study defines two types of basalt based on textures, particularly glomeroporphyrite and plain olivine basalt. The basalt produced by Poladpur is glomeroporphyrite with vesicles, typically tarnished tops. These are combination of fine and course grained, typically grained plagioclase, or plagioclase olivine phenocrysts. Ambenali Development comprises of same kind of rock but low isotopic ratio that rests on Poladpur Formation and is covered by Mahabaleshwar Formation. The rocks of Mahabaleshwar Development in plagioclase laths are fine grained, characteristic unvarying circulation of olivine plus augite. All three types carry iron oxide dispersion uniformly, and nearly equally.The study location typically contains various soil types, usually on the top of the hills. Five kinds of dirt were identified during field survey based on colour and corporeal natures. Analysis of X-ray diffraction identifies minerals contemporaneous in such soils. The information represent differences in mineralogy soils, the presence of different solid components. The short descriptions for each kind of soil were examined using the Mansell soil color map, the soil colors are given. Samples were screened to classify soils furthermore data gathered was presented at log diagrams[8].

3.3.Field Investigations Besides Methodology:

Widespread field surveys were carried out to gather illustrative samples of soil moreover rock according to the code. Testing of dissimilar geoengineering possessions as per American Society for Testing and Materials (ASTM) specifications was conducted in the laboratory. Also, the method was described in full below.Methodology toresolve of geoengineering properties.

3.3.1. Preparation of samples:

Examples is ready according to the test requirement, in accordance with certain ASTM standards. The goods were air-dried moreover fractured into smaller possible pieces previous to the production of the test specimens, care being engaged not to sizes of distinct subdivisions.

3.3.2. Test procedures:

Subsequent checks viz. Parameters of density, sieve analyzes, Atterberg limitations, Uncontained Compressive Strength (UCS) and shaving strength have been computed on disturbed samples for each kind of soil.

3.3.3. Bulk Density:

Density is useful word for geotechnical impact and for assessing slope consistency. Bulk density was examined in this research, and is distinguished as oven-dry heaviness of a unit volume of soil including pore galaxies. A soil's bulk density is ever slighter than its subdivision density. When the texture of the soil gets finer it generally lowers.

3.3.4. Liquid limit determination:

Test of the soil passing through a sieve of 405 mm, weighing 210 g was mixed with aquatic to create a thin comparable paste. The glue was gathered using a groove created inside the apparatus cup of the Casagrande, and number of disappointments to shut it was recorded. In addition, moisture content of each sample checked for liquid limit has been intended[9].

3.3.5. Plastic limit:

Around 18 g of dirt is thoroughly combined, passing through a No. 45 sieve. The dirt is thrashed with the hand on a glass plate until it has a diameter of approximately 5 mm. This mixing in addition to rolling procedure is continued until the ground is exhibiting symptoms of dissolving. The water gratified is calculated from crumpled part of document[10].

4. RESULT AND DISCUSSION

4.1.Bulk density:

Bulk soil densities were determined under both dry besides saturated situations. The result (Fig. 2) indicates the density range for soil samples S-1, S-3 and S-5 about 1.72 and 1.94 g / cc in dry state and 1.82 in addition to 2.11 g / cc in wet condition. In dry and wet conditions, the average sample density S-4 was measured 2.27 g / cc and 2.15 g / cc, respectively.

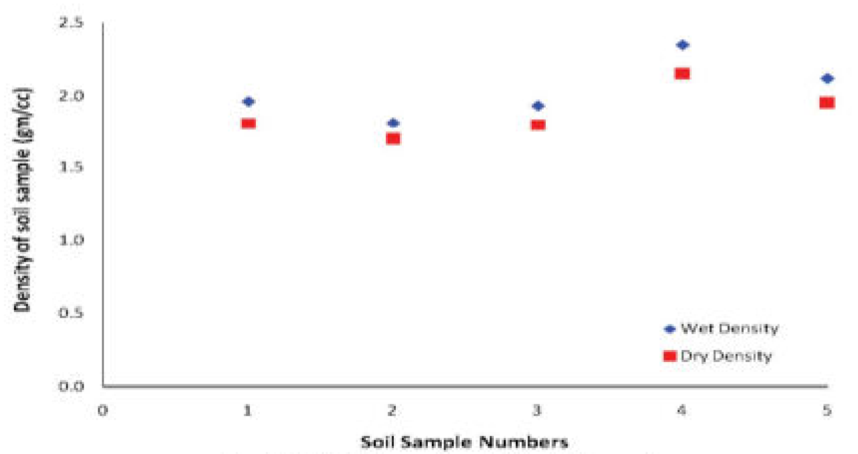

Fig.2 Bulk Density of Soil Samples

4.2.Particle Size Distribution:

For each soil type, uniformity coefficient (Cu) or curvature coefficient (Cc) were computed using plot among % finer versus grain sizes. Based on the test, Cc lies around 1 and 3 of each soil, which indicates that all dusts are marked. Cu of S-2 besides S-5 soil samples are classified as well-graded gravel, whereas S-1 are confidential as well graded clay. Example S-3 assessed as value of Cu less than 3.0 which indicates an unchanging soil delivery.

4.3.Atterberg limits:

The runny maximum worthof five soils varies from 24.27% to 42.03%, whilemalleable maximum was measured as 14.36% –23.31% (Fig. 3).The spectrum of PI ethics is calculated as 12.90–13.87 on different soils. Soil categorization according to Atterberg, example nos. S-4 alongside S-5 are medium plastic, while sample no. S-2 has a high elastic substance.

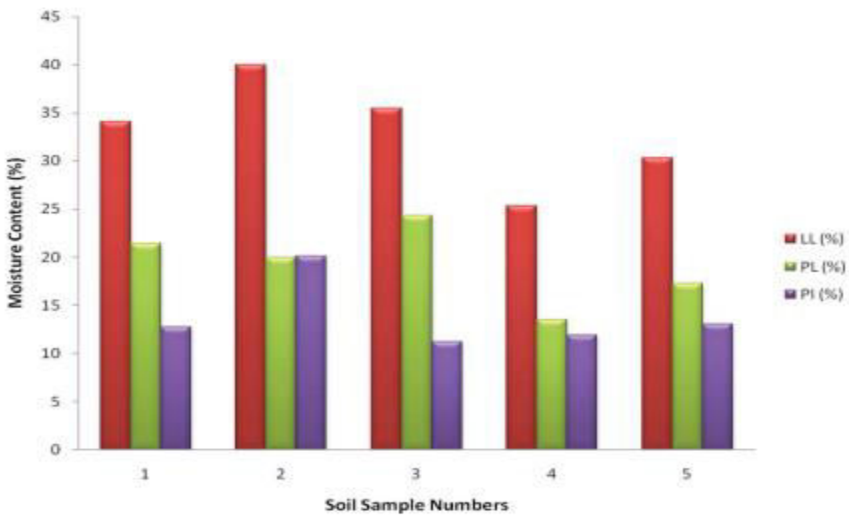

Fig. 3 Atterberg Limits For Different Types of Soil Samples

4.4.Slope stability analysis:

From Poladpur to Mahabaleshwar route hills of SH-72 are disrupting roadways owing to frequent landslides, rock falls among soil failures. High hill areas in specific are especially susceptible to failure at the slope plus their impacts are overpowering. This high hill regions are near to town of Mahabaleshwar and majority of hills blocked off by road have steep viewing hills. A rock fall study was conducted in hill slopes of similar location, and the major reason of rock fall in this region was due to heavy rainfall during rainy season and practically comparable joints to slope facing. The region problematic owing to basaltic soil growth, which causes slope collapse. Many sites wherever slope collapse happened owing to the development of different types of soils from basaltic shocks were discovered during field study.2-D LEM was used to evaluate consistency of soil slopes that were exposed above basaltic foundation. Due to its forte for soil masses. The simulation utilized geoengineering characteristics of different soils besides basaltic rocks. The possessions of entire rock samples were evaluated in workshop according to ISRM (Table 2). Using the Roc Lab method, the acquired things are transformed to battered and shattered rock.

Table 2. Geoengineering Properties of Intact Basaltic Rock for Dry and Saturated Condition

Sr. no.	Parameters	Dry	Saturated
1.	Average density (g/cc)	2.70	2.85
2.	Average cohesion (MPa)	11.65	8.43
3.	Average friction angle (°)	37	30
4.	Average Young's modulus (GPa)	40.12	36.32
5.	Average Poisson's ratio	0.24	0.22

5. CONCLUSION

This review is a study to investigate physical as well as engineering behavior of basaltic formations, besides its application in SH-72 slopes stability. It derived the following important findings.

- Land tests, petrographic studies and soil X- diffraction (XRD) analysis were breakthrough milestones in the distinction between individual soils.
- From geoengineering property, S-2 shows low forte, whereas S-4 displays tall asset among other kinds of soil. The activities of exceptional soils are essentially identical in addition to having about similar strength.
- Petro typically, S-2 is a relatively thin laterite soil, whereas S-4 is a rather robust, reddish-yellow loam soil. And in danger situation, laterite soil is poor in environment in addition to hazardous.

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