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Analysis of Soil Liquefaction Potential through Field Tests Based Method

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Abstract: Liquefaction is the phenomena when there is loss of strength in saturated and cohesion-less soils because of increased pore water pressures and hence reduced effective stresses due to dynamic loading. It is a phenomenon inwhich the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. The recent increase in Landslides and the repeated evidence of ground failure due to liquefaction motivated this research project. Liquefaction is a soil mechanics problem that often impacts structures that are supported on saturated sanddeposits. The large deformations of the foundation soils typically cause major failures of civil engineering structures. This project involved research of the liquefaction phenomena and the impact experienced on select recent landslides
Keywords: Eco-friendly, Broken rocks, Bamboo, Pre-stressed sheets, Fly ash bricks.

I. INTRODUCTION

Liquefaction is the phenomena when there is loss of strength in saturated and cohesion-less soils because of increased pore water pressures and hence reduced effective stresses due to dynamic loading. It is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. Liquefaction occurs in saturated soils and saturated soils are the soils in which the space between individual particles is completely filled with water. This water exerts a pressure on the soil particles that. The water pressure is however relatively low before the occurrence of earthquake. But earthquake shaking can cause the water pressure to increase to the point at which the soil particles can readily move with respect to one another. Soil liquefaction can also exert higher pressure on retaining walls, which can cause them to slide or tilt. This movement can cause destruction of structures on the ground surface and settlement of the retained soil.

A. Causes Behind Liquefaction

It is required to recognize the conditions that exist in a soil deposit before an earthquake in order to identify liquefaction. Soil is basically an assemblage of many soil particles which stay in contact with many neighboring soil. The contact forces produced by the weight of the overlying particles holds individual soil particle in its place and provide strength. Earthquake-induced liquefaction has caused extensive damages to residential lands and houses, as well as to infrastructures, such as roads, ports and water supply/sewage systems. This phenomenon is associated with the generation of large pore-water pressures in soils due to cyclic loading effects of earthquakes, resulting in a reduction of effective stress, a sudden loss in stiffness and a consequent loss of strength. The investigation of failure of soil masses during earthquakes requires sciences of geology and engineering [1]. To confront liquefaction destructive effects, evaluation of liquefaction potential of soils and recognition of liquefiable regions are essential. There are several methods for determination of liquefaction potential. The liquefaction of soils can be estimated using laboratory tests such as cyclic triaxial and cyclic torsional shear tests. Since the cost of collecting high quality undisturbed samples is considerably high and the laboratory conditions can not simulate actual conditions of field, methods based on in-situ tests such as the Standard Penetration Test (SPT), the Cone Penetration Test (CPT) and the shear wave velocity test (Vs) are widely accepted by geotechnical engineers for estimating the liquefaction of soils. The Standard Penetration Test (SPT), due to its simplicity of execution, is the most commonly used insitutest to gain idea about the stratigraphic profile at a site [2]. SPT-based methods have been adoptedfor liquefaction evaluation of soils for decades and Standard Penetration resistance has been used as an index of soil liquefaction resistance during earthquakes in engineering practice.

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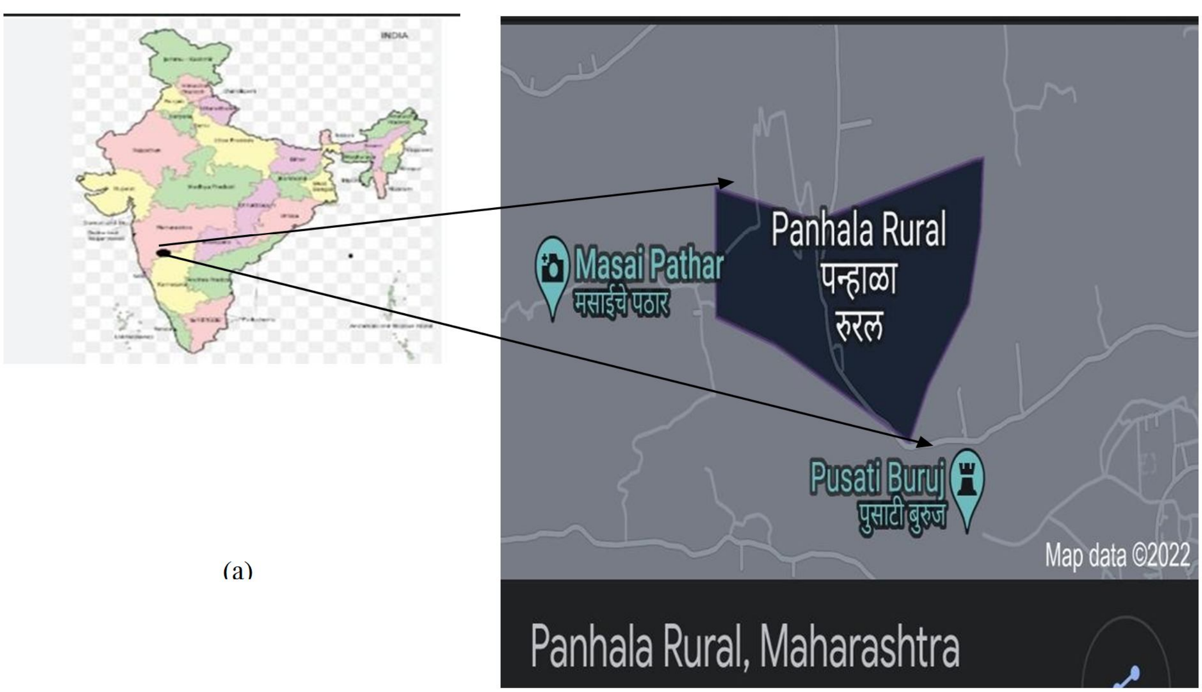
Development of SPT-based methods began in Japan by studies performed by some investigators such as Kishida [3] and Ohsaki [4]. Then, many researchers studied and recommended procedures for estimation of liquefaction using SPT [5-11]. The Cone Penetration Test (CPT) is an advantageous test in characterizing subsurface conditions and estimating various soil properties. CPT provides a continuous record of the penetration resistance. In comparison with SPT, CPT is less vulnerable to operator error and can find thin liquefiable strata that are missed by SPT. However, by CPT, no sample can be obtained. CPT is a reliable test that has found widespread use as a tool for evaluating the liquefaction resistance of soils. Development of Časopis GRAĐEVINAR Journal CIVIL ENGINEER 3/25 CPT-based methods for evaluation of liquefaction began with work by Zhou [12]. Then, various investigators assessed CPT-based liquefaction methods [13-20]. Moreover, applying shear wave velocity (Vs) measurements for evaluating the liquefaction resistance of soils is an effective method because shear wave velocity and liquefaction resistance are both influenced by similar factors (such as void ratio, geologic age and state of stress). Shear wave velocities can be measured in situ by several tests such as cross-hole, downhole and Spectral Analysis of Surface Waves (SASW). Vs measurements are possible in soils that are difficult to penetrate with CPT and SPT (such as gravelly soils). Generally, the precision of different kinds of shear wave velocity tests is higher than that of penetration tests. However, shear wave velocity testing does not produce samples for classification or may not be performed with sufficient details to detect thin liquefiable layers if the measurement interval is too large. Numerous studies have been performed to investigate the relationship between shear wave velocity and liquefaction resistance [21-30]. Although some researchers conducted studies about soil liquefaction potential of Babol city [31, 32], the obtained results were different because they applied only one method in their investigations. Therefore, in this paper, a focus is made on the most widely accepted methods utilized for estimating liquefaction. For this purpose, three different analysis methods were selected in this study to evaluate the liquefaction potential: (1) Idriss and Boulanger [33] method (which is a SPT-based method); (2) Andrus and Stokoe [34] method (which is a Vs-based method); and (3) Moss et al. [35] method (which is a CPT- based method). In this study, first, seismology and geology of Babol is presented. Then, the utilized methods for assessment of soil liquefaction potential of this city are briefly reviewed. Finally, soil liquefaction potential of Babol city is studied using the mentioned methods and the obtained results are compared.

Main objectives for the present work include to determine soil properties of the selected site, suggestions to improve the soil strength, if needed and to apply suitable mitigation techniques for soilliquefaction.

II. MATERIALS AND METHODS



(a)

(b)

Fig.1: Location map of the study area

Fig.2 explains the methodology followed under the present work.

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Idriss and Boulanger re-examined semi-empirical procedures for evaluating the liquefaction potential of soils during earthquakes and suggested relations for use in practice. Andrus and Stokoe presented a method for the evaluation of liquefaction potential through measurement of shear wave velocity. Their method was based on field performance data from 26 earthquakes and in situ shear wave velocity measurements at over 70 sites. Moss et al., evaluated the probability of liquefaction using CPT and proposed a correlation for CPT-based assessments of seismically induced soil liquefaction hazard. The reliability of any liquefaction estimation depends on the quality of the site characterization. In order to evaluate the liquefaction potential of Babol soil using three mentioned methods, a total number of 60 borehole logs were collected for this study. Figure 3 shows the location of available geotechnical boreholes in Babol region. In order to measure the shear wave velocity, down hole tests were performed in boreholes. Moreover, CPT tests were conducted at the nearest possible locations to boreholes.

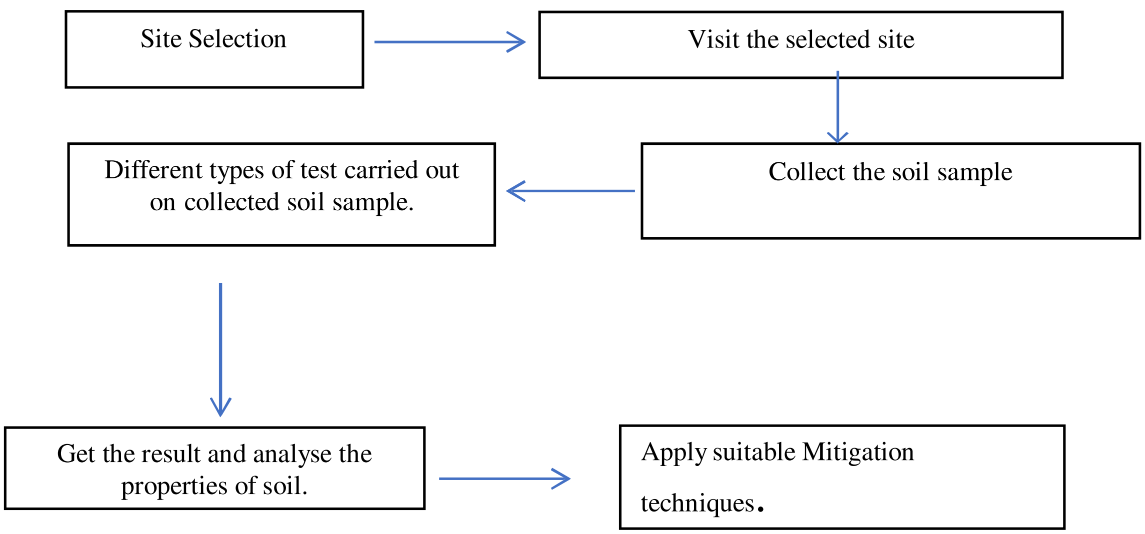


Fig.2: Flow chart for methodology followed

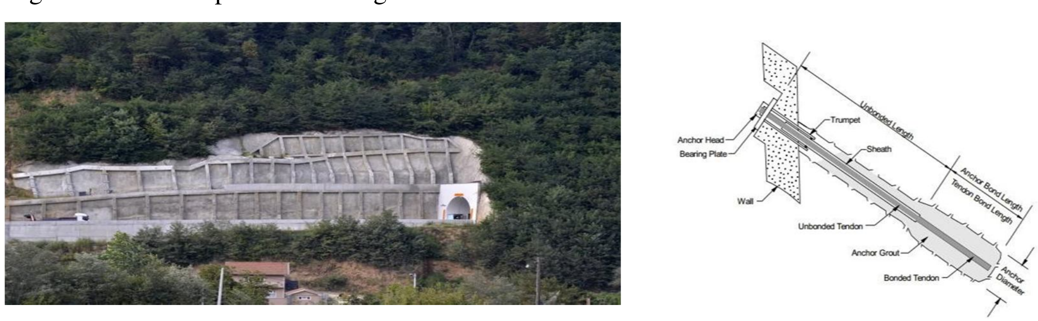
III. RESULTS AND DISCUSSION

Test carried out on collected soil sample:

1) Field density test
2) Determination of specific gravity of soil
3) Grain size distribution of soil by sieve analysis

A. *Landslide Mitigation Techniques*

1) *Earth Retaining Systems using Ground Anchors:* Common applications of earth retaining systems using ground anchors include soldier pile walls with anchors, sheet pile walls with anchors, diaphragm walls with anchors, and secant pile walls with anchors. Typical construction proceeds in a top-down fashion. Ground anchors are also often used to stabilize landsides. A view and the sketch for ground anchor is presented in Fig.3.



(a) (b)

Fig.3: (a) View of Earth retaining system with ground anchors (b) Sketch for ground anchors

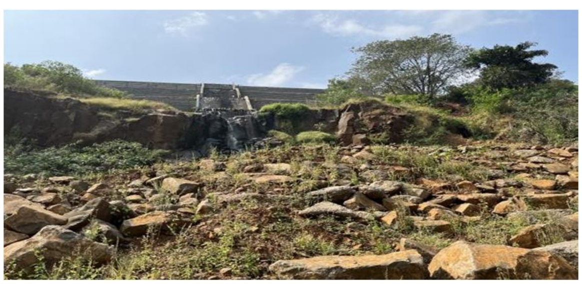
2) *Soil Nails Technique:* Soil nailing is a ground stabilization technique used to reinforce and strengthen existing ground. It can be used on either natural or excavated slopes. It involves drilling holes for steel bars to be insertedinto a slope face which are then grouted in place. It is economical and also applicable in seismic zones. Increases shear strength of overall soil mass and can be used in wide soil types. Fig.4 (a) and (b) present the technique of soil nails.

(a)

(b)

Fig.4: (a) View of soil nail technique (b) Work under progress for soil nails technique.

3) *Horizontal Drains for Slope Stabilization: The* presence of water is one of the most critical factors contributing to the instability of hill slopes. A common solution to stabilize hill slopes is installation of horizontal drains to decrease the elevation of the water table surface. Lowering the water table dries a large portion of the hill slope which increases the shear strength of the soil, thereby decreasing the probability of slope failure. The purpose of thismanual is to provide a single comprehensive reference for geotechnical engineers and hydro-geologists on designinghorizontal drainage systems to improve slope stability. Fig.5 presents the stabilization of slope with horizontal drains.



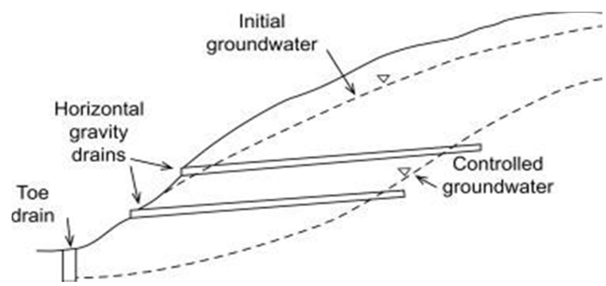


Fig.5: Horizontal drains for slope stabilization

4) *Bamboo Planting for Preventing Landslides:* Using bamboo to prevent landslides has been found successful in many countries like Malaysia, the Philippines and Nepal. The bamboo tree has a wide-spreading root system capableof holding loose soil. In other words, the tree is deep-rooted and best suited against landslides. It was learned that theroots of a bamboo tree are capable of expanding by 25 percent to hold six cubic meters of soil. Bamboo anchors the soil with its spreading root system thus preventing landslides [Fig.6]. Aside from this, bamboo is used as barrier against soil erosion and other environmental services such as protection of water sources though reforestation of watersheds.

i.

(b)

Fig.6: Bamboo planting to prevent landslide

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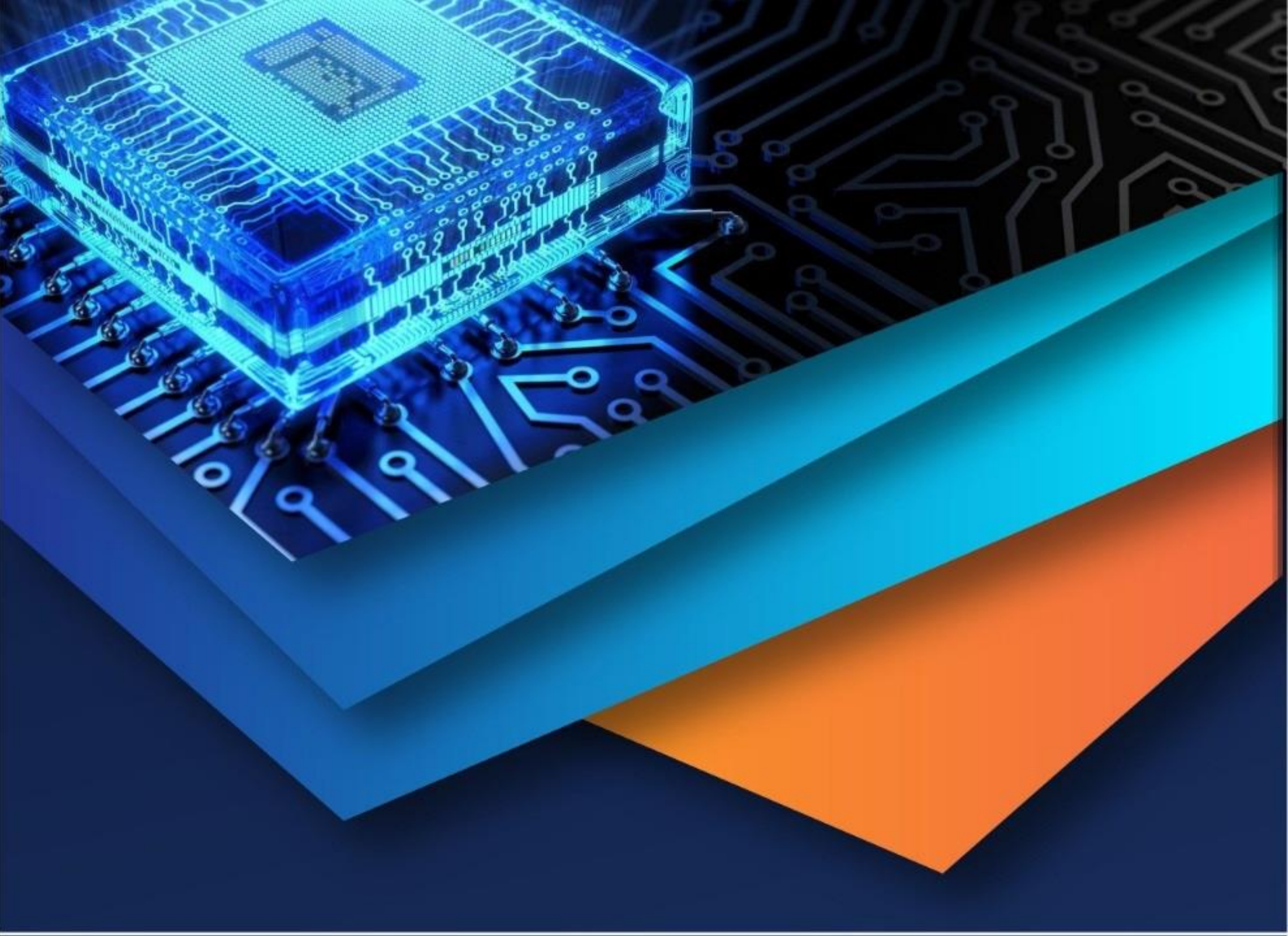

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