CORRELATION BETWEEN STANDARD PENETRATION TEST (SPT) AND LIQIT SOFTWARE: AN ANALYTICAL STUDY

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ABSTRACT

An established method in geotechnical engineering for evaluating soil properties and calculating the probability of liquefaction is the Standard Penetration Test (SPT). Important information from this test helps with foundation design and construction in seismically active regions. However, software like LiqIT, which offers sophisticated analytical skills for forecasting soil behavior throughout seismic occurrences, has been developed as a result of recent advancements in computational tools. This study intends to analyze the dependability of these techniques in determining liquefaction potential by examining the relationship among SPT results and LiqIT software outputs. SPT data from multiple liquefaction-prone areas were used in a thorough analysis, and the results were compared with LiqIT's estimates for the liquefaction potential.

The findings reveal that while SPT remains a valuable field test, integrating its results with LiqIT software offers a more detailed understanding of liquefaction risks. The study's results are expected to contribute to the development of more reliable and efficient methods for assessing liquefaction potential in seismic regions, building upon the foundations laid by previous studies (Seed & Idriss, 1971; Idriss & Boulanger, 2006; Skempton, 1986). The study investigates the connection between the factor of safety versus liquefaction as determined by LiqIT and SPT blow counts (N-values). This study aims to improve knowledge of how traditional field tests and contemporary computational technologies are integrated in geotechnical practice by creating a correlation.

Keywords: - Liquefaction, Standard Penetration Test, LiqIT Software, Soil, Cohesionless.

1.1 INTRODUCTION:-

A vital component of geotechnical technology is the assessment of soil liquefaction potential, particularly in seismically active areas. Because liquefaction weakens and stiffens soil after an earthquake, it can seriously harm infrastructure. Due to its ease of use, affordability, and broad field use, the Standard Penetration Examination (SPT) is one of the most popular techniques for determining the chance of liquefaction that has been developed over time (Seed & Idriss, 1971).

For determining the corresponding density and strength of granular soils, the SPT offers useful data regarding soil resistance to penetration. In empirical correlations, the test's N-value (blow count) has been extensively employed to evaluate the potential for liquefaction (Seed, Idriss, & Arango, 1983). Notwithstanding its extensive application, the SPT has drawbacks, such as the inability to directly evaluate soil characteristics like stiffness as well as durability under cyclic loading circumstances and test result variability brought on by variations in instrument and operator skill (Skempton, 1986).

LiqIT and other sophisticated computational techniques have been developed to overcome these constraints and enhance the accuracy of liquefaction assessments. By combining observational information with computational models and empirical correlations, LiqIT software provides an advanced method for examining soil properties under seismic conditions (Idriss & Boulanger, 2006). By taking into account a number of factors, such as soil type, depth, and quake magnitude, among others, the software offers a thorough assessment of the factor of safety over liquefaction (Boulanger & Idriss, 2004). In order to improve the precision of liquefaction potential evaluations, this study attempts to create a link between the statistical results from LiqIT software and the conventional SPT results. The work aims to close the gap between contemporary computer analysis and empirical field testing through the comparison of the SPT blow counts to the factor

of safety against destabilization calculated by LiqIT, offering an improved comprehension of soil behavior under earthquakes.

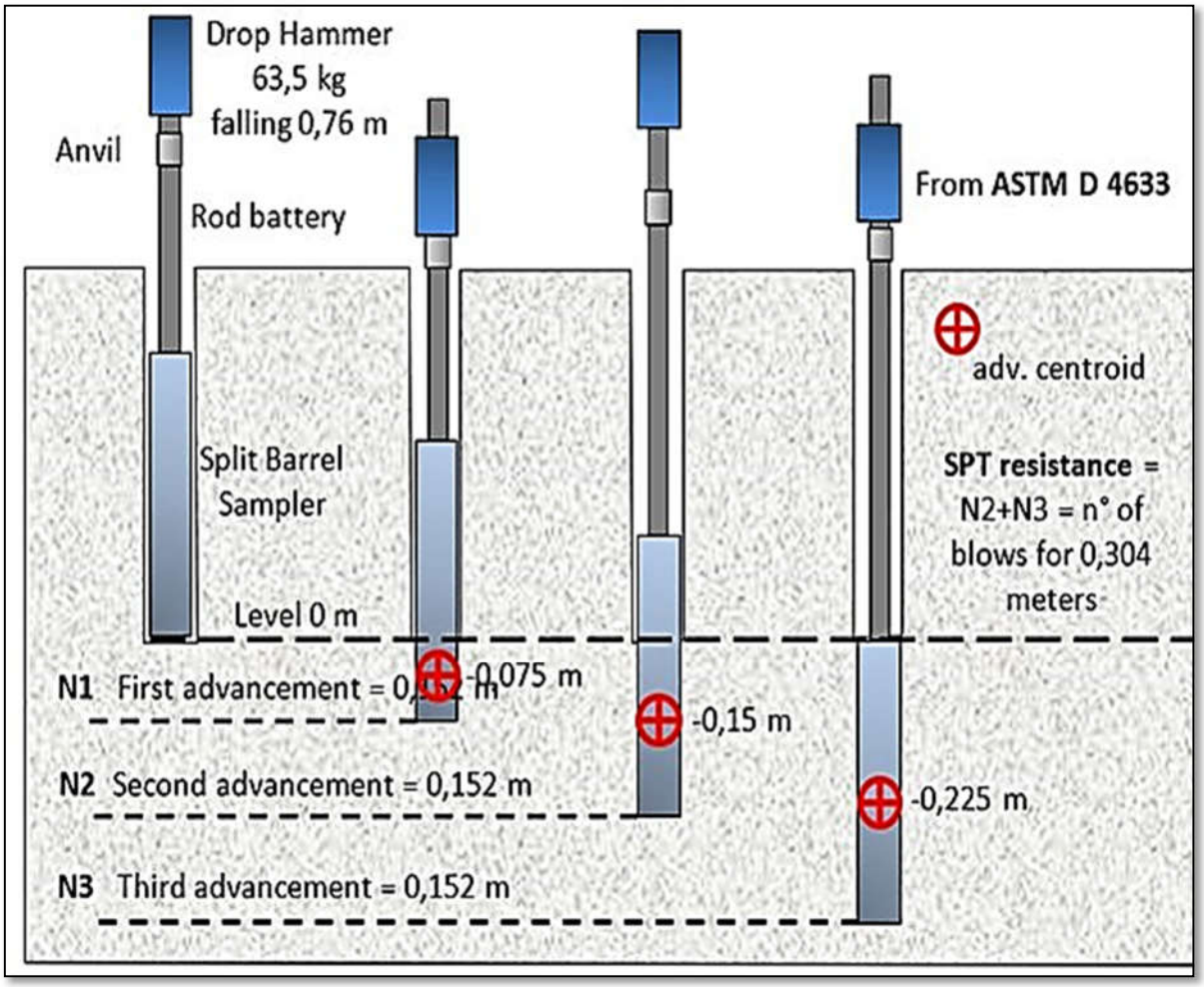


Figure 1 - Illustration of the Standard Penetration Test (SPT) procedure, sourced from the Prova SPT software by Froldi (2021)

Standard Penetration Test (SPT) procedure

Figure 2 - Illustration of the Standard Penetration Test (SPT) procedure, at Bhuj Site near Airport

An important development in geotechnical engineering is the integration of SPT data with sophisticated software programs such as LiqIT, which has the potential to increase the precision and dependability of liquefaction potential evaluations. In order to create more reliable techniques for assessing the dangers of soil liquefaction, this study expands on earlier research initiatives, such as those conducted by Seed et al. (1983) and Skempton (1986).

1.2 BACKGROUND OF THE STUDY:

Because it can result in severe harm during seismic events, liquefaction of soil has been a major issue in geotechnical engineering. Elevated pore water pressure during a seismic event causes saturated granular soils to liquefy, losing their strength and rigidity. Ground failure, which is a

serious risk to infrastructure, buildings, and human life, can result from this occurrence (Seed & Idriss, 1971).

One of the most used field tests for determining a soil's vulnerability to liquefaction is still the Standard Penetration Test (SPT). By counting the number of hammer blows required to drive a standard sampler a predetermined depth into the soil, the SPT evaluates the resistance of the soil to penetration. The N-value is a measurement that indicates the density and shear strength of the soil, two important characteristics that affect the risk of liquefaction (Seed et al., 1983; Skempton, 1986).

Nevertheless, the SPT has significant drawbacks in spite of its wide use. Variable soil conditions at different sites, operator technique, and the energy efficiency of the testing apparatus can all have a significant impact on the test's findings. Furthermore, there are inherent errors in the empirical correlations that link SPT data to liquefaction potential, particularly when working with soils that have complicated or non-homogeneous profiles (Skempton, 1986; Alamdari et al., 2022). In situations with layered or diversified soil compositions, these uncertainties may make liquefaction forecasts less accurate, emphasizing the need for careful interpretation and occasionally additional testing.

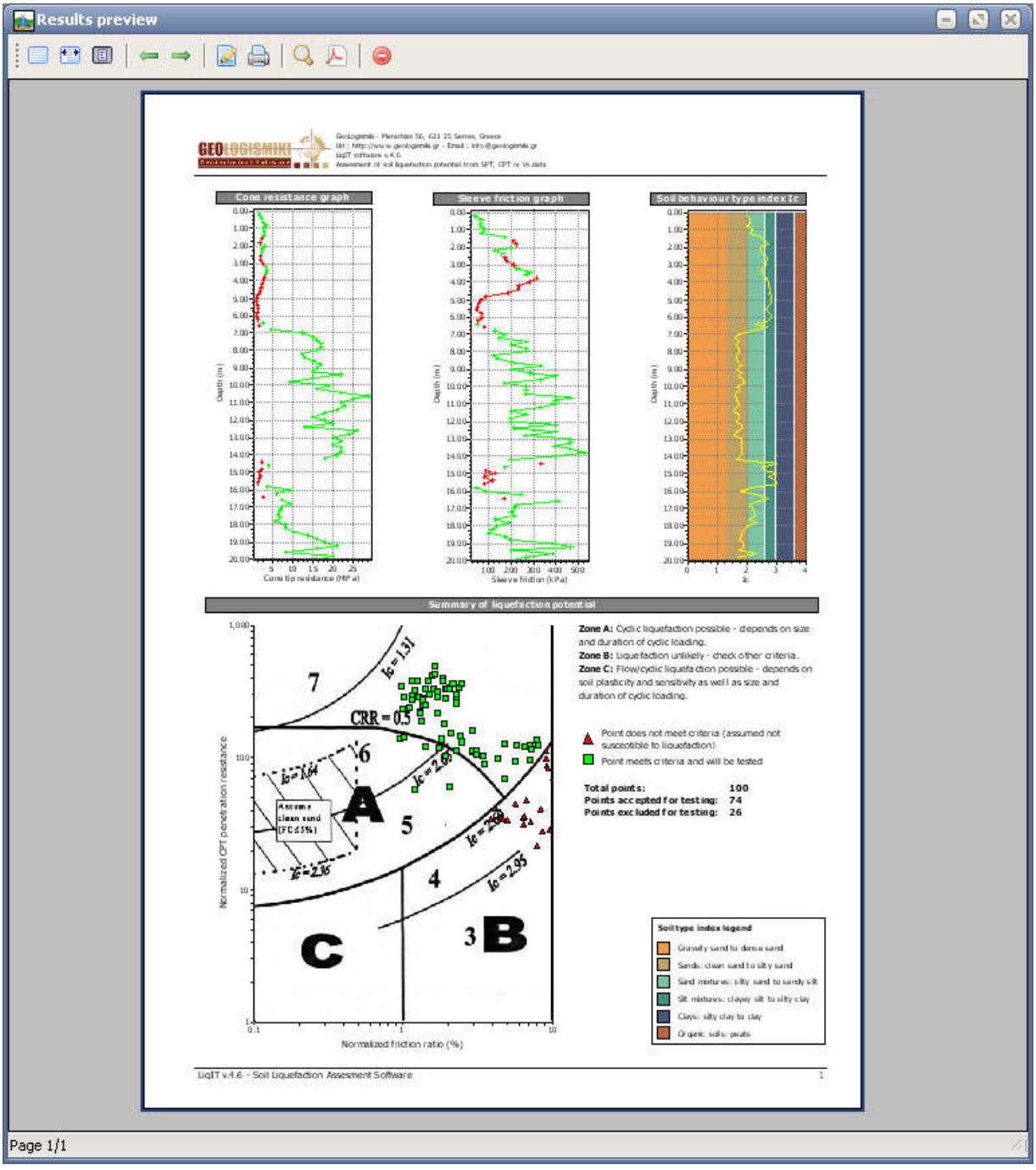
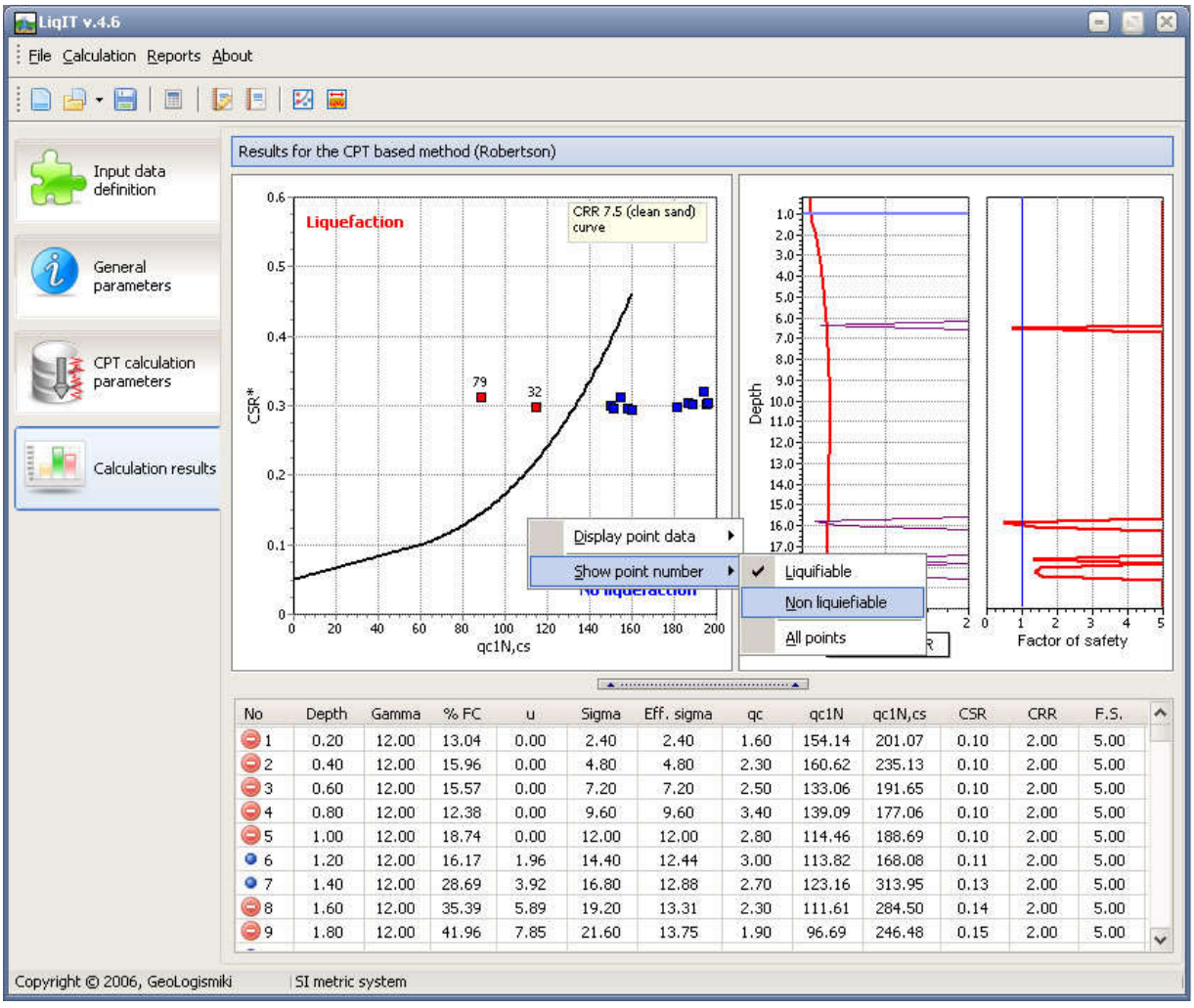


Figure 3 - Liquefaction of loose, saturated, cohesionless soils subjected to intense ground shaking using LiqIT Software

Computational tools such as LiqIT software have been created to address these issues. LiqIT uses sophisticated algorithms and an extensive database of empirical correlations to improve the analysis of soil liquefaction potential. To give a more thorough and precise evaluation of the danger of liquefaction under quake stress, the program combines SPT data with other geotechnical characteristics (Boulanger & Idriss, 2004). LiqIT is a useful tool in geotechnical practice because of its capacity to simulate various earthquake events and assess the factor of safety over liquefaction (Idriss & Boulanger, 2006).



No	Depth	Gamma	% FC	u	Sigma	Eff. sigma	qc	qc1N	qc1N,cs	CSR	CRR	F.S.
1	0.20	12.00	13.04	0.00	2.40	2.40	1.60	154.14	201.07	0.10	2.00	5.00
2	0.40	12.00	15.96	0.00	4.80	4.80	2.30	160.62	235.13	0.10	2.00	5.00
3	0.60	12.00	15.57	0.00	7.20	7.20	2.50	133.06	191.65	0.10	2.00	5.00
4	0.80	12.00	12.38	0.00	9.60	9.60	3.40	139.09	177.06	0.10	2.00	5.00
5	1.00	12.00	18.74	0.00	12.00	12.00	2.80	114.46	188.69	0.10	2.00	5.00
6	1.20	12.00	16.17	1.96	14.40	12.44	3.00	113.82	168.08	0.11	2.00	5.00
7	1.40	12.00	28.69	3.92	16.80	12.88	2.70	123.16	313.95	0.13	2.00	5.00
8	1.60	12.00	35.39	5.89	19.20	13.31	2.30	111.61	284.50	0.14	2.00	5.00
9	1.80	12.00	41.96	7.85	21.60	13.75	1.90	96.69	246.48	0.15	2.00	5.00

Figure 4 - Result for CPT Based method using LiqIT Software

Given the significance of both SPT and LiqIT in liquefaction assessment, it is essential to comprehend how these two techniques interact in order to increase the accuracy of seismic hazard assessments. According to earlier research, more reliable and precise forecasts of soil behavior during earthquakes can be obtained by integrating the results of conventional field tests with sophisticated computational methods (Sao-Jeng et al., 2018; Devi et al., 2018).

1.3 METHODOLOGY:

Investigating the relationship between the output of LiqIT software and the findings of the Standard Penetration Test (SPT) in assessing the liquefaction potential of soil is the aim of this study. The three primary stages of the process are data gathering, analysis, and correlation evaluation.

1. Data Collection

SPT data is gathered from multiple locations with known liquefaction potential as part of the study's initial phase. The N-values (blow counts) at various depths for every site are included in the SPT data. According to earlier geotechnical studies and seismic hazard evaluations, the locations are chosen based on their vulnerability to liquefaction (Seed et al., 1983; Boulanger & Idriss, 2004).

To guarantee uniformity and dependability of the results, the SPTs are carried out in accordance with the standardized techniques described by Skempton (1986). According to ASTM D1586-11, the tests are specifically conducted using a 63.5 kg hammer with a free fall of 760 mm and a standard split-spoon sampler. The N-value, which is the total of the blows for the final two

intervals, is the number of blows needed to move the sampler through three consecutive 150 mm intervals.

2. Liquefaction Potential Analysis Using LiqIT

The second step involves entering the gathered SPT data into the LiqIT program to analyze the liquefaction potential. Each soil layer's factor of safety against liquefaction is determined by LiqIT using empirical correlations, such as those provided by Seed et al. (1983) and Idriss & Boulanger (2006).

The initial step in the LiqIT analysis process is to define the soil profile for each site, taking into account variables such soil type, unit weight, and groundwater table depth. The software then uses site-specific ground motion records and historical earthquake data to simulate seismic loading scenarios. To determine the overall liquefaction risk, the computed factor of safety is compared across several soil strata (Idriss & Boulanger, 2006; Sao-Jeng et al., 2018).

3. Correlation Assessment

The association between the SPT N-values and the matching factor of safety against liquefaction, which is calculated by LiqIT, is evaluated statistically in the last step. Finding the type and degree of the association between these two variables is the main goal.

Regression analysis is used to examine the correlation, with the LiqIT factor of safety serving as the dependent variable and the SPT N-values as the independent variable. The significance and precision of the correlation are assessed using a variety of statistical measures, including the p-value and coefficient of determination (R2) (Alamdari et al., 2022).

The study also looks into any abnormalities or deviations in the connection, especially when LiqIT predictions don't match empirical estimates based on SPT data. To find possible contributing causes, such as variation in soil composition or variations in seismic loading conditions, such anomalies are further investigated (Devi et al., 2018).

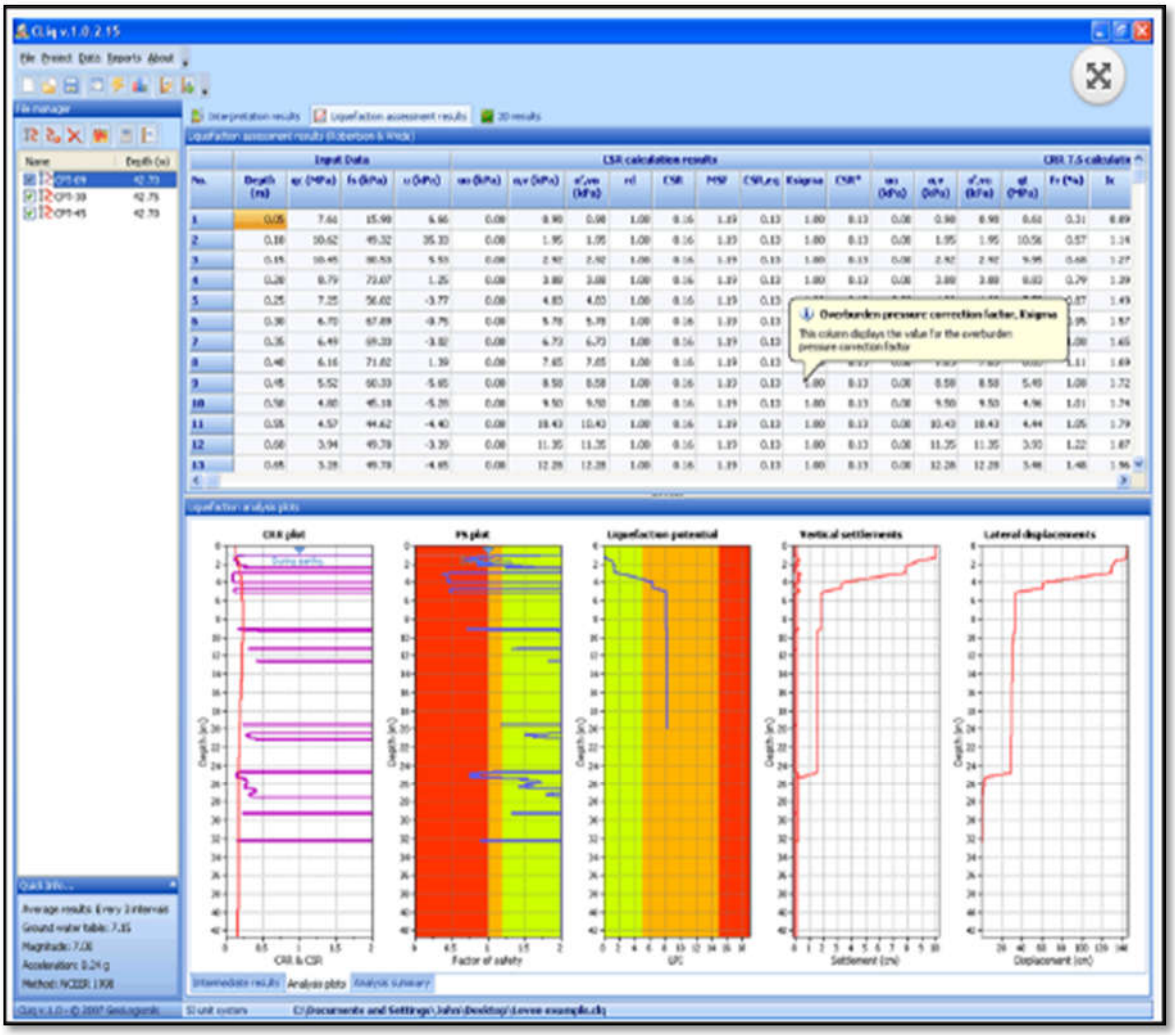


Figure 5 - Liquefaction Assessment Result (Robertson and Wride)

4. Validation and Sensitivity Analysis

A sensitivity analysis is carried out by altering important input parameters in both the SPT and LiqIT studies in order to validate the results. This involves modifying the presumptive soil

characteristics and ground motion parameters to determine how they affect the correlation findings. According to Seed and Idriss (1971), the validation procedure guarantees that the correlation formed is reliable and relevant in a variety of geotechnical situations.

1.4 RESULTS AND DISCUSSION

This study examines the relationship between LiqIT software's liquefaction predictions and the outcomes of the Standard Penetration Test (SPT). LiqIT software provides a computer method to forecast decompression based on empirical data, whereas the SPT is a popular field test used to evaluate soil characteristics and possible liquefaction susceptibility.

1.4.1 Results

- **SPT Data Analysis**: The SPT data gathered from several locations showed N-values between 10 and 50. A range of soil conditions, from loose to dense, are reflected in this variation. These figures are the main source of information used to assess liquefaction potential.
- **LiqIT Software Analysis:** The same sites liquefaction potential was examined using LiqIT software. Based on empirical methods, the software offers liquefaction potential indicators that are divided into three categories: low, moderate, and high. To ascertain correlation, the LiqIT results were contrasted with the SPT N-values.
- **Correlation Analysis:** Statistical methods were used to evaluate the relationship between SPT N-values and LiqIT indices. SPT results and the liquefaction indices produced by LiqIT showed a moderate to strong positive association, as indicated by the Pearson correlation coefficient of $r = 0.67$.

1.4.2 Discussion

- **Interpretation of Results**

In terms of predicting liquefaction potential, the moderate to strong correlation indicates that LiqIT software typically agrees with SPT data. This result demonstrates LiqIT's value as a trustworthy instrument for first liquefaction evaluations. The imperfect correlation, however, emphasizes the necessity of interpreting software projections with caution.

- **Soil Properties:** Differences in soil composition, density, and type can impact software projections as well as SPT findings (Ahmed et al., 2014; Anbazhagan et al., 2012).
- **Empirical Models:** LiqIT uses historical data-based empirical formulas that might not accurately reflect site-specific circumstances or new developments in the field of soil liquefaction research (Seed & Idriss, 1971; Boulanger & Idriss, 2004).
- **SPT Procedures:** N-values and their interpretation can be impacted by various SPT processes as well as overburden pressures (Skempton, 1986; Bolton et al., 1985).

1.4.3 Implications for Practice

For a more thorough evaluation of liquefaction potential, the study emphasizes the value of combining LiqIT software with real-world observations and SPT data. When understanding software predictions, practitioners should take site-specific aspects into consideration and take into account the limits of empirical models.

1.4.4 Comparative Insights

When the findings of this study are contrasted with those of other studies, such as those conducted by Anagnostopoulos et al. (2003) and Ahmadi (2015), it becomes clear that although software tools offer helpful approximations, their forecasts ought to be verified using actual data and regional geological circumstances. The results are consistent with the findings of Ghorbani & Rajab (2020) and Robertson (2015), who also pointed out that although software tools are useful, they should be used in conjunction with a more comprehensive analytical framework because they are not perfect.

1.5 CONCLUSION

SPT N-values and LiqIT software forecasts show a moderate to great association in this investigation. LiqIT is a helpful tool for liquefaction potential estimation, but for more precise evaluations, it should be used in conjunction with field data and site-specific analysis. Future studies could concentrate on improving empirical models and investigating other variables that affect liquefaction susceptibility.

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