International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 452-460 www.ijaem.net ISSN: 2395-5252

A Comparison between Casagrande Tool and Drop-Cone Methods for Determine Liquid Limit

Sahdev
M B M University, Jodhpur, Raj. India

Date of Submission: 01-10-2022 Date of Acceptance: 13-10-2022

ABSTRACT: The liquid limit (LL) is an essential parameter for classify soil. The use of the cone drops penetrometer method for determining the liquid limit is an attractive alternative technique since the percussion method is highly operator dependent. In this work, the importance of specially the equipment and procedure used to measure the LL of a soil is highlighted using LL test results conducted on different soils. The results of LL, obtained by the percussion method proposed by the penetration cone method and by Casagrande on soils of different geological origins and results were compared. The LLcone penetrometer values were determined using the cone (20 mm fall cone penetration) method. The LLCasagrande values were measured using different hardness of Casagrande tool. The LL test results show that variations on the investigated methods depend on the soil sample and the hardness base of the Casagrande apparatus. The results obtained for soils with high LL values indicated liquid limit by cone drop is less than liquid limit by Casagrande and a greater dispersion among the results. Statistical analyses of residues show that empirical LLcone penetrometer to LLCasagrande correlations through a linear regression analysis should be used with caution.

KEYWORDS: Liquid Limit, Cone Penetrometer, Casagrande Apparatus, Plastic Limit.

I. INTRODUCTION

The Liquid limit of soil is the maximum water content at which soil changes its state from liquid state to plastic state. Determination of liquid limit is essential as it is one of the important properties of soil, which used to classification of soil and shows the soil behaviour. The liquid limit value used to calculate plasticity index, the activity of clays and toughness index of soil, also used to predict settlement of soil and the allowable bearing capacity of soil. There are two techniques to calculate the liquid limit value of soil, which are, Casagrande tool method and Cone penetrometer method. These both the techniques are used for measured the same property of soil there are chances of obtaining different results of same soil sample. Also some studies show different results obtain by these two method of same soil sample. The cone drop penetrometer method imposes the slow static shear deformation and penetration due to gradually falling cone, while the Casagrande tool imposes a sudden deformation of soil due to vibration of cup. Large number of studies explored the relationship between liquid limit values determined using Casagrande apparatus and Cone drop penetrometer methods. These studies compare the results obtain by both method casagrande apparatus and cone penetrometer method. In India, most of the studies use the Casagrande tool to measure the liquid limit of plastic soil and sandy soil. The casagrande method adopted in India due to its working process is easy and versatile. The casagrande apparatus divide based on cup base are soft base casagrande tool and hard base casagrande tool. The hard base Casagrande tool always shows lesser liquid limits than those from the soft base of the Casagrande tool. The soft base casagrande tool shows high liquid limit because the vibration on soft base tool is low so required large number of blow. The difference between these two hard and soft base Casagrande tool near about 5% for soils with a liquid limit greater than 40%. In parallel another study, observed that Casagrande apparatus gives higher liquid limits than those determined from the cone penetrometer. The difference in results values depends on the parameters of soils which is types of mineral contents and clay contents in the soil. The according to some author liquid limit value, measured by the Casagrande tool systematically 2-3% lesser than the cone penetrometer apparatus values for soils with lower clay soil contents(Di Matteo, 2011). This variation of these studies is completely based on soils parameters. With the decrease in clay content, the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 452-460 www.ijaem.net ISSN: 2395-5252

liquid limit, and free swelling capacity of the bentonite present in the soil mixture, the difference between the two techniques is reduced. Also, the difference between the liquid limit values get by both these techniques is reduced with an increase in salt concentration in soil sample. A correlation developed by an another author, based on the results were obtain for standards clays and compared with other correlations from other studies (Spagnoli, 2012). For a constant depth of penetration of 20 mm, that Standard cone penetrometer method gives significantly lesser value of liquid limit in comparison to Casagrande tool method for high plasticity soils (Hrubesova, Lunackova and Brodzki, 2016). As above mention an another author get the liquid limit values measured by Russian cone the were normally higher than those found by the Casagrande device penetration apparatus (El-Shinawi, 2017). Also, according karakan, the Based on the experimental results, the liquid limit values found from the cone penetrometer and Casagrande cup tests are consistent and close to both of each (KARAKAN and DEMİR, 2018). Also observed that cone drop penetrometer test is more powerful and versatile useful tool for the practical soil classification test and other works. An another study established linear correlation between results of a relatively harder base Casagrande tool and cone penetrometer test as compared to a softer base apparatus(A Study on Correlation between Liquid Limit by Cone Penetrometer and Casagrande Method, 2017). The large several studies has been discovered the correlation between Casagrande device and the cone penetrometer device. Most of the studies are conducted for soils found in out of India or other countries and get that the relationship between both the tests depends on soil properties and soils parameters of these countries. However, in the literature, no study conducted on Indian soils. Therefore, the experimental studies were conducted to find out the comparison between the liquid limit value of different soils found in Rajasthan, India by using casagrande apparatus and cone drop penetrometer.

COMPARISON WITH PREVIOUS STUDIES

It is compared with results obtained by this study with other studies in table 1. It is not possible to directly compare the results of this study with the others studies due to the differences in the geological characteristics of the other soil formations(Di Matteo, 2011). Other side, regarding the results of (Karlsson, 1961, 1977) and (Leroueil and Le Bihan, 1996) the authors both used a Swedish cone penetrometer. However, as previously studies, (Farrell et al., 1996) stated that the differences in liquid limit values for the Swedish and the British cone penetrometer are negligible.

Table 1. Comparison with results obtain with previous studies to present study.

Authors	Year of studied	Liquid limit range studied	Difference between results obtain by CA and CPT
Karlsson	1961, 1977	30-76%	5-6%
Sherwood and Ryley	1970	30-72%	0-1%
Wires	1984	38-55%	0-1%
Belviso et al.	1985	34-134%	1-3%
Wasti and Bezirci	1986	27-110%	4-5%
Leroueil and Le Bihan	2008	30-74%	7-8%
Ozer	2009	28-74%	6-7%
Di Matteo	2012	24-40%	2-3%
Present study	2022	30-40%	5-6%

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 452-460 www.ijaem.net ISSN: 2395-5252

II. STUDY ON METHOD AND APPARATUS

For this report the soil sample collected are from four different location in Rajasthan as shown in Fig 1. In the Rajasthan, according to ICAR eight type are present, which are alluvial soil (gangas Yamuna doewab), black cotton soil (south east area), red and yellow soil (the banas belt), mountainous soil (the arawalli mountain), arid soil (western Rajasthan), saline and alkaline soil (western Rajasthan), and peaty soil. The locations of sample are (soil A) Jodhpur location 1, (soil B) Jodhpur location 2, and (soil C) Jodhpur location 3, Jodhpur location 4 (soil D). The type of soil A dry alluvial soil, soil B is black cotton soil, soil C is low plastic sandy soil and soil D is plastic dark brown soil. The collected samples of soil are shown below in Fig. 1.

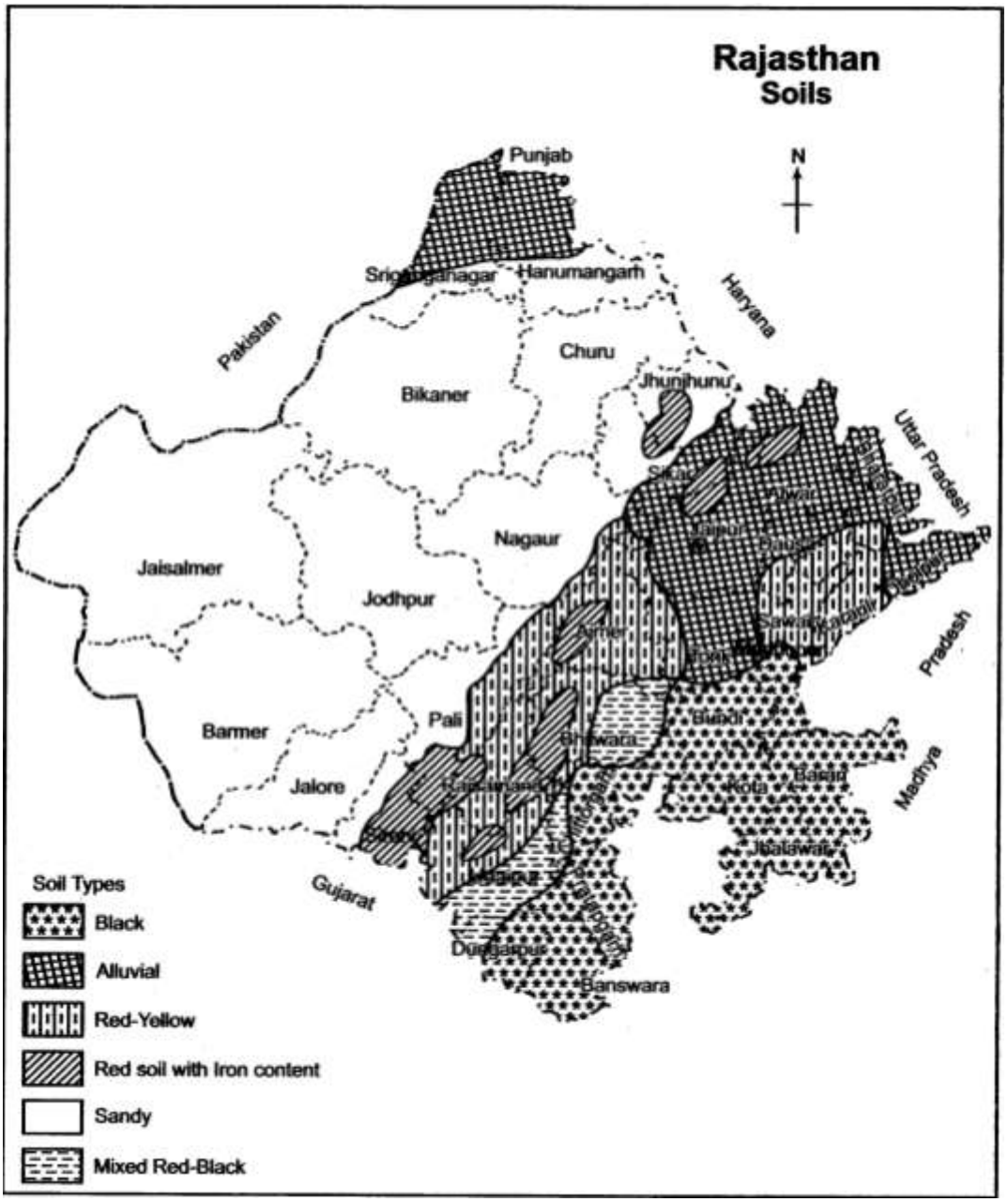


Figure 1 Soil classification of Rajasthan

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 452-460 www.ijaem.net ISSN: 2395-5252

Figure 2. Soil sample collected from different location

Alluvial soil, it is transported soil which is transport by running water or river. This type soil present nears the river bank and deltas. The colour of the alluvial soil varies from light grey to ash grey.

Sandy soil, it is a naturally occurring granular material composed of finely divided rock and minerals particles. If the soil particle size rand between 4.75 mm to 0.075 mm than its sand. If the sand particles is more than 85% than its sandy soils.

In this report the liquid limit values of soil is measured by the method mentioned in the IS 2720 'method of test for soils', Part 5 Determination of liquid and plastic limit. The detailed procedure of both the methods is discussed separately below,

1.Casagrande apparatus method
2.Cone penetrometer method.

1. CASAGRANDE METHOD

In this experiment, near about 120 gm of air-dried soil sample is collected and passing from 425 microns I.S sieve is taken in mixing dish, and distilled water is mixed to form a uniform paste by spatula. A part of soil sample water paste is placed in the cup of Casagrande apparatus and spread into portion with few strokes of a spatula. Then a groove is made by a grooving tool at the canter of cup which is shown in Fig 10. By rotate the turning crank Lift and drop the cup at the rate of two revolutions per second until the two half of soil paste come in contact with each other for a length of about 1 cm by flow only. The number of blows shall be counted, and this should be conducted with different water content for blows between 10 and 40.

Equipment:

Liquid limit device, Porcelain (evaporating) dish, Flat grooving tool with gage, eight moisture cans, Balance, Glass plate, Spatula, Wash bottle filled with distilled water, drying oven set at 105°C.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 452-460 www.ijaem.net ISSN: 2395-5252

Figure 2. Casagrande apparatus

2. CONE PENETROMETER METHOD

In the cone penetrometer method, the liquid limit is taken as the water content at which a standard 30-degree, 80 g cone will penetrate the soil sample a depth of 20 mm in time taken 5 sec. The basic principle is to observe depths of penetrations of soils at various initial moisture contents of a metal cone of a certain weight and apex angle with the point barely touching the surface is allowed to drop into the surface. The standardization has been to identify liquid limit water content for a specified depth of penetration.

Apparatus:

Balance - Sensitive to 0.01 g, Containers - non-corrodible and air-tight for moisture determination. Ovitz - thermostatically controlled with interior non-corroding material to maintain the temperature between 105 and 110°C, Soil Sample - A soil sample weighing about 150 g from thoroughly mixed portion of the soil passing 425 micron IS Sieve obtained in accordance to IS: 2720.

In this experiment, near about 150 gm. of air-dried soil sample is collected and passing from 425-micron IS sieve is taken in mixing dish, and distilled water is mixed to form a uniform 5 paste with help of spatula. Then the moist soil paste is filled to the cylindrical cup of cone penetrometer device, with no air trapped and placed on the base of the cone penetrometer device. The penetrometer is so set that the cone point touches the surface of the soil paste in the cup, and the initial reading is to be note down. The vertical clamp skrew is then released, allowing the cone to penetrate soil paste sample under its weight for a time 5 seconds and reading is note down. The test is repeated with different moisture contents of soil pastes for values of penetration in the range of 15 to 25 mm. Shown in fig 11. Cone Penetrometer test apparatus which is used in the present time.

Figure 3. Cone penetrometer apparatus

III. RESULTS AND DISCUSSION

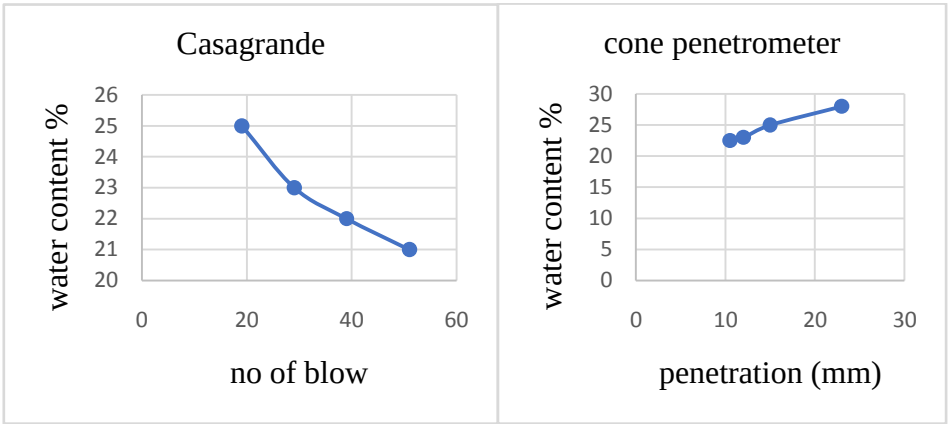
All the four soils samples were tested for many times to ensure the repeatability of tests and find out unique values. A several experiments were conducted on soil samples and taken out liquid limit. However, in above table only some typical tests are shown. In Casagrande apparatus, the liquid limit value is measured at the value of moisture content to 25 no. of blows by the graph, while in cone penetrometer method the liquid limit value is measured at the value of moisture content with respect to 20mm depth of penetration by graph. The results obtain by casagrande apparatus and cone penetrometer are shown separately for low plastic soils sample and medium to highly plastic soil sample.

LOW PLASTIC SOILS

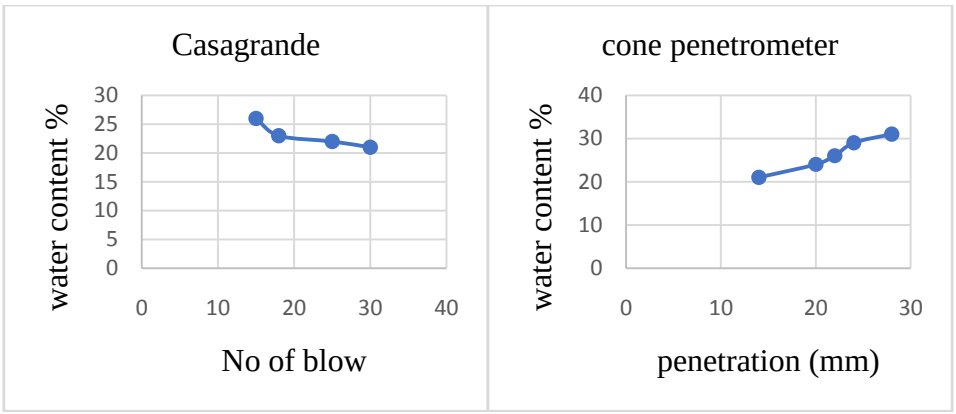
The tests conducted on low plastic soil and results of liquid limit obtain by both method casagrande apparatus and cone penetrometer are shown in Fig. The right and left parts in each figure represent the liquid limit test results obtained by the cone penetrometer apparatus and Casagrande tool respectively. According to data and graphs, it shows that the liquid limit value is lowest for soil A (LL 21%) and increases higher side for soils B (LL 23%) and soil C (LL 27%) in chronical order. Soil B is black cotton soil so its nature is alkaline. Therefore, liquid limit is found to be relatively less as compared to normal expansive soils. It is also observed that when liquid limit increases the flow index (slope of flow line) increases of soil. The liquid limit value measured by Casagrande

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 452-460 www.ijaem.net ISSN: 2395-5252

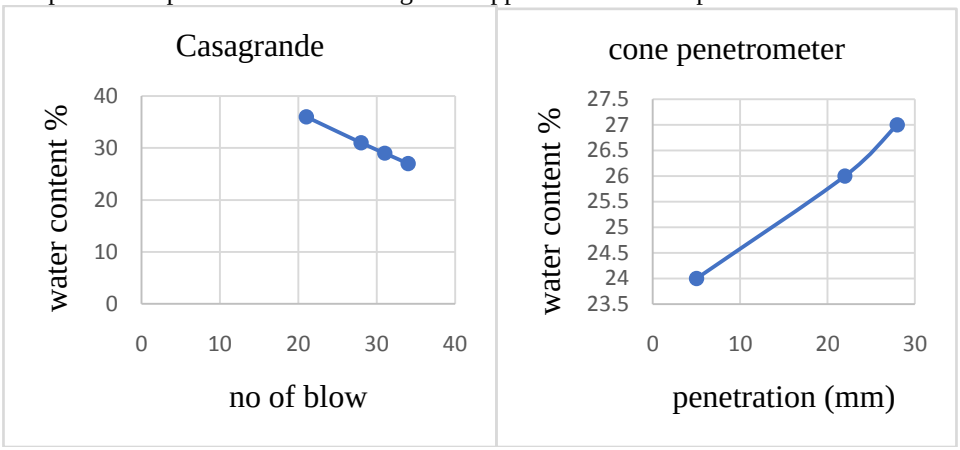
apparatus of soil A (LLcone 26%, LLcasagrande 21%) and soil B (LLcone 25%, LLcasa22%) is found to be lower than those determined by Cone penetrometer method. Other hand the liquid limit of Soil C (LLcone 26% , LLcasagrande 30%) is higher. Also we can say that the cone pentrometer gives higher liquid limit value than the casagrande apparatus for same soil sample. It also observe that the liquid limit value difference near about 5 % between both method cone drop penetrometer and casagrande apparatus.



Graph 1. Comparison between Casagrande apparatus and Cone penetrometer for soil A.



Graph 2. Comparison between Casagrande apparatus and Cone penetrometer for soil B.

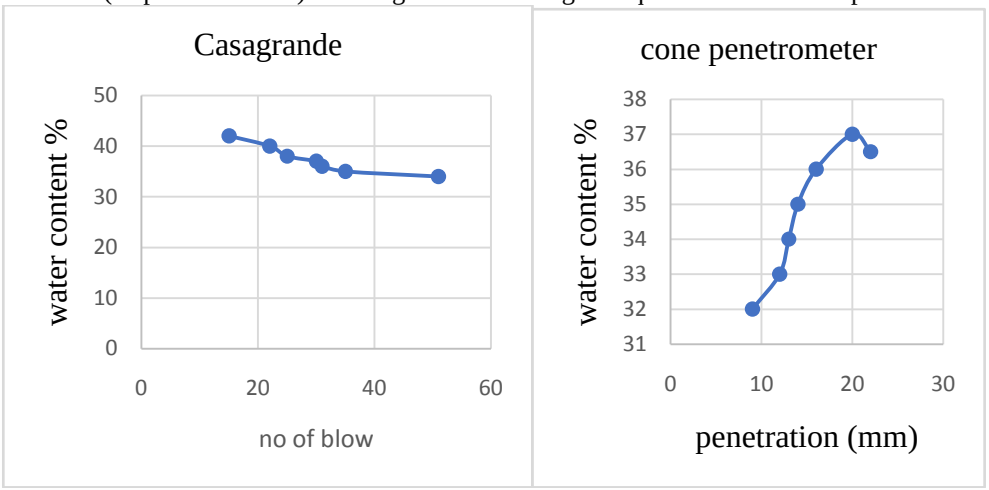


Graph 3.Comparison between Casagrande apparatus and Cone penetrometer for soil C.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 452-460 www.ijaem.net ISSN: 2395-5252

MEDIUM TO HIGH PLASTIC SOILS

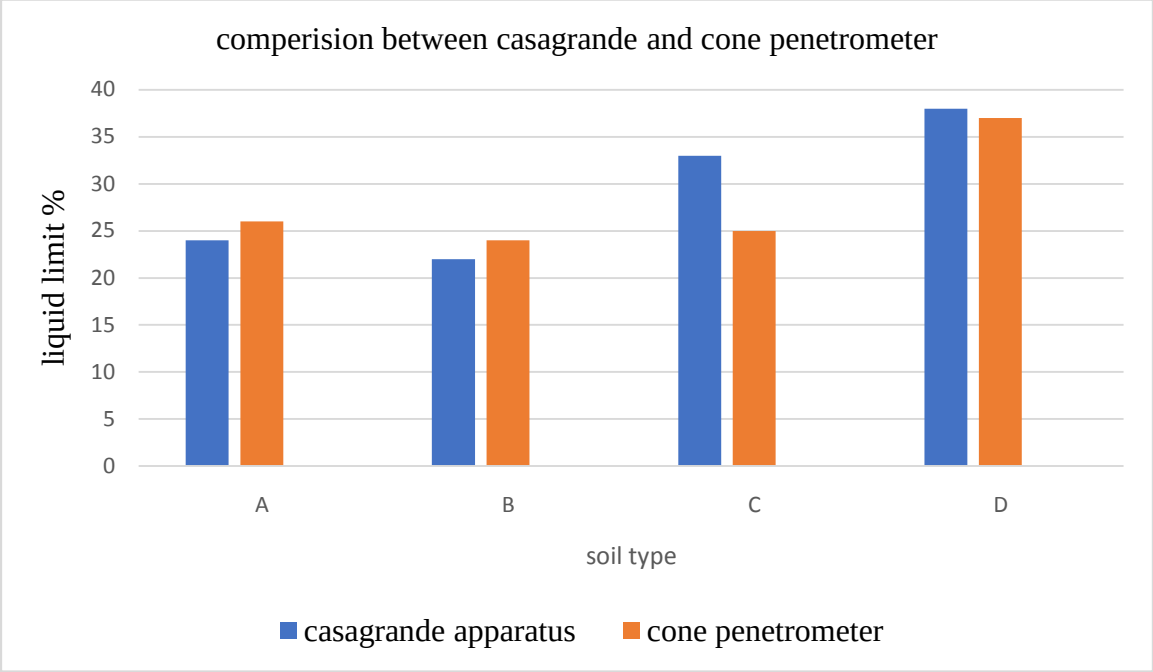
The tests conducted on soils D with medium to high plastic soils and results of liquid limit obtain by casagrande apparatus and cone penetrometer is shown in graph. Similarly to above the left and right parts in each graph shown the liquid limit test results obtained by Casagrande apparatus and the cone penetrometer device. The slope of curves in cone penetrometer is lower than the slope of curve in Casagrande apparatus. It mean the flow index (slope of curve) is higher. According to graph it show that the effect of variation in the moisture content is relatively more in case of Casagrande tool compared to the Cone penetrometer test. The Casagrande apparatus based on sudden jark so it imposes sudden deformation of soil whereas in cone penetrometer cone fall gradually. Therefore, the Casagrande apparatus might have been higher sensitive to variation in moisture content than the cone pentrometer. According to results casagrande apparatus show higher liquid limit than cone penetrometer.



Graph 4. Comparison between Casagrande apparatus and Cone penetrometer for soil D.

The comparison between liquid limit values obtained for a different type of soils low plastic, medium to high plastic soil (A, B, C and D) is shown in graph 5. It found that the difference in the liquid limit values is vary with the types of soils or soil parameter. According to IS soil classification system, the soils are classified as, when the liquid limit is below 35%, it is low plastic soil, liquid limit between 35 % to 50% , it is medium plastic soil and liquid limit more than 50%, it is high plastic soil. The Casagrande tool estimates the lower value of the liquid limit for soil have liquid limit less than 30%. The soils can be classified, when the liquid limit is varying between 35% to 50% it called medium plastic soils. However, no information is provided in the IS about transition state, from low plastic to medium plastic state. Any correlation between Casagrande method, and the cone penetrometer test results in soils with plasticity higher than 30% and less than 40% is difficult because this range show transition state which is not define by IS soil classification system. This range is near to the boundary separating between low and medium plastic soil. A few tests have been conducted for the soil with a liquid limit of 30-40%. Therefore, it is required to conducted a large number of tests on soils with liquid limit value falling in this range. The liquid limit measured by Casagrande tool is found to higher than those measured by the Cone penetrometer method for highly plastic soils. Other hand the liquid limit value is found lower of casagrande apparatus than cone penetrometer for low plastic soil.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 452-460 www.ijaem.net ISSN: 2395-5252



Graph 5. Comparison between results of Casagrande apparatus vs Cone penetrometer test

IV. CONCLUSIONS

In this report the liquid limit value was measured by cone penetrometer and casagrande apparatus, for low plastic soil, medium plastic soil and highly plastic soils found in Rajasthan, India. The liquid limit value of low plastic soil obtained by cone penetrometer method is higher than those obtained by Casagrande tool near about 5%. Also we can say the difference between these two method Casagrande apparatus and cone penetrometer is 5% for low plastic soil. Other hand for highly plastic soils, the opposite trends have been seen that the liquid limit value determine by cone penetrometr is lesser than those obtain by Casagrande apparatus. The relationship between both the techniques is clear for high plastic and low plastic soils, and both are opposite. Therefore, it is difficult to made any conclusion for soil with liquid limit ranging from 32%-42% because this range is transition state between low plastic soil to medium plastic soil.. However, it is required to conduct a large number of tests sample and different parameters to make any conclusion regarding the soil close to the boundary of low to medium plastic soils.

REFERENCES

[1]. Spagnoli, G., 2012. Comparison between Casagrande and drop-cone methods to calculate liquid limit for pure clay. Canadian Journal of Soil Science, 92(6), pp.859-864.

[2]. Hrubesova, E.,. Brodzki, O., 2016and Lunackova, B. Comparison of Liquid Limit of Soils Resulted from Casagrande Test and Modificated Cone Penetrometer Methodology. Procedia Engineering, 142, pages .364-370.

[3]. International Journal of Science and Research (IJSR), 2017. A Study on Correlation between Liquid Limit by Cone Penetrometer and Casagrande Method. 6(1), pp.1386-1389.

[4]. El-Shinawi, A., 2017. A comparison of liquid limit values for fine soils: A case study at the north Cairo-Suez district, Egypt. Journal of the Geological Society of India, 89(3), pages .339-343.

[5]. KARAKAN, E. and DEMİR, S., 2018. Düşenkonive Casagrande deneyleriileçeşitlikum-kilkarışımlarındalikit limit hesaplaması. BalıkesirÜniversitesi Fen BilimleriEnstitüsüDergisi, pp.361-371.

[6]. Crevelin, L. and Bicalho, K., 2019. Comparison of the Casagrande and Fall Cone Methods for Liquid Limit Determinations in Different Clay Soils. RevistaBrasileira de Ciência do Solo, 43.

[7]. CAMPBELL, D., 1976. PLASTIC LIMIT DETERMINATION USING A FALL-CONE PENETROMETER. Journal of Soil Science, 27(3), pages.295-300.
[8]. Arora, k. R. (1992). soil mechanics and foundation engineering. standard publishers.
[9]. 1991. Basic and applied soil mechanics. 3rd ed. New age international limited.
[10]. Di Matteo, L., 2011. Liquid limit of low- to medium-plasticity soils: comparison between Casagrande cup and cone penetrometer test. Bulletin of Engineering Geology and the Environment, 71(1), pages.79-85.
[11]. Kang, G., Tsuchida, T., Tang, T. and Kalim, T., 2017. Consistency measurement of cement-treated marine clay using fall cone test and Casagrande liquid limit test. Soils and Foundations, 57(5), pp.802-814.
[12]. Rehman, H., Pouladi, N., Pulido-Moncada, M. and Arthur, E., 2020. Repeatability and agreement between methods for determining the Atterberg limits of fine grained soils. Soil Science Society of America Journal, 84(1), pp.21-30.
[13]. International Journal of Science and Research (IJSR), 2017. A Study on Correlation between Liquid Limit by Cone Penetrometer and Casagrande Method. 6(1), pp.1386-1389.
[14]. Karlsson, R. 1961. Suggested improvements in the liquid limit reference to flow properties of remoulded clays, the 5th International Conference on Soil Mechanics and Foundation Engineering 1961, Paris, France. pp. 171–184
[15]. O'Kelly, B., Vardanega, P. and Haigh, S., 2018. Use of fall cones to determine Atterberg limits: a review. Géotechnique, 68(10), pp.843-856.