Study of Liquid and Shrinkage Limit of Kaolinite-Bentonite Minerals

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Abstract—Shrinkage limit and liquid limit are the Atterberg limits and it is important in many plasticity characteristics of soil behavior. Sridharan A and Prakash K[1] proved that natural soil shrinkage limit does not rely upon plasticity characteristics. In the present study confirms the using of cohesive clay kaolinite and bentonite mixed with non-cohesive sand and mechanism shows that the variation of liquid limit and shrinkage limit and the natural soil shrinkage limit does not rely upon plasticity characteristics.

Keywords-Shrinkage limit, liquid limit, clay minerals

I. INTRODUCTION

The fundamental material in geotechnical engineering field is soil. The behavior of soil in terms of strength , stiffness and stability is vital important and also it is the fundamental for all the constructional activities. The characteristics of expansive soil can be known by the presence of high amount of clay mineral in the natural soil . The expensive soil consist of montmorrillonite or bentonite , kaolinite , illite and other non-clay minerals in different proportions. Study of expensive soil behavior is restricted in demographical areas and also study of expensive soil in different proportions around the world requires lot of time and financial implications .

In the present study, the experimental investigation conducted for the expensive soil consist of different mix proportions of clay minerals kaolinite and bentonite and also non cohesive soil sand in different proportions . Analysis of Atterberg limits is vital importance in study of fundamental behavior of clay minerals. These characteristics of clay minerals are answerable for the designing of structure and to know about the subsoil behavior of expensive clay.

Consistency is the obstruction of soils to deformity and crack. The terms delicate, medium, firm, exceptionally solid, and hard are applied to rate consistency of soil. Atterberg distinguished three restricting water substance that is seen in soil states that can be called as Atterberg's limits. The higher water content and lower water content within which the behavior of clay element exhibits a characteristics of plastic state then this states represented by the liquid and plastic limits respectively.

Essentially, the lower state of water content between semi-hard and hard states is the shrinkage limit. Shrinkage is a collaboration of volume decline that occurs because of fine squeezing factors actuated by the scattering of water from the soil and Shrinkage cutoff of a common soil is basically an element of general grain size circulation of soil, notwithstanding of the fundamental clay mineral of the soil and that as far as possible doesn't rely upon versatility attributes of the soil.

II. LITERATURE REVIEW

Sridharan, A. and Prakash, K (2000) studied Shrinkage limit, one of the Atterberg limits, and presented that natural soil shrinkage limit is not depend upon characteristics of plasticity.

Naser Al Shayea (2001) established that clay minerals impact the conduct of the whole soil mass regardless of whether they are available just as little parts of the clay. Likewise, the degree of soil division in a clay is required in deciding its geotechnical qualities like strength and compressibility.

Mehdi Gharib (2012) et.al studied that impact of including cementitious to expensive clay and to study the properties of shrinkage and its effects to the various soil substances. An impressive count of extension tests were done on blended examples in with various weight rates. The outcomes proposed the huge impact of alteration of clay soils by including cement their shrinkage properties, to such an extent that expanded level of added substances builds the shrinkage furthest reaches of additives added substance blend and the breaks brought about by shrinkage decline as far as length and width.

Christodoulias J (2015) Expensive soil cause critical harm to construction and streets by cyclic therapist swell inside the dynamic zone of soil. This is one research center approach to recognize the shrinkage capability of clay soil. Lab tests were performed to inspect the adequacy of different techniques in lightening the antagonistic after effects of occasional expanding – contracting regarding streets and structures establishment, focusing on shrinkage limit test utilizing the mercury contraption, recommended by the Transport and Road Research Laboratory.

Yong et al. 1986 examined that when designing the backfill material it requires the low shrinkage value sand also with other rigid prerequisitse.

III. MATERIAL AND METHODOLGY

Materials procured for the present investigational study are,

Table 1 : Material required for Experimental work

Materials used	River Sand (Passing through 425 μ)
	Kaolinite Clay Mineral
	Bentonite clay mineral

Expensive clay materials, which is commercially available and was procured from Bangalore and stored in separate plastic bins. Similarly, natural river sand was procured from single source and was wet washed to remove organic contents and oven dried and stored in separate plastic bins. For preparation of the sample, they will be kept in oven for a period of 24 hours for oven drying, after which they will be kept for cooling at room temperature. Kaolinite mixed with different proportions of sand and the following samples were prepared.

	PROPORTION I		**PROPORTION II**	
	KAOLINITE (%)	SAND (%)	BENTONITE (%)	SAND (%)
PROPORTIONS	100	-	100	-
	10	90	10	90
	20	80	20	80
	30	70	30	70
	40	60	40	60
	50	50	50	50
	60	40	60	40
	70	30	70	30
	80	20	80	20
	90	10	90	10

IV. LABORATORY TESTS FOR THE PREPARED SAMPLES

In the present investigational studies, the below mentioned experiments were conducted for the mix proportions 1 and 2 which is highlighted in the table -2.

1. Liquid limit (Casagrande method of finding liquid limit) (IS:2720-Part-5-1985)
2. Determination of Shrinkage limit by mercury displacement method (IS:2720-Part-5-1985)

V. RESULTS AND DISCUSSION

TABLE 2 Shows Index Properties of kaolinite and Sand blends

Sl No	Percentage Kaolinite K (%)	Percentage sand S (%)	Liquid Limit WL (%)	Shrinkage limit Ws (%)
1	10	90	NP	NP

2	20	80	NP	NP
3	30	70	37	22.2
4	40	60	38.5	22.5
5	50	50	43	22
6	60	40	50.5	21.9
7	70	30	53	21.2
8	80	20	57	21
9	90	10	63	20.1
10	100	0	65	18

*NP – Non plastic

TABLE 3 Shows Index Properties of Bentonite and Sand blends

Sl no	Percentage Bentonite B (%)	Percentage sand S (%)	Liquid Limit WL (%)	Shrinkage limit Ws (%)
1	10	90	NP	NP
2	20	80	NP	NP
3	30	70	102	22
4	40	60	147.5	21.2
5	50	50	175.5	20.1
6	60	40	211	18.2
7	70	30	242	17.1
8	80	20	291	16
9	90	10	310	13.2
10	100	0	550	12

*NP – Non plastic

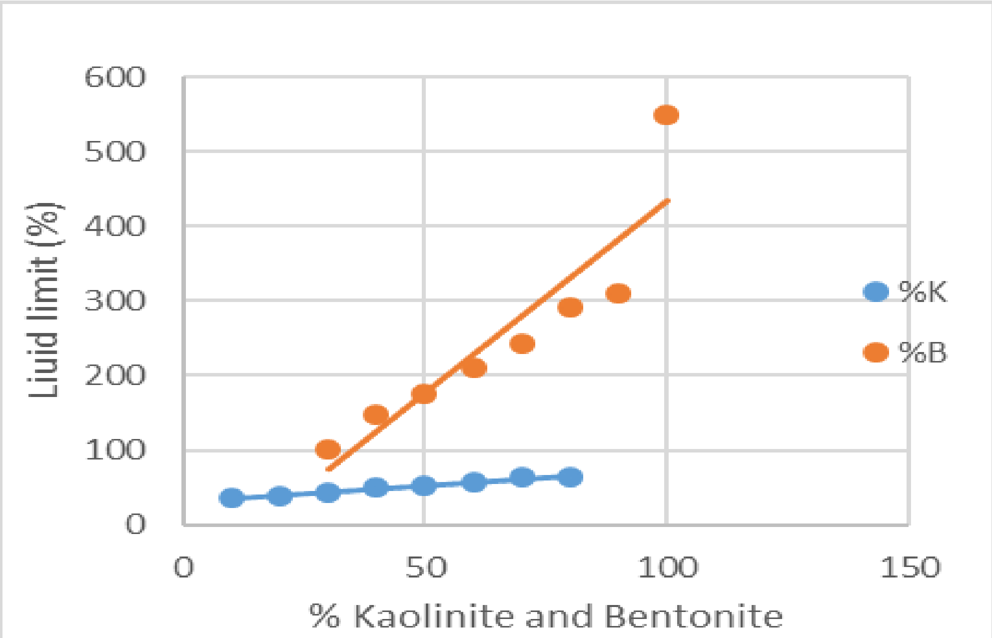

Fig 1 Variation of clay minerals with liquid limit

From Fig 1 it tends to be seen that as the rate of kaolinite in the kaolinite and sand blends as well as bentonite in the bentonite and sand blends increases, which intern leads to increase in the value of liquid limit. This is due to the fact that activities of the clay minerals is more with the higher available specific surface area.

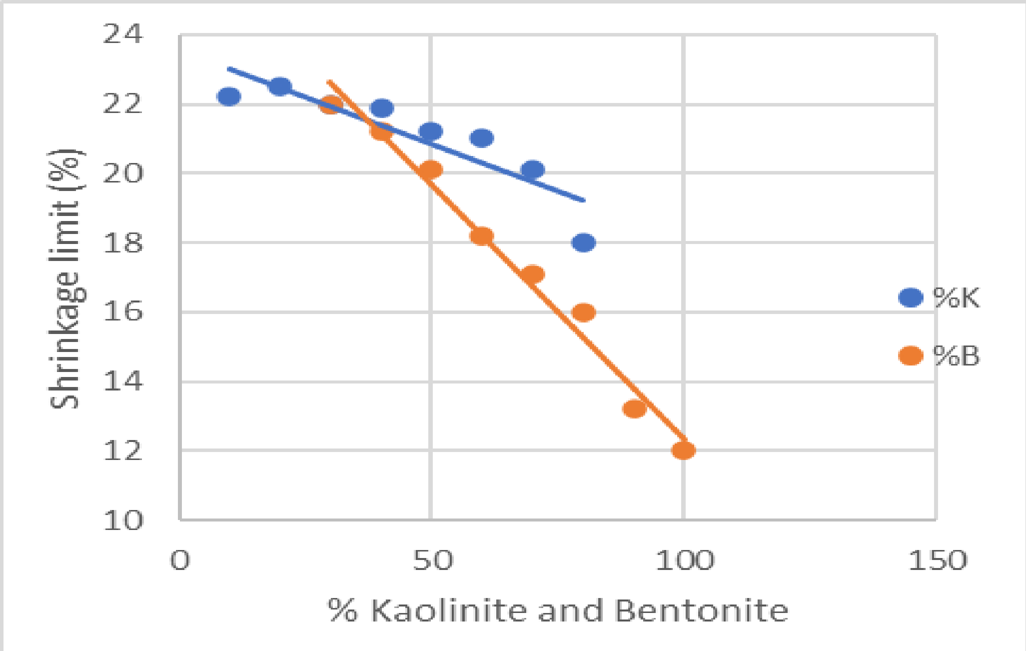

Fig 2: Variation of clay minerals with shrinkage limit

From Fig 1 it tends to be seen that as the rate of kaolinite in the kaolinite and sand blends as well as bentonite in the bentonite and sand blends increases which intern tends to decrease in the value of shrinkage limit. This is due to the fact that shrinkage of soil is fundamentally an element of relative grain size dispersion of the soil and independent of the vital clay mineral present in the soil matrix.

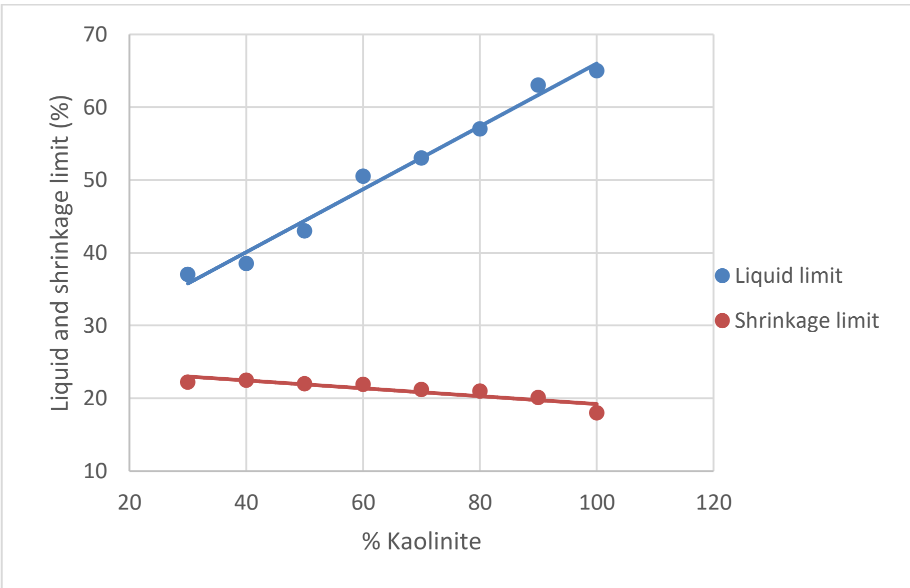

Fig 3: Variation of kaolinite with Liquid and Shrinkage Limit

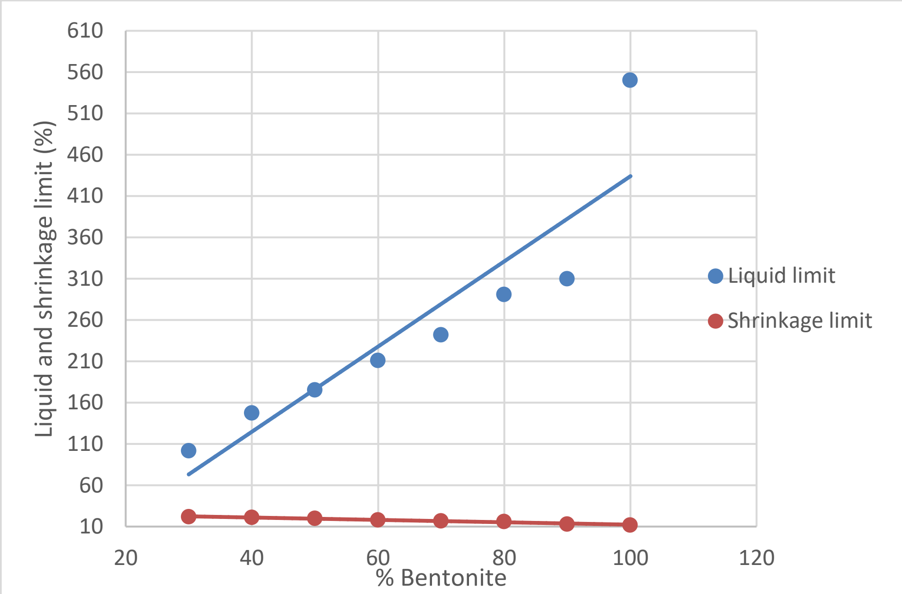

Fig 4: Variation of bentonite with Liquid and Shrinkage limit

From fig 3 and 4 it shows that with the increase of %K and %B in the mix proportions intern leads to increase in liquid limit and the value of shrinkage limit reduced/decreased. This is mainly due to that the shrinkage limit is not a plastic behavior. Hence, with increment in liquid limit the shrinkage limit decreases.

VI. CONCLUSIONS

- As the addition of kaolinite is increased in the proportionate of kaolinite -sand mixtures,the liquid limit is increased to about 37% to 65% and further with the addition of bentonite in the proportionate of bentonite -sand mixtures, the liquid limit is increased to about 550% from the initial 147%.
- The increment is observed with the addition of bentonite and this is mainly due to which bentonite has more surface region andis strongly active clay mineral.It displays high cation contacts between particles. Because of this property, the liquid limit increases more with the bentonite and sand mixtures than the kaolinite and sand mixtures.
- The Shrinkage limit of pure Kao-linite is about 18 % and the value of shrinkage limit increases with the decrease in percentage kaolinite of 22.8%. Like-wise, shrinkage limit of bentonite and sand blends changing from from 22 to 12%, this is mainly due to packing phenomenon of shrinkage process and also shrinkage limit decreases with the increases of liquid limit in the clay blends.

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