Experimental Investigation of Clayey Soil mixed with Rubber Flash

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***Abstract*— Over the years, the expanse of solid waste generated has been increasing at an alarming rate every year and the disposal of the same has become a serious problem. Particularly, recycling ratio of rubber waste is low and most of which has to be reclaimed because of the incongruity for incineration. This study presents a modest approach of utilizing rubber waste in the field of civil engineering as reinforcing material. Clayey soil sample is mixed with rubber strips randomly distributed to anticipate its reinforcing effects with respect to change of percentage of strip content and aspect ratio on the engineering properties of compacted soil. California Bearing Ratio Test (CBR) is performed to evaluate the mechanical response of fiber reinforced clay in terms of compaction characteristics and penetration resistance.**

Keywords*— Rubber waste, Reinforced soil, Aspect ratio, Compaction. Penetration Resistance.

I. INTRODUCTION

Natural soil is both a complex and highly variable material; yet because of its universal availability and low cost, it offers a great opportunity for skillful use as an engineering material/foundation material. Soil according to a geotechnical engineer can be fine grained or coarse grained based on size; out of which fine grained soil is usually weak in taking higher amount of stresses for which stabilization is essential. Soil stabilization refers to the procedure in which a special soil, a cementing material, or other chemical or non-chemical materials are added to a natural soil or a technique use on a natural soil to improve one or more of its properties. One may achieve stabilization by physically mixing the natural soil and stabilizing materials together so as to achieve a homogeneous mixture or by adding stabilizing material to an undisturbed soil deposits and obtaining interaction by letting it permeate through soil voids (Abood, Kasa, & Z.B., 2007). Soil stabilizing additives are used to improve the properties of less desirable road soils. When used these stabilizing agents can improve and maintain soil moisture content, increase soil particle cohesion and serve as cementing and water proofing agents (Janathan Q.A., 2004). Most of stabilization has to be undertaken in soft soils (silty, clayey peat or organic soils) in order to achieve desirable engineering properties. Fine grained granular materials are the easiest to stabilize due to their large surface area in relation to their particle diameter. A clay soil compared to others has a large surface area due to flat and elongated particle shapes. On the other hand, silty materials can be sensitive to small change in moisture and, therefore, may prove difficult during stabilization (Sherwood, 1993). On the Contrary, every year, over one billion tyres are manufactured worldwide, and equal number of tyres are permanently removed from vehicles, becoming waste. The U.S. is the largest producer of waste tyres, about 290 million a year, although increases in new vehicles sales in China and India are rapidly contributing to waste tyre volumes. Globally, in 2011, only 7% of waste tyres were recycled on site, 11% were burned for fuel, 5% were exported for processing elsewhere. The remaining 77% were sent to landfills, stockpiled, or illegally dumped; the equivalent of some 765 million tyres a year wasted. India's waste tyres account for about 6-7% of the global total. With the local tyre industry growing at 12% per annum, waste volumes are rising (Lalatendu, 2016). To address the problems related to improving physical properties of clayey soil and find new alternatives to use rubber an attempt has been made in this paper to mix rubber with clay soil and foresee changes in properties of soil.

II. STATE OF THE ART

For any structure, a strong foundation is very important to support the superstructure and thereby safely transfer the loads to the soil. Hence the properties of the soil on which any structure is placed should be strong and stable. However, Expansive soils when come in contact with water exhibit swelling and swelling pressure characteristics. These soils are considered to be problematic and cause damages to the structures due to alternate swelling and shrinking as a result of seasonal moisture changes (Katti, 1979). Indian soils comprised of expansive soils, a large portion of these structures pass through expanses of such soils. Among various methods for the solutions to the problems posed by expansive soils, especially for large area coverage, the stabilization of such soils would be a natural choice (Kate, 2005). The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work (Harshita., 2018). In India, the modern era of soil stabilization began when there occurred a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site (S.P.Kanniyappan, 2019). Many areas of India consist of soils with high silt contents, low strengths and minimal bearing capacity (Ganesha, 2009). Soil stabilisation was used, but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor. In recent times, with the growth in the demand for infrastructure, sensitive materials and fuel, soil stabilization has begun to call for a fresh form (Bandna Kumari, 2016). The stabilization process can result in higher resistance values, reduction in plasticity, lower permeability, reduction of pavement thickness etc. (Harshita., 2018). Till date many research has been done on stabilisation of clay soil with different methods. (Harshita., 2018) concluded that the unconfined compression strength and california bearing ratio increases with increase in lime content in a clayey soil. (R. Saravanan, 2013) indicated that in addition of fly ash reduces the plasticity index and specific gravity of the expansive clayey soil. The optimum moisture content (OMC) and maximum dry density (MDD) curves indicate that addition of fly ash increases the OMC and maximum dry density of the expansive soil. (Alzaidy, 2019) concluded that an increase in Egg Shell Powder (ESP) content causes to an initial increase in unconfined compressive strength, California bearing ratio and shear strength parameters of the clayey soil followed by a slight decrease. The optimum (ESP) requirement for strength improvement is about 5% by dry weight of soil. On the other hand, the swelling potential had reduced with an increase in (ESP) content. (A.K. Choudhary, 2010) concluded the results of CBR tests improved with the inclusion of waste high density polyethylene (HDPE) strips in soil with appropriate amounts improved strength and deformation behavior of subgrade soils substantially. Gray and Ohashi(1983) conducted a series direct shear tests on dry sand reinforced with different types of fibers and concluded shear strength increases are directly proportional to the fibre area ratio, fibre content, and fibre stiffness. Tyre tube was cutted into small chips and was mixed into the clay soil in varying percentages, with these mix compositions CBR test was carried out at different dry densities obtained from the standard penetration test was concluded by (Deepanshu, Mayank, & Purohit, 2017). (Umar Jan, 2015) in their study used shredded rubber tyre having sizes ranges from 15mm to 25mm (Width) and 30mm to 50mm (Length) was mixed into the clay soil in varying percentages which showed CBR has got the improvement of 66.28% than in comparison of the plain soil.

So from the literature review it can be concluded that rubber tyre strips are already mixed with clay soil and results are computed which shows improvement, but rubber tyre added in the soil the aspect ratio was not changed, so objective of this study is to foresee the changes in soil physical properties if aspect ratio of tyre to be added in a soil is not constant.

III. METHODOLOGY

Experimental work done by various investigation from last many years have established beyond doubt that additional of fibre in soil improves the overall engineering performance of soil. Among the notable properties that improves are shear strength, ductility, toughness, isotropy in strength, CBR values etc. with reduction of compressibility characteristics.

The flow chart of the proposed methodology for the study is shown in the Fig.1

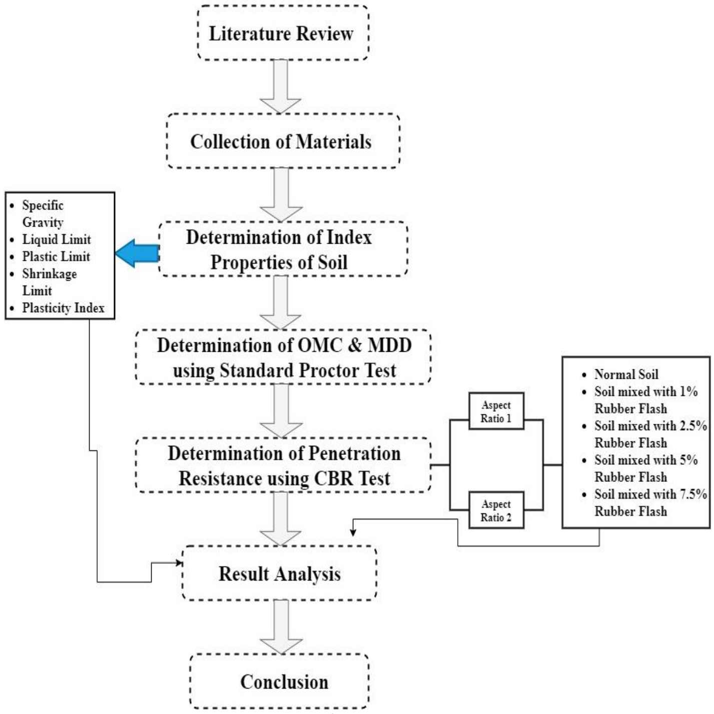

Fig. 1: Methodology of the Proposed Study

In the present study, the soil selected is clayey soil which is generally is not used in subgrade layer during construction of pavement. Soil of low strength is selected in order to determine substantial change in CBR value. Material for the current study was collected from the Saini Rubber Industries (SRI) which is located at Sativali Road in Vasai Road (E) and bags of Soil sample were collected from an on-going site of a building project situated at Sri Ramprasad Agarwal Marg in Bhayander (W). The various test performed and the procedure adopted for the same is mentioned below:

- **Specific Gravity Test** - To determine specific gravity of the solids by density bottle method as per IS 2720 (Part 3/Sec-1) 1980.
- **Liquid Limit** - Casagrande's apparatus (conforming to IS: 9259-1979) was used to determine the liquid limit of the soil. This test was carried out as per IS: 2720 (Part 5) 1985.
- **Plastic limit -** The test to determine the plastic limit is conducted conforming to IS: 2720 (Part 5) 1985.
- **Shrinkage limit -** The test is conducted conforming to IS: 2720 (Part 6) 1972.
- **Standard Proctor Test -** This test was conducted conforming IS 2720 (Part 7) 1980.
- **California Bearing Ratio Test -** To determine CBR value of given soil by conducting CBR test on statically compacted unsoaked specimen as per IS: 2720 – Part 16.

Various tests were conducted on the virgin soil for its classification and determination of basic engineering properties and results of the same is shown in Table I below.

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TABLE I. PROPERTIES OF VIRGIN SOIL

Sr. No.	Properties	Value
1	Liquid Limit (%)	85.6
2	Plastic Limit (%)	40.5
3	Plasticity Index (%)	45.1
4	Shrinkage Limit (%)	13.9
5	Shrinkage Index (%)	26.6
6	Flow index (%)	9.68
7	Toughness Index	4.66

Also, other test like particle size distribution and standard proctor test were performed on the soil, the results of which are shown in Fig. 2 and Fig. 3 respectively.

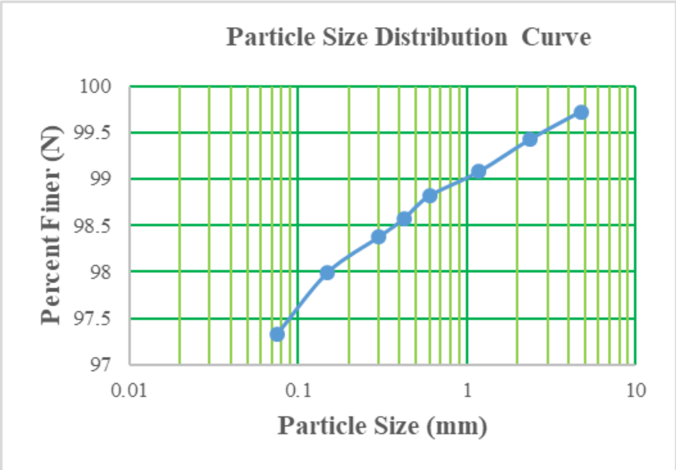

Fig. 2 Particle Size Distribution Curve of Virgin Soil

From Fig. 2 it is seen that since more than 50% soil passing 75 micron sieve the soil is fine gained soil.

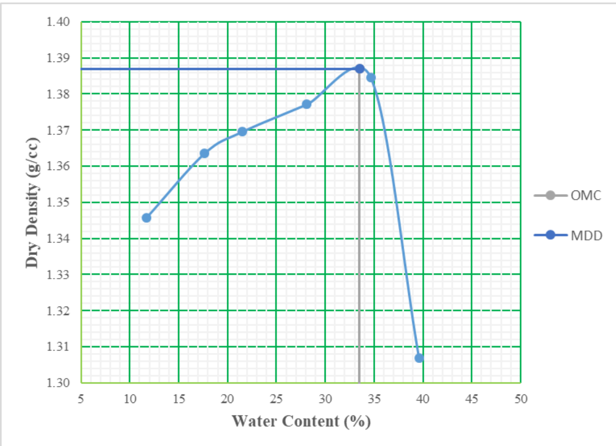

Fig. 3 OMC vs MDD Curve of Virgin Soil

From Fig. 3, the values of obtained are OMC = 33.5% and MDD = 1.387 gm/cc.

IV. RESULT & DISCUSSION

After performing Standard Proctor Test, the next step was to find penetration resistance of virgin soil as well for the soil mixed with rubber flash in varying proportions as discussed before using CBR Test the results for which is shown below. For performing CBR Test, a CBR machine was used having a strain rate of 1.25mm/min as well as proving ring of 50kN (6.57kg/Div.) capacity was used along with strain dial gauge having least count of 0.01mm to measure the penetration. The test was done only for unsoaked condition and tyre waste was mixed with soil like a reinforcement in the form of strips having aspect ratio 1 (10mmx10mm) and aspect ratio 2 (10mmx5mm)

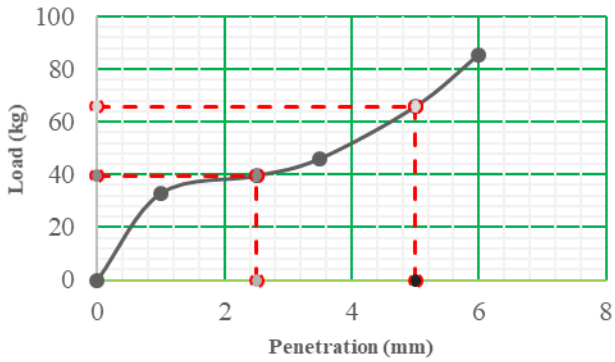

Fig. 4 Load Penetration curve for Virgin Soil

The CBR value obtained at 2.5mm and 5mm penetration for the virgin soil is 2.88% and 3.20% respectively.

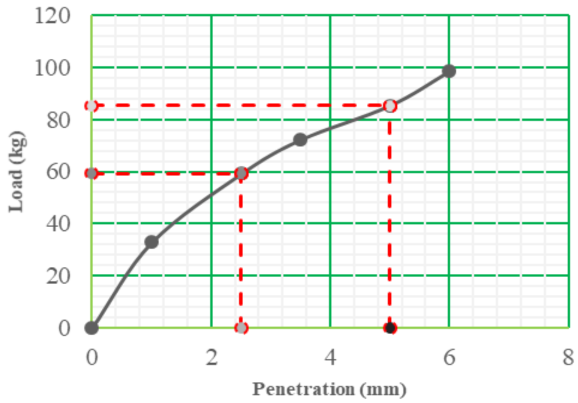

Fig. 5 Load Penetration curve at AR – 1 & strip content = 1%

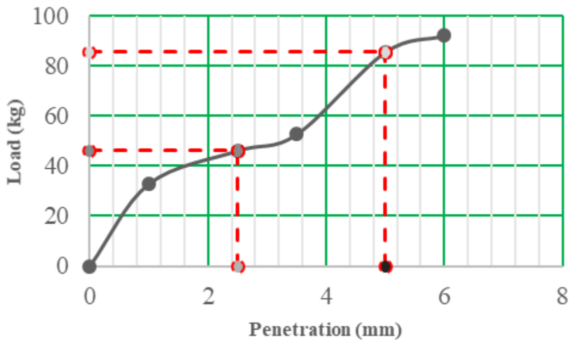

Fig. 6 Load Penetration curve at AR – 2 & strip content = 1%

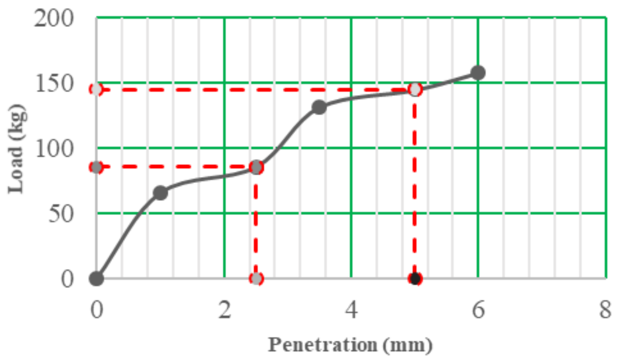

Fig. 7 Load Penetration curve at AR – 1 & strip content = 2.5%

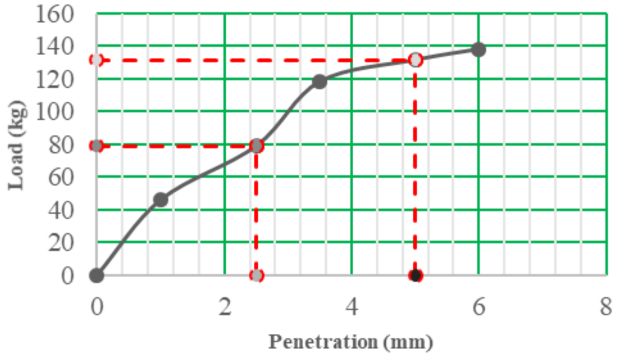

Fig. 8 Load Penetration curve at AR – 2 & strip content = 2.5%

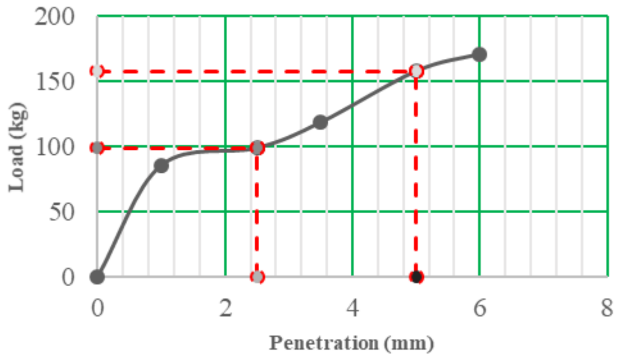

Fig. 9 Load Penetration curve at AR – 1 & strip content = 5.0%

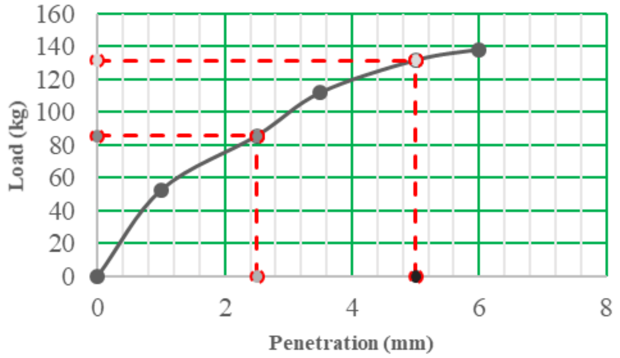

Fig. 10 Load Penetration curve at AR – 2 & strip content = 5.0%

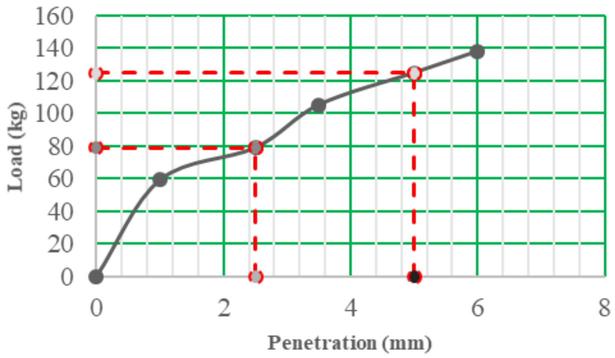

Fig. 11 Load Penetration curve at AR – 1 & strip content = 7.5%

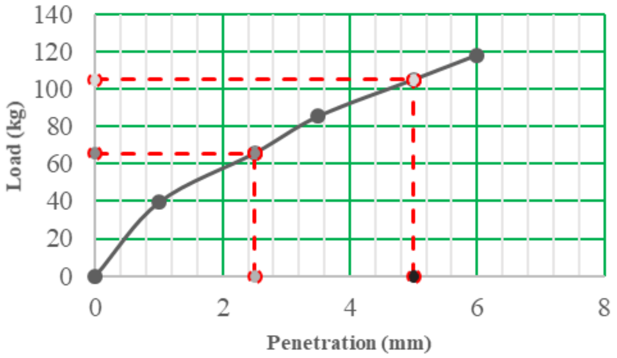

Fig. 12 Load Penetration curve at AR – 2 & strip content = 7.5%

The values obtained at 2.5mm and 5mm penetration for varied proportions of tyre waste mixed with soil with different aspect ratio is shown in Table II.

TABLE II. CBR VALUES WITH VARYING AR VALUES

Waste Proportion (%)	CBR Values			
	AR - 1		AR - 2	
	2.5 mm	5 mm	2.5 mm	5 mm
1	4.32	4.16	3.36	4.16
2.5	6.23	7.03	5.75	6.39
5.0	7.19	7.67	6.23	6.41
7.5	5.75	6.07	4.80	5.12

V. CONCLUSION

After the completion of experimentation, it is seen that CBR value increases with increasing waste content is the soil. However, at higher percentage of the waste, it is observed that the CBR value started decreasing. The optimum waste content is found to be 5% (for AR=1 & AR=2). Also, CBR value at 5mm for AR = 1 & AR = 2 is almost same whereas the value of CBR at 5mm for 5% waste content at AR = 2 is 2.89% higher than value at 2.5mm. Compared to the value of Virgin soil, Optimum waste content value for AR = 1 is 59.94% higher for 2.5mm and 58.28% for 5mm whereas for AR = 2 it is 53.77% for 2.5mm and 50.07% for 5mm. This study can be further expanded for different soils having excessive swelling and shrinking characteristics and for clayey soil keeping same aspect ratio but of slightly higher size or changing the aspect ratio completely.

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