Performance Assessment of Waste Plastic Inclusions on the Strength of Expansive Clays blended with Vitrified Polish Waste and Lime

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Abstract. Expansive clays will tend to increase in volume as it absorbs water and lessen in volume as water is drawn away. Foundations, building structures, pavements may crack (or) heave as the underlying expansive clays become wet and swell. Thus, for safe design such weak soils need to be improved before construction. Various techniques are available in practice and one of these processes of improving the properties weak or soft soils is stabilization. On the other hand, collection of different industrial waste materials is a major concern to the environmentalists. Vitrified polish waste is a waste from ceramic industry and it requires effective disposal, because it contaminates the environments, creates dust in the summer and endangers agricultural and public health. Today plastic is one of the major toxic pollutants because of its nature of non-biodegradable composed of plastic pollutes and toxic chemicals. During its production and disposal plastic causes severe damage to the environment. The main importance of the present study is to assess the use of new industrial waste material vitrified polish waste, different waste plastics and also a binder lime. To understand the performance of stabilized soil, laboratory tests like Atterberg's limits, compaction parameters, swell and strength parameters were studied. The outcome revealed an encouraging performance and the efficiency of the added materials. The optimum combination was 6% lime, 20% vitrified polish waste and 1.0% waste plastic inclusions which gave the improvement in strength characteristics. Thus, from this experimental study a two-fold solution was evolved, i.e. resolving the problem of disposal of waste and also improving the strength properties of problematic expansive soil.

Keywords: Expansive clay, Vitrified polish waste (VPW), Waste plastic inclusions (WPI) and strength parameters.

1.INTRODUCTION

Expansive soils are the soils which has tendency to decrease in the volume in the absence of water and increase the volume in the presence of water. This expansive behavior in the soil is due to presence of clay minerals in expansive clay mostly of swelling clay mineral like montmorillonite and kaolinite, illite in some cases. Due to presence of high amount of these minerals in expansive soil causes cracks in buildings, damage to the building foundations and to underground infrastructures. So it is necessary to find the problems with the expansive soils and prevent damage of structures. It is, therefore, important to use new techniques by utilizing the locally generated waste materials that are produced from industrial and agricultural byproducts for improving the properties of problematic soil. Due to low cost and convenience more interest in soil stabilsation in recent times, particularly in the soil related projects that require a high volume of soil improvement. The stabilization with pozzolana and especially with silica rich admixtures can be explained with the formation of gelation process when mixed with the cementing agents like lime etc. The main importance of this paper is to find the performance of new industrial waste material vitrified polish waste (VPW), different waste plastics and also a binder lime.

Stabilization using waste materials with and without a binder like lime, cement etc. is one of them. Umar et.al [5] stated that the metakaolin can be used as stabilizing agent for increase in the lateritic soil properties.

Konstantinos G. Kolovos et.al [3] reported that stabilization of expansive soils with metakaolin is to be helpful for improving the properties of expansive soils and can be used as a structural material. According to Binici [2] about 30% of daily production in the ceramic industry goes to waste are some of the prominent waste materials which have been successfully utilized for stabilization of expansive soil.

As reported by Koyuncu et al [1] the potential of using ceramic tile dust as an addition up to 40% to investigate its effect on swelling potential and swelling pressure of Na –bentonite and the results showed that for the addition of 40% ceramic tile dust waste, swelling pressure decreased by 86% and swelling potential decreased by 57%. Gaeta Rani et al [4] investigated the effect of tile waste on expansive soil. Different percentages of tile waste (0, 10%, 20% and 30%) were added to find the variation in its strength. From the laboratory test results, Optimum amount of tile waste was determined as 20% and it can be used for increase in the strength of expansive soil sub grade of flexible pavement with a substantial save in the construction cost.

From the available literature it is found that limited research has been done to study the use of waste ceramic dust on different strength properties of clayey soil. Therefore for the present study undertaken to investigate the performance assessment of waste plastic inclusions (WPI) on the strength of expansive clays blended with vitrified polish waste and lime.

1. METHODOLOGY

Expansive clay was taken from Amalapuram region at a depth of 2 m below the ground level. The soil is dark grey to black in colour. The properties of the expansive clay is assessed based on relevant I.S. Code provisions, are given in Table 2.1

Table 2.1. Properties of expansive clay

S.No.	Property	Value
1	Specific gravity	2.68
2	Differential free swell Index (%)	101
3	Liquid limit (%)	68.6
4	Plastic limit (%)	25.2
5	Plasticity index (%)	43.4
6	Sand Size Particles (%)	12
7	Silt & Clay Size Particles (%)	88
8	IS soil classification	CH
9	Max. Dry Density (g/cc)	1.45
10	Optimum Moisture Content (%)	27.9
11	CBR - Soaked (%)	1.5
12	CBR - UnSoaked (%)	3.3
13	Unconfined Compressive Strength (kN/m^2)	82

2.1 Vitrified polish waste (VPW)

VPW is a waste produced from ceramic tile industry with low porosity. A lot of waste is produced during the process of formation and transportation of ceramic tiles. These vitrified polish waste mainly consisting of CaO and Silica. Vitrified polish waste was collected from a local industry RAK Ceramics, Samarlakot, Kakinada district, Andhra Pradesh.

Table 2.2 Properties of Vitrified polish waste

S.No	Property	Value
1	Specific gravity	2.46
2	Optimum moisture content	12.5
3	Maximum dry density (g/cc)	1.58

2.2 Lime

The lime used for the present study was taken from local market in Kakinada, Andhra Pradesh state for the purpose of stabilizing the weak soil.

2.3 Waste plastics

Pieces of polythene bags which may be cut into standard dimensions of waste plastic inclusions (2 mm wide and 50 mm long) are cut into discrete fibres and used in the project. The usage of waste plastics is as the soil reinforcement and was taken from locally available factory.

2. RESULTS AND DISCUSSIONS

Various laboratory experiments were conducted by adding various percentages of vitrified polish waste and lime in the expansive clay. Compaction, California bearing ratio and unconfined compressive strength tests were conducted to determine the optimum combination of VPW and lime and further with waste plastics as reinforcement and the results are discussed in following sections.

3.1 Effect of vitrified polish waste and lime on the swelling property of expansive clay

Figures 1 and 5 shows the variation of differential free swell index (DFSI) for replacement of VPW and to the optimum percentage of VPW, percentage addition of lime respectively. The percentage of VPW was varied from 0% to 40% with an increment of 10%. From the optimum percentage of VPW percentage addition of lime was varied from 0% to 6%. All these materials showed a decrease in DFSI value with increase in % of material as replacement. Among these VPW as a 40% replacement shows decrease in DFSI about 24.7% and further decrement was more when lime is added.

3.2 Effect of VPW and lime on the compaction properties of expansive clay

In the present study Standard Proctor Compaction test as per IS: 2720, Part VII, 1980 [6], was conducted on soil .Figures 2 and 6 shows the variation of compaction properties for replacement of VPW and to the optimum percentage of VPW, percentage addition of lime respectively. From the graphs, it was observed that the treatment as individually with 20% VPW has moderately improved the properties of expansive soil and for the 20% replacement the improvement is about 2.75% and further addition of lime to the optimum percentage of VPW there is a gradual increase in maximum dry density for the % addition of 6% lime and the improvement is about 6.71%.

3.3 Effect of VPW and lime on the CBR values of expansive clay

In the present study IS 2720-Part 16: Methods of test for soils – Laboratory Determination of CBR [7] was conducted on soil. Figures 3 and 7 shows the variation of CBR values for replacement of VPW and to the optimum percentage of VPW, percentage addition of lime respectively. From the graphs, it was observed that the individual treatment of soil with 20% VPW has shown more effect on the expansive soil. It can be inferred from the graphs, that there is a gradual increase in CBR values for soaked and unsoaked with an increment in the % replacement of VPW up to 20% with an improvement of about 24.24% for unsoaked, 34.7% for soaked and further addition of lime to the optimum percentage, CBR values improved about 109% for unsoaked and 191.5% for soaked CBR for 6% addition of lime.

3.4 Effect of VPW and lime on the UCS values of expansive clay

In the present study IS 2720-Part 10: Methods of test for soils – Determination of unconfined compressive strength [8] was conducted on soil. Figures 4 and 8 shows the variation of UCS Values for replacement of VPW and to the optimum percentage of VPW, percentage addition of lime respectively. From the graphs, it was observed that the treatment of soil with 20% VPW has moderately improved the UCS values of expansive soil. It can be inferred from the graphs, that there is a gradual increase in UCS values with an increment in the % replacement of VPW up to 20% with an improvement of about 20.7 % further addition of lime to the optimum percentage there is a gradual increase in UCS values with % addition of 6% lime and the improvement is about 73.7%.

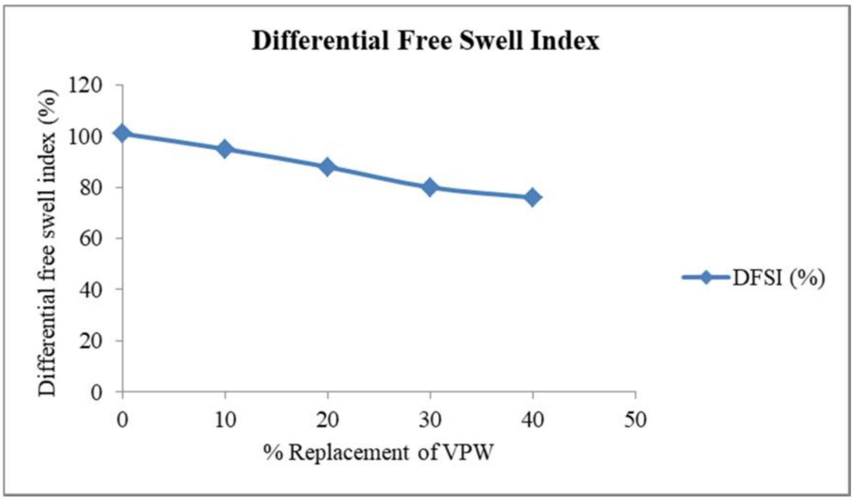

Fig. 1 Variation of DFS with % replacement of VPW

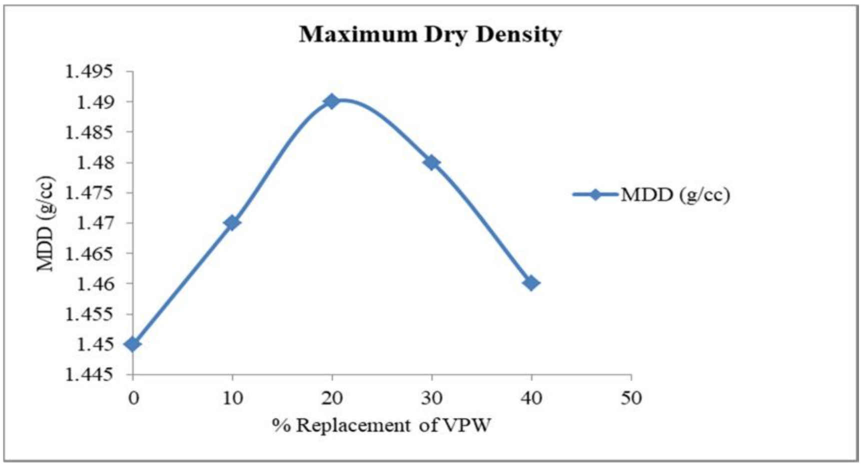

Fig. 2 Variation of MDD with % replacement of VPW

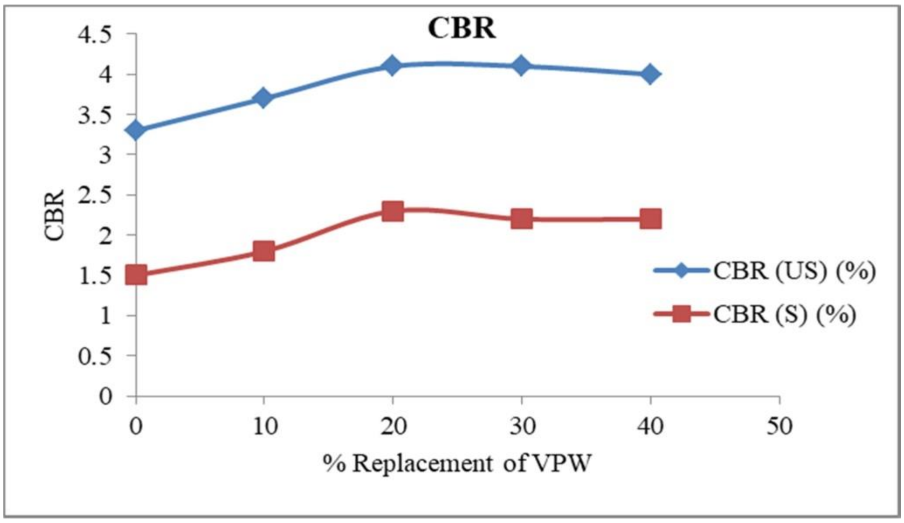

Fig. 3 Variation of CBR with % replacement of VPW

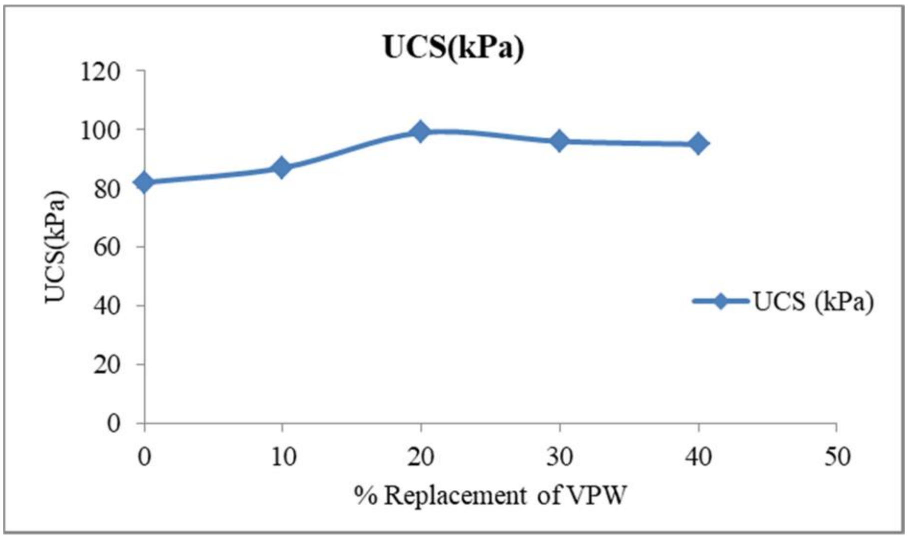

Fig. 4 Variation of UCS with % replacement of VPW

It can be inferred from the graphs, that there is a gradual increase in soil properties with percentage replacement of VPW. From the above results the 20% replacement of Expansive clay with VPW can be considered as optimum. Further evaluated the opti- mum content of lime content with 20% VPW as replacement. From the experimental results the following graphs are drawn.

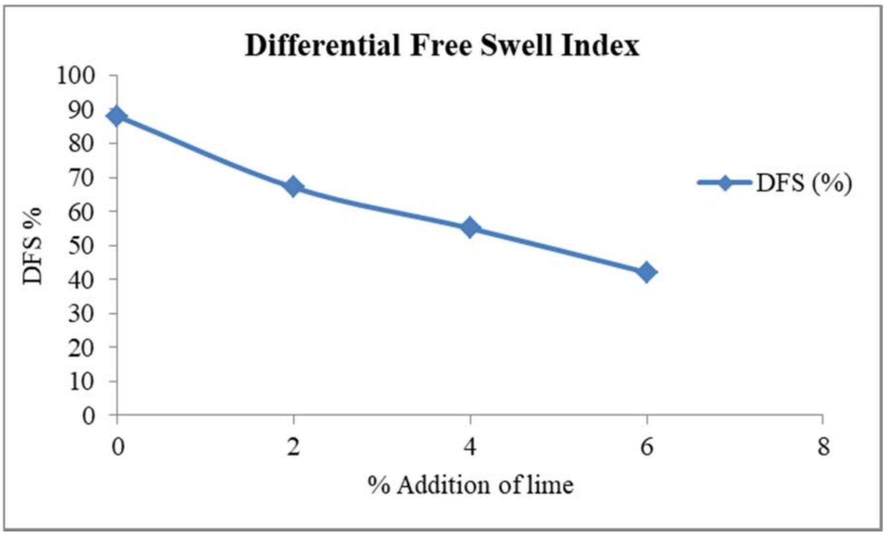

Fig.5 Variation of DFS with % addition of lime at 20% VPW as replacement

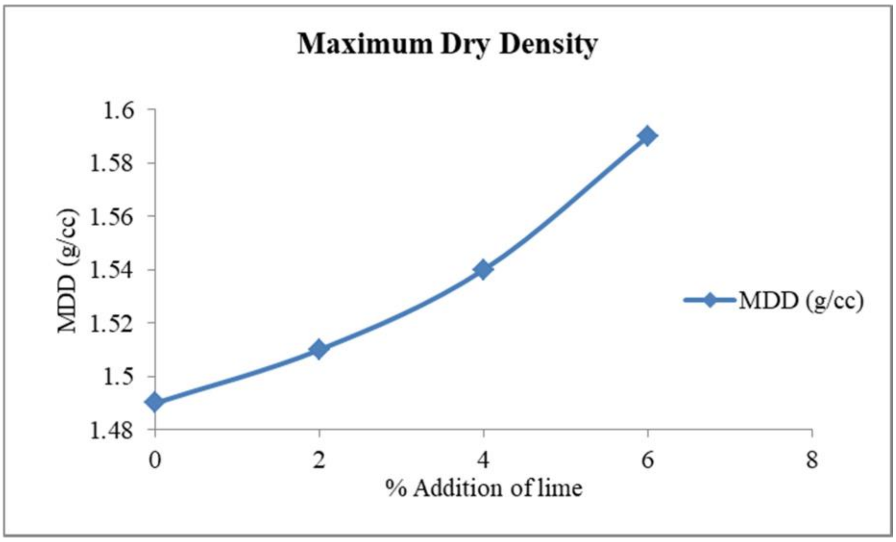

Fig.6 Variation of MDD with % addition of lime at 20% VPW as replacement

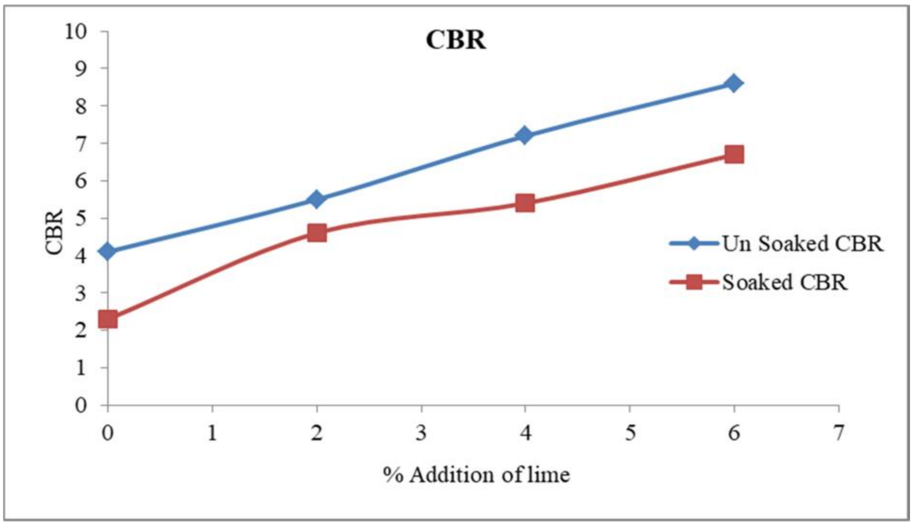

Fig.7 Variation of CBR with % addition of lime at 20% VPW as replacement

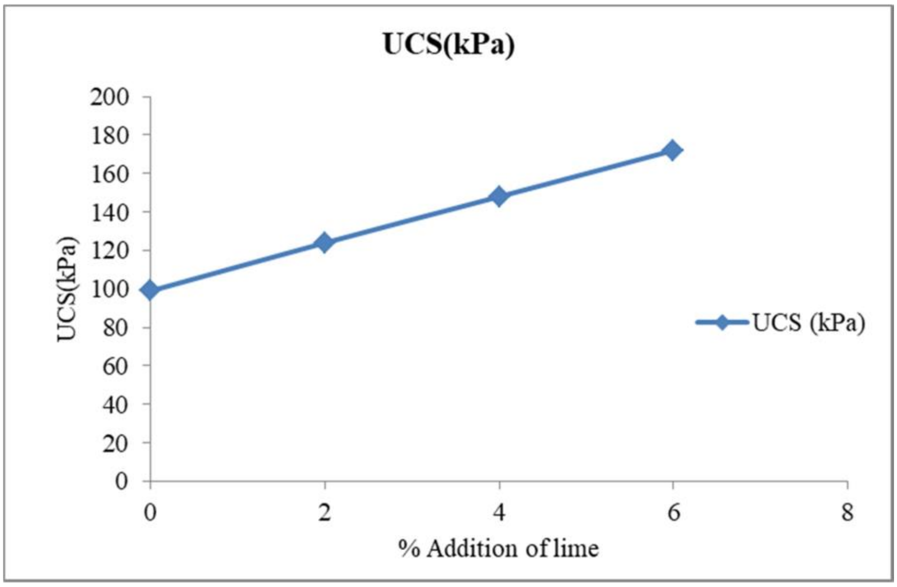

Fig.8 Variation of UCS with % addition of lime at 20% VPW as replacement

It can be inferred from the graphs, that there is a gradual increase in soil properties with percentage replacement of VPW and percentage addition of lime. From the above results the optimum content of lime with 20% VPW as replacement of expansive soil is 6%.The addition of lime showed a constant increase in the soil properties and the trend also showed the same and hence the percentage lime was limited to 6% keeping in view of economic criteria and further waste plastics were used to enhance the strength of expansive soil to achieve a sustainable solution.

Further different waste plastic inclusions were added to the VPW treated expansive soil with an optimum percentage of lime i.e. 6% and the studies were done.

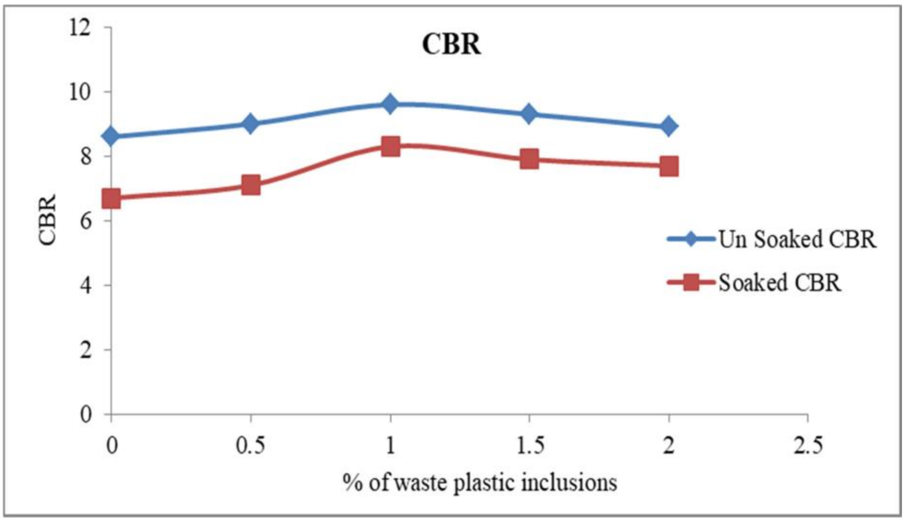

Fig.9 Variation of CBR with % of different waste plastic inclusions at 20% VPW as replacement and 6% addition of lime

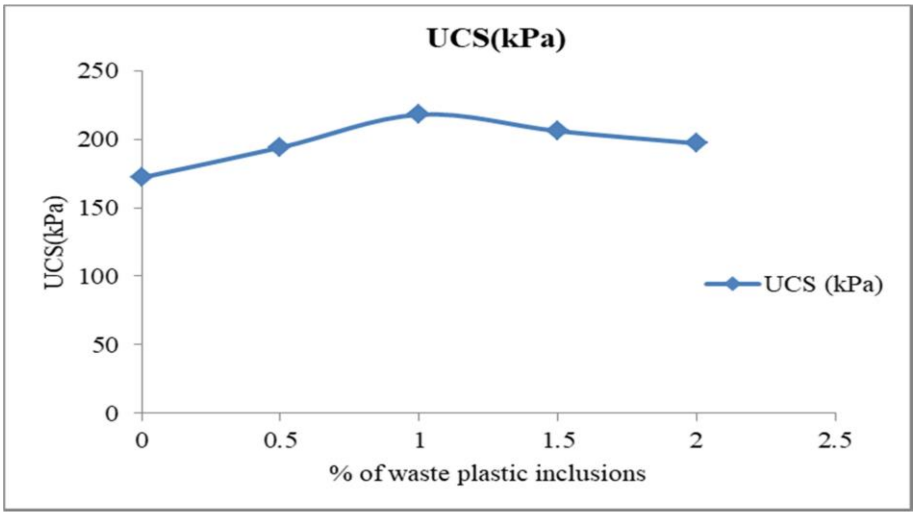

Fig.10 Variation of UCS with % of different waste plastic inclusions at 20% VPW as replacement and 6% addition of lime

Finally from the above discussions and from the above results the optimum content of waste plastic inclusions with 6% Lime + 20% VPW as replacement of expansive clay is 1.0%. It is evident that the addition of VPW to the virgin expansive soil showed an improvement in compaction and strength characteristics to some extent and on further addition of lime shows prominent results and further blending it with discrete waste plastic inclusions, the improvement was more pronounced. The en- hancement in the strength characteristics is due to the formation of CSH gel due to the chemical reactions between lime and pozzolanic material in VPW and further the waste plastic inclusions added inter particular discrete reinforcement and hence the further enhancement in the strength.

3.CONCLUSIONS

The following conclusions are made based on the laboratory experiments carried out in this investigation.

- It is observed that the expansive soil chosen was a problematic soil having high swelling, and high plasticity characteristics. It was observed that the treatment as individually with 20% VPW has moderately improved the expansive soil.
- There is a gradual increase in maximum dry density with an increment in the % replacement of VPW up to 40% with an improvement of about 10% and it is observed that for the replacement of 20% there is gradual increase in maximum dry density about 2.75%.
- There is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the lime content from 0% to 6% with an increment of 2%.There is an improvement of 191.5% In CBR and 73.7% in UCS values.
- Further blending with different waste plastics with 0% to 2% with an increment of 0.5% there is increment of CBR and UCS values is about 23% and 26.7% respectively.
- It is evident that the addition of VPW to the virgin expansive soil showed an improvement in compaction, strength and penetration characteristics to some extent and on further blending it with lime and waste plastic inclusions the strength mobilization was more pronounced thereby giving an advantages of resolving the problem of disposal of waste and also improving the strength properties of problematic expansive soil.

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