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Improvement in CBR value of Black Cotton Soil by Stabilizing it with Vitrified Polish Waste

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ABSTRACT: Today the world is facing a major problem in scarcity of materials for infrastructure development. On the other hand disposal of waste materials generated in the development process is also a main concern. In this context, usage of locally available natural materials for infrastructure development by stabilizing them with these waste materials is suggested. Vitrified Polish Waste (VPW) is one among those waste materials which is generated during the manufacturing of ceramic tiles, which is growing at a rapid phase in the present world. The authors have chosen a stretch of 7km (i.e., Km 6 to Km 13) of Samalkot-Uppada road which is a Major District Road (MDR) in East Godavari District, Andhra Pradesh. Heavy traffic load is coming on to this road and it is growing day by day due to development in and around this area. The authors found that this area constitutes black cotton soil which is having low sub grade strength. Therefore, there is a need for soil stabilization at this place. In order to stabilize this existing soil, Vitrified Polish Waste (VPW) is used as an admixture. In this study, experimental observations were carried out on addition of VPW in different proportions with locally available soil and its influence on strength characteristics of the soil obtained. Strength characteristics of locally available soil, VPW and combination of these both were determined by using California Bearing Ratio (CBR) test.

KEYWORDS: Black cotton soil, Vitrified Polished Waste, MDD, OMC, CBR

I. INTRODUCTION

Today the world is developing at a faster pace. To achieve these developments every country requires good infrastructure. Roads play a prominent role as they connect door to door. The construction and maintenance of these roads is becoming more difficult due to increasing traffic day by day. In order to have a good road which can accommodate this traffic we require good quality construction materials. But the world is facing a scarcity of quality construction materials as they are depleting rapidly. Governments are also imposing taxes and many clearances are necessary for using these materials. On the other hand there are many waste products generated from industries and disposal of these waste materials is becoming difficult as they are being produced in huge quantity. Companies are wasting a lot of money in order to dispose these waste materials, as common mode of disposal is land fill, releasing into nearby water bodies. To overcome these problems many researchers and organizations are experimenting to utilize these waste materials. Since utilization of these waste materials generate revenue, thus achieving a significant reduction in construction cost.

Vitrified Polish Waste (VPW) is one among those waste materials which is generated during the manufacturing of vitrified tiles, which is growing at a rapid phase in the present world. Author have chosen a stretch of 7km (i.e., Km 6 to Km 13) of Samalkot-Uppada road which is a Major District Road (MDR) in East Godavari District, Andhra Pradesh. Heavy traffic load is coming on to this road and it is growing day by day due to development in and around this area. I found that this area constitutes black cotton soil which is having a low sub grade strength. In site soil replacement technique is being used to address this issue. Therefore, there is a need for soil stabilization at this place. In order to stabilize this existing soil Vitrified Polish Waste (VPW) is used as an admixture. In this study, experimental observations were carried out on addition of VPW in different proportions with locally available soil and its influence

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on strength characteristics of the soil obtained. Strength characteristics of locally available soil, VPW and combination of these both were determined by using California Bearing Ratio (CBR) test.

Objectives of the study are as follows:

- i. Design of flexible pavement for next five years.
- ii. To find properties of soil
- iii. To find properties of VPW
- iv. To evaluate performance of the black cotton soil when treated with Vitrified Polish Waste

II. PAVEMENT DESIGN

Traffic Volume data

Traffic Volume data of 2012 at 12/0 km.

Source: R&B department data.

- No of commercial vehicles/day are 8,800.
- No of non-commercial vehicles/day are 14,044.
- Iron tire vehicles/day is 206.
- Bullock carts/day is 162.
- Total traffic volume in PCU/day is 50,200.
- Total traffic intensity factor in tones are 1,14,076.

Computation of Design traffic

Design of flexible pavement is done according to the IRC: 37-2012 by using the above data . The cumulative number of standard axles to be catered for design (N) was found to be 50msa for a design period of five years. The traffic at the end of year of completion is estimated to be 9680.

According to IRC: 37-2001, CBR Value of 2% and design traffic of 50msa, the total pavement thickness to be provided will be 925mm as shown in Table 1.

Table 1. Pavement design catalogue Plate 2 - Recommended design for traffic range 10 - 150 msa

CBR 2%				
Cumulative Traffic (msa)	Total Pavement Thickness (mm)	PAVEMENT COMPOSITION		
		Bituminous Surfacing		Granular Base & Sub-base (mm)
		BC (mm)	DBM (mm)	
10	850	40	100	Base = 250
20	880	40	130	
30	900	40	150	
50	925	40	175	
100	955	50	195	Sub-base = 460
150	975	50	215	

III. MATERIALS

A. Black cotton soil

The soil used in this study was obtained from Samalkot - Uppada road at Km 8/2 collected from a depth of 0.5m below the ground surface.

B. Vitrified Polish Waste (VPW)

Vitrified Polish Waste (VPW) is collected from Rak Ceramics India Pvt. Ltd, Samalkot, East Godavari District, Andhra Pradesh, India. VPW is a powdered waste which is generated during the manufacturing of vitrified

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polished tiles. This is gaining momentum over the manmade tiles and other natural materials as they are being superior to these materials.

IV. LABORATORY TESTING

1. The properties of the Black Cotton Soil, VPW and the chemical composition of the VPW were presented in Table 2, Table 3, Table 4 respectively. The index and engineering properties of the soil are determined as per IS code of practise.

Table 2. Properties of the Soil

S.No	Property	Properties
1.	Grain size distribution	
	Gravel (%)	0
	Sand (%)	32
	Silt & Clay (%)	68
2.	Atterberg limits	
	Liquid limit (%)	39.9
	Plastic limit (%)	15.56
	Plasticity index (%)	24.34
3.	Compaction properties	
	Optimum Moisture Content (O.M.C) (%)	17.13
	Maximum Dry Density (M.D.D) (g/cc)	1.7
4.	Specific Gravity (G)	2.71
5.	IS Classification	CI
6.	Soaked C.B.R (%)	2.1
	Unsoaked C.B.R (%)	2.88
7.	Differential free swell (%)	55.56
9	Cohesion (C) (Kg/cm ²)	0.9
10	Angle of internal friction (ø)	2°

Table 3. Properties of VPW

S. No.	Property	Value
1	Specific Gravity	2.465
2	Grain Size Distribution	
	Coarse sand (%)	2
	Medium sand (%)	4
	Fine sand (%)	92
	Silt & Clay (%)	2
3	Composition Properties	
	Maximum Dry Density (g/cc)	1.32
	Optimum Moisture Content (%)	21.23

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S. No.	Property	Value
4	Atterberg Limits	
	Liquid limit (%)	NP
	Plastic limit (%)	NP
	Plasticity Index (%)	NP
5	Cohesion (C) (Kg/cm ²)	1.25
6	Angle of internal friction (ϕ)	26°
7	Differential free swell (%)	140
8	Soaked C.B.R (%)	7.29
	Unsoaked C.B.R (%)	36.09

Table 4. Chemical composition of VPW

S. No.	Constituent elements	Percentage content (%)
1	Silica as SiO ₂	49.52
2	Alumina as Al ₂ O ₃	14.70
3	Calcium as CaO	1.40
4	Iron as Fe ₂ O ₃	0.40
5	Magnesium as MgO	2.45
6	Sodium as Na ₂ O	2.71
7	Potassium as K ₂ O	2.69
8	Phosphorus as P ₂ O ₅	0.05
9	Loss on ignition	26.08

[Courtesy: Rak Ceramics, Samalkot, Andhra Pradesh]

Soil strength can be increased with 1.4% and 49.52% of CaO and SiO₂ respectively which are present in VPW. In this regard Authors have tested with different proportions of VPW to the soil and observed its influence on strength characteristics of soil. Based on Liquid limit, Plasticity index, Compaction and CBR values. Strength of Soil, VPW and different mix proportions were assessed.

Table 5. Comparison of Index properties of the mix proportions

% Mix	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)
100% Soil	39.9	15.56	24.34
95% Soil + 5% VPW	34	17.84	16.16
90% Soil + 10% VPW	33	19.07	13.93

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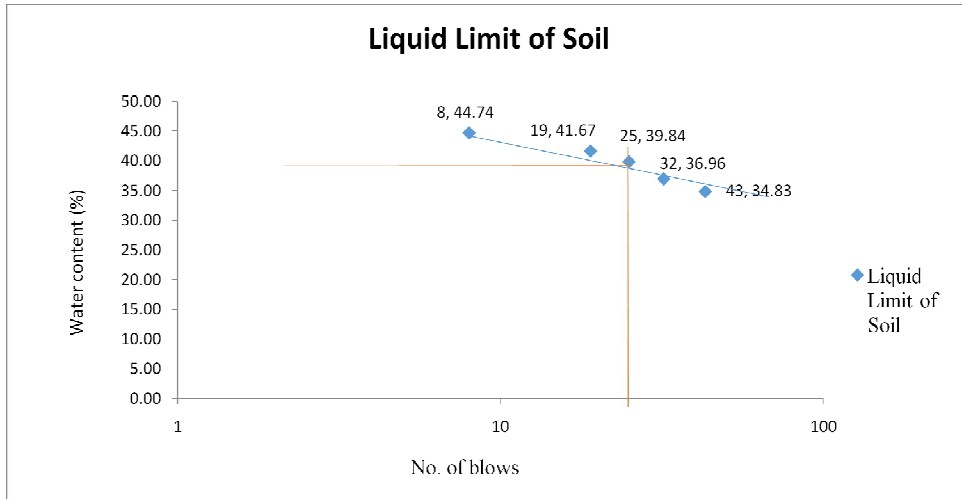


Fig.1 Liquid limit of Soil

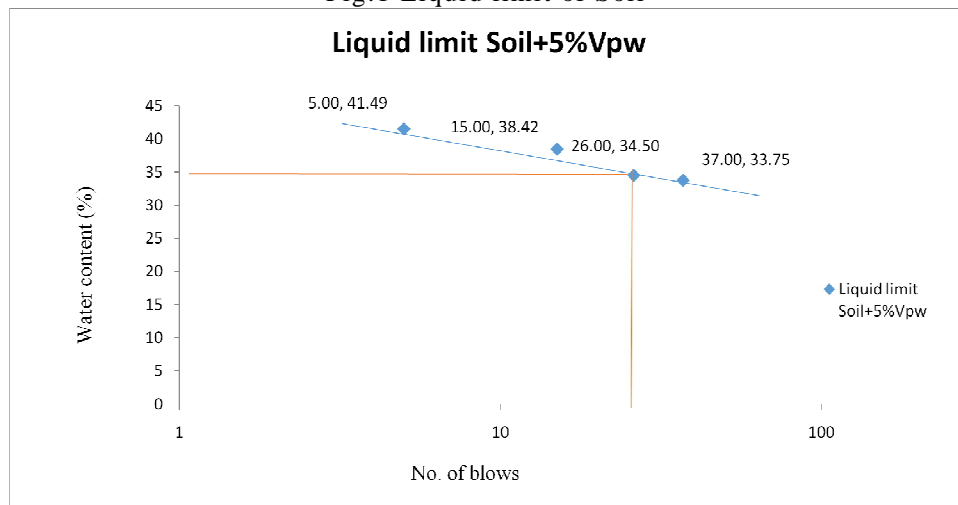


Fig. 2 Liquid limit of Soil+5% VPW

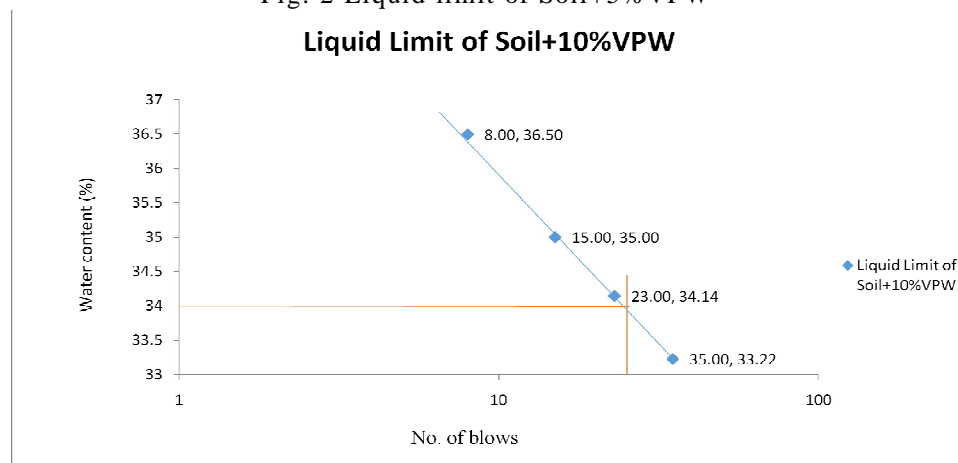


Fig. 3 Liquid limit of the Soil+10% VPW

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Table 6. Comparison of MDD and OMC of Soil, VPW and mix proportions

% Mix	MDD (g/cc)	OMC (%)
100% Soil	1.7	17.13
100% VPW	1.32	21.25
95% Soil + 5% VPW	1.90	11.95
90% Soil + 10% VPW	1.92	12.8

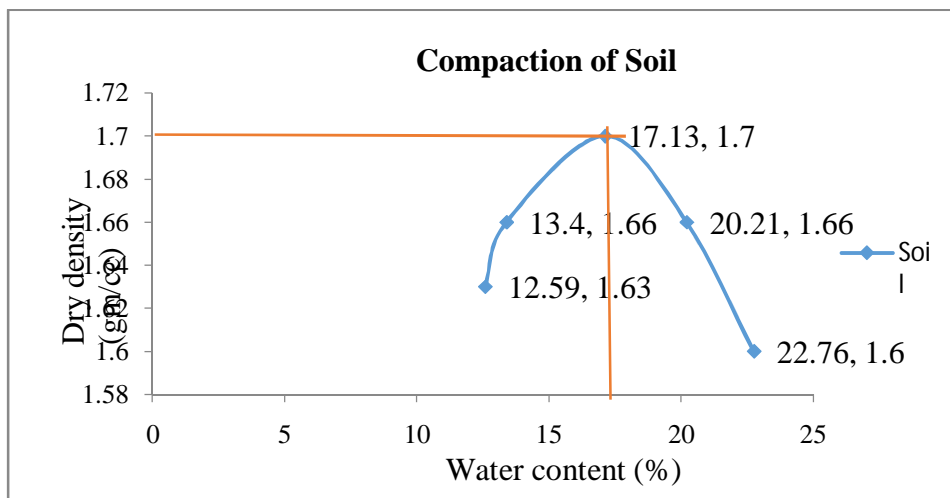


Fig. 4 Compaction of the Soil

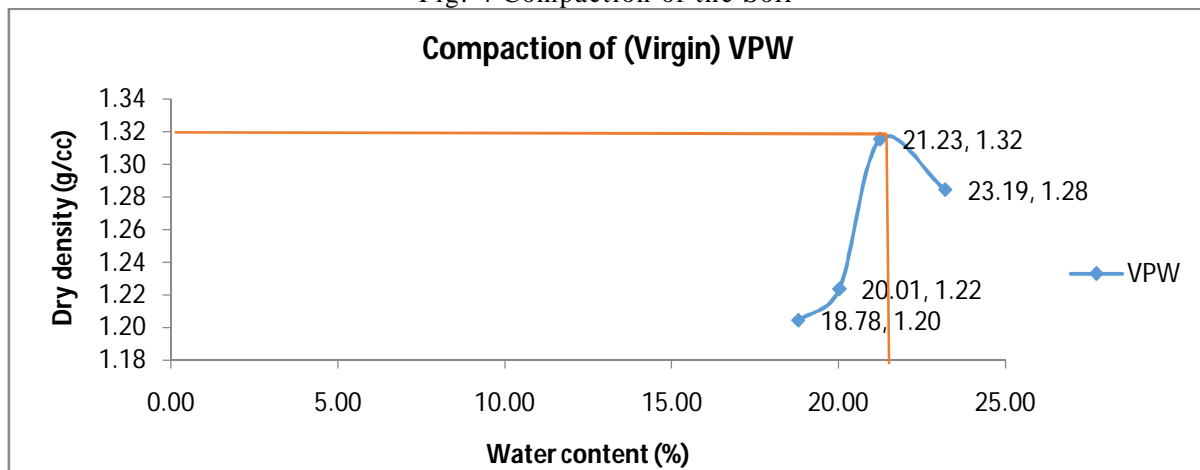


Fig. 5 Compaction of VPW

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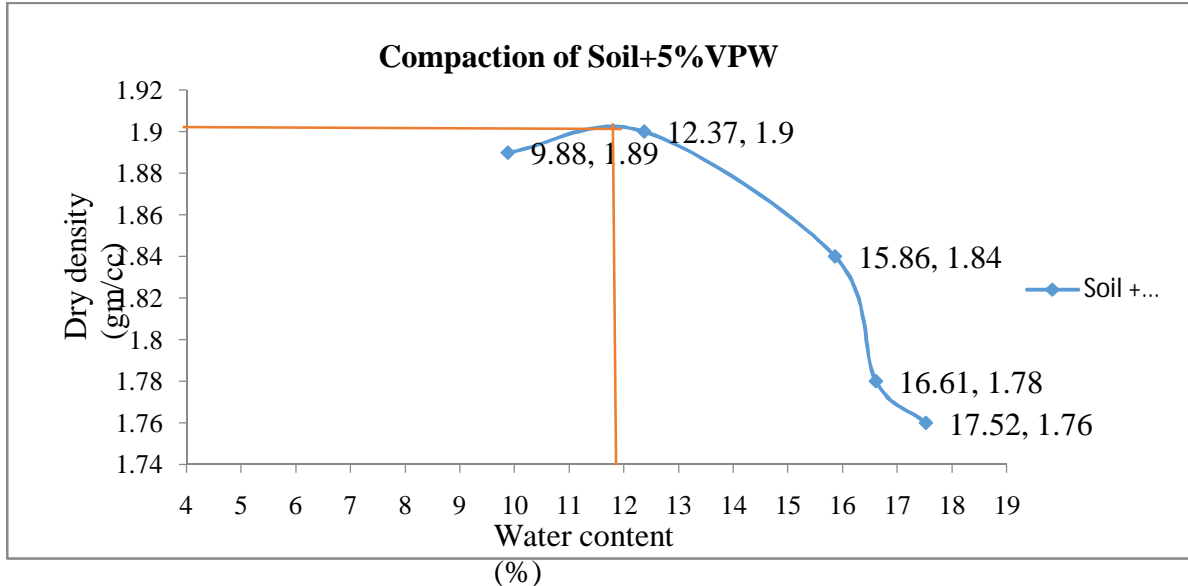


Fig. 6 Compaction of Soil+5%VPW

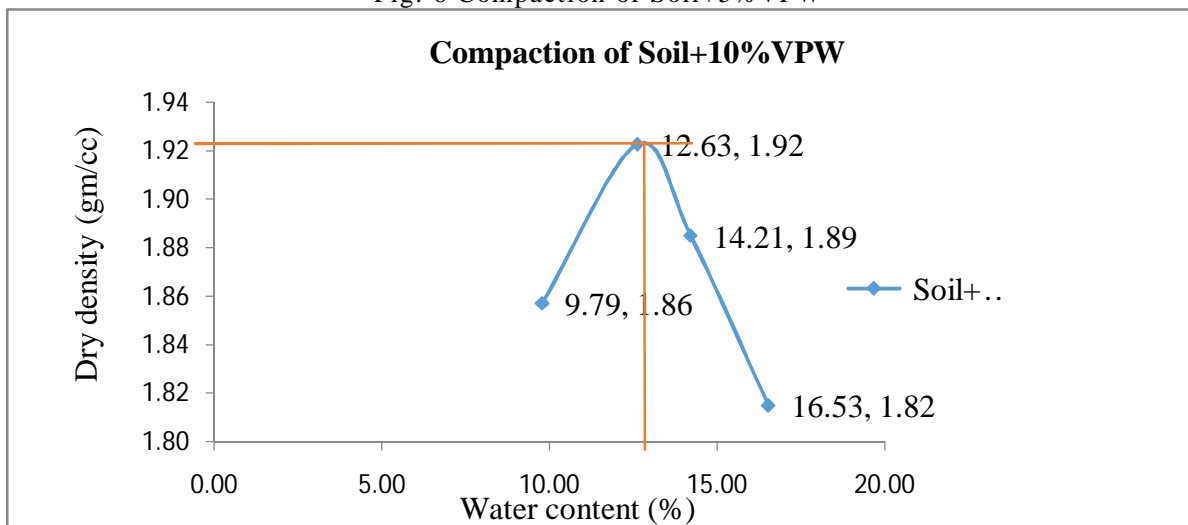


Fig.7 Compaction of Soil+10%VPW

Table 7. Comparison of the CBR values

% Mix	Soaked C.B.R (%)	Unsoaked C.B.R (%)
100% Soil	2.1	2.88
95% Soil + 5% VPW	5.49	6.82
90% Soil + 10% VPW	7.07	16.69

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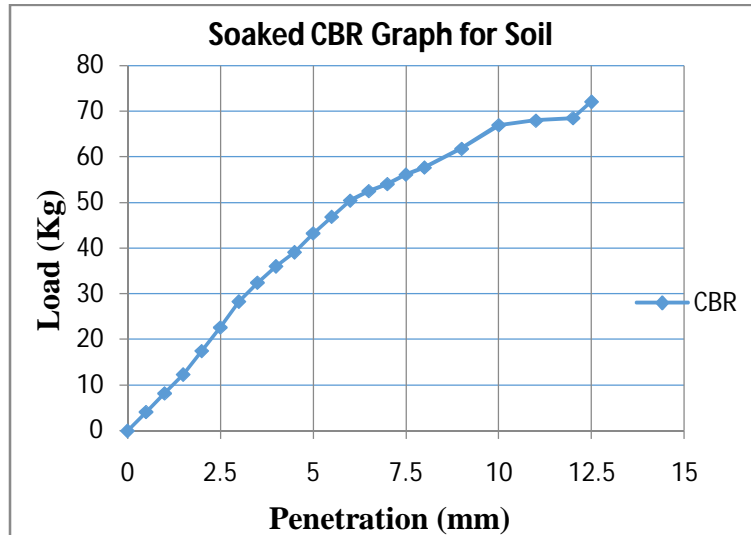


Fig. 8 Soaked CBR for Soil

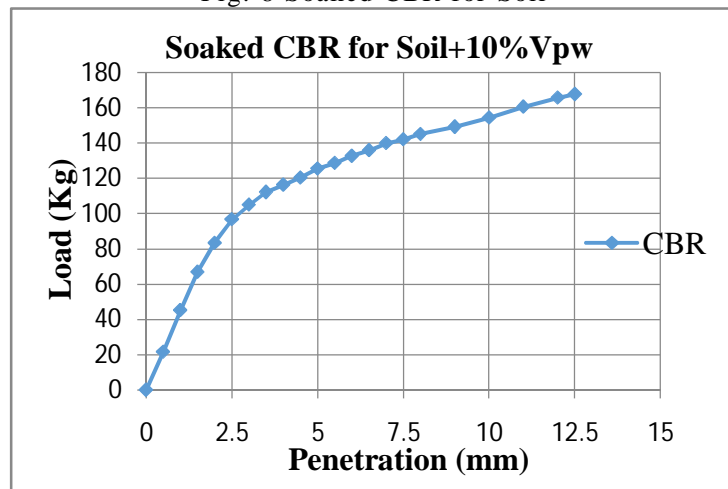


Fig. 9 Soaked CBR for Soil+10%VPW

Table 8. Properties of Soil untreated and treated with VPW

S.No	Descriptions	Untreated Black cotton Soil	Treated Black cotton Soil with 10% VPW
1.	Atterberg limits		
	Liquid limit (%)	39.9	34
	Plastic limit (%)	15.56	19.07
	Plasticity index (%)	24.34	13.93
2.	Compaction properties		
	O.M.C (%)	17.13	12.8
	MDD(gm./cc)	1.69	1.92
3.	Soaked C.B.R (%)	2.01	7.07
	Unsoaked C.B.R	2.88	16.69
4.	Differential free swell (%)	55.56	40
5.	Soil classification	CI	CL

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V. SUMMARY AND CONCLUSIONS

1. The design load coming on to the road in next five years is 50msa.
2. At 10% mix proportion of soil and VPW, Plastic limit of the soil was increased by 22.56%. The increase in plastic limit is due to reduction in diffused double layer of clay which results in flocculation of the soil particles.
3. Therefore at 10% mix proportion of soil and VPW, Liquid limit and Plasticity index of the soil obtained are decreased by 17.29% and 42.77%.
4. Decrease in Plasticity Index is desirable as it increases workability.
5. Maximum Dry density increased by 13.61% when 10% VPW added to the soil.
6. Differential free swell index of the soil decreased by 27.93% when 10% VPW added to the soil.
7. Soil classification changes from the CI to CL.
8. CBR value increases from 2.1% to 7.07%, according to IRC: 37-2012 the minimum CBR value required for the subgrade of the soil is 8% hence it must be tested with different proportions to find the optimum percentage of VPW that should be added to soil.
9. Soaked and Unsoaked CBR values increased 3 to 4 times when 10% of VPW added to the soil compared to virgin soil.
10. For CBR value of 7.07% the pavement thickness provided must be 620mm as per IRC: 37-2012.
11. Therefore a significant reduction in thickness of pavement about 305mm is achieved by stabilizing the soil with VPW as an admixture at 10%.

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