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Soil Stability Investigation with Treated Waste PVC Wrappers

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Abstract - *In this study, examine the possible capability of stabilizing soil utilizing treated waste PVC wrappers for sub-grade soil stabilization. The pieces of waste polyvinyl chloride (PVC) wrappers size in between 10mm to 15mm length and 5mm to 10mm width wrappers was taken which is treated with chemical potassium chloride (KOH) for dispersibility check. MDD, OMC, UCS and CBR Values were computed using waste PVC wrappers percentages of 0.25%, 0.50%, 0.75%, 1%, and 1.25% in this experiment. When the amount of waste PVC wrappers increases from 0.25% to 1% the soil of high compressibility (CH) converts to soil of low compressibility (CL). The MDD value has also been raised from 1.92 Kg/cm² to 2.06 Kg/cm², equating to 1% waste PVC wrappers. When the percentage of waste PVC wrappers is increased, the strength values rise, then fall at 1.25%. However, due to the low density of waste PVC wrappers, the percentage of increase is minimal. The unconfined compressive strength increases from 3.14N/mm² soil sample to 7.31N/mm² for soil sample treated with 0.1% waste PVC wrappers. In addition, the value of Soaked CBR rises from 2.32 to 5.25, equating to 1% waste PVC wrappers. And the value of un-soaked CBR improves from 4.41 to 6.83 when 1% waste PVC wrappers is added, indicating that we can reduce the thickness of pavement for pavement design, lowering the cost of construction in any structure, and therefore increasing the slope of pavement for slope stability. The use of waste PVC wrappers as a stabilizer solves the problem of disposing of waste synthetic polymers while also increasing the density and proportion of CBR soils in a cost-effective manner.*

Keywords: **Soil stabilization, waste PVC wrappers, MDD&OMC, UCS test, CBR test, Potassium Chloride, non-biodegrable, Economical**

1. INTRODUCTION

In today's world, everyone's main concern is the expanding population. Land for building of any facility is becoming increasingly scarce. Building any construction that meets the requirements for residential and commercial purposes is quite difficult for a civil engineer. As a result, we civil engineers work to improve the soil's strength so that it can support a large and heavy construction. Enhancing soil will become increasingly significant and necessary in the future for the construction of any structure, including bridges, commercial buildings, and residential buildings, but due to a shortage of good quality soil, India's economic progress is slowing. As a result, soil stabilization is required. The use of soil stabilization to upgrade sub-grade soil to reinforced soil can be quite beneficial. Soil stabilization can be accomplished using one of three methods: mechanical, chemical, or polymer. One of the novel techniques utilized in the field of soil stabilization is soil reinforcement with polymer wrappers. Due to the non-biodegradable nature of synthetic polymer and the production of toxic gases, the surge in manufacturing of waste synthetic polymer materials is producing huge health and environmental problems. The one of the most effective engineering implementations for soil reinforcement is waste polymer wrappers. We improve the characteristics and other qualities of soil to improve its quality. In this inquiry, waste PVC wrappers are mostly utilized to keep food items such as chips, biscuits, chocolate, and food containers wrappers fresh for longer periods of time. And with more advancements in the field of food packaging, this type of food factory or industry is increasing. The number of food wrappers is rapidly increasing. PVC plastic wrapping are also becoming more popular. Plastic recycling is both costly and time-consuming. Plastic incineration emits hazardous gases that trap heat and contribute to global warming. The use of landfills to dispose of plastic has a negative impact on environment.

2. MATERIAL AND METHODS

2.1 Soil

The natural soil from the BIT Sindri Campus is subsequently transported to the BIT Sindri, civil engineering department's soil laboratory. Wet dirt was scattered over the floor for 3 to 4 days to dry naturally, after which it was hammered into small pieces that passed a 4.75mm sieve size and could be utilized in experiments.

2.2 Waste PVC wrappers

The waste PVC wrappers like chips, chocolate, biscuit wrappers is collected from the food factory in Ranchi, Jharkhand. These wrappers are most commonly used for food packaging.

2.3 Test Procedure

1. Treatment of waste PVC wrappers with (Potassium Chloride)KOH

2. Preparation of Test specimen

a) MDD & OMC Test

b) UCS test

c) CBR test

2.3.1 Treatment of waste PVC wrappers

PVC wrappers do not absorbed any moisture content, these wrappers are also not dispersed in alcohol, vegetable oil, water and glycerin that's why I am using chemical Potassium Chloride (KOH) for proper dispersed.

Some work has to be done on the wrapper treatment:-

1) Create a solution of 2%, 3% and 5% Sodium Hydroxide and Potassium Hydroxide in six different beaker.
2) Add PVC wrappers in the solution and observed which one give proper dispersion on 48 hours.
3) After 48 hours observed that PVC wrappers proper dispersed with the solution of 2% KOH.
4) 2% of KOH used in further experiment.
5) Weight the PVC wrappers and is fully dispersed for 48 hours.
6) Remove the PVC wrappers from the solution and rinse them with distilled water.
7) At room temperature, natural dried for 48 hours.
8) Weigh the wrappers again to check that there has been no weight gain and that the wrappers have been spread and are ready to be used as soil reinforcement.

Table 1: Preparation of test specimen for MDD, OMC & CBR test

Sl. no.	Percentage of soil (by weight)	Percentage of PVC wrappers (by weight)
1.	100%	0.25%
2.	99.98%	0.50%
3.	99.96%	0.75%
4.	99.85%	1%
5.	98.99%	1.25%

3. Test Methodology

Experiments were carried out to determine the soil's various qualities, as shown in Table 2. The influence of different percentages and specific dimensions of waste PVC wrappers on compaction and strength characteristics as well as soil strength parameter was investigated using standard proctor tests (SPT), wet and un-soaked CBR tests.

SL No.	Laboratory Test	Results
1.	Specific gravity	2.41
2.	%finer	4.41%
3.	Liquid limit	31.1
4.	Plastic limit	15.8
5.	Plasticity Index	15.3
6.	Maximum Dry Density	1.91g/cc
7.	Optimum moisture content	11.62
8.	Unconfined Compressive Strength	3.42 kg/cm2
9.	Soaked CBR value	2.32%
10.	Un-soaked CBR value	4.41%

Table 2: Properties of soil used in this experiment

Fig 1 waste wrappers

Fig 2 Treated waste PVC wrappers

PVC wrappers (Figure 2) were used in this study and properties are listed in table 2. The wrappers were mixed manually with soils to ensure homogeneous mixture of soil and wrappers.

Table 3: specification of PVC wrappers

PROPERTIES	VALUE
Melting point	100-260 degree Celsius
Tensile strength	Rigid PVC: 34-62 MPa Flexible PVC: 6.9-25MPa
Heat deflection temp.	92 degree Celsius
Specific gravity	1.35-1.45
KOH effect	Excellent
Dispersibility	good

To determine the result of wrappers concentration on the properties of wrappers reinforced soil, a number of tests were carried out. At wrappers concentrations of 0%, 0.25%, 0.5%, 0.75%, 1%, and 1.25%, tests were done to examine compaction characteristics, penetration resistance through the California bearing ratio (CBR) test. A second MDD set of tests was carried out to investigate the effect of wrappers length on the above-mentioned soil attributes at optimum wrappers concentration.

4. Results and Discussion

4.1 Proctor test data

Table shows the Variation of maximum dry density with the variation of waste PVC wrapper

Table 4.1: Values of OMC & MDD Test results

SL No.	Soil (%)	PVC wrappers (%)	MDD (g/cc)	OMC (%)
1.	100%	0	1.91	11.62
2.	99.98%	0.25	1.92	11.29
3.	99.89%	0.50	1.96	12.26
4.	99.76%	0.75	1.99	12.75
5.	99.54%	1.00	2.04	13.15
6.	98.12%	1.25	1.97	13.84

The influence of wrappers content on the compaction parameters of wrappers reinforced soil is shown in Table 2. As the fraction of wrappers content increases, the MDD decreases, while the moisture content increases. The maximum dry density reduced to 2.04 g/cc with the addition of wrappers in the 0 to 1% range, and the optimum moisture content increased from 11.62% to 13.84%. The inclusion of wrappers, which reduces the unit weight of the soil and generates more pore space, could explain the decrease in maximum dry density. The creation of extra pore spaces and the availability of increased specific surface area in wrappers.

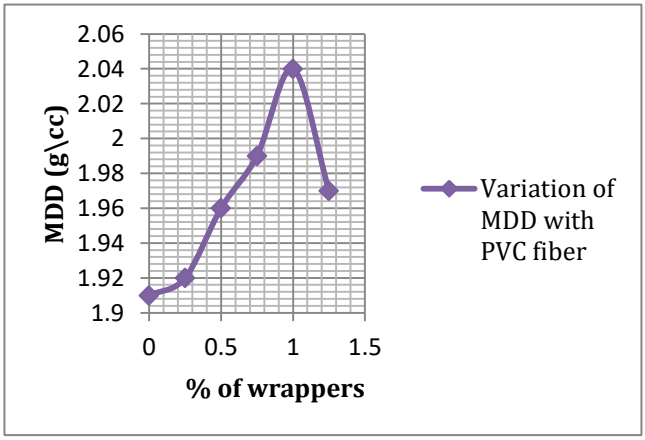


Fig 4.1: MDD with various % of waste PVC wrappers

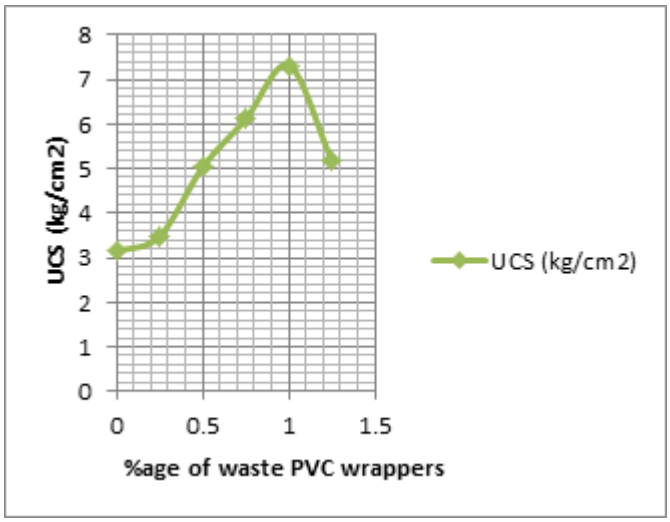
The water content-density relationship shows that increasing the wrappers content up to 1% by dry weight of soil has a significant effect on the magnitude of maximum dry density and optimum moisture content. With waste PVC wrappers, the difference in maximum dry density and optimal moisture content is depicted in the accompanying image. As seen in the graph above, the maximum dry density of soil increases up to 1% with an increase in polyvinyl chloride wrappers and there after declines, but the increase in MDD is not much bigger due to the low density of waste PVC wrappers.

4.2 Unconfined Compressive Strength Test Data

Values of UCS of the soil sample mixed with different percentages of treated waste PVC wrappers and its variation with natural soil have been tabulated below

Table 4.2: Values of UCS Test results

S.N.	Soil (%)	PVC wrappers (%)	UCS (kg/cm2)
1.	100	0	3.14
2.	99.85	0.25	3.48
3.	99.65	0.50	5.03
4.	99.40	0.75	6.11
5.	99.24	1.00	7.31
6.	98.09	1.25	5.17



The variation in the values of Unconfined Compressive Strength of the soil sample and soil samples which are treated with 0.25% 0.5%, 0.75%, 1%, and 1.5% waste PVC wrappers. The unconfined compressive strength increases from 3.14N/mm2 soil sample to 7.31N/mm2 for soil sample treated with 0.1% waste PVC wrappers. The strength of the sample then decreases with the further addition of wrappers. The maximum value in strength is achieved corresponding to optimum wrapper content, i.e., 1% wrapper content. With the addition of wrappers to the sample of soil, there is an increase in the cohesion of soil, which leads to an increase in the unconfined compressive strength of the soil. However, increasing the content of the wrappers causes a decrease in cohesion and, as a result, a decrease in strength. Also, the shear strength of the soil, which is directly related to the cohesion, shows a similar pattern such that a maximum value is obtained at 1% waste PVC wrapper replacement and then it decreases.

4.3 California bearing ratio (CBR) Test

a) Un-soaked CBR

The CBR values of soil samples combined with various percentages of treated waste PVC wrappers in an un-soaked state, as well as their fluctuation with natural soil, are shown in the table below.

Table 4.3: Value of Un-Soaked CBR Test results

SL No.	Soil (%)	PVC wrappers (%)	Soaked CBR (%)
1.	100	0	2.32
2.	99.85	0.25	3.72
3.	99.65	0.5	4.24
4.	99.40	0.75	4.98
5.	99.24	1	5.25
6.	98.09	1.25	4.85

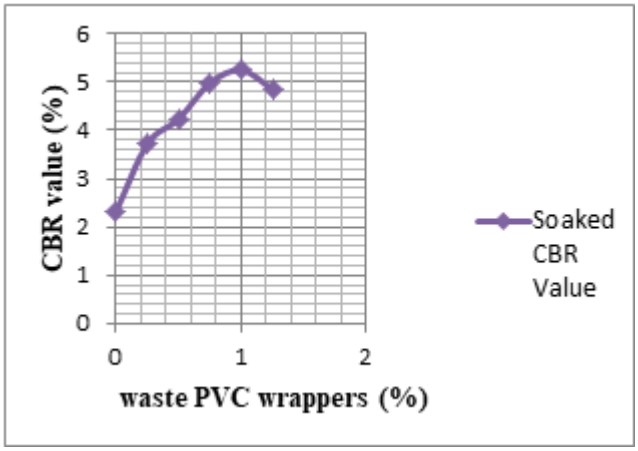


Fig 6: un-soaked CBR value with various % waste PVC wrappers

b) Soaked CBR

The CBR values of soil samples combined with various percentages of PVC wrappers in a soaked state, as well as their fluctuation with natural soil, are shown in the table below.

Table 4.4: Value of soaked CBR Test results

Sl. No.	Soil (%)	PVC wrappers (%)	Un-soaked CBR (%)
1.	100	0	4.41
2.	99.85	0.25	5.08
3.	99.65	0.5	5.47
4.	99.40	0.75	6.21
5.	99.24	1	6.83
6.	98.09	1.25	5.79

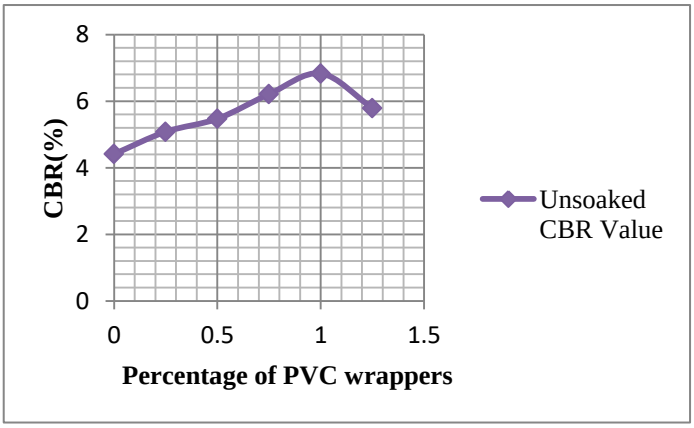


Fig 8: soaked CBR value with various % waste PVC wrappers

4.4 Comparison between Soaked and Un-soaked condition CBR value

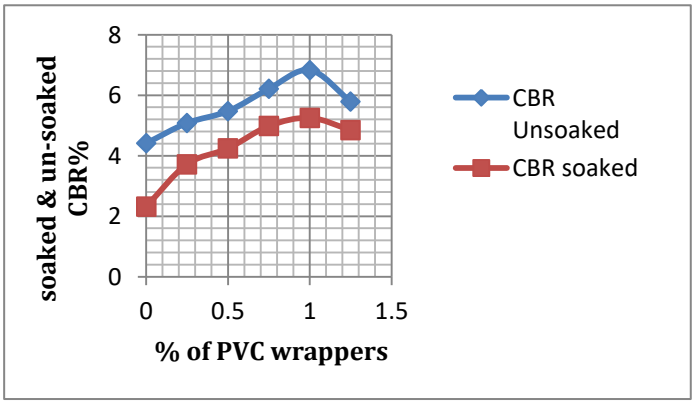


Fig 9: comparison of soaked and un-soaked CBR value with various PVC %

The value of Soaked and Un-soaked CBR increases upto 1% addition of waste PVC wrappers and after further addition it starts decreasing. Waste PVC wrappers can be used for stabilization of sub-grade soil

5. CONCLUSIONS

1. According to the sieve analysis results, 4.02% of soil particles are finer than 75 micron sieve, and 95.98% of particles are retained on the 75 micron sieve. As a result, the soil is well grained. The fraction of waste PVC wrappers in soil of high compressibility (CH) converted to soil of low compressibility (SL) increases from 0.25% to 1.25% (CL).
2. The Maximum Dry Density increased by 1%, from 1.91g/cc to 2.04g/cc, as the percentage of treated waste PVC wrappers increased. As the percentage of treated waste PVC wrappers increased, the MDD value decreased.
3. The rise in the soil's Maximum Dry Density is attributable to the reduction in voids caused by the inclusion of treated waste PVC wrappers, which results in effective compaction and increased cohesion.
4. The value of Soaked and Un-soaked CBR improves up to 1% addition of waste PVC wrappers, then starts to decrease beyond that. Sub-grade soil can be stabilized using waste PVC wrappers.
5. The advantage of using leftover PVC wrappers is that it is cost-effective because it is non-useful trash. It also solves the problem of waste wrapper disposal.

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