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# Experimental Investigation on Soil Stabilization using Waste Fiber Materials

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**ABSTRACT:** The main objective of this study is to investigate the use of waste fiber materials in geotechnicalapplicationsandtoevaluatetheeffectsof wastepolypropylenefibersonshearstrengthofunsaturatedsoil by carrying out direct shear tests and unconfined compression tests on two different soil samples. Theresults obtained are compared for the two samples and inferences are drawn towards the usability andeffectiveness of fiber reinforcement as a replacement for deep foundation or raft foundation, as a costeffectiveapproach.In this paper, a review is given on utilization of different solid waste materials which have been used to stabilize soft soils. Though, there are lots of methods and techniques are available to stabilize these soil.

## I. INTRODUCTION

For any land-based structure, the foundation is veryimportant and has to be strong to support the entirestructure. In order for the foundation to be strong,the soil around it plays a very critical role. So, towork with soils, we need to have proper knowledge about their properties and factors, which affect their behavior. The process of soilstabilizationhelps to achieve the required properties in a soil needed for the construction work. Fromthebeginning of constructionwork, thenecessity ofenhancingsoilpropertieshascometothelight.Ancient civilizations of the Chinese, Romans and Incasutilized various methods to improves oilstrength etc., someofthesemethodsweresoeffective that their buildings and roads still exist.InIndia, the modern era of soil stabilization began inearly 1970's, with a general Shortage of petroleumand aggregates, it becamenecessaryfortheengineers to look at means to improve soil otherthan replacing the poor soil at the building site. Soilstabilization was used but due to the use of obsoletemethodsandalsoduetotheabsenceofpropertechnique,soilstabilizationlostfavor.Inrecenttimes,with theincreaseinthe demandforinfrastructure,rawmaterialsandfuel,soilstabilization has started to take a new shape. Withtheavailabilityofbetterresearch,materialsandequipment, it is emerging as a popular and cost-effectivemethodforsoilimprovement.Here,inthis project, soil stabilization has been donewiththehelpofrandomlydistributedpolypropylenefibersobtainedfromwastematerials.Theimprovement in the shear strength parameters hasbeen stressed upon and comparative studies havebeen carried out using different methods of shearresistancemeasurement.

## II. EXPERIMENTALINVESTIGATION

### Scope ofWork

The experimental work consists of the followingstep

- Specificgravityofsoil
- Determination of soil index properties(Atterberg Limits)
- LiquidlimitbyCasagrande'sapparatus
- Plasticlimit
- Particlesizedistributionbysieveanalysis
- Determinationofthemaximumdry density(MDD)andthecorrespondingoptimummoisture content (OMC) of the soil by Proctorcompactiontest
- Preparationofreinforcedsoilsamples.
- Determination of the shear strength by:Directshear test(DST)

Unconfinedcompressiontest(UCS).

### Materials

I. Soilsample-1
II. Reinforcement:ShortPP(polypropylene)fiber.

**FigureNo1POLYPROPYLENE FIBRE**

**TableNo.1Indexand strengthparametersofPPF**

| **Behaviorparameters** | **Values** |
|---|---|
| Fibertype | Singlefiber |
| Unitweight | 0.91g/cm$^3$ |
| Averagediameter | 0.034mm |
| Averagelength | 10mm |
| Breakingtensilestrength | 350 MPa |
| Modulusofelasticity | 3500 MPa |
| Fusionpoint | 165$^0$C |
| Burningpoint | 590$^0$C |
| Acidandalkaliresistance | Verygood |
| Dispersibility | Excellent |

**Preparation Of Samples**

Followingstepsarecarriedoutwhilemixingthefiber tothe soil-

i) Allthesoilsamplesarecompactedattheirrespective MaximumDryDensity(MDD)andoptimum moisture content (OMC),corresponding tothestandardproctorcompactiontests

ii) Contentoffiberinthesoilsarehereindecidedbythe followingequations

Where,ρf=ratiooffibercontentWf=weightofthefiber W =Weightoftheair-dried soil

iii) Thedifferentvaluesadoptedinthepresentstudy for the percentage of fiber reinforcement are0,0.05, 0.15,and0.25

iv) In the preparation of samples,if fiber is notusedthen,theair-driedsoilwasmixedwithanamount of water that depends on the OMC of thesoil If fiber reinforcement was used, the adoptedcontent of fibers was first mixed into the air-driedsoil in small increments by hand, making sure thatallthefibersweremixedthoroughly,sothatafairly homogenousmixture is obtained, and thentherequiredwaterwasadded.

**BriefSteps InvolvedInThe Experiments**

**Specific gravity of the soil**The specific gravity ofsoilistheratiobetweentheweightofthesoilsolids and weight of equal volume of water. It ismeasured by the help of avolumetricflask in avery simple experimentalsetupwhere thevolumeof the soil is found out and its weight is divided bytheweight of equal volume of water W1- Weightof bottle in gms W2 –weight of bottle + Dry Soil ingms. W3-weight of bottle + Soil + Water. W4 -Weight of bottle + Water Specific gravity is alwaysmeasured in room temperature and reported to thenearest0.1

**Liquid limit**The Casagrande's tool cuts a grooveof size 2mm wide at the bottom and 11 mm wide atthe top and 8 mm high. The number of blows usedfor the two soil samples to come in contact is noteddown. Graph is plotted taking numberof blows onalogarithmicscaleontheabscissaandwatercontent on the ordinate. Liquid limit corresponds to25 blowsfrom

**Plastic limit** This is determined by rolling out soiltill its diameter reaches approximately 3 mm andmeasuringwatercontentforthesoil,whichcrumblesonreachingthisdiameter.

Plasticity index (Ip) was also calculated with thehelp ofliquidlimitandplasticlimit;

Ip=wL–wP

WL-LiquidlimitWP-Plasticlimit

**Particle size distribution** The results from sieveanalysisofthesoilwhenplottedonasemi-loggraph with particle diameter or the sieve size as theabscissa with logarithmic axis and the percentagepassing as the ordinate gives a clear idea about theparticlesizedistribution.Fromthehelpofthiscurve, D10andD60aredetermined.ThisD10isthediameterof thesoil belowwhich 10% of thesoil particles lie. The ratio of, D10 and D60 givesthe uniformity coefficient (Cu), which in turn is ameasure of the particle size, range. 2.4.5 Proctorcompactiontest

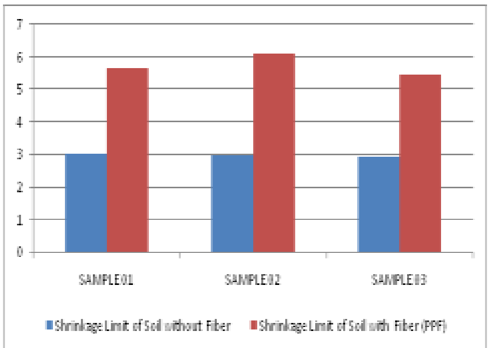
This experiment gives a clear relationship betweenthe dry density of the soil and the moisture contentof the soil. The experimental setup consists of (i)cylindrical metal mold (internal diameter-10.15 cmand internal height-11.7 cm), (ii) detachable baseplate,(iii)collar(5cmeffectiveheight),(iv)rammer(2.5kg).Compactionprocesshelpsinincreasing the bulk density by driving out the airfrom thevoids. The theory used in the experimentis that for any compactive effort, the dry densitydepends upon the moisture content in the soil. Themaximum dry density (MDD) is achieved when thesoiliscompactedatrelativelyhighmoisturecontent and almost all the air is driven out, thismoisturecontentiscalledoptimummoisturecontent (OMC). After plotting the data from theexperiment with water content as the abscissa anddry density as the ordinate, we can obtain the OMCandMDD.TheequationsusedinthisExperimentis as follows 2.4.6 Direct shear test This test is usedtofindoutthecohesion(c)andtheangleofinternal friction (φ) of the soil, these are the soilshear strength parameters. The shear strength is oneofthemostimportantsoilpropertiesanditisrequired wheneveranystructuredependsonthesoil shearing resistance. The test is conducted byputting the soil at OMC and MDD inside the shearbox, which is made up of two independent parts. Aconstant normal load (σ) is applied to obtain onevalue of c and φ. Horizontal load (shearing load) isincreased at a constant rate and is applied till thefailure point is reached. This load when dividedwith the area gives the shear strength 'τ' for thatparticularnormalload.Theequationgoesasfollows:τ=c+ς*tan(φ)Afterrepeatingtheexperiment for different normal loads (σ) we obtaina plot which is a straight line with slope equal toangle of internal friction (φ) and intercept equal tothe cohesion (c). Direct shear test is the easiest andthe quickest way to determine the shear strengthparameters of a soil sample. The preparation of thesampleisalsoveryeasyinthisexperiment3

## III. RESULTSANDDISCUSSION

The tests results are summarized in Table 2. ThevariationintheOptimummoisturecontents, Maximumdrydensity, Californiabearingratio, unconfined compressive strength and Differential freeindexare shownin Figures1to3.

**Table2:SummaryofResults**

| | Sample01 | Sample02 | Sample03 |
|---|---|---|---|
| SpecificGravityOfSoilWithout Fiber | 2.631 5 | 2.65 | 2.684 2 |
| SpecificGravityOfSoilWithFiber | 2.64 | 2.655 | 2.689 5 |
| LiquidLimitOfSoilWithoutFiber | 40.33 % | 47.05 % | 45.31 % |
| LiquidLimitOfSoilWithFiber | 43.89 % | 36% | 41.80 % |
| PlasticLimitOfSoilWithoutFiber | 28.68 % | 29.67 % | 29.72 % |
| PlasticLimitOfSoilWithFiber | 22.35 % | 28.14 % | 27.03 % |
| ShrinkageLimitOfSoilWithout Fiber | 3.029 | 2.97 | 2.94 |
| ShrinkageLimitOfSoilWithFiber(Ppf) | 5.65 | 6.1 | 5.46 |




**FigureNo2 ShrinkageLimit**

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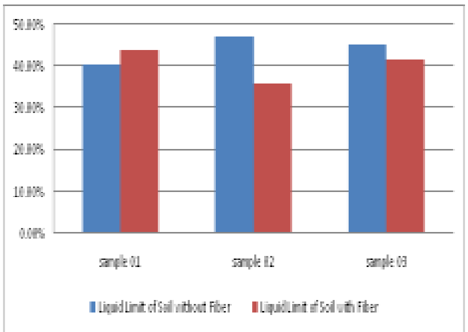
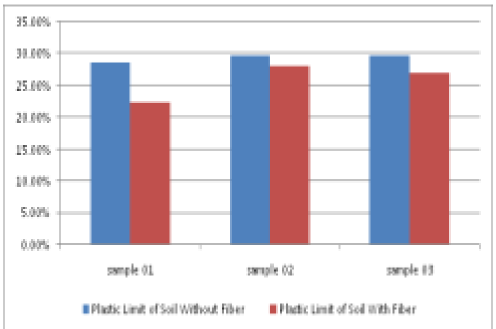


FigureNo 3LiquidLimit



**FigureNo 4 PlasticLimit**

## IV. CONCLUSION

[1].BasedonSpecificgravityofasoil-Withmixing of 0.5% fibers (PPF) specificgravityofthesoilincreasesby0.3%.(Fromtableno 3and4)Strengthofthesoilisdirectlyproportional to specific gravity, more is thespecific gravity more will be the strength ofsoil.

[2].Based on liquid limit of a soil - Soil withoutreinforcementandwithreinforcementhaveliquid limitdifferenceof18.18%.

[3].Based on plastic limit of a soil - As similar toliquidlimittheplasticlimitofsoilisalsoreduces. It reduces from 29.35% to 25.8% . %decreasein plasticlimitis12%(From tableno 7 and 8) , This result shows increase inshear strength , Cohesiveness and consistencyofsoilmass.

[4].Basedonliquidlimitofasoil-Thevalueoftheshrinkagelimitinreinforcedsoilislessthanthatofunreinforcedsoil.Hencewiththeuseofpolypropylenefiber shrinkagereduces.

[5]. hevalueofshrinkagelimitisusedforunderstandingtheswellingandshrinkagepropertiesofcohesivesoil.lesser istheshrinkage more will the suitability of materialforfoundation,roadandembankmentasmore willbethe strength.

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