Utilization Methods of Polymer Waste in Geotechnical Applications

Rohit Maurya*, Umesh Kumar**

*M.Tech from KNIT (Sultanpur)
**Associate Professor in Civil Engineering Department from KNIT, Sultanpur, UP, 228118

Abstract- In this study, the enhancement procedures over the pre-existing problem is studied that is solid waste (MSW) which is increases increasing. In Future, when we don't even have land to dispose or landfill till we find a way. Therefore this study can be necessitate to study the properties, major issues, harmful effect on environment ecology and utilization. Therefore, the present study will focus based on literature work related to the field of soil improvement and solid waste related problems. Also Plastic waste (polymer) is more suitable for geotechnical purposes. The various plastic waste with different properties may also be used for different suggested methods. The present study also discusses the methods to be adopted for soil enhancement with the various plastic waste.

Index Terms- Municipal Solid waste, Permeability, HDPE, LDPE, PET, PP, Polymer waste, Utilization, Hazardous, Environment.

I. INTRODUCTION

The importance of the soil comes in engineer's mind, whenever we got to find the requirement of the material that could do sustain or hold every structure into its own place. The object of this paper is to reinforce the soil at various places like roads, foundation, embankments, hilly areas etc. wherever the soil reinforcement is needed. The basic approach in this paper is to figure out the problems of soil and the failure. How the use of additive in soil will be stabilize effectively. For stabilization we have various methods and materials but they seems to be uneconomical for the constructors. Which leads us to go with the alternative methods and materials.

Solid waste is another major problem of whole world to consider it seriously. According to the data published by Environmental Protection Agency US 1992[26]. The total solid waste produced is 14.4 million tons and covers 20% of the area by the volume of available area .Approx. 2.2million tons HDPE is produced every year and only 7% is recycled .The Production municipal solid waste data estimated in India up to 2000 is 39 million tons per year and it will be reached 56 million tons at end of the year 2010.The typical percentage of plastics waste in Municipal solid waste is 1%. The main reason cited behind the Mumbai flood in (2005) was choking of drains by plastic waste thrown everywhere carelessly.

After implication of Solid waste management system there's still solid effecting the environment and covers large land area to dump. The solution of this indiscriminately thrown solid waste is to utilize it intelligently use for engineering purposes.

The other problems discussed are as follows:

a) To analyze the different types of solid wastes, which will be the major problems for the future generation to save environment, land areas and to save ground water from open dumping waste land.
b) We transport soil from one place to other by extract soil and fill it in elsewhere. This will harm the surface layer soil which is best suited for farming having nurturing minerals waste which avoided by replacing the material.
c) To analysis the problem of solid waste management that may be really utilized for recycling and re-utilization processes.

II. PROBLEMS IN USE OF REGULAR SOIL

The regular soil have various weaknesses for different kinds of geotechnical uses in civil engineering .So here we discuss about some of the problems with the soil.

a) Firstly, soil is basically strong in compression than in tension or in horizontal phase. It has no tension so this emerges its negative point.
b) Soil is eroded by environmental effect on it such as wind, heat, water, and rain or runoff water by living animals etc. and weaken the soil mass till failure.
c) Poorly graded soil in environment is easily failed by the conditions of its physical and chemical properties like grain size, chemical composition, shear strength etc.
d) The natural soil directly cannot be used in civil engineering purposes unless improvement is to be made.
e) It may be behave like liquid in vibration or in seismic condition.

III. LITERATURE REVIEW

Jegede (2000) has shown that more and more building and highway are failed or collapsed due to un-appropriate property of soil to sustain. It's dangerous for any structure to have that concludes that we have to make soil somehow reliable to use in construction. And this actually concerns with mixing of some kind of external material (additives) in soil to increase in these following properties and we called stabilization of soil. Moisture content, bearing capacity, particle size, consistency limits, compressibility, swelling potential and volume change etc.

To alter and enhance the soil properties by *Amadi(2010)* studies with chemically active additive to use in soil to enhance

property like Portland cement , lime , sawdust ash , rise husk ash etc. or sometime the collection of these material . As these material got in use, the prices escalated higher with time. It's uneconomically to use i.e lime and cement in improvement of soil according to *Neville (2000).*

Therefore it's needed to redirect our view to change the additives to improve the soil by different kinds of solid waste (MSW). Due to worthlessness of these materials, these may be used for construction as a cheap material.

IV. PREVIOUS STUDIES AND INVESTIGATION

Bauer and Oancea (1996) – By his tri-axial test result show that to measure stiffness called secant modulus of reinforced soil the initial vertical strain is 2 % decreased with increasing polypropylene fiber 0.5% but there's not enough decrement to notice fairly beyond the vertical strain .

Feitag (1986)-Notices that randomly distributed fiber could result better increment in stiffness when mixing with compacted fine grained soil.

Consoli et al. (1998) - Experiment on tri-axial comparison test fiber reinforced dressed the stiffness at a level.

Gray and Al-Refeai (1986) - Conduct tri-axial compression test and found that randomly discrete fiber in Sand resulted in a loss of compressive stiffness at low strains (lower than 1 percent).

Gray and Ohashi (1983) - According to his result that it comes out there is an increased in shear strength and leveled the post peak shear resistance and no increase in stiffness in fiber sand composite.

Benson and Khire (1994)- In his study they uses cut pieces of waste milk jugs and showed that there is an increment in CBR value by 5 and secant modulus also improved .

Bueno (1997) - In his laboratory test study on mechanically stabilized soil with thin plastic strips of different length (Aspect Ratio) and content (by weight) will enhanced the bearing capacity.

Michalowski and Zhao (1996) - By his tri-axial test result steel fiber led increased the stiffness of soil prior to the failure.

Yetmoglu and salbas (2003) - this study said that there's no increase in stiffness with consideration of the randomly distributed fiber.

Kumar (1999) - In his Investigation of laboratory on silty soil and pond ash specimen with randomly distributed polyester fiber found that it'll increased the CBR value and ductility.

Venkatappa Rao and Dutta (2004)- Papered in his theoretical analysis of tri-axial test result to found the improvement in bearing capacity of footing in reinforced sand bed resting on clay soil by waste plastic strips and get , it was improved.

Yetimoglu et al. (2005)- Conducted CBR test on sand fill reinforced with randomly distributed discrete fiber overlying soft clay and test result that's its increased the piston load penetration curve no satisfactory effect by fiber reinforcement .

Datir et al. (1997)- Investigate that the effect of polypropylene fiber on tensile strength of cohesive soil stabilized with lime and fly ash with the ratio of 1:2 and found that there is 25% reduction in stabilize soil when it did with fly ash and lime .But 251% of increase in tensile strength when stabilize with 2% of polypropylene fiber .

Kumar et al. (2007) - Made an experimental study programmed and find the effect of polyester fiber inclusion and lime stabilization as the geotechnical properties of expensive soil by mixing and 28 days of curing of it and got it increased.

Huntohar (2004)- He made program to study and investigate the strength of stabilized clay soil reinforced with randomly distributed discrete plastic waste fiber by curing out (UCT) unconfined compression test for strength and tensile split strength test .

V. SOLID WASTE

Solid waste is a big task to handle by engineers planners groups of society. A huge amount of waste need to be utilize by different methods and ways cause its generated in large amount as it seems by collected data around world . As we seen in the Figure-1

Fig-1 Open Dumped Solid waste [Behind KNIT campus]

A. TYPES OF WASTE

Sources of Solid Waste

Sources of solid waste are generated from various places such as Municipal services, treatment plants and special category.

a) Municipal solid waste concluded residential, commercial and institutional areas, construction and demolition waste. And the term is mainly used as a solid waste.
b) Solid waste generation in continuous action which increasing day per day and proportional to the population and lifestyle of the people.
c) In India, 150 times of body weight of per person solid waste is generate in his life time. In Delhi about 6000 tons of MSW are generated every day.

The detail version of sources and types of soil combined is giving as below. This configures the sources, places of generation and type of solid waste.

B. IMPACT ON ENVIRONMENT BY SOLID WASTE

As we suspect that there are various solid waste dumped on environment which raises harming effect. The answer may be yes, it will harm our life and environment in different ways. Table [1] shows the effect of these waste in different areas of our life.

Table -1 Impact Table in ways

Environme-ntal pollution	Land quality , air and water , poor aesthetics , deterioration high level of noise
Disease	Diarrhea , gastrointestinal disorder , jaundice , dermal disease , cancer
Injury	Pieces of glass, chemically active substance in water.

C. PHYSICAL AND GEOTECHNICAL PROPERTIES OF SOLID WASTE

Solid waste analysis is the priority to figure out how and which kind of waste do we use and will be used in soil enhancement only by the use of various solid waste.[Table-2] So these are the some physical and geotechnical properties of solid waste.

i. Specific weight
ii. Moisture content
iii. Particle size and size distribution
iv. Field capacity
v. Permeability

Chemical Properties of Solid Waste

i. Moisture content –chemically change
ii. Volatile matter
iii. Ash
iv. Fixed carbon
v. Fusing point of it
vi. Calorific value
vii. Percentage of carbon, oxygen, sulphur and ash

Table -2 Composition Municipal Solid Waste in Delhi

Component	Percent fraction
Food	20-30
Paper	3-5
Cardboard	3-4
Plastics	4-6
Textile	0.2-0.5
Rubber	1-2
Leather	0.2-0.5
Yard-waste	20-30
Wood	1-2
Glass	0.2-0.7
Metals	0.2-0.5
Silt/ ash/ dirt	30-40

VI. LITERATURE REVIEW OF SOLID WASTE

In our country the amount of municipal solid waste that was generated every day is about 160,000 Metric tons (MT) .Accordance with the population of cities per capita waste generation varies from 0.2kg to 0.6kg and the analytically probable it will increase 1.33% annually. Solid waste management of India it is estimated that by the end of the year of 2047 the total amount of Municipal solid waste generation will be 260,000 Metric tons , which actually cover the 1400 km2 area equivalent to the city of Delhi. Papered about 4.8 million tons/year waste is recycled and rest 3.2 million tons/year waste remains non-recyclable. This concern with the waste of plastics of different variety and synthetic material. According to a survey 1500 bottles are dumped into garbage every second. PET investigate and said that its one of the most abundant urban solid waste *(de Mello et al .2009).* As we sees and know that all waste is just large loss of raw material land resources. So it could be recycled, recover or re-use in any way. World's annual consumption papered that PET bottles 10 million tons and its increasing 15% BY per year. Its analysis shows that 4-5% post-consumer plastic comes by Municipal solid waste in India and in USA its 6-9%. As per the MSW data shows 4000-5000 tons per day by post-consumer plastic waste generated.

VII. LITERATURE REVIEW OF SOIL STABILIZATION

The artificial traditional admixes in order of high usage

i. Portland cement (cement fly ash)
ii. Lime (lime fly ash)
iii. Fly ash
iv. Fly ash with cement and lime
v. Bitumen and tar
vi. Cement and kiln dust

Here are some previous works done on some of these methods to stabilize soil. But as we aware most of less economic or costly material to employ as a stabilization material is not worth it to use.

a) *Hussain M. and Dash S.K. (IGC 2009)-* [27]Analyze that the soil stabilization done by lime sure increase its properties and performance like increase of lime in soil up to 3% decrease the MDD afterword its star increasing , an increase of lime content up to 3% increase the OMC and afterwards in star decreasing .
b) *Pal, Sujit Kumar and Ghosh, Ambarish (IGC 2009)* - In this study of various fly ash with the soil under different confining pressure like 100, 200 and 300Kpa and the effect of this confining pressure, MDD and OMC on fly ash sample was analyzed and found that the increase in confining pressure also increases the shear strength irrespective of type of ash. [28]
c) *T.K. Roy, B.C. Chattopadhyay and S.K. Roy (IGC 2009)* - Soil improvement by the use of ash and lime were conducted and found that the mixing of fly ash in increasing order with the soil lime mixed soil decreases the MDD but increasing the both lime and ash increases the OMC. [30] And CBR value increases up to the 20% RHA with lime after that it start decreasing.

In recent years increment of non-traditional additives developed enough to stabilize soil and fulfill their purpose. And these stabilizers became popular because of there, relatively low cost, ease of application and short curing time. So non-traditional stabilizers are –

i. Polymers based products

ii. Copolymer based products
iii. Fiber Reinforcement
iv. Calcium carbide
v. Sodium chloride

These are some work and studies on recent day's stabilization materials which is basically related to polymer based products. Which is having a lots feature to use.

a) *R.M. Subramanian and S.P. Jeyapriya (IGC 2009)* - In this investigation waste tyre used as a stabilization material to soil performance, when crumb tyre mixed with soil at different percentage in CBR test only marginal increase was found. [29] But when it performs on the 30*30*30 cm tank of soil mixed with and without of crumb tyre, decrease in deflection in mm found under increase in pressure.

b) *M.S. Dixit and S.H. Pawar (IGC 2009)*- This study concerns with soil stabilization with the use polypropylene fiber and found that the increasing of polypropylene fiber ranges 0.75% to 3% decreases the MDD and increases the OMC by 3% to 14% and 1% to 9% respectively .[31] Cohesion increases

Table-3 Waste Types By composibility

Decomposable	Non decomposable
a) Food waste b) Garden waste c) Animal waste d) Human waste	a) Tin can/metal b) Glass c) Plastic/ rubber d) Dry cloth e) Feather / leather f) Hard shell / bone

c) 2% to 21% at the 2.25% of fiber mix and after that it starts decreasing. CBR value increases from 11% to 47% at 2.25% fiber and then decreasing.

VIII. SOLID WASTE MANAGEMENT ISSUES

A. WASTE REDUCTION

Due to limited availability of land space it is not suitable solution to dispose waste in landfill for a long time. In India many urban centres already face problems to dispose waste that will accumulate in next 25 to 30 years.

There's only two or three ways to reduce the solid waste to make in it a 'zero waste' society like. there limited pollution will be which can utilize as whole by society or other than this we can recycling the waste product left and use and reuse of municipal and industrial waste .These are the ways to do that –

a) Recycling of paper, metal, glass of the household level organized through the local kabahdi wallah or rag picker.
b) Conversion of kitchen organic waste to compost and using it as manure.
c) Use of fly ash, fine component of coal ash, as pozzolonic material for production of cement.
d) Use of slag from steel plants in construction of sub-base course of roads.

B. SOLID WASTE MATERIAL AS CONSTRUCTION MATERIAL

In construction, soil was use as a material in various applications for earth dams, for road and rail embankments, for filling of low lying area, for embankments of canal and lakes, for backfilling behind retaining wall structure. [6] Several million cubic meter of earth works are excavated each year alone in India. If soil could be replaced by solid waste material in some of these application, not only would soils waste material disposed of but would result in the following added benefits.

i. Reduction in the quantity of valuable top soil, that is suitable for agriculture, for being used in non-agriculture application.
ii. Reduction in the number of depression created in flat or undulating ground due to excavation of soil for earthwork projects leading to land degradation.

C. SOLID WASTE USED AS SOIL REPLACEMENT

a) Should not be classified as hazardous material
b) Should not have any biodegradability in its components.
c) Particle should remain physically and chemically stable in long term ,i.e. ,
d) They should not be soluble, not volatile not be susceptible for disintegration.
e) Should not have potential of harming the ground water quality.
f) Should not contain deleterious material chlorides and sulpher which can harm there building material.
g) Particle should in clay to gravel size ranges to enable ease in handling by standard earth moving equipment s.
h) Should not exhibit a high degree of heterogeneity or variability.

In most of the above wastes, the basic mineral is silica and that is suitable for geotechnical construction works.

D. NON BIODEGRADABLE SOLID WASTE

In vast variety of solid waste existence there are some non-biodegradable solid wastes present with it. Some of non-biodegradable solid wastes are as follow according to the feature of utilization in our analysis. [Table-4] These solid wastes will also be recycled but somehow only some fraction of it is recycled. That's the reason we can utilize it in Geotechnical purposes.

Table -4 Non degradable wastes

Plastic	1. Carry bags 2. Milk oil bags 3. Plastic bottles 4. Thermo-Cal
Rubber	1. Automobile tires 2. Tubes of it 3. Bottles
Glass	1. Electric bulbs 2. Tube light 3. Glass bottles

IX. PLASTIC WASTE

Plastic waste buy at the local shop in the market as required or Buy from the rag picker. Cut it in a specified aspect ratio. As we know importance of aspect ratio like why we not using plastic

waste in same size? Why in a different size by aspect ratio? That's because of the un-identification of a perfect size required to improve soil performance and characteristics. [Figure-2] That is the main reason of using different aspect ratio to overcome the identification problem of perfect size of plastic waste

Fig -2 some collected Plastic waste

But next problem is that how we find out, what is aspect ratio and minimum aspect ratio we choose or assume. One way to follow that is too aware with the past research literature of this field of stabilization. [Table-5, 6, 7] Or we assume some fundamental points what is best suitable options to choose.

i. Maximum aspect ratio should approx. equal to ¼ of the diameter of the mould
ii. Minimum aspect ratio depends upon the other part of the size factor so this should be 1.

Table -5Waste plastic and its sources

Waste Plastic	Origin
Low Density Polyethylene (LDPE)	Carry bags, sacks, milk pouches, bin lining, cosmetic and Detergent bottles.
High Density Polyethylene (HDPE)	Carry bags, bottle caps, house hold articles etc.
Polyethylene Terephthalate (PET)	Drinking water bottles etc.,
Polypropylene (PP)	Bottle caps and closures, wrappers of detergent, biscuit, vapors packets, microwave trays for readymade meal etc.,
Polystyrene (PS)	Yoghurt pots, clear egg packs, bottle caps. Foamed Polystyrene: food trays, egg boxes, disposable cups, protective packaging etc.
Polyvinyl Chloride (PVC)	Mineral water bottles, credit cards, toys, pipes and gutters; electrical fittings, furniture, folders and pens, medical disposables; etc.

Table -6 Thermal behaviour of plastic

Polymer	Softening Temp in (oC)	Decom position Temp. (oC)	Products papered	Ignition Temp. range (oC)
PE	100-120	270-350	CH4, C2H6	>700
PP	140– 160	270-300	C2H6	>700
PS	110-140	300-350	C2H6	>700

Table -7 Physical and Mechanical properties

Plastic	Absorption of water (%)	Melting point (°C)	Density	Tensile strength
PE	0.013	130	0.93	24
PET	0.016	250	1.32	42
PP	0.010	160	0.90	33

X. PROCESS PLAN FOR PLASTIC WASTE PREPARATION

In these tests, we test out the best proportion of waste material and check out to mix with soil in different percentage of with respect to soil like 0%, 1.0%, 1.5%, 2.0% etc. if required that enough. And we will do the applicable test on that as we noted out before to get the better idea about the increment in strength of soil with graph of this combined test.

Now we test these waste one by one with soil in compaction test in different aspect ratio .Then we have the best proportion of AR with these waste.

After this we know the best aspect ratio and the proportion of to mix with soil .Then at the very last these three solid waste will be teat with soil in different % of mixing with soil by weight.

This is how we prepare the solid waste thoroughly in big quantity to start making soil samples with this mixer of waste to perform various tests.

XI. COMPARISON OF SOIL ENHANCEMENT

Prepare solid waste like (plastics waste, cardboard ,other fibre) and mix with both soil sample with different proportion and percentage which is as follows 0%,1.0%,1.5%,2.0% or may be 0.25%, 0.50%,0.75%, 1.0% or 0.1%.0.2%,0.3%,0.4% for various types of soils. And then we perform these tests. After conducting the influential test which required also we put this data in manner we can visit comparatively. [Table-8] This simplifies the main influential part of soil enhancement with various solid wastes. This comparison come in between percentage of particular solid waste with the specific performed test like what's the variation happen when we mix different ad-mixers.

Table -8 Comparison Table

Tests /	Soil Sample X			
% Solid waste	0.50%	1.00%	1.50%	2.00%
Specific Gravity	A1	A2	A3	A4
CBR Test	B1	B2	B3	B4
Proctor Test	C1	C2	C3	C4
Triaxial Test	D1	D2	D3	D4
Permeability	E1	E2	E3	E4

XII. CONCLUSION

a) The solid waste in future will be major problem and needed the solution. Otherwise a large land area will not be utilized due to solid waste layer overtopping ti. The solid waste may be utilized as a stabilizing material with the soil instead of high costs materials like lime, cement etc.

b) Out of various waste material present, the suitable once are non-degradable waste that is plastic waste. This plastic waste have a vast variety to use the types of plastic that can be used effectively are PET, HDPE, LDPE, PP etc.

c) The suggested proportion of these plastic waste to be mixed with soil is 0.1% to 2.0% or 0.1% to 1.0% generally. The need uses to carry out the tests have the influential properties like Specific gravity, MDD, OMC, CBR, Permeability, Tri-axial test has to compared for the suggested proportions to see the effect for various plastic waste. This will pave the way to use these plastic waste in a more technical manner for various civil engineering construction purposes.

REFERENCES

[1] Dutta, R. K and Surda, D.K;"CBR behavior of waste plastic strip reinforced stone dust, fly ash overlying saturated clay". Turkish T.Eng.Env. Sci. 31 (2007) , 171 -182

[2] Chamberlin, shyam k with Neoponey, Megnath and Kezong wangchuk, Ugyen, Tenzin sherub."Stabilization of soil by plastic waste ". International Journal of Emerging trends in Engineering and development ,ISSN2249-6149 issue 2 ,vol-2 (March 2012)

[3] A.K. Choudhary, J.N. Jha and K.S. Gill," A study on cbr behavior of waste plastic strip reinforced soil". Emirates Journal fo Engineering Research, 15 (1), 51-57 (2010)

[4] Chebet, F C and Kulumba, D,"Laboratory investigation on reusing polyethylene (plastic) by waste material for soil reinforcement in geotechnical engineering ". Civil Engineering and Urban Planning an International Journal (CiVEJ) vol-1 ,No-1 June 2014

[5] Muntohar, A S," Influence of plastic waste fiber on the strength of lime-rise husk ash stabilization clay soil ". Civil Engineering, Dimension, Vol-11, No-1 March.2009, 32-40. ISSN .1410-9530 print

[6] Bolden .Johny, Lebdeh, TaherAbu and Fini, Ellie,-"Utilization of recycled and waste material in various construction application ". American Journal of Environment Science, 9(1):14-24, 2013, ISSN: 1553-345X.

[7] C. Gümüşer1, A. Şenol." Effect of fly ash and different lengths of polypropylene fibers content on the soft soils". International Journal of civil engineering

[8] G L Sivakumar Babu. "Laboratory shear strength studies of soil admixed with plastic waste". CiSTUP Indian Institute of Science Bangalore 560 012 , Project Paper

[9] Agus Setyo Muntohar1; Anita Widianti2; Edi Hartono3; and Wilis Diana4." Engineering properties of silty soil stabilized with lime and rice husk ash and reinforced with waste plastic fiber" American Society of Civil Engineers.

[10] Ario Muhammad and Agus Setyo Muntohar. "Uses of lime -rice husk ash and plastic fibers as mixtures-material in high-plasticity clayey subgrade: a preliminary study".

[11] Salvacion S. tidon."Management and utilization of urban solid waste " .Research information series on Ecosystem .Vol-12 , No-3 Sep-Dec 2000

[12] Delfin G. Carreon." Stabilization of marginal soils using recycled materials". University of South Florida Scholar Commons. 2006

[13] Babu, G.L. Sivakumar, Chouksey, S., Anoosha, G. Manjari, K. Geetha," Strength and compressibility response of plastic waste mixed soil". Indian Geotechnical Conference – 2010, GEOtrendz December 16–18, 2010 IGS Mumbai Chapter & IIT Bombay

[14] Maheshwari, K.V. Desai, A.K. Solanki, C.H. "Model footing tests on fiber reinforced soil ". Indian Geotechnical Conference – 2010, GEOtrendz December 16–18, 2010 IGS Mumbai Chapter & IIT Bombay

[15] S. Twinkle, M.K.sayida," Effect of polypropylene fibre and lime admixture on engineering properties of expansive soil". Proceedings of Indian Geotechnical Conference December 15-17, 2011, Kochi (Paper No.H-085)

[16] Ashraf Anas, Arya Sunil, J. Dhanya, Mariamma Joseph, Meera Varghese, M. Veena," Soil stabiliisation using raw plastic bottles". Proceedings of Indian Geotechnical Conference December 15-17, 2011, Kochi (Paper No. H-304)

[17] Sen Arpan (108CE019) and Rishabh Kashyap (108CE018) under the supervision of Prof. N. Roy." Soil stabilization using waste fiber materials". Thesis Department of Civil Engineering National Institute of Technology, Rourkela Rourkela- 769008, India.

[18] Meera Manuel, Shyla Joseph A." Stability analysis of kuttanad clay reinforced with pet bottle strips". International Journal of Engineering Research & Technology (IJERT) IJERTIJERT ISSN: 2278-0181

[19] Dhanya J.S., Ilamparuthi K.," Stress-strain response of fibre reinforced admixed soil" Proceedings of Indian Geotechnical Conference December Delhi (Paper No. A103)

[20] Dixit M.S., Pawar S.H.," Study of improvement in properties of soil by addition of polypropylene fibers" Indian geotechnical sosciety, IGS 2009,GUNTUR ,INDIA

[21] Sreedhar M.V.S., STU. T. Sathish, K. Kranthi Kumar and P. Krishna Pravallika." Investigations on effect of reinforcement in planar and fiber forms on cbr value of sand". Indian geotechnical sosciety, IGS 2009,GUNTUR ,INDIA

[22] Ghosh Mahuya, Choudhury P.K., Sanyal Tapobrata," Suitability of natural fibres in geotextile applications". Indian geotechnical sosciety, IGS 2009,GUNTUR ,INDIA

[23] K. Suresh, Padmavathi V., Sultana Apsar," Experimental study on stabilization of black cotton soil with stone dust and fibers". Indian geotechnical sosciety, IGS 2009,GUNTUR ,INDIA

[24] Gawande Amit , Zamre G. S., Renge V. C., Bharsakale G. R. and Tayde Saurabh ." utilization of waste plastic in asphalting of roads". – A REVIEW Sci. Revs. Chem. Commun.: 2(2), 2012, 147-157 ISSN 2277-2669

[25] Konin A." effect of plastic waste content on physico-mechanical properties of flexible pavements". International Journal of Civil and Structural Engineering Volume 2, No 1, 2011 ISSN 0976 – 4399

[26] Snapshot "solid waste management of india". EUROPEAN BUSINESS AND TECHNOLOGY CENTRE , www.ebtc.eu

[27] Hussain, M. and Dash, S.K." influence of lime on compaction behaviour of soils". IGC 2009, Guntur India GEOTIDE.

[28] Pal, Sujit Kumar and Ghosh, Ambarish." shear strength behaviour of indian fly ashes". IGC 2009, Guntur India GEOTIDE.

[29] Subramanian R.M. and Jeyapriya S.P. (IGC 2009)." study on effect of waste tyres in flexible pavement system". IGC 2009, Guntur India GEOTIDE.

[30] Roy T.K., Chattopadhyay B.C. and Roy S.K. "effect of lime on the properties of subgrade of roads with addition of rice husk ash". IGC 2009 , Guntur India GEOTIDE

[31] M.S. Dixit and S.H. Pawar." study of improvement in properties of soil by addition of polypropylene fibers". IGC 2009, Guntur India GEOTIDE.

AUTHORS

First Author – Rohit Maurya , M tech , KNIT Sultanpur (Email-rohitmaurya12ce@gmail.com)

Second Author –Prof. Umesh Kumar, Phd, Associate Professor in KNIT , Sultanpur