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Study on Possible use of Waste Plastic in Locally available Subgrade Soil

Somabho Chatterjee [1], Soumav Das[2], Aishwarya Kundu [3], Sarmita Basak[4], Sudipta Adhikary[5]

[1, 2, 3, 4] *Student of B-Tech (Civil), 3rd year Camellia school of engineering & technology, Nadibhag, Barasat, Kolkata, India, under MAKAUT (WBUT) West Bengal*

[5.,] *Assistant Professor, Department of Civil engineering, Camellia school of engineering & technology, Nadibhag, Barasat, Kolkata, India*

Abstract: In the global scenario now it is the main concern to develop or stabilize the subgrade soil. Soil stabilization means alteration of the soils properties to meet the specified engineering requirements. Since most of the available studies were on the evaluation of treated/stabilized subgrade soil like Black cotton soil, Bentonite, Sandy/Silty soil, Organic clay by using stabilizing additives like Fly Ash, Cement, Lime, some other chemical compounds and Plastic also. The concept of utilization of waste plastic in construction of flexible road pavement has been done since 2000 in India for making Polymer modified Bitumen. So this study will give a limelight on the use of Waste Plastic as reinforcing materials in subgrade soil (Alluvial) in an economical manner. Also this investigation will emphasise specifically on the use of randomly pieces Plastic strips instead of using specific Aspect Ratio which require a less skilled operation and it will help to minimise the processing time and cost also.

Keywords: Waste plastic, Flexible Pavement, Polymer modified Bitumen, Plastic strips.

I. INTRODUCTION

Subgrade layer is the lowest layer in the pavement structure underlying the base course or surface course, depending upon the type of pavement. Generally, subgrade consists of various locally available soil (Alluvial of Indo-Gangetic Plane) materials that usually week in nature and cannot have enough strength/stiffness to support pavement loading. A sound knowledge of performance of the subgrade soil under prevailing in-situ condition is necessary prior to the construction of the pavement. The better the strength/stiffness quality of the materials the better would be the long-term performance of the pavement. Hence, the design of pavement should be focused on the efficient, economical and effective use of existing subgrade materials to optimize their performance. In case of soft and wet subgrades, proper treatment like stabilization with other materials might be needed in order to make the subgrade workable for overlying layers (e.g., creating working platform) for pavement construction.Reinforced soil construction is an effective and reliable technique for improving the strength and stability of soils. A simple way of recycling plastic in the field of civil engineering as reinforcing material may be resulting an economical and environmental friendly solution. Plastic is a very versatile material.

The use of plastic and related materials is increasing tremendously due to growth in population, urbanization and modern life style. Municipal solid waste in India contains 1-4 per cent by weight of plastic waste. India's rate of recycling of plastic waste is the highest (60%) in the world as compared to other countries (China 10%, Europe 7%, Japan 12%, South Africa 16% and USA 10%). Recently this waste plastic is used as reinforcing material with soil in road construction. Generally, PET, HDPE were used for road construction to increase the load bearing capacity and strength of subgrade soil. However a limited work has been done using LDPE as reinforcing material to improve the strength characteristics of soil subgrade. The use of this innovative technology will not only strengthen the road construction but also increase the road life as well as will help to improve the environment.

II. MATERIALS AND METHODOLOGY

A. Alluvial Soil

Practically this types of soil has been deposited within the regions of river bank, on both sides (Approx. basin area: Ganga – 71485 sq.km &Damodar – 24235 sq.km in West Bengal) since ancient time. Types of deposits depend on the river type. But now a day in urban areas alluvial deposits are available at a greater depth (Approx. from 2m below) as artificial filling materials (Like Brick Bats, Cinders, Stone chips etc.) are available at the top layers.

B. Sample Collection Area for This Study

Table I.Sample Designation and Details for Alluvial Of Ganga and Damodar

INFORMATION ON	SAMPLE DESIGNATION– G
ALLUVIAL OF RIVER -	GANGES
LOCATION DETAILS -	36 NO LOWER FORESHORE ROAD, B.GARDEN GHAT
DISTANCE OF LOCATION FROM RIVER -	200 m
DATE -	20.11.17
TIME -	10:40 AM
TEMPERATURE (°C) -	17

C. Physical Properties of Collected Sample

Table II. Physical Properties of collected samples

Sample No	Depth (m)	Natural Moisture Content (%)	Grain Size Analysis (%)			Specific Gravity	LL (%)	PL (%)	Plasticity Index (%)	Light Compaction		CBR (%)	
			Sand	Silt	Clay					MDD (gm/cc)	OMC (%)	Unsoaked	Soaked
G	2.95	23	2	66	32	2.63	46	27	19	1.52	23	3.60	2.64

Collected samples are taken to the lab to know the different physical properties of the sample by different tests as per BIS Standard. From the experiment it is observed that the Natural Moisture Content [as per IS:2720 (Part II)-1973] of sample G-1 is 23% (Depth-2.95m) Grain size analysis [as per IS:2720 (Part 4)-1985] shows that the alluvial of Ganga are mostly Clayey Silt (Sand, Silt and Clay % are respectively 2, 66, 32 for sample G Specific gravity [as per IS:2720 (Part III/Sec 1)-1980] of sample G 2.63. Atterbergs limits [as per IS:2720 (Part 5)-1985] of the specified sample are (LL=46%, PL=27% for G). Compaction characteristics are determined by Light Compaction Test [as per IS:2720 (Part VII)-1980] in which MDD for sample G 1.52gm/cc and OMC is 23%. Unsoaked CBR [as per IS:2720 (Part 16)-1987] for G 3.60%. In addition 4-days soaked CBR value is determined which is most effective for the area having rainfall greater than 500mm annually (as per IRC: 37-2001) and the obtained values are 2.64% for G.

D. Waste Plastic

In the last few years, State and Central Governments have started paying attention to the issues of plastic waste seriously. Each SPCB or PCC shall prepare and submit Annual Report to CPCB by 30th day of September each year. The Central Pollution Control Board (CPCB) shall consolidate the report on use of plastic carry bags, sachets/pouches etc. and management of plastic waste. A summarised status published by CPCB on June, 2012 is as follows:

E. Specification For Plastic Sample

Sample of 40micron LDPE plastic strips for experimental purpose are collected from the local commodity and sample size is determined on the basis of Aspect Ratio. The Aspect Ratio is used in this investigation fixing the maximum size of strips within 10mm as for best performance strip size should be less than the 1/4th of the minimum available dimension for test specimen in the mould (i.e. 125mm of CBR mould). All this sample specification for plastic are summarized below in the following table.

Table III. Sample Specification for Plastic

Items	Description of Items	Specification
Sample Type	Category of Plastics	LDPE
Sample Thickness	-----	40μ
Sample Size	Aspect Ratio 1	10mm X 10mm

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Table IV. Material Composition and Mix Designation for different Alluvial Soil Sample

Material Composition and Mix Designation for Alluvial Soil Sample G			
Sl. No.	Aspect Ratio	Mix Designation	% of Plastic Mixed (By Weight of Soil)
1	1	G + P-0	0
2		G + P-1-0.25	0.25
3		G + P-1-0.50	0.50
4		G + P-1-1	1
5		G + P-1-1.50	1.50

F. Sample G

Table V.Atterbergs Limit for the different mixes of Sample G

Sl. No.	Mix Designation	Atterbergs Limit		Plasticity Index (%)
		Liquid Limit (%)	Plastic Limit (%)	
1	G + P-0	46	27	19
2	G + P-1-0.25	47	28	19
3	G + P-1-0.50	47	29	18
4	G + P-1-1	46	29	17
5	G + P-1-1.50	46	28	18

For the different mixes of sample G-1 the value of Liquid limit, Plastic limit and Plasticity Index are tabulated above.
An appreciable increase in the Liquid Limit is observed from the graph above up to certain percentage of plastic (0.5%) mixed soil but after that it starts decreasing. Both the increasing and decreasing phenomenon occur in an irregular manner. The same phenomenon is also observed in case of Plastic Limit.

III. RESULTS AND DISCUSSIONS

A. Effect on Compaction characteristics in terms of MDD & OMC

Compaction Test is performed at laboratory as per standard IS: 2720 (Part 7) - 1980 to get the value of MDD and OMC for each sample with different aspect ratio and treated with different percentage of plastics. The obtained values and there graphical representation are demonstrating here.

B. Sample G

For the sample G-1 Plastic is mixed with soil with Aspect Ratio–1 for all types of percentage i.e. 0.25%, 0.50%, gets different results of MDD and OMC.

Table VI.Compaction Characteristics of Different Mixes of Sample G

Sl. No.	Mix Designation	Compaction Properties	
		MDD	OMC
1	G + P-0	1.52	23
2	G + P-1-0.25	1.57	22
3	G + P-1-0.50	1.61	22
4	G + P-1-1	1.63	20
5	G + P-1-1.50	1.62	21

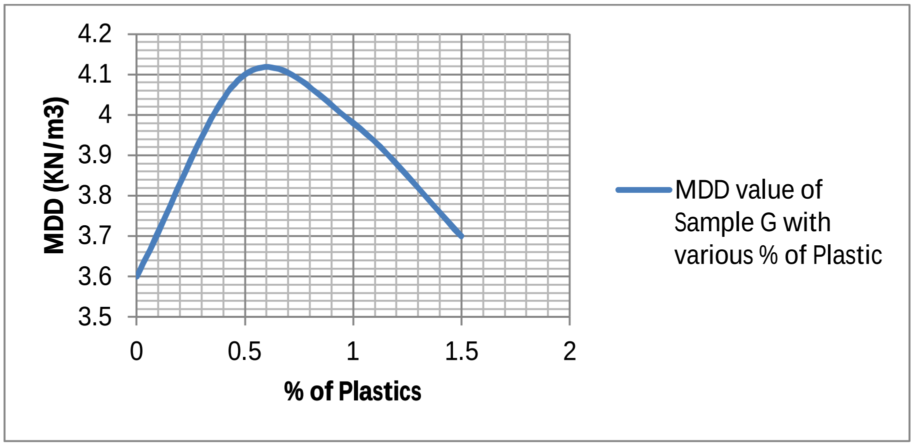

Figure 1.MDD Value of Sample G mixed with Plastic in different ratio

For sample G, MDD value is increasing gradually up to 0.5% of reinforced plastics and after that it is decreased for 1% and 1.5% of reinforced plastics for Aspect Ratio-1. Also it is observed that the value of MDD for 0.5% of reinforced plastics for all Aspect Ratio-1 is much more than that of unreinforced sample.

C. Effect on Strength characteristics in terms of Soaked and Unsoaked CBR

In this study some of the test specimens are checked by CBR test (Both Unsoaked and Soaked). For each specimen unsoaked value of CBR is taken from the average of three individual tests and also checked for permissible variation in CBR value (As per IRC: 37-2001/ Table No. 2). The same process is applied to get the value of soaked CBR. Both the values are tabulated below against particular specimen.

D. Sample G

For the sample G Plastic is mixed with soil with Aspect Ratio–1 for all types of percentage i.e. 0.25%, 0.50%, 1% and 1.5% and gets different results of un-soaked and Soaked CBR.

Table VII.Strength Characteristics of Different Mixes of Sample G

Sl. No.	Mix Designation	CBR Value	
		Unsoaked	Soaked
1	G + P-0	3.60	2.64
2	G + P-1-0.25	3.9	2.81
3	G + P-1-0.50	4.11	2.98
4	G + P-1-1	3.98	2.85
5	G + P-1-1.50	3.69	2.68

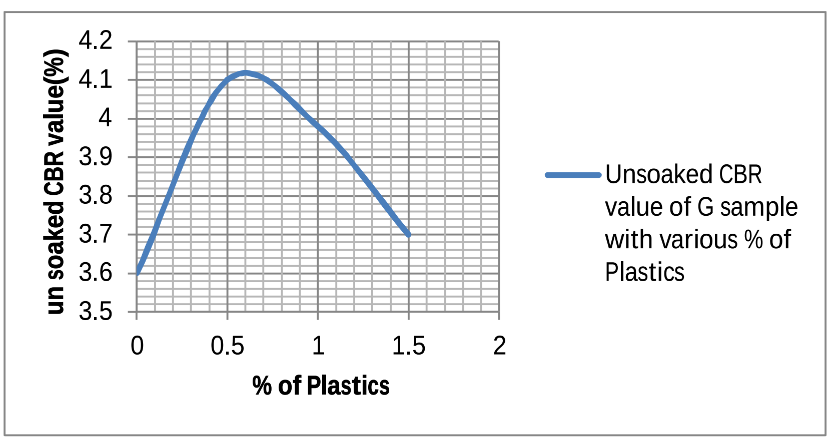

Figure 2.Un-Soaked CBR Value of Sample G-1mixed with Plastic in different ratio

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For sample G, un-soaked CBR value is increasing gradually up to 0.5% of reinforced plastics and reaches its maximum, after which it is decreased for 1% of reinforced plastics and it is checked for 1.5% of reinforced plastics also to confirm the decreasing characteristics of CBR value.

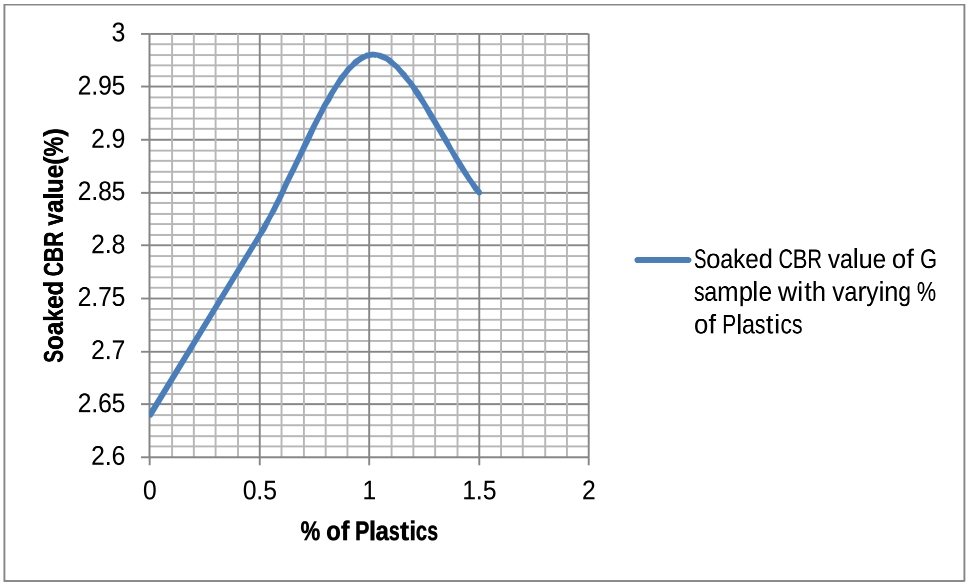

Figure 3.Soaked CBR Value of Sample G-1mixed with Plastic in different ratio

Going to analyse the soaked CBR value for sample G, it is observed that the value is increasing gradually up to 0.5% of reinforced plastics and reaches its maximum, after which it is decreased for 1% of reinforced plastics and it is checked for 1.5% of reinforced plastics also to confirm the decreasing characteristics of CBR value.

IV. CONCLUSIONS

The feasibility of reinforcing soil with strips of reclaimed LDPE was investigated in this study. Strips of LDPE were mixed with local alluvial soil and tested to determine CBR values. The tests show that reinforcing alluvial soil with waste LDPE strips enhances its strength. Based on the results, the following conclusions can be drawn:

1) Plastic reinforced alluvial soil sample does not lose its plastic properties. Overall liquid limit of the same is increased more than that of virgin soil and plasticity index is declined about 2% for incorporating all such polymeric substances in fresh local alluvial soil which attributes the better quality of the subgrade material used for construction of roadway pavement.
2) In compaction characteristics, with the increase in the value of MDD, OMC is decreased reasonably of about 2% compare to all types of conventional mix. So it can be saidthat demand of water will be less for achieving the MDD at the field condition.
3) The addition of reclaimed LDPE strips, a waste material, to local alluvial soil (alluvial of Ganga and Damodar) increases the both soaked and unsoaked CBR value for all types of conventional mix. The maximum improvement in unsoaked CBR value of about 21% and in soaked CBR value of about 18% is obtained when the strip content is 0.5% of size (10mm X 10mm). From the graphical representation it is observed that a further increase in percentage of strip decreases the value of CBR.
4) As the increasing amount of CBR value (21%) is significant with respect to unreinforced alluvial soil so there is a possibility of reduction of pavement thickness if LDPE strip reinforced alluvial soil is used as sub-grade material. This suggests that the strips of appropriate size cut from reclaimed LDPE may prove beneficial and cost effective as soil reinforcement in highway sub-grade if mixed with locally available alluvial soils in appropriate quantity.
5) Plastic has many harmful effects or creates adversity to living body. Being present into the subgrade it helps to resist the growth of plant or weeds or any creature in it thus to resist the decay of subgrade.

Also it will not contaminate the ground water as the functioning layer is situated above the ground water table which is environment friendly also.

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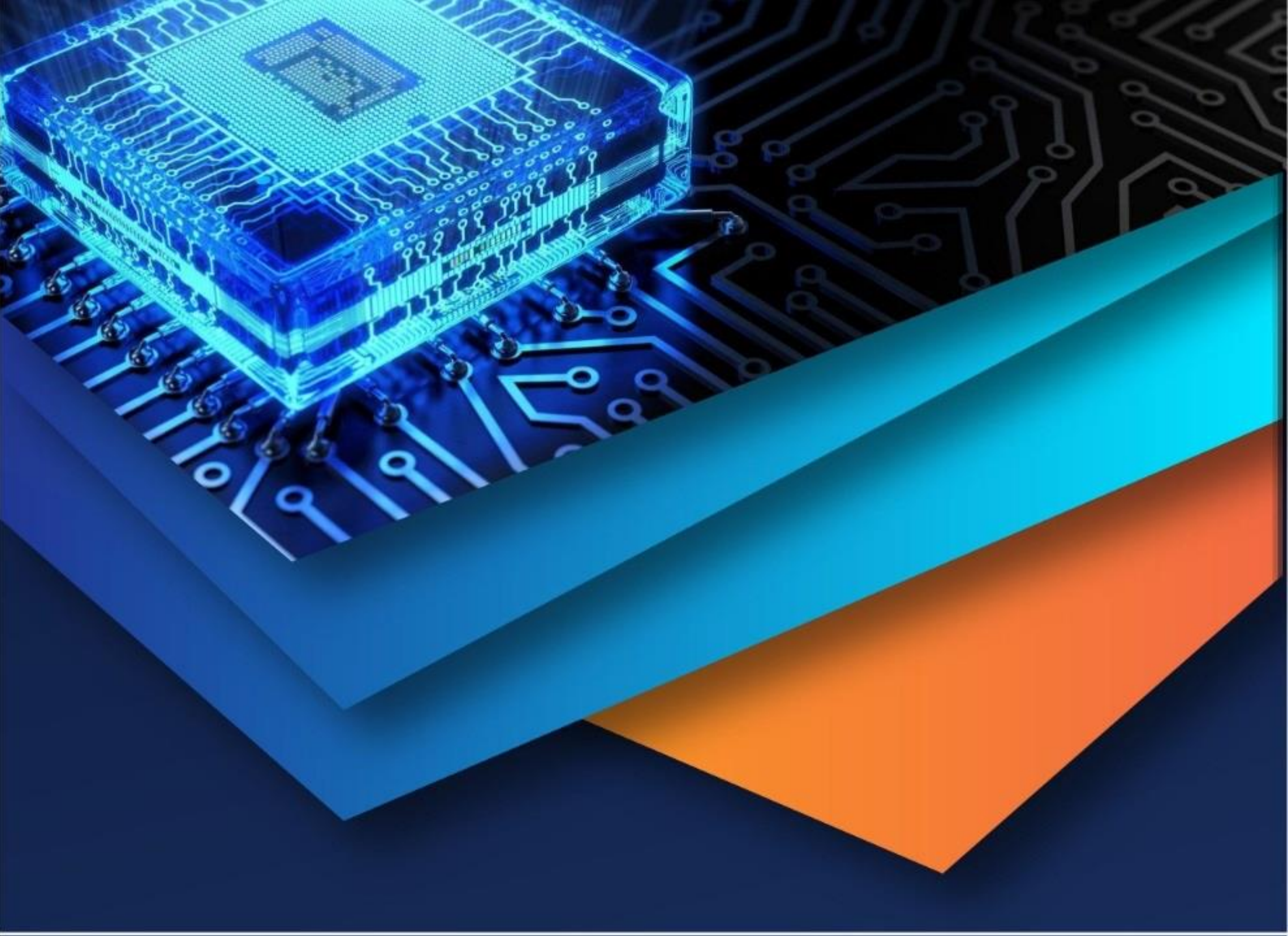

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