Comparative Study of Strength Characteristics of Clayey Soil Mixed with Natural & Synthetic Fibers

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Abstract. Soil reinforcement is now a days, an important method of improving ground by enhancing the properties of the in-situ soil. Sometimes soils available near the construction site is not strong and improving such soils will be beneficial for the project. Reinforcing such soils either by synthetic or natural fiber is a technique to improve strength of such soils. [Maity J., et al. Proceedings of Indian Geotechnical Conference, pp. 285-288. Delhi (2012)]. However each day millions of plastic bags of cement or jute bags of food grains are released to the market and disposal of such bags after use generally forms a part of solid waste requiring disposal. However, such bags can be gainfully used in improving soil properties by random mixing for compaction [Santoni, RL., et al. Journal of Transportation Engineering 127, 96-104 (2001)], thereby causing gainful disposal of such materials and simultaneously improving soil properties at a low cost.

In view of large scale infrastructure development and wide spread rural road construction in India, such use may be very welcome. Aiming this an experimental program of testing local fine-grained soil, randomly mixed with plastic cement bags and jute bags cut in square shape of varying sizes and mixed with soil in various percentages was made for finding compaction characteristics and California Bearing Ratio values at Optimum Moisture Content to estimate improvement of these properties over those of virgin soil. Results of these tests are reported in this paper.

Keywords: Re-use, Jute and Cement Bags, Random mixing, Ground improvement, Disposal.

1 Introduction

Large scale construction for development of infrastructures and rural roads are being made in India for necessary growth and development for the country. For successful implementation, optimum and efficient use of construction resources in the country is essential. Major efforts in this country are being directed towards construction of

roads bridges, railways and ports. Large quantities of fill materials are necessary for such cases. Unfortunately available fill materials near the sites of constructions may not and actually do not fulfil the quality of good fill material in-terms of strength and compressibility. In such cases, requirement arises to improve the properties of available local soils to a desired level by different possible methods. One of such methods which has been recommended for use in practice is by using synthetic and natural fibers of different lengths and percentages by weight in random mixing by Santoni et al. [1], Maity et al. [2], Maheswari et al. [3], Singh et al. [4], but in such cases the cost of used fiber are quite high. On the other hand, millions of plastic cement bags or jute bags are being used for marketing cement or food grains all over the country. After using those materials these bags form part of solid waste requiring disposal. However no plan disposal system has been yet being developed. Kalita et al. [5], Saha et al. [6] and Konar et al. [7] have suggested that these worn cement bags or jute bags can be used in improving compaction characteristics of fine-grained soil so that the dual purpose of improvement of soil & disposal of used bags could be possible.

To check the feasibility of this methodology an experimental program was undertaken to use such bag materials in square shape of different sizes mixed with locally available fine-grained soil in different percentages by weight for checking the compaction characteristics and California Bearing Ratio (CBR) values at Optimum Moisture Content (OMC) of the mix soil where the mixing is done randomly.

2 Methodology of work

Large numbers of cement and jute bags holding cement and food grains respectively are being introduced in markets everyday all over India. Such bags after consumption of holding materials become waste products and need disposal to maintain pollution-free environment. From such bags, samples of square shape and of 3 different sizes of 5mm×5mm, 10mm×10mm and 20mm×20mm respectively were taken out. Materials of each size were randomly mixed with chosen soil in 3 different percentages by weight of 0.5%, 1% and 1.5%. The samples of each size are randomly mixed with the dried powdered soil by chosen percentages by weight as stated above. Later, these mix soils were subjected to standard proctor test as per IS 2720 part 7, 1980 [8] to determine OMC and Maximum Dry Density (MDD) of the chosen mixed soil. Then the said mixed soil was compacted at OMC and subjected to CBR test in unsoaked and soaked conditions respectively as per IS 2720 part 16, 1987 [9]. The result of the above tests were utilized to see efficacy of using the added square shaped jute and cement bag portions of various sizes and percentages of mixing with the local soil on compaction characteristics and CBR value.

3 Materials Used

Soil- For the present investigation soil was chosen from a construction area at Newtown near Kolkata in West Bengal. The above soil was collected during soil exploration in a bore hole at the site for residential building projects.

The soil was obtained from auger cutting around a depth of 6m below the existing ground surface. The above soil was transported to soil mechanics laboratory at Meghnad Saha Institute of Technology, Kolkata for this experimental program. Index properties of the soil were determined as per codal provisions. Grain size distribution curve of the soil is shown in Fig. 1. Summary of geotechnical properties as determined in laboratory are given in Table 1. As per Indian Standard classification the soil is classified as Silt with Intermediate Plasticity (MI).

It is observed that OMC of the soil is 16% while MDD is 1.74 gm/cc. At OMC the CBR value in unsoaked and soaked conditions are 5.77% and 4.87% respectively.

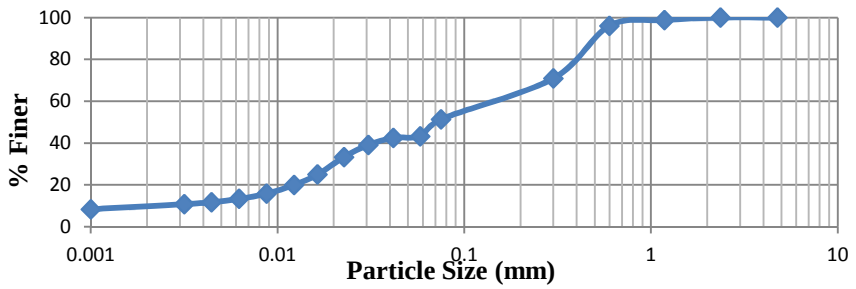

Fig. 1. Grain Size Analysis

Table 1. Physical properties of soil

Property	**Value**
Specific Gravity	2.61
Liquid Limit	46.9
Plastic Limit	32.25
Plasticity Index	14.65
Sand	48.61%
Silt	43.16%
Clay	8.23%
Maximum Dry Density	1.74 gm/cc
Optimum Moisture Content	16%
California Bearing Ratio (CBR) Unsoaked	5.77%
California Bearing Ratio (CBR) Soaked	4.87%

Jute & Cement Bag- Jute bags were purchased from local shops while cement bags was collected from a construction site. These bags were utilized for providing samples of square shapes of various sizes as stated above. Jute bags are made from woven jute fabric and cement bags were made from impermeable plastic sheet.

The thickness of the cement and jute samples are 0.048 to 0.061mm and 1.4 to 1.7 mm respectively, having weight of 0.115 kg/m^2 and 0.5512 kg/m^2 respectively. Typical samples from jute bag and cement bag are shown in Figs. 2 and 3 respectively.

Fig. 2. Used cut pieces from Jute bag

Fig. 3. Used cut pieces from Cement bag

4 Result and discussion

Experimental results of different tests conducted on the selected local soil mixed with different percentages by weight and sizes of square shaped jute and cement bags cuttings mixed randomly with soil are described in this section. Initially results of compaction tests are presented and subsequently result of CBR test in unsoaked and soaked conditions on samples compacted at OMC are described.

4.1 Compaction tests

Compaction tests were conducted on the local soil mixed with different sizes and different percentages jute and cement bag cuttings and the values of optimum moisture content and corresponding maximum dry density were obtained from those tests.

4.1.1 The variation of OMC

The values of OMC are plotted against percentage of jute bag cuttings mixed in Fig. 4 and against percentage of cement bag cuttings mixed in Fig. 5, for different sizes of the cutting.

From Fig. 4 it is observed that OMC increases with addition of jute bags cutting of any size and any percentages with respect to that of the virgin soil. However the relative increase in value of OMC is maximum when size of jute bag is 20mm×20mm. But the increase in the value of OMC reach approximately same value for all sizes when percentages of mix is 1.5%.

Similar observations are seen from Fig. 5 for cement bag cuttings. Here also OMC increases with increase in percentages of cement bag cuttings for any sizes for random mixing. But maximum increase for any percentage is observed is largest at 20mm×20mm size. Further the value of OMC is not converging to same value for different sizes when percentage of mixing is increased.

The difference in behaviour seeing in Figs. 4 and 5 is probably due to difference in behavioural pattern of jute and plastic cement bag materials. Plastic bags are totally impermeable where jute is a material which absorbed large amount of water and allow passage of water through it surrounding. When jute is introduced in soil during compaction it will absorbed water itself and allow the required water movement for compaction of the surrounding soil needed for the compaction. Thus the value of OMC will be increasing compare to that of soil but this tendency will continue only up to certain value of percentages of jute bag cutting mix for eg. 1.5% in this case of study. But in case of addition of plastic cement bag cuttings the additive being completely impermeable it does not allow water movement through their body and thereby for compaction of mixed soil requirement of larger amount of water to make compaction to be optimum and the need for excess water will gone increasing as size of impermeable additive goes on increasing. This is directly observed from Fig. 5 that the OMC is increasing with increase of both percentages of mixing and size of mixing.

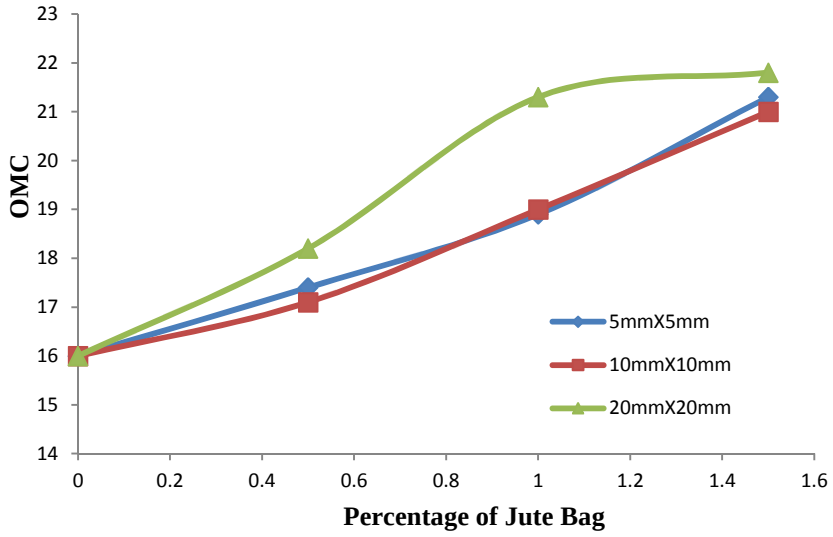

Fig. 4. OMC variation with jute bag % variation

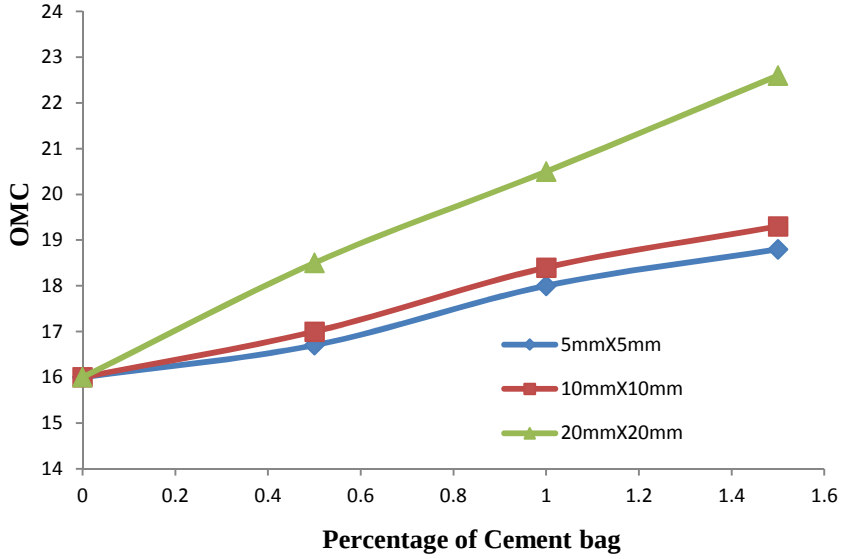

Fig. 5. OMC variation with Cement bag % variation

4.1.2. The variation of MDD

The values of MDD are plotted against percentage of jute bag cuttings mixed, in Fig. 6 and against percentage of cement bag cuttings mixed, in Fig. 7 for different sizes of the cuttings.

From Fig. 6 it is observed that MDD decreases with addition of jute bag cutting of any size and any percentages with respect to that of the virgin soil. However the relative decrease in value of MDD is maximum when size of jute bag cutting is 20mm×20mm. But the decrease in the value of MDD reach maximum in all cases when percentage of mixing is 1.5%.

Similar observations are seen from Fig. 7 for cement bag cuttings. Here also MDD decreases with addition of percentages of cement bag cuttings of any sizes for random mixing. But maximum decrease for any percentage is largest again for 20mmX20mm size.

Materials of jute bag and cement bag are very light weight compared to virgin soil. As a result when such materials are mixed randomly with soil the density of composite material will be obviously lesser than that of the virgin soil. The decrease of density will further be affected because of variation in characteristics of the material mixed. Jute is a material which soaks water many times more than its volume and allow free passage of water through it. But the material of cement bag neither soaks water and more light weight than jute. Effect of these factors during compaction of these mixed materials are reflected on the test results presented in Figs. 6 and 7.

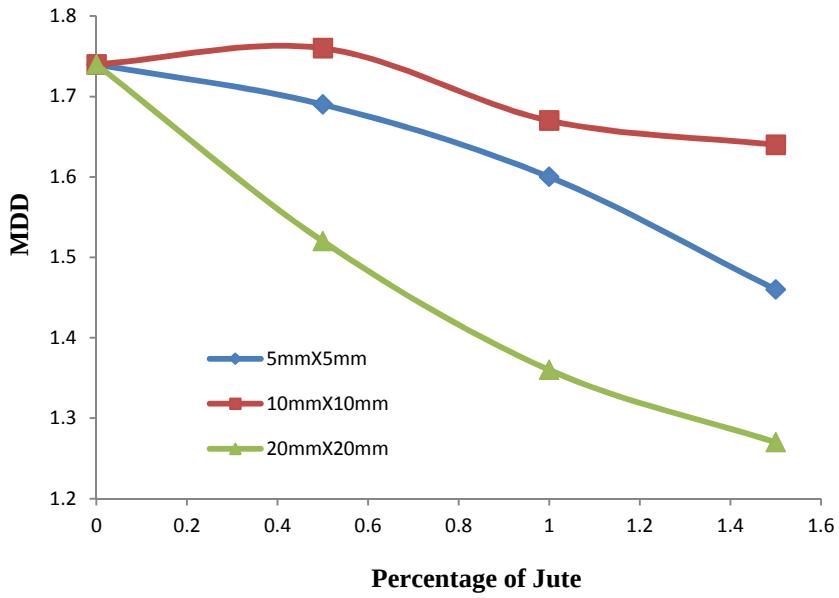

Fig. 6. MDD variation with jute bag % variation

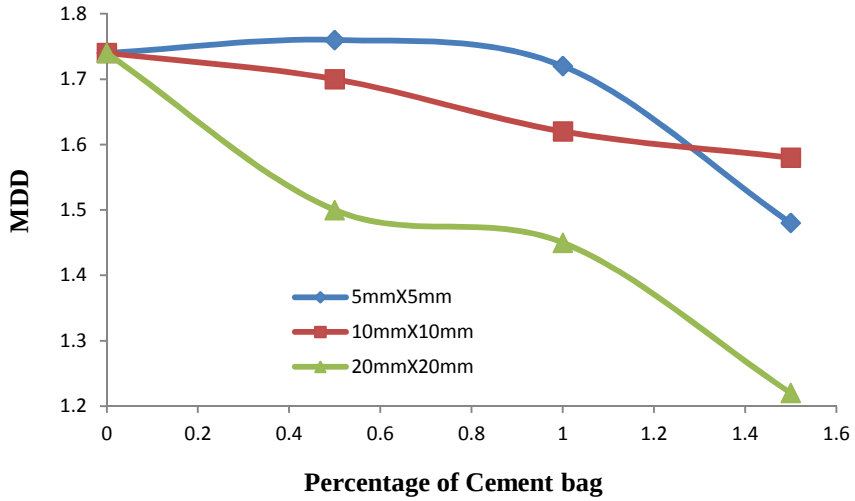

Fig. 7. MDD variation with Cement bag % variation

4.2 California Bearing Ratio test

CBR tests were conducted on the local soil mixed with different sizes and different percentages of jute and cement bag cuttings at corresponding OMC, both in unsoaked and soaked condition. The values of CBR obtained from these tests are described below.

4.2.1 The variation of Unsoaked CBR

The unsoaked CBR values for the soil randomly mixed with different sizes of jute bag and cement bag cuttings, are plotted against percentage of mixing of such materials in Fig. 8 for jute Fig. 9 for cement bag cuttings.

From Fig. 8 it is seen that for jute bag cuttings, the CBR value for unsoaked condition shows some increase in value for lower size of cutting namely 5mm×5mm and 10mm×10mm when percentages of mixing is 0.5% but the value goes on decreasing with higher values of percentage mixing but for higher value of size namely 20mm×20mm unsoaked CBR value goes on decreasing from beginning.

However from similar plot for cement bag cuttings in Fig. 9 it is seen that there is nearly 15% increase in unsoaked CBR value for all the tested cutting sizes but with further increasing percentage of mixing there is decrease in value of unsoaked CBR, the decrease being drastic for higher size, namely, 20mm×20mm.

Thus from the results of unsoaked CBR test on randomly mixed fine grain soil with jute and cement bag cuttings of square shape having different sizes and mixed in various percentages, improved CBR values are obtained when size of the cutting is smaller and percentage of mixing is around 0.5%.

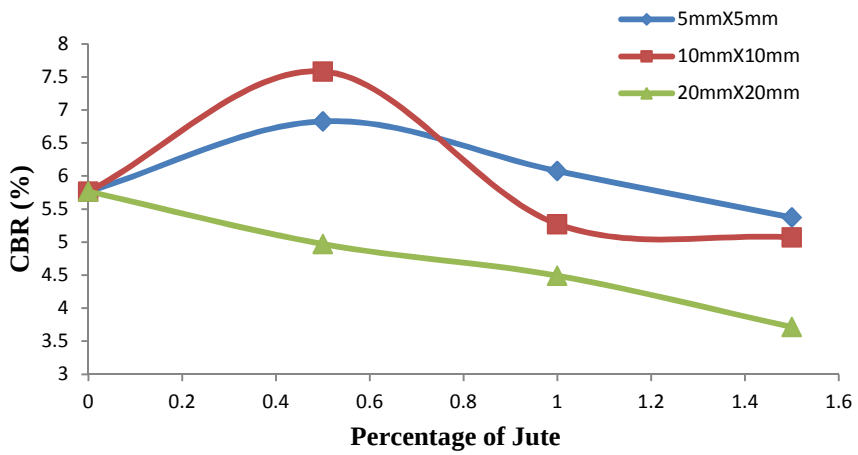

Fig. 8. CBR (Unsoaked) variation with jute bag % variation

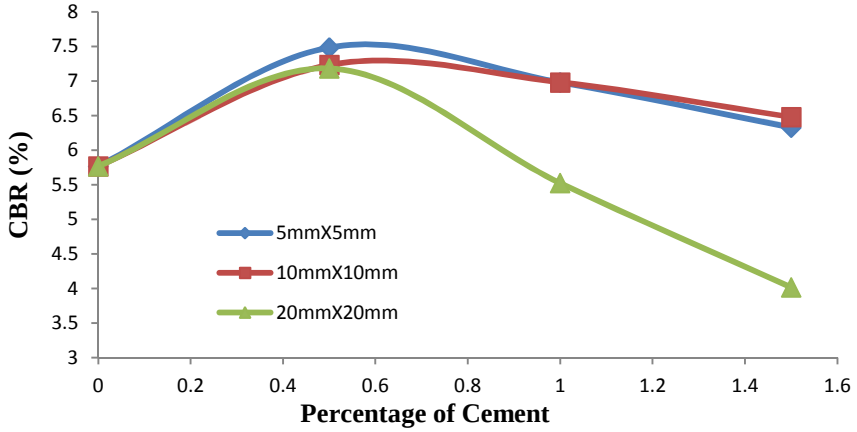

Fig. 9. CBR (Unsoaked) variation with Cement bag % variation

4.2.2 The variation of Soaked CBR

The soaked CBR values for the soil randomly mixed with different sizes of jute bag and cement bag cuttings, are plotted against percentage of mixing of such materials in Fig. 10 for jute Fig. 11 for cement bag cuttings.

From Fig. 10 it is seen that for jute bag cuttings, the CBR value for soaked condition shows some increase in value for lower size of cutting namely 5mm×5mm and 10mm×10mm when percentages of mixing is 0.5% but the value goes on decreasing with higher values of percentage mixing but for higher value of size namely 20mm×20mm soaked CBR value goes on decreasing from beginning.

For similar plot of cement bag cuttings shown in Fig. 11 very small increase in soaked CBR value is observed for smallest size of cutting namely 5mm×5mm but for other sizes most significant increase is observed at that percentage of mixing for other sizes. When percentage of mixing is further increased there is decrease in soaked CBR value.

Thus from the results of soaked CBR test on randomly mixed fine grain soil with jute and cement bag cuttings of square shape having different sizes and mixed in various percentages, improved CBR values are obtained when size of the cutting is smaller and percentage of mixing is around 0.5%.

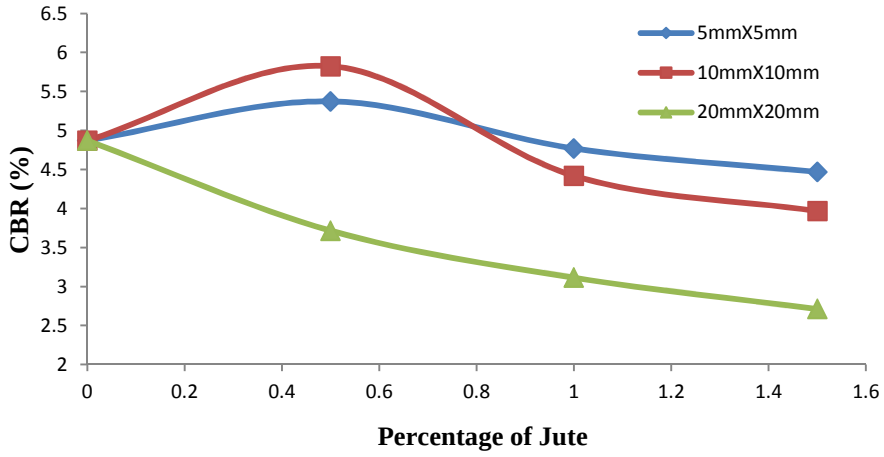

Fig. 10. CBR (Soaked) variation with jute bag % variation

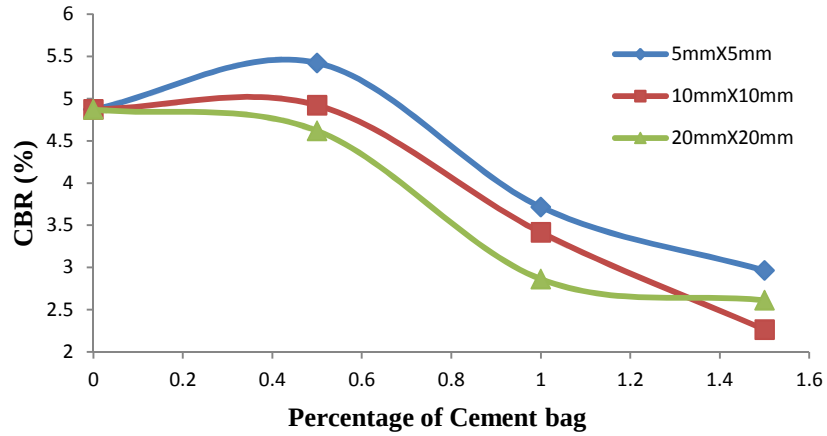

Fig. 11. CBR (Soaked) variation with Cement bag % variation

5 Conclusions

Following conclusions may be drawn on the basis of the experimental program on local fine-grained soil randomly mixed with square shaped pieces of different sizes and percentages from jute and cement bags which require pollution-free disposal.

1 The addition of any type of material used in this program for random mixing cause appreciable increase in OMC value compared to that of virgin soil. For jute materials maximum increase in OMC was seen for the size of 20mm×20mm when adding percentage by weight was 1.5%. Similar observation was seen when materials from plastic cement bag were used.
2 As a result of random mixing for both the type of materials, MDD values also show decrease in the value. For jute materials maximum decrease was observed for 20mm×20mm size when mixing percentage is 1.5% but for cement bag material maximum decrease was seen for 10mm×10mm size when mixing percentage was 1.5%.
3 There is a general trend of increase in the CBR in unsoaked or soaked conditions when size of the added material is lower and percentage of mixing is around 0.5%. Maximum increase in the value of CBR for jute material is for the size 10mm×10mm at a mixing percentage of 0.5%. Similar observation was seen for other materials also.

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