A PARAMETRIC STUDY ON BLACK COTTON SOIL STABILIZEDUSING RICE HUSK ASH

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Abstract:

Expansive soils are the residual soil formed by the weathering of igneous rocks such as basalt. These soil experience significant volume changes associated with change in moisture content. This study presents results of the geotechnical investigation of treated black cotton soil with Rice Husk Ash. Unconfined compressive strength and California Bearing Ratio were performed to estimate the optimum percentage up to which RHA can be added to the soil. The percentages of additives of RHA varied from 5% to 20% by dry weight of soil. It is observed that with increase in the RHA by weight to the soil there is an increase in Optimum moisture content and decrease in maximum dry density. Based on the UCS and CBR test, the optimum percentage of RHA obtained was 10%. The UCS value of the soil increased from 30 kN/m^2 to 74.02kN/m^2 for 10% RHA. The percentage improvement in strength was 147%. The CBR value of the soil increased from 1.18% to 2.97 % for 10% RHA. The percentage improvement in strength was 152%.

Index Terms – Black Cotton Soil, RHA, Unconfined Compressive Strength, CBR.

I. INTRODUCTION

Expansive soil is one among the problematic soils that has a high potential for shrinking or swelling due to change of moisture content. Expansive soils can be found on almost all the continents on the Earth. Destructive results caused by this type of soils have been reported in many countries. In India, large tracts are covered by expansive soils known as black cotton soils.

Black cotton soils are expansive clays with high potential for shrinking or swelling as a result of changing moisture content. Due to intensive shrink-swell processes, surface cracks resulting in openings during dry seasons. Cracks disappear during wet season but an uneven soil surface stays as a result of irregular swelling and heaving. The black cotton soils have low strength and are susceptible to excessive volume changes, making their use for construction purposes very difficult. World over, problem of expansive soils have appeared as cracking and break-up of pavements, railway and highway embankments, roadways, building foundations, irrigation systems, water lines, sewer lines, canal and reservoir linings. Rice milling generates a byproduct know as husk. Large silica content in rice husk ash makes it a good pozzolanic material and can be used for soil stabilization.

Bhasin et al. (1988), [1] made a laboratory study on the stabilization of black cotton soil as a pavement material using RHA, along with other industrial wastes like fly ash, bagasse ash, lime sludge, black sulphite liquor independently with and without lime. The RHA causes greater improvement than that caused by other wastes due to presence of higher percentage of reactive silica in it. In combination with lime, RHA improved the properties of black cotton soil significantly. Aparna Roy (2014), [2] has presented a study which gives details about soil which is stabilized with different percentages of Rice Husk Ash and a small amount of cement. IT is observed that with increase in RHA content the Optimum Moisture Content increases and there is a decrease the Maximum Dry Density. Also, the CBR value and Unconfined Compressive Strength of soil are considerably improved with the Rice Husk Ash content. Ashango and Patra (2014), [3] had studied the static and cyclic properties of clay subgrade stabilized with RHA and Portland slag cement. The optimum percentage of RHA was found to be 10% and Portland slag cement as 7.5% for stabilization of expansive soil. They concluded that the stabilized expansive soil was found suitable for subgrade of flexible pavement as, there was significant increase in strength and the stabilized soil was durable Marble Dust.

II. MATERIALS

The natural soil sample was collected from a site in Sattevanipalem, Sheela Nagar, Andhra Pradesh at 1.5 m depth from the ground level by making open trench. The collected soil was dried and pulverized into the required sizes and tested for properties like gradation, compaction, strength as per IS: 2720. The rice husk ash was collected from, Vijayanagaram, Andhrapradesh. The constituents of Rice Hush Ash are listed in Table 1.

Table 1 Chemical Properties of RHA

SNo.	Chemical Compound	Percentage (%)
1	SiO_2	97.69
2	Al_2O_3	0
3	Fe_2O_3	0.22
4	CaO	0.29
5	Na_2O	0.41
6	K_2O	1.39

III. METHODOLOGY

For finding out of the influence of RHA, the compaction characteristics of soil – RHA was determined at various proportions like 0%, 5%, 10%, 15%, 20%. After the determination of compaction characteristics the specimen are prepared with 0%, 5%, 10%, 15%, 20% of RHA for determination of unconfined compressive strength. Simultaneously the soaked California bearing ratio at various proportions was determined. The details of work plan are presented in the figure 1.

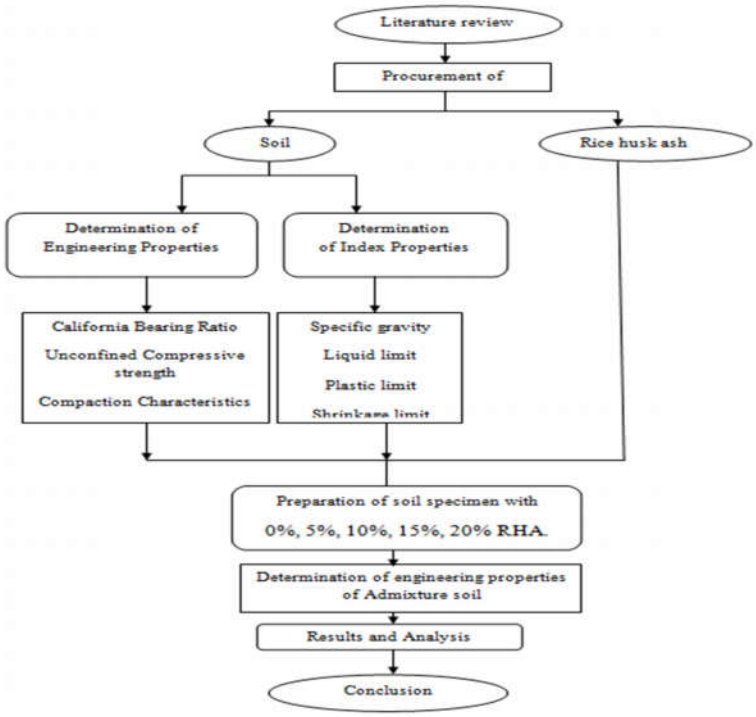

Figure 1Flowchart showing Work plan

IV. EXPERIMENTAL RESULTS AND DISCUSSION

4.1 NATURAL SOIL

The collected soil was dried and pulverized into the required sizes and tested for properties like gradation, compaction, strength as per IS: 2720 and the results are shown in Table 2 and Figure 2.

Table 2 Properties of Natural Soil

SNo.	Physical Properties	Value
1	Liquid Limit (%)	49
2	Plastic Limit (%)	23
3	Shrinkage Limit (%)	10.96
4	Plasticity Index (%)	26
5	Specific Gravity	2.4
6	Sand (%)	35.1
7	Fines (%)	64.9
	(a) silt (%)	32.45
	(b) clay (%)	32.45
8	IS Classification	CI
9	Differential Free Swell (%)	50
10	Optimum moisture Content (%)	17.4
11	Maximum dry density (g/cc)	1.82
12	California bearing ratio (Unsoaked) (%)	2.15

13	California bearing ratio (soaked) (%)	1.18
14	Unconfined Compressive Strength (kN/m^2)	30

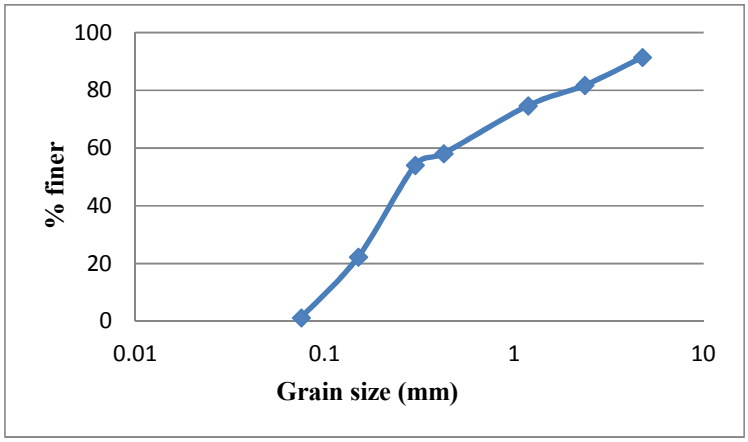

Figure 2 Grain size distribution curve of Black Cotton Soil

From the test results it is identified that it contains fines (less than 75μ) of 65% .shows it is of alluvial origin and contains 32.45% of silt and 32.45% as clay particles. The presence of fines contributed for high liquid limit (w_L) of 49 % and plasticity index of 26 % and classified as CI soil based on IS: 1498-1970.It also exhibited high swelling characteristics with Differential Free Swell of 50%. It exhibited very low strength values under soaking condition in terms of CBR as 1.18%.

4.2 RICE HUSK ASH (RHA)

The collected Rice husk ash was dried and subjected to various geo-technical characterizations such as gradation, index properties etc., and the test results are shown in Table 3 and Figure 3.

Table 3 Geotechnical Properties of RHA

SNo.	Physical Properties	Value
1	Liquid Limit	NP
2	Plastic Limit	NP
5	Specific Gravity	1.4
6	Gravel (%)	0
7	Sand (%)	97
8	Fines (%)	3
9	IS Classification	SP

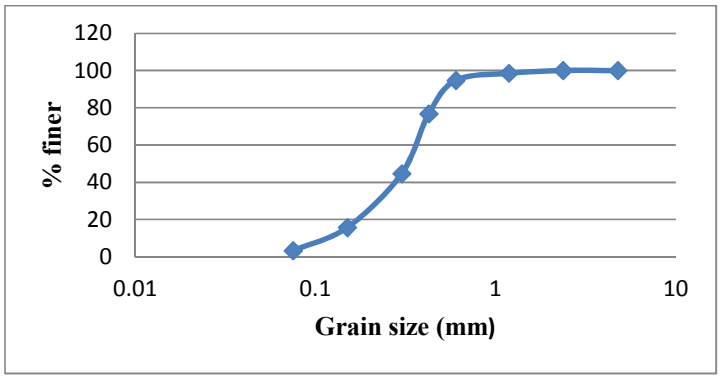

Figure 3 Grain size distribution curve of Rice Husk Ash

4.3 EFFECT OF RICE HUSK ASH ON FREE SWELL INDEX

Free Swell Index test was conducted on soil with increasing percentage of RHA by weight basis. The effect of RHA on free swell index of black cotton soil is shown in Table 4 and variations are shown in Figure 4.

Table 4 Effect of RHA on Free Swell Index

RHA (%) in Soil	Free Swell Index (%)
0	50
5	25.23
10	18.00
15	13.33
20	9.09

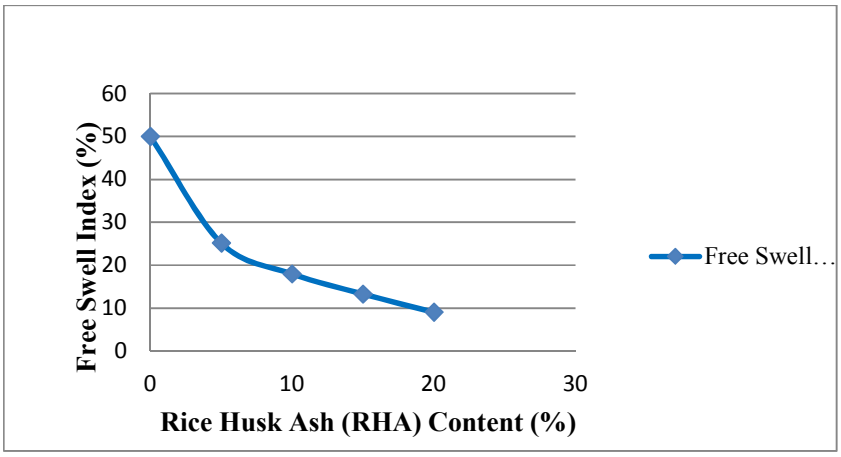

Figure 4 Effect of RHA on Free Swell Index (%) of Black Cotton Soil

From the graph, it is observed that with increase in rice husk ash content there is a decrease in free swell index.

4.4 EFFECT OF RICE HUSK ASH ON COMPACTION CHARACTERISTICS OF SOIL

Procter compaction test was conducted on soil with increasing percentage of RHA by weight basis. The effect of RHA on maximum dry density and optimum moisture content of black cotton soil is listed in Table 5 and variations are shown in Figure 5 and 6.

Table 5 Effect of RHA on Compaction Characteristics

SNo.	Properties	Percentage of Rice Husk Ash				
		0%	5%	10%	15%	20%
1	Optimum moisture Content (%)	17.4	19.04	21	22.56	23.82
2	Maximum dry density (g/cc)	1.82	1.71	1.6	1.57	1.54

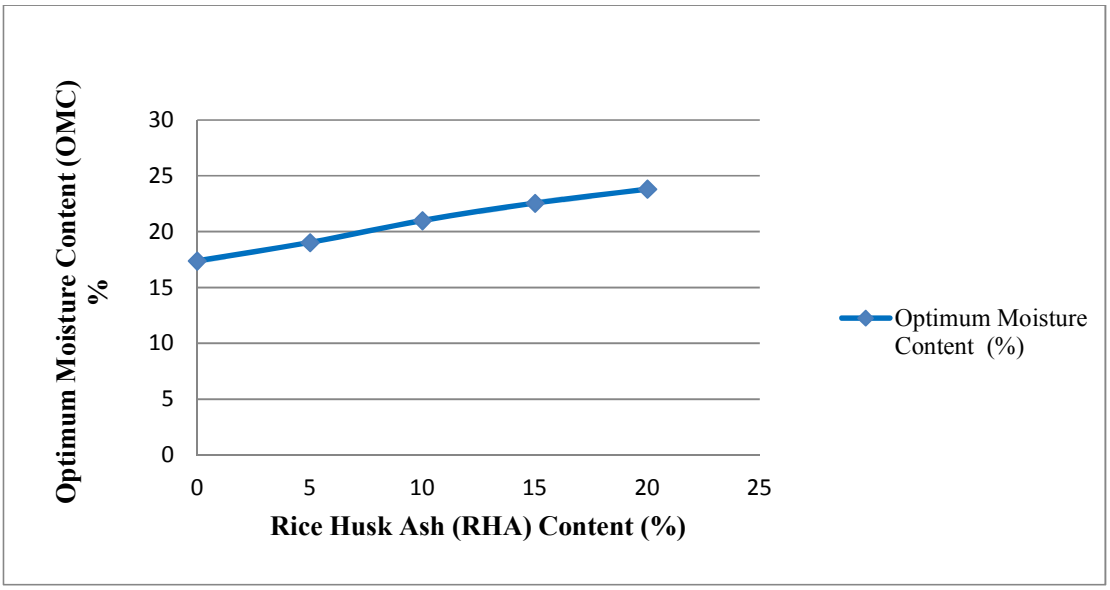

Figure 5 Effect of RHA on Optimum Moisture Content (%) of Black Cotton Soil

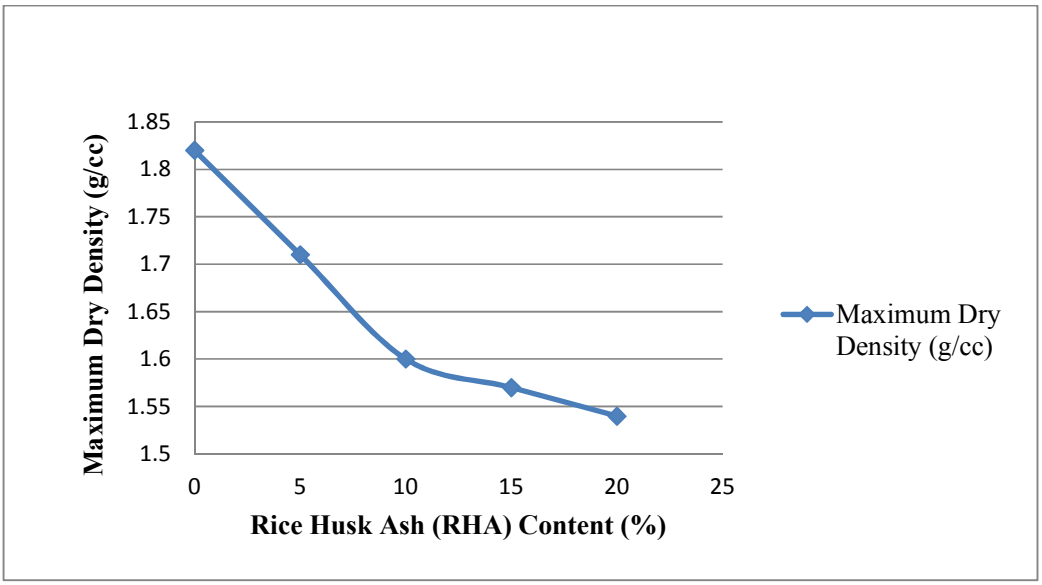

Figure 6 Effect of RHA on Maximum dry density γ_{dmax} (g/cc) of Black Cotton Soil

From the graph, it is observed that with increase in rice husk ash content there is a decrease in maximum dry density and increase in optimum moisture content.

4.5 EFFECT OF RICE HUSK ASH ON UNCONFINED COMPRESSIVE STRENGTH OF SOIL

Unconfined compressive strength test was conducted on soil with increasing percentage of RHA by weight basis. The effect on unconfined compressive strength of soil on addition of RHA is shown in the Figure 7.The comparative effect are listed in Table 6 and variations are shown in Figure 8.

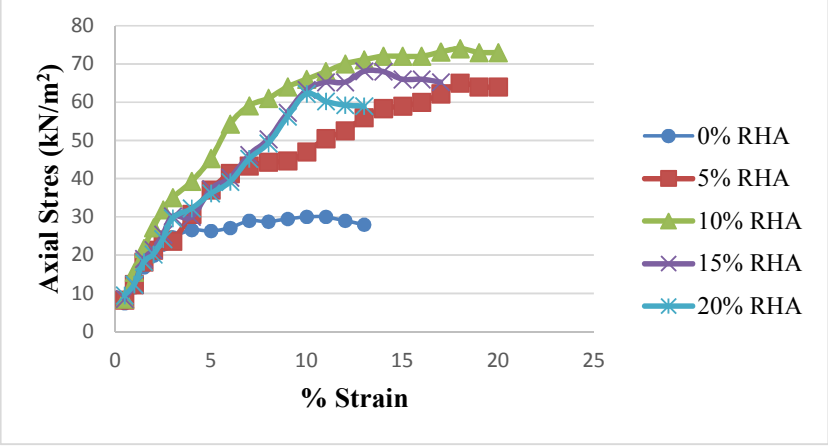

Figure 7 Effect of RHA on Unconfined Compressive Strength (kN/m^2) of Black Cotton Soil

Table 6 Comparative Effect of RHA on Unconfined Compressive strength

SNo.	Properties	Percentage of Rice Husk Ash				
		0%	5%	10%	15%	20%
1	Unconfined Compressive Strength (kN/m^2)	30	65.03	74.02	68.07	62.2
2	Improvement in Strength (%)	-	117	147	127	107

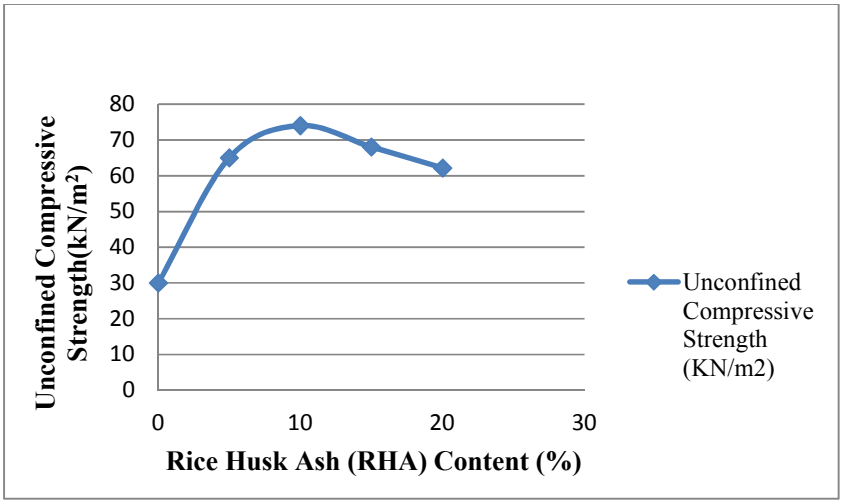

Figure 8 Comparative Effect of RHA on Unconfined Compressive Strength (kN/m^2) of Black Cotton Soil

From the graph, it is observed that initially the UCS value increases with increase in percentage of RHA, reaches a maximum, and then it starts decreases. Maximum strength was obtained for soil treated with 10% of RHA, and the percentage improvement in strength was about 147%.

4.6 EFFECT OF RICE HUSK ASH ON CALIFORNIA BEARING RATIO OF SOIL

Soaked CBR test was conducted on soil with increasing percentage of RHA by weight basis. The CBR of Black Cotton Soil at Varying Proportion of RHA is shown in the figure 9.The comparative effects are listed in Table 7 and variations are shown in Figure10.

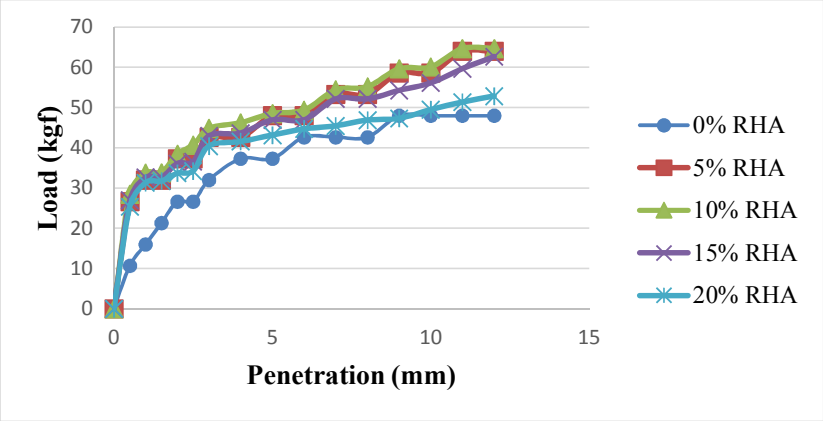

Figure 9 California Bearing Ratio of Black Cotton Soil at Varying Proportion of RHA

Table 7 Effect of RHA on California Bearing Ratio

SNo.	Properties	Percentage of Rice Husk Ash				
		0%	5%	10%	15%	20%
1	California Bearing Ratio(%)	1.18	2.72	2.97	2.67	2.5
2	Improvement in Strength (%)	-	144	152	126	112

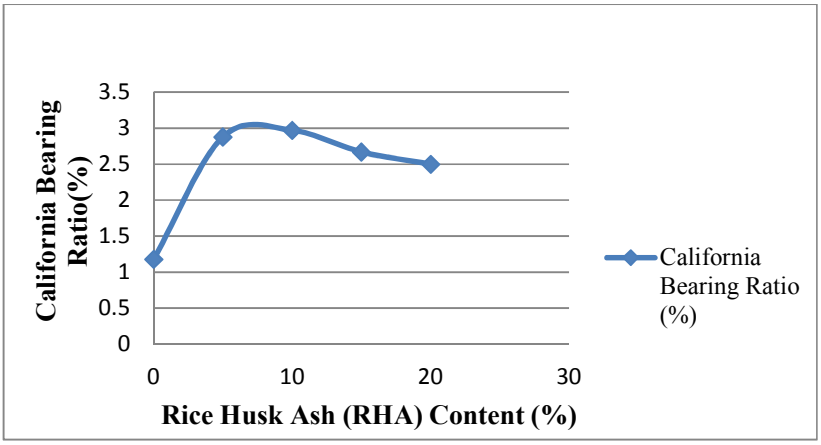

Figure 10 Effect of RHA on California Bearing Ratio of Black Cotton Soil

From the graph, it is observed that initially the CBR value increases with increase in percentage of RHA, reaches a maximum, and then it starts decreases. Maximum strength was obtained for soil treated with 10% of RHA, and the percentage improvement in strength was about 152%.

V.CONCLUSION

Based on the laboratory test carried out on soil rice husk ash mix, following conclusion can be drawn.

- Based on the compaction characteristics it is found that, with increase in percentage of RHA, MDD decreases and OMC increases.
- Based on free swell index test it is observed that with increase in rice husk ash content there is a decrease in free swell index.
- Based on the UCS test, the optimum percentage of RHA obtained was 10%.The UCS value of the soil increased from 30 kN/m^2 to 74.02kN/m^2 for 10% RHA. The percentage improvement in strength was 147%.
- Based on the CBR test, the optimum percentage of RHA obtained was 10%.The CBR value of the soil increased from 1.18% to 2.97 % for 10% RHA. The percentage improvement in strength was 152%.
- From test result it is observed that, RHA can be used as a soil stabilization material.

VI. REFERENCES

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