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VARIABILITY IN THE GEOTECHNICAL PROPERTIES OF SOILS OF BARIND TRACT IN BANGLADESH

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Abstract—**Soils from Barind tract have been investigated to finding out their geotechnical properties and determine the possible variations between them. Three types of soil samples has been collected from Godagari, Tanore and Kakonhat and they were subjected to a number of geotechnical tests in the laboratory. Then the obtained values were subsequently subjected to statistical analysis. This investigation revealed that the soils are inorganic, well graded and are expected to compact to a low porosity and hence permeability than uniformly graded materials from same parent materials and from same geologic origin, with medium plasticity, suitable for used as landfill purpose. Statistical ANOVA test showed significant difference exists between the soils in terms of specific gravity, liquid limit, plastic limit, linear shrinkage, % clay size fraction, unconfined compressive strength, maximum dry density and significant difference exists between soils in terms of plasticity index, optimum moisture content, amount of fines. Coefficient of variation is maximum for clay size fraction and the coefficient of variation is minimum for maximum dry density. Although most of the parameters examined are not as varied, the equations generated provide an option in the estimation of properties considering..**

Keywords— **Barind Tract, Geotechnical Properties, UC Strength, MDD**

I. INTRODUCTION

The relationship between all engineering infrastructure and their foundation soils is too important to be ignored. For improving infrastructural development it is necessary to increase soil utility for engineering works. Negligence of using good quality soil will lead to uncountable road and structural failure. Clay is predominant in most of these soils. However clay is also a predominant soil of Bangladesh. Soils are being used for various construction works in Godagari, Tanore and various other North Bengal part of Bangladesh which are under Barind tract. Various houses are built with clay soils. Soils are also being used for production of ceramic materials and burnt bricks. Various researchers have done investigations on geotechnical properties of clay soils in all over the world. Adeyemi et al. (1990) worked on some index properties and crushing strength of three Barind lateritic clay deposits with the aim of seeing how the materials could be used for bricks. I.A Oyediran and H.F Durojaye (2011) investigated the geotechnical properties of residual clay soils of Southwestern Nigeria, using statically and linear regression analysis determined strength of soils of geotechnical properties. Adesunloye (1987) has through standard laboratory testing procedures, identified the problem soils in the Lagos area as peaty clays. Wu and El–Jandali (1985) used statistically analysis to carry out systematic studies of the variability of rock and soil parameters. Que et al. (2008) investigated the geotechnical properties of the soft soil in Guangzhou college city in China which were found to be difficult both to sample and test. The authors developed equations using statistical and linear regression analysis and confirmed that using these equations, the mechanical indices of the soils could be estimated from the physical indices determined by routine testing. Various researches have also been done on behavior of soils in Barind track of Bangladesh. However a few of work has been done to understand the variations which exist in the geotechnical properties of soils from Barind track .As a result of the extremely variable nature of geologic materials, this paper is a bid to determine the variation in the geotechnical properties of soils collected from three different places of Barind track in Bangladesh.

II. SCOPE OF THE RESEARCH

The scope of the research is to determine details information about collected soils. The main scope of the study are-

a) It is to identify the soils.

b) It is to classify the soils.

c) It is to recognize whether or not the soils are suitable to be used for construction purpose.

III. OBJECTIVE OF THE RESEARCH

The objective of the research is as follows –

a) To determine geotechnical properties of collected soils by accompanying different laboratory tests such as specific gravity test, liquid limit test, plastic limit test, shrinkage limit test, grain size analysis, unconfined compressive strength test and standard proctor test.

b) To determine possible variation of physical properties of the soil samples by forming statistical analysis and relationships.

IV. STUDY AREA

A. Brief Description of Study Area –

Our study area is Tanore and Godagari Upazila of the North-West parts of Rajshahi district in the division of Rajshahi, Bangladesh. Tanore Upazila is located in northwestern part of Bangladesh and is an upazila under the District of Rajshahi of Rajshahi Division (Fig.1). The geographical location of the study area is located in between 24° and 88° and 24°43'N latitudes and between 88°24'E 38'E longitudes side to western side.

The study area has diverse elevation from mean sea level its elevation increase from eastern only river Shiva is flowing in eastern most part of the study area and wetland Beelkumari is also located in eastern part. The river Shiva originate 4ft from the wetland Mandau Beal of Mandau Upazila under Naogaon District and flowing across the wetland Beelkumari and this river is also fed by numerous creeks originated from the western side of High Barind Tract. The river and Beal almost dried in the winter season and used for boron paddy cultivation by using groundwater from deep tube wells. Physiographically study area includes Barind Tract (81.8%) old Gangetic Floodplain (3%), Taste Floodplain (4.8%) and others (10.4%) including wetlands, river, homesteads etc. Soil textural classes of the study area are Clay loam 46%, Loam 35%, Clay 8% and miscellaneous 11% (home-steads, wetlands etc.). On the other hand, Godagari is the place where Mahananda River falls to Padma or Ganges. This Upazila is located at 24.466ºN88.3306ºE.

This area displays the typical type alluvial plain of the delta in the East and South and the hill is called Barind Tract in the West. The alluvial plain is about 12m or 40ft above the mean sea level, whereas Barind Tract being between 12-45m and 40-130ft.

Fig.1. Location of study area (Source: bpedia.org)

Fig. 2 shows some cracking of barind tract soil due to shrinkage failure in selected studied are.

Fig.2. Cracking due to failure of clay soils

V. MATERIALS AND METHODS

Three types of clay soils has been collected from three study area Godagari, Tanore, kakonhat which is denoted by soil sample A, B and C respectively. The collected soil samples were taken in the laboratory and dried for 24 hours. Then the soil samples were subjected to various laboratory tests including specific gravity, grain size distribution, consistency limits, linear shrinkage, unconfined compressive strength and compaction. All the getechnical tests were done in accordance with ASTM test procedures. Subsequently the results were subjected to statistical analysis to better evaluate and understand the variations and relationships which exist.

VI. RESULTS AND DISCUSSIONS

A. Specific Gravity –

Specific gravity is an important index property of soils that is closely linked with mineralogy and/or chemical composition the average values of specific gravity for sample A is 2.53, sample B is 2.50, and sample C is 2.55. The higher the specific gravity the higher the degree of laterization indicate that sample C exhibit higher degree of laterization than that of sample A and B, the degree of laterization of sample B is less than that of sample A and C and sample A exhibit higher degree of laterization than that of sample B. It also indicates that the soils are from the same parent materials. This classification is made according to Maignien (1966) who established a positive correlation between the specific gravity of soils and their degree of linearization. On the basis of the classification by T.N. Ramamurthy, and T.G. Sitharam (2005) the soils fall within either sand, silt or clay type of soil with mica or iron.

B. Liquid Limit –

From figures 3, 4 and 5 it is shows that, the average values of liquid limit of sample A, B, C are 33.83, 30.00, 31.50 respectively. Based on the specification of maximum liquid limit of 40% by Federal Ministry of Works and Housing for soils used as highway subgrade materials, the average liquid limit of the three soil samples under consideration shows they are not suitable for use.

C. Plastic Limit –

The average values of plastic limit for sample A, B, C are 18.81, 15.06, 16.49 respectively. It was assumed that the plastic limit of a soil follows the same behavior as that of the liquid limit. These relationships are valid only if the non-clay particles are not in contact.

D. Shrinkage Limit –

The shrinkage limit (SL) is the water content where further loss of moisture will not result in any more volume reduction. The shrinkage limit of sample A is more than sample B and C. And shrinkage limit of sample C is more than sample B. All the soil samples have higher linear shrinkage than the maximum 8% specified for highway sub grade soils.

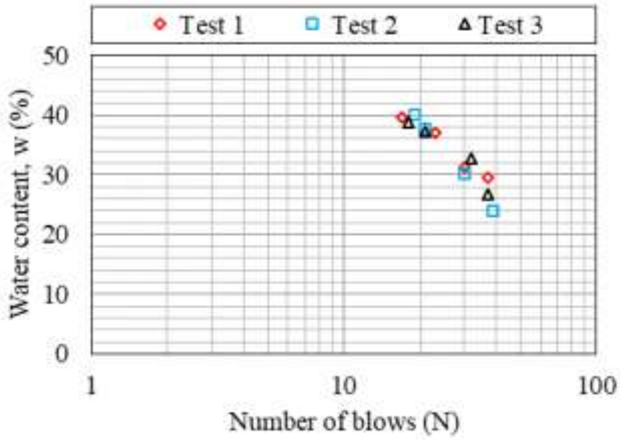

Fig. 3. Flow curve of liquid limit (for sample A)

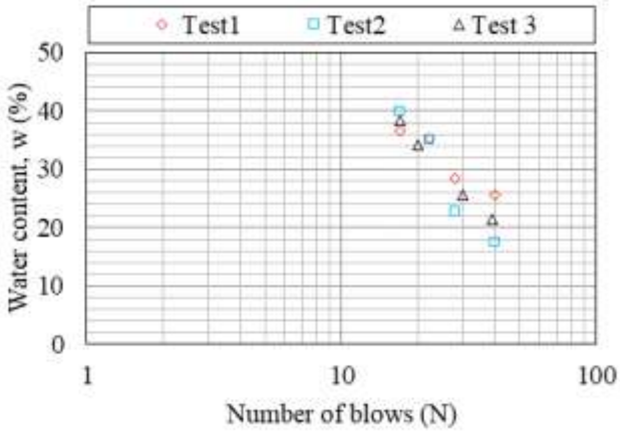

Fig. 4. Flow curve of liquid limit (for sample B)

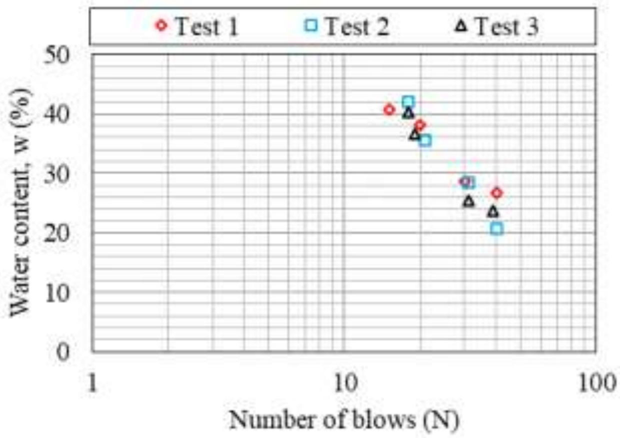

Fig. 5. Flow curve of liquid limit (for sample C)

D. Grain Size Analysis –

Figures 6, 7 and 8 represents the average amounts of clay, silt, sand and gravel for sample A, sample B and sample C are respectively 28%, 69%, 3.05%, .77% and 17%, 78%, 3.95%, .98% and 20%, 75.5%, 3.5%, .745%. The average amounts gravels and sands are higher for sample B than sample A and C. Amount of fines are nearly same for both soil sample. Sample A is silty clay, sample B is silty clay loam, sample C is silty clay loam.

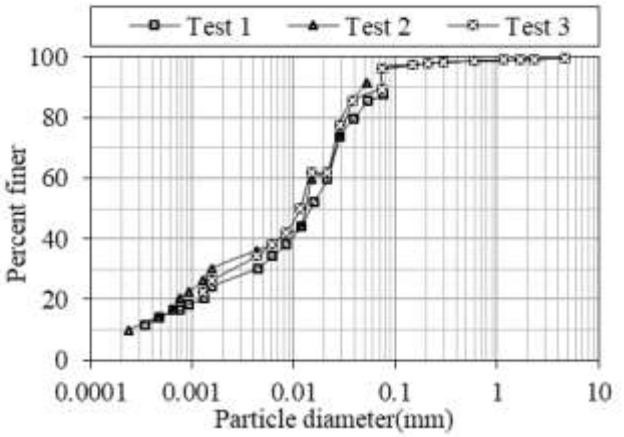

Fig. 6. Grading curve (for sample A)

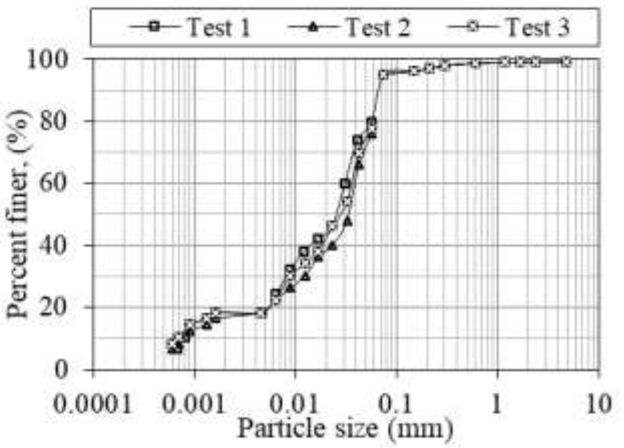

Fig. 7. Grading curve (for sample B)

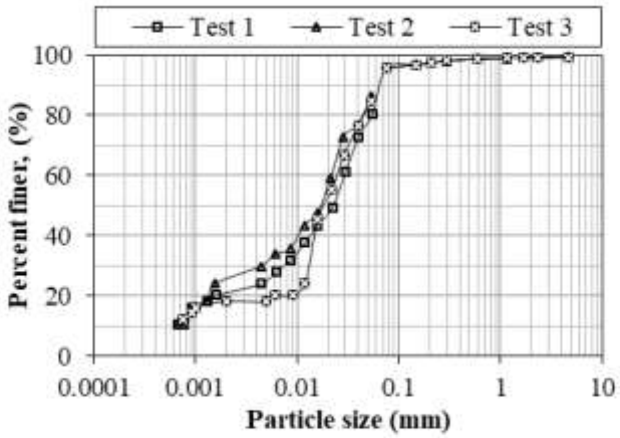

Fig. 8. Grading curve (for sample C)

Grain size distribution of soil samples is important for determining the gradation of soil samples which is an indicator of other engineering properties such as compressibility, shear strength, and hydraulic conductivity. The average amount of fines 59.50 and 64.50% indicative of soils with poor engineering properties since the amount of fines are greater than 50%.

E. Unconfined Compressive Strength –

The Unconfined Compression test is used to measure the shearing resistance of cohesive soils. Figures 9, 10 and 11 indicates that the unconfined compressive strength for tested sample are shows that sample A have higher average unconfined strength than that of sample B and C, and sample C has higher unconfined compressive strength than sample B.

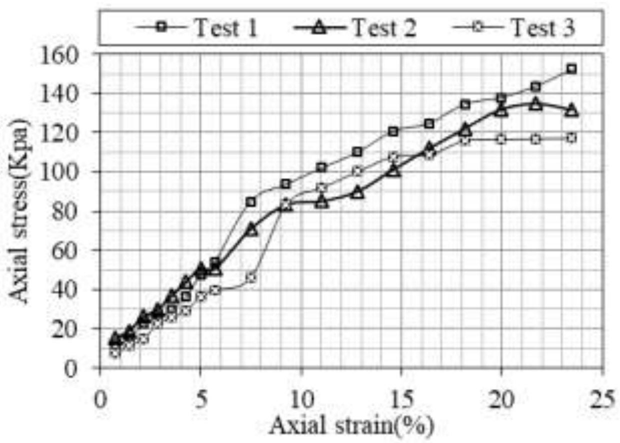

Fig. 9. Typical stress vs strain graph from an unconfined compressive strength test (for sample A)

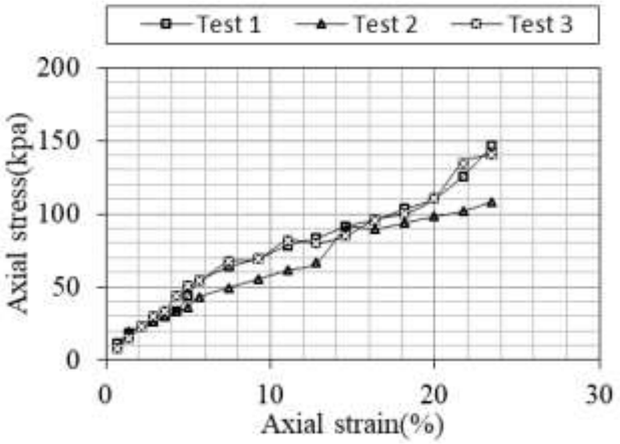

Fig. 10. Typical stress vs strain graph from an unconfined compressive strength test (for sample B)

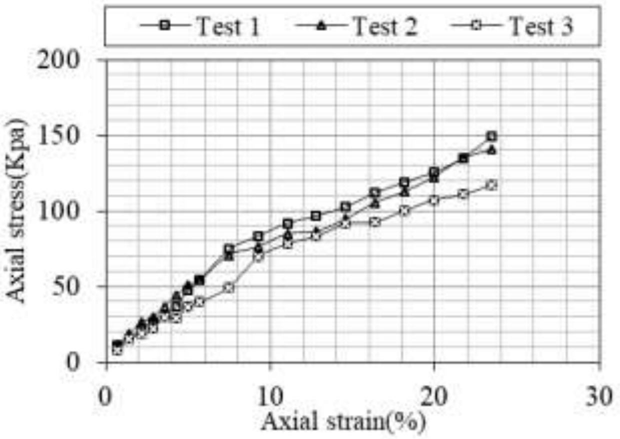

Fig. 11. Typical stress vs strain graph from an unconfined compressive strength test (for sample C)

F. Compaction Characteristics –

Soil compaction is defined as the method of mechanically increasing the density of soil. The soils for the present study were compacted at the modified AASHTO level of compaction. From figures 12, 13 and 14, the average maximum dry density and optimum moisture content of the soils are higher for sample A than sample B and C and higher for sample B than sample C. The nature of a soil itself has a great effect on its response to a given compactive effort. Soils that are extremely light in weight, such as diatomaceous earths and some volcanic soils may have maximum densities under a given compactive effort as low as .96g/cm2. OMC varies from about 12 to 25 percent for fine-grained soils and from 7 to 12 percent for well-graded granular soils.

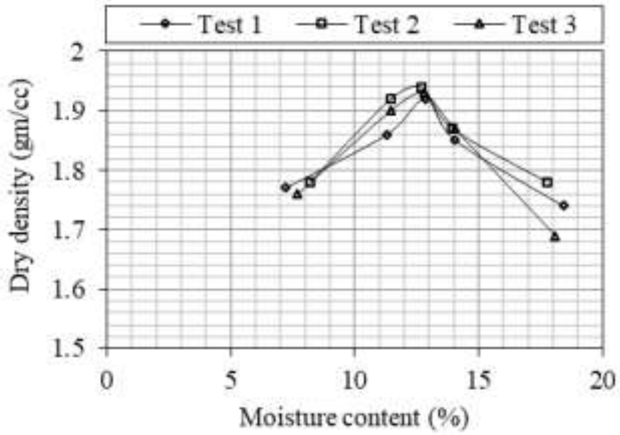

Fig. 12. Standard proctor compaction test curve (for sample A)

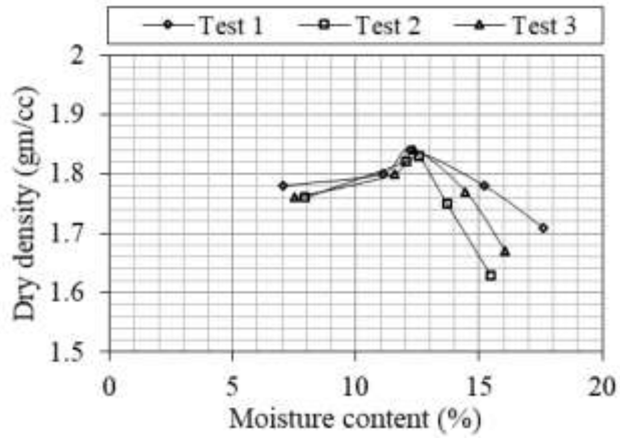

Fig. 13. Standard proctor compaction test curve (for sample B)

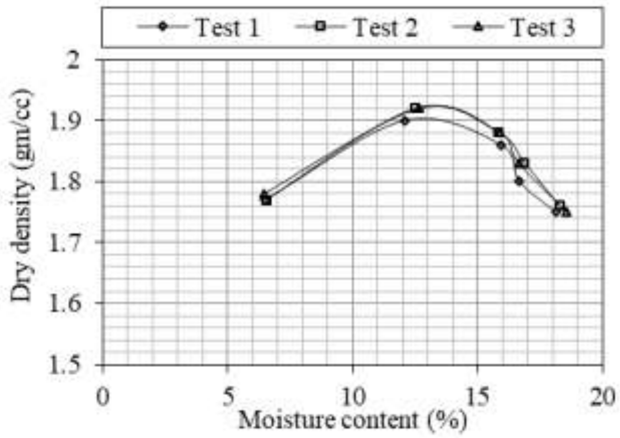

Fig. 14. Standard proctor compaction test graph (for sample C)

F. Statistical Analysis and Relationships –

The results of all the parameters examined were first subjected to statistical ANOVA test, correlation coefficient, coefficient of variation and linear regression analysis and the observations are dis-played in tables 1 and 2. From the analysis of the data sets observed for soils , statistical ANOVA test showed no significant difference exists between the soils in terms of specific gravity, liquid limit, plastic limit, plasticity index, linear shrinkage, % clay size fraction, amount of fines and significant difference exist between soils in terms of unconfined compressive strength and optimum moisture con-tent, maximum dry density. Furthermore in terms of correlation coefficient, strong positive correlation exist between sample A and B in terms of specific gravity, liquid limi, plastic limit, plasticity index, unconfined compressive strength, optimum moisture content, strong positive correlation exist between sample B and C in terms of specific gravity, liquid limit ,plastic limit, plasticity index, % clay size fraction, unconfined compressive strength. strong positive correlation exist between sample C and A in terms of specific gravity, liquid limit, plastic limit, plasticity index, linear shrinkage ,amount of fines, unconfined compressive strength. Again,, strong negative correlation exist between sample A and B in terms of %clay size fraction, linear shrinkage, amount of fines, maximum dry density, strong negative correlation exist between sample B and C in terms of linear shrinkage, amount of fines, optimum moisture content, maximum dry density, strong negative correlation exist between sample C and A in terms of % clay size fraction, optimum moisture content, maximum dry density. The coefficient of variation determined showed that the % clay size fraction is the most variable parameter at 26.244% which does not show notable difference as the case may be. The value of specific gravity, liquid limit, plastic limit, plasticity index, linear shrinkage, amount of fines, unconfined compressive strength, optimum moisture content and maximum dry density were varied not greatly and hence they show no significant variation. Linear regression equations between three soil samples for different parameters have also been established, which is useful to depict the linear relation-ships which exist between the properties of soils.

Table -1 Results of statistical analysis and relationships

Parameter	ANOVA test (Nature of difference)	Correlation coefficient		
		Between sample A and sample B	Between sample B and sample C	Between sample C and sample A
Specific gravity	Significant	0.866	0.866	-1
Liquid limit	Significant	0.9608	0.5	0.7206
Plastic limit	Significant	0.9953	0.9963	0.9836
Plasticity index	Insigificant	0.9608	0.8719	0.9735
Linear shrinkage	Significant	-0.9904	-0.9993	0.9949
% clay size fraction	Significant	-0.866	-0.9449	0.9949
Amount of fines	Insignificant	-0.9177	-0.866	0.596
Unconfined compressive strength	Significant	0.8846	0.9862	0.7954
Optimum moisture Content	Insignicant	-0.982	-0.9449	0.866
Maximum dry density	Significant	0.3647	0.5544	-0.5727

Table -2 Results of statistical analysis and relationships of all Sammples

Parameter	Coefficient of variation (%)	Linear regression equation		
		Between sample A and sample B	Between sample B and sample C	Between sample C and sample A
Specific gravity	7.91	1.2417 + 0.5 x	1.2317 + 0.5 x	-0.02 + 1 x
Liquid limit	6.073	14.38 + 0.46 x	24.75 + 0.17 x	17.17 + 0.53 x
Plastic limit	11.27	-2.81 + 0.95 x	4.20+ 0.655 x	7.58 + 0.68 x
Plasticity index	4.45	-5.13 + 1.33 x	5.34 + 0.67x	7.31 + 0.54 x
Linear shrinkage	12.12	41.34 -2.26 x	25.45 -1.23 x	8.18 + 0.45 x
% clay size fraction	24.21	32.5 -0.5 x	29.61-0.5357 x	15.07 + 0.64 x
Amount of fines	4.21	97.58 -0.21 x	95.93 -0.2 x	36.87 + 0.6 x
Unconfined compressive strength	10.08	65.19 + 0.22 x	50.24 + 0.41 x	-16.53+ 1.32 x
Optimum moisture Content	2.93	12.25 + 0.009 x	-117.15 +2.38x	5.3124 + 0.55x

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