Characterization of soft soil deposit of Indo Bangla Railway Project

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Abstract:- Tripura, one of the north-eastern state of India, Agartala being the capital city with fast growing infrastructural facilities and population due to its global importance by acting as business corridor for South East Asian countries through Bangladesh. Present study attempts to highlight the characterization of sub-soil deposits encountered in Indian part of the Indo Bangla railway project which may be an important study for safe and sustainable design of foundation. Total 47 number of exploratory bore holes upto 25-30 mtr depth were conducted physical and engineering parameters are accordingly investigated. This study presents properties of subsoil of that area from 3 undisturbed soil samplers. Laboratory investigation was carried out for evaluating grain size analysis, shear strength parameters, consolidation parameters. From the tests conducted on the samples it was found that the samples had very low shear strength and high compressibility values. Rate of change of pore water pressure along with shearing was also developed which gave an idea of the effect of pore water on the clay and organic soil. Thus the outcome of present study will be helpful for carrying out safe and economic foundation design of the proposed railway embankment as well as assess vulnerability of the proposed construction from future disasters.

Keywords: Soft peat clay, Engineering parameters, Indo-Bangla Railway.

1 Introduction

Very soft peaty type clay mixed with decomposed matter are very problematic type of soil from constructional point of view for a geotechnical engineer due to high compressibility, amorphous nature of soil, settlements of high order, creep and subsequently low bearing capacity which may ultimately lead to low bearing capacity, not suited for the superstructure (Terzaghi et.al., 1996). Soil mixed with decomposed matter which may be characterized as organic soil (OS) consists of organic matter (OM) mixed in varying percentages of decomposed plants and animals which are synthesized by chemical reactions.

The Indo-Bangla railway project which is to be constructed at Agartala, Tripura, whose 5km stretch passes through India, mostly encountered soft clay(SC) and OS which were obtained during the 47 borings conducted in that stretch having boring length upto a depth of 25-30m. The present study deals with the experimental investigation of the soil collected from three undisturbed soil samplers of bore holes which were collected from the site during sub soil investigation, which would give a detailed idea about the sub soil deposit. The collected samples were undergone tests to determine the physical parameters, percentage of OM, Atterberg limits, shear strength parameters and consolidation properties.

2 Experimental Investigation

2.1 Sample Collection

SC and OS were obtained by samplers having Inside Clearance (C_i) ranging from 1 to 3% and having Area Ratio (A_r) of less than 10%. OS obtained was amorphous in nature with varying decomposition of plant and animal remains whereas two samples of SC were devoid of OM. Thin tube samplers were used for collecting undisturbed soil (UDS) samples from the site at a depth varying from 1.5 to 3.00m from earth ground level (EGL). Collected samples were waxed on both the open ends in order to fully secure the collected samples and to minimize the moisture loss. Samplers were kept vertically in upright position in a room having 85% humidity and at a constant temperature of 20˚C.

2.2 Physical Parameters

Water content of the soil were determined by oven drying the SC at 105˚C and OS at 75˚C, as per Indian Standards (IS): 2720 (Part 2). Organic Content (OC) of soil was obtained by igniting 50gm of ovendried soil sample in a muffle furnace at a temperature of 450˚C following ASTMD2974 (ASTM 2007). OC was obtained by igniting OS which had 26% OM and having 74% ash content as shown in Fig. no.1. Grain size analysis and hydrometer test were further conducted in order to determine the percentages of sand, silt and clay as per IS: 2720 (part4). In case of OS pretreatment of the soil was necessary in order to oxidize the OM of the soil, which was done by treating the OS with 20volume hydrogen peroxide (H_20_2). From the results obtained from grain size and hydrometer test it was found that almost the entire soil was finer than 75μ and 36% finer than 2mμ, in case of OS whereas in case of first and second sample of SC almost 10% was retained on 75μ Sieve, nearly 55% passed through 2mμ and 8% was retained on 75μ Sieve and nearly 48% passed through 2mμ, respectively as shown in fig. 2, which indicated that there is an increase in the fines content with the increase in the OM in the soil which might be due to the chemical changes occurring in the soil during decomposition.(Mesri et.al., 2007)

Laboratory investigation yielded different results in case of SC and OS which are presented in Table no.1. Specific Gravity yielded much lower value in case of OS compared to SC. (Devi et.al, 2015)

Liquid limits (LL) were also on the higher side in case of OS which is mainly due to the fact that they are colloidal in nature and higher water absorption capacity compared to SC, whereas plastic limit (PL) had lower values mainly due to the fibrous nature of the soil due to decomposed matter, which resulted in higher plasticity index (PI), similar trends were observed by (Andersland et.al., 1981).

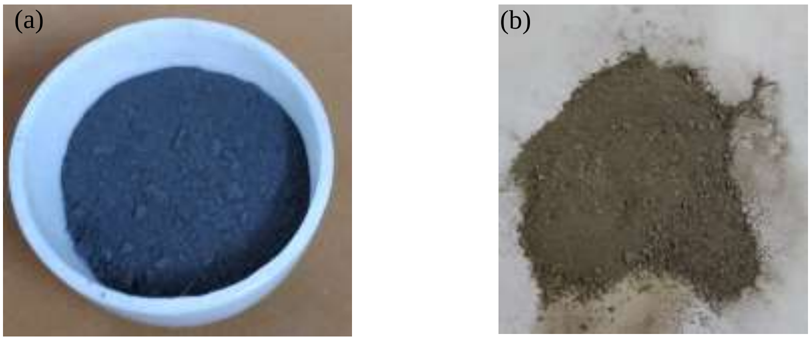


Fig. 1. (a) Oven dried OS. (b) Ash content of OS.

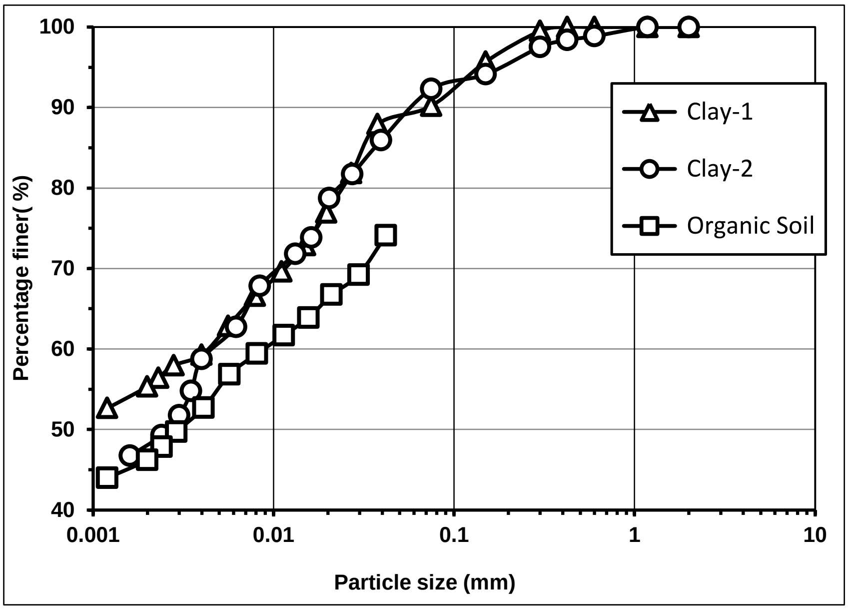


Fig. 2. Grain size distribution of soil

Table 1. Index parameters of soil

Nature of Soil	Organic Content (%)	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Specific Gravity (G)
Clayey Soil	Nil	42.12	49	23	26	2.69
Clayey Soil	Nil	48.23	51	28	23	2.71
OS	26	116.64	179	87	92	1.98

2.3 Sample Preparation

Thin walled sampling tubes, as per IS:1892-1972, were used to obtain UDS samples from the site, which were then mounted on the sample extractor to obtains UDS samples to carry out consolidated-undrained (CU) triaxial test and consolidation test, as shown in fig.no.3. In case of consolidation test, consolidation ring was used to obtain sample for the test from tube sampler having 20mm height(H) and diameter(D) of 60mm, having D to H ratio of 3:1, as per IS:2720 (Part 15). In case of CU triaxial test small sampling tubes of 38mm dia. were used to extract soil from the sampler, from which soil samples of 38mm D and 76mm H were obtained for undergoing the test maintaining a D to H ratio of 1:2, as per IS:2720 (Part12).

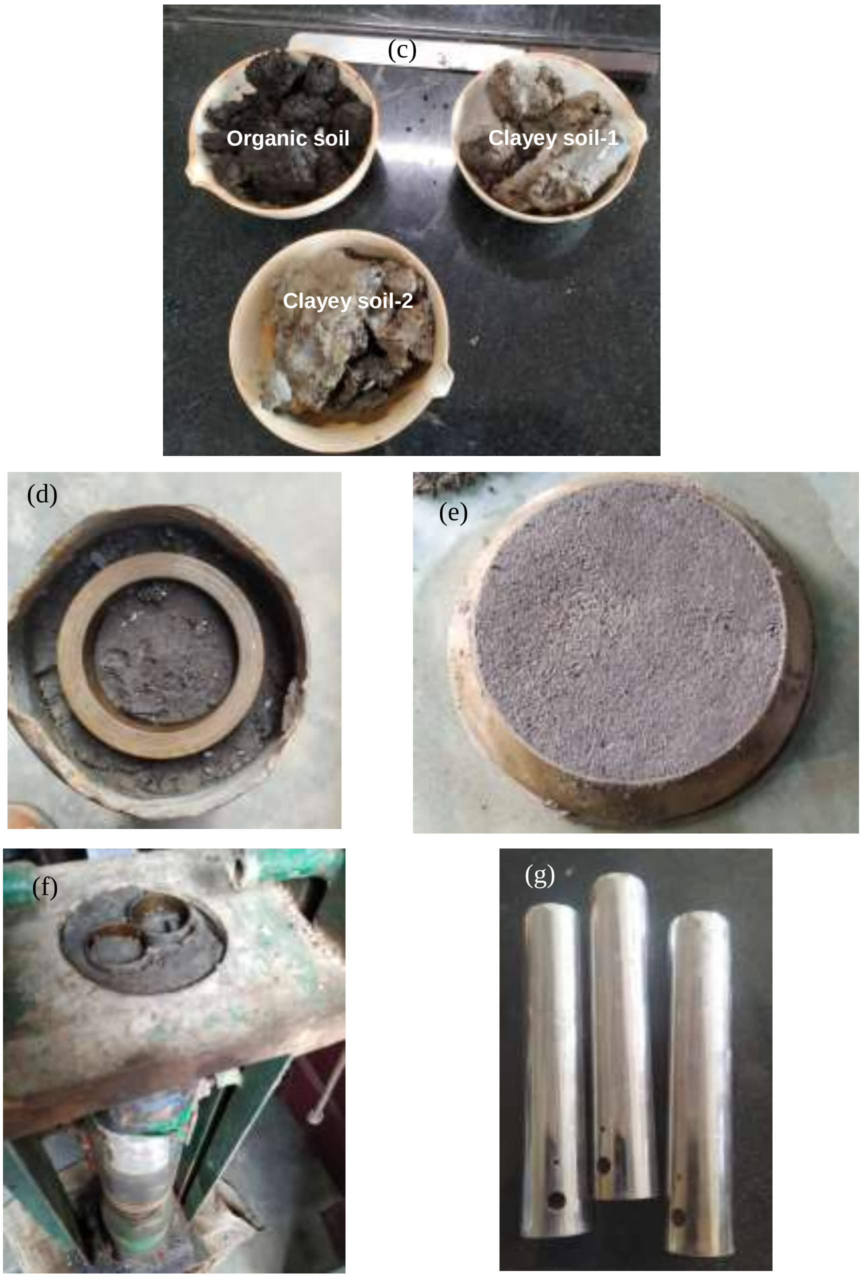

(c)
Organic soil
Clayey soil-1
Clayey soil-2
(d)
(e)
(f)
(g)

Fig. 3. (a) Extraction of sample from site. (b) Thin tube soil samplers. (c) 3 types of soil samples. (d) Consolidation ring in sampler. (e) Soil sample for consolidation. (f) Extraction of soil sample from sampler for triaxial test. (g) Soil collected in small D samplers. (h) Samples for CU triaxial test.

2.4 Consolidation Test

Consolidation test were conducted on the UDS soil samples collected by the consolidation ring of 3 soil samples, out of which two were SC and one consisted of OS having 26% OM. Isotropic consolidation stresses were applied on each sample through consolidometer placed in position such that stresses are applied vertically on the specimen. Initially a seating pressure of 0.05kgf/cm^2 was applied for 24 hrs. and a stress sequence of 0.1, 0.2, 0.4, 0.8, 1.6 and 3.2 kgf/cm^2 and each loading deformations of the specimen were recorded at time intervals of 0, 0.25, 0.50, 1, 2, 4, 8, 15, 30 and 60 mins. interval and 2, 4, 8 and 24 hrs. which would facilitate plotting of changing of thickness of specimen against sq.rt. of time ($\sqrt{t}$). (Leonards et.al., 1964)

2.5 CU Triaxial Test

Samples of 38mm D and 76mm H were used for this test in order to determine the shear strength parameters of the soil along with change in pore water pressure (PWP) during shearing and also measuring changes in volume of sample during consolidation. Consolidation of the soil sample was carried out and the change in soil volume can be recorded in the burette and the graph of change in volume change (ΔV) vs. sq.rt. of time($\sqrt{t}$) is shown in Fig. no.4, from this graph, time is recorded for 100% (t_{100}) consolidation of the sample and post consolidation length and diameter of the sample can be evaluated, coefficient of consolidation(C_v) of the specimen can also be determined at different cell pressure. After full consolidation, back pressure were applied to the samples in order to fully saturate the soil sample in such a manner that the ratio of change in cell pressure ($\Delta\sigma_c$) to change in PWP is 0.95 to 1.00, which is also known as B-factor, as per IS;2720(Part 12). After attaining a B-factor of 0.95, triaxial test were conducted at a strain rate of 1.25mm/min. and at an effective confining stress of 1, 2 and 3 Kg/cm^2 respectively. During shearing PWP measuring apparatus was again taken into consideration in order to measure change in PWP during shearing of soil sample.

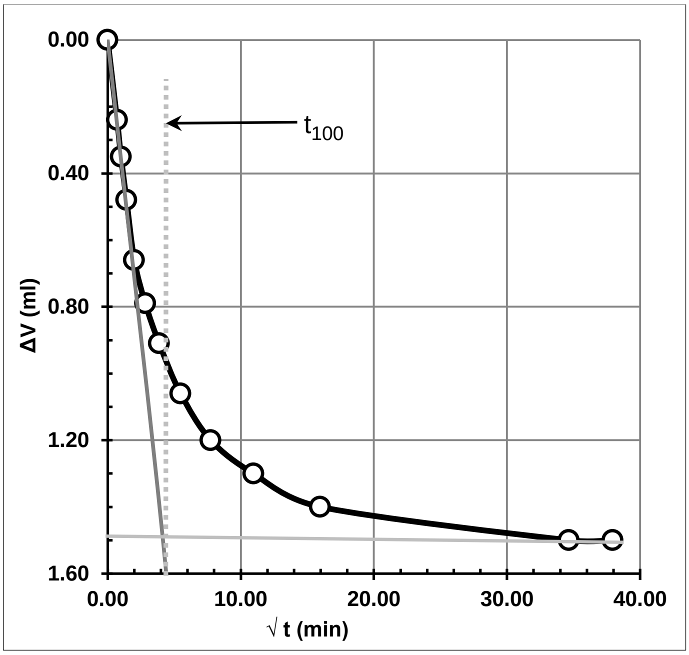


Fig. 4. Plot of ΔV vs. $\sqrt{t}$

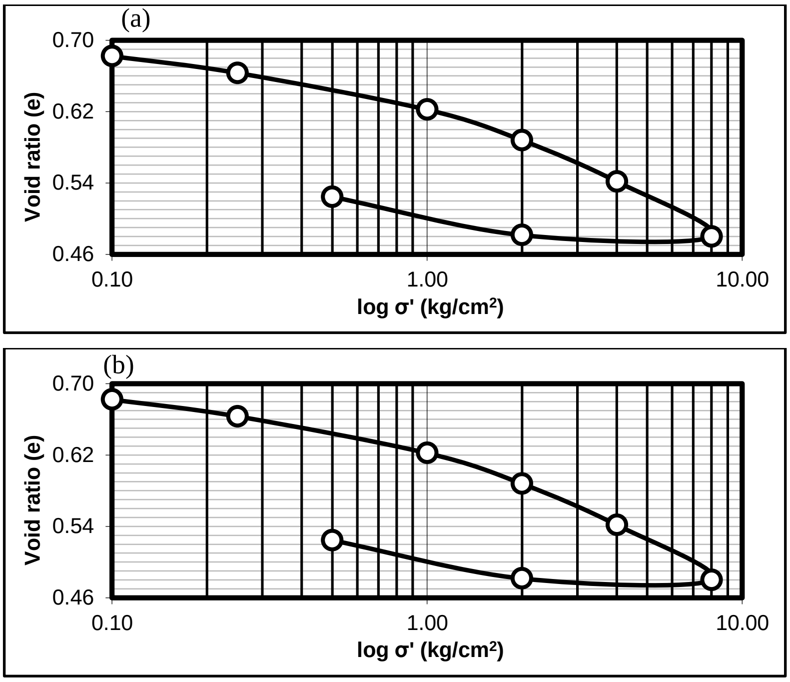
3 Results and Discussion

3.1 Consolidation Characteristics

Change in void ratio (Δe) under each stress increment (σ_c') is deduced. From e vs logarithmic change in shear stress (log σ_c') graph, compression index (Cc) can be determined, as shown in fig. 5. Three samples were experimentally investigated to determine the consolidation parameters such as coefficient of compression (C_c), coefficient of volume compressibility (m_v), coefficient of compressibility (a_v) which yielded nearly similar values in case of SC, whereas higher values in case of OS, as shown in Table No. 2.

Table 2. Consolidation parameters of soil

Nature of Soil	**Cc**	**m_v (cm^2/kgf)**	**a_v (cm^2/kgf)**
Clayey Soil-1	0.292	0.014	0.022
Clayey Soil-2	0.205	0.010	0.015
OS	0.998	0.118	0.188



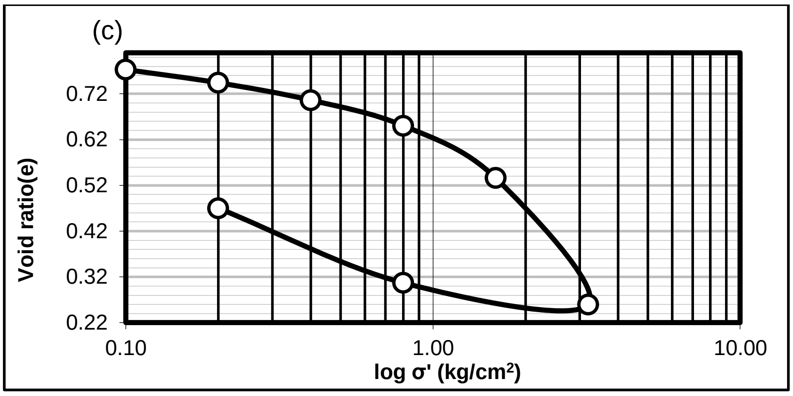


Fig. 5. Void Ratio (e) vs. log σ′ graph (a) & (b) SC (c) OS

3.2 Shear Strength Characteristics and PWP

Triaxial CU tests were conducted at different confining pressure of 1, 2 and 3 kgf/cm^2 and the corresponding change in PWP was recorded and plotted in graph, as shown in fig. 5. Along with the increase in confining pressure, deviator shear stress also increased, which was on the higher side in case of SC compared to OS and the shear strength parameters Cohesion(C) and angle of internal friction (φ) were obtained, as shown in Table no.3. PWP initially increased slightly during shearing of the sample and showed a decreasing trend as shearing continued, as shown in fig.no.6.(Roscoe et.al., 1968). PWP parameter at failure showed a lesser value for OS. (Devi et.al. 2015)

Table 3. Shear strength parameters of soil

Nature of Soil	C (T/m^2)	φ(◦)
Clay Soil-1	1.40	2
Clay Soil-2	1.20	1
OS	0.70	-

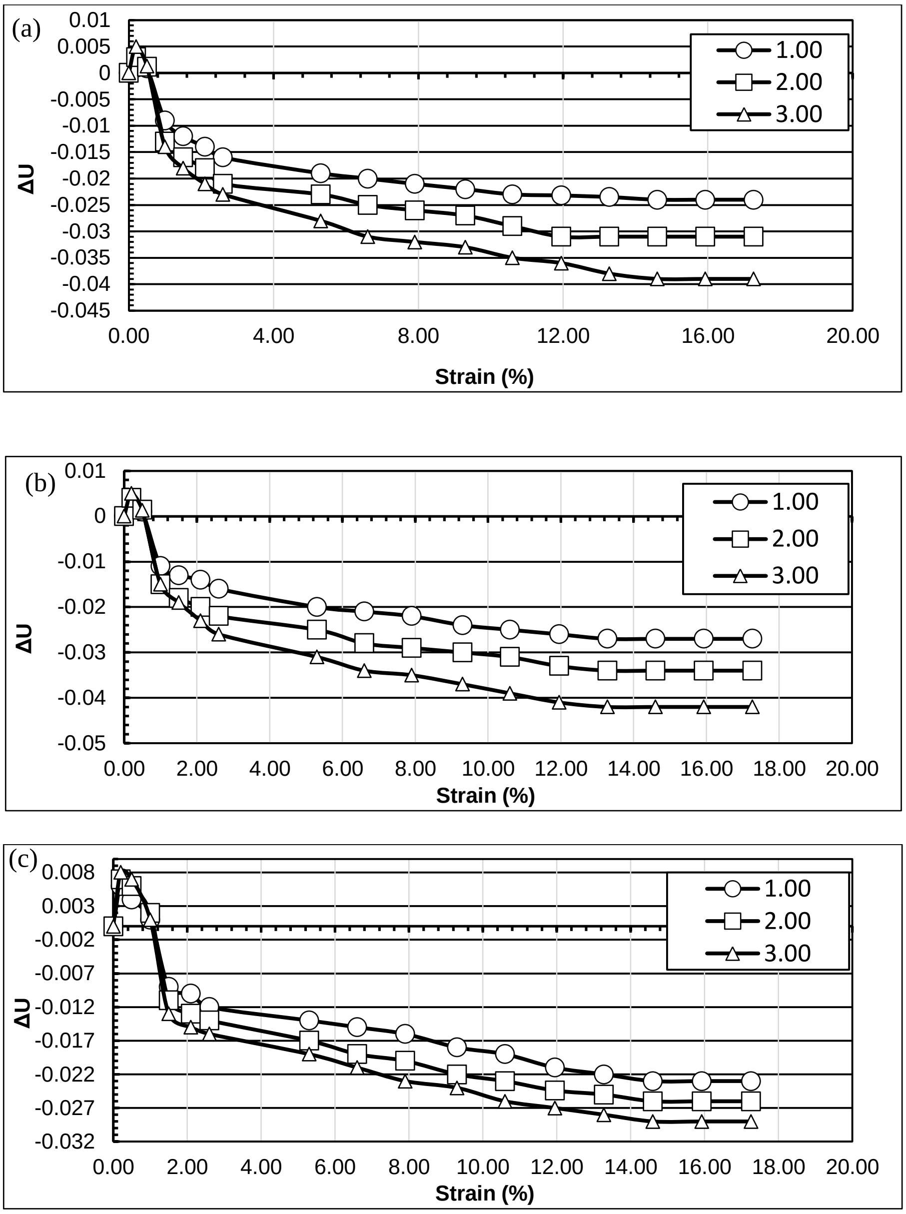


Fig. 6. Rate of change in PWP vs Strain at varying cell pressure of 1, 2 and 3 kg/cm^2 in case of (a) & (b) SC (c) OS

4 Conclusion

Conducting consolidation test, CU triaxial test and other experimental investigation on SC and OC the following conclusions can be stated:-

- Atterberg limits were on much higher side for OS having LL value of 116.64 which is a much higher value as compared to SC having LL of 49 and 51 respectively.
- Consolidation parameter such as C_c is also on the higher side for OS compared to SC which is mainly due to the amorphous nature of the soil having value of 0.998 compared to 0.292 and 0.205 in case of two clayey samples mainly due to high water absorbing capacity of the soil which might result in creep and inadmissible settlements.
- Shear strength parameter such as C value obtained for OS is on the lower side having value of 0.70 T/m^2 compared to 1.40 and 1.20 T/m^2 in case of both clayey soils.
- From the results obtained from the tests it can be stated that ground improvement in such type of soil is necessary and may be adopted as a future scope.

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