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Assessment of Gravel Properties Sourced within Oyo North Senatorial District: Case Study of Ogbomoso

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Abstract. The study evaluated the properties of gravel aggregate sourced within Oyo north senatorial district for concrete production in place of crushed granite crushed at exorbitant cost since characteristic properties show significant reflections on the qualities of gravel aggregate used and also play major role in determining the properties of hardened concrete.

Samples of gravel from four commonly used borrow pits: Aroje, Bolanta, Sunsun and Olomi sites were obtained and tested for Aggregate Crushing Value (ACV), Aggregate Impact Value (AIV), Specific Gravity, Water absorption Capacity, Bulk Density, Moisture Content and Particle Size Distribution.

On the average the results of the observation for the selected four locations were 22.56 g, 28.17 g, 33.37 g and 40.19 g for Aggregate Crushing Value (ACV), 2.44 g/ml, 2.53 g/ml, 2.57 g/ml and 2.62 g/ml for Bulk density, 0.17 %, 1.43 %, 2.42 %, and 2.48 % for moisture content, 2.02 %, 2.92 %, 2.00 % and 3.15 for water absorption, 2.52, 2.63, 2.60 and 2.55 for specific gravity, 41. 55 %, 45.25 %, 45.59 % and 47.08 % for aggregate Impact respectively.

The study revealed that, gravel aggregates from Aroje has superior properties over those of Sunsun, Bolanta and Olomi as compared with coarse aggregate properties in BS 812: 1995 and BS 882: 1992. It is hereby recommended for coarse aggregate in concrete production.

Introduction

Construction materials are either naturally occurring or manufactured in factories. Examples of materials in the first category are timber, sand, granite and gravel, while those in the latter category are steel, cement and roofing sheets. Some materials are a combination of composite materials. An example of composite materials is concrete. Aggregates, which are prominent material in concrete, constitute 60-80 % of total concrete constituent [1], it is not surprising that its properties and qualities are of considerable important because of the volume its occupies. Kasmatka et al*.*, in [2] found that coarse aggregates consist of one or a combination of gravels or crushed stone with particles predominantly larger 5 mm and generally between 9.5 mm and 37.5 mm. Bamigboye et al*.*, in [3] reported that there is a remarkable difference between the strength of mortar and that of concrete of the same mix proportion (about three times the strength of mortar). This is mainly because of the presence of coarse aggregate in concrete and strongly influence the concrete's freshly mixed and has a major role to play in the hardened strength of the concrete [4]. Close to half of the coarse aggregate used in Portland cement concrete in North America are gravels while most of the remainder are crushed stones [2]. Gravels are result of the natural disintegration of rocks which are at least 2 mm in diameter. Larger sizes maybe called pebbles, cobble or boulders. They are usually rounded and as such require less amount of cement paste, this saves about (4-5) % cement paste [5]. Adebayo et al*.*, in [6] investigated the effect of different aggregate types on the strength of concrete. Three types of aggregates namely granite, gravel and laterite were studied. It was reported that granite concrete gives the highest compressive strength followed by concrete made from gravel and lastly the one from laterite. Bamigboye et al., in [7] reported that the presence of impurities will affect the strength of concrete produced with the aggregates. Chen and Liu [8] discovered that aggregate is the skeleton of concrete and consequently suggested that all form of coating should be avoided in order to achieve a good concrete. Gravel aggregates have not been adequately utilized as they should, partly because of the fear that gravel cannot withstand as much pressure as granite due to its chemical composition. Inasmuch as it is accepted that gravel aggregate cannot withstand as much pressure as granite aggregates especially when major structures are involved which have high loading as a results of this it is important to assess its properties to determine its strength because the strength of concrete depends greatly on the internal structure. The composition, shape and size of aggregates have significant impact on workability, durability, strength, weight and shrinkage of the concrete. Gravel is in abundance and easily accessible when compared to granite. Having gone through past researches on factors influencing the strength of concrete, of which aggregate play important role, this study assesses the gravel aggregate properties sourced within Oyo North Senatorial District, Southwest Nigeria.

Material and Methods

The coarse aggregates used for this study were gravels sourced locally from Ogbomoso land, Oyo North senatorial district, South-West Nigeria namely: Olomi, Aroje, Bolanta and Sunsun. The concrete samples obtained were identified based on the sources and named based on their location name. The fine aggregate was obtained from natural river sand. The coarse aggregates used for this research were divided into two: washed and unwashed gravel. The maximum aggregate sizes were 10 mm and 20 mm. Dangote brand of Ordinary Portland cement (42.5R) was used for this study. Potable water was used for mixing. Particle size distribution test, specific gravity test, water absorption test, aggregate crushing value test, aggregate Impact value, bulk density, moisture content, water absorption were determined in accordance with [9].

Results and Discussion

Particles Size Distributions

Tables 1 – 4 are the sieve analysis carried out on the gravel aggregate obtained from Aroje, Bolanta, Sunsun and Olomi in accordance with the guideline specified in [9]. The graphical representations of these results are represented sequentially in Figures 1- 4. From the tables it can be deduced that the gravel from Olomi, Bolanta and Sunsun are poorly graded: Aroje gravel has majority of particles fall between sizes 9.5 mm and 19mm; Bolanta gravel has major sizes between 2.36 mm and 4.75 mm and Sunsun gavel has sizes uniformly between 2.36 mm and 19 mm. It has a relative percentage of the particles in the gravel section of the distribution or curve indicating that high percentage of gravel is present. Table 1 shows that Aroje site is uniformly graded it has a greater percentage of particles falling with the coarse and gavel section which is in line with [10].

Table 1: Aroje Sieve Analysis.

Sieve Diameter (mm)	Mass Retained (g)	Percentage Retained (%)	Cumulative (%)	Percentage Passing (%)
37.5	0	0	0	100
25	102	4.1	4.1	95.9
19	117	4.7	8.8	91.2
9.5	1600	64.26	73.06	26.94
4.75	572	22.97	96.03	3.97
2.8	62.5	2.57	98.54	1.46
1.4	16.3	0.65	99.19	0.81
710μm	4.9	0.2	99.39	0.61
355 μm	6	0.24	99.63	0.37
Pan	9.3	0.37	100	0
Total	2490	100		

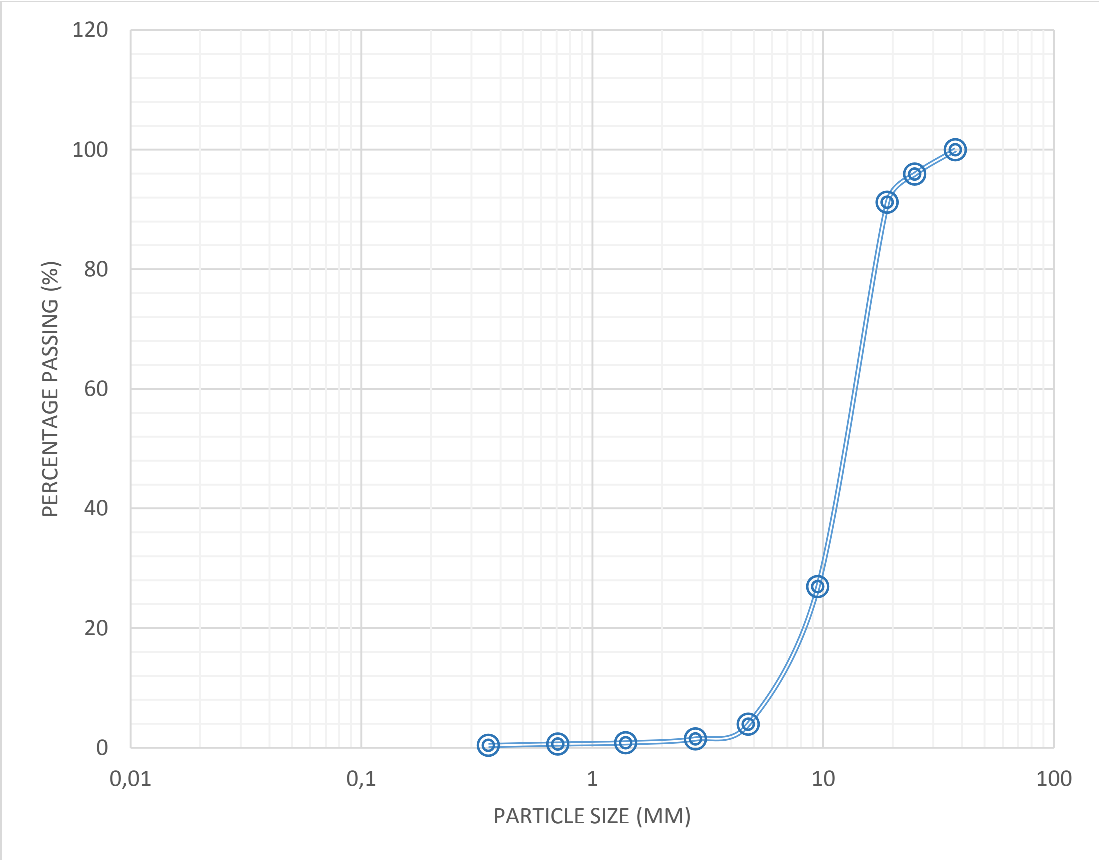

Figure 1: Particle size distribution for Aroje.

Table 2: Bolanta Sieve Analysis.

Sieve Diameter (mm)	Mass Retained (g)	Percentage Retained (%)	Cumulative (%)	Percentage Passing (%)
37.5	0	0	0	100
25	304	7.66	7.66	92.34
19	264	6.65	14.31	85.69
9.5	862	21.71	36.02	63.98
4.75	669	16.85	52.87	47.13
2.8	1669	42.04	94.91	5.09
1.4	96.5	2.43	97.34	2.66
710μm	39.5	0.99	98.33	1.67
355 μm	29	0.73	99.06	0.94
Pan	37	0.94	100	0
Total	3970	100		

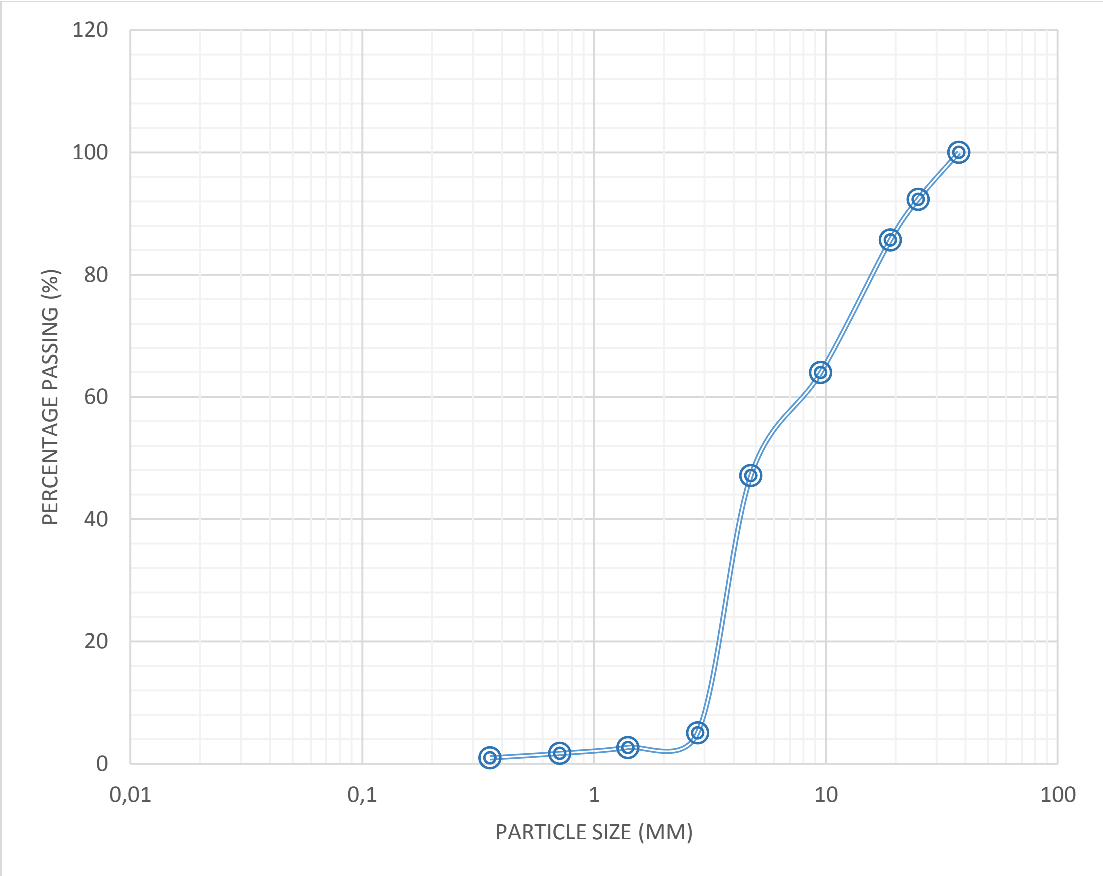

Figure 2: Particle size distribution for Bolanta.

Table 3: Sunsun Sieve Analysis.

Sieve Diameter (mm)	Mass Retained (g)	Percentage Retained (%)	Cumulative (%)	Percentage Passing (%)
37.5	0	0	0	100
25	426	12.99	12.99	87.01
19	341	10.4	23.39	76.61
9.5	945	28.81	52.2	47.8
4.75	539	16.43	68.63	31.37
2.8	883	26.92	95.55	4.45
1.4	60.5	1.84	97.39	2.61
710μm	12.5	0.38	97.77	2.23
355 μm	10.5	0.32	98.09	1.91
Pan	62.5	1.91	100	0
Total	3280	100		

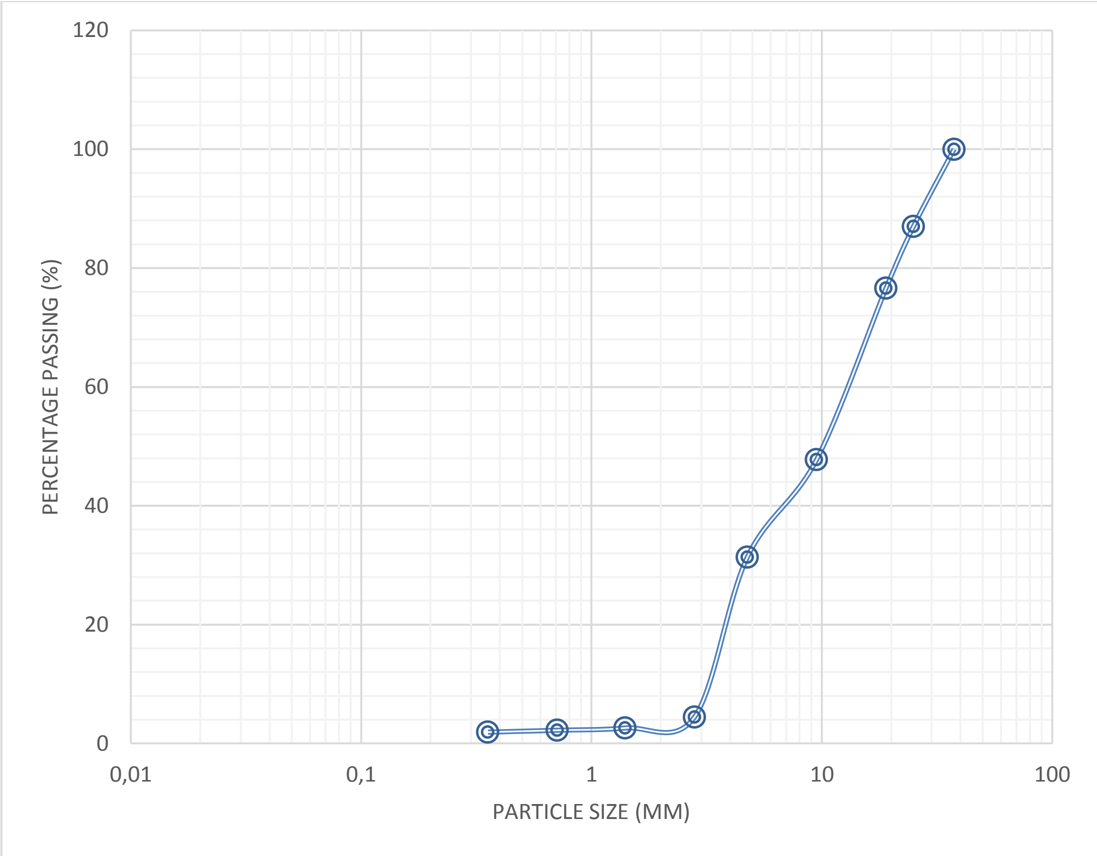

Figure 3: Particle size distribution for Sunsun

Table 4: Olomi Sieve Analysis.

Sieve Diameter (mm)	Mass Retained (g)	Percentage Retained (%)	Cumulative (%)	Percentage Passing (%)
37.5	0	0	0	100
25	237	9.65	9.65	90.35
19	164	6.68	16.33	83.67
9.5	1661	67.66	83.99	16.01
4.75	347	14.18	98.12	1.88
2.8	23	0.94	99.06	0.94
1.4	8.9	0.36	99.42	0.58
710μm	4.6	0.19	99.61	0.36
355 μm	4.7	0.19	99.8	0.2
Pan	4.8	0.2	100	0
Total	2455	100		

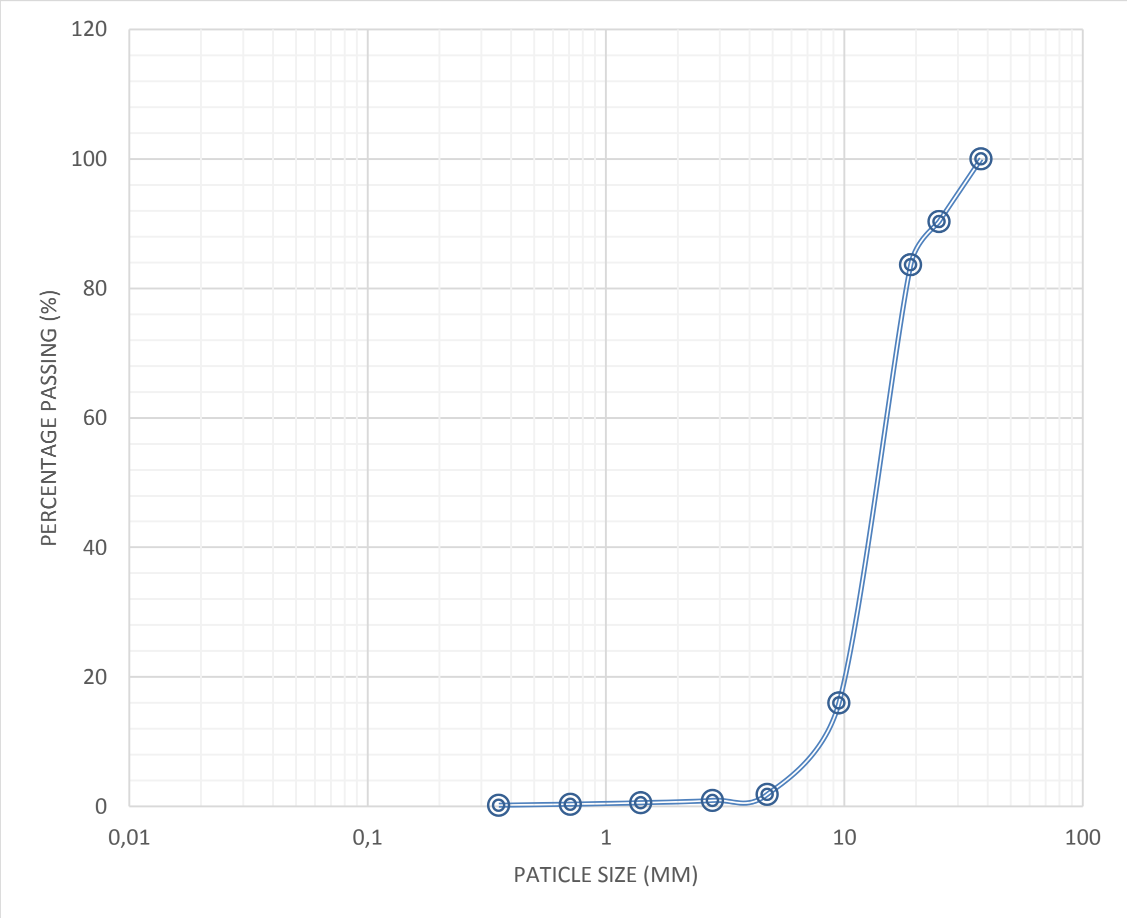

Figure 4: Particle size distribution for Olomi.

Aggregate Crushing Value

Tests on aggregates value were carried out on each sample. The results obtained were shown on Table 5 below. It is obvious that the gravel from Aroje has the highest strength when the distributed load from the crushing machine was applied and it enhances the attainable characteristics compressive strength of concrete when used for concrete production as compared to other samples whereas the gravel sourced from Olomi site has the lowest strength which is in line with [10].

Table 5: Aggregate crushing Value.

Sample Reference	Test 1(g)	Test 2 (g)	Average Test
Aroje	22.52	22.60	22.56
Bolanta	33.33	33.40	33.37
Sunsun	28.17	28.17	28.17
Olomi	40.28	40.10	40.19

Aggregate Impact Value

The results of the test carried out on Aggregate Impact Value are shown in Table 6. It was observed that when a sudden load was applied on different samples of gravel the Aroje site has the lowest fines as compared to others, which means that Aroje site can withstand the impact load whereas Olomi has the highest fines and it could be deduced that Olomi has the lowest strength which is in line with [10].

Table 6: Aggregate Impact Value (AIV)

Sample Reference	Test 1(g)	Test 2 (g)	Average Test (g)
Aroje	41.50	41.59	41.55
Bolanta	45.24	45.26	45.25
Sunsun	45.58	45.59	45.59
Olomi	47.07	47.08	47.08

Bulk Density

The results of the bulk density carried out on different samples of aggregate were shown in Table 7 below in accordance with [11]. From the results, it is shown that Olomi gravel has the highest bulk density and from this it could be established that Olomi gravel has the highest equal mass of sample. Whereas, Aroje has the least bulk density among the four sites

Table 7: Bulk Density of Aggregate.

Sample Reference	Test 1 (g/ml)	Test 2 (g/ml)	Average Test (g/ml)
Aroje	2.43	2.44	2.44
Bolanta	2.57	2.56	2.57
Sunsun	2.54	2.52	2.53
Olomi	2.61	2.62	2.62

Specific Gravity

The tests on gravel from different site were carried out on specific gravity and their results were given in the Table 8. From the results, it shown that Bolanta has the highest specific gravity whereas as Aroje has the least which is in line with [12].

Table 8: Specific gravity.

Sample Reference	Test 1 (g)	Test 2 (g)	Average Test (g)
Aroje	2.52	2.52	2.52
Bolanta	2.63	2.63	2.63
Sunsun	2.60	2.60	2.60
Olomi	2.57	2.52	2.55

Moisture Content

The results of moisture content determination test being carried out on different samples of aggregate were shown in Table 9. From this result, it was observed that gravel with the highest moisture content is Olomi gravel and this shows that the percentage of water in the sample is higher than others, it contains more water and it is due to the presence of pores at the surface of the samples as being observed physically which is in line with [10].

Table 9: Moisture Content.

Sample Reference	Test 1(g)	Test 2 (g)	Average Test (g)
Aroje	2.41	2.43	2.42
Bolanta	1.43	1.43	1.43
Sunsun	0.17	0.17	0.17
Olomi	2.47	2.49	2.48

Water Absorption Capacity

The test on water absorption capacity carried out on different sample obtained from different site in line with [12] and the results were shown Table 10. From the results, the sample that absorbed water most is Olomi and the one with least water absorption is Aroje. From these series of results, it can be established that Aroje gravel sample has no much affinity for water absorption whereas Olomi has more tendency to absorb water than any of the sourced gravel from this study.

Table 10: Water Absorption Capacity.

Sample Reference	Test 1 (g)	Test 2 (g)	Average Test (g)
Aroje	2.02	2.02	2.02
Bolanta	2.92	2.91	2.92
Sunsun	2.70	2.71	2.70
Olomi	3.15	3.15	3.15

Conclusion

Based on this findings the following conclusion were drawn.

1. The best gravel site is Aroje in Ogbomoso Oyo North Senatorial District, Nigeria and is due to best properties it exhibited because it has the highest strength when uniformly load is applied on it as seen from Aggregate Crushing Value.
2. Gravel aggregates with high strengths could be used in construction of low rise buildings and rural roads while low strengths gravel could be employed in applications (walkways) where high strengths are not required.
3. The results provide data bank for technical and economical infrastructure in Oyo North senatorial district Nigeria.

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