e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:03/Issue:06/June-2021 Impact Factor- 5.354 www.irjmets.com

SPLIT TENSILE STRENGTH OF PAVING STONES MADE WITH GROUND PALM KERNEL SHELL AS REPLACEMENT OF FINE AGGREGATE

O.G Oyesanya[*1]

[*1]Department of Civil Engineering, University of Nigeria, Nsukka.

ABSTRACT

This is a feasibility study on the use of palm kernel shell as replacement for stone dust in the production of paving stones. It investigates the impact palm kernel shell (PKS) will have on the flexural strength and split tensile strength of the paving stones produced. The sizes of the palm kernel shell were less than 5mm. Stone dust paving stones (SDPS) were used as control using mix ratios of 1:3, 1:4, 1:5 and 1:6. Particle size distribution, moisture content and bulk density were determined for the stone dust aggregate and palm kernel shell. Paving stones were cast using stone dust and palm kernel shell (PKS), and both were cured for 28 days. Thereafter, tests were carried out which included flexural strength test, split tensile strength test and water absorption test. The results of the tests carried out after 28 days of curing showed that only paving stones made with mix ratio 1:3 gave significant result with these values - flexural strength of 1.240 N/mm^2, split tensile strength of 0.700N/mm^2 and moisture content of 24.85%. Based on this, the study suggests that the palm kernel shells be treated in further research to test for the feasibility of its use as a replacement for stone dust in the production of paving stones.

Keywords: Palm Kernel Shell, Paving Stones, Split Tensile Strength Test, Stone Dust.

I. INTRODUCTION

It is no news that most available natural resources are gradually depleting and this situation, if not handled quickly, can lead to imbalance in the ecological systems. This has led to several researches been geared towards finding alternatives that can be used to either replace the existing natural resources or to use them as partial replacement. These researches have yielded significant results as it has led to discovering the use of pumice, sawdust, palm kernel shell, coconut shell and several others as possible replacements. Of the various aggregates available, palm kernel shell is becoming increasingly used especially in the tropical regions. This is due to its similar physical and mechanical properties with granite and gravel, and is readily available in large quantities since it is a by-product of palm oil production.

II. LITERATURE REVIEW

Ezekiel et al in 2017 researched on the use of palm kernel shell as partial replacement for normal weight aggregate in concrete. It was observed that the compressive, tensile strength, workability, and concrete density reduce as PKS content is increased in the mix while water absorption increases with increased in PKS content[1].

Zarina et al in 2016 worked on the feasibility of palm kernel shell as a replacement for coarse aggregate in lightweight concrete. The findings were that by using PKS for aggregate replacement, it increases the water absorption but decreases the concrete workability and strength also the results are within the range acceptable for lightweight aggregates, hence it can be concluded that there is potential to use PKS as aggregate replacement for lightweight concrete[2].

A research by Donald and Jonas on the use of Palm Kernel Shells as a partial replacement for Sand in Sandcrate block production in 2015 made use of PKS replacement varying from 0%, 10%, 20%, 30%, 40% and 50% with water cement ratio of 0.5. The results showed that the compressive strength of PKS blocks exceeds the minimum requirement of 2.8N/mm2 when the PKS replacement do not exceeds 40%.[3]

There has been notable researches carried out on paving stones and some which are relevant to the project work will be highlighted.

Rahul et al in 2019 worked on the use of plastic waste as a partial replacement of aggregate in paver blocks. Paver blocks of 0%, 2%, 2.5%, 3%, 3.5%, 4%, 8% and 10% of plastic coarse aggregrates were casted. The results gotten showed that the compressive strength for 2.5%, 3%, 4% replacement of plastic coarse aggregate is high and decreases at 10% replacement of plastic coarse aggregate. [4].

Mohammad in his research considered the performance evaluation of m35 grade concrete paver blocks using coal bottom ash as partial replacement of fine aggregate. The results showed that 30% replacement of fine aggregate by bottom ash can be used in manufacturing of concrete paver blocks [5].

Kazi et al studied the Manufacturing of paver block by partially replacement of fine aggregate and coarse sggregate with nonrecyclable plastic waste. The results showed that the recycled plastic aggregates can be used up to 15% replacement of fine aggregates in the concrete mixture.and 20% replacement of coarse aggregate [6].

III. METHODOLOGY

Materials

The following materials were used:

- Dangote Portland Cement bought from the retail sellers in Ibadan
- Stone dust – this was gotten from a construction site in University of Ibadan
- Palm Kernel Shell (PKS) – This was gotten from Oko in Ibadan and grinded into fine by a grinding mill.
- Water
- Lubricating oil – This was used to lubricate the paving stone formwork before casting the paving stone.

Procedure:

Procedure for Production of Paving Stones

In carrying out this research, trial test was carried out. The trial test was to help determine which set of ratios will be best suited for the experiment. The mix ratio of 1:5 and 1:6 were used to cast the paving stone using only the stone dust and the palm kernel shell (PKS). The paving stone formwork was oiled and then the stone dust was batched (batching was done by volume). The required proportion of cement and water was added. Followed by the mixing of the stone dust and cement into a consistent and workable mixture. This was poured into the formwork and compacted by slightly shaking it sideways at the edges of the formwork which afterwards was left to set. The next day, it was de-molded, weighed and taken to the curing tank – curing was done for 28 days. From the results gotten, the main research was carried out using 1:3 and 1:4 as the mix ratios for the casting of paving stones using stone dust, palm kernel shell (PKS). The same procedure used in the trial was also used in the casting of the 1:3 and 1:4 mix ratios. After curing for 28 days, various tests were carried out on it – split tensile strength test, flexural strength and the water absorption test.

Procedure for Moisture Content

$$w = \frac{m_2 - m_3}{m_3 - m_1} x\ 100\%$$

where

m_1 is the mass of the container (in g)

m_2 is the mass of the container and the wet test portion (in g)

m_3 is the mass of the container and the dry test portion (in g)

The container is clean and dried, then weighed to the nearest 0.1g m_1. The sample is then placed in the container and weigh the whole m_2. The container and the test sample is placed in the oven to dry at 105^0C for minimum 12 hours. After drying, the container and its content is weighed m_3.

Procedure for Split Tensile Strength Test

The paving stone sample was placed in the centering jig with packing strip (steel rods) carefully positioned along the top and bottom of the plane of loading of the specimen. The jig was then placed in the machine so that the specimen was located centrally. The load was applied without shock and increased continuously at a nominal rate within the range 1.2N/(mm²/min) to 2.4N/(mm²/min). As failure was approaching the loading rate decreased; at this stage the controls was operated to maintain as far as possible the specified loading rate. The maximum load applied was recorded.

The formula for calculating splitting tensile strength (calculated to the nearest 0.05 N/mm²) is:

$$f_{ct} = \frac{2P}{\pi l d}$$

where P = maximum load in Newton applied to the specimen,

l = length of the specimen (in mm)

d = cross sectional dimension of the specimen (in mm

IV. RESULTS AND DISCUSSIONS

Moisture Content Tests:

Table 1 – Moisture Content for Stone Dust And Palm Kernel Shell

	Stone Dust		Palm Kernel Shell (PKS)	
Can No.	A	B	C	D
Weight of can (g)	14.1	13.0	15.4	14.4
Weight of can + wet sample (g)	26.2	28.1	24.9	24
Weight of can + dry sample (g)	26.0	27.8	23.0	22.1
Weight of dry soil (g)	11.9	14.8	7.6	7.7
Weight of water (g)	0.2	0.3	1.9	1.9
Moisture Content (%)	1.7	2.0	25	24.7
Average moisture content	1.85		24.85	

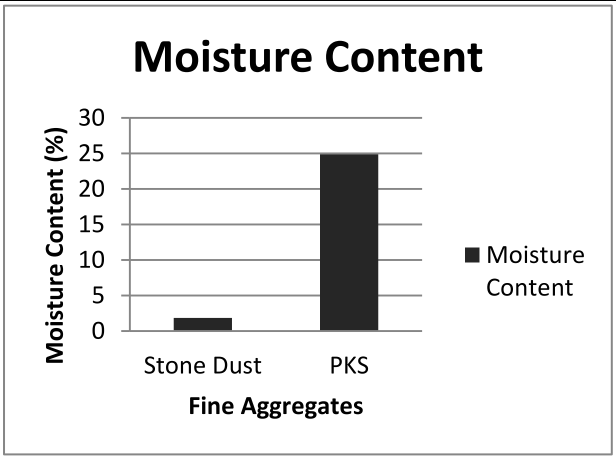

Figure 1 – Moisture Content of Stone Dust and Palm Kernel Shell

Bulk Density Test

Table 2 – Bulk Density of Stone Dust and Palm Kernel Shell

	STONE DUST		PALM KERNEL SHELL (PKS)	
Can No.	1	2	3	4
Weight of can (g)	14.7	14.2	14.5	15.1
Height of can (g)	3.6	3.7	3.5	3.4
Diameter of can (cm)	5.0	5.0	5.0	5.3
Radius of can (cm)	2.5	2.5	2.5	2.65
Weight of can + soil (g)	161.7	167.0	78.2	75.1
Weight of soil (g)	147.0	152.8	63.7	60.0
Volume of can (cm^3)	70.66	72.65	68.72	75.01
Bulk density (g/cm^3)	2.08	2.10	0.93	0.80

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:03/Issue:06/June-2021 Impact Factor- 5.354 www.irjmets.com

Average bulk density (g/cm³)	2.09	0.87

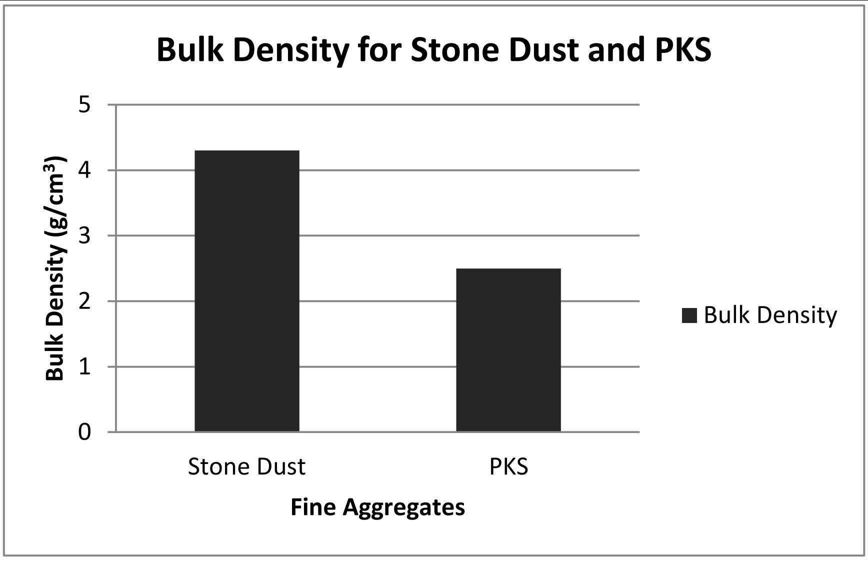

Figure 2 – Bulk Density for Stone Dust and Palm Kernel Shell

Particle Size Distribution Data for Palm Kernel Shell (PKS) Sample

Table 3 – Particle Size Distribution of PKS

Sieve Size	Container+ mass retained (g)	Mass Retained (g)	Weight of empty sieve (g)	% retained	% Passing
6.70mm	459.15	0	459.15	0	100
4.75mm	491.85	3.30	488.55	0.66	99.34
2.36mm	512.10	86.65	425.25	17.33	82.01
1.18mm	587.70	194.25	393.45	38.85	43.16
850µm	424.50	47.30	377.20	9.46	33.70
600µm	390.65	45.40	345.25	9.08	24.62
425µm	375.20	34.35	340.85	6.87	17.75
212µm	282.05	40.90	341.15	8.18	9.57
Pan	488.85		443.6	9.57	0

Particle Size Distribution Data for Dust Sample

Table 4 – Particle Size Distribution for Stone Dust

Sieve Size (mm)	Mass of Empty Sieve (g)	Mass of Sieve + Retained (g)	Mass Retained (g)	% Retained	Cumulative % Retained	% Passing
6.70	464.50	464.50	0.00	0.00	0.00	100.00
4.75	494.50	563.60	69.10	13.82	13.82	86.18
2.36	432.60	567.40	134.80	26.96	40.78	59.22
1.18	397.00	479.30	82.30	16.46	57.24	42.76
0.85	380.10	406.50	26.40	5.28	62.52	37.48
0.6	350.00	384.70	34.70	6.94	69.46	30.54
0.425	390.00	429.90	39.90	7.98	77.44	22.56
0.212	341.50	375.60	34.10	6.82	84.26	15.74

Pan	160.50	239.20	78.70	15.74	100.00	0.00

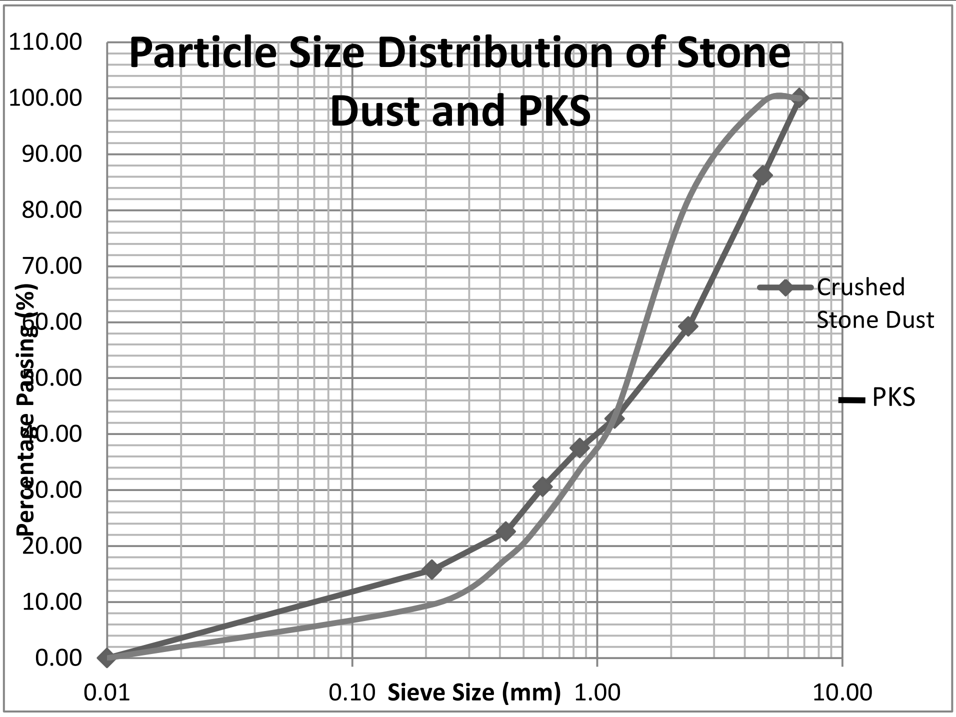

Figure 3 –Particle Size Distribution Chart of Stone Dust and Palm Kernel Shell

Results for Tests Carried Out On Paving Stone

Result for the Split Tensile Strength Test

Palm Kernel Shell:

Table 5 – Split Tensile Strength for Palm Kernel Shell Paving Stone

Mix Ratio	Weight	Density (g/cm³)	Load (KN)	Stress (N/mm²)
1:3	2.065	1.374	11.00	0.569
	2.030	1.351	14.30	0.739
	1.985	1.321	15.30	0.791
Average	2.027	1.349	13.53	0.700
1:4	1.935	1.287	3.30	0.171
	1.905	1.267	3.90	0.202
	1.930	1.284	4.00	0.207
Average	1.923	1.279	3.73	0.193
1:5	1.850	1.231	2.90	0.150
	1.845	1.228	5.30	0.274
	1.875	1.248	2.40	0.124
Average	1.857	1.236	3.53	0.183
1:6	1.770	1.178	2.80	0.145
	1.810	1.204	1.80	0.093

	1.830	1.218	----	-----
Average	1.803	1.200	2.30	0.0793

Stone Dust:

Table 6 – Split Tensile Strength for Stone Dust Paving Stone

Mix Ratio	Weight	Density	Load (KN)	Stress (N/mm²)
1:3	3.275	2.179	29.20	1.510
	3.230	2.149	44.80	2.316
	3.195	2.126	31.80	1.644
Average	3.233	2.151	35.27	1.823
1:4	3.405	2.265	30.60	1.582
	3.305	2.199	45.20	2.337
	3.230	2.149	30.80	1.392
Average	3.313	2.204	35.53	1.770
1:5	3.295	2.192	20.30	1.050
	3.335	2.219	10.40	0.538
	3.320	2.209	24.20	1.251
Average	3.322	2.207	18.30	0.946
1:6	3.300	2.196	16.80	0.869
	3.285	2.186	17.90	0.925
	3.340	2.222	15.80	0.817
Average	3.308	2.201	16.53	0.870

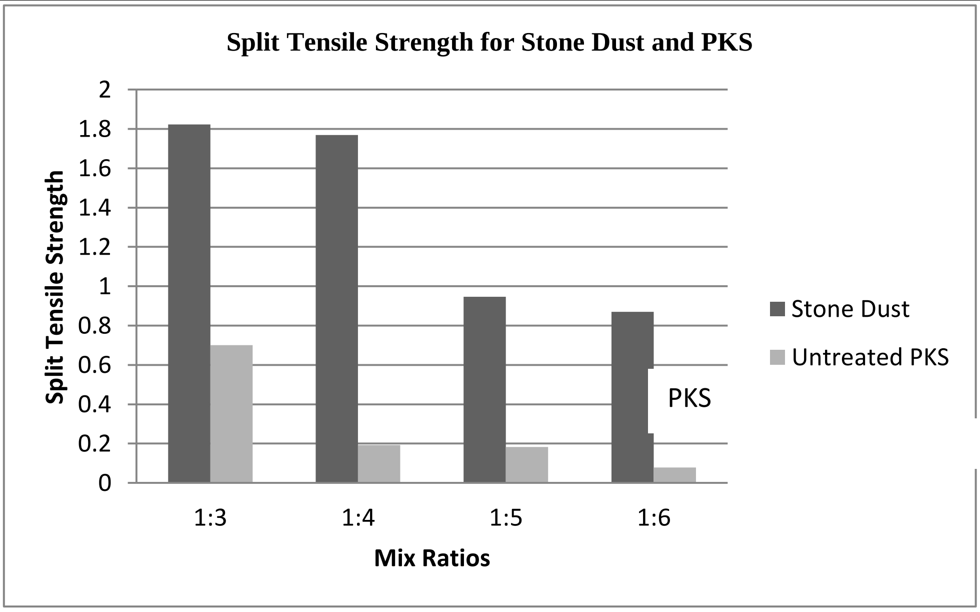

Figure 4 – Split Tensile Strength for Stone Dust and Palm Kernel Shell

Water Absorption Test:

Water Absorption for Palm Kernel Shell Paving Stone

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:03/Issue:06/June-2021 Impact Factor- 5.354 www.irjmets.com

Table 7 - Water Absorption for Palm Kernel Shell Paving Stone

Mix Ratio	Weight before submerging (kg)	Weight after submerging (kg)	Weight of water absorbed (kg)	Water absorption (%)	Average Water absorption (%)
1:3	1.305	1.395	0.090	6.9	
	1.405	1.490	0.085	6.0	6.3
	1.895	2.010	0.115	6.1	
1:4	1.640	1.765	0.125	7.6	
	1.820	1.960	0.140	7.7	8.0
	1.710	1.860	0.150	8.8	
1:5	0.655	0.735	0.080	12.2	
	0.785	0.885	0.100	12.7	12.3
	0.630	0.705	0.075	11.9	

Water Absorption for Stone Dust Paving Stone

Table 8 - Water Absorption for Palm Kernel Shell Paving Stone

Mix Ratio	Weight before submerging (kg)	Weight after submerging (kg)	Weight of water absorbed (kg)	Water absorption (%)	Average Water absorption (%)
1:3	2.880	2.995	0.115	4.0	
	2.945	3.050	0.105	3.6	3.8
	2.795	2.905	0.11	3.9	
1:4	2.935	3.070	0.135	4.6	
	2.830	2.960	0.13	4.6	5.2
	1.640	1.745	0.105	6.4	
1:5	2.830	2.995	0.165	5.8	
	2.840	3.000	0.160	5.6	5.3
	2.835	2.960	0.125	4.4	
1:6	2.760	2.915	0.155	5.6	
	2.625	2.800	0.175	6.7	5.7
	2.660	2.790	0.130	4.9	

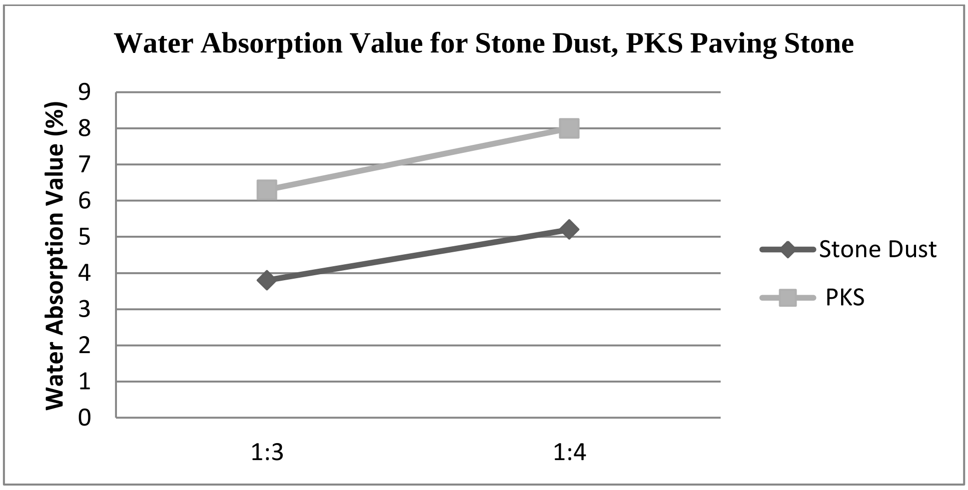

Figure 5 – Water Absorption Value for Stone Dust and Palm Kernel Shell Paving Stones

From the results gotten from the split tensile strength test, it was observed that the values for the stone dust paving stones was consistently higher in all the mix ratios than those gotten from using palm kernel shell and palm kernel shell. However it was observed that the values decreased from 1:3 to 1:6 as shown in Fig. 3.4.

From the water absorption test, it can be observed that for the PKS, and stone dust paving stones, the values increased as their proportion in the mix increased. This can be seen in Figure 3.6. Also it was observed that only the mix ratio of 1:3 for PKS paving stone met the standard requirement according to BS EN 1338:2003 which stated that the percentage of water absorption should be less than 7%.

V. CONCLUSION

The following are the conclusion gotten from this research work:

- Using palm kernel shell as fine aggregate as replacement for stone dust led to the reduction in the split tensile strength as the mix ratios increased.
- None of the mix ratios of palm kernel shell used as fine aggregate in the production of paving stones was suitable.
- Using palm kernel shell as fine aggregate as replacement for stone dust is not viable.

This study thereby suggests that the palm kernel shells be treated in further research to test for the feasibility of its use as a replacement for stone dust in the production of paving stones.

VI. REFERENCES

[1] Ezekiel S. Philips, Raphael N. Mutuku and John N. Mwero. 2017. Palm Kernel Shell as Partial Replacement for Normal Weight Aggregate in Concrete. Civil and Environmental Research. Vol.9, No.11.pp 40 – 47.

[2] Zarina Itam, Salmia Beddu, Nur Liyana Mohd Kamal, Md Ashraful Alam and Usama Issa Ayash. 2016. The Feasibility of Palm Kernel Shell as a Replacement for Coarse Aggregate in Lightweight Concrete. International Conference on Advances in Renewable Energy and Technologies. pp 1 – 4.

[3] Donald Kwabena Dadzie and Jonas Ekow Yankah. 2015. Palm Kernel Shells as a partial replacement for Sand in Sandcrete block production. Chemistry and Materials Research. Vol.7 No.10. pp 61 – 72.

[4] Rahul Mane, Shivani Rayewar, Swapnil Katageri and Dr. N. K. Patil. 2019. Use of Plastic Waste as a Partial Replacement of Aggregate In Paver Blocks. International Research Journal of Engineering and Technology. Vol. 6 Issue 3. pp 102 – 105.

[5] Mohammad Jamil Fazli. 2021. Performance Evaluation of M35 Grade Concrete Paver Blocks using Coal Bottom Ash as Partial Replacement of Fine Aggregate. International Journal of Engineering Research & Technology. Vol. 10 Issue 04. pp 122 – 124.

[6] Kazi Bushra Abdulla, Manihar Sabrin Ziyaullah, Shaikh Shamsher Siraj and Sayed Arshadul Quadri. 2021. Manufacturing of paver block by partially replacement of aggregates with plastic. EasyChair Preprint. № 5099.