A Study On Cement Stabilized Laterite Paver Blocks

Tanu H M, Minakshi Mishra, Sunitha M, Reshma T V, Sankalpasri S S,

Abstract: Precast interlocking concrete paver blocks are used in immense extent and its demand is increasing day by day for creating the pavement or for exterior flooring. But largely paver blocks are cast using concrete, in which cement is the binder. But it is an energy absorbing product which consumes more energy during its all phases of production process and it gives out great volume of carbon di-oxide (CO2) to the outside environment causing serious treat on the atmosphere. Thus there is needful to minimize the usage of cement or to find the other possible binding agent which is eco friendly. In the other hand large quantity of agro- industrial wastes are getting accumulated which is simply burnt or dumped in a place as a result of which environmental problems are rising and the valuable lands are getting turned into dumping yards. Only little percentage of these wastes is being used for various purposes. The materials which can improve the performance of the building elements can be effectively used in the construction field, thus helping to overcome the complications of disposal issues. Hence in this study an effort is made to use locally available laterite soil, rice husk ash and areca husk fiber to make paver blocks which is then stabilized using some percentage of cement. Further its performance is enhanced by usage of SBR latex. The pavers were cast and tested for compressive strength, abrasion resistance and water absorption. The mixture of soil with 20% replacement of rice husk ash and 0.4% addition of areca husk fiber by the weight of soil and ash, with addition of 30% cement and constant 2% latex showed satisfactory results.

Keywords: Laterite Soil (LS), Rice Husk Ash (RHA), Areca Husk Fibre (AHF), Cement, SBR Latex, Compressive Strength

1. INTRODUCTION

Block paving is an attractive practice of building a pavement or hard standing. Usually precast interlocking concrete paver blocks are used for this purpose of exterior flooring. Paver blocks are used greatly in different countries over past two decades in order to get control of the problems of providing paved path in areas where typical types of creating pavement is not workable or it is not reasonable and durable due to road congestion, geological, functioning or environmental constraints. Concrete paver blocks are ideal materials for paved path construction and they are available in various colours & shapes like square, rectangular, zig zag, dumbly, wavy ,cosmic etc with interlocking patterns so that it can lock with the adjacent paving blocks. It is applicable for both traffic and non traffic categories.

2. MATERIALS USED AND ITS TEST RESULTS

Cement

Cement is the binding agent which is commonly used as construction materials as it sets, hardens and adheres to the other materials bonding them together. ACC OPC 53 grade cement satisfying to IS 12269 was used in the present study.

- *Tanu H M: Assistant Professor, REVA University, Yelahanka, Bengaluru, Karnataka, India-560064,Email: tanu.hm@reva.edu.in*
- *Minakshi Mishra :Assistant Professor, REVA University, Yelahanka, Bengaluru, Karnataka, India-560064, minakshi@reva.edu.in*
- *Suintha M: Assistant Professor, Government Engineering college,Kushalnagar,kodagu,karnataka,India-560064,Email: sunithamuthappa@gmail.com*
- *Reshma T V:Assistant Professor, REVA University, Yelahanka, Bengaluru, Karnataka, India-560064,reshma.tv@reva.edu.in*
- *Sankalpasri SS:Assistant Professor, REVA University, Yelahanka Bengaluru, Karnataka, India-560064,reshma.tv@reva.edu.in*

Figure 1: *Cement*

Properties of Cement		Values
Specific Gravity		3
Fineness of Cement		0%
Standard Consistency		31%
Cement Setting Time	Initial Setting Time (IST)	40min
	Final setting Time (FST)	5.5 hours
Compressive Strength	3 days	27.95
	7 days	41.20
	28 days	55.33
Soundness Test of Cement		2mm

TABLE 1: *Physical Properties and Mechanical Properties of Cement*

The physical and chemical characteristics ,of foundry sand will depend. in great part on the type of casting process .and the industry sector from which it originates. Foundry sand is produced by five different foundry classes. The ferrous foundries (gray iron, ductile iron and steel) produce the most sand. Aluminum, copper, brass and bronze produce the rest. Foundry sand is basically fine aggregate. It can be used in many, of the same ways as natural or manufactured sands. This includes many civil engineering applications such as embankments, flowable fill, hot mix asphalt ,(HMA) and portland cement concrete (PCC). Foundry sands have also been used. extensively agriculturally as topsoil. Block paving is an attractive practice of building a pavement or hardstanding. Usually precast interlocking concrete paver blocks are used for this purpose of exterior flooring. Paver blocks are used greatly in different countries over past two decades in order to get control of the problems of providing paved path in areas where typical types of creating pavement is not workable or it is not reasonable and durable due to road congestion, geological, functioning or environmental constraints. Concrete paver blocks are ideal materials for paved path construction and they are available in various colours & shapes like square, rectangular, zig zag, dumbly, wavy ,cosmic etc with interlocking patterns so that it can lock with the adjacent paving blocks. It is applicable for both traffic and non traffic categories. Laterite Soil (LS) The laterite stones are the usual building materials which are used in house construction and the distributed sample of this laterite rock is the Laterite Soil (LS). Its colour is commonly Rusty red/reddish brown because of the presence of Iron oxides in great amount. These soils are very soft when wet and becomes hard on loosing moisture. It is formed by long-lasting deterioration of underlying parent igneous rock in high temperature and high rainfall areas (tropical regions). The alternating wet and dry seasons results in eroding away silica and lime of the parent rocks by leaving back the elements like iron and aluminium.

Figure 2: *Laterite soil*

Specific Gravity of Soil		2.55
Particle Size Distribution	Gravel (%)	21%
	Sand (%)	51%
	Silt and Clay (%)	28%
Soil Group Symbol		SP (Poorly Graded Soil)
Atterberg's Limit	Liquid Limit (%)	35
	Plastic Limit (%)	24
	Shrinkage Limit (%)	15
	Plasticity Index (%)	11
For Standard Proctor's Test	OMC (%)	19.92
	MDD (g/cc)	1.76
	UCC (kN/m^2)	126
For Modified Proctor's Test	OMC (%)	17.35
	MDD (g/cc)	1.93
	UCC (kN/m^2)	177

TABLE 2: *Geotechnical Properties of Laterite Soil*

Rice Husk Ash (RHA)

RHA is an agro industrial waste residue obtained as by product after milling process of paddy in rice milling industry. Rice husk (RH) is the hard protecting cover above rice which is a waste residue and this RH is mostly used for firing purpose for processing of paddy. After burning RH, the ash is received which is known as RHA and this is also a waste. The total global RHA production is about 20 to 25 million tons per year. Thus RHA is the major agricultural waste generated in rice producing countries. Only little amount of the ash is used for various purposes and rest of the ash generated are simply dumped.

Figure 3: *Rice Husk Ash*

Properties	Results
Specific Gravity	2.10
Moisture Content	8.2
Colour	Black
Shape Texture	Irregular
Odour	**Odourless**

TABLE 3: *Physical Properties of RHA*

Areca Husk Fibre (AHF)

Areca husk fibre is the natural fibre obtained from areca husk which is an agricultural waste produced after extraction of areca. Areca nut is one of the most prominent cash crop grown in Southeast Asia. It is even called as betal nut which falls to Areca Catechu L species belonging to the family Palmecea.

Figure 4: *Areca Husk Fibre*

Properties	Range
Diameter	0.1-0.5 mm
Length	40 -50 mm
Density	1.1-1.2 g/cc
Tensile Strength	10-250 MPa
Young's Modulus	1000-2700 MPa

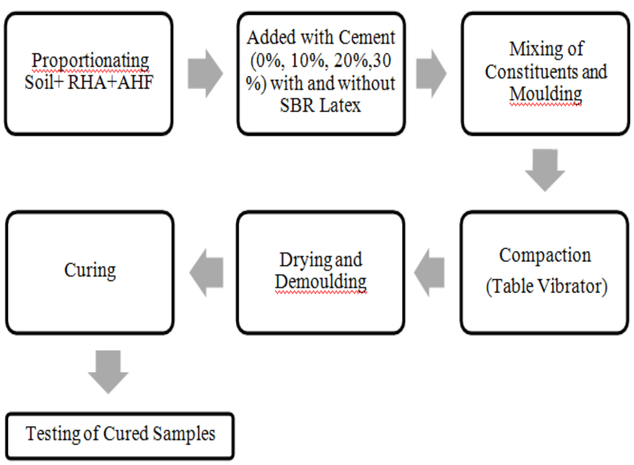
TABLE 4: *Physical AND MECHANICAL PROPERTIES OF AHF*

Styrene Butadiene Rubber (SBR) Latex
Super Latex is the milky white sticky liquid either natural or synthetic. Natural latex is produced from plants mainly rubber tree which emerges out when plant is cut and which coagulates when exposed to the environment. The latex is in huge demand as it is useful for making of paints, strong adhesives, plasters, gloves etc. So as the technology developed synthetic latex was produced in order to reach the market needs. Synthetic latex is made by polymerising a monomer (styrene) which is emulsified with surfactants. Fig 1.2 shows the natural and synthetic latex.

***Figure 3:** Areca husk*

WATER
Casting and curing of specimens were done using portable water which shall be free from deleterious materials.

3. METHODOLOGY



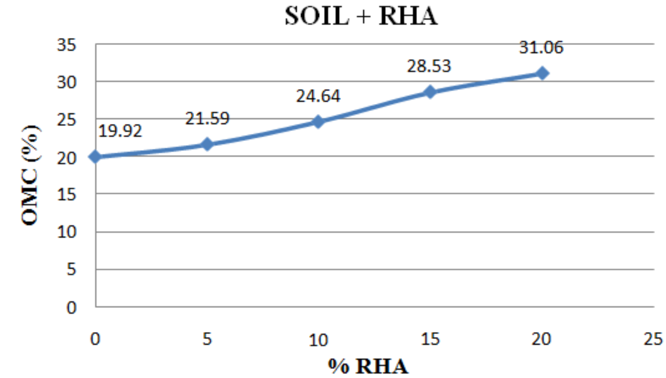
Mix Proportion
Initially basic tests on soil were conducted in order to find out its geotechnical properties. Soil was blended with different proportion of RHA (as given in the Table 3.8) as replacement to soil; then Standard Proctor's Test and UCC Test was conducted to determine its optimum range to mix with soil. Later soil and optimum RHA was added with varying percentage of AHF)by weight of total solids.

4. RESULTS

Standard proctor test For Soil Replaced By RHA
The Table 5 gives the OMC of Standard Proctor's Test with varied percentage of RHA as replacement to soil. It was observed that as the percentage of ash increases there will be the increase in OMC from 19.92 to 31.06%. This is may be because of the reason that ash was absorbing excess water as noticed.

RHA Content (%)	0	5	10	15	20
OMC (%)	19.92	21.59	24.64	28.53	31.06

***TABLE 5:** OMC for RHA Replaced Soil*

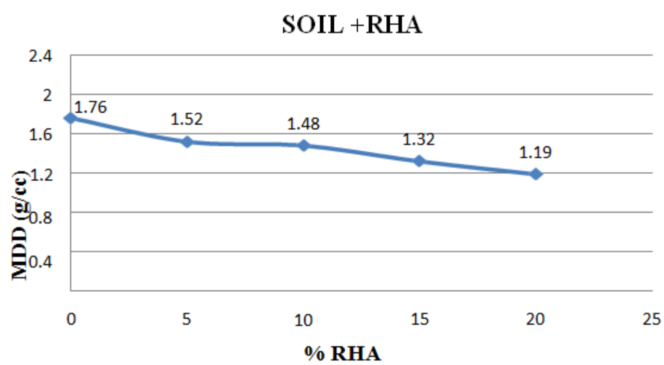


***Graph 1:** OMC for RHA Replaced Soil*

Modified proctor test For Soil Replaced By RHA
The Table 6 gives the MDD of Standard Proctor's Test with varied percentage of RHA replacing soil. It was observed that as the percentage of ash increases there will be the decrease in MDD from 1.76 to 1.19 g/cc. This may be due to the replacing of higher specific gravity soil (2.55) by lower specific gravity RHA (2.10).

RHA Content (%)	0	5	10	15	20
MDD (g/cc)	1.76	1.52	1.48	1.32	1.19

***TABLE 6:** MDD for RHA Replaced Soil*



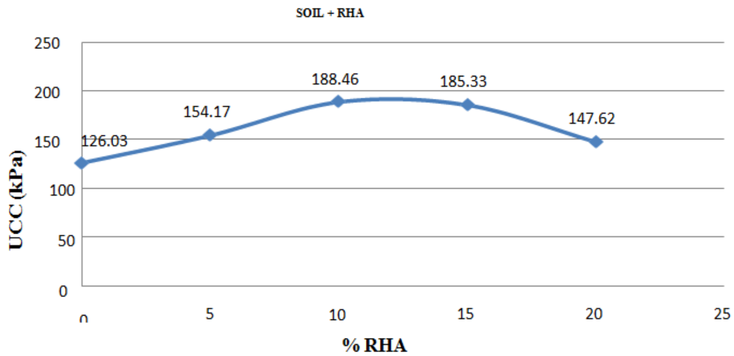
***Graph 2:**MDD for RHA Replaced Soil*

UCC For Soil Replaced By RHA:
The Table 7 gives the UCC value obtained for varying proportion of RHA replacing soil. It was noticed that, as the percentage of RHA goes on increasing, the UCC value increased from 126.03 to 188.46 kPa upto 10% replacement and further it decreases. It may be because of the reason that, reduction in frictional resistance.

RHA content (%)	0	5	10	15	20

UCC (kPa)	126.03	154.17	188.46	185.33	147.62

***TABLE 7:** UCC for RHA Replaced Soil.*



***Graph 3:** UCC for RHA Replaced Soil*

As the UCC value obtained for 10% and 15% replacement of soil by RHA was nearly same188.46 and 185.33 kPa. So these two replacements were considered to know its behavior with addition of different percentages of AHF.

SPT & MDD FOR SOIL REPLACED WITH RHA AND ADDED WITH AHF:

The Table 8 gives the OMC of Standard Proctor's Test for 10 and 15% RHA replacing soil with varying percentage of AHF. It was observed that as the percentage of fiber increases there will be the increase in OMC from 24.64 to 28.31% for 10% RHA and it increases from 28.53 to 32.08 % for 15% RHA content. This is may be due to the soil requirement of large amount of water for rearranging of particles with fibers

AHF content (%)	0	0.1	0.2	0.3	0.4	0.5
OMC for 10% RHA (%)	24.64	24.99	25.41	26.36	27.94	28.31
OMC for 15% RHA (%)	28.53	29.01	30.34	30.91	31.46	32.08

***TABLE 8:** OMC for AHF Added with Soil RHA Mix*

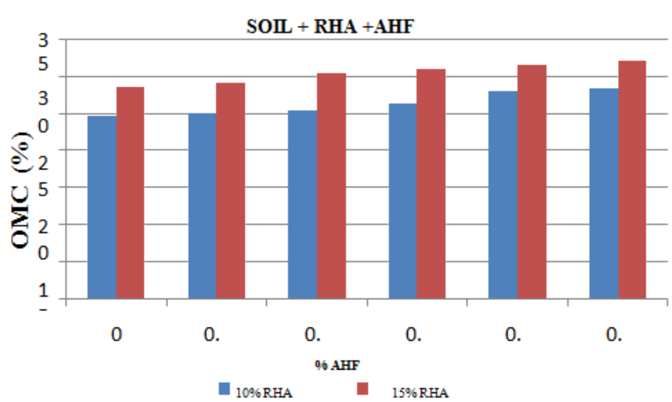


***FIG 1**: OMC for AHF Added with Soil RHA Mix*

The Table 9 gives the MDD of Standard Proctor's Test for 10 and 15% RHA replacing soil with varying percentage of AHF. It was observed that as the percentage of fiber increased there was decrease in MDD from 1.48 to 1.39 g/cc for 10% RHA and it decreased from 1.32 to 1.22 g/cc for 15% RHA content. This is may be due to the light weight and less specific gravity of fibers. However the variation is negligible.

AHF content (%)	0	0.1	0.2	0.3	0.4	0.5
MDD for 10% RHA (%)	1.48	1.47	1.45	1.43	1.40	1.39
MDD for 15% RHA (%)	1.32	1.31	1.28	1.27	1.24	1.22

TABLE 9: MDD for AHF Added with Soil RHA Mix

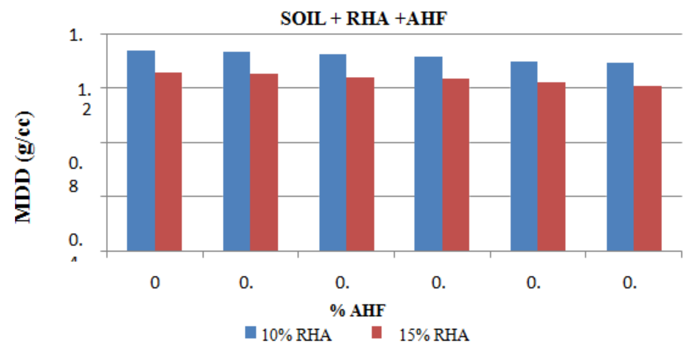


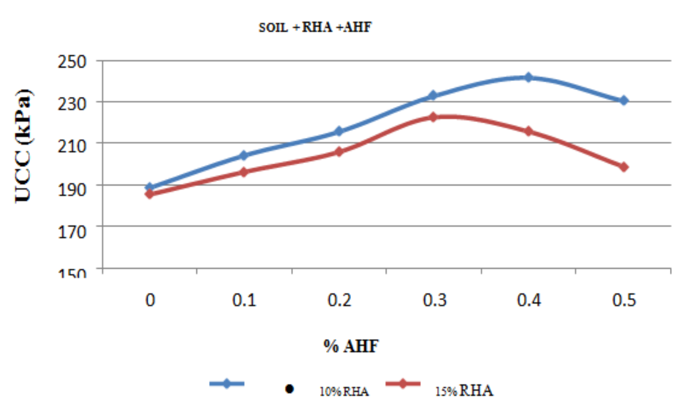
Fig 2: MDD for AHF Added with Soil RHA Mix

UCC FOR SOIL REPLACED WITH RHA AND ADDED WITH AHF:

The Table 9 gives the UCC value obtained for 10 and 15% RHA replacing soil with varying proportion of AHF. It was noticed that, as the percentage of AHF goes on increasing, the UCC value for 10% RHA replacement increases from 188.46 to 241.56 kPa up to 0.4% fiber content and further it decreases for 0.5%. Similarly as the percentage of AHF increases, the UCC value for 15% RHA replacement increases from 185.33 to 222.52 kPa upto 0.3% fiber content. It may be because of the reason that, inclusion of fibers upto certain limit, improves resistance to deformation under load by interacting of fibers with soil particles mechanically through interlocking and friction, which in turn helps to transfer the stress from soil to fiber.

AHF Content (%)	0	0.1	0.2	0.3	0.4	0.5
UCC for 10% RHA (kPa)	188.46	204.11	215.62	232.77	241.56	230.41
UCC for 15% RHA (kPa)	185.33	196.25	205.9	222.52	215.67	198.78

***TABLE 10:** MDD for AHF Added with Soil RHA Mix*



***GRAPH 4:** UCC for AHF Added with Soil RHA Mix*

As the UCC value has shown a maximum result of 241.56 kPa for 10% RHA replaced soil and 0.4% AHF addition. The dosage of RHA is fixed to, replacement of 10% of soil and addition of AHF to 0.4% of soil and ash mixture

Compressive Strength Test Of Paver Blocks

The Table 11 gives the 7, 14, 28 days compressive strength of paver blocks without the addition of SBR latex. It was noticed that compressive strength is increasing with the increase in the amount of cement content addition. This may be because of availability of more calcium content from cement which reacts with the silica content of RHA to undergo pozzalonic reaction to form cementing materials which gives sufficient strength to the paver blocks by holding the constituents.

% of Cement	0 (M-1)	10 (M-2)	20 (M-3)	30 (M-4)
7 Days Compressive Strength (MPa)	4.9	8.5	9.2	10.8
14 Days Compressive Strength (MPa)	5.2	10.3	11.2	13.1
28 Days Compressive Strength (MPa)	5.5	10.9	13.4	17.2

TABLE 11: *Compressive Strength of Paver Blocks without SBR Latex*

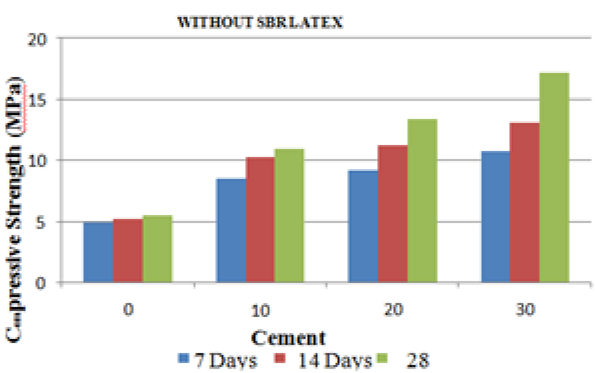


Fig 3: *Compressive Strength of Paver Blocks without SBR Latex.*

The Table 12 gives the 7, 14, 28 days compressive strength of paver blocks with the addition of SBR latex. It was noticed that the compressive strength is further increasing with the increase in the amount of cement and with the addition of SBR latex. This may be because of availability of lime content from cement which lacks in Soil and RHA and also due to the bonding property of latex which holds the constituents strongly making the paver blocks giving high strength. It was also observed that the compressive strength at early age was less but rapidly increases after 7 days of curing. This may be due to the reason that Latex will be involved in building the polymer structure which matures by age and thus early strength gain is less.

% of Cement	0 (M-5)	10 (M-6)	20 (M-7)	30 (M-8)
7 Days Compressive Strength (MPa)	3.5	7.1	8.6	9.4
14 Days Compressive Strength (MPa)	8.5	16.3	19.9	23.4
28 Days Compressive Strength (MPa)	10.2	17.7	22.7	25.2

TABLE 12: Compressive Strength of Paver Blocks with SBR Latex

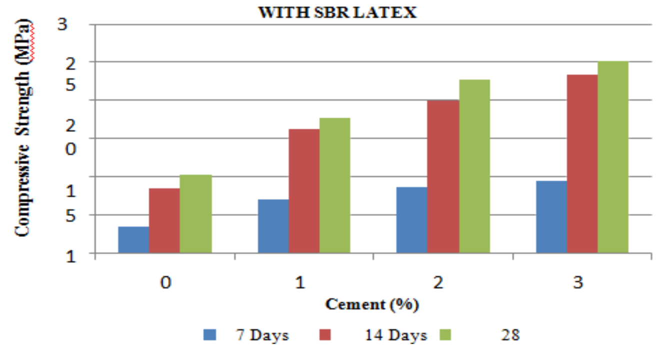


Fig 4: *Compressive Strength of Paver Blocks without SBR Latex*

5. CONCLUSION

Based on the experimental study following conclusions are drawn:

- Replacement of RHA by 0% to 20 % of laterite soil; increases the OMC from 19.92 to 31.06% with 11.14% increment and decreases MDD from 1.76 to 1.19 g/cc with a decrement of 0.57 g/cc.
- The usage of RHA by replacing soil from 0% to 20% increases the UCC value from 126.03 to 188.46 kPa upto 10% replacement with an increment of 62.43 kPa and for further replacement it decreases.
- For the addition of fibers from 0% to 0.5%, OMC was increased from 24.64 to 28.31% for 10% RHA and it increases from 28.53 to 32.08 % for 15% RHA content and MDD was decreased from 1.48 to 1.39 g/cc for 10% RHA and it decreases from 1.32 to 1.22 g/cc for 15% RHA content.
- For the usage of AHF from 0 to 0.5%, the UCC value for 10% RHA replacement increases from 188.46 to 241.56 kPa up to 0.4% fiber content with an increment of 53.1kPa and further it decreases for 0.5%. Similarly as the percentage of AHF increases, the UCC value for 15% RHA replacement increases from 185.33 to 222.52 kPa upto 0.3% fiber content with an increment of 37.19kPa.
- In the study the maximum 28 days compressive strength was obtained for M- 8 Mix, which is about 25.2 MPa which got increased from 4.9 Mpa (M-1 Mix) with an improvement in strength by 4.15%.

6. FUTURE SCOPE

The present work investigation can be carried out to the following future cases:

- Present work can be carried out by using different agricultural and industrial wastes which can be used for other type of soil.
- The work can be further carried out by using the natural rubber latex instead of synthetic latex.
- Percentage of cement usage can be further increased and can cast pavers with those percentages and also with varying percentage of SBR Latex instead of keeping it constant.

- The particular project is tested for vibrated pavers which can be tried for compressed paver blocks.Can make a study of Tensile and Flexural behavior of Paver blocks.

REFERENCES

[1] Anil Kumar., Anoop Kishan. K., Divakar L., Sudheer (2015) “Study on Compressive Strength of Concrete Using Areca Fibre as Reinforcement”., International Journal of Engineering Trends and Technology., Vol 24., No 3., pp 121-124.

[2] Anji Reddy. E., Vishal Gupta., Deepak Garg (2015) “Effect of Partial Replacement of Cement by Rice Husk Ash using Nylon Fiber in Concrete Paver Block”., International Journal for Scientific Research and Development., Vol.3., Issue 03., ISSN : 2321-0613., pp 45-48.

[3] Kabiraj. K., Mandal. U.K (2012) “Experimental Investigation and Feasibility Study on the Stabilised Compacted Earth Block using Local Resources”., International Journal of Civil and Structural Engineering., Vol 2., No3.,pp 838-850.

[4] Kapil Soni Er., Joshi. Y. P (2014) “Performance Analysis of Styrene Butadiene Rubber Latex on Cement Concrete Mixes”., Journal of Engineering Research and Applications., Vol 4.,Isuue 3.,pp 838-844.

[5] Muni T, Jeram Y., Padu., Omo, Y and Singh H.P (2014) “Strength and Stiffness Response of Itanagar Soil Reinforced with Areca Nut Fibre”., International Journal of Innovative Research in Science, Engineering and Technology., Vol 3, Issue 10.

[6] Mohan Kumar. G.C (2008) “A Study of Short Areca Fibre Reinforced PF Composites”., Proceedings of the World Congress on Engineering. Vol 2., Issue 8.,pp 10-14.

[7] Makarand Suresh Kulkarni., Paresh Govind Mirgal., Prajyot Prakash Bodhale., Tande S.N(2014) “Effect of Rice Husk Ash on Properties of Concrete”., Journal of Civil Engineering and Environmental Technology., Vol 1.,No 1.,pp 26-29.

[8] Megha Kalra., Garima Srivastav., Atul Thakur (2015) “The Study on Use of Rice Husk Ash”., International Journal of Science and Engineering., Vol 3.,ISSN: 2347-2200.,pp 85-88.