PRODUCTION OF ECO FRIENDLY COMPOSITE BLOCKS INCORPORATING SISAL FIBER AND SCRAP TYRE RUBBER AND STEEL SLAG AS COARSE AGGREGATE

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The modernization developments globally lead to an abundance of infrastructure progression. This progression is consequential to numerous sources of predicament like scarcity of construction resources on the other hand increases productivity thrown away from industry. Of late, managing scrap is the principal concern faced globally. The throwaway problem is the most significant issue facing the world as a source of ecological contamination. Recent growth in transportation has generated an immense number of motor vehicles creating an enormous quantum of scrap tyres. This paper investigates incorporating the salvage of scrap tyre rubber of coarse aggregate in M_{30} eco-friendly composite blocks as a fragmentary substitution. As per the recent government norms M_{30} eco-friendly composite is used for principally constructional works. This research is to appraise the accomplishment of steel slag as coarse aggregate in the fly-ash-based eco-friendly composite. Eco-friendly composite(EFC) is 100 % cement Scrap tyre rubber and steel slag were progressively incorporated with 0%, 5%, 10%, 15% ,and 20% to substitute coarse aggregate with sisal fiber in, 4% of fly ash. Properties of coarse aggregates, fine aggregates, fly ash and scrap tyre rubber were found. Paver Blocks were cast and tested for 7, 14 and 28 days of strength. The result shows that the compressive and flexural strength of M_{30} eco-friendly composite with scrap tyre rubber is 5% for Blocks is optimal. Laboratory tests were carried out and the conclusion was made based on the results. The outcome shows that the mechanical characteristics of M30 eco-friendly composite with scrap tyre rubber are 5% for eco-friendly composite (EFC) Blocks are most advantageous. Also, structural characteristics were studied.

Keywords:: *Eco-friendly composite, fly ash, Sisal fiber, Steel slag, Scrap tyre rubber,*

1. Introduction

In topical time, Ecological and eco-friendly composite has depicted a staid notice of researchers for the conception of an "Environmentally Ecofriendly attitude to the environment". The role of cement manufacture globally in greenhouse gas emanation is projected to be around 1.35 billion tonnes/annum. It is vital to substitute cement by substituting resources available as byproducts from industries.

Geopolymer composites are created when a variety of alumina and silica-containing resources react under highly alkaline conditions and form a three-dimensional system of Si-O-Al-O bonds.[1,3,4,6,10] Electric arc furnace steel slag is a derivative obtained from the steel-producing industry through the melting of steel scrap from impurities and fluxing agents. Electric arc furnace steel slag is obtained by cooling the electric arc furnace steel liquid slag in the air at the manufacturing site.[15,19,20] The properties of slag fluctuate based on the type of furnace and charge, the longing grade of steel purity and the furnace process circumstances. In the production of steel process, we are getting around 15% of slag. Slag has components of calcium silicates, Ca-Al-ferrites, and molten oxides of calcium, iron, magnesium, and manganese.

As the global population rises, wastes of diverse types are being generated Forming of non-crumbling and low--eco-friendly waste materials, mingling with mounting consuming inhabitants face consequences in throw-away clearance disasters. [2,6,7,11,14]. One way out of this disaster is to reuse or throw away useful wares. A lot of investigations were sectors and researchers attempted to conquer waste salvaging considering the viability, environmental appropriateness and recital of using waste in the construction field which needs better and cost-effective construction material and reuse of waste scrap tyre rubber and save our globe from ecological pollution.[4,5,13,14]With the augment in growth, there is a rise in expenditure on construction and the maintenance activities of pavements. So, we are trying a new idea of utilizing waste scrap tyre rubber in the Eco-friendly composite (EFC) using the geopolymer composite blocks industry.These composites are with a reduction of vulnerable to rutting, minimum fatigue or thermal cracking, low stripping due to dampness, and proffer great strength, modest or no impact on processing, and also generate eco-friendly manufacturing of blocks for construction projects and schemes with minimal outlay of cost.

The scrap tyre rubbers from factories are large and are augmenting with time. Globally waste configuration are different from place to place [8,16,17,18]. since it is influenced by socio-economic uniqueness and utilization outline, but generally, scrap tyre rubbers from industries in waste composition are soaring. The huge quantity of materials necessary for construction is prospective a main locale for the recycling of throw-away resources. [9,10,12,13] Reuse of throw-away from industries in concrete dominates due to it is extensive utility and has a lengthy

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executed by state bodies, private usefulness and due to that the throw-away is being eliminated. Because the quantity of ingredients comprised of aggregates required in composites is large, the ecological advantages are not only associated with the safe removal of bulk throw away from industries, but also with the reduction of ecological brunt arising from the utilization of aggregate materials. to the reduction of ecological brunt arising from the utilization of aggregates materials.

We use sisal fiber a provincially obtainable eco-friendly construction & structural material having optimum strength characteristic properties, durableness & minimal cost. Sisal fiber eco-friendly material. Sisal is an organic fiber material liable for bio-degradability. In this paper, we are using sisal fiber is mainly utilized for applications in the manufacturing of ropes in naval and construction activities. As it has optimal potential correlated with other fibers, chosen for this investigational work. Geo polymer paste is done with the help of fly ash, filler materials, and aggregates are prepared. We are using sisal fibres as a reinforcing element for binders.

2. Scope and Objective

To find the basic characteristic properties of Fine and coarse Aggregates and binders.

Finding out the physical characteristic properties of scrap tyre rubbers.

For conducting mixed design as per IS: SP 23 – 1982 (1).

For casting eco-friendly composite paver blocks with scrap tyre rubbers.

For studying the compressive and flexural characteristic strength 0%, 5%, 10%, 15%, and 20% of scrap tyre rubbers samples were added by incorporation with a partial replacement of coarse aggregate with sisal fiber in 4% of fly ash.

To study the Compressive and flexural strength in 0%, 5%, 10%, 15%, and 20% of steel slag aggregate added samples by incorporation with a partial replacement of coarse aggregate with sisal fiber in 4% of fly ash.

3. Materials

Fly ash:

Class F type-low calcium fly ash conforming to ASTM C 618 obtained from lignite burning thermal power station was collected in a dry state from Mettur Thermal Power Station (MTP), Salem, Tamil Nadu ,and used for making eco-friendly composite blocks.[9,14,15,19,20] The specific gravity of fly ash is 2.27. The chemical composition of fly ash used is listed in Table 1.

Table 1 - Chemical composition of fly ash

S.No	Component	Weight%
1	SiO2	61.28
2	Al2O3	29.35
3	K2O3	1.320
4	MgO	0.74
5	CaO	1.27
6	Fe2O3	3.29
7	SO3	0.005
8	TiO2	0.02
9	Na2O	0.75
10	Cl	0.035
11	LOI	0.69

Fine aggregate:-

The fine aggregate used is bottom ash conforms to the requirement of IS 383.Bottom ash of maximum size 4.75mm conforming to Zone II of IS 383-1970 was used as fine aggregate [11,12, 13, 17 ,18]. The physical properties of bottom ash are illustrated as table.2.

Table 2 - Physical properties of bottom ash

S.No	Parameter	Value
1	Bulk Density	1.72kg/m^3
2	Specific Gravity	2.79
3	Water Absorption	0.8
4	Fineness Modulus	2.95

Coarse Aggregate:-

Coarse aggregate shall conform to the requisite of IS 383 as far as possible crushed stone aggregate shall be used to ensure ample durability. The aggregate used for making a block shall be durable and free from flaky and honeycomb particles the nominal maximum size of coarse aggregate utilized for producing of paver block conforming to IS 383-2016 of a maximum size of 20mm was made use of for this investigation.. The physical characteristic properties of coarse aggregate are listed in Table3.

Table 3 - Physical properties of coarse aggregate

S. No	Parameter	Value
1	Bulk density	1490kg/m^3
2	Specific gravity	2.91
3	Water absorption	0.8%
4	Crushing value	18.25%
5	Impact value	19.79%
6	Fineness modulus	6.80

Steel slag aggregate:

Scrap steel slag from JSW steel Industry, Salem, Tamil Nadu steel re-rolling mill was trampled down using a mechanical jaw type crusher and graded to a maximum size of 20mm [7, 8, 11]. The physical properties of steel slag are listed in Table 4.

Table 4 - Physical properties of steel slag aggregate

S.No	Parameter	Value
1	Bulk Density	1290kg/m^3
2	Specific Gravity	3.45
3	Water Absorption	1.45%
4	Fineness Modulus	5.48
5	Crushing value	20.45%
6	Impact value	25.95%

Reshaped Tyre Rubber:

The truck tyres which were surrounded with thread fibres were torn to attain scrap rubber chips. The tyres are subsequently cut to shape into tiny cubes having sizes 20x20x10 mm. A 10mm diameter bore was done on the scrap rubber aggregate's facet. Table 5 illustrates its physical characteristics and Figure 1 shows scrap rubber.

Curing:

Eco-friendly composite specimens were cured at an ambient temperature of (32°C+2°C) for 7 days, 14 days and, 28 days.

Table 5 - Mechanical characteristics of Rubber Chips

PROPERTIES	CA
Specific gravity	1.88
Bulkdensity	480.85 kg/m^3

Fig.1-10mm diameter hole on the surface of the reshaped tyre rubber

Sisal fiber properties

The physical properties of sisal fibers are a density of 1.475 g/cm3, an average length of 400 mm, an average diameter of 0.15 mm and water absorption of 78.275 % are the physical properties of sisal fiber [2,5].

The sisal fiber is composed of 12.75 % hemicellulose, 9.87 % lignin, and 65 % cellulose whereas banana fiber is composed of 7.25 % hemicellulose 7.25 % lignin, and 62 % cellulose. In addition to these chemicals, sisal fibre has waxes of 0.375% water soluble compound of 7.25% pectin 0.78%.

The following mix quantities arrive for the grade of eco-friendly composite - (**M_{30}**) are listed as table.6.

Table 6 - Quantity of materials

MATERIAL	QUANTITY(kg/m^3)
Binder content	411.00
Fine aggregate	546.40
Coarse aggregate	1168.40
Alkaline solution	191.58
Solution to binder ratio	0.43

4. EXPERIMENTAL WORK

Mixing:

The mixing procedure is similar to normal concrete. To begin with we have to prepare the sodium hydroxide and mix it with sodium silicate solution a day before casting. At the start, all the materials were mixed in dry form and then the alkaline solution was added to the dry mix and the mixing was done until a homogenous mix was achieved.

Casting:

Usually, M_{30} geo-friendly composite is utilized for most construction projects in present days, this investigation is taken with M_{30} geo-friendly composite, and scrap tyre rubbers were used as partial replacement of coarse aggregate. Scrap tyre rubbers such as 0%, 5%, 10%, 15%, and 20% were added in percentage to coarse aggregate as a partial replacement. Casting of specimens were illustrated in Fig.2 .Tests were conducted on fly ash, bottom ash, coarse aggregates, and scrap tyre rubbers to ascertain their physical characteristics. Paver blocks of the I-section (Paver Block) were cast and after 24 hours, the specimens were demoulded. Samples were tested for 7, 14, and 28 days strength characteristics.

Casting:

Fig.2 - Casting of specimen

5. Test Results

5.1. Testing for Mechanical Properties

Testing of the casted specimen is tested for 7, 14, and 28 days for mechanical characteristics namely compressive and flexural characteristics, utilizing a universal testing machine. The outcome of the conducting tests of both compressive and flexural characteristics are shown in figure 3a& b and figure 4a& b.

Compressive characteristics Test Report M 30Grade Paver Block

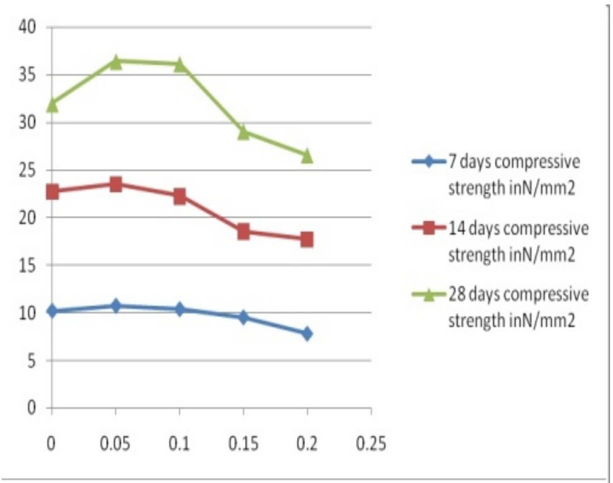

Fig.3 - a) Compressive characteristics results of M_{30} Grade Paver Block using scrap tyre rubbers sisal fiber

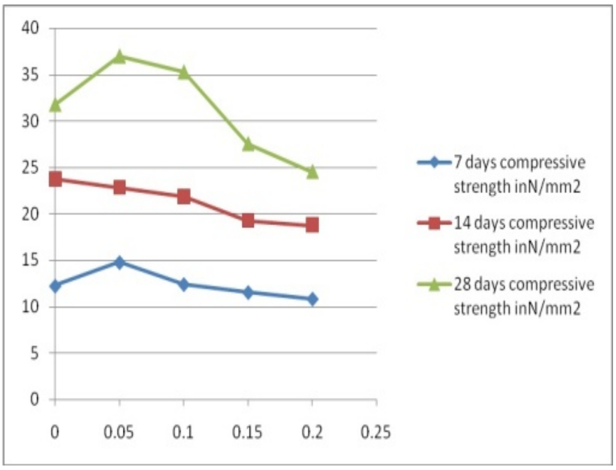

Fig.3 - b) Compressive characteristics results of M_{30} Grade Paver Block using Steel slag Sisal fiber

Flexural characteristics Test Report M_{30} Grade Paver Block

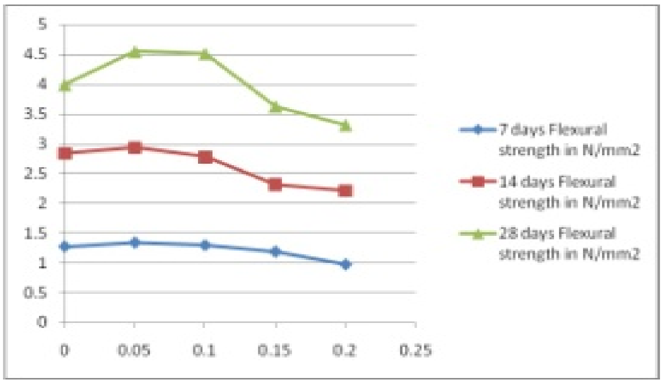

Fig. 4a - Flexural characteristics of M_{30} Grade Paver Block using scrap tyre rubbers Sisal fiber &

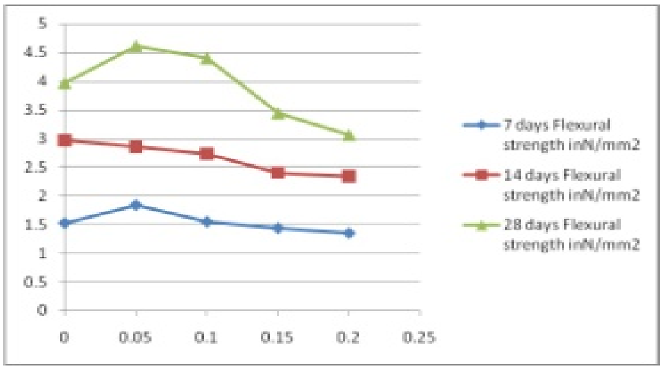

Fig.4b - Flexural characteristics of M_{30}Grade Paver Block using Steel slag Sisal fiber

5.1.2. Microstructural analysis of scrap tyre rubbers Sisal fiber and Steel slag Sisal fiber

The microstructure of fly ash is analyzed using a Scanning Electron Microscope (SEM). From the figure, the microstructure of fly ash appears to be a flat, unfilled, sphere-shaped particle that is thin-walled unoccupied globe-shaped. The surface crumb emerges to be flat and intense to greatly spongy.

It is comprehensible illustrated in the figure that the outline of steel slag is not globular; it has diverse and dissimilar pulverizing techniques Images were principally anomalous form along with clear splits and position SEM Images of steel slag with sisal fiber are illustrated as fig.5(a-e) and SEM Images of scrap tyre with sisal fiber are illustrated as fig.6 (a-e).

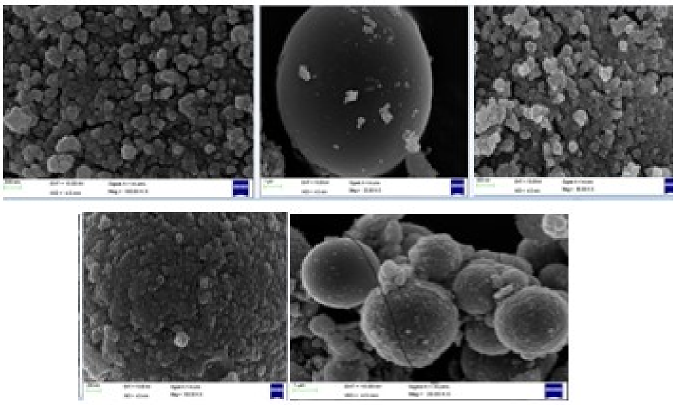

Fig 5(a-e) - SEM images of M_{30} Grade Paver Block using scrap tyre rubbers Sisal fiber

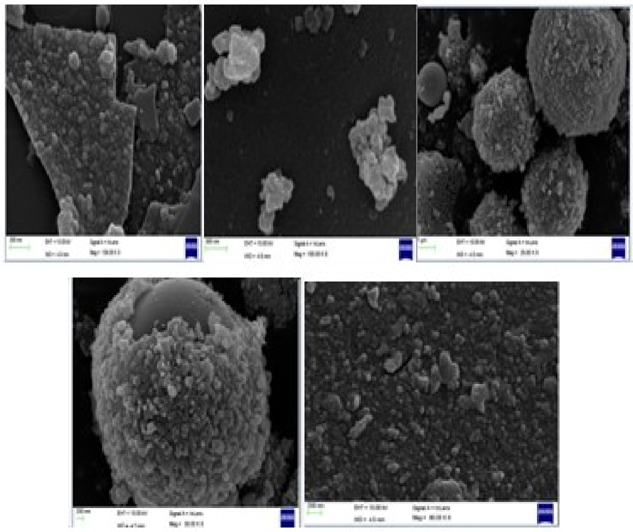

Fig6(a-e) -SEM images of M_{30}Grade Paver Block using Steel slag Sisal fiber

Edax analysis

The various mixes emerge slightly bigger voids and candor in gel configuration; it is perhaps sourced by the crystallization of the gel phase and hydration function. The micro crack commences to decrease with the alteration of voids leading to densified gel formations in specimens. This conclusion convincingly testifies that the addition of sisal fiber is advantageous for the configuration of an opaque microstructure and homogeneity in the geopolymer composite matrix. The results from (EDAX) were also construed. The outcome indicates that the opaque configuration was due to the addition of sisal fiber which increases the Si-O-Al bond in the solidifying state. EDAX Images of steel slag with sisal fiber are illustrated as fig, 7(a-e) and SEM Images of scrap tyre with sisal fiber are illustrated as fig 8(a-e).

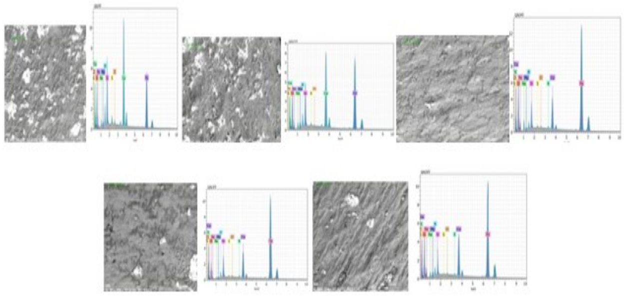

Fig7(a-e) EDAX images of M_{30}Grade Paver Block using scrap tyre rubbers Sisal fiber

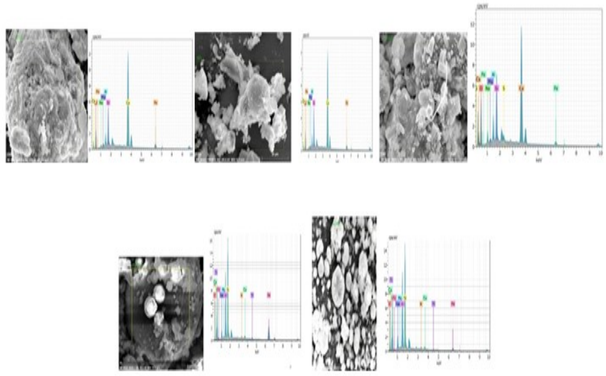

Fig8(a-e) EDAX images of M_{30}Grade Paver Block using Steel slag Sisal fiber

6. Discussion

A critical exploration was performed in eco eco-friendly composite with constituents fly ash, and bottom ash, integrated with scrap tyre rubbers as coarse aggregate and sisal fiber employed as auxiliary buttress substance in eco composite blocks. In the present research, it is established that prime up to 5% by partial replacement of scrap tyre rubbers there is a significant variation of compressive strength. From the test results it was established that the compressive characteristics value of the eco-friendly composite mix decreased with the addition of more than 5% of scrap tyre rubbers. So we can add scrap tyre rubbers in paver blocks this will help to reuse scrap tyre rubbers in paver blocks Conservative eco composite mechanical characteristic explored at the interlude indicated in Indian concrete code.

The compressive characteristics at the interlude indicated in the Indian concrete code and assessment demonstrate that eco composites integrated by 5% of steel slag as coarse aggregate accompanied by sisal fiber have accomplished the best possible strength.

The compressive characteristics were appraised ensuing 7 days. The existence of sisal fiber in steel slag exerts influence on its compressive characteristics. For EFC it was 12.53 N/mm^2. For EFCSS$_1$, it accrues to 15.11 N/mm^2. Its compressive characteristics diminish to 12.70 N/mm^2 in EFCSS$_2$, 11.82 N/mm^2 in EFCSS$_3$, and 11.09 N/mm^2 in EFCSS$_4$.

The compressive characteristics were appraised ensuing 14 days. The existence of sisal fiber in steel slag exerts influence on its compressive characteristics. For EFC it was 24.28 N/mm^2. For EFCSS$_1$, it accrues to 24.36 N/mm^2. Its compressive characteristics diminish to 22.34 N/mm^2 in EFCSS$_2$, 19.68 N/mm^2 in EFCSS3, and 19.17 N/mm^2 in EFCSS$_4$.

The compressive characteristics were appraised ensuing 28 days. The existence of sisal fiber in steel slag exerts influence on its compressive characteristics. For EFC it was 32.46 N/mm^2. For EFCSS$_1$, it accrues to 37.78 N/mm^2. Its compressive characteristics diminish to 36.04 N/mm^2 in EFCSS$_2$, 28.14 N/mm^2 in EFCSS$_3$, and 25.07 N/mm^2 in EFCSS$_4$.

The above appraisal proves that integrating 5% of steel slag as coarse aggregate with sisal fiber has accomplished the prime strength in compressive characteristics.

The compressive characteristics were appraised ensuing 7 days. The existence of sisal fiber scrap tyre rubber exerts influence on its compressive characteristics. For EFC it was 10.56 N/mm^2. For EFCST$_1$, it accrues to 11.11 N/mm^2. Its compressive characteristics diminish to 10.73 N/mm^2 in EFCST$_2$, 9.85 N/mm^2 in EFCST$_3$, and 8.09 N/mm^2 in EFCST$_4$.

The compressive characteristics were appraised ensuing 14 days. The existence of sisal fiber scrap rubber tyres exerts influence on their compressive characteristics. For EFC it was 23.44 N/mm^2. For EFCST$_1$, it accrues to 24.21 N/mm^2. Its compressive characteristics diminish to 22.90 N/mm^2 inEFCST$_2$, 19.06 N/mm^2 in EFCST$_3$, and 18.23 N/mm^2 in EFCST$_4$.

The compressive characteristics were appraised ensuing 28 days. The existence of sisal fiber scrap tyre characteristics. For EFC it was 32.86 N/mm^2. For EFCST$_1$, it accrues to 37.50 N/mm^2. Its compressive characteristics diminish to 37.19 N/mm^2 inEFCST$_2$, 29.88 N/mm^2 in EFCST$_3$, and 27.30 N/mm^2 in EFCST$_4$.

The above appraisal proves that integrating 5% of scrap tyre rubber as coarse aggregate with sisal fiber has accomplished the prime strength in compressive characteristics.

The flexural characteristics were appraised ensuing 7 days. The existence of sisal fiber in steel slag exerts influence on its flexural characteristics. For EFC it was 1.33 N/mm^2. For EFCSS$_1$, it accrues to 1.61 N/mm^2. Its flexural characteristics diminish to 1.35 N/mm^2 inGPCSS2, 1.26 N/mm^2 in EFCSS$_3$, and 1.18 N/mm^2 in EFCSS$_4$.

The flexural characteristics were appraised ensuing 14 days. The existence of sisal fiber in steel slag exerts influence on its flexural characteristics. For EFC it was 2.27 N/mm^2. For EFCSS$_1$, it accrues to 2.48 N/mm^2. Its flexural characteristics diminish to 2.38 N/mm^2 in EFCSS$_2$, 2.09 N/mm^2 in EFCSS$_3$, and 2.04 N/mm^2 in EFCSS$_4$.

The flexural characteristics were appraised ensuing 28 days. The existence of sisal fiber in steel slag exerts influence on its flexural characteristics. For EFC it was 3.45 N/mm^2. For EFCSS$_1$, it accrues to 4.02 N/mm^2. Its flexural characteristics diminish to 3.83 N/mm^{2}in EFCSS$_2$, 2.99 N/mm^2 in EFCSS$_3$, and 2.67 N/mm^2 in EFCSS$_4$.

The above appraisal proves that integrating 5% of steel slag as coarse aggregate with sisal fiber has accomplished the prime strength in flexural characteristics

The flexural characteristics were appraised ensuing 7 days. The existence of sisal fiber in scrap tyre rubber exerts an influence on its flexural characteristics. For EFC it was 1.38 N/mm^2. For EFCSS1, it accrues to 1.46 N/mm^2. Its flexural characteristics diminishes to 1.41 N/mm^2 in EFCSS$_2$, 1.29 N/mm^2 in EFCSS$_3$, and 1.06 N/mm^2 in EFCSS$_4$

The flexural characteristics were appraised ensuing 14 days. The existence of sisal fiber in scrap tyre rubber exerts an influence on its flexural characteristics. For EFC it was 3.07 N/mm^2. For EFCSS$_1$, it accrues to 3.17 N/mm^2. Its flexural characteristics diminishes to 3.00 N/mm^2 in EFCSS$_2$, 2.50 N/mm^2 in EFCSS$_3$, and 2.39 N/mm^2 in EFCSS$_4$

The flexural characteristics were appraised ensuing 28 days. The existence of sisal fiber in scrap tyre rubber exerts an influence on its flexural characteristics. For EFC it was 4.31 N/mm^2. For EFCSS$_1$, it accrues to 4.91 N/mm^2. Its flexural characteristics diminishes to 4.87 N/mm^2 in EFCSS$_2$, 3.92 N/mm^{2}in EFCSS$_3$, and 3.58 N/mm^{2}in EFCSS$_4$

The above appraisal proves that integrating 5% of scrap tyre rubber as coarse aggregate with sisal fiber has accomplished the prime strength in flexural characteristics

7. Conclusion

Looking into the above characteristic investigation arrived that the scrap tyre rubbers can be exploited in the geocomposite mix.

rubber exerts influence on its compressive

The addition of scrap tyre rubbers and steel slag reduces the workability of eco-friendly composite which was overcome by the addition of bottom ash as incorporation of coarse aggregate.

The 7-day cube compressive strength results show reduced strength characteristics of eco-friendly geo composite due to sluggish pozzolanic accomplishment.

The strength of eco-friendly composite cubes at 28 days with 5% replacement along with scrap tyre rubbers shows augmentation of 120% in compressive characteristics

This modified eco-friendly composite mix is appropriate for the production of firm pavements.

The compressive characteristics of modified eco-friendly geo composite are equal to the geocomposite

The optimal of scrap tyre rubbers is established to be 5% and steel slag is also instituted to be 5% for paver blocks.

The cost of construction will be reduced and also helps to avoid the general disposal technique of scrap tyre rubbers namely landfilling and incineration which has a certain burden on ecology.

In this research, bottom ash is an industrial by-product with hazardous characteristics made use of as fine aggregate for minimizing pollution.

Sisal fiber is used as a reinforcing material which improves mechanical characteristics

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