International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 07 | July 2019 www.irjet.net p-ISSN: 2395-0072

UTILIZATION OF COCONUT SHELL AND COCONUT FIBER IN CONCRETE - A REVIEW

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Abstract- *Concrete is the primary prerequisite for any infrastructure development. One of the real segment used in concrete production is aggregate, which is going to diminutive. To sustain construction activity, it is imperative to find alternatives to the natural aggregate. A lot of studies are led to discover elective materials for the production of concrete. On the opposite side, the rate of solid waste is extended day by day, while the issue of disposal is additionally expanding because of the absence of landfill site accessibility. Utilization of agricultural waste in the development of infrastructure holds a high capability of reducing environmental pollution. Most solid waste is created by agriculture, for example, sugar stick, paddy and wheat straw, husk, wooden mill waste, foodstuffs, tea, oil generation, coconut husk, cotton stalk, etc. India is one of the leading coconut growers in the world and enormous quantities of solid waste are produced by coconut. In the replacement of traditional coarse aggregates, the waste coconut shell can be used. Besides, coir fiber (coconut fiber) in concrete additionally might be utilized. This can also contribute to the economic production of concrete and at the same time help reduces the problem of waste disposal. This paper reviews the work carried out on concrete production using coconut shell and coconut fiber.*

Key Words**: Concrete, Solid waste, Coarse aggregate, Coconut shell, Coconut fiber.**

1. INTRODUCTION

Concrete is the world's most generally utilized development material made out of cement, aggregates, water, and admixtures. Concrete is a powerful, simple, abundant, sturdy and extremely robust development material. The production of concrete requires its ingredients, for example, cement, coarse aggregate, fine aggregate, and water. The aggregate gives a volume of 66-78 percent of the concrete [34]. In construction development, large scale manufacturing of concrete using traditional ground aggregates like granite reduces natural stone deposits immoderately and thus this is caused by ecological imbalance. For economical improvement & sustainable development, the colossal interest for natural aggregate raises a difficult issue to control the aggregate sources.

Almost everywhere throughout the world, various measures are being taken to decrease the utilization of aggregate that retreat to the reuse and recycling of solid waste where it is technically, monetarily, ecologically, and environmentally acceptable. In anticipation of this issue, the reuse of different sorts of waste items has been investigated and reported for concrete production, for example, waste plastic, consumed bricks, coconut shell, oil palm shell, fly ash, industrial slag, waste rubber tires, marble waste residue, broken glass pieces, glass powder, reused coarse aggregate, papercrete, etc [33]. The solution for controlling natural aggregate might be reuse coconut shell which can lead to the protection of the environment. Some works on the application of coconut shell waste for concrete production have been reported.

Sangeetha G.,[26] reported that approximately 4.6 million tons of coconut shell solid waste produced annually which is expected to rise further day by day. Various sorts of coconut waste materials, e.g., coconut shell, coir fiber, coconut shell powder, coconut husk, etc have been utilized as in part or completely coarse aggregate substitution material in the concrete production and their properties have been differentiated with control concrete. A couple of studies demonstrate that agricultural waste coconut shell and coir fiber can be utilized in concrete. On the view that appropriate engineering properties are researched on a coconut shell and coir fiber, the investigation is probably going to take care of a huge issue of aggregate substitution in the development of construction and will likewise solve the disposal issues.

1.1 COCONUT SHELL

According to the report of Gunasekaran et al. [7], Coconut is grown in over 96 countries. India having development on a region of about 2.076 million ha for coconut creation and the yearly production of coconut is about 16.837 million tones [3]. Utilize these materials in concrete to lessen the environmental impacts of agricultural waste items, for example, coconut shell and coconut fiber, which are agricultural waste items. In addition to the fact that it improves concrete quality, yet it additionally prompts the best possible disposal of these materials, in this manner decreasing the environmental impacts of these waste materials. Coconut shell can be used for crushed stones as an elective material. The chemical substances of coconut shell are like wood and contain 33.61% cellulose, 36.51% lignin, and 0.61% ash and as a result of low cellulose content, it retains less moisture when compared with other agricultural waste [29]. Coconut Shell-solid composite is immaculate and there is no necessity for pretreatment and the shell of coconut is suited with cement.

1.2 COIR FIBER

Coir fiber is extricated from the external shell of a coconut. There are two sorts of coir filaments, darker (brown) strands expelled from natural coconuts and white filaments removed from youthful coconuts. Dark-colored filaments are chiefly utilized in engineering. The coir industry in India has available large quantities of coir fiber waste of approximately 7.5 million tons annually [2].

The general advantages of coir filaments; moth-proof, parasitic and spoil safe, assurance from high temperature and sound, heatproof, non - immersing, intense and strong, safe, spring back to shape even after predictable use [1]. Coir fiber is non-toxic and biodegradable. Likewise, Property-based advantages of coir fibers are; not effectively burnable, impervious to moisture and clamminess, extreme and solid, absolutely static-free, and simple to clean.

Table 1: Chemical composition of coir fiber [1]

S. No.	Constituent	Percentage (%)
1.	Cellulose	38.4
2.	Lignin	31.8
3.	Hemicelluloses	24.5
4.	Pectin	0.5
5.	Ash	1.6
6.	Fats and waxes	1.1

Many researchers like Majid et. al. [15], Mahyuddin et. al. [19], Pusit et. al. [23], Wenjie Wang & Nawawi Chouw [25], Onkar et. al. [27], Mehran Khan & Majid Ali [31], have been examined the impact of coir fiber on the concrete for Mechanical & dynamic properties, bond strength, durability, toughness and flexural strength. According to Sanjay Sen & Rajeev Chandak [24], by using of coir fiber ash in concrete, the compressive strength of concrete is increased with curing aging. Darsana et. al. [25], reported that properties like breaking load and ductility were improved by the addition of coir fibers in concrete.

2. RESEARCH FINDING

Based on the literature review and research planning, the outcomes of the researches are as follows-

E.A. Olanipekun, K.O. Olusola, O.Ata (2006) utilized the coconut shell and palm kernel shell, in the production of concrete as a coarse aggregate at a rate of 0%, 25%, 75%, and 100%, respectively. Water/Cement proportion of 0.75 and 0.50 was utilized, for mix proportion 1:2:4 and 1:1:2 for cement: sand: aggregate, individually. The physical properties of coconut shell and palm kernel shell - moisture content, water retention capacity, strength, thickness, and specific gravity were resolved. Nonetheless, the outcome demonstrated that the compressive strength of the concrete diminished as the percentages of shell substitution is increased. Cost decrease could be accomplished somewhere in the range of 30% and 42% if the concrete is delivered with coconut shell and palm kernel shell as a coarse aggregate. In perspective on the strength/economy proportion, coconut shells were observed to be more fitting than palm kernel shells [4].

K. Gunasekaran, P.S. Kumar and M. Lakshmipathy (2010) considered the technical feasibility of utilizing coconut shell (CS) particles and testing the similarity with cement. Coconut shell-cement similarity appraisals might be completed by utilizing tests of Coconut Shell fines with cement and neat cement to quantify properties, for example, Normal consistency, Initial and Final setting time, Compressive strength and Hydration tests. On tests arranged utilizing every 100 grams of cement and 7.5 grams of CS fines, the effects of CS cement fines were evaluated.

Normal consistency of the neat cement and coconut shell fines with cement is observed to be 31% and 38% by weight of cement. The initial and final setting time of neat cement was found as 76 minutes and 7 hours 10 minutes, respectively. Likewise, 88 minutes and 9 hours 50 minutes was found the initial and final setting time of CS fines with cement. The compressive strength of CS fines with cement was observed to be 22.89 N/mm^2 and 28.78 N/mm^2 at 3 days and 7 days and the greatest hydration temperature worth was seen in this examination are 63°C.

They reasoned that the coconut shell concrete composites required more water for making standard consistency paste. This investigation uncovers that there is no requirement for Pretreatment of coconut shell and the coconut shell-concrete composite is perfect [5].

Ralf Winterberg (2010) presents a paper that gives a thorough diagram of the conceivable outcomes and capability of fiber-reinforced concrete. The author concludes that ongoing research and continuous development on fiber reinforced concrete made it a modern and cost-efficient building material today. The use of fibers can achieve substantial time and cost savings by reducing the cost-intensive labor required to prepare, place and control ordinary reinforcement [14].

K. Gunasekaran, P.S. Kumar, M. Lakshmipathy (2011) in his experimental study, the significant mechanical properties of CSC, in particular, compressive strength, flexural strength, splitting tensile strengths and impact resistance have been estimated to survey its suitability as a lightweight aggregate. The bonding property of CS was additionally studied to analyze the reasonableness from a basic perspective. To investigate the impact on the flexural and dividing tensile strengths and effect strength of coconut shell concrete, two unique water-cement proportions (0.42 and 0.44) were regarded for the design mix. The characteristics of the bonding were fixed by pull out the experiment. The outcomes demonstrated that the concrete of coconut shell experimental bond strength is much greater than the bond strength for the selected mix. The exploratory reveals that shells of coconut satisfied the needs for use as a lightweight aggregate [6].

K. Gunasekaran, R. Annadurai, and P.S. Kumar (2012) considered the effects on the long-term execution of the coconut shell of three types of curing (complete watering immersion, discontinuous watering, and complete air drying, i.e. no curing). Over 365 days for the blend configuration were looked into for the impact of coconut shell aggregate concrete compressive strength and bond strength. The mix design proportion was 1:1.47:0.65:0.42 by weight of cement (Cement: Sand: CS: Water) for the production of coconut shell aggregate concrete. The outcome demonstrated that coconut shell aggregate concrete indicated amazing execution in later ages under a wide range of curing. They inferred that coconut shell aggregate is not degraded because of its ages in the concrete [7].

Majid Ali, Xiaoyang Li, Nawawi Chouw (2012) tentatively explored the bond strength between coconut fiber and cement on the impact of embedment length (10 mm, 20 mm, 30 mm, and 40 mm), diameter {0.15-0.20 mm (thin), 0.20-0.30 mm (medium), 0.30-0.35 mm (thick)}, pretreatment (Soaked fiber, CaAl fiber, and Boiled fiber) and mix design (1:2:2, 1:3:3, and 1:4:4) relations. The water-cement proportion is taken as 0.48. Empirical equations are developed to decide the bond strength and energy required for fiber pullout dependent on the examination led. In any case, the examination outcome that filaments have the most extreme bond strength with concrete when

(1) Embedment length is 30mm.

(2) Fibers are thick.

(3) Treated with boiling water.

(4) Concrete mix design proportion is 1:3:3.

Likewise, the impacts of fiber pullout energy are examined [15].

Amarnath Yerramala, Ramachandrudu C (2012) carried out the study to give more information on the qualities of Coconut Shell (CS) concrete at various CSs substitutions and concentrate the transport properties of concrete with CS as coarse aggregate substitution. Besides, in this examination, the impact of fly ash as cement substitution and aggregate substitution on properties of the CS supplanted concrete were additionally researched. They looked at the slump value of coconut shell concrete with control concrete somewhere in the range of 20 and 26 mm and decreased with the development of the coconut shell, the flat-shaped particle of which limited the motion of aggregate particles. They also saw that the development of fly ash as a replacement of cement or as an aggregate replacement improves functionality in concrete coconut shell [16].

Majid Ali, Anthony Liu, Hou Sou, Nawawi Chouw (2012) carried out the study on the damping ratio and the basic frequency of the simply supported Coir Fiber Reinforced Concrete (CFRC) beams were provisionally fixed about the mechanical characteristics. An examination is conducted between the static and dynamic modules. The 1%, 2% and 3% and 5% of the fibers are examined for their material mass, with their fiber length 2.5, 5 and 7.5 cm. The percentage of the mixed layout for concrete, sand, and aggregate was 1, 2, and 2 with a water-cement ratio of 0.48 individually. Furthermore, damping of the CFRC beams improves, while structural damage reduces its fundamental frequency. Higher damping CFRC has a reduced dynamic and static versatility modulus. They concluded that CFRC has the best characteristics with a fiber length of 5 cm and the fiber content of 5% [17].

Saravana Raja Mohan, P. Jayabalan and A. Rajaraman (2012) researched an investigation embraced in improving properties of fly ash concrete composites with Coconut fiber. A composite with fly ash concrete and treated coconut fiber, tentatively explored the impacts of substitution of 43 grade Ordinary Portland Cement (by weight) with various rates (10%, 15%, 20%, 25%, and 30%) of fly ash and the impacts of expansion of prepared regular coconut fiber having 40 mm length with various rates (0.15%, 0.30%, 0.45%, and 0.60%) on structural properties were taken up. They reported that the fly ash based coconut fiber strengthened concrete demonstrates a superior execution than ordinary concrete [18].

K. Gunasekaran, R. Annadurai, P.S. Kumar (2013) in this experimental study, the flexural behavior of the reinforced concrete beam made of coconut shell is dissected in this exploratory examination. In the study, deflection, ductility, end rotation, moment capacity, corresponding compression, tension, and cracking stresses are included. 12 beams were scheduled and tested, 6 with coconut shell concrete and 6 with plain concrete. Mix design ratio (by weight) for cement, sand, and aggregate was (1:1.47:0.65) taken for Coconut shell concrete with water-cement ratio of 0.42 and, (1:2.22:3.66) taken for control concrete with water-cement ratio of 0.55. CSC beams, however, showed excellent conduct in ductility. In flexural loads, CSC can also attain its complete strain ability [8].

K. Gunasekaran, R. Annadurai and P. S. Kumar (2013) in this experimental study, the shear behavior of the reinforced concrete beam made of coconut shell is dissected in this exploratory examination. In this study, deflection, ductility, shear capacity, strains in concrete and cracking stresses are included. 8 beams were scheduled and tested, 4 with coconut shell concrete and 4 with plain concrete. Mix design ratio (by weight) for cement, sand, and aggregate was (1:1.47:0.65) taken for Coconut shell concrete with water-cement ratio of 0.42 and, (1:2.22:3.66) taken for control concrete with water-cement ratio of 0.55. The results have shown that the coconut shell concrete can reach its complete shear load strain ability. However, the coconut shell concrete failure zones were more than those for concrete beams [9].

Mahyuddin Ramli, Wai Hoe and Noor Faisal Abas (2013) tentatively examined the properties of reinforced concrete with coconut fiber under aggressive environmental conditions. They uncovered in three kinds of environmental conditions; air condition in a tropical atmosphere, substitute air and seawater situations, and continuous immersion in seawater. For each condition, compressive strength and flexural strength test were utilized to analyze. In concretes four unique substances of coconut fibers, 0.6%, 1.2%, 1.8% and 2.4%, were added. The outcome demonstrated that the compressive and flexural strength of the structures improves up to 13% and 9% individually, with the consolidation of coconut filaments presented to the tropical atmosphere. At the point when the specimens are exposed continuously to seawater, coconut fibers show demoralizing impacts on quality [19].

Vishwas P. Kulkarni and Sanjay Kumar B. Gaikwad (2013) in this experimental study coconut shell as coarse aggregate were investigated to replace the aggregate in concrete. M20 Concrete is produced by 0%, 10%, 20%, 30% coarse aggregate replacement by coconut shell. Before use as an aggregate, there is no need to treat the coconut shell except for water absorption. The moisture content and water absorption averaged 4.20 percent and 24 percent, respectively, of the crushed coconut shell, were observed. The compressive strength of coconut shell concrete for 28 days was differentiated as 24.21, 22.81, and 21.08, exchanging coconut shell aggregates for 10 percent, 20 percent, and 30 percent. There was no bond failure, confirming adequate bonding between the concrete of the coconut shell aggregate and the bars of steel [20].

Dewanshu Ahlawat & L.G. Kalurkar (2014) studied the potential for the production of concrete grade M20 by replacing conventional granite aggregate with a coconut shell. Forty-five cubes were cast. The percentage of conventional coarse aggregate replacement by coconut shell was 2.5 %, 5 %, 7.5 %, 10 %. Compressive strength of coconut shell concrete for 28 days was distinguished as 24.21, 22.81, and 21.08, swapping coconut shell aggregates for 10%, 20%, and 30%. The concrete compressive strength reduced as the proportion of substitute increased. Increasing percentage substitution by coconut shell improves concrete workability. It can be concluded from these results that coconut shell concrete can be used in the construction of reinforced concrete [21].

Parag S. Kambli and Sandhya R. Mathapati (2014) prepared three design mix structures for concrete evaluations M20, M35, M50 were readied. The level of coconut shell substitution fluctuated as 0%, 10%, 20%, 30%, 40%, respectively. In this examination, it has come about that Coconut Shell is progressively suitable as low quality giving lightweight total when used to supplant basic coarse aggregate in the production of concrete. Coconut shell can be utilized for the development of low-cost housing society [22].

K. Gunasekaran, R. Ramasubramani, R. Annadurai, S. Prakash Chandar (2014) in this experimental study, the torsion behavior of the reinforced concrete beam made of coconut shell is dissected in this exploratory examination. In this study, torsional reinforcement, pre cracking behavior and analysis, post cracking behavior and analysis, cracking characteristics and crack width and stiffness are included. 8 beams were scheduled and tested, 4 with coconut shell concrete and 4 with conventional concrete. Mix design ratio (by weight) for cement, sand, and aggregate was (1:1.47:0.65) taken for Coconut shell concrete with water-cement ratio of 0.42 and, (1:2.22:3.66) taken for control concrete with water-cement ratio of 0.55. The results have shown that coconut shell concrete specimens have higher ductility compared to traditional concrete specimens. The crack width at the beginning of the cracking torque is practically comparable for both traditional and coconut shell concrete with respective ratios of reinforcement [10].

K. Gunasekaran, R. Annadurai and P. S. Kumar (2015) in his experimental study, the durability efficiency of the coconut shell in three curing conditions (full water immersion, intermittent watering, and full air drying) was investigated and the strength and resistance at elevated temperatures (100, 200, 300, and 400°C) was examined. The durability properties examined incorporate the absorption, sorptivity, volume of permeable voids, rapid chloride penetrability, and chloride concentration profile. The mix design proportion used for the production of Coconut Shell Aggregate Concrete (CSAC) was 1:1.47:0.65:0.42 by weight of cement. The test outcome showed that CSAC durability characteristics are similar to that of other standard lightweight concrete, and for CSAC to achieve better durability if the efficient curing is essential. They concluded that the coconut shells are can be a reasonable elective material for aggregate for concrete production [11].

Pusit Lertwattanaruk and Anchisa Suntijitto (2015) presents an investigation into the properties of composite building materials based on natural fiber that applies to hot and humid climatic regions. This investigation focused primarily on the effects on the physical, mechanical and thermal properties of products of coconut coir and oil palm fibers. Materials used in this study were cement, powdered limestone, sand, water, and natural fibers at the levels of 5%, 10% and 15% by weight of the binder. The water- binder (w/b) ratio was 0.25. The test findings showed that increasing the proportion of natural fiber substitution tends to reduce material density, compression, and flexural strength. They concluded that fiber cement products can be used for residential building applications [23].

Sanjay Sen and Rajeev Chandak (2015) carried out the experimental investigation to know the effect of coconut fiber ash on strength properties of concrete. The coconut fibers are collected in this study and properly dried and burnt out in the open air, when fibers become ash, at temperatures ranging from 600°C to 700°C. The ash passed through a sieve of 150 microns. This work presents the results of laboratory tests in concrete production using coconut fiber ash as a partial replacement for cement. Cubes are tested at 7, 28, 60 and 90-day aging with replacement levels of 0%, 5%, 10%, 15%, 20%, and 25%. The result showed that the compressive strength of coconut fiber ash concrete increased with curing aging. Compressive strength of 59.25 N/mm² was obtained at 5% replacement at 90 days of ages. The slump value decreases as the coconut fiber ash percentage increases. This indicates that as the content of coconut fiber ash increased, the concrete becomes less stiff [24].

Darsana P, Ruby Abraham, Anu Joseph, Arakkal Jasheela and Binuraj P.R (2016) carried out the study has resulted to the production of cost-efficient roofing tiles without compromising their quality by replacing 10% and 15% of the cement with coir fiber. For that examination a 1:4 mix design (concrete: fine aggregate) and a 0.60 water-cement percentage were selected. They revealed the optimal composition to be considered a composite with a fiber quantity of 10 percent. Even more, fibers decrease the weight and price of themselves [25].

Sangeetha G, Nirmala P, Pugazhselvi D, Ramya K and K. Jegan Mohan (2016) prepared two mixes with coconut shell and clay. In this study, they focus on the replacement of aggregate by coconut shell and cement by clay. 0 percent, 10 percent, 20 percent, and 30 percent substitution by coconut shell and clay by the quantity of coarse aggregate generated. For all the concrete, the 0.50 water-cement ratio is maintained. M20 grade of concrete was produced.

However, the result showed a reduction in concrete compressive strength as the percentage replacement increased. It is concluded that in reinforced-concrete construction, it is possible to use coconut shell and clay in concrete. Its use is cost-effective and environmentally friendly [26].

Wenjie Wang and Nawawi Chouw (2016) tentatively examined the conduct of Coconut Fiber Reinforced Cement (CFRC) cylinders under single and repeated effects of drop weight. By modifying the drop height, different impact energies were applied to the specimens. The mix proportion by mass was 1:0.48:2:2 for cement: water: sand: coarse aggregate, individually. The measure of coconut fibers required was 1.5% of the cement mass, comparing to a rough fiber substance of 0.6%. The length of the fibers was 50 mm. A single impact load was used to examine the history of impact load, change of young modules and the dynamic increase factor (DIF). In the repeated Impact tests, the impact of effect height on the greatest compressive stresses and the damage pattern was assessed. However, CFRC had better resistance to spreading and splitting, due to the bridge function of the distribution of coconut fiber. It would be useful to protect people from damaged construction [27].

Apeksha Kanojia and Sarvesh K. Jain (2017) noted the impact of substantially replacing the natural aggregate with coconut shell to produce concrete. This research was performed in two phases. Firstly, they designed the conventional concrete without replacement and then, the coarse aggregate was replaced by coconut shell in the proportions of 10%, 20%, 30% and 40% by volume respectively in which water-cement ratio of 0.55 and M20 grade of concrete was carried out. In the next phase, Concrete was taken for varying proportions of coarse aggregate (CA) and coconut shell (CS). They regarded that six proportions of CA and CS were (100:0), (95:5), (85:10), (80:20), and (75:25) respectively. And then three varying water-cement ratios (0.55, 0.50, and 0.45) were regarded. The target strength was determined by the water-cement ratio. The impact of the CS amount was noted concerning parameters such as density, compressive strength, and cement requirement.

Finally, they found that it makes the concrete lighter by replacing the standard aggregate with the waste coconut shell. The density of approximately 7.5% reduces by 40% substitute. They also suggest that there is no need for additional cement for 5% replacement of coarse aggregate and for 10% replacement, 3.6% additional cement is required [28].

K. Gunasekaran, R. Annadurai, S. Prakash Chandar, K.S. Satyanaryanan (2017) experimentally investigated the properties of concrete using Coconut Shell (CS) as coarse aggregate and Quarry Dust (QD) as fine aggregate. Mix design ratio (by weight) for cement, sand, aggregate, and water was (1:1.58:0.65:0.42) taken for Coconut shell concrete with QD, and, (1:2.40:3.66:0.55) taken for control concrete with QD. For all the mixes, workability, density, compressive strength, flexural strength, split tensile strength and impact resistance were tested. However, the result shows that the use of QD enhances the mechanical properties of concrete irrespective of CS aggregate and control concrete as well [12].

Shrikant M. Harle (2017) has carried out a study on partial substitution of coarse aggregates with a concrete coconut shell. Density, slump and pressure resistance of cement have been evaluated in this research. A substitution by coconut shell in three varying quantities (10%, 20%, and 30%) was carried out for the ground aggregate. M20 grade of concrete and water-cement ratio of 0.50 was carried out. The author concluded that the replacement of more than 20% leads to lightweight aggregate concrete. As the percentage replacement increases, the density is reduced, the slump to increases, and the compressive strength to be decreased [29].

Sravika V, G. Kalyan (2017) researched a mixture of coconut shell and quarry dust to replace coarse and fine aggregate in part. The fine aggregate is substituted by 30% of quarry dust and the coarse aggregate is partially substituted by the coconut shell. The ground coconut aggregate is substituted by the 10%, 20%, 30% and 40% coconut shell. The project design mix isM-20 (1:1.5:3) with a water-cement ratio of 0.50. The standard concrete and coconut shell were cast and tested for compressive strength and tensile strength with samples of quarry powder concrete. As a result, concrete strength improves with a rise of up to 20 percent in the proportion of coconut shell, and there is a gradual reduction of 30% substitute [30].

Onkar V. Potadar and Ganesh S. Kadam (2018) presented the work on the preparation and testing of composites using waste groundnut shells and coir fibers. They are relatively compared between the coir fiber composite and the groundnut shell composite. The groundnut shells are broken to 1 mm, 1.5 mm, 2 mm particle sizes and the epoxy resins are added by weight of the fibers in a proportion of 70:30. Tests were carried out for mechanical strength such as tensile strength and the flexural strength and moisture absorption as well. However, the result showed that the coir fiber composite is comparatively better than groundnut shell composite [31].

K. Gunasekaran, R. Annadurai, S. Prakash Chandar, K.S. Satyanaryanan (2018) experimentally investigated the durability properties of concrete using Coconut Shell (CS) as coarse aggregate and Quarry Dust (QD) as fine aggregate. Mix design ratio (by weight) for cement, sand, aggregate, and water was (1:1.58:0.65:0.42) taken for Coconut shell concrete with QD, and, (1:2.40:3.66:0.55) taken for control concrete with QD. The durability properties examined incorporate the absorption, sorptivity, volume of permeable voids, rapid chloride penetrability, and chloride concentration profile. However, the result shows that the use of QD enhances the durability properties of concrete irrespective of CS aggregate and control concrete as well [13].

Mehran Khan and Majid Ali (2019) investigated the behavior of concrete with fly ash, coir fibers, and silica-fume. The silica-fume material is included in cement mass by 15 percent, with the alternative of 0 percent, 5 percent, 10 percent, and 15 percent cement mass fly ash content. The mix design proportion of FA-SPC was (1:2:2:0.50) for cement, sand, coarse aggregate and water, respectively. The comparable mix design proportion was utilized for the planning of FA-SCFRC with moderately high w/c proportion of 0.55. The coir fiber with a 5 cm length and 2% content, the mass of concrete, were included. They inferred that coir fiber reinforced concrete (CFRC) can be utilized for improved mechanical properties with 2% coir fiber content, 10% fly ash and 15% silica fume content [32].

3. CONCLUSIONS

Due to wide consideration given to the effects of coconut shell and coir fiber on concrete, this review has been carried out to discuss the overall effectiveness of coconut shell and coir fibers on the properties of conventional concrete. The study outcomes showed that-

- By utilizing waste coconut materials for development, the virgin materials will turn into a sustainable material and also the cost will be diminished.
- Coconut shell can be used for the construction of low-cost housing society, as well as coir fiber can be utilized in concrete production to increase the mechanical properties of concrete. Both of them are cost-effective as well.
- In reinforced concrete construction, it is possible to use coconut shell and coir fiber in conventional concrete production when used to replace common coarse aggregate and reinforced in concrete.
- From the above researches, it also found that coconut shell and coir fiber, both can be used in concrete individually. But, we can utilize both the materials together to observe the effectiveness and properties of concrete.
- Overall, coconut waste can contribute to the economic production of concrete and at the same time, the problem of waste disposal is reduced as well. Its usage is financially savvy and eco-accommodating.

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