RESEARCH ARTICLE OPEN ACCESS

Experimental Investigation on Light Weight Concrete Using Coconut Shell, Rice Husk ASH and Limestone Powder

J Verjilin E mariba[1], S Mariraj Mohan[2]

PG student[1], Associate professor[2]

Department of Civil Engineering, Government College of Engineering,Thirunelveli

***Abstract*—In this study, coarse aggregate was partially replaced with coconut shell, fine aggregate with rice husk ash, and cement with limestone powder to produce lightweight concrete (LWC). Concrete is one of the most widely used materials in the construction industry, with aggregates serving as a fundamental component. However, the large-scale extraction of natural rocks for aggregate production has raised serious environmental concerns. To address these issues and promote sustainable construction practices, this research investigates the use of alternative materials. Cement was replaced with limestone powder at a constant rate of 20%, fine aggregate with rice husk ash at varying proportions of 5%, 10%, 15%, 20%, and 25%, and coarse aggregate with coconut shell at replacement levels of 5%, 10%, 15%, 20%, and 25%. The mechanical properties evaluated included compressive strength, split tensile strength, and flexural strength. The addition of limestone powder improved both the workability and strength characteristics of the concrete. Moreover, the inclusion of coconut shell aggregate reduced the overall weight of the concrete, making it suitable for lightweight structural applications. The results indicated that the optimum strength was achieved with 10% coconut shell, 10% rice husk ash, and 20% limestone powder replacements.**

***Keywords*— Coconut shell, Limestone powder, Rice husk ash, Compressive strength, Split tensile strength, Flexural strength.**

I. INTRODUCTION

Concrete is the most widely used construction material because of its desirable properties such as high compressive strength, stiffness, and durability under normal environmental conditions. However, it is inherently brittle and weak in tension with low strain at fracture, as also reported by Marthong [34]. To overcome these shortcomings, concrete is generally reinforced with steel bars or prestressing tendons.

Advancements in concrete technology now focus on sustainability by reducing the consumption of natural resources and energy, and by minimizing environmental pollutants. One approach is the incorporation of agricultural and industrial wastes as alternative binders or aggregates. Among these, coconut shell (CS), rice husk ash (RHA), and limestone powder have gained increasing attention due to their availability, environmental benefits, and performance in lightweight concrete.

Large quantities of coconut shell are generated as waste, creating disposal problems and environmental impacts. Researchers such as Mat Zain et al. [1], Mukesh [2], Tejashree [3], Mardiha [4], and Khileshwari [6] have reported the use of CS as a partial replacement of coarse aggregates in concrete. Coconut shell is wood-based and organic in nature [37], and has a density between 550–650 kg/m³, placing it within the specified limits for lightweight aggregates [30].Several studies confirm its suitability as a lightweight aggregate, though high water absorption remains a challenge. Sanjay [9], Ratandeep [21], and Dileep [19] observed that presoaking CS in water for 24 hours ensures a saturated surface dry (SSD) condition during mixing, thereby preventing absorption of mixing water. Ahmed [32] and Akinyemi [7] limited the CS particle size to 20 mm in their investigations. Other experimental findings on strength and durability have been reported by Abdullahi [10], Jayasree [11], Mohd [17], Sivakumar [18], Gopinath [20], Adewuyi [24], Damodhara [31], Islam [29], Alengaram [36], and Gunasekaran [37].

Rice husk is another major agricultural byproduct with potential in concrete production. When burnt under controlled conditions, it produces rice husk ash (RHA), rich in amorphous silica and exhibiting strong pozzolanic properties. Studies by Zhang [5], Mohamed [22], Tutur [23], and Kanchana [25] highlight the performance of RHA in concrete. Thakur [15], Nwofor [28], and Baral [13] also reported its effectiveness as a supplementary cementitious material.

Further investigations by Akhtaruzzaman [12], Kunaraj [14], Yeasmin [16], and Ganiron [33] confirmed improvements in concrete strength and durability. However, proper mix design adjustments are essential to optimize performance. RHA has been used both as a partial replacement for cement and as a fine aggregate substitute, demonstrating versatility in sustainable concrete applications

Lightweight concrete (LWC) is defined as concrete with a density between 1400–1850 kg/m³, as reported by Abdullahi [10] and Alengaram [36]. It is produced by replacing normal aggregates with lightweight materials such as expanded clay, shale, pumice, or waste-based alternatives like CS. The benefits of LWC include reduced dead load on structures, better thermal insulation, and lower transportation costs [11, 17, 29].

There are three main types of LWC:

- Lightweight aggregate concrete (using natural or waste-based lightweight aggregates such as pumice, scoria, CS, etc.) [29, 34, 35].
- Aerated concrete (formed by introducing air voids during mixing).
- Foamed concrete (created using foaming agents).

Madurwar [35] and Taha [27] emphasized that particle size and aggregate type significantly influence the performance of LWC.

II. LITERATURE REVIEW.

Mat Zain Muhamad Azffar Irham(2024) [1] investigated the use of coconut shell (CS) as a partial replacement for coarse aggregate in concrete. Sixty samples were cast with 0%, 10%, 20%, and 30% CS replacement. The results showed improvements in workability, porosity, density, and UPV, but a decrease in compressive and tensile strength. Despite this, the concrete met the minimum strength for M30 grade, making it suitable as lightweight concrete. The study concluded that using CS is cost-effective, eco-friendly, and helps address material shortages and waste disposal issues.

Mardiha Mokhtar et al. (2022) [4] explored the use of rice husk and coconut shell as partial replacement materials in the production of lightweight concrete for low-load and dry applications. The study found that RHA concrete exhibited better workability than CS concrete, attributed to higher slump values. The density of both RHA and CS concrete decreased as the amount of replacement material increased. RHA, containing about 85–90% amorphous silica, contributed to increased strength through pozzolanic reactions. CS concrete demonstrated good impact resistance and surface finish, improving workability. The study concluded that RHA is more suitable for partial replacement, achieving a compressive strength of 41 MPa at 28 days, compared to 20 MPa for CS.

M. Mohamed Barveen et al.(2018) [22] investigated the properties of concrete using rice husk ash (RHA) as partial replacement for ordinary Portland cement (OPC) and coconut shell (CS) as coarse aggregate were examined in this study.OPC was replaced by RHA by 0%, 2%, 4%, 6%,8%, 10% and 12%. Workability, density of concrete, mechanical properties such as compressive strength, splitting tensile strength, flexural strength, impact resistance and modulus of elasticity were examined and compared with the standard values. The compressive strength increases with increase in RHA replacement and gives good results up to 10% replacement of RHA.This study proves that replacement of RHA at 10% in coconut shell concrete enhances the workability and mechanical properties of both conventional concrete and coconut shell concrete.

III. METHODOLOGY

MATERIAL TESTING

A. *Ordinary Portland cement*

Ordinary Portland Cement (OPC) 53 grade is seems to be better in term of ultimate strength gain.The same behavior was also observed by Marthong [2002][34].The important properties of cement are given in Table 1.

TABLE 1
TEST ON CEMENT

S.No	Test Performed	Result
1	Fineness test	3%
2	Consistency test	28%
3	Specific gravity of cement	3.164
4	Initial setting time	40min
5	Final setting time	5 hrs 46 mins

B. *Aggregate*

The river sand confirming to IS: 383 - 1970 issued as the fine aggregate and Coarse aggregate of maximum size 20 mm was used as the coarse aggregate which is taken from Akinyemi [7]. The properties of fine and coarse aggregates are presented in Table 2.

TABLE 2
PROPERTIES OF FINE AGGREGATE

S.No	Property	Fine Aggregate Value
1	Specific gravity	2.645
2	Fineness test	3.68
3.	Bulk density	1849 kg/m3

TABLE 3
PROPERTIES OF COARSE AGGREGATE

S.No	Material	Coarse Aggregate Value
1	Specific gravity	2.83
2	Fineness test	7.4
3.	Bulk density	1720 kg/m3

B. *Limestone Powder*

Limestone powder is a fine, white or off-white powder that is made by crushing and grinding lime stone rocks. It is a natural product and is often used as a filler or pigment in various industries, including construction, agriculture, and cosmetics. In the construction industry, limestone powder is often used as a substitute for cement or as a component in cement mixtures. It can also be used as a filler material in asphalt and concrete, and as a binding agent in bricks and blocks.The properties of Limestone powder is given in Table 4

S.No	Test Performed	Result
1	Specific gravity of coconut shell	1.17
2	Water absorption	19.01%
3	Bulk density	511 kg/m3

TABLE 4
TEST ON LIMESTONE POWDER

C. Rice Husk Ash

Rice Husk Ash (RHA) is a byproduct obtained from burning rice husks, the outer coverings of rice grains, during controlled combustion processes.Using RHA in construction materials promotes sustainable practices by utilizing an agricultural waste product that might otherwise be discarded. This contributes to waste reduction, lowers carbon emissions, and conserves natural resources. However, proper testing and mix design adjustments are crucial to ensure the desired concrete performance when using RHA. The properties of Ricehusk ash is given in Table 5.

TABLE 5
TEST ON RICE HUSH ASH

S.No	Test Performed	Result
1	Specific gravity of Ricehusk ash	2.42
2	Water absorption	1.01%
3	Bulk density	3448 kg/m3

D. Coconut Shell

Coconut shell is the hard, outer layer that covers the fruit of the coconut palm. It is a natural material that has been used for various purposes for centuries, including as a source of fuel, fiber, and building material. The properties of Coconut Shell is given in Table 6.

S.No	Test Performed	Result
1	Fineness test	6%
2	Specific gravity of Limestone powder	3.19

TABLE 6
TEST ON COCONUT SHELL

IV. EXPERIMENTAL WORK

Mix design was done according to IS 10262:2009 and IS456:2000. Replacing cement with limestone powder at a constant rate of 20%, fine aggregate with rice husk ash at varying proportions of 5%, 10%, 15%, 20%, and 25%, and coarse aggregate with coconut shell at 5%, 10%, 15%, 20%, and 25% replacement levels. The mix proportion adopted here is 1: 1.53: 2.79.

E. Density Of Concrete

The light weight concrete is a type of concrete which is having lighter weight than conventional concrete. These types of concrete consist of light weight aggregates which reduces the density.The LWC can lead to a reduction in the weight of the concrete structure and improve its insulation, fire resistance and sound absorption properties. The density of light weight concrete should be equal to less than 1850 kg/m^{3}. The light weight aggregate used here is coconut shell aggregates. The results for the density of conventional and proposed concrete are shown in Table 7.

TABLE 7
DENSITY OF CONCRETE

Sl.No	Proportions	28 Days Hardened Density (Kg/M^3)
1	Control mix	2572
2	20% LSP+5%(RHA,CS)	2203
3	20% LSP+10%(RHA,CS)	2116
4	20% LSP+15%(RHA,CS)	2002
5	20% LSP+20%(RHA,CS)	1861
6	20% LSP+25%(RHA,CS)	1793
7	20% LSP+30%(RHA,CS)	1623

F. Experimental Results of Compression Strength

The test was carried out as per IS 15658: 2006. The 150 x 150 x 150mm cube of various concrete mixtures was cast to test under compressive testing machine. The specimen after demoulding were stored in curing tank and on removal of specimen from water the compressive test was conducted at 7 days and the results are represented in tables given below. Compressive strength is defined as the ratio of load to contact area and unit is N/mm². After 7 days the compressive strength of control mix is 20 N/mm², and the highest value reaches in 20% of lime stone powder with 10% of rice husk ash and 10% of coconut shell. The compression strength for 7 days is shown in the table 8.The Graphical representation is shown in the figure 1.

TABLE 8
COMPRESSION TEST ON CUBES

SI NO	PROPORTIONS	AVERAGECOMPRESSIVE STRENGTH (N/MM²)	
		7 DAYS	28 DAYS
1	Control mix	19.2	28.2
2	20%-LSP 5%-RHA 5%-CS	18.0	26.9
3	20%-LSP 10%-RHA 10%-CS	17.6	26.4
4	20%-LSP 15%-RHA 15%-CS	16.2	24.8
5	20%-LSP 20%-RHA 20%-CS	13.5	22.0
6	20%-LSP 25%-RHA 25%-CS	12.3	19.5

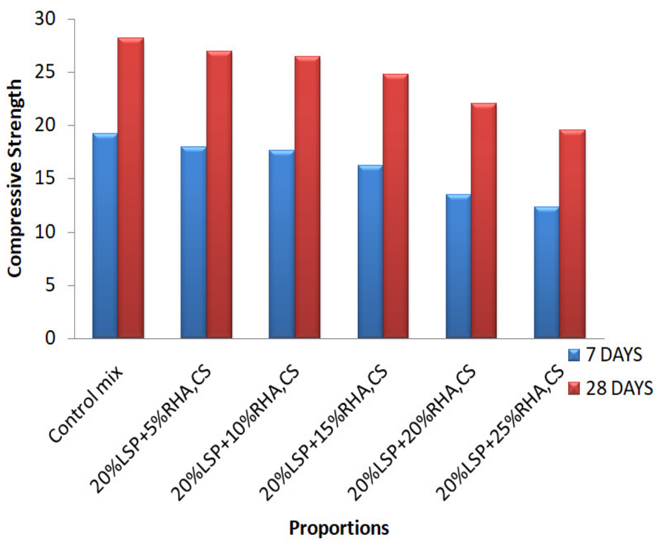


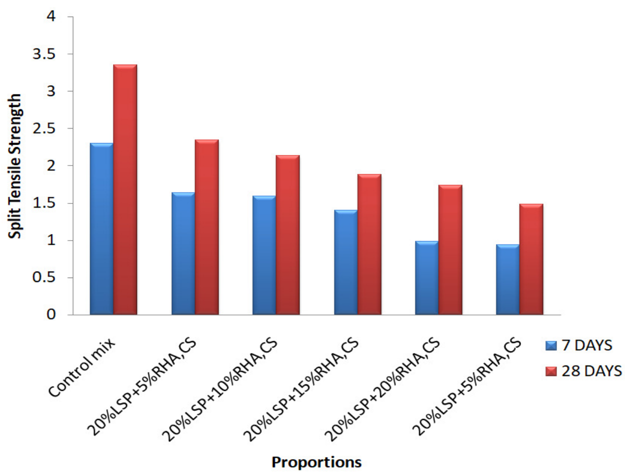
Fig. 1 Average Compressive strength (N/mm²)

F. Experimental Results of Split Tensile Strength

The test was carried out as per IS 15658: 2006. The 150mm diameter with 300mm height cylinder of various concrete mixtures were cast to test under split tensile testing machine. The specimen after demolding were stored in curing tank and on removal of specimen from water the split tensile test was conducted at 7 days and 28 days and the results are represented in table given below. After 7 days the split tensile strength of control mix is 2.3 N/mm².The split tensile strength for 7 days is shown in the table 9. The graphical representation is shown in the figure 2.

TABLE 9
SPLIT TENSILE TEST ON CYLINDER

SI NO	PROPORTIONS	AVERAGE SPLIT TENSILE STRENGTH (N/MM²)	
		7 DAYS	28 DAYS
1	Control mix	2.3	3.35
2	20%-LSP 5%-RHA 5%-CS	1.64	2.35
3	20%-LSP 10%-RHA 10%-CS	1.59	2.14
4	20%-LSP 15%-RHA 15%-CS	1.4	1.88
5	20%-LSP 20%-RHA 20%-CS	0.98	1.74
6	20%-LSP 25%-RHA 25%-CS	0.94	1.48



-- -- Fig. 2 Average Split Tensile strength (N/mm²)

G. *Deflection behavior of beam*

The load-carrying capacity of a beam refers to the ultimate load it can withstand before failure. In this study, the beams were cast with dimensions of 1000 mm × 100 mm × 100 mm and cured for 7 and 28 days prior to testing. The maximum ultimate load observed for the beams was 20.3 kN. The load-carrying capacities of all tested beams are presented in Table 10.During flexural testing, it was observed that deflection increased progressively with the applied load. A dial gauge was employed to measure the deflection at each load increment. The load was applied by increasing the pressure using a pressure gauge, and corresponding deflection values were recorded from the dial gauge. This process was continued until the beams reached failure, providing a comprehensive set of deflection data throughout the loading phase.

SI NO	PROPORTIONS	ULTIMATE LOAD (P_U) KN	ULTIMATE (ΔU) MM
1	Control mix	20.3	6.5
2	20% LSP+5%(RHA,CS)	18.2	8.5
3	20% LSP+10%(RHA,CS)	17.2	9.8
4	20% LSP+15%(RHA,CS)	13.9	9.5
5	20% LSP+20%(RHA,CS)	15.6	8.5
6	20% LSP+25%(RHA,CS)	14.8	10.5

TABLE 10
ULIMATE LOAD AND CORRESPONDING DEFLECTION

The relation between the loads and the values of mid-span deflection obtained experimentally are plotted in Fig. 4.1 for all tested beams.

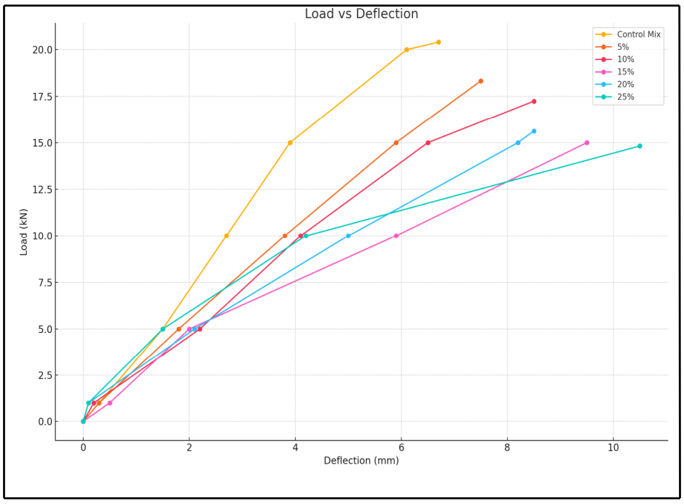


Fig. 3 Comparison of load deflection characteristics between various mixes

V. CONCLUSION

1.The density of concrete decreases with the increase in the proportion of coconut shell used as a partial replacement of coarse aggregate.The light weight concrete is achieved by incresing the propotion above 20% replacement.

2.The results suggest that replacing 10% of coarse coarse aggregate with coconut shell, 10% of fine aggregate with rice husk, and 20% of cement with limestone powder yields an optimum compressive strength of concrete.

3.The results suggest that replacing 10% of coarse coarse aggregate with coconut shell, 10% of fine aggregate with rice husk, and 20% of cement with limestone powder yields an optimum split tensile strength of concrete.

4.For flexural, the ultimate load carrying capacity of 20% of lime stone powder and 10% of rice hush and coconut shell has of 18.2 kN was found to be 10% lesser when compared to conventional beam(20.3 kN).

5.Thus, making the replacement both technically and economically feasible and viable. On further replacement, decrease in the compressive strength of Coconut Shell Concrete has been observed.

6.Coconut Shell Concrete can also be for non structural members e.g. partition wall, hollow concrete brick, floors tiles etc. Even after more than 10% partial replacement of coconut shell with aggregate.

REFERENCES

[1] Mat Zain Muhamad Azffar Irham, Zuhan Nurizaty, Nadiah Sa'ari, Kasali A. Mujedu, Bishir Kado "Mechanical Properties Of Concrete Containing Coconut Shell As Coarse Aggregate Replacement" On Journal Of Sustainable Civil Engineering And Technology Volume 3 Issue 1 (2024), 69-80.

[2] Mukesh Kumar Mahato "Experimental Investigation On The Effect Of Rice Husk Ash & Coconut Shell On Compressive Strength Of Concrete" On International Journal Of Creative Research Thoughts Volume 10, Issue (2022)

[3] Tejashree Mohan Kanjawane,Manoj Wagh "Partial Replacement Of Agricultural Waste Such As Rice Hush Ash, Sugarcane Bagasse Ash, Banana Skin Powder, And Coconut Shell In Concrete To Make Green Concrete"On International Journal Of Research And Technology Volume 10, (2022), 185-192.

[4] Mardiha Mokhtar, Nurul Ain Fakhirah Abdul Halim, Nur Hizati Mahmod, Nurin Nabila Mohd Rashdan " Use Of Rice Hush And Coconut Shell Ash In Concrete Production" Multidisciplinary Applied Research And Innovation Vol. 3 No. 2 (2022) 205-213.

[5] Li, X., Li, J., Zhang, Y., Li, L., & Shang, X. "Properties And Microstructure Of Concrete Incorporating Rice Husk Ash As A Partial Replacement Of Fine Aggregate". Journal Of Cleaner Production, 298, 126711. (2021).

[6] Khileshwari Kumari, Mr. Honey Gaur "Coarse Aggregate And Fine Aggregate Are Partially Replaced By Coconut Shell And Rice Husk" On International Research Journal Of Engineering And Technology (Irjet) E-Issn: 2395-0056 Volume :07 Issue :08 (2020).

[7] Akinyemi, B. A., & Oluwatobi, A. O.. "Evaluation Of Coconut Shell As Coarse Aggregate In Concrete". International Journal Of Civil Engineering And Technology, 11(6), (2020). 404-412.

[8] Kim, H. K., Kim, S. J., & Kang, S. T. "A Study On The Workability And Compressive Strength Of Concrete With Partial Replacement Of Fine Aggregate With Rice Husk Ash". Sustainability, 12(21), 9133. (2020).

[9] Sanjay Kumar Verma, And Sagar Shrivastava, "Use Of Coconut Shell As Partly Substitution Of Coarse Aggregate - An Experimental

Analysis" On Proceedings Of The International Conference On Sustainable Materials And Structures For Civil Infrastructures(2019) .
[10] Abdullahi, M., Abdulkadir, M. R., & Ayuba, A. "Performance Evaluation Of Coconut Shell As Partial Replacement Of Coarse Aggregate In Concrete". International Journal Of Scientific & Engineering Research, 10(5),1248-1253. (2019).
[11] Jayasree, M. G., & Lekshmi, R. R. " An Experimental Study On Properties Of Coconut Shell As Coarse Aggregate In Concrete". Materials Today: Proceedings, 18(Part 4), (2019). 1823-1830.
[12] Akhtaruzzaman, A., & Hasnat, A. (2019). "Effect Of Rice Husk Ash As Partial Replacement Of Cement And Fine Aggregate On Concrete". Journal OfBuilding Engineering, 26, 100842.
[13] Baral, S., & Das, S. "Performance Of Rice Husk Ash As Partial Replacement Of Cement In Concrete": A Review. Journal Of Materials Research And Technology, 8(2), 2051-2065. (2019).
[14] Kunaraj, S., & Senthilkumar, M. "An Experimental Study On Rice Husk Ash As Partial Replacement Of Fine Aggregate In Concrete". Journal Of Engineering And Applied Sciences, 14(8), 2723-2727. (2019).
[15] Thakur, A., & Kumar, V. "Mechanical Properties Of Rice Husk Ash As Partial Replacement Of Fine Aggregate In Concrete". International Journal Of Engineering And Advanced Technology, 8(6), 1296-1299. (2019).
[16] Yeasmin, N., Haque, M. N., & Nizam, A. M. "Study On Properties Of Concrete With Partial Replacement Of Fine Aggregate By Rice Husk Ash". Journal Of Engineering And Technology, 7(2.9), 75-78. (2019).
[17] Mohd, S. S., & Samad, A. A. "Experimental Investigation On The Properties Of Concrete With Partial Replacement Of Fine And Coarse Aggregate With Rice Husk Ash And Coconut Shell". International Journal Of Civil Engineering And Technology, 10(2), 1221-1228(2019).
[18] Sivakumar, V., & Suresh, R. "A Study On Partial Replacement Of Fine And Coarse Aggregate By Rice Husk Ash And Coconut Shell In Concrete". International Journal Of Innovative Technology And Exploring Engineering, 8(8s2), 307-310. (2019).
[19] Dileep Kumar B M 1, S Suresh "A Experimental Investigation On Partial Replacement Of Rice Husk Ash Ascement And Coconut Shell As Coarse Aggregate For The Production Of Light Weight Concrete". International Research Journal Of Engineering And Technology (Irjet) E-Issn: 2395-0056. Volume: 05 Issue: (2018).
[20] R Gopinath', T Ajithkumar², M Nithin³, V Sanjay Srikanth, P Sivakumar, "Experimental Study On Partial Replacement Of Coarse Aggregate By Coconut Shell And Ordinary Portland Cement By Rice Husk Ash" International Journal Of Scientific & Engineering Research Volume 9, Issue 4, (April-2018).
[21] Ratandeep Kumar,Ashfaq Malik,Vivek Kumar Kashyap "Partial Replacement Of Cement With Rice Husk Ash And Fine Aggregates By Coconut Shell Powder In Concrete"On International Journal Of Civil Engineering And Technology (Ijciet)Volume 9, Issue 4, (2018), Pp. 544–551,
[22] M. Mohamed Barveen,K. Gunasekaran "Study On The Effect Of Rice Husk Ash In Coconut Shell Concrete"On International Journal Of Civil Engineering And Technology (Ijciet).Volume 9, Issue 5, (May 2018), Pp. 264–273
[23] N. Tutur; R. N. H. R. M. Noor "The Potential Of Rice Husk Ash (Rha) And Coconut Fiber (Cf) As Partial Replacement Of Cement"On Aip Conference Proceeding (2018).
[24] Adewuyi, A. P., & Raheem, A. A. "Comparative Study Of Concrete Properties Using Coconut Shell And Gravel As Coarse Aggregates". Journal Of Building Engineering, 19, 266-272(2018).
[25] Kanchana, K., & Devi, R. K. "An Experimental Study On Partial Replacement Of Fine Aggregate By Rice Husk Ash In Concrete". International Journal Of Engineering And Technology, 7(2.34), 496-500(2018).
[26] Gunasekaran, K., & Annadurai, R. "An Experimental Study On Concrete With Rice Husk Ash And Coconut Shell As Partial Replacement Of Fine And Coarse Aggregate". International Journal Of Pure And AppliedMathematics, 118(20), 603-610. (2018).
[27] Taha, B., Al-Mansob, R. A., & Alengaram, U. J.Effect of particle size of coconut shell on concrete properties. Journal of Building Engineering, 9, 27-34.(2017).
[28] Nwofor, T. C., & Alkali, A. U "Effect Of Rice Husk Ash As Partial Replacement Of Fine Aggregate On The Strength Of Concrete". International Journal Of Engineering Research And Applications, 7(6), 12-17. (2017).
[29] Islam, M. S., Islam, M. A., Islam, A. K. M. S., & Alam, M. S. " Effect Of Coconut Shell As Coarse Aggregate On Properties Of Concrete". (2016).
[30] S. A. Kakade, Dr. A. W. Dhawale, "Light Weight Aggregate Concrete By Using Coconut Shell" On International Journal Of Technical Research And Applications E-Issn: 2320-8163,Volume 3, Issue 3 (2015), Pp. 127-129
[31] B.Damodhara Reddy, S.Aruna Jyothy, Fawaz Shaik "Experimental Analysis Of The Use Of Coconut Shell As Coarse Aggregate"On Iosr Journal Of Mechanical And Civil Engineering, Volume 10, Issue 6 (2014)
[32] Ahmed, I., & Ahmed, M. "Investigation On Coconut Shell Aggregate In Concrete". International Journal Of Scientific & Engineering Research, 5(3), 39-45. (2014).
[33] Tomas U. Ganiron Jr, "Effects Of Rice Hush As Substitute For Fine Aggregate In Concrete Mixture"On International Journal Of Technical Research And Applications International Journal Of Advanced Science And Technology Vol.58, (2013), Pp.29-40
[34] C.Marthong, "Effect Of Rice Husk Ash (Rha) As Partial Replacement Of Cement On Concrete Properties"On International Journal Of Engineering Research & Technology (Ijert) Vol. 1 Issue 6, (August – 2012)
[35] Madurwar, M. V., Ralegaonkar, R. V., & Mandavgane, S. A. "Coconut Shell And Waste Plastic Composite Material As Partial Replacement Of Coarse Aggregate In Concrete". Journal Of Cleaner Production, 59, 224-231(2013).
[36] Alengaram, U. J., Jumaat, M. Z., & Mahmud, H. B. "Utilization Of Coconut Shell As Coarse Aggregate In Concrete": A Review. Construction And Building Materials, 36, 290-302. (2012).
[37] Sk.Gunasekaran, P.S.Kumar, "Lightweight Concrete Using Coconut Shells As Aggregate" On Proceedings Of International Conference On Advances In Concrete And Construction, Icacc-2008 ,7-9 (February, 2008).