Multidisciplinary Applied Research and Innovation Vol. 2 No. 1 (2021) 25-35

MARI

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/mari
e-ISSN : 2773-4773

Concrete Block with Partial Replacement of Coarse Aggregate by Coconut Shell: A Review

Mardiha Mokhtar[1*], Nge Zhuo Zhen[2], Chai Wei Jing[2], Lim Jia Le[2]

[1] Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia (UTHM) Kampu Pagoh, Hab Pendidikan Tinggi Pagoh, KM 1, Jalan Panchor, Muar, 84600, Malaysia

DOI: https://doi.org/10.30880/mari.2021.02.01.003
Received 11 November 2020; Accepted 01 January 2021; Available online 03 February 2021

Abstract: Nowadays, the cost of construction materials is increasing day by day due to the increment in the prices of building materials. The main ingredient of concrete is cement, coarse aggregate, fine aggregate and water. Due to the quick development of the infrastructure development, the usage of the aggregates is increasing extremely, this situation has affected the environment and lead to ecological inequality. A lot of researchers have doing their research on the materials which can used to reduce the negative impact of concrete as well as increased the strength. Some waste materials such as fly ash, rice husk and slag are used in concrete according to their properties. In this research, the partially replacement of coconut shell as coarse aggregate was discussed based on the results from comprehensive review of literature. The coconut shells are a big problem for the disposal as it becomes useless after the usage of the coconut. Therefore, the partially replacement of coconut shell as coarse aggregate may help to reduce the cost of the construction and have the solution for the coconut shell disposal. The objective of this paper is to study and evaluate the published reviews that related to the physical characteristic of concrete that made by using coconut shells and to approach towards the feasibility of incorporating coconut shell as a replacement for coarse aggregate in concrete production. The recommendation is that the coconut shell able and suitable to use in lightweight aggregate to replace the conventional coarse aggregate. The partially replacement of coconut shell create a more economic concrete structure and leads to a sustainable development in construction field.

Keywords: coconut shell, concrete block, coarse aggregate, compressive strength

1. Introduction

Concrete is world's most widely used structural materials in the construction industry. The utilization of concrete is increasing at a higher rate due to rapid growth of infrastructure development and construction activities all around the world [1]. However, there are some negative impacts of the large scale production of concrete such as the continuous extensive extraction of aggregate from natural resources will cause depletion which will affecting the environment and lead to ecological inequality

**Corresponding author: mardiha@uthm.edu.my*

[2]. Furthermore, the cost of construction materials is increasing day by day because of high demand, scarcity of raw materials, and high cost of energy. From the standpoint of energy saving and conservation of natural resources, the use of alternative constituents in construction material is a global concern. Hence, the extensive research and development works towards exploring alternative materials are required for producing sustainable and environmentally friendly construction materials [3].

According to the published research, there are about 114, 000 hectares of coconut plantation in Peninsular Malaysia and the area is more or less static. Agricultural waste was disposed of in large amount in most of the tropical countries particularly in Asia for countries like Philippine, Thailand, and Malaysia. The disposal of agricultural waste materials which is coconut shell has constituted an environment challenge as it required a large space area for the disposal of waste materials. If coconut shells dumped improperly to the environment, it will lead to environmental problems and provides breeding places for disease vectors such as rats and mosquitoes which is dangerous to the safety of human beings [4].

Furthermore, the weight of concrete that made by using conventional coarse aggregate is heavier than concrete that made by using crushed coconut shell. Figure 1 and Figure 2 shows coconut shells and crushed coconut shells. The weight of coconut shell concrete is lighter than normal aggregate concrete because coconut shell is categorised as light weight aggregate and the density of coconut shell is lighter than conventional coarse aggregate [5]. Figure 3 shows coconut shell concrete. Hence, it is essential if successfully convert them into a useful ingredient for the production of concrete as it minimizes their negative impact on the environment and fulfill almost all the qualities of the original form of concrete.

Figure 1: Coconut shells

Figure 2: Crushed coconut shells

Figure 3: Coconut shell concrete

This review paper aims to raise awareness about the utilization of coconut shells as partially replacement of coarse aggregate in concrete which technically and economically feasibility of the same. In this review paper, the main objective is to study and evaluate the published reviews that related to the physical characteristic of concrete that made by using coconut shells and to approach towards the feasibility of incorporating coconut shell as a replacement for coarse aggregate in concrete production. It is followed by the systematic review of all relevant research and studies related the uses of crushed coconut shells to partially replace coarse aggregate in concrete in order to collect and analyse data from the studies that are included in the review.

2. Methodology

2.1 Systematic Review Process

The first phase in develop the systematic review is identification. In this phase, the papers are collected and evaluated for their suitability based on the analysis of their title and abstract. The relevant keywords were used to find the research papers. During this phase of the selection process, the paper that had been searched were classified into two categories that are possible select (PS) or non-selected

paper (NS). Keyword such as concrete block, coconut shell, partial replacement of coarse aggregate and others have been used to search information in the databases.

The second phase is screening. The inclusion and exclusion criteria have been decided before the process of screening start. Screening is taken on the title and abstract of each research papers. The inclusion and exclusion criteria were considered to prevent irrelevant information enter the next phase of process. Table 1 shows the inclusion and exclusion criteria. Eligibility is third phase that reviewed the selected articles pass from phase one and phase two which meet the criteria required in this review paper. The review on the research paper is thoroughly. Reading on the conclusions or even full text were done to have a more detail information. After this phase, the relevant of the accepted research paper is confirmed and is useful to this review paper.

Table 1: Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Literature type	Indexed Journal (research article)	Non-indexed journals, Systematic review journals, chapter in book, conference proceeding, unpublished data, non-English manuscript
Language	English	Non-English
Time line	2010-present	<2010
Indexes	Social Science Citation Index	Science Citation Indexed Expanded
Method used in research paper	Qualitative and quantitative	Non-qualitative and non-quantitative
Availability of text	Full text available	Full text not available, partially text available only

2.2 Flow Diagram

Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) is the guideline used in this study. In this system, it contains four-phase flow diagram to help the readers' more understanding about the systematic review process. Figure 4 shows the PRISMA flow diagram for this study

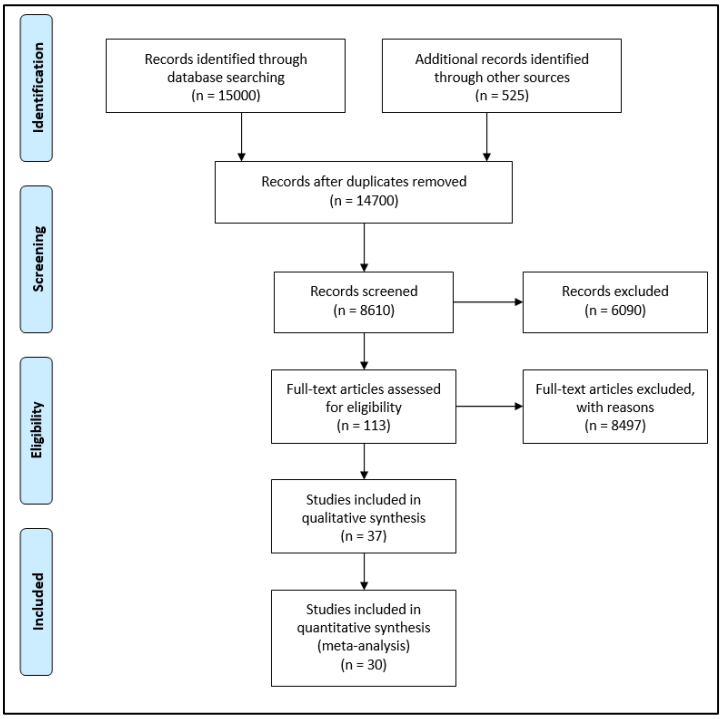

Figure 4: The PRISMA flow diagram

3. Results and Discussion

Verma and Shrivastava, [1] is concluded that coconut shell concrete can be categorized in light weight concrete. It is also serving the purpose of solve the problem of the deficit of conventional material. This type of concrete is suitable for non-structural members such as partition wall, floor tiles, hollow concrete brick etc. Harish M K, Ashwini B T, Chethan V R, [2] casted cube and cylinder as samples that evaluated at 7, 28 and 56 days at 10%, 20% and 30%. Result obtained shows that the decline of compressive strength when the increment of the percentage replacement. It is concluded that the replacement can be used up to 20%. Sandeep et al., [3] investigated the percentage of coarse aggregate with partial replacement of coconut shell and cured for 7 days and 28 days. He recommended that the optimum replacement of coconut shell is 15% in the production of lightweight concrete.

Azunna et al., [4] studied on the mechanical properties of coconut shell as the replacement of coarse aggregate at 10%, 20% and 30%. It is concluded that the pore structure of the concrete is the criteria that affect the strength and water absorption and inversely proportional to one another. The recommendation of replacement of coconut shell is 10% for low strength, indoor and dry applications. Subashi and Singhapura, [5] investigated the percentage of coconut shell with 20%, 25% and 30% have been tested in this study. Based on the result, the 25% replacement of coarse aggregate with coconut shell reached the maximum compressive strength of crushed coconut shell-based cement sand block. Ahlawat & Kalurkar, [6] used M20 grade of concrete to replace the coarse aggregate by coconut shell. Percentage of the replacement is 2.5%, 5%, 7.5% and 10%. They have drawn the conclusion that the increment in percentage replacement by coconut shell will cause the reduction in compressive strength of concrete but increases the workability of concrete.

Shaikh et al., [7] have been studied on the structural behaviour of concrete of M25 that substitute coarse aggregate by coconut shell with percentage of 0%, 5%, 10% and 15%. It is concluded that the replacement of coconut shell as aggregate is suitable to use for light weight structure and not require high strength. Kamal & Singh, [8] investigated on the M25 grade of concrete that replaced 10%, 20% and 30% of coarse aggregate by coconut shell. The result showed that the elevation of the percentage of substitution reduce the strength of concrete. It is inspired that the use of coconut shell as aggregate

is reasonable in the manufacture of structural lightweight concrete. Patel et al., [9] examined the percentage replacement of coconut shell of 0%, 10%, 20%, 30%, 40% and 50%. It is concluded that the replacement of coconut shell at 20% has a good result of compressive strength which achieved M20 concrete grade as compared to normal concrete.

Shraddha et al., [10] investigated the replacement of percentage of coconut shell is 25%, 50%, 75% and 100% which evaluated at 3 days, 7 days and 28 days. Result shows that production of sustainable lightweight concrete is achieved. Overall cost reduction of construction is checked. Subramani and Anbuvel, [11] aimed to analyse split tensile and compressive strength with partial replacement of coconut shell using M25 grade concrete. Based on the results, the addition of coconut shell is potential as a lightweight aggregate in concrete. Anwar et al., [12] observed the compressive strength when the coarse aggregate is partially replaced by coconut shell. The result shows that the compressive strength of concrete on 10% partial replacement of natural coarse aggregate with coconut shell is 20.75N/mm2 which is making the replacement both technically and economically feasible and viable.

Saifullah, [13] in his experimental study, 0%, 10%, 25% and 50% of coarse aggregate were replaced by coconut shell. He recommended that 20% replacement by coconut shell as the strength of structural lightweight concrete meet the requirement of American Concrete Institute. Kambli, [14] studied three different mix designs grade of concrete that include M20, M35 and M50. The percentage of coarse aggregate that replaced by coconut shell varied between 0%, 20%, 30% and 40%. It has been concluded that for M20 grades concrete cube, 30% of coconut shell replaced the coarse aggregate possess the strength of 23MPa at 28 days. De Costa et al., [15] aimed the suitability of the partial replacement of coarse aggregate with coconut shells in the production of concrete. The researcher observed that the proportion in the range of 4% to 8% satisfied the target strength of M25 concrete grade. Meanwhile, the proportion above 12% but below 20% satisfied the target strength of M20 concrete grade

Uday Bhaskar et al., [16] investigated on M20 and M25 grades of concrete by using four percentage of replacement of coconut shell in the ratio of 0%, 10%, 20% and 30%. It is concluded that the replacement of coarse aggregate by using coconut shell can be up to 30% in order to keep the strength, economy and serviceability of the concrete. Oswal et al., [17] examined the compressive strength of cubes of M15, M20, M25 and M30 for 7, 14 and 28days. It is acceptable up to 20% replacement as over than 20% shows the sudden decline of compressive strength. As it is classified as light weight concrete, it can be used in construction of Pedestrian road Pavement, Compound walls and etc. SwagatikaMohapatra*, [18] target on evaluating the properties for different percentage of recycled and coconut shell aggregate using M25 grade concrete. Higher water absorption of coconut shell led to the lower aggregate impact value as compared with crushed stone aggregate. So, it has better shock absorbance and it can be categorized in lightweight aggregate.

Kanojia and Jain, [19] studied on the effects of the partial replacement of coarse aggregate by 10%, 20%, 30% and 40%. The investigation shows that addition of coconut shell has low strength development at 7 days but rapid strength development at 28 days. Yerramala, [20] investigated four mixes which contains 0%, 10%, 15% and 20% of coconut shell content. Based on the result, the workability, density and split tensile strength decreases as the addition of coconut shell increases. Tharwani et al., [21] investigated on the varying percentage of coconut shell, 5%, 10% and 15%. The researcher concluded that up to 15% of aggregate replaced by the coconut shell is well-being according to compressive strength and cost wise.

Sonawane and Chitte, [22] explored the percentage of replacement were 0%, 25%, 50% and 100% with mix design of M20. It is concluded that the rising in the percentage of replacement by coconut shell shows a downturn in compressive strength. They recommended that the strength of coconut shell concrete can be added by put in admixture. Srilakshmi and Navya, [23] investigated the percentage of replacement is 0%, 10% and 20% with mix design of M30. The researcher concluded that using coconut shell as partially replacement of coarse aggregate is a nice plan for waste disposal. The 10% replacement

of coconut shell has a good result which achieved the strength at M30 concrete grade. Damodhara et al., [24] aimed on determining flexural, split tensile and compressive strength characteristics with partially replacement with 0%, 25%, 50% and 100%. This study shows increment of coconut shell decreases the workability of concrete. The density of the concretes decreases as the coconut shell percentage increases.

Mandal et al., [25] projected on the physical and mechanical properties of concrete by partially replacement of coconut shells for coarse aggregates. The optimum mix for the concrete is 10% with partially replacement of coconut shell. Chandraul et al., [26] investigated the percentage replacement used for 0%, 20%, 40%, 60%, 80% and 100% at 7 days, 14 days and 28 days. Based on the result, up to 40% of aggregate replaced by coconut shell is good according to strength and cost wise. Selwyn and Mahendran, [27] projected on the percentage replacement of coconut shell used include 0%, 25%, 50%, 75% and 80%. It is concluded that the percentage replacement of coconut shell up to 75% satisfied the requirement for structural lightweight concrete. Raut, [28] aimed to check the strength by substituting the coarse aggregate with 0%, 10%, 20%, 30%, 40%, 50% and 100% by coconut shell. It is concluded that 10% and 30% of substitution poses the good strength. Coconut shell is suitable to replaced coarse aggregate and lower the construction cost.

3.1 Compression Strength

In designing the structure, the popular performance attribute used is the compressive strength. The sample used in this compressive strength can be on a cube or a cylinder. The Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens has been provided by American Society for Testing Materials ASTM C39/C39M. Compressive strength can be defined as the capacity of a material to withstand under the action of compression. It is determined by the ability of the material to withstand the failure in the form of cracks and fracture. The compressive strength will be calculated from the failure of load divided by the cross-sectional area resisting the load and the units reported in units of pound-force per square inch (psi) or megapascals (MPa). Table 2 shows part of the result of compressive strength of concrete with different percentage of coconut shell replacement.

Table 2: **Compressive Strength Result**

Author	Type of Mix/Grade of mix	Coconut Shell Percentage (%)	Compressive Strength (MPa)			
			7days	14Days	28Days	90days
[6]	Coconut shell	0	13.19	-	26.83	29.96
		10	12.91	-	24.28	26.53
		25	11.94	-	16.68	19.15
		50	9.28	-	10.28	11.26
[7]	Coconut shell	0	25.04	31.17	34.85	-
	M25	5	19.10	22.74	23.89	-
		10	17.12	19.16	22.77	-
		15	15.80	17.83	21.74	-
[8]	Coconut shell	0	25.77	28.46	34.10	-
	M25	10	19.29	22.55	28.53	-
		20	15.86	18.72	22.32	-
		30	12.22	16.32	20.12	-
[9]	Coconut shell	0	20.53	24.00	27.58	-
	M20	10	18.14	21.05	23.46	-
		20	16.83	18.92	20.95	-
		30	15.63	17.30	18.94	-
		40	13.51	15.04	17.06	-

		50	11.05	13.54	15.48	-
[10]	Coconut shell	0	37.10	-	50.50	-
		25	31.30	-	42.60	-
		50	30.40	-	41.30	-
		75	29.80	-	40.50	-
		100	23.30	-	31.20	-
[11]	Coconut shell	0	15.29	18.60	20.30	-
	M25	5	14.72	18.34	19.60	-
		10	14.38	17.35	18.84	-
		15	14.24	17.12	18.62	-
		20	14.14	16.98	18.46	-

3.2 Split Tensile Strength

Tensile strength is an important criterion of concrete as it is required in the stage of designation of buildings or structure. It is difficult to determine the direct tensile strength, so indirect methods are used. The indirect techniques include split cylinder test and flexural test. The procedure taken is depend on ASTM C496 (Standard Test Method of Cylindrical Concrete Specimen) that similar to other codes such as IS5816 1999. Table 3 shows part of the result of split tensile strength of concrete with different percentage of coconut shell replacement.

Table 3: Split tensile strength result

Author	Type of Mix/Grade of mix	Coconut Shell Percentage (%)	Split Tensile Strength			
			7days	14Days	28Days	90days
[8]	Coconut shell	0	2.330	2.680	3.420	-
	M25	10	2.066	2.320	3.040	-
		20	1.480	2.150	2.800	-
		30	1.350	1.980	2.330	-
[9]	Coconut shell	0	1.620	2.020	2.550	-
	M20	10	1.550	1.770	2.170	-
		20	1.200	1.580	2.060	-
		30	1.050	1.190	1.860	-
		40	0.890	1.050	1.300	-
		50	0.690	0.960	1.070	-
[10]	Coconut shell	0	-	-	2.100	-
		25	-	-	1.800	-
		50	-	-	1.700	-
		75	-	-	1.700	-
		100	-	-	0.800	-
[11]	Coconut shell	0	0.760	1.620	2.390	-
	M25	5	0.620	1.230	2.120	-
		10	0.580	1.030	1.860	-
		15	0.430	0.840	1.240	-
		20	0.250	0.640	0.800	-

3.3 Flexural Strength

Flexural strength is the mean used to measure the tensile strength of concrete. The function of this strength is used to measure the resistance of failure in bending for beam or slab. The flexural strength is expressed in Modulus of Rupture (MR) in psi (MPa). The standard based on ASTM C78 (third-point loading) or ASTM C293 (centre-point loading). Table 4 shows part of the result of split tensile strength of concrete with different percentage of coconut shell replacement.

Table 4: Flexural strength result

Author	Type of Mix/Grade of mix	Coconut Shell Percentage (%)	Flexural Strength			
			7days	14Days	28Days	90days
[8]	Coconut shell M25	0	6.900	-	7.950	-
		10	6.000	-	6.850	-
		20	5.600	-	6.400	-
		30	5.100	-	5.900	-
[9]	Coconut shell M20	0	2.880	3.010	3.910	-
		10	2.710	3.060	3.580	-
		20	2.060	2.870	3.200	-
		30	1.850	2.410	2.900	-
		40	1.590	2.080	2.570	-
		50	1.260	1.920	2.100	-
[10]	Coconut shell	0	-	-	4.800	-
		25	-	-	4.100	-
		50	-	-	4.100	-
		75	-	-	3.900	-
		100	-	-	3.000	-

3.4 Workability

The objective of the slump cone test is to measure the workability and consistency of concrete which can be employed either in laboratory or at site of work. The slump value shows the characteristic of concrete. In order to get the ideal of the workability of concrete, the true slump is the only reliable condition. It will be repeated if obtained other results. The procedure based on ASTM C143 in the United States, IS: 1199-1959 in India and EN12350-2 in Europe. Table 5 shows the slump value with different percentage of coconut shells.

Table 5: Slump value

Author	Type of Mix/ Grade of mix	Coconut Shell Percentage (%)	Slump(mm)
[6]	Coconut shell M20	0	85
		2.5	61
		5	67
		7.5	73
		10	79
[7]	Coconut shell M25	0	69
		5	62
		10	58

		15	56
[8]	Coconut shell	0	40
	M25	10	30
		20	34
		30	42
[9]	Coconut shell	0	72
	M20	10	66
		20	60
		30	52
		40	46
		50	37
[10]	Coconut shell	0	110
		25	70
		50	65
		75	60
		100	50

4. Conclusion

Based on the result and discussion in this review paper, it is concluded that the overall strength of concrete decrease when the coarse aggregate in partially replaced by coconut shells in comparison with control concrete. The compressive strength, split tensile strength and flexural strength shows decline when the percentage replacement of coconut shells increases. Furthermore, the results demonstrate that as the percentage of coconut shell aggregate increase, the slump value and workability of concrete will decrease. The data obtained from the researches of De Costa et al., [15] and Azunna et al., [4] increase with the increment of the percentage of coconut shell in the concrete due to the reason that the data obtained is slump height instead of slump value. The partially replacement of coarse aggregate with coconut shells for concrete production decrease the compressive strength, spilt tensile strength, flexural strength and workability of concrete in comparison with control concrete. Therefore, it is concluded that the coconut shell has potential and more suitable as low strength-giving lightweight aggregate when used to replace conventional coarse aggregate in concrete production. The utilisation of coconut shells to partially replace aggregates make concrete structure more economic along with good strength criteria. This can be useful for construction of low-cost housing society and leads to a sustainable development in construction field.

For future studies, the durability properties of coconut shell concrete can be determined by having durability test such as water absorption test, surface absorption test and water permeability test. Review study on impact value and crushing value can be done in order to analyse the strength properties of coconut shells. Moreover, utilisation of other agricultural wastes such as palm kernel shells, oil palm shell, rice husk and sugarcane bagasse can also be an option for further studies in replacement of conventional aggregates in concrete production for lowers the costs of building materials and produce sustainable eco-friendly construction material [29]. Last but not least, further studies can be done on the methods to increase the strength of coconut shell concrete by adding admixtures such as chemical admixtures and mineral admixture that included fly ash and silica fume [30].

Acknowledgement

The authors would like to thank the Centre of Diploma Studies, Universiti Tun Hussein Onn Malaysia (UTHM) for its support.

References

[1] S. K. Verma and S. Shrivastava, "Use of coconut shell as partly substitution of coarse aggregate - An experimental analysis," *AIP Conf. Proc.*, vol. 2158, 2019, doi: 10.1063/1.5127145.

[2] S. M. Y. Harish M K., Ashwini B T, Chethan V R, "Experimental Investigation on Partial Replacement of Coarse Aggregate With Coconut Shell in M20 grade Concrete," vol. 2, no. 6, pp. 534–540, 2017.

[3] B. Sandeep Reddy Asst. Professor Svec, asst. P. S. Ch. Gopi Chand, and pg S. C. B. Anusha, "Experimental Investigation of Concrete using Coconut Shell as a Coarse Aggregate Replacement," *Int. J. Eng. Res.*, vol. 6, no. 04, pp. 1036–1041, Apr. 2017, [Online]. Available: http://www.ijert.org/view-pdf/16666/experimental-investigation-of-concrete-using-coconut-shell-as-a-coarse-aggregate-replacement.

[4] S. U. Azunna, F. N. A. Abdaziz, N. Abu Bakar, and N. A. Mohd Nasir, "Mechanical properties of concrete with coconut shell as partial replacement of aggregates," *IOP Conf. Ser. Mater. Sci. Eng.*, pp. 1–7, 2018, doi: 10.1088/1757-899X/431/3/032001.

[5] S. D. S. G. H. M. J and S. D. K. G. Singhapura, "Structural Performances of Solid Masonry Blocks Made Using Crushed Coconut Shell Aggregates," vol. 5, no. 4, pp. 1796–1803, 2016.

[6] D. Ahlawat and L. G. Kalurkar, "Coconut Shell as a Partial Replacement to Coarse Aggregate in Concrete," *Aust. J. Basic Appl. Sci.*, pp. 61–64, 2014.

[7] F. A. Shaikh, A. Raza, M. Awais, and M. Abubakar, "Comparative Study of the Compressive Strength of concrete by Partially Replacing Coarse Aggregate with Coconut Shell Aggregate," pp. 1–4, 2019.

[8] J. Kamal and P. J. P. Singh, "Experimental Study on Strength Characteristics of M25 Concrete with Partial Replacement of coarse aggregate with coconut shell and cement with Fly Ash," *Int. J. Inov. Res. Sci. Eng.*, vol. 3, no. 7, pp. 32–39, 2015, doi: 10.15680/IJIRSET.2015.0406114.

[9] P. Patel, L. E. Collage, and S. R. Vaniya, "Experiments on Partial Replacement of Coconut Shell as Coarse Aggregate in Concrete," vol. 2, no. 1, pp. 78–87, 2015.

[10] D. Shraddha, F. Hitali, D. Pradeep, and S. Varpe, "Sustainable Concrete by Partially Replacing Coarse Aggregate Using Coconut Shell," *J. Today's Ideas - Tomorrow's Technol.*, vol. 2, no. 1, pp. 41–54, 2014, doi: 10.15415/jotitt.2014.21004.

[11] T. Subramani and A. Anbuvel, "Experimental Behaviour Of Reinforced Concrete Beams With Coconut Shell As Coarse Aggregate," *Int. J. Appl. or Innov. Eng. Manag.*, vol. 5, no. 5, pp. 67–75, 2016.

[12] A. Anwar, A. Sabih, and A. S. Aqeel, "Performance of Waste Coconut Shell as Partial Replacement of Natural Coarse Aggregate in concrete," *Int. J. Sci. Eng. Res.*, vol. 7, no. 8, pp. 1802–1809, 2016.

[13] I. Saifullah, "Coconut Shell As a Replacement of Coarse Aggregate," no. 4, pp. 22–26, 2017.

[14] P. S. Kambli, "Compressive Strength of Concrete by Using Coconut Shell," *IOSR J. Eng.*, vol. 4, no. 4, pp. 01–07, 2014, doi: 10.9790/3021-04470107.

[15] M. B. M. De Costa, D. D. T. Dasanayaka, M. N. Tantirimudalige, K. M. L. A. Udamulla, and T. C. Ekneligoda, "Use of Waste Coconut Shells as Substitute for Coarse Aggregate in Light-Weight Concrete Mixes," pp. 1–5, 2017.

[16] M. Uday Bhaskar, S. Manasa, and T. Anith Kumar, "Concrete mix using solid waste aggregates (Coconut shell concrete)," *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 10, pp. 84–89, 2019, doi: 10.35940/ijitee.I8658.0881019.

[17] K. D. Oswal, S. Pal, and U. S. Patil, "Experimental Analysis on Coconut Shell as Coarse Aggregate," pp. 505–510, 2016.

[18] P. P. K. P. SwagatikaMohapatra*, "Experimental Investigation on the Propertiesof Recycled Concrete and Coconut Shell Aggregate Concrete," *Int. J. Sci. Res. Publ.*, vol. 7, no. 6, pp. 710–716, 2017.

[19] A. Kanojia and S. K. Jain, "Performance of coconut shell as coarse aggregate in concrete," *Constr. Build. Mater.*, pp. 150–156, 2017, doi: 10.1016/j.conbuildmat.2017.02.066.

[20] A. C. Yerramala Ramachandrudu, "Properties of Concrete with Coconut Shells as Aggregate Replacement," *Int. J. Eng. Invent.*, vol. 1, no. 6, pp. 21–31, 2012.

[21] A. Tharwani, A. Sablani, G. Batra, S. Tiwari, D. Reel, and M. N. Gandhi, "Study of Strength of Concrete by Using Coconut Shell," *IJISET-International J. Innov. Sci. Eng. Technol.*, vol. 4, no. 5, pp. 37–41, 2017, [Online]. Available: www.ijiset.com.

[22] Y. N. Sonawane and C. J. Chitte, "Waste Coconut Shell as a Partial Replacement of Coarse Aggregate in Concrete Mix - An Experimental Study," *Int. J. Sci. Res.*, vol. 5, no. 4, pp. 649–651, 2016, doi: 10.21275/v5i4.nov162608.

[23] K. Srilakshmi, P. Navya, and M. Tech, "Improving the Strength Parameters of Concrete By Partial Replacement With Coconut Shell As Coarse Aggregate," vol. 5, no. 2, pp. 1016–1019, 2018.

[24] B. D. Reddy, S. A. Jyothy, and F. Shaik, "Experimental Analysis of the Use of Coconut Shell as Coarse Aggregate," *IOSR J. Mech. Civ. Eng.*, vol. 10, no. 6, pp. 06–13, 2014, doi: 10.9790/1684-1060613.

[25] T. A. Mandal B., Tiwari S., Ghimire S., "Mechanical properties of concrete with partial replacement of coarse aggregates by coconut shells and reinforced with coconut fibre," *IOP Conf. Ser. Mater. Sci. Eng.*, pp. 227–238, 2018, doi: 10.1088/1757-899X/431/3/032001.

[26] C. Kirti, S. M. Kumar, S. A. Kumar, and T. R. Arora, "Experimental Study of Coconut Shell Concrete," *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 3, no. 2, pp. 49–53, 2015.

[27] M. N. Selwyn Babu J, "Coconut Shell as a Partial Replacement to Coarse Aggregate in Concrete," pp. 693–697, 2014.

[28] P. B. Raut, "Study of Behaviour Concrete Structure By Using Coconut Shell," vol. 4, no. 12, pp. 48–51, 2017.

[29] M. Maghfouri, P. Shafigh, and M. Aslam, "Optimum Oil Palm Shell Content as Coarse Aggregate in Concrete Based on Mechanical and Durability Properties," *Adv. Mater. Sci. Eng.*, vol. 2018, pp. 1–14, 2018, doi: 10.1155/2018/4271497.

[30] M. Santhosh Kumar, V. R. Prasath Kumar, and K. Gunasekaran, "Study on mechanical properties of high strength concrete using coconut shell as coarse aggregate," *Int. J. Chem. Sci.*, vol. 14, pp. 247–256, 2016.