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A Comparison Study in Partial Replacement of Coarse Aggregate with Coconut Shell in Concrete

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Abstract: Demanding for natural resources in construction are increase and caused the resources to deplete and this paper studies about the coconut shell substitution with coarse aggregate's impact to the concrete. The main objective is to investigate the percentage replacement of coconut shell's influence to the work-ability and strength of the concrete by comparing two previous research. The methods of this study are review the previous research, collect the data from those research and lastly process and explain the data obtained. The coarse aggregate's substitution with coconut shell caused the water absorption and water permeability to increase and compressive strength to decrease. Those stated are influenced by properties of coconut shell, cement, aggregate, admixtures, and process of treating the coconut shell. If future work are on comparison study, it is recommended to compare between the specimens with the same percentage replacement to get more accurate outcomes.

Keywords: Coconut Shell Aggregate, Partial Replacements

1. Introduction

Economic, environmental and also the technological can derived the benefits of the material thanks to the utilizing of alternate aggregate in construction industries has been widely necessary and needed. Alternative aggregate will be used as material's replacement within the housing industry, since industrial wastes and abundant agricultural are discharged in most developing countries. One of the many alternative materials from agricultural solid waste is coconut shell. Coconut shell is the most prominent agro-wastes with its possible advantages in the production of concrete as coarse aggregate [1]. The major material in civil engineering material is concrete where its production involves the utilization of ingredients like aggregates, cement, additional substances and water. As infrastructure development across the globe rose, it caused the increasing in construction material's demand [2]. Coconut shell from local industries have more than 60% of domestic waste volume [5]. However, the

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strength of coconut shell concrete is lower than conventional concrete that make it limited to used for low cost buildings. Strength and workability of the concrete influenced by the different percentage substitution of coconut shells [11]. A comparison between two previous research will be conducted in this research. Recommendation are required based on the result and discussion obtained, some recommendations can be made and then the recommendations will be considered to improve the research.

In recent years, the use of agricultural wastes as building material in construction have taken the attention of researcher. Some researcher substitute coarse aggregate in concrete with Periwinkle shell and fine aggregate in concrete replaced with palm kernel shell by some [12]. There are also research that used granular coconut and palm kernel shell for the purpose of regular coarse aggregate's replacement and the experimental results indicated that the rising of coconut shell's percentage substitution will cause the declined in concrete's compressive strength [10]. According to previous study, based on the properties of the coconut shell, the coconut shell concrete can be characterized as the structural lightweight concrete [4].

Figure 1: Transform coconut shell into aggregate

2. Literature Review

Coconut shell available in local industries [10][5] and can be found in many tropical countries usually in Asia [4]. The third largest country that widely plant and produce coconut based product is India. The study of coconut shell to replace certain amounts of aggregate are important to reduce the waste and create sustainable or green materials from waste [3]. Coconut shells have potential to replace material in construction and building field [10]. The increased in the percentage substitution of coconut shells will decreased the compressive strength of coconut shell concrete [3][6][7]. 10% and 20% of coconut shell substitution with aggregate are suitable to be used but not 30% of substitution because it is unprofitable and unacceptable to be used in the construction field [5]. It is stated that the suitable percentage to substitute coarse aggregate with coconut shells for construction are 15% to 20% [10]. Coconut shell's nature is high in absorbing the water [6]. Water permeability of coconut shell concrete is directly proportional to the percentage substitution of aggregate with coconut shell [5][6][7]. The workability of coconut shell concrete can be increased by using fly ash to replace cement or aggregate[6][7][8]. Water reducing admixtures is possible to increase the coconut shell concrete's strength [7].

3. Methods

The methods conducted in this study are reviewed previous research, data collecting and lastly data processing.

3.1 Data collection

Since this study is a comparison study, two (2) previous research were chosen. These research must meet the criteria that have been set to achieve the objectives. The criteria that the previous journal must have or stated in it are properties of the coconut shell, percentage replacement of coconut shell as aggregate, process of transform the coconut shell into coarse aggregate, admixtures used, compressive strength test, water absorption test, permeability test, and fire resistance (if applicable). By referring to the chosen research, collected the information needed before continue with data processing.

Figure 2: Steps in data collection

3.2 Data processing

After collect the information needed from the research, the criteria must be explained and justified in details. If there are any difference between those research based on the criteria, justification are needed. The evaluation of the criteria will lead to finding the issues regarding the coconut shell concrete. Solution are needed in order to solve the issues that arises. As for this study, there are several limitations and gaps. So, recommendations for these limitations can be made for future studies.

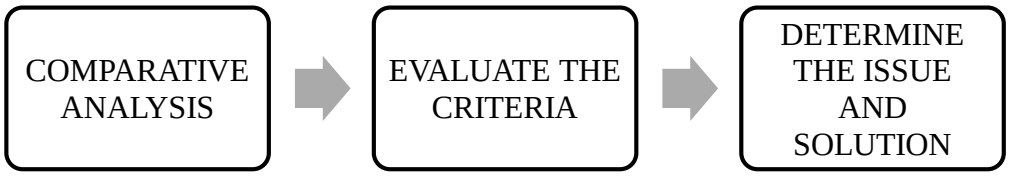

Figure 3: Steps in data processing

4. Results and Discussion

The selected research for the comparison study are as listed below:

Research 1:-

Author : B.Damodhara Reddy, S.Aruna Jyothy, and Fawaz Shaik (2014)

Title : Experimental Analysis of the Use of Coconut Shell as Coarse Aggregate

Research 2:-

Author : Amarnath Yerramala and Ramachandrudu C (2012)

Title : Properties of Concrete with Coconut Shells as Aggregate Replacement

4.1 Results

Table 1: Information obtained from research selected

Item	Research 1	Research 2
Replacement of coconut shell (%)	Have two (2) types of specimens: 1. To investigate the properties of concrete: 0%, 10%, 15%, 20%, 20%CS & 25% fly ash, 20%CS & 5% fly ash 2. To investigate the effect of coconut shell replacement: 0%, 25%, 50%, 100%	Only have one (1) type of specimen that is apply for the properties of concrete and effect of the replacement: 0%, 10%, 15%, 20%, 20%CS & 25% fly ash, 20%CS & 5% fly ash
Mix proportion (cement: fine agg.: coarse agg.)	1:2:4	1:2:4
Size of coconut shell	4.75mm - 12mm	Not exceeds 12 mm
Aggregate type	Blue granite	Blue granite
Cement type	Grade 53 of Portland Pozzolana cement (IS: 12269 and ASTM C 642-82 type I)	Grade 53 of Ordinary Portland cement (IS: 12269 and ASTM C 642-82 type I)
Admixtures or additional substances	Fly ash (only on the first type of specimens)	Fly ash
Compressive strength test (MPa) after 28 days of curing	Second specimens: 0% = 24 25% = 22.62 50% = 14.93 100% = 5.48	0% = 23 10% = 14 15% = 13 20% = 10 20%CS & 25% fly ash = 7 20%CS & 5% fly ash = 9

Moisture content of coconut shell	4.20%	4.20%
Water absorption of coconut shell	8%	8%
Water permeability	Directly proportional to the CS replacement	Directly proportional to the CS replacement
Procedure (Submerge)	- Washed the crushed coconut shell in order to get rid of mud, fibres and other matter from them, the crushed shells has been washed and then dried for 2 days under the sunlight. - Saturated surface dry (SSD) condition	- At 25℃ to 30 the coconut shell were air dried for 5 days; get rid of the husk and fibre from the dried shells. By using hammer, crushed the shells manually into small pieces and sieved through the 12 mm sieve. - Not submerge
Fire resistance	The concrete of coconut shell aggregate was categorized under the Type III construction. The product can retain fire resistance for 2 hours.	No information

4.2 Properties of coconut shell concrete

Coconut shell can replaced the aggregates in concrete but in certain amounts. A comparison between two researches that named as Research 1 and Research 2 has been made on properties (aggregate type, cement type, and size of coconut shell), compressive strength, process before concrete mixing, water absorption, water content, water permeability, and admixtures used. The cement's type will effect the workability of the concrete. In this study, Research 1 used PPC while Research 2 used OPC whereas OPC is stronger than PPC. Strength of PPC is low when compared to OPC but eventually getting stronger over the time with appropriate curing. OPC has 3 grades of cement which are grade 33, 43, and 53. These grades indicates the cement's maximum strength obtained after 28 days. The strength of PPC are equivalent with OPC 33. Coconut shell particle shape could be the reason to the decreases of CS concrete's workability and strength.

4.3 Compressive strength test and Process (Submerge or not Submerge)

Table 2: Compressive Strength (MPa) of Research 1

% Replacement of aggregates	Trial No.	Load (kN)	Compressive Strength (Mpa)	Average Compressive Strength (Mpa)
0	1	513	22.80	24.00
	2	531	23.60	

	3	576	25.60	
	1	548	24.35	
25	2	490	21.78	22.62
	3	489	21.74	
	1	365	16.22	
50	2	330	14.80	14.93
	3	310	13.78	
	1	105	4.67	
100	2	130	5.78	5.48
	3	135	6.00	

Table 3: Compressive Strength (MPa) of Research 2

% Replacement of Aggregates with coconut shell	% Replacement of fly ash	Name of cube	Load (kN/s)	Compressive Strength (Mpa)
0	-	M1	2.5	23
10	-	M2		14
15	-	M3		13
20	-	M4		10
20	25 (as cement)	M5		7
20	5 (as coarse aggregate)	M6		9

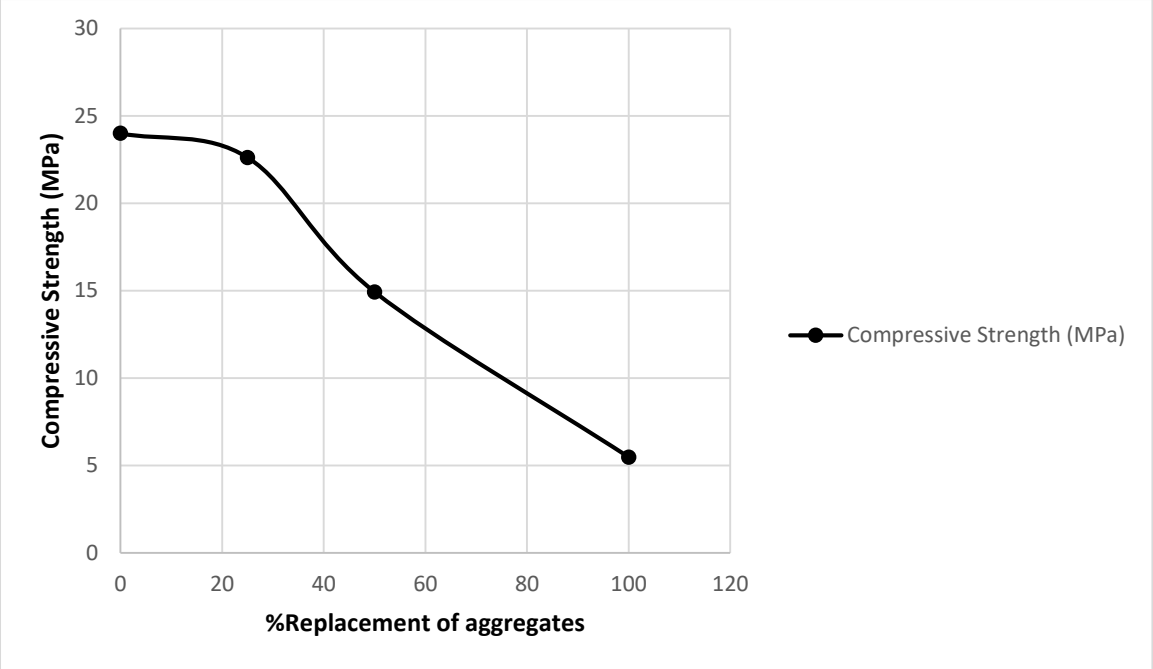

Figure 4: Graph of Compressive Strength Test vs %Replacement of CS for Research 1

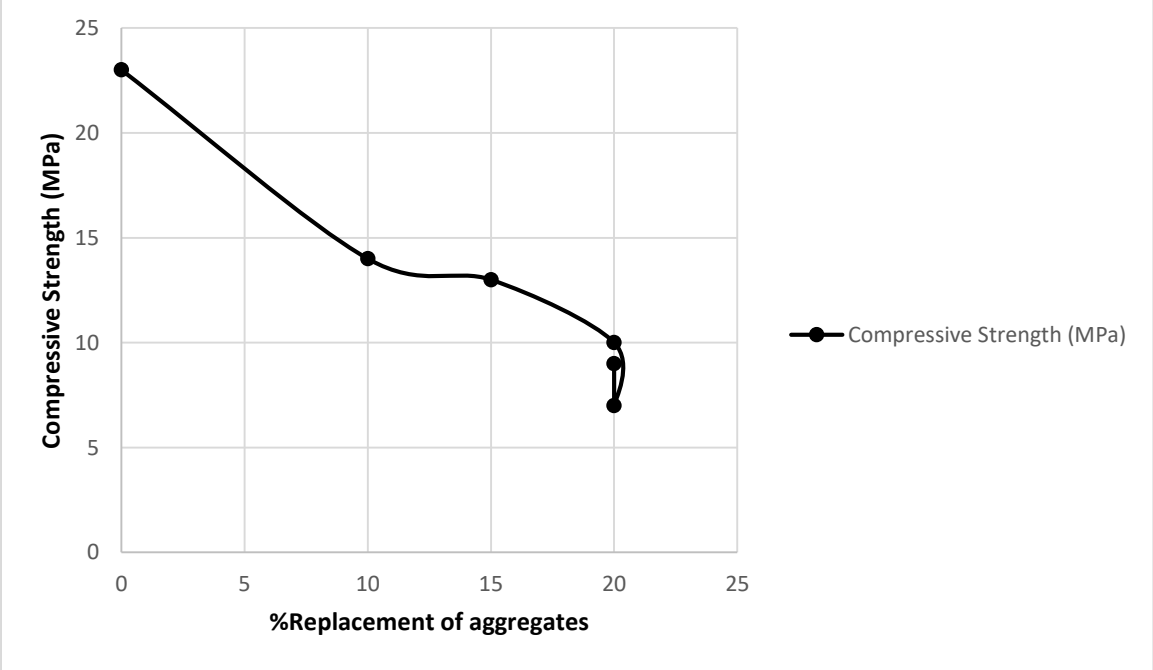

Figure 5: Graph of Compressive Strength Test vs %Replacement of CS for Research 2

Based on the observation of the compressive strength outcomes, Research 1 is better than Research 2 although both researches used the same mix ratio and admixtures. This may be because of the condition of crushed coconut shell. The compressive strength of Research 2 is not satisfied because the crushed coconut shell is not submerged in water or not in SSD condition. If not submerged in water, the coconut shell will absorbing the water when mixing the batch. This will effect the work-ability of the concrete. This is happen because CS has flat shape that can restrict aggregate particles overall

movement and thus decline the workability of the concrete. When look at the compressive strength test result, Saturated Surface Dry (SSD) condition of coconut shell or submerge before mixing is important. SSD condition will prevent the coconut shell aggregate to absorb the water content when mixing since coconut shells properties are high in absorbing the water. SSD state means the outside of the material are dry but the interparticle voids are soaked with water.

4.4 Moisture content, Water Absorption, and Water Permeability

Both research share same value of water absorption and moisture content, respectively 8% and 4.20%. The result of water permeability of both researches shows that the increase of coconut shell's replacement causes the water permeability to increase. This means the concrete is in porous condition and lower in resist the penetration of water through and then weaken the concrete. Water permeability can be controlled by adding water repellent admixtures or water proofing.

4.5 Admixtures

Admixture is an additional substance to the concrete mix whether before or after batching. Admixtures has many types with different advantages effect to concrete. Different proportion or percentages of admixtures in concrete will give different effect. Both research added fly ash to enhance the work-ability and strength of the concrete. Fly ash is an admixtures that can improve the concrete work-ability and durability. By adding admixtures, it will not give negative effect towards the concrete as long as the addition amounts is within the optimum value (25%) [5].

4.6 Fire resistance

Table 4: Minimum period of fire resistance for Single Storey Building

No. of purpose group	Purpose Group	Maximum floor area (m^2)	Minimum period of fire resistance (in hours) for elements of structure
I	Small residential	No limit	1/2
II	Institutional	3000	1/2
III	Other residential	3000	1/2
IV	Office	3000	1/2
		No limit	1
V	Shop	2000	1/2
		3000	1
		No limit	2
VI	Factory	2000	1/2

		3000	1
		No limit	2
VII	Assembly	3000	1/2
		No limit	1
		500	1/2
		1000	1
VIII	Storage and general	3000	2
		No limit	4

Coconut shell concrete can hold out fire resistance for 2 hours, fire resistance that offered by coconut shell concrete are complied all the purpose group except for Group VIII (applicable only for 500m^{2}to 3000m^2). Coconut shell concrete can be used as elements of structure as long as the structure is in those stated group. As for purpose group of storage and general, coconut shell concrete cannot be used for floor area that more than 3000m^2 because this floor area need at least 4 hours of fire resistance. The storage and general group also known as Group VIII. Coconut shell concrete cannot be applied on Group VIII if the areas are exceeds 3000m^2 maybe because it is fire risk areas and need for separation and full attention. According to Part VII Clause 139 in UBBL 1984, there are several areas that may be separated from other areas that also included the storage room in order to prevent fire hazard. The areas are storage that have boiler and fuel storage, storage that mean for hazardous materials, petroleum gas storage, flammable solid and liquid storage, linen rooms, and transformer rooms and substations [8].

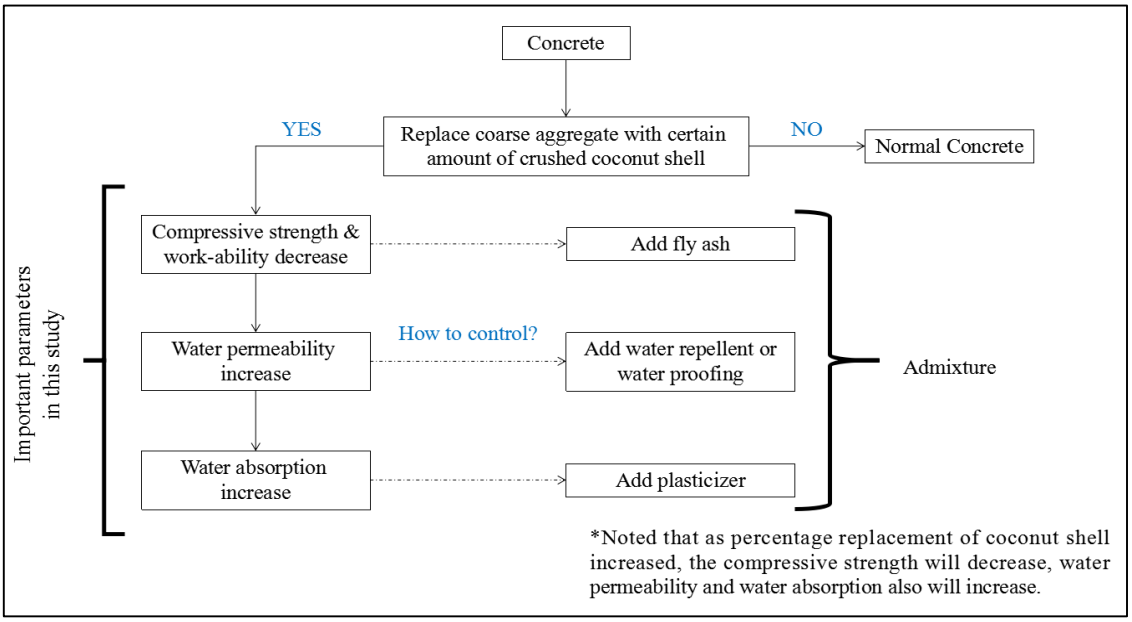

Figure 6: Overall criteria relationship

5. Conclusion

Coconut shell can replace coarse aggregate but in a certain quantity because the increase of percentage substitution of coconut shell will cause the compressive strength to decline. Besides, the increase in percentage substitution of coconut shell will cause the water permeability and water absorption to rise rapidly. The optimum value that is most suitable to replace coarse aggregate with coconut shell is 15% and below. The percentage replacement of coconut shell that exceeds 15% will effect the result of experimental whereas compressive strength will decrease, water permeability and water absorption will increase. The compressive strength can be improved by adding fly ash. Fly ash can increase the concrete's workability. Water absorption can be reduced by adding plasticizer while water permeability can be controlled by adding water repellent or water proofing. Coconut shell in Saturated Surface Dry (SSD) or submerged in water before mixing the concrete can help in reduce the absorption of water. The properties of the coconut shell concrete such as type of cement and aggregate, size of crushed coconut shell, and mix proportion also play an important roles to ensure the effectiveness of the coconut shell replacement as coarse aggregate. By utilize coconut shell to substitute a certain amount of coarse aggregate, coconut shell waste can be reduced since it can be utilized as green building materials. However, coconut shell concrete are not suitable and cannot be used for high rise building but only for low cost building. Further study can do a research on young coconut shell versus matured coconut shell as aggregate's alternative. If the study are based on comparison, it is recommended to compare between the specimens with the same percentage replacement to get more accurate outcomes.

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