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Recycle Materials Coconut Shell And Plastic Bottle Cap As An Alternatives Of Coarse Aggregate In Concrete

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ABSTRACT

Concrete were made up of constituent element which included Ordinary Portland Cement (OPC), coarse aggregate, fine aggregate, amount of water content required, and chemical admixture if necessary. It is estimated that Malaysia is the top eighth country which produced almost one million tonnes of mismanaged plastic waste in 2010, of which 0.14 to 0.37 million tonnes may have washed into the oceans. Coconut shell have good physical properties in terms of durability, toughness, abrasion resistant and can be used for longer time. In this research, coconut shell and plastic bottle cap were used as second-hand for the coarse aggregate in concrete mix. The objective of this research were produced more eco-friendly concrete for the reinforced concrete by implement 3R concept. It help to reduce the environmental problem such as waste disposal on the landfill, ocean as well as to reduce the costing on the coarse aggregate demand in the construction industry. Appropriate experimental testing such as sieve analysis, specific gravity and water absorption have been conducted to determine physical properties of materials used. Amount of both coconut shell and plastic bottle cap were weighted after compared the weight of both materials. From the result obtained, additional of plastic bottle cap in concrete sample were shown that significant increase in compressive strength and flexural strength by the limited amount of its proportion such as 27.80 kN/m2 (4.0% of coconut shell and 2.0% of plastic bottle cap) and 3.0 kN/m2 with same mix proportion as mentioned above.

Keywords:
Compression strength; flexural strength; water absorption

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1. Introduction

In general, concrete could be defined as the combination of Ordinary Portland Cement (OPC), coarse aggregate (crushed or uncrushed), fine aggregate (river sand), and water content. If required, chemical admixtures such as air entraining admixture, water reducing admixture, retarding admixture, and super plasticizer admixture would be used immediately into concrete mixing before [4]. All of the chemical admixture which listed above have their own properties, advantages, disadvantage, and also its function in the construction. On the other hand, water-cement ratio were important design parameter required in the production of good quality of concrete. This is because this design parameter would play an important role in both the strength and the durability of concrete.

According to Sidney [5], he have been stated that higher water-cement ratio in concrete mixing would lead to the increment of concrete workability. Conversely, the flow of concrete would

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decreased when water-cement ratio were lower. From the statement above, one of the experimental testing would be suitable used to determine the workability of concrete flow which called as concrete slump test and this type of testing would be discussed in next chapter together with concrete slump for various mix proportions of recycle material such as coconut shell (CS) and plastic bottle cap (PBC).

Main problem of doing research were related to environmental issue such as waste disposal and also higher demand of coarse aggregate in construction field. Beside that, the selection of recycle material used for doing research were save more cost and time consuming. As an additional information, recycle materials such as plastic bottle cap were easily to find at roadside, landfill, and other location as well as coconut shell could be found at the coconut milk shop. Coconut shell could be used for many purpose such as hand-craft.

1.1 Problem Statement

Nowadays, environmental problem have been become global issue in whole country. According to U.S.'s statistic report (2018) shown that the waste plastic disposal were main waste materials to cause the environmental pollution in the world. Plastic materials are non-biodegradable waste materials and it may take longer time to decompose. As a result, it would cause serious affect to the human being and also ecosystem such as food chain. Most of this waste disposal could be found on the landfill, ocean, roadside and everywhere. Rock materials demand on the construction field will be increased dramastically in order to achieve the high quality of concrete structure in the building [2].

1.2 Research Objective

In this research study, the main objective of conducting this research were as follow:

i. To analyse the mechanical properties of concrete sample on 7 day and 28 day.
ii. To compare the mechanical properties between control concrete sample and the concrete sample with the replacement of coconut shell and plastic bottle cap as coarse aggregate.
iii. To determine optimum strength of concrete with the replacement of of plastic bottle cap and coconut shell.

1.3 Scope of Study

The purpose of this research are to determined the compression strength, flexural strength, and moisture adsorption of concrete sample with the replacement of both coconut shell and plastic bottle cap. Coconut shell were main element in the concrete mix while secondary element which is plastic bottle cap were added into concrete mixing to increase its concrete strength. Plastic bottle cap with appropriate proportion would added into concrete sample with the mix proportion of coconut shell with 2.0%, 4.0%, 6.0%, 8.0%, and 10.0%. Total of 9 plain concrete cube with 100mm x 100mm x 100mm and 2 plain concrete beam with 100mm x 100mm x 500mm would used for each concrete sample. Basic water-cement ratio taken are 0.61. Mechanical testing of concrete will be conducted for both the specified curing period of 7 days and 28 days.

1.4 Literature Review

A coconut fruit consisting of six layer which is exocarp, mesocarp, endocarp, seed coat, solid endosperm, and liquid endosperm. further discussion would be made on the endocarp of a coconut

fruits [3]. Endocarp or sometimes called as coconut shell are structure layer which growth to surround and protect entire white coconut seed (this consist of endosperm and coconut meat). In the application, this type of natural shell could be used for many purpose such as ornamental, hand-craft, plant fertilization, charcoal, and other [6].

On the other hand, in term of its physical properties, coconut shell are hard in properties due to its distinct features of structures arranged. According to Gludovatz *et al*., [1], the strength of coconut shell were depend on its mature stage either it is younger or older. From mechanical properties testing, it were found that more mature of coconut shell have higher tensile strength than less mature which is about 48.5 MPa with Young's modulus of 1.92 GPa. This could be explained that younger coconut shell were more soft than mature one. Younger coconut seed have a very thin shell. As it reached enough mature stage, this natural shell would became more thicken and harden. Coconut shell have higher strength in terms of its tensile and young's modulus. This type of natural materials would be taken for the further investigation.

2. Methodology

Research methodology would divided into three categories such as preliminary stage, execution stage, and final discussion stage. Preliminary stage of the research were first step needed to be conducted before the design of concrete mixing were implemented. In this stage, it would be involved the experimental testing on the physical properties of the construction materials used such as coarse aggregate and fine aggregate. Experimental testing were needed to conduct on this stage such as sieve analysis, specific gravity, and water absorption test, and sample preparation. Execution stage were essential section which involved the labwork such as concrete mixing process, slump testing, and curing period. Concrete mixing process were the combination of all constituents element such as cement, coarse aggregate, fine aggregate, water content, and recycle materials such as coconut shell and plastic bottle cap. After that, slump testing would be implemented to the fresh concrete mix in order to determine the flow or the workability of the fresh concrete and also determined the height of concrete slump which were measured from the top of inverted cone to the top of the concrete slump. Placing of concrete shall be done immediately without any delay because longer exposure the fresh concrete to ambient condition would leaded to the reduction of the moisture content in concrete mix. Removal of concrete sample were needed to immerse into water for curing period of 7 days and 28 days. There were three experimental implemented namely compressive strength of concrete strength of concrete cube, flexural strength of plain beam, and also water-absorption of concrete cube. Final stage were involved the final discussion from overall result obtained. Three parameter of mechanical properties were shown in graphical form.

Preliminary Stage

1. Sieve Analysis (ASTM C136-C136M)	2. Specific Gravity & Water Absorption (ASTM C127-88)	3. Sample Preparation
- Conducted for coarse aggregate and fine aggregate	- Conducted for coarse aggregate and coconut shell	- Coarse aggregate - Coconut shell - Fine aggregate - Plastic bottle cap

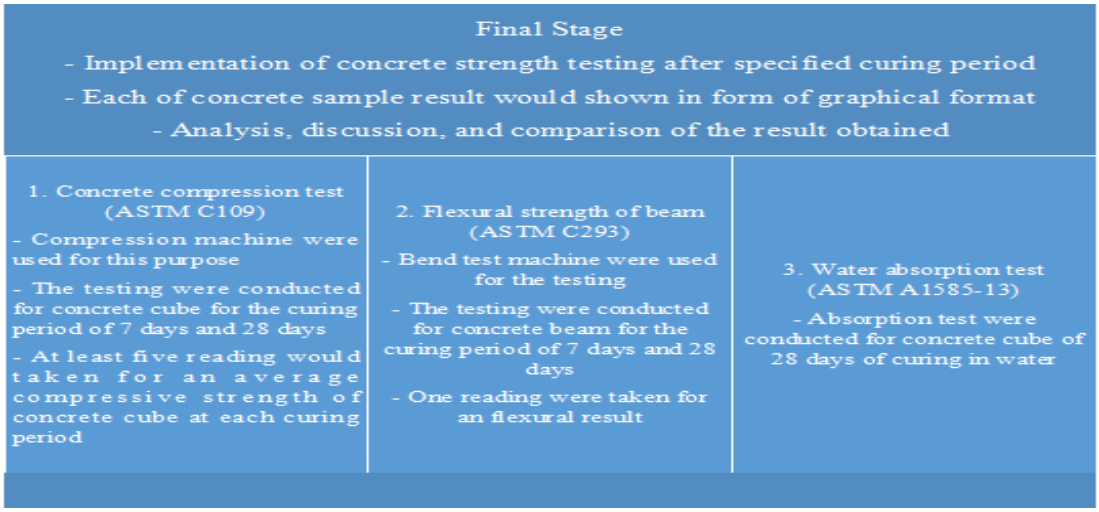
Execution Stage

- Design for concrete mix (C=1 : W=1 : FA=5 : CA=3)
- Water-cement ratio taken were 0.61
- Trial mix for each concrete sample were taken 0.021 m^2

1. Coconut shell treatment	2. Mix proportion	3. Equipment required	4. Materials preparation
- Collection from shop - Smoothen the shell surface using rough sand paper - Crushed into different sizes of pieces manually	- Coconut shell (0%, 2%, 4%, 8%, 10%) - Plastic bottle cap (2.0%, 2.5%, 3.0%)	- Concrete cube = 9 - Concete beam = 2 (Note: Internal mould surface would applied with oil grease before concrete are poured	- Black basket provided were used for the storage of each sample materials - Water tank provided were used for the curing period concrete about 7 days and 28 days respectively.

Execution Stage (Continued)

1. Concrete mix process	2. Slump test (ASTM C143)	3. Concrete placing process	4. Curing period
- Involved the combination of cement, coarse aggregate, fine aggregate, water, coconut shell, and plastic bottle cap - During mixing process, water would poured gradually into the mixing - After that, all the element would mixed to achieve consistency - Mxing of cement were operated by mixer	- To determine the workability of concrete flow - To measure the height of the concrete slump from top of cone until top of concrete slump	- After previous activities have done, concrete mix would placed into the mould shape provided - Concrete mix in the mould would compacted 25 stroke using tamping rod - Compaction shall be done immediately without delay to prevent the hardening of concrete due to the ambient affect.	- After removal of concrete sample, samples would immersed into water for specified curing period - In this research, curing period were taken for 7 days and 28 days respectively.



3. Results

Further investigation on the result obtained would be discussed and analyzed for each concrete sample. After 24 hour of concrete hardening, concrete cubes would immersed into water for curing period of 7 days and 28 days. All the experimental result would recorded and illustrated in graphical form.

3.1 Compressive Strength

Table 1
Compressive Strength of Concrete at 7 Days

Curing Period of 7 Days				
Sample No.	CS Proportion (%)	PBC Proportion (%)	Average Compressive Strength (kN/m^2)	
1	0	-	7.32	-
2	2	-	13.44	-
3	4	-	13.22	-
4	4a	2	-	16.74
5	6	-	10.90	-
6	6a	2.5	-	12.86
7	8	-	11.84	-
8	8a	3.0	-	8.80
9	10	-	14.88	-

* Coconut Shell
** Plastic Bottle Cap

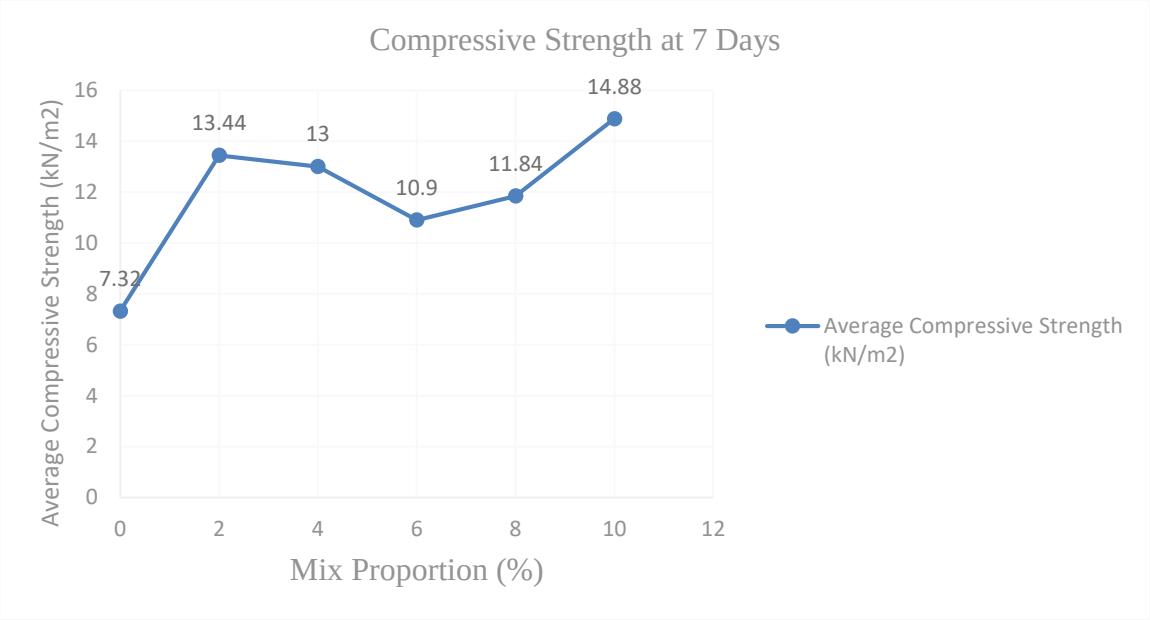


Fig. 1. Compressive Strength Against Mix Proportion (Coconut Shell)

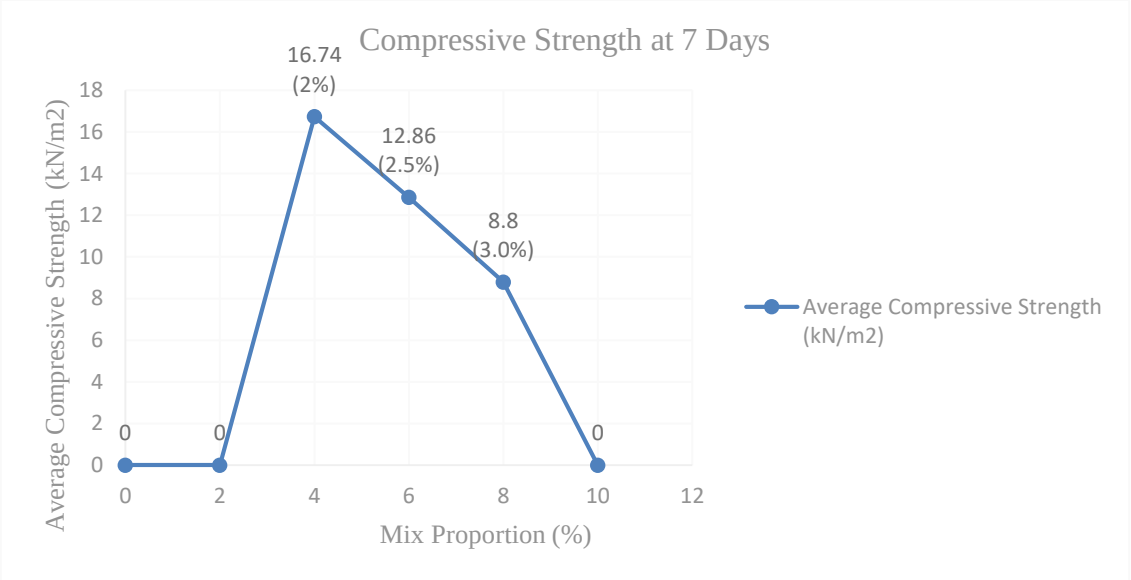


Fig. 2. Compressive Strength Against Mix Proportion (Coconut Shell & Plastic Bottle Cap)

Table 2
Compressive Strength of Concrete at 28 Days

Curing Period of 28 Days				
Sample No.	CS Proportion (%)	PBC Proportion (%)	Average Compressive Strength (kN/m^2)	
1	0	-	30.28	-
2	2	-	27.50	-
3	4	-	27.76	-
4	4a	2	-	27.80
5	6	-	18.52	-
6	6a	2.5	-	20.00
7	8	-	19.60	-
8	8a	3.0	-	13.84
9	10	-	19.48	-

* Coconut Shell
** Plastic Bottle Cap

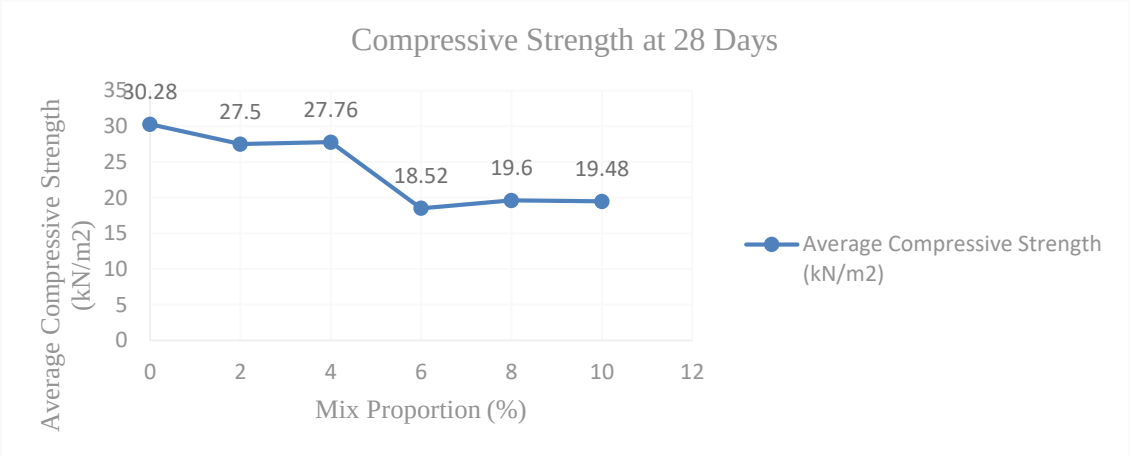


Fig. 3. Compressive Strength Against Mix Proportion (Coconut Shell)

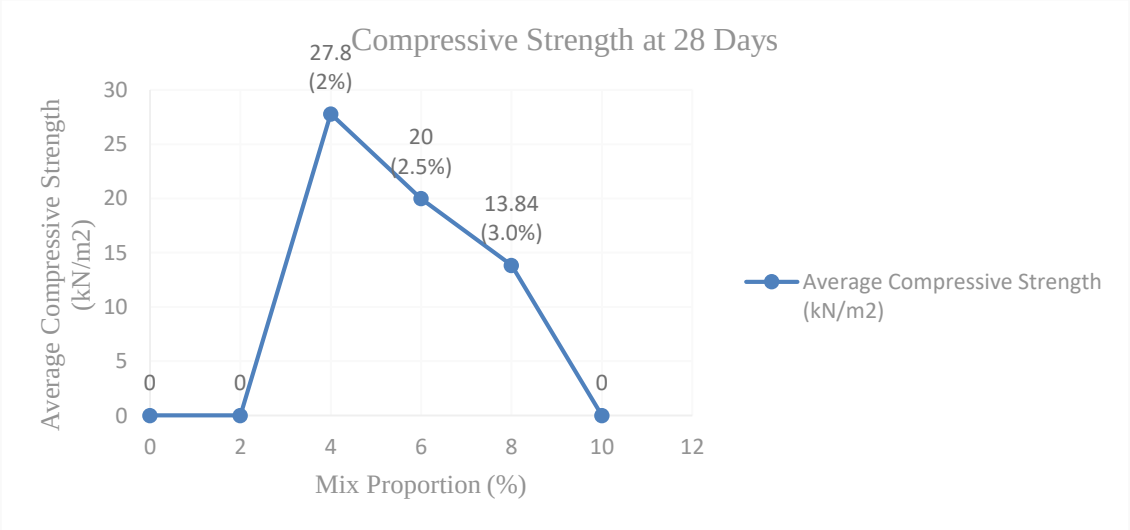


Fig. 4. Compressive Strength Against Mix Proportion (Coconut Shell & Plastic Bottle Cap)

Trend in Figure 1 shown that the compressive strength of concrete were increased when increased in the mix proportion. Lower value of compressive strength were control sample which is fully coarse aggregate in mixing. Those value for control sample were 7.32 kN/m^2. This could be explained that the content of fine aggregate in concrete mix were more than the content of coarse aggregate used. Highest compressive of concrete after 7 days were 14.88 kN/m^2 with the replacement of coconut shell about 10%.

Trend in Figure 2 shown that decreased in the compressive strength of concrete as the mix proportion of PBC were increased. From the result obtained, PBC with 2% mix proportion have showed the significant improvement in the compressive strength of concrete at 7 days of curing period (16.74 kN/m^2) when mixed with 4% of CS together in the concrete mixing. When the quantity of P.B.C. were added into the concrete at a certain amount, the concrete properties would be suddenly changed as the higher amount of P.B.C. would lead to the concrete become “soft”.

Result trend in Figure 3 were shown that the reduction of compressive strength of concrete sample when the replacement of the recycle materials were gradually increased. First of all, after 28 days of curing period in water, control concrete sample have been increased dramatically in its compressive strength. As compared with the previous result obtained in 7 days, the difference between the compressive strength for control concrete sample were +22.96 kN/m^2.

Result trend in Figure 4 shown that the compressive strength of concrete sample against the mix proportion with both the replacement of coconut shell and plastic bottle cap during 28 days. From the trend shown, it is indicated that the reduction of the compressive strength in concrete sample as the proportion of P.B.C. added would increased gradually. As compared with concrete sample with the replacement of C.S. only, the compressive strength have been shown that the significant improvement in the concrete sample 4. Its could be withstand the compressive load about 27.80 kN/m^2. On the other hand, the result were shown that only limited proportion of P.B.C. could be added into the concrete as the tendency of the increment of its amount would lead to the concrete sample less harden than original concrete, but also caused to the lost of its own compressive strength.

3.2 Flexural Strength

Table 3
Flexural Strength of Concrete Beam at 7 Days

Curing Period of 7 Days				
Sample No.	CS Proportion (%)	PBC Proportion (%)	Flexural Strength (kN/m^2)	
1	0	-	1.30	-
2	2	-	2.50	-
3	4	-	1.20	-
4	4a	2	-	2.80
5	6	-	2.10	-
6	6a	2.5	-	2.90
7	8	-	2.80	-
8	8a	3.0	-	1.30
9	10	-	2.50	-

* Coconut Shell
** Plastic Bottle Cap

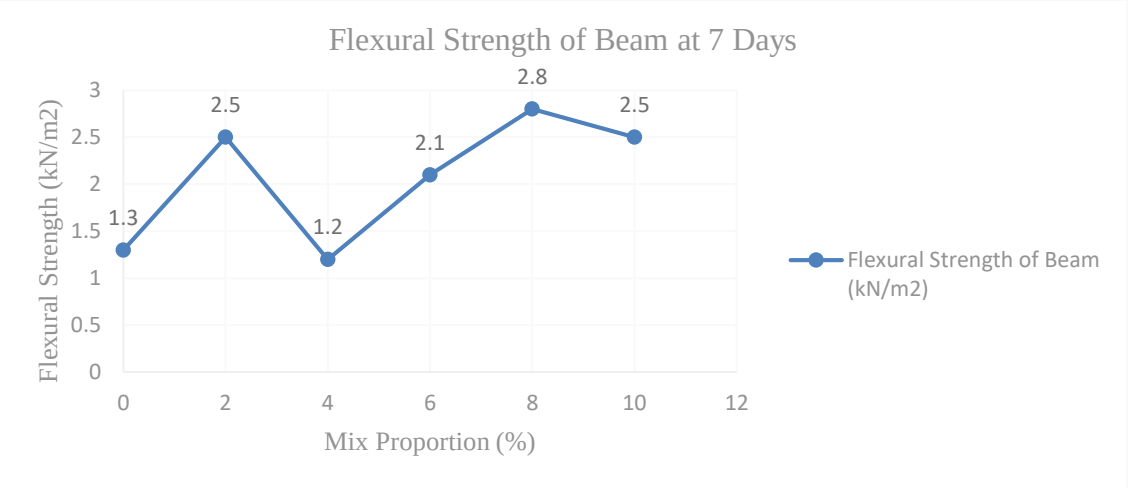


Fig. 5. Flexural Strength Against Mix Proportion (Coconut Shell)

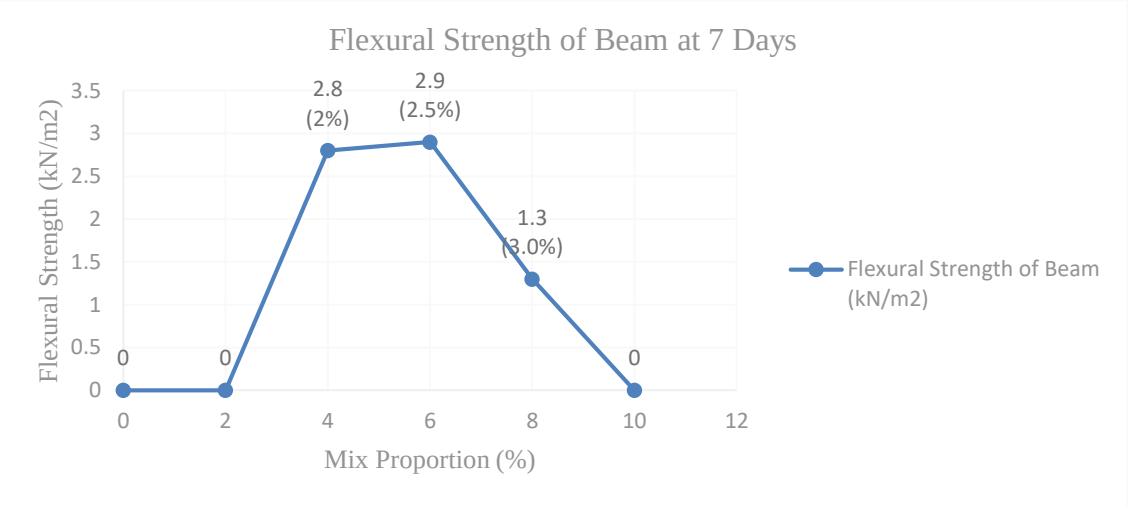


Fig. 6. Flexural Strength Against Mix Proportion(Coconut shell & Plastic Bottle Cap)

Table 4
Flexural Strength of Concrete Beam at 28 Days

Sample No.	Curing Period of 28 Days			
	CS Proportion (%)	PBC Proportion (%)	Flexural Strength (kN/m^2)	
1	0	-	4.50	-
2	2	-	3.00	-
3	4	-	3.00	-
4	4a	2	-	3.00
5	6	-	2.60	-
6	6a	2.5	-	2.80
7	8	-	2.60	-
8	8a	3.0	-	2.40
9	10	-	3.30	-

* Coconut Shell
** Plastic Bottle Cap

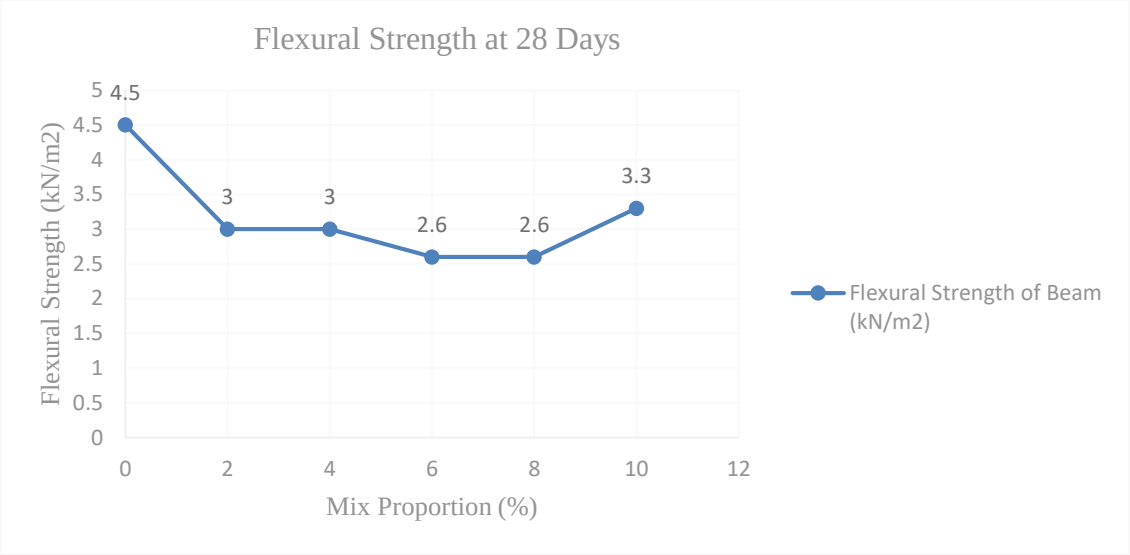


Fig. 7. Flexural Strength Against Mix Proportion (Coconut Shell)

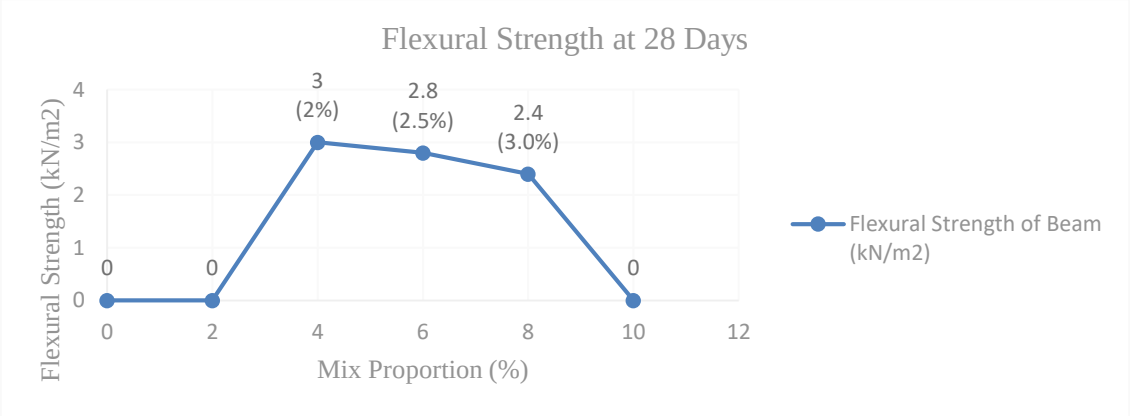


Fig. 8. Flexural Strength Against Mix Proportion (Coconut Shell & Plastic Bottle Cap)

The trend of the flexural strength of concrete beam in Figure 5 were shown fluctuation in overall result. Result above were indicated that the optimum flexural strength of concrete beam sample 7 which is 2.8 kN/m^2. In those sample, 8 % of coconut shell were used as the replacement of coarse aggregate.

Concrete beam sample 7 in Figure 6 were decreased dramatically in its flexural strength when 3.5% of P.B.C. were added into those concrete sample. Its flexural strength were decreased from 2.8 kN/m^2 to 1.3 kN/m^2 and the different between this two strength value were -1.5 kN/m^2. It were indicated that limited amount of P.B.C. replaced into concrete sample wouldn't be effectively improve the flexural strength of concrete beam.

Next, the highest value of flexural strength in Figure 6 were 2.9% for the concrete beam sample 6 with 2.5% replacement of P.B.C. while the second highest value of flexural strength were 2.8% for the concrete beam sample 4 with 2.0% replacement of P.B.C.. All of this two concrete sample were second additonal mixing process for sample 5 and sample 3 respectively. This two concrete sample have shown significantly improvement in its flexural strength. As compared with the result obtained with the replacement of C.S., concrete beam sample 5 have increased about +0.8 kN/m from 2.1 kN/m^2 to 2.9 kN/m^2 while concrete beam sample 3 have increased about +1.6 kN/m^2 from 1.2 kN/m^2 to 2.8 kN/m^2.

At 28 days, the trend in Figure 7 shown that the reduction of flexural strength for concrete beam sample with the increment of the C.S. mix proportion. Control beam sample without the replacement have achieved its flexural strength to 4.50 kN/m^2. Compared with the result during 7 days, its flexural strength obtained were 1.30 kN/m^2. concrete sample with the replacement of C.S., concrete beam sample 2 (2% C.S.) and concrete beam sample 3 (4% C.S.) have shown its flexural strength at 3.00 kN/m^2 as well as concrete beam sample 5 (6% C.S.) and concrete beam sample 7 (8% C.S.) were maintained at similar flexural strength which is 2.6 kN/m^2. Amoung concrete beam sample with the replacement of C.S., the highest value of flexural strength were 3.3 kN/m^2 with 10 % C.S..

Figure 8 shown that the flexural strength of concrete beam with the replacement of both coconut shell and plastic bottle cap during 28 days. As compared with the flexural strength at 28 days with the replacement of C.S. only, the flexural strength of concrete beam have been decreased gradually from 3.0 kN/m^2 (Sample 4) to 2.4 kN/m^2 (Sample 8). For sample 4, its flexural strength of concrete beam would maintained at same value which was 3.0 kN/m^2. Sample 6 with both the replacement have its flexural strength about 2.8 kN/m^2 and higher than previous one which +0.2 kN/m^2 from 2.6 kN/m^2. On the other hand, sample 8 with 3.0% of P.B.C. have reduced its flexural strength to -0.2 kN/m^2 from 2.6 kN/m^2.

3.3 Water Absorption

Table 5
Water Absorption of Concrete Cube at 28 Days

Curing Period of 28 Days				
Sample No.	CS Proportion (%)	PBC Proportion (%)	Water Absorption (%)	
1	0	-	6.36	-
2	2	-	8.82	-
3	4	-	9.36	-
4	4a	2	-	8.02
5	6	-	4.87	-
6	6a	2.5	-	4.55
7	8	-	4.55	-
8	8a	3.0	-	5.53
9	10	-	4.44	-

* Coconut Shell
** Plastic Bottle Cap

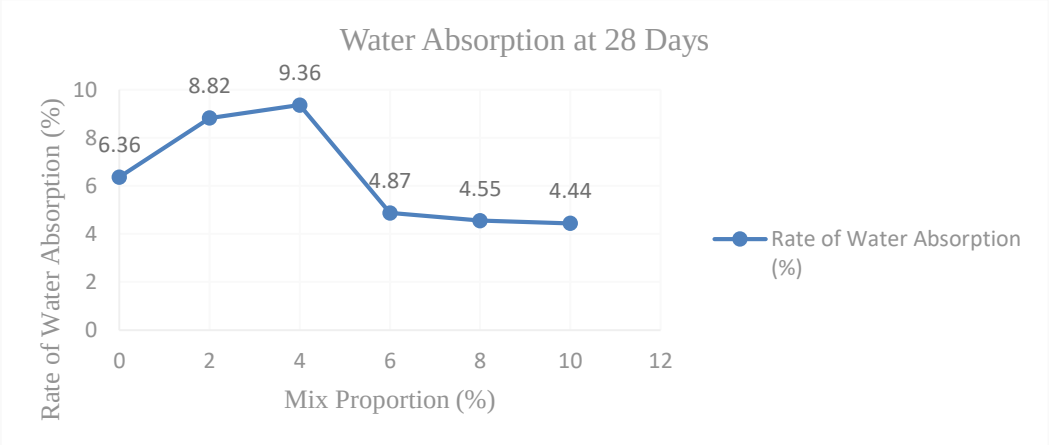


Fig. 9. Rate of Water Absorption Against Mix Proportion (Coconut Shell)

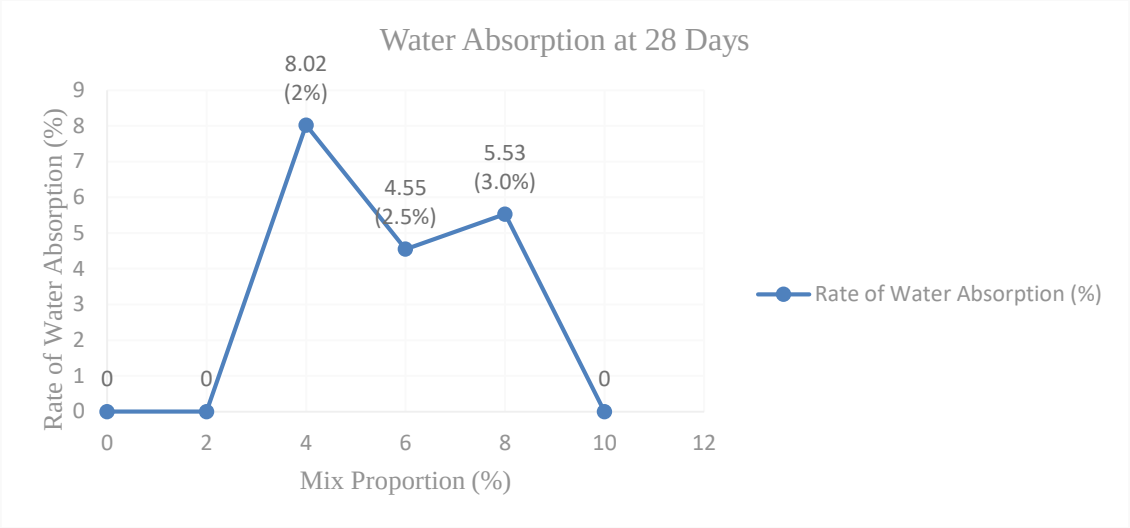


Fig. 10. Rate of Water Absorption Against Mix Proportion (Coconut Shell & Plastic Bottle Cap)

Figure 9 above shown that the water absorption of concrete cube at 28 days after placed in oven for 24 hours. As the proportion of coconut shell increased, the result trend were shown that the reduction of the water absorption by concrete cube. From the result obtained as above, water absorption rate of a concrete cube were increased from 6.36% (Control sample) to 9.36 (4% of C.S.) and then decreased from 4.87% (6% of C.S.) to 4.44% (10% of C.S.). This could be explained that the capability of coconut shell to absorb water were higher than coarse aggregate used in concrete mix which is 0.35 under S.S.D. condition. After water-absorption test were conducted, it were indicated that the coconut shell capable to absorb 20% of water under S.S.D. condition. On the other hand, with the additional of plastic bottle cap, the water absorption have shown that the trend lower than the previous result obtained with only the replacement of coconut shell. Based on the outcome, the absorption rate of P.B.C. were almost approaching to 0% due to the unability to absorb water. For sample 8, the trend were shown the increment in the absorption rate from 4.55% to 5.53%. there were some reason could be explained to this situation. Based on the observation and estimation, the amount of coconut shell in sample 8 with 3.0% of P.B.C. might be more than that in similar sample with only the coconut shell.

4. Conclusions

Three of research objective were achieved. Optimum compressive strength of concrete cube at 28 days were 27.76 kN/m^2 (4% CS) and 27.80 kN/m2 (4% CS & 2% PBC). Plastic bottle cap could improve the strength of a concrete but only with the limited amount. Concrete strength would started to drop as high amount of PBC were added. Coconut shell are hard but not durable materials. It is suitable used only for non-load bearing structure. Optimum flexural strength of concrete beam at 28 day were 3.3 kN/m2 (10% CS), 3.0 kN/m2 (4% CS & 2% PBC), and 2.8 kN/m2 (6% CS & 2.5% PBC). Control concrete beam have highest value of flexural strength as compared with other concrete beam sample. Plastic bottle cap rarely to absorb water and its capability of absorption were almost 0%. Fire resistance testing can be conducted. Aggregate Impact Value (AIV) and Aggregate Crushing Value (ACV) can be conducted to determine the its own strength.

Acknowledgement

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