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Research Article

Exploratory Study of Rubber Seed Shell as Partial Coarse Aggregate Replacement in Concrete

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Abstract: Malaysia being a major rubber trees growing country has been generating a large amount of rubber seed shell which regarded as waste. At the same time, the growing construction industry which boosts the concrete production trade has results in higher consumption of natural coarse aggregate which open the door for depletion of this material in future. This study focuses on investigating the possibility of integrating crushed rubber seed shell as partial coarse aggregate replacement material in concrete making. Total of five mixes consisting various content of crushed rubber seed shell as partial coarse aggregate replacement ranging from 0, 5, 10, 15 and 20%, respectively were prepared in form of cubes. All the specimens were water cured before tested at 7 and 28 days. The workability test, compressive strength test and flexural strength test of the mixes was conducted in accordance to MS26 Part 1: Section 2, BSEN 12390 and ASTM 293-79 respectively. Generally, workability, compressive strength and flexural strength decrease with the increase in the crushed rubber seed shell replacement level. However, mix consisting around 10% of crushed rubber seed shell is suitable for the application in concrete work.

Keywords: Concrete, crushed rubber seed shell, engineering properties, partial coarse aggregate replacement, water curing, workability

INTRODUCTION

Malaysia is one of the major rubber tree growing country (Eka *et al*., 2010) which produces latex for material production also produces rubber seeds with hard shell which falls from the tree and left to biodegrade. The fact that rubber seed shell is either used as manure or discarded and left to rot has been highlighted by previous researcher (Oladoja *et al*., 2008). Since the Malaysian annual production of rubber seed is projected to be 1.2 million metric tons (Eka *et al*., 2010), it is seen that this freely available waste could be explored its potential for the benefit of mankind. At the same time, the increasing demand for concrete product for the use in developing construction industry has lead towards continuous consumption of aggregate from natural resources in increasing quantity which would create ecological imbalance. Since, the high consumption of raw material by construction industry which becomes one of the main factors of natural resources depletion and environmental damage can be handled through integration of waste material in concrete production (Wai *et al*., 2012), there are researchers (Mannan and Ganapathy, 2004; Falade *et al*., 2010; Gunasekaran *et al*., 2012) who manage to integrate waste materials as coarse aggregate replacement in concrete production.

In Malaysia, there are concrete materials that has been produced by incorporating local waste as coarse aggregate replacement through incorporation of oil palm shell (Johnson Alengaram *et al*., 2013), recycled coarse aggregate (Wai *et al*., 2012) and palm oil clinker (Bashar *et al*., 2013). However, to the best of author's knowledge, no results are available regarding the workability and strength performance of concrete containing rubber seed shell as partial coarse aggregate replacement material. Success in producing concrete consisting rubber seed shell would reduce the high dependency of concrete manufacturer towards natural aggregate and optimize the utilization of this rubber plantation waste.

Experimental work carried out Structure and Material Laboratory of Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang has been focused on investigating the fresh and engineering properties of concrete when Crushed Rubber Seed Shell (CRSS) of various content is used as partial coarse aggregate replacement material. This study reports the result of a research undertaken to investigate the workability, compressive strength and flexural strength of a normal concrete containing Crushed Rubber Seed

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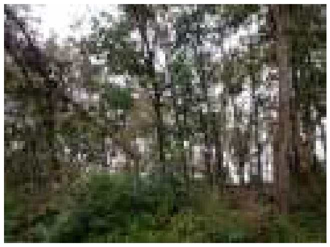

Fig. 1: Rubber seed shell collected from the local rubber estate

Fig. 2: Rubber seed shell (left side) and crushed rubber seed shell (right side)

Shell (CRSS) as partial coarse aggregate replacement material.

EXPERIMENTAL PROGRAMME

Ordinary Portland Cement (OPC) that complies with the Type 1 Portland cement as in ASTM C 150-05 (2005) was used as a binder in this experiment. Tap water was used in mixing and curing. The fine river sand was obtained from quarry located in Sg.Panching. Single size coarse granite aggregate of 10 mm with water absorption of 0.92% were used for preparing the concrete mixes. Rubber seed shell was collected from a nearby rubber estate shown in Fig. 1 located in Gambang area in the state of Pahang, Malaysia. This material which identified as Crushed Rubber Seed Shell (CRSS) after crushed to reduce it size to be 10 mm was found to possess water absorption of 28.24%. The original rubber seed shell and the coarsely Crushed Rubber Seed Shell (CRSS) is illustrated in Fig. 2.

Two types of mixes have been used in this study that is control specimen consisting 100% granite aggregate and concrete consisting crushed rubber seed shell as partial coarse aggregate replacement. Five mix is prepared by integrating crushed rubber seed shell by weight whereby the proportion of granite aggregate replaced ranged from 5 to 25% with 5% interval. The water cement ratio of 0.36, fine aggregate content, percentage of super-plasticizer used and quantity of cement used has been kept constant in all the mixes except for the variation in the percentage of granite aggregate used. All mixes were subjected to slump test following the procedures specified in MS26 Part 1: Section 2 (2009) before cast in cubes of 100×100×100 mm. Specimens were left for 24 h before demoulded and then subjected to water curing until the testing date. Compressive strength and flexural strength test was carried out when the specimen reach the curing age of 7 and 28 days following the procedures specified in BSEN 12390-3 (2009) and ASTM C 293-79 (2005) respectively.

RESULTS AND DISCUSSION

Workability: It is evident from Fig. 3 that integration of CRSS which physical properties vary from granite aggregate affects the concrete mix workability. Variation in shape and the higher water absorption value of CRSS compared to granite aggregate causes the concrete workability continues to drop gradually as the amount of this natural agricultural waste added in the mix increases. Integration of this lighter and slightly concave shaped CRSS which unmistakably differs from the dense and angular granite aggregate causes the mix become harsher making it difficult to be mixed as compared to the mix consisting lesser percentage of this rubber plantation agricultural waste. Since the replacement of this lighter CRSS is by weight of granite used in the concrete mix, the specific surface area increases with the increment of CRSS percentage of replacement in the mix. As a result, the existing cement paste in the mix is not sufficient enough to coat the CRSS aggregate thus leading to lower workability of concrete mix consisting larger percentage of CRSS shell replacement. The negative impact of inadequate cement content in the mix towards lubrication of aggregate which in turn decreases the wokability has been pointed out by Daneshmand and Saadatian (2011).

Compressive strength and flexural strength: The results presented in Fig. 4 and 5 show that both compressive and flexural strength of concrete reduced as the percentage of CRSS substitution increased. The lighter particle of CRSS as compared to dense granite aggregate produces mixes with lower density which results in concrete with reduced strength as well. It is observed that contrast in the physical characteristic of CRSS compared to granite aggregate is also the reason for changes in concrete bonding structure which influence the concrete engineering properties. The lower strength performance of concrete containing CRSS is due to reduction in bonding strength between aggregates as a result of inadequate cement paste to coat the larger specific surface area of this low density CRSS. The negative effect of insufficiency of cement paste to coat the aggregate towards concrete strength reduction has been highlighted by Abdullahi (2012) and Neville (2005).

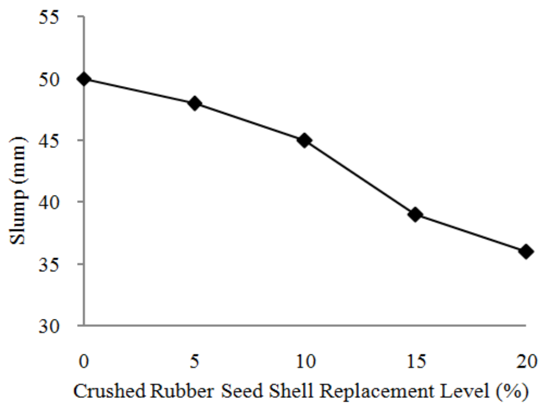

Fig. 3: Effect of crushed rubber seed shell content on workability of concrete mix

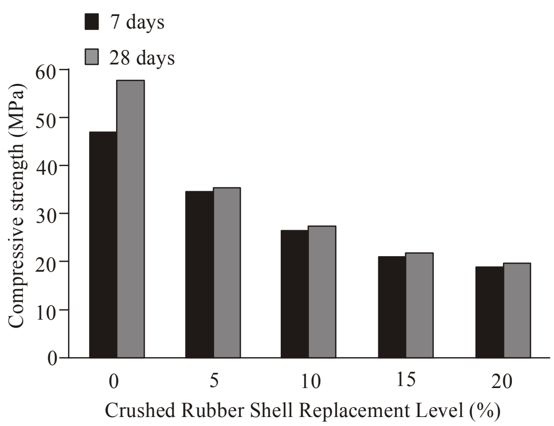

Fig. 4: Effect of crushed rubber seed shell content on compressive strength of concrete cubes at the age of 7 and 28 days

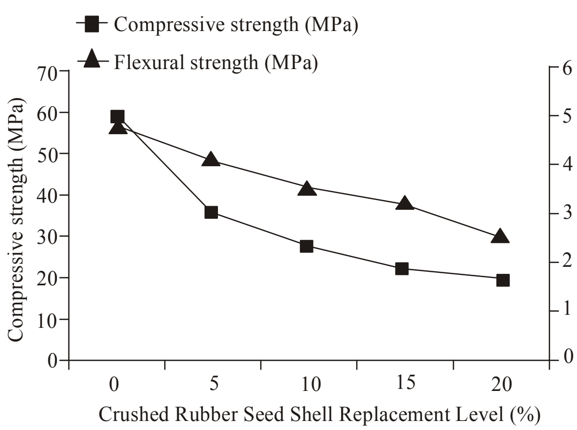

Fig. 5: Relationship between compressive strength and flexural strength of concrete consisting a range of crushed rubber seed shell content at the age of 28 days

On overall, this study discover the proportion and characteristic of crushed rubber seed shell used as partial coarse aggregate replacement influence the workability and strength performance of concrete. Looking at the application part point of view, mix consisting around 10% of CRSS is suitable for concrete study. However, more studies need to be carried out to determine the behavior of this newly modified concrete in terms of durability and its structural behavior.

CONCLUSION

The data presented in this study shows that there is a promising potential for the use of crushed rubber seed shell in concrete material production. Replacement of crushed rubber seed shell which is around 10% would be able to produce mix with compressive strength suitable for application in concrete study. However, to increase the amount of this waste material used in concrete making, it is recommended that the future investigation focus on exploring the potential of this waste material to be used as partial or full coarse aggregate replacement in lightweight aggregate concrete making.

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