Durian pectin and rice husk ash (RHA) as partial replacement of cement in concrete

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Abstract. Cement is one of the important materials in concrete mixture and use for building construction. High demand for cement usage due to the rapid development of construction in the country needs to be addressed. The objective of this study is to identify the workability and compressive strength of concrete at different level of replacement of cement. Cement was replaced with durian pectin and RHA by weight at 10%, 15% and 20%. Compressive strength and water absorption test were carried out on hardened 150mm x 150mm x 150mm concrete cubes after 7, 14 and 28 days of curing. The results revealed that the compressive strengths reduced as the percentage durian pectin and RHA increased in same ratio 5:5, 7.5:7.5 and 10:10. The sample consist of 5% of durian pectin and 5% of RHA is the optimum ratio replacement of cement in concrete with highest compressive strength 27.5 N/mm², medium workability and water absorption 6%.

1. Introduction
Concrete is a mixture of cement, sand, coarse aggregate and water. It’s the most important material used in building industry. On average approximately one ton of concrete is produced each year for every human being in the world. Because of its abundance in the world market, understanding the environmental implications of concrete and cement manufacturing are becoming increasingly important [1, 2]. Recently, Portland Cement Association (PCA) members found that an average of 927 kg of \( \text{CO}_2 \) are emitted for every 1000 kg of Portland cement was produced [3]. Cement production process causes environmental impacts in all stages include excavation activities, dumps, tips, conveyer belts, crushing mills and kiln emissions. These includes emission of airborne pollution in the form of dust and greenhouse gases [4, 5].

In order to produce the cement material, major quarrying of limestone has been carried out. Limestone is a valuable natural resources that used to make things such as glass and concrete. Quarrying is significantly impact to the environment and cause major extinction of natural resources. Explosives method is used to extract the material and it will cause air pollution, for an example limestone quarries produce high alkaline dusts especially surrounding area [6].

Therefore, to reduce the consuming natural sources are by recycling the waste. The waste is transform into a useful materials or products, which can help to reduce environmental pollution. According to Charoenvai (2011) [7], it was found that the fineness of durian fibre has a significant effect on compressive strength of composites. The composites with finer rice husk ash possess higher compressive strength than those with the coarser ash. While, refer to the study of Dabai (2009) and Obilade (2014) [8, 9], the replacement of cement by RHA in concrete shows a very good result for...
workability. Thus, the study of durian pectin and RHA as supplementary cementitious materials in concrete was conducted.

Durian pectin was added in cement due to same characteristics where it tend to hydrate and form a paste when water is added. RHA contains the same chemical properties as cement, which are Calcium Oxide (CaO), Silica Dioxide (SiO$_2$), Aluminium Oxide (Al$_2$O$_3$), Magnesium Oxide (MgO), Iron Oxide (Fe$_2$O$_3$), and Sulfur Trioxide (SO$_3$) and it also can increase the strength and helps in reducing the voids in concrete [10]. Usage of RHA in concrete exhibit's the same or better results compared to a standard concrete and reusing RHA would not only get rid of dumping but also decreases the $CO_2$ emission to atmosphere by bringing down the cement production [11].

This study work examined the use of durian pectin and RHA as partial replacement for cement in concrete. It involved the determination of workability and compressive strength of concrete at different level of replacement.

2. Materials and methods

2.1. Mixing of materials
The durian pectin was extracted from durian rinds by using conventional method and RHA was obtained from paddy processing factory at Sekinchan, Selangor. Batching of materials were done by weight. The percentage replacement of cement by durian pectin and RHA were 10%, 15% and 20%. The 0% replacement was conducted to serve as control for other samples. The replacement ratio between durian pectin and RHA as shown in Table 1.

| Sample | Ratio of Durian Pectin to RHA (%) |
|--------|----------------------------------|
| A      | 5 : 5                            |
| B      | 10 : 5                           |
| C      | 5 : 10                           |
| D      | 7.5 : 7.5                        |
| E      | 10 : 10                          |
| F      | Control mixture                  |

2.2. Concrete mix design
The concrete mix design used was 1:2:4 ratio for cement, sand and coarse aggregate. That means, the proportion of every ratio was respective measured by weight. The water-cement ratio of 0.40 was used.

2.3. Casting of samples
Based on BS EN 12390-4:2009 [12], the size of concrete cube of 150mm x 150mm x 150mm was used. Nine cubes of each sample were prepared for 7, 14 and 28 days compressive strength test as required.

2.4. Testing of samples
Three test were carried out in this study, namely slump test, compressive strength test and water absorption test. Slump test and water absorption test were been done accordance to BS EN 12350-2:2009 [13] and BS 1881-122:2011 [14] respectively. The compressive strength tests on the concrete cubes were carried out with the Universal Testing Machine (UTM) at JKR Sungai Besar, Selangor. This test is accordance to BS EN 12390-4:2009.
3. Results and discussions

3.1. Workability
In order to determine the workability of the concrete, the slump test has been done. Table 2 shows the workability of the concrete mixtures. The result shows all the samples indicate medium degree of workability which is in range of 50 mm-100 mm. The control mixture had highest in slump compared to the other samples mixtures with durian pectin and RHA. Therefore, sample F without replacement of cement obtain lower water absorption. The samples with total 15% replacement of cement achieved 90 mm and 93 mm slump while the samples with total 10% and 20% replacement achieved 87 mm and 86 mm slump respectively. These results indicate that total 15% of durian pectin and RHA is the optimum replacement of cement to get the more workable concrete.

Table 2. Degree of concrete workability.

| Sample | Ratio of Durian Pectin to RHA (%) | Slump (mm) | Degree of Workability |
|--------|----------------------------------|------------|-----------------------|
| A      | 5 : 5                            | 87         | Medium                |
| B      | 10 : 5                           | 85         | Medium                |
| C      | 5 : 10                           | 90         | Medium                |
| D      | 7.5 : 7.5                        | 93         | Medium                |
| E      | 10 : 10                          | 86         | Medium                |
| F      | Control mixture                  | 95         | Medium                |

3.2. Water absorption
Figure 1 shows the results of an average water absorption test. The variation of water absorption on 28th day is in range of 6% - 7%. Eventually, the highest water absorption was recorded by sample E, follow by sample B, D, F, A and sample C with the water absorption value were marked at 6.8%, 6.6%, 6.6%, 6.6% and 6% respectively. The highest sample of water absorption for sample E was contribute to the effect of durian pectin and RHA which is finer and particles of durian pectin and RHA where is fibrous that absorb more water as compared to the other samples. According to Dabai et al (2009) and Obilade (2014) [8, 9], more water required as the RHA content increases is due to increased amount of silica in the mixture.

3.3. Compressive strength
The result of compressive strength tests were carried out for 7, 14 and 28 days as shown in Table 3, Figure 2 and Figure 3. It can be seen that for the control cube, the compressive strength increased from 14.47 N/mm² at 7 days to 20.00 N/mm² at 28 days and the increasing about 38%. It’s fulfill the standard for concrete which is 20.00 N/mm² for grade 20 at 28 days strength [15]. Sample A with 5%
durian pectin and 5% RHA achieved a highest compressive strength of 27.50 N/mm². The results of the compressive strength show that the compressive strength reduced as the percentage durian pectin and RHA increased in same ratio 5:5, 7.5:7.5 and 10:10 as partial replacement of cement. This finding is similar with research by Dabai et al (2009), Obilade (2014) and Kartini et al [8, 9, 16] about the RHA as a partial replacement of cement. Unfortunately, it is very limited research on durian rinds pectin. According to Obilade (2014) [9], the optimum addition of RHA as partial replacement for cement is in the range 0-20%. For total 15% pectin durian and RHA in replacement of cement, the compressive strengths increased with increasing of percentage RHA and decreasing of percentage durian pectin. However, the compressive strengths is increased directly proportional with the number of days of curing for each ratio of durian pectin to RHA replacement.

Table 3. Result of compressive strength test.

| Sample | Ratio of Durian Pectin to RHA (%) | Compressive Strength (N/mm²) | Results |
|--------|-----------------------------------|-----------------------------|---------|
|        |                                   | 7th | 14th | 28th |                 |
| A      | 5 : 5                             | 26.52 | 26.96 | 27.50 | > 20 N/mm²      |
| B      | 10 : 5                            | 22.30 | 23.70 | 24.20 | > 20 N/mm²      |
| C      | 5 : 10                            | 23.63 | 26.00 | 27.10 | > 20 N/mm²      |
| D      | 7.5 : 7.5                         | 26.00 | 26.58 | 26.95 | > 20 N/mm²      |
| E      | 10 : 10                           | 25.57 | 25.85 | 26.50 | > 20 N/mm²      |
| F      | Control mixture                   | 14.47 | 18.10 | 20.00 | 20 N/mm²        |

Figure 2. Compressive strength of concrete at different ratio of durian pectin to RHA.
4. Conclusion
Based on this study, the optimum addition of durian pectin and RHA as partial replacement of cement is 15%. For that percentage, the sample shows a good workability and lower water absorption compared to 10% and 20% of the replacement. Also, the compressive strength increases as increasing of the RHA content, while the pectin durian is vice versa. For sample consist of 20% durian pectin and RHA, the compressive strength become decreased and had a highest water absorption compared to 10% and 15% of the replacement.

5. Recommendation
The following are recommendations for this study:

- The research on the durian rinds pectin as supplementary cementitious material is very limited. The use of durian pectin as partial replacement of cement should be conducted separately to identify the characteristics and behaviors of durian pectin in increasing the workability and compressive strength of concrete.
- Need more research on additive material which may be used to improve the fire resistance of concrete which is one of the importance characteristics of concrete as a construction material.

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