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Waste Paper Sludge as a Cement Replacement Material in Green Concrete: Engineering Properties

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ABSTRACT

Nowadays, the cost of cement becomes issue due to less of resource and increasing of development especially in cities or development country. Therefore, to overcome this issue, there are needed to be replacing cement in concrete mix design. Besides that, Paper making generally produces a large amount of solid waste. Paper fibers can be recycled only a limited number of times before they become too short or weak to make high quality paper. It means that the broken, low-quality paper fibers are separated out to become waste sludge. While, in this experiment was to approve the best properties of wastepaper in concrete mix design. The wastepaper was replaced of concrete about 5%, 10% and 20%. The tests were carried out within day 1, 3, 7, 14, 28, and 40. There is different result within normal concrete and wastepaper product that was using. The result show the highest percent of wastepaper product was replace, the best properties will show within 40 days.

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INTRODUCTION

Concrete is being used over 150 years. It is mixed, placed into form and then compacted. It is essential to compact the concrete so that it should completely cover the reinforcement and fill all the space in the form for meeting strength and durability requirement. The air entrained in concrete during mixing has to be completely expelled out for getting uniform dense mass. If compaction is not complete, it will lead to loss in strength and also affect performance of the structure. Besides that, concrete mix design process also must take account that effect to the properties of concrete. Design of concrete mix require consists of selecting the correct of cement, fine and coarse aggregate and water. There are many properties of concrete that can be specified such as workability, strength, density, thermal characteristic, elastic modulus and durability requirements.

Wastepaper has been used as building materials for decades, especially in cementations matrices. Use of wastepaper in structural concrete could be become an economic and profitable substitute to landfills, incinerator, or other use options.Paper making generally produces a large amount of solid waste. Paper fibers can be recycled only a limited number of times before they become too short or weak to make high quality paper. It means that the broken, low-quality paper fibers are separated out to become waste sludge. All the inks, dyes, coatings, pigments, staples and "stickies" (tape, plastic films, etc.) are also washed off the recycled fibers to join the waste solids. The shiny finish on glossy magazine-type paper is produced using a fine kaolin clay coating, which also becomes solid waste during recycling.

This paper mill sludge consumes a large percentage of local landfill space for each and every year. Worse yet, some of the wastes are land spread on cropland as a disposal technique, raising concerns about trace contaminants building up in soil or running off into area lakes and streams. Some companies burn their sludge in incinerators, contributing to our serious air pollution problems. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them.

This experiment is to prove the addition of wastepaper to concrete mix. Therefore, their result will show the effect of wastepaper on the strength of concrete. The mechanical properties of the composite like compressive, tensile, flexural strength, and etc will conduct on this concrete mix. The cement has been replaced by wastepaper according in the range 5% to 20%.

Experimental Program:

Cement and Aggregates:

Ordinary Portland cement of 30 grade confining to BS 1881 was used throughout the work. Fine aggregates used throughout the work consisted of clean river sand with maximum size of 4.75 mm conforming to zone III as per BS 812 part 103: 1985

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with specific gravity of 2.65. Coarse aggregates used consisted of machine crushed stone angular in shape passing through 30 mm BS sieve and retained on 4.75 mm BS sieve with specific gravity of 2.67.

Waste paper Sludge (WSA):

Waste paper sludge was obtained from Nibong Tebal Paper Mill Sdn Bhd. It was then sun dried and incinerated so as to convert it into ash. The ash was sieved through 90 micron (90µm) British Standard sieve. The specific gravity of waste paper sludge ash was found to be 2.6.

Mix Proportion:

The concrete mix design was proposed by using BS 1881. The grade of concrete used was M-30 with water to cement ratio of 0.56. The density is 2375 kg/m target strength is 40 kN/mm2. The aggregate size used is 20 mm + 10 mm.

RESULTS AND DISCUSSIONS

Density:

The density test very important tool used to control quality of freshly mixed concrete. After a concrete mix proportion has been established. A change in the concrete density will indicate a change in one or more of the other concrete performance requirement. The aim to determine the density of the sample concrete that the properties of both the fresh and harder material are as required for the specific purpose.

The result of cube specimens and prism specimens are recorded as in table and figure below and the data of density from the process measure and weight the specimen of prism and cube. The purpose to check density of specimen is to get more detail about the size and weight according 1, 3 7, 14, 28 and 40 day specimen test. The data are recorded before testing compressive strength, flexural strength was occurs for make sure the specimen always It the good condition. The unit for this average total density is gram (g).

Figure 1 shows the result of for density each cement replacement for each cube samples for 1, 3, 7, 14, 28 and 40 days.

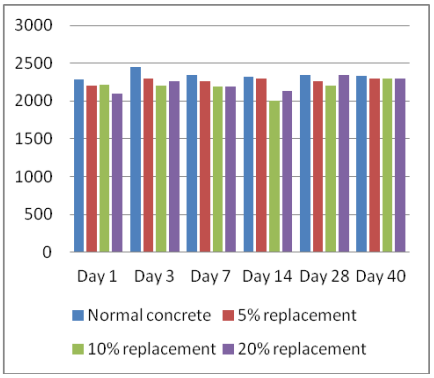

Fig. 1: The average total density for the cube test.

Figure 2 shows the result of for density each cement replacement for each prism samples for 1, 3, 7, 14, 28 and 40 days.

From the figure 1, the bar chart of concrete density of normal cube concrete, 5% and 10% replacement waste paper shows the consistency of concrete density between 3 days, 40 days and 14 days even though there are a little amount of difference value between the age tested. For the 20% replacement water paper on the age of 28 days tested the density of the concrete slightly higher than the 14 and 40 days of tested. But as for 5% replacement waste paper, a huge difference of density of the concrete occurs when it reaches to 28 days. The difference value of this density might be occurs because of compaction or vibration has not well compacted causing the particles to be trapped inside the concrete thus reduced the density of the concrete. The result obtained from the experiment contains error by comparing it to theory. This can be summarizing as when increasing of the age of the specimen, the concrete density will be more increased even though the increasing value is not so constant. This is because of the curing factor during the specimen is cured inside the water curing tank which cause the increasing weight of the specimen.

The second factor is that the test specimen might not much be dry enough perfectly to obtain the dry weight. Therefore the inaccuracy actual value of concrete density specimen occurs for every concrete mix with the increase of the age. There is a small variation between actual and theoretical data. The error occurred are due to several factors. Human error and improper use of cube mould because cube and prism was no tighten properly. Apparatus failure due to even surface of the cube mould because of pro long usage so it caused the cube mould might be slight deformed and the apparatus should be calibrated after certain period. Sometimes, a technical error during the test is done may occur for

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example the weighting equipment has been set in to different unit which gives the wrong reading.

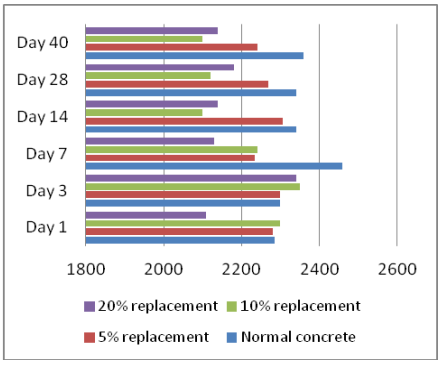

Fig. 2: The average total density for the prism test.

Compression strength:

Compressive strength test was done to the cubes sample after cured for 1, 3, 7, 14, 28 and 40 days. The size is 100 x 100 mm and the machine used with the rate loading of 0.2kN/second and compresses the cube until it failed. The average of the cube sample will take as ultimate compressive strength values forget the result. Figure 3, 4, 5 and 6 shows the result of compressive strength for each cement replacement and force applied for each cube samples for 1, 3, 7, 14, 28 and 40 days.

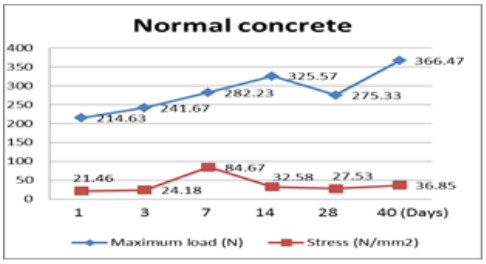

Fig. 3: Normal concrete.

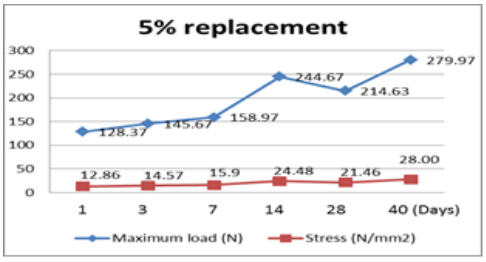

Fig. 4: 5% of cement replacement.

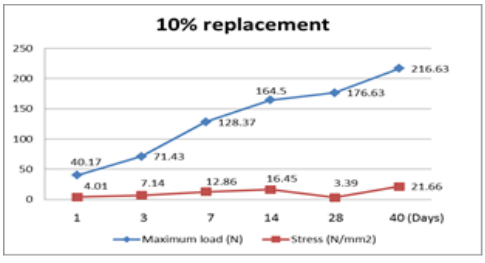

Fig. 5: 10% of cement replacement.

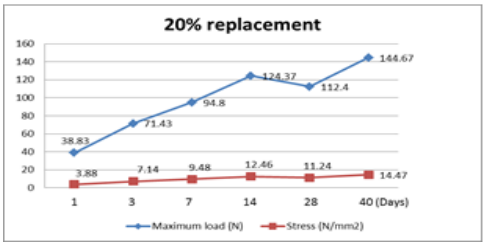

Fig. 6: 20% of cement replacement.

The results show the result obtains from the experiment compressive strength for test 1, 3, 7, 14, 28 and 40 days. On the figure 3, 4, 5 and 46 represents the compares of compressive strength with density of cube according to percentage of volume of paper waste product in concrete. It can be seen in day the compressive strength from day 1 to day 14 increased and drop at day 28 from Figure 3, 4 and 6. However, it is increased in day 40. In Figure 5, it can be seen the compressive strength increased from dah 1 to day 40. In Table 3, it can be seen the compressive strength decreased while the cement replacement increased.

Flexural strength

The flexural strength test used rectangular beam whereas in this test using the two point loading arrangement specified in the method BS 1881-part 118, 1983. The test must be development of first rack and the cracking up to the failure is closely observed. When the specimen fail, measurement are will be appear and display will decrease immediately and maximum display is recorded before specimen fail completed. The distance between the cracks to nearest support is measured.

Flexural strength test was done to the cubes sample after cured for 1, 3, 7, 14, 28 and 40 days. The size is 100 x 500 mm and the machine used with the rate loading of 0.2kN/second and flexure the prism until it failed. The average of the cube sample will take as ultimate flexural strength values forget the result. Figure 7, 8, 9 and 10 shows the result of compressive strength for each cement replacement and force applied for each prism samples for 1, 3, 7, 14, 28 and 40 days.

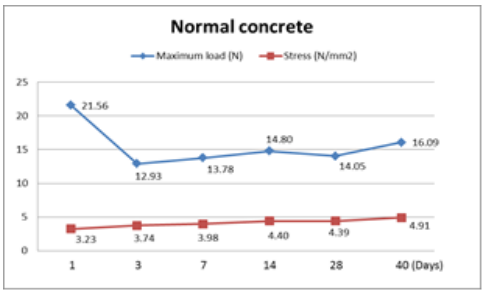

Fig. 7: Normal concrete.

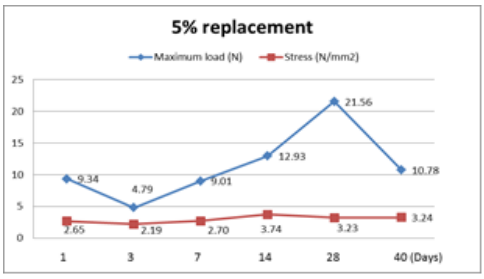

Fig. 8: 5% of cement replacement.

Figure 8, shows the maximum flexural strength is in day 28. The strength decreased from day 1 to day 3 then it increased until day 28 which is shows the maximum flexural strength before it decreased in day 40. However, Figure 9, shows the flexural strength proportionally increased from day 1 to day 40 which is the maximum strength. While Figure 10, shows increased from day 1 to day 14 which is the maximum flexural strength and it is decreased until day 40.

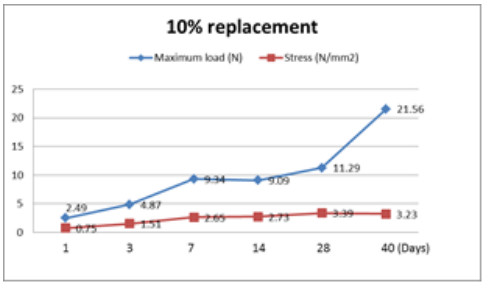

Fig. 9: 10% of cement replacement.

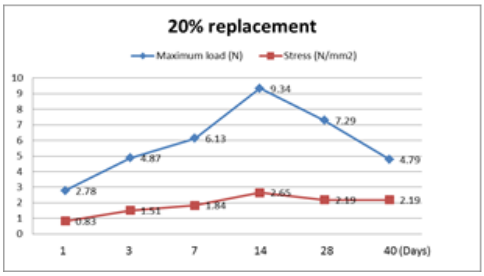

Fig. 10: 20% of cement replacement.

5.0 ***Conclusion:***

Based from results of study, it can be concluded that:

a) For the 20% replacement water paper on the age of 28 days tested the density of the concrete slightly higher than the 14 and 40 days of tested. But as for 5% replacement waste paper, a huge difference of density of the concrete occurs when it reaches to 28 days.

b) For normal concrete and 5% cement replacement shows good and excellent probable concrete quality. While for 10% and 20% of cement replacement shows majority probable quality concrete are good but there are some is in medium and doubtful.

c) The compressive strength from day 1 to day 14 increased and drops at day 28. However, it is increased in day 40 it can be seen the compressive strength decreased while the cement replacement increased.

d) The maximum flexural strength is in day 28. The strength decreased from day 1 to day 3 then it increased until day 28 which is shows the maximum flexural strength before it decreased in day 40

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