CONCRETE MIX WITH WASTEPAPER

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ABSTRACT: Malaysia is facing a serious challenge in disposing of waste in the many landfills throughout the country that are near or at capacity. The landfill situation is resulting in high disposal costs and potential environmental problems. If current trends continue, with waste production projected to grow by 5% each year, landfills would be at full capacity by 2020. This paper reports on the results of an investigation of utilization of wastepaper as additional materials in concrete mixes to be used for housing projects, for which it must be assured that the resulting concrete has the proper mechanical strength. Concrete mixes containing various contents of the paper were prepared and basic strength characteristics such as compressive strength, splitting tensile, flexural, and water absorption were determined and compared with a control mix. Four concrete mixes containing of the waste, which are control mix, 5%, 10%, 15% as an additional materials to concrete were prepared with ratios of 1:2:3 by weight of cement, sand, and aggregate respectively. The maximum size of aggregate was 20mm. In earlier work on the subject during trial mix, it was shown that the addition of wastepaper reduces the mechanical strength of concrete. The test results also revealed that as the content of the paper increased the water to cement ratio for the mix was also increased. With the addition of 25% wastepaper in proportion to the amount of cement, the mechanical strength decreases significantly. Overall, a high correlation was observed between density and strength of concrete containing paper.

Keywords: Wastepaper, Compressive strength, Concrete mix

1.0 INTRODUCTION

This research is aim to evaluate the addition of wastepaper to concrete mix, to study the effect of wastepaper on the strength of concrete, and to develop mixture proportions for concrete containing wastepaper. Wastepaper has been used as building materials for decades, especially in cementitious matrices, and since then a lot of research has been conducted to develop the mechanical properties of the composite like compressive, tensile, flexural strength, and etc. Most of the published works on recycling of papers are from paper mill (Bai et al., 2003; Chin et al., 1998; Chun et al., 2006; Gallardo, 2006; Kraus, 2003; Naik et al., 2004), or to manufacture cement board (Fuwape et al., 2007; Okino, 2000).

Use of wastepaper in structural concrete could become an economical and profitable substitute to landfills, incinerator, or other use options.

No research results have been reported on the use of wastepaper in structural concrete. This paper reports the results of research on the use of wastepaper in concrete.

1. MATERIALS

Cement and Fine Aggregates

Type I Portland cement which meeting the requirements of BS 12: 1996 was used in this research. River sand and crushed granite with 5 mm and 20 mm maximum size respectively were used in this research. Physical properties of sand and gravel are presented in Table 1. The sand and gravel met the requirements of ASTM C 33.

2.2 Wastepaper

Wastepaper used in this study was collected from School of Housing, Building, and Planning (HBP) Administration Office. Physical properties of wastepaper are presented in Table 1.

2.3 Pulping the Wastepaper

Wastepapers were blend using kitchen blender. Mechanical pulping was performed by immersing the wastepaper in room temperature water and subjected to medium speed rotation for not less than 1 min.

3 SPECIMEN PREPARATION

Mixing was done in accordance with ASTM C 192 using a revolving-drum tilting mixer. First, coarse aggregate, some of the mixing water, and pulped wastepaper were added into the mixer. The mixer was then started and, after it turned a few revolutions, it was stopped. Next, sand was added, and the mixer was started and stopped again after it turned a few more revolutions. Finally, cement and the rest of the mixing water were added.

After all of the ingredients were in the mixer, the fresh concrete was mixed for 3 min. followed by a 3-min. rest, followed by additional 2 min. of final mixing. When necessary, water was incrementally added during the mixing process to modify the concrete mixture to achieve the desired slump.

The properties of freshly mixed concrete were determined, and test specimens were cast for the evaluation of strength of concrete. Specimens were demoulded 24h after casting and stored for air curing until the time of the test.

For each percentage additional with wastepaper, three cube specimens were tested for compression, another three cube specimens for tensile tests, and two prism specimens were tested for flexural test and water absorption test. A total of 64 specimens were made for the experimentation of this study. All of them were tested for 7 and 28 days curing period.

4 MIXTURE PROPORTIONS, RESULTS, AND DISCUSSION

4.1 Mixture Proportions

Four concrete mixes containing Portland cement, wastepaper, gravel with 20 mm maximum size, and river sand with maximum size of 5 mm, and water were studied and compare with control. Various proportions of the wastepaper were investigated by batching each mix with 0%, 5%, 10%, and 15% by weight (Table 2). The mix proportions for all mixes were based on weight proportions of 1:2:3 (cement:sand:gravel). The water to cement ratio for the mixes containing the wastepaper was based on preliminary testing to obtain a workable mix with enough water because of high water absorption of the wastepaper.

4.2 Compressive Strength

The test results showed that as the amount of wastepaper in the mix increased the compressive strength of the mix decreased. As shown in Figure 1, the 7 days compressive strength for various mixes with wastepaper decreased from 16.03 to 11.0 N/mm^2 but increased from 19.0 to 15.67 N/mm^2 (Figure 2) for 28 days strength. This reduction in the compressive strength is mainly due to high water to cement ratio of the mix.

4.3 Tensile Strength

The tensile test results in Figure 3 and 4 indicate that the highest tensile strengths were obtained in the mix with 5% wastepaper. At 7 days the concrete mix containing wastepaper was approximately 6.1% stronger in tension than control mix but 5.8% at 28 days, lower than 7 days.

4.4 Flexural Strength

The flexural strength of concrete mixes was determined according to BS 1881: Part 118: 1983. The variations of flexural strengths for all specimens are shown in Figure 5 and 6. Mixture 5% and 15% showed higher strength than mixture 10%. This may attribute to lower water to cement ratio of 5% and 15% compared to 10%.

4.5 Water Absorption

Figure 7 and 8 showed that as the amount of wastepaper increased the water absorption of the concrete mixes also increased. The absorption rates for 7 days are between 13.9% – 62.3% when compared to control mix and between 10.8% – 118.4% for 28 days.

5. CONCLUSIONS

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

1. In general, each group of concrete mixes containing wastepaper, compressive strength, tensile strength, and flexural strength of concrete decreased with the increase of the amount of wastepaper.
2. Concrete mix with 5% wastepaper showed higher tensile strength and flexural strength than control mix.
3. Good relationship was observed in compressive, tensile, and flexural strength of concrete mixes containing wastepaper.
4. Good relationship was observed between density and strength of concrete mixes containing wastepaper.

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Table 1. Physical Properties

Properties	Wastepaper		Fine aggregate	Course aggregate
	Office paper	Newspaper		
Moisture content (%)	2.67	4.17	0.87	0.09
Specific gravity (SSD)	0.98	0.81	2.59	2.61
Absorption (%)	197.54	207.50	1.00	0.70

Table 2. Mixture Proportions

	0%	5%	10%	15%
Cement (kg)	12	11.5	11	10.5
Sand (kg)	24	23	22	21
Gravel (kg)	36	34.5	33	31.5
Wastepaper (kg)	0	0.58	1.1	1.58
Water (kg)	7.2	6.9	6.6	6.3
Additional water (kg)	0	0.9	2.2	1.1
Total water (kg)	0	7.8	8.8	7.4

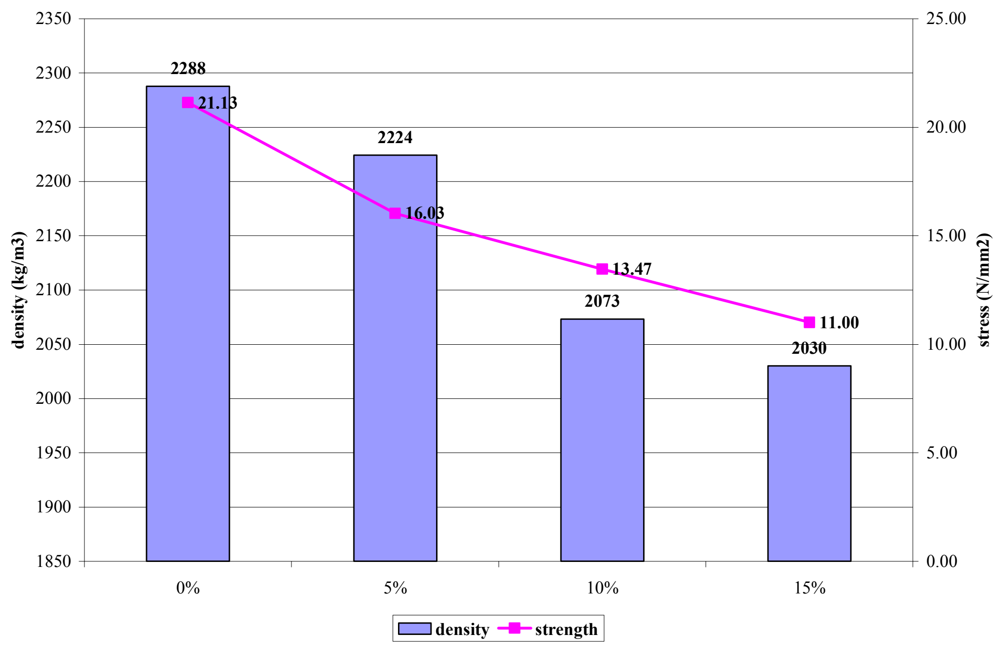

Figure 1. Variation in compressive strength with density for composites subjected to different mixes in 7 days of curing.

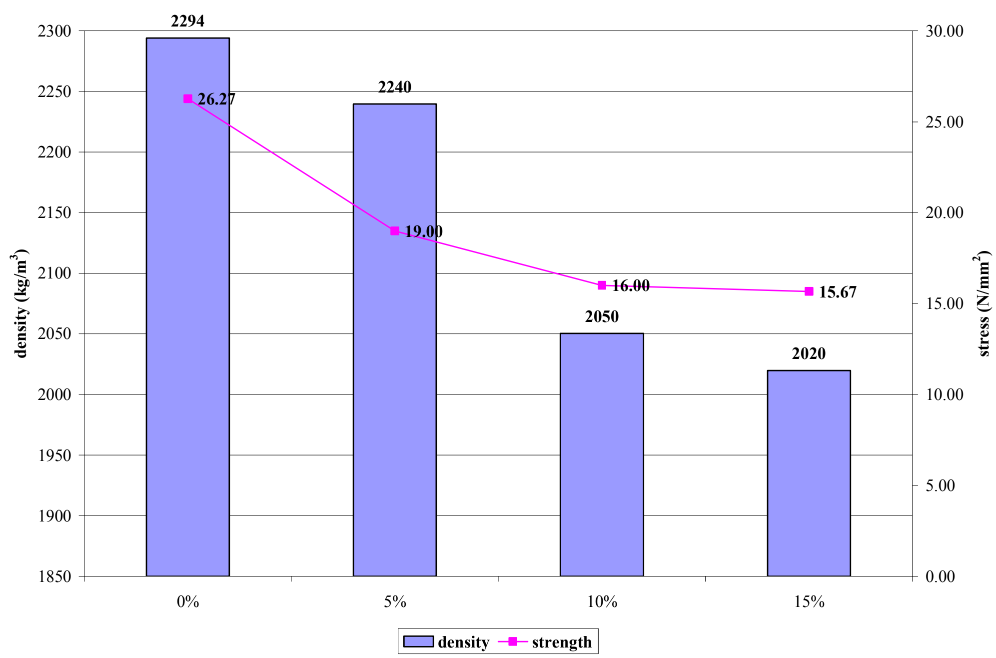

Figure 2. Variation in compressive strength with density for composites subjected to different mixes in 28 days of curing.

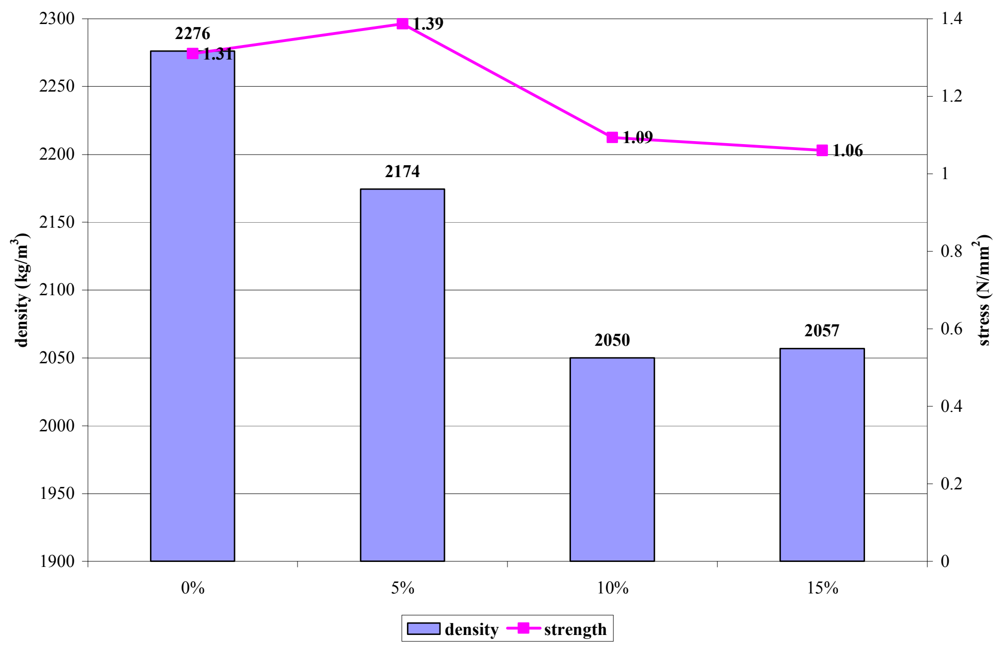

Figure 3. Variation in tensile strength with density for composites subjected to different mixes in 7 days of curing.

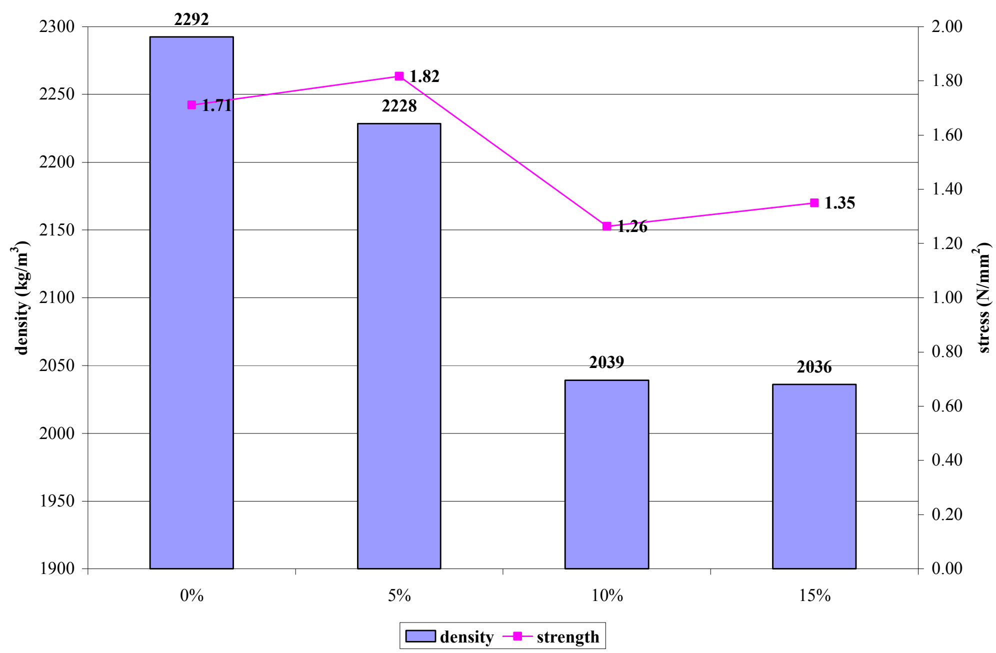

Figure 4. Variation in tensile strength with density for composites subjected to different mixes in 28 days of curing.

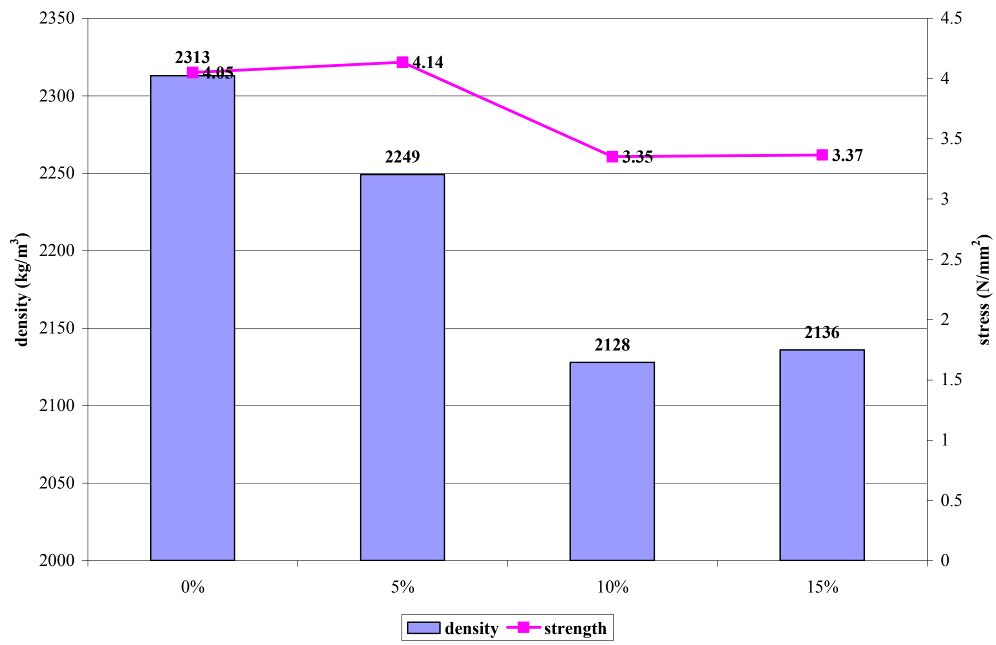

Figure 5. Variation in flexural strength with density for composites subjected to different mixes in 7 days of curing.

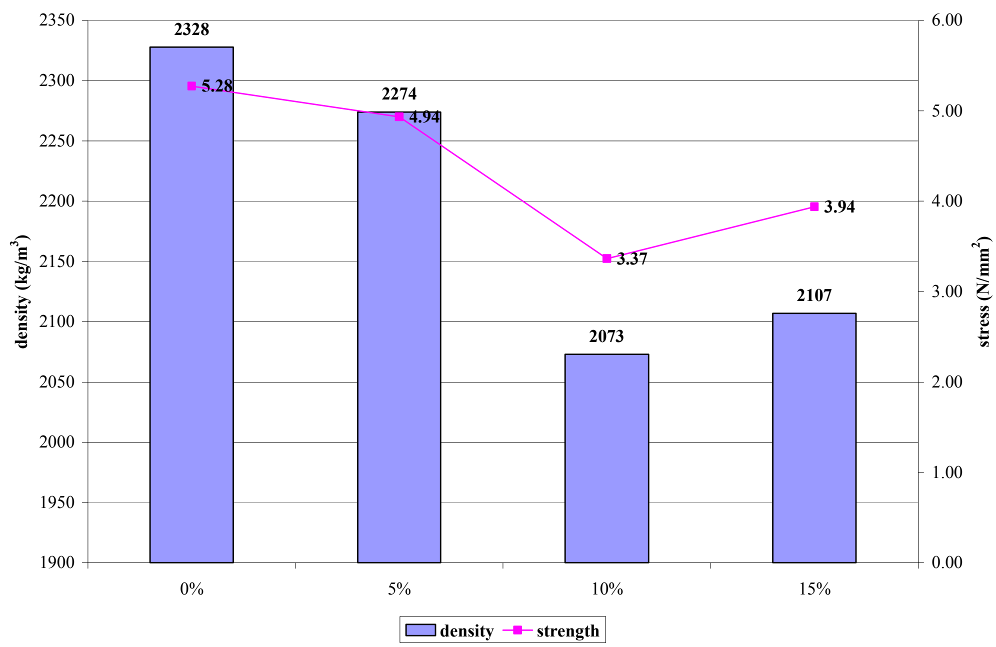

Figure 6. Variation in flexural strength with density for composites subjected to different mixes in 28 days of curing.

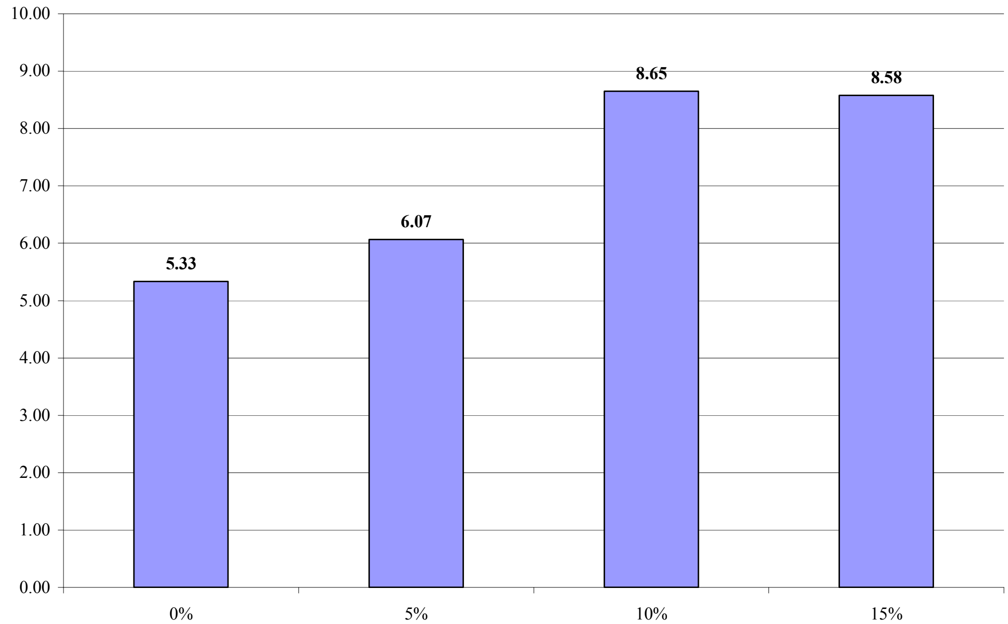

Figure 7. Variation in water absorption for composites subjected to different mixes in 7 days of curing.

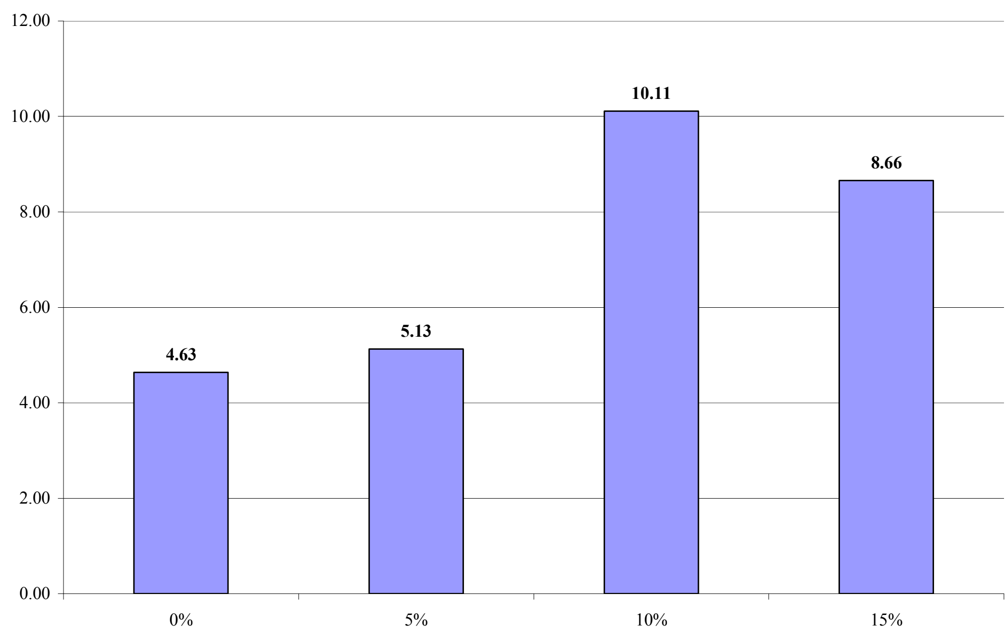

Figure 8. Variation in water absorption for composites subjected to different mixes in 28 days of curing.