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JILID 1

EFFECT OF USING CRUSHED CONCRETE ROOF TILES AS COARSE AGGREGATES ON PROPERTIES OF CONCRETE

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ABSTRACT

The research work reported herein is to investigate the possibility of developing new materials that can be used in the production of Ordinary Portland Cement (OPC) concrete. The potential use of some recycled concrete roof tiles (CRT) as aggregates in OPC are documented in this paper.The use of CRT aggregates, in the right proportions, may provide the much-needed improvement in concrete performance and in the development of mechanical properties without substantially increasing the unit weight of the resulting mix compared with that of an equivalent conventional aggregate concrete. Tests were performed on 28-day-old specimens to determine sorptivity and compressive strength of concrete containing CRT aggregates. In general, the specimens were found to possess lower sorptivity and higher compressive strength compared with those of the control mix.

Key Words: Concrete Roof Tiles (CRT), Sorptivity, Compressive Strength, Coarse Aggregates.

INTRODUCTION

Until recently, the scope of learning of construction materials especially in Malaysia is limited to studying the traditional materials such as steel and conventional concrete. Consequently almost all buildings were and are still being constructed using these two traditional materials, with concrete being the most widely used material in construction industries. Concrete has three major components namely aggregates, water and cement. The aggregates are usually a mixture of coarse and fine materials such as gravel or crushed stone and sand. In many countries, there is a growing shortage of these naturally occurring aggregates that are suitable for use in concrete, which has led to a growing need to develop replacement sources of aggregates in areas where natural aggregates are in short supply.

Our present patterns of resource exploitation will dispossess the earth of its natural resources within the space of a few lifetimes. In the next few years, the construction industry must move to an approach, which views the earth and its resources (including people), as a capital to be carefully tended (Nertz, 1995). Thus, there is a large potential for new types of concrete aggregates as they continue to gain acceptance as more efficient substitutes to conventional concrete material (Aji boye, 1999).

The requirements for improved mechanical properties, coupled with research finding on the inadequacies of concrete made from conventional coarse aggregates such as gravel, have indicated the need to develop and test new coarse aggregates other than the conventional coarse aggregates for the production of concrete.

The present research investigates the possibility of developing new CRT materials that can be used in the production of concrete, with superior strength and durability.

RESEARCH SIGNIFICANCE

At present, concrete used in the construction industry is primarily produced using conventional stone aggregates. The development of CRT aggregates is a new approach in producing a concrete made of recycled materials. In Malaysia, manufacturers of concrete roof tiles (CRT) frequently encounter serious disposal problems for tiles that are discarded due to nonconformity with relevant specifications, and generally, this makes up to about 5% of CRT production (Naim, 1999). This study is mainly directed towards exploring the possibility of making good use of these rejected tiles.

EXPERIMENTAL PROGRAM

Materials

Cement
The cement used in the present investigation was Type 1,General Purpose Ordinary Portland Cement supplied by the Concrete Laboratory of Faculty of Civil Engineering UiTM Shah Alam.

Aggregates
Natural Gravel was supplied by the Concrete Laboratory of Faculty of Civil Engineering at UiTM Shah Alam. The specific gravity and the moisture content of the aggregates are summarized in Table 1.
Concrete Roof Tile (CRT) was supplied by a manufacturer located at Salak Tinggi Industrial Park, Selangor, and later crushed. The physical properties of the crushed tiles are also summarized in Table 1.
Fine Aggregates were supplied by the Concrete Laboratory of Faculty of Civil Engineering at UiTM Shah Alam. Table 1 summarizes the specific gravity, moisture content and fineness modulus of the aggregates.

MIXING, CASTING AND BATCHING

For all the concrete mixtures, the mix proportions corresponding to grade 20 and 30 concretes were used. The details of the mix proportions are shown in Tables 2 and 3. Concrete mixes with 0%, 30%, 50%, 70% and 100% replacement of natural aggregates with CRT aggregates were prepared, and the resulting specimens tested after 28 days of water-curing.

Table 1

Physical Properties Of Aggregates

Properties	Gravel	CRT	Sand
Specific density (SSD) (Mg/m^3)	2.56	2.03	2.61
Particle shape	Angular	Angular	-
Surface texture	Crystalline	Rough	-
Nominal size (mm)	14	14	-
Moisture content (%)	0.11	2.45	0.95
Fineness modulus	-	-	4.93

Table 2

Details Of Grade 20 Mix Proportions

Replacement of gravels with crushed CRT (%)	Water -to-cement ratio	Weight per m³ of concrete (kg)			
		Cement	Sand	Coarse Aggregate	
				Gravel	CRT
0	0.64	320	697	1188	0
30	0.64	320	697	832	356
50	0.64	320	697	594	594
70	0.64	320	697	356	832
100	0.64	320	697	0	1188

Table 3

Details Of Grade 30 Mix Proportions

Replacement of gravels with crushed CRT (%)	Water -to-cement ratio	Weight per m³ of concrete (kg)			
		Cement	Sand	Coarse Aggregate	
				Gravel	CRT
0	0.54	380	639	1186	0
30	0.54	380	639	830	356
50	0.54	380	639	593	593
70	0.54	380	639	356	830
100	0.54	380	639	0	1186

Soaking both types of coarse aggregates in water for 24 hours and then air-drying them to a saturated surface dry condition, or SSD before mixing ensured good workability of the fresh concrete. Mixing was done in a drum mixer and the workability of the fresh concrete was measured with a standard slump cone immediately after mixing. The test specimens were cast in plastic moulds and compacted on a vibrating table. They were demoulded one day after casting. The specimens were cured underwater until the test date.

TESTS

After curing, the specimens were tested for compressive strength and sorptivity. Nine 100 mm cubes were tested to determine the compressive strength at the age of 28 days, each for 0, 30, 50, 70 and 100 percent replacement of gravel with CRT aggregates for each grade 20 and 30 mix proportions, respectively.
Three 80 mm x 100 mm cylindrical specimens from each mix were subjected to the sorptivity test, and the method of obtaining the sorptivity follows that of Stanish et al (1997) and Martys (1995).

The sorptivity test involves measuring the weight change of a submerged concrete sample as water is absorbed through one of the flat faces. For one-dimensional flow, the sorptivity, S is defined as,

$$S = M / t^{\frac{1}{2}}$$

Where M is the cumulative water absorption per unit area of inflow surface, and t is the elapsed time.
The gain in mass per unit area divided by the density of water is plotted against the square root of the elapsed time, and the slope of the corresponding best-fit line of these points (ignoring the origin) is reported as the sorptivity.

RESULTS AND DISCUSSIONS

The 28-days compressive strength of the concrete specimens corresponding to grade 20 and 30 mix proportions are shown in Figures 1 and 2, respectively. The figures indicate that the replacement of CRT coarse aggregates into a concrete mix can be very beneficial in enhancing the development of the compressive strength. The compressive strength of the two mix proportions increases appreciably with the replacement level of CRT, with the increase being 50 percent and 13 percent for the grade 20 and grade 30 mix proportions, respectively. The increase is more pronounce for the grade 20 mix proportions than that of grade 30.

Figures 3 and 4 show the sorptivity of the concrete specimens corresponding to grade 20 and grade 30 mix proportions with different percentages of CRT aggregates. In general, the decrease in the sorptivity is more pronounce for specimens corresponding to grade 20 concrete than that of grade 30, the former being 26 percent and the latter 11 percent of the control specimens. It was suspected that the concrete with CRT has low permeability due to the effect of the improvement in the quality of the interfacial transition zone. Since low permeability is one of the factors that is required in a durable concrete (Pomeroy, 1985), it is therefore logical to subscribe to the notion that the increase in strength reduces the sorptivity and improves the durability performance of the concrete.

It has also been reported that aggregates that are porous or are of pozzolonic character result in a decreased in the internal bleeding area, which in turn lowers the permeability of a freshly placed concrete. In addition to this, part of the bleed water will move into the porous aggregates, thus decreasing the water-cement ratio in the interfacial transition zone (Chandra, 2001). The porous structure of CRT used in the present study might have induced diffusion of the cement paste into the surface pores of CRT, thus producing a cohesive mix and a strong bond between the aggregates and the matrix.

The strength of concrete depends on the bond between the aggregates and the cement paste as well as on the strengths of the individual constituents and the interfacial effects zones since the interfacial interaction between the aggregates and the cement paste are of utmost significance in that cracking in concrete more often than not follows their interface (Illston, 1987). Generally, it is noted that a higher compressive strength and a lower sorptivity were obtained for every concrete samples containing different percentages of CRT replacement.

CONCLUSIONS

From the results of the experimental investigations reported in this work, the following conclusions can be drawn: -

1. The 28-day compressive strength of the concrete specimens corresponding to grade 20 and 30 mix proportions increases with an increase in CRT aggregate content in the mixture Specimens corresponding to grade 20 mix proportions made with gravel aggregates recorded a lower compressive strength than any concrete mixtures of various percentages of CRT replacement
2. The percentages increase in the compressive strengths of concrete grade 20 mix proportions is higher than that of grade 30 mix proportions for all level of CRT replacement.
3. The sorptivity of the concrete decreases with an increase in CRT aggregate content.
4. The percentages increase in the sorptivity of concrete corresponding to grade 30 mix proportions is smaller than that of grade 20.
5. Finally, the results generated indicated a very good prospect of utilizing these rejected tiles in producing acceptable quality concrete.

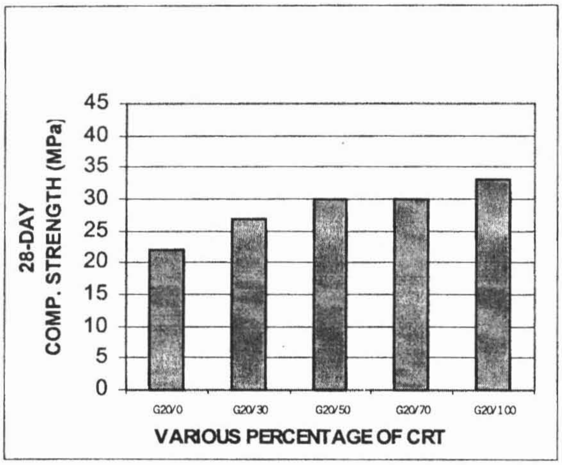

Figure 1- Compressive strength of concrete corresponding to grade 20 mix proportions with various percentages of CRT

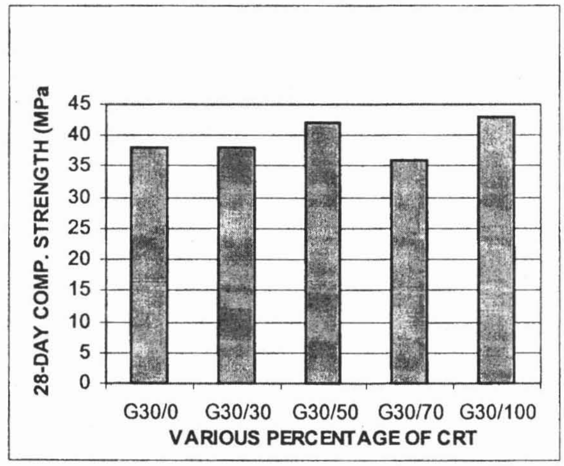

Figure 2- Compressive strength of concrete corresponding to grade 30 mix proportions with various percentages of CRT

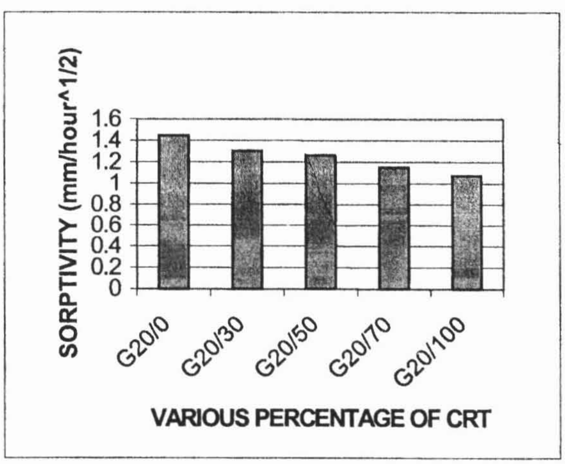

Figure 3- Sorptivity of concrete corresponding to grade 20 mix proportions with various percentages of CRT

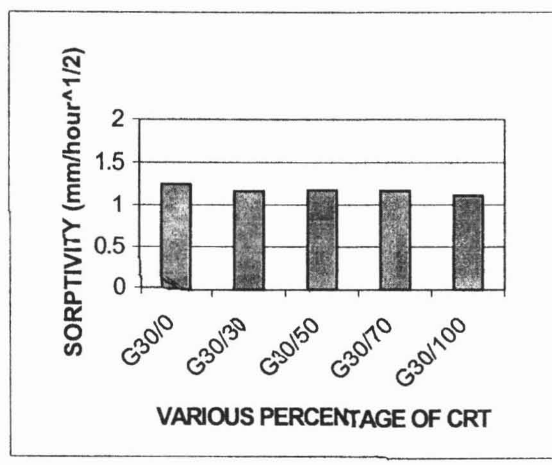

Figure 4- Sorptivity of concrete corresponding to grade 30 mix proportions with various percentages of CRT

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