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Fresh and Hardened Properties of Concrete Containing Ceramic Tile Waste as Coarse Aggregate and Glass Waste as Fine Aggregate

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Abstract: This study focused on the recycling of Glass Waste (GW) and Ceramic Tile Waste (CTW) in the concrete. However, GW was considered as fine aggregate replacement and CTW was considered as coarse aggregate replacement in the concrete. The concrete of grade 20 (M20) was prepared in the laboratory with various proportions of waste materials. The GW was introduced with 5%, 10%, and 15% replacement of fine aggregates, and CTW was incorporated with 10%, 20% and 30% replacement of coarse aggregates in the concrete. After that, fresh mix and hardened properties of concrete were evaluated. It was noticed that the with increases the partial replacement of GW as FA slump value increases. Glass waste particles absorbed less water as compared to natural FA and thus improving the workability of concrete. Based on the compressive strength results of 28days the optimum replacement was noticed as fine aggregate with 10% GW and coarse aggregate with 20% CTW. However, combined use of both wastes materials could not improves the strength performances of concrete significantly.

Keywords: Glass waste, ceramic tile waste, concrete, workability, compressive strength

1. Introduction

In building construction concrete, steel, brick, stone, clay, mud, wood, glass etc. are the basic ingredients to build any structure. But looking at concrete consumption in world increases which is about two and a half tons per capita per year. 2.62 billion tons of cement, 13.12 billion tons of aggregate, 1.75 billion tons of water is necessary to prepare this volume (Mohammed, Hasnat, Awal, & Bosunia, 2015). The extraction of aggregates itself is an effort consuming process and all these operations require labor, machinery, and transportation etc. The working of machinery and transportation of the processed material (aggregates) also results in the environmental pollution and at the same time we are utilizing the natural resources (Mangi, Jamaluddin, Wan Ibrahim, Noridah, & Sohu, 2017). At present, the amount of global demolished concrete is estimated at 2-3 billion tons. 20% of normal aggregates can be saved by recycling of

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demolished concrete. The amount of demolished concrete will be increased to 7.5-12.5 billion tons in the next 10 years (Mobili, Giosuè, Corinaldesi, & Tittarelli, 2018). Globally, cities generate about 1.3 billion tone of solid waste per year.

Demolition waste is the waste produced by demolishing or renewing the old buildings made up of concrete (Reema, Ram Kishore, Md, & Sitesh Kumar, 2020). Now days most of the buildings are renovated as per new requirement. The renovation of old buildings produces 10 times the waste as compared to new construction (Centre for Science and Environment, New Delhi 2014). Building waste production of 2 to 3 billion tons per annum is estimated at global level, of which 30-40 % is concrete (Mahesh & Mata, 2017).

Worldwide concrete is main material for construction sector. Moreover, the requirement of concrete will rise to almost 7.5 billion m^3 by 2050 which is approximately 18 billion ton per year (Mangi et al., 2018). In accountable usage of natural aggregate related to construction industry will cause scarcity of natural reserve. Scarcity of aggregates will drive to any country towards import of aggregate that will impact on supply of aggregates. In response to this situation, various studies have been conducted to develop alternative resources for concrete (Choi, Choi, Kim, & Yang, 2018).

Beside this it has also been observed that construction activity such as renovation, demolition and repairing work has bringing up the waste like ceramic tile, brick, roof tile, other ceramic product and glass waste being one of them. This waste is also caused ill impact to the environment (Zimbili, Salim, & Ndambuki, 2014). Therefore, this study considered the recycling of crushed aggregate with ceramic tile and glass waste as fine aggregate to make concrete production economical, retard the usage of natural resources and reduce the construction and demolition waste percentage among environment waste.

2. Materials and Methodology

In this study involving the usage of GW & CTW. Both wastes were utilized individually and combined as fine aggregate and coarse aggregate in partially substituted cement concrete.

The cement used for whole experimental study is DG cement, the fine aggregates used throughout the experimental work comprises of clean sand which is natural granular material with max size of 4.75mm, specific gravity 2.6 and fineness modulus 3.33. The coarse aggregate used consisted of crushed stone angular in shape passing through 20mm sieve and retained on 4.75mm sieve with specific gravity of 2.6 and fineness modulus 4.77. The glass waste collected from local Aluminum Shops consisting of waste door and window glass used as partial substitute for fine aggregate at 5%, 10%. 15%. The GW was produced at site by manually crushing the glass waste into fine aggregate as shown in Fig. 1. The manual procedure involves the use of hammer and very hard surface. The specific gravity of waste glass was found to be 2.42.

The Ceramic tiles, Quarry tiles, Porcelain tiles, and Marble tile were collected from nearby industry. However, Ceramic Tile Waste (CTW) as shown in Fig. 2 was used as partial substitution of CA at 10%,20% &30% Broken ceramic tile waste was collected from solid waste unit of local Tile Shops and then breaks into pieces by hammering. In Laboratory preliminary test i-e Sieve analysis Specific gravity and water absorption were conducted to check the quality for aggregates to be used in partially substituted cement concrete. The pieces of tiles are sieved to get a 20mm size.

Fig. 1 - Preparation of fine aggregates through glass waste

Fig. 2 - Preparation of coarse aggregates through ceramic tile waste

2.1 Concrete Mix Details

The concrete of grade 20 (M20) was prepared in the laboratory as the proportions are shown in the Table 1. Initially the concrete mix (CM) concrete was prepared with zero percentage replacement of aggregates. Next, the GW was incorporated as partial replacement of fine aggregate and CTW was incorporated as coarse aggregate replacement as the proportions are mentioned in the Table 1.

Table 1 - Concrete mix proportions

Mix Code	Description	Glass waste %	Ceramic Tile Waste %
M0	Control Mix	0	
M1	GW 5%	5%	
M2	GW 10%	10%	
M3	GW 15%	15%	
M4	CTW 10%	0	10%
M5	CTW20%	0	20%
M6	CTW 30%	0	30%
M7	GW5%+CTW10%	5%	10%
M8	GW10%+CTW 20%	10%	20%
M9	GW15%+CTW 30%	15%	30%

3. Results and Discussion

3.1 Workability

The workability of concrete was evaluated through slump cone, it determines the consistency of fresh mix, slump cone test was conducted for prepared concrete before the moulding process. Fig-3 shows the slump values recorded during the test. It shows the concrete containing GW as FA at 5%, 10%, and 15% which increase the workability due to smooth and sharpness of glass waste particles. Besides that, concrete containing ceramic tile waste as 10, 20 and 30% reduces the workability because the presence of ceramic waste in concrete absorbed the more water and resulting in the reduction of slump value.

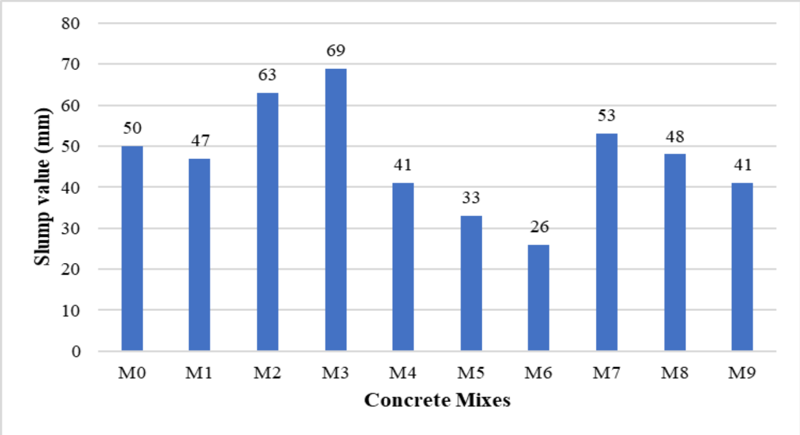

Fig. 3 - Workability of concrete containing glass waste and ceramic tile waste

3.2 Compressive Strength

The compressive strength of concrete was evaluated through CTM machine, concrete samples of size 150mm x 150mm x 150mm were evaluated at the age of 3, 7 and 28days. The consolidated results are shown in Fig-4, results declared that the compressive strength of concrete varies as -8%, -20%, -11%, 1%, 3%, -17%, -12%, -25%, -11% for M1, M2, M3, M4, M5, M6, M7, M8 and M9 respectively compared with conventional concrete after 3 days of curing. Besides that, at the age of 7days compressive strength of concrete containing individual and combine substitution of GW and CTW varies at -15%, -18%, -17%, -2%, -1%, -21%, -33%, -12% when compared with conventional concrete. Next the comparing compressive strength of concrete containing combine substitution of GW & CTW with conventional concrete after 28 days of curing varies at -17%,1%, -9%, -12%, -6%, -18%, -18%, -28%, -30%. It was noticed from the experimental results that the compressive strength at 28days, the optimum replacement was noticed as fine aggregate with 10% GW and coarse aggregate with 20% CTW. However, combined use of both wastes materials could not improves the strength performances of concrete significantly.

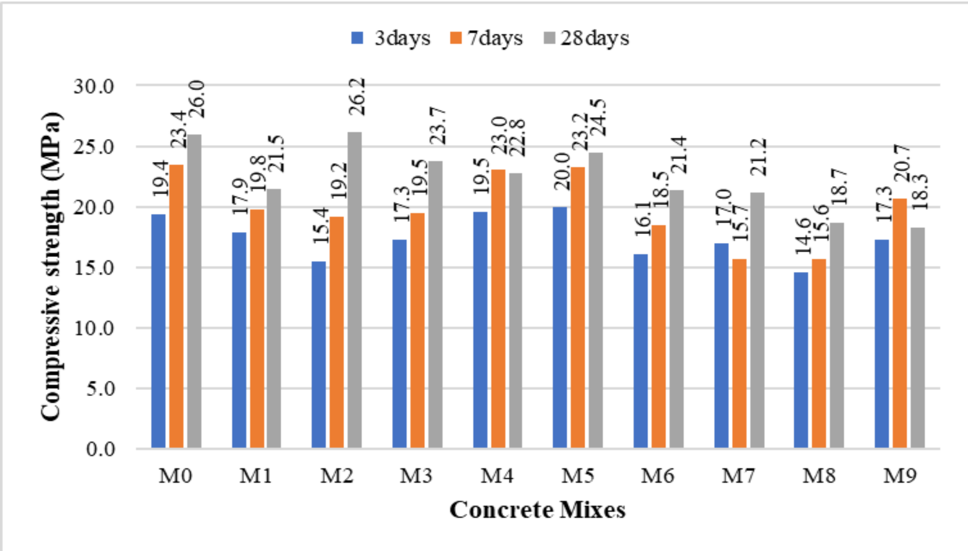

Fig. 4 - Compressive strength of concrete containing glass waste and ceramic tile waste

4. Conclusion

After completion of all experimental test, obtained test results analyze and discussed. Based on detailed analysis it is concluded that, glass waste and ceramic tile waste can be used in place of fine aggregate and coarse aggregate.

It was noticed that the increment in the fine aggregate replacement with Glass Waste (GW) gives positive slump values. It shows that the glass waste particles absorbed less water as compared to natural fine aggregates and thus improving the workability of concrete. Besides that, the incorporation of Ceramic Tile Waste (CTW) causes the reduction in the slump values which shows that the presence of CTW in the concrete absorbed more water as compared to the natural coarse aggregates. Furthermore, comparing the strength of concrete containing GW with control mix, the best performances were noticed in concrete containing 10% GW as fine aggregate replacement. Based on the compressive strength results of 28days the optimum replacement was noticed as fine aggregate with 10% GW and coarse aggregate with 20% CTW. However, combined use of both wastes materials could not improves the strength performances of concrete significantly.

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