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Investigation on Hollow Concrete Blocks Incorporating Waste PET

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Presented by
Mohammed Tariq Adham

Supervisor
Prof. Dr. Isam Jawad Abdalaali

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Abstract

The global challenge of solid waste, particularly in terms of resource conservation and pollution mitigation, is becoming increasingly critical. A major constituent of mixed waste streams is plastic, whose pollution has become a prominent concern for the global ecosystem. The issue could worsen in terms of detrimental effects if there is mismanagement of plastic solid waste. Plastics have woven themselves into the very fabric of our existence and their annual usage is on a noticeable upward trajectory. A growing trend worldwide for plastic recycling is incorporating plastic waste into the mixture for making concrete. In Iraq, a nation producing thousands of tons of plastic waste daily, the existing capabilities to manage and dispose of solid waste, in general, are believed to satisfy a mere 25% of the country's requirements. There is a pressing need for innovative methods to repurpose plastic waste. Such waste could potentially be used as a replacement for either coarse or fine aggregate in concrete mixtures. In the country, hollow concrete blocks are among the most frequently used building materials. Owing to the lack of recycling operations for soft plastic waste like Polyethylene Terephthalate (PET), this study explored the feasibility of using PET waste as a partial replacement for coarse aggregate in the production of hollow concrete blocks. The study being conducted in Al-Muthanna Governorate, Southern Iraq. PET plastic waste was shredded with a maximum size of 20 mm and utilized in percentage of 2%, 4%, 6%, and 8% of the total weight of coarse aggregate. Hollow blocks with dimensions of (360 × 200× 200) mm were manufactured and their physical properties were tested after curing for 7 and 28 days. It is one of the most commonly used concrete blocks in the governorate. This research revealed and highlighted the important properties of these blocks. Also, the study examined the impact of recycling plastic waste as strips on the compressive and flexural strength, among other physical properties, of hollow concrete bricks. After curing for 28 days, the blocks were assessed in their fresh states (slump and fresh density) and hardened states (compressive and flexural strength, water absorption and oven dry density). This study identified and detailed all properties of the block. The concrete mixtures included various plastic additions such as lamellar strips, ring strips, and ring clasps. Each type of plastic strip (lamellar strips and "O" rings) was separately added to the concrete mixture at different weight percentages (0%, 0.25%, 0.5%, 0.75%) of the total concrete weight. In

addition, ring clasps were introduced to the mixture in varying number of clasps (3, 4, 6, and 8). During the tests, no slump (zero slump) occurred in the reference mixture, as well as that contains shredded PET waste and lamellar strips added for all mixing percentages. The results of the fresh density decreased by 1.68%, 4.47%, 6.12%, and 10.1% as the content of shredded PET plastic waste aggregate increased in the percentages of 2%, 4%, 6%, and 8%, respectively. The fresh density of lamellar and ring strip clasps decreased as the content of PET plastic strips increased. Dry density of block that contains shredded PET waste aggregate decreased by 4.01%, 5.22%, 10.52%, and 11.47% as the quantity of the shredded PET waste aggregate raised at 2%, 4%, 6%, and 8% respectively. The dry density of concrete containing lamellar strips of PET decreased in percentage of 3.52%, 3.20%, and 6.18% with the increase of PET added in 0.25%, 0.50%, and 0.75%, respectively. The dry density of concrete containing clasps of ring strips of PET decreased in percentage by 2.14% with the increase of the number of PET clasps to 3. After that, the dry density starts to increase by 2.81%, 3.72% and 1.49% with the increase of number of PET clasps to 4, 6, and 8, respectively. The water absorption capacity of blocks increased in direct proportion to the amount of shredded PET plastic waste aggregate used. The results indicated that as the content of lamellar strips in concrete increased in percentage of 0.25%, 0.50%, and 0.75%, the water absorption capacity of concrete experienced an increase with percentage of 0.7%, 0.2%, and 1.3%, respectively. The results also indicated that the water absorption of concrete containing clasps of ring strips of PET increased by 0.8% with the increase of a number of PET clasps to 3. After that, the water absorption starts to decrease by 0.4%, 1.0 %, and 1.0 % with the increase in the number of PET clasps to 4, 6, and 8, respectively. The compressive strength of the hollow concrete blocks cured for 28 days were increased by 1.4% for a replacement of 2% shredded PET waste and then they started to lose strength for a percentage replacement of 4% and after. The compressive strength of the hollow concrete blocks cured for 28 days with lamellar strips increased in the percentage of 4.67%, 21.11%, and 15.01% with the increase of PET waste added in the percentage of 0.25%, 0.50%, and 0.75%, respectively. While the compressive strength of specimens with ring strips decreased in the percentage of 5.38%, 14.45%, and 3.82% with the increase of PET waste added in the percentages of 0.25%, 0.50%, and 0.75%, respectively. Compressive strength for hollow concrete block specimens with

clasps of ring strips increased in the percentages of 5.52%, 7.37%, and 15.58% with the increase of number of PET clasps to 3, 4, and 6, respectively. However, with an increasing in the number of PET clasps to 8, the compressive strength decreased by 14.87%. A slight decline in flexural strength was observed in specimens with a low shredded PET waste aggregate content (2% and 4%), compared to the reference specimens. However, concrete specimens containing 6% and 8% shredded PET waste aggregate exhibit a significant decrease in strength, by 30.84% and 35.24% respectively. Flexural strength of specimens with lamellar strips decreased in percentage of 9.69%, 10.57%, and 14.98% with the increase of PET added in 0.25%, 0.50%, and 0.75%, respectively. The flexural strength of specimens with rings strips increased by 5.73% with the increase of PET added in 0.25%, but with the increase of PET added in 0.50% and 0.75%, the flexural strength decreased by 5.29% and 19.38% respectively. Averages of flexural strength for specimens with clasps of ring strips increased in the percentage of 8.81%, 3.96%, 11.45%, and 10.13% with the increase of number of PET clasps to 3, 4, 6, and 8 respectively. The findings showed that the optimal configuration in the initial round of tests involved a 2% replacement of coarse aggregate with shredded PET waste. Although the addition of PET waste led to a reduction in both compressive and flexural strength, the blocks remained satisfactory for industrial applications. This research showcased the potential to produce hollow concrete blocks with PET waste, offering a new type of construction block that lessens the aggregate demand and mitigates plastic waste pollution. The subsequent round of tests determined that the ideal blend for this investigation consisted of adding 0.50% of lamellar PET strips. The study encourages concrete manufacturers to adopt PET waste plastic, particularly a 2% aggregate replacement, to enhance the compressive strength of blocks.

Keyword: Plastic waste, Polyethylene Terephthalate (PET), Hollow concrete blocks, fresh properties, compressive and flexural strength.