

Impact of the Content Variation of the Different Recycled Wastes to the Properties of Concrete Paving Block

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Abstract. Recycled concrete aggregates have been widely studied and used in concrete products nowadays. However, other recycled wastes, such as glass, have not been involved too much in recycled aggregate concrete studies. This paper aims to study the impact of the content variation of the different recycled wastes to the properties of the concrete paving block. In this paper, not only recycled coarse concrete aggregates, crushed glass are also used as the recycled aggregate in the concrete paving block in different replacement levels. According to test the properties of blocks mixed with different recycled wastes, the experimental results indicate that: (1) adding recycled concrete coarse aggregate (RCCA) in the blocks can decrease the blocks' strength, and increase the water absorption. The suggested replacement levels for RCCA is 60%; (2) mixing crushed glass (CG) in the concrete paving blocks as a type of coarse aggregates can obviously improve the blocks' strength and decrease the blocks' water absorption.

1. Introduction

In China, the construction industry has developed rapidly since the late of the 1990s [1]. High-rise buildings are established, and the old buildings and constructions are demolished at the same time. Due to the irreplaceability of concrete in the construction industry, large quantities of concrete needs to be widely used in engineering, and this situation leads to the generation of large volumes of construction waste. Thus, using recycled demolished concrete as the aggregate in the new construction products could reduce the utilization of the limit-resource in nature and reduce the environmental burden at the same time.

However, construction wastes do not only represent recycled concrete aggregates which contain crushed concrete, crushed bricks, and granites. Glass, woods, plastic, rubbers and so on are also counted as construction wastes [2]. Nowadays, concrete paving blocks cast with recycled aggregates have been studied and manufactured in many countries [3–6]. Thus, the concrete paving block is selected as the type of concrete product to be manufactured and investigate in this paper.

In this paper, not only recycled coarse concrete aggregates, the crushed glass are also used to investigate the impact of the content variation of the different recycled wastes to the properties of concrete paving blocks. Plus, for all the experiments in this paper, all the parameters of the production machines, as well as the mode of production, are in accordance with the actual industrial production standards of the company named

Suzhou Construction Material Recycling Application Co., Ltd.

2. Experimental program

2.1. Materials

The entire materials used in this series of experiments are listed as follow:

- Natural coarse aggregate;
- Natural fine aggregate;
- Ordinary Portland cement (42.5MPa compressive strength at 28 days);
- Recycled concrete coarse aggregate (contain crushed concrete, crushed stone, and crushed bricks);
- Crushed glass.

In this experiment, there are two types of construction wastes are used: recycled concrete coarse aggregate (RCCA) and crushed glass (CG). RCCA was collected from a local recycled aggregate manufacture factory. Crushed glass was sourced from a local glass recovery plant and crushed into 5mm~2.5mm in the laboratory. Figure 1 shows the graphics of recycled wastes used in this experiment.



(a) RCCA



(b) Crushed glass

Figure 1. Characteristics of recycled wastes.

2.2. Mix proportion and replacement levels

In order to investigate the impact of the content variation of the different recycled wastes to the properties of concrete paving blocks, two different types of waste materials were used to replace the coarse aggregates in the concrete mixture with 28-days target strength of 30MPa. The original mix proportion was designed according to the “mass method” in Chinese standard JGJ55-2011 [7]. The concrete paving blocks which were cast by replacing the natural coarse aggregate by weight with different replacement levels of recycled materials.

According to the previous articles and experiments results, the replacement levels of RCCA in the experiment were determined as 20%, 40%, 60% 80% and 100%. As the same as RCCA, crushed glass was also used to replace the coarse aggregates in the blocks. According to the previous articles and trial test results [8], the final replacement levels of crushed glass were decided as 10%, 20%, 30% and 40%.

2.3. Specimens preparation

The specimens are designed as typical concrete paving blocks. The whole procedures, including preparing the concrete mixture, casting concrete paving blocks and

curing, were in accordance with the actual industrial production standards of the company in Suzhou. Plus, the parameters of the production machines (a small hydraulic brick making machine) were set as same as the company’s requirements. Figure 2 shows the image of the brick making machine. All the concrete mixtures were sent into the small hydraulic brick making machine to be compacted under 80kN force to be cast into 200mm*100mm*60mm concrete paving blocks [9].

2.4. Test and requirements

Both British standard BS EN -1338: 2003 [10] and Chinese standard GB 28635-2012 [11] stipulate the requirements for concrete paving blocks. In this series of experiments, four properties of the concrete paving block were tested: Dimensions, compressive strength, tensile splitting strength, and water absorption.

Figure 3 shows the universal test machine (UTM) for testing block’s strength

3. Test results



Figure 2. Hydraulic brick making machine.



Figure 3. Universal testing machine.

3.1. Dimensions

All the concrete paving blocks in this series of experiments were manufactured by a small hydraulic brick making machine. The size of molds in the machine is 200mm*100mm*60mm. In this case, all the blocks' dimensions are 200mm*100mm*60mm, and the error of each side was less than 2mm. Figure 4 and figure 5 show the front and side faces of one concrete paving block.



Figure 4. Front face of concrete paving block.



Figure 5. Side face of concrete paving block.

3.2. Compressive strength

Figure 6 shows the relationship between the different replacement levels of materials and the compressive strength of specimens.

Specimens mixed with RCCA maintained a stationary compressive strength until the replacement level reached 40%. The compressive strength fluctuated as 41.07MPa, 38.04MPa and 40.38MPa when replacement levels were 0%, 20%, and 40% respectively. After the replacement levels were higher than 40%, the compressive strength almost linearly decreased from 40.38MPa at 40% to 21.04 MPa. According to the BS EN 1338 [10], the compressive strength of concrete paving blocks should equal or higher than 30MPa, which indicated that the specimens with replacement level higher than 60% were not meet the specification [11].

As another material replacing the coarse aggregates in this series of experiments, the crushed glass had a positive impact on the concrete paving blocks' compressive strength. According to the figure 6 results, the specimens had a higher compressive strength when the replacement levels of crushed glass were 10%, 20%, 40% and 60%,

and the strength peak the highest value, 43.45MPa, at the replacement level equals 20%.

3.3. Tensile splitting strength

Figure 7 demonstrates the relationships between the different research materials' replacement levels and the tensile splitting strength of concrete paving blocks.

Specimens mixed with RCCA had an even higher tensile splitting strength 11.73MPa at replacement level was 20%. However, the tensile splitting strength almost linearly decreased from 11.73MPa to 8.80MPa when the replacement level increased from 20% to 80% and bottomed at 6.37MPa with 100% RCCA in the specimen.

According to the test results, using crushed glass as the coarse aggregates in the concrete paving blocks had a positive effect on the blocks' tensile splitting strength. The overall tendency was that the tensile splitting strength kept increasing with the replacement level changed from 10% to 40%, and reached the highest value 12.79MPa at 40%. When the replacement level was 30%, the tensile splitting strength was only 11.38MPa. However, this value was still a little bit higher than the blocks mixed with natural aggregates.

3.4. Water absorption

According to figure 8, it is clear to observe that for the blocks mixed with RCCA, the increase of the replacement levels of the material increases the specimens' water absorption. Furthermore, for blocks mixed with the RCCA, the water absorption value could maintain 3.91% at the replacement levels 20%, and then peaked 7.60% while the replacement levels were 100%.

Crushed glass is proved to be a material that can reduce the water absorption when it mixed into blocks. The values of water absorption ranged from 3.50%, 3.24% 3.65 and 3.72% while the replacement levels were 10%, 20%, 30% and 40%.

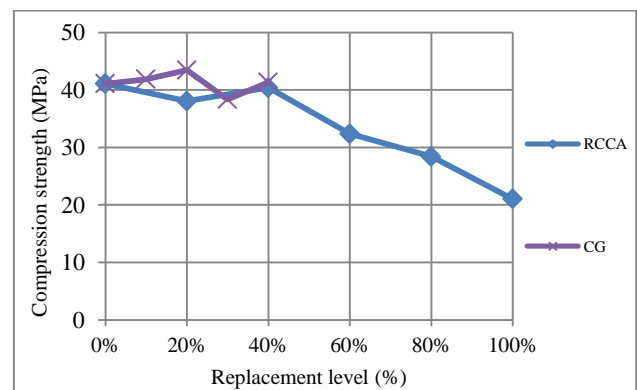


Figure 6. Relationship between the different replacement levels of materials and the compressive strength of specimens

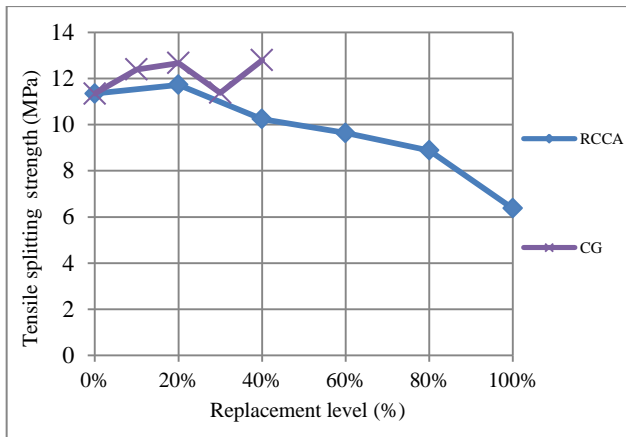


Figure 7. Relationship between the different replacement levels of materials and the tensile splitting strength of specimens.

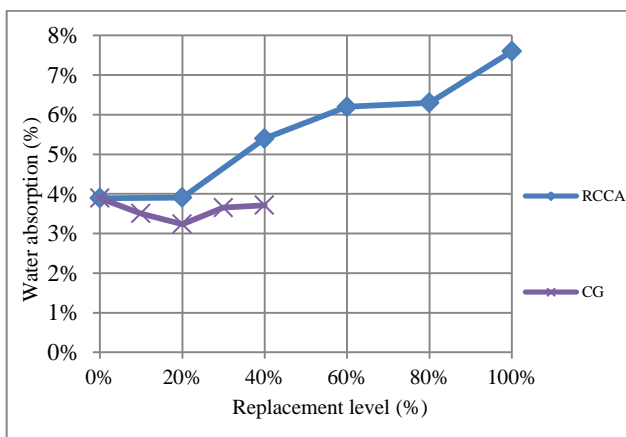


Figure 8. Relationship between the different replacement levels of materials and the water absorption of specimens

4. Conclusions

According to the experiment results in the properties of concrete paving blocks mixed with different types of recycled wastes, the conclusions can be drawn as follow:

- Using the RCCA as the coarse aggregate of the concrete paving blocks can lead a significant decrease of both compressive strength and tensile splitting strength of blocks, and also increase the water absorption of the concrete paving blocks. In order to meet the standard requirements, the replacement level of RCCA should be less than 60%.
- Replacing the coarse aggregate with crushed glass could enhance the strength of concrete paving blocks. With the replacement level ranging from 10% to 40%, all concrete paving

blocks mixed with crushed glass had higher strength and lower water absorption than the blocks mixed with natural aggregates. When the replacement level of crushed glass at 20%, the concrete paving blocks had a highest compressive strength and lowest water absorption. The tensile splitting strength of concrete blocks reached the maximum value at replacement level of crushed glass equalling 40%.

Acknowledgement

The authors gratefully acknowledge Xi'an Jiaotong-Liverpool University for the financial support. We would also like to thank Suzhou Construction Material Recycling Application Co., Ltd for providing recycled concrete aggregates and machine parameters for the experiments.

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