Experimental study on the effect of volcanic residue on the performance of recycled lightweight aggregate concrete

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Abstract: Recycled lightweight aggregate concrete prepared with waste brick recycled light aggregate has high water absorption, large apparent density and poor frost resistance. The technical measures of regenerating lightweight aggregate concrete with modified waste bricks from volcanic slag are put forward. The effects of volcanic slag on the properties of waste lightweight aggregate concrete were studied. The experimental results show that volcanic slag can significantly reduce the apparent density of recycled lightweight aggregate concrete and improve its frost resistance.

1. Introduction

In recent years, with the rapid development of urban construction, housing construction, the construction of new buildings and the removal of old buildings resulted in a large amount of construction waste. Recycled concrete technology can realize the effective recycling of waste concrete, which is of great significance for protecting the environment, saving resources and developing ecological buildings. In recent years, many domestic and foreign constructors use of this recycled aggregate instead of natural aggregate preparation of new concrete (commonly known as recycled concrete) research. However, there are relatively few studies on the recycled aggregate of waste bricks. As the waste bricks recycled aggregate has the characteristics of large porosity and high water absorption, according to the design method of ordinary concrete mix design, the slump of recycled concrete is low and the apparent density is larger. Volcanic residue is a natural light aggregate, with volcanic slag modified waste brick recycled aggregate concrete, can improve its performance.

2. Part of the Trial

2.1 Raw materials and their properties.

Recycled aggregate: Recycled aggregate for a building old red brick wall after removal by the broken processing the main technical performance are shown in Table 1; Cement: Jilin honored cement limited company. Production tripod deer card P.O 42.5 R ordinary Portland cement; Fly ash: meeting the national standards of grade II; Volcanic slag: Huinan County, Jilin Province, the main performance parameters in Table 2; Water reducing agent: Air-entraining type water-reducing agent, water reduction rate of 20%; Water: tap water.

| category     | Particle size (mm) | Bulk density (kg/m3) | Cylinder strength (Mpa) | Water absorption (%) |
|--------------|--------------------|----------------------|-------------------------|---------------------|
| Coarse aggregate | 5-10               | 886                  | 9.7                     | 15.3                |
| Fine aggregate    | 0.18-5             | 924                  | 7.6                     | 16.8                |

Table 1: Basic properties of waste brick recycled aggregate
Table 2: The main performance parameters of volcanic slag

| category                  | Particle size(mm) | Bulk density(kg/m³) | Cylinder strength(MPa) | Water absorption(%) |
|---------------------------|-------------------|--------------------|------------------------|---------------------|
| Volcanic coarse aggregate | 4.75-8            | 815                | 5.9                    | 12.8                |
| Volcanic slag fine aggregate | 0.18-4.75        | 1200               | 6.5                    | 13.7                |

2.2 Mix design
Concrete specimens are divided into 11 groups, the main research objectives were the effects of volcanic coarse aggregate content and volcanic slag fine aggregate content on compressive strength, dry apparent density and frost resistance of waste brick recycled lightweight aggregate concrete. Volcano slag aggregate incorporation was considered in three cases, with the ratio design shown in Table 3. The replacement rates of fine aggregate and volcanic aggregate of volcanic slag were 10%, 30%, 50%, 70% and 100%. No.0 represents the thickness of aggregate used in all broken waste brick recycled lightweight aggregate concrete. No.1-5 for the use of volcanic slag part or all to replace the waste brick recycled coarse aggregate of renewable light concrete, No. 6-10 for the use of volcanic slag fine aggregate part or all of the waste brick to replace the regeneration of fine aggregate of lightweight aggregate concrete.

Table 3: Composition ratio of recycled concrete for waste of construction waste

| number | Cement | Recycled coarse aggregate | Recycled fine aggregate | Volcanic coarse aggregate | Volcanic slag fine aggregate | Fly ash | Water-cement ratio |
|--------|--------|---------------------------|-------------------------|---------------------------|-------------------------------|---------|-------------------|
| 0      | 398    | 810                       | 432                     |                            | 52                            | 0.5     |                   |
| 1      | 398    | 730                       | 432                     | 75                         | 52                            | 0.5     |                   |
| 2      | 398    | 567                       | 432                     | 230                        | 52                            | 0.5     |                   |
| 3      | 398    | 405                       | 432                     | 388                        | 52                            | 0.5     |                   |
| 4      | 398    | 243                       | 432                     | 543                        | 52                            | 0.5     |                   |
| 5      | 398    | 0                         | 432                     | 776                        | 52                            | 0.5     |                   |
| 6      | 398    | 810                       | 389                     |                            | 33                            | 52      | 0.5               |
| 7      | 398    | 810                       | 302                     |                            | 120                           | 52      | 0.5               |
| 8      | 398    | 810                       | 216                     |                            | 206                           | 52      | 0.5               |
| 9      | 398    | 810                       | 130                     |                            | 302                           | 52      | 0.5               |
| 10     | 398    | 810                       | 0                       |                            | 432                           | 52      | 0.5               |

2.3 Preparation and testing of test pieces
The size of the recycled aggregate concrete specimens in each group was 100mm × 100mm × 100mm, a total of 6 specimens were produced in each group. The compression test was carried out on a YES-2000 compression test machine. The frost resistance test was carried out with reference to "concrete quality control standard GB50164-92". The strength loss rate and mass loss rate of each group of concrete specimens after 100 freeze-thaw cycles were measured.

3. Test Results and Discussion
3.1 Effect of Volcanic Slag Content on Compressive Strength of Recycled Aggregate Concrete for Construction Waste

The effect of volcanic coarse aggregate content on the compressive strength of recycled aggregate concrete is shown in Figure 1. The effect of volcanic fine aggregate content on the compressive strength of recycled aggregate concrete is shown in Figure 2.

It can be seen from Figure 1 fine aggregate is still using recycled waste brick fine aggregate, coarse aggregate part or all of the use of volcanic residue instead of coarse aggregate. Volcano slag coarse aggregate content of 10% of the recycled aggregate concrete compressive strength and the whole building waste recycled aggregate concrete compared to almost no difference. But the volcanic slag due to volcanic slag cylinder pressure is low, when the volcanic coarse aggregate content of 10% or more. The compressive strength of recycled aggregate concrete is gradually reduced and the degree of reduction is more than 5%. Figure 2 can be seen that the coarse aggregate is still recycled red brick aggregate, and fine aggregate part or all of the use of volcanic residue to replace. When the volcanic fine aggregate content of 10%-30%, the construction of recycled concrete concrete compressive strength slightly improved, and when the volcanic fine aggregate content of over 30%, the recycled aggregate concrete compressive strength is continued to decrease.

Figure 1: Effect of coarse aggregate of volcano slag on compressive strength of recycled aggregate concrete

Figure 2: Effect of fine aggregate of volcano slag on compressive strength of recycled aggregate concrete

3.2 Apparent Density of Recycled Lightweight Aggregate Concrete in Modified Slag

The results of the determination of the apparent density of the reconstituted light aggregate concrete of the modified waste brick of the volcanic slag are shown in Table 4

Table 4 volcanic slag modified waste brick recycled light aggregate concrete absolute dry apparent density

| Concrete type                              | All waste brick recycling light aggregate concrete | Volcano slag 100% alternative to waste brick Recycled coarse aggregate prepared concrete | Volcano slag 100% alternative to waste brick Recycled fine aggregate prepared concrete |
|-------------------------------------------|---------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Apparent density(kg/m3)                  | 1776                                              | 1694                                                                                 | 1753                                                                                 |

It can be seen from Table 4 that the apparent density of reconstituted lightweight aggregate concrete with flammable slag modified is less than the apparent density of recycled lightweight aggregate concrete.
3.3 Effect of Volcano Slag on the Frost Resistance of Recycled Aggregate Concrete for Construction Waste

The freezing and thawing tests of recycled aggregate concrete with coarse aggregate and volcanic slag fine aggregate are shown in Table 5.

Table 5 Frost Resistance of Recycled Lightweight Aggregate Concrete Modified by Flame Slag Modified Waste Brick

| Concrete type                  | All waste brick recycling light aggregate concrete | Volcano slag 100% alternative to waste brick Recycled coarse aggregate prepared concrete | Volcano slag 100% alternative to waste brick Recycled fine aggregate prepared concrete |
|--------------------------------|--------------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Freeze-thaw cycles             | 100                                              | 100                                                                                   | 100                                                                                |
| Strength loss rate(%)          | 16.5                                             | 9.3                                                                                   | 11.6                                                                               |
| Mass loss rate(%)              | 2.7                                              | 1.3                                                                                   | 1.8                                                                                |

It can be seen from the table, the incorporation of volcanic slag is clearly mentioned waste brick recycled lightweight aggregate concrete frost resistance. The porous structure of volcanic slag and the effect of "micro pump" of volcanic slag on the improvement of concrete structure have great influence on improving the frost resistance of concrete, the interface between the volcanic slag microstructure and the volcanic slag and the concrete cement transition zone is shown in Figure.3 and Figure.4.

Volcanic slag itself, the apparent density of small, in the mixed concrete, it was in the concrete was floating state, and waste brick recycled aggregate in the mixing was sinking state. The mixing of the two improves the homogeneity of the light aggregate concrete, reduces the loss of water, prevents the early plastic cracking, and greatly improves the frost resistance of the lightweight aggregate concrete. The porosity of the volcanic slag determines that it has significant water absorption and backwater in the cement slurry. It can be seen from Figure 4, volcanic slag and the interface transition zone cement stone structure matrix is more compact. Volcanic slag has a "self-curing" effect in the concrete, making the cement at the interface of the volcanic slag more fully hydrated. When the blended slag waste slag recycled light aggregate concrete, for the waste brick recycled lightweight aggregate concrete as a whole cement hydration more fully, the cement structure is more compact, thereby enhancing the concrete frost resistance.

![Figure 3: Pore structure of volcanic slag SEM](image1.png)

![Figure 4: Transitional interface between volcanic slag and cement](image2.png)
4. Conclusion
Volcanic slag can effectively reduce the apparent density of recycled lightweight aggregate concrete. The apparent density of the concrete prepared by replacing the waste aggregate with the volcanic slag is reduced from 1776 kg/m3 to 1694 kg/m3. In addition, volcanic slag greatly improves the frost resistance of waste concrete recycled aggregate concrete.

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