Study on Experimental of Waste Cathode Ray Tube Glass Fine Aggregate in Barite Concrete

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Abstract. In order to study the waste cathode ray tube glass fine aggregate (particle size < 0.15 mm) on barite concrete performance, the waste cathode ray tube glass fine aggregate is blended into the barite concrete at 0%, 4%, 6%, 8%, and 10% of the mass of the barite sand quality to conduct experimental research on the related properties of barite concrete. The experimental results show that when the amount of waste cathode ray tube glass fine aggregate is 6%~8%, the prepared barite concrete has the best working performance. The slump expansion reaches 560mm×560mm, and the 28d cube compressive strength is 37.76MPa. The V-box passage time is 17.56s, and barite concrete has the best shielding gamma ray capability.

1. Introduction
With the rapid replacement of display products, the cathode ray tube in display products becomes waste, and the oxides such as BaO, SrO and PbO will pollute soil and water resources, so it is not suitable to bury them directly, and proper disposal is required[1]. Therefore, harmless treatment and reuse of waste cathode ray tube glass is of great practical significance[2].

At present, a lot of research has been done on replacing part of coarse and fine aggregate to prepare concrete by grinding and sifting waste cathode ray tube glass. However, in the process of waste cathode ray tube glass processing, fine aggregates with particle size less than 0.15mm will be formed. In the past, it has been determined that such fine aggregates will have a negative impact on concrete performance, but some studies have found that such fine aggregates will have a positive impact on concrete, and their content should not be too high.

Foreign Moncea[3] took waste cathode ray tube glass fine aggregates as filling cementing materials and found that waste cathode ray tube glass fine aggregates could play a good role in filling and reducing strength loss. Khaled Saidani[4] pointed out that the addition of barite fine aggregate reduces the total shrinkage of concrete and increases the compressive strength of concrete. Liu xiaojun and Gong zhenbin[5] added barite fine aggregates with particle size less than 0.15mm into the barite concrete to improve the workability of the concrete, and pointed out that the reason why barite fine aggregates were added was because of its microaggregate effect. Hong hailu[6] mixed a certain amount of barite fine aggregate in the development of barite concrete, and found that it was helpful to improve the performance of barite concrete and improve its shielding ability. Tahir Celik, Khaled Marar[7] found that fine aggregates in mechanical sand could improve the performance of concrete mixture and the performance of cured concrete, but the content should not be too large, because excessive content would cause strength loss. Nam-shik Ahn[8] studied the influence of mechanical sand fine aggregate on the performance of concrete mixture, and found that mechanical sand fine aggregate could improve the working performance of concrete and the compressive strength was improved.
chuan, Li guhua[9] added fine aggregates less than 0.15mm in the mechanical sand into the concrete and found that it could improve the flow performance of high-strength and low-strength concrete, but when the content was too high, the flow performance of high-strength concrete would be adversely affected. On this basis, waste cathode ray tube glass microaggregates of 0%, 4%, 6%, 8% and 10% of the mass of barite sand were added to prepare barite concrete specimens, and the study was carried out from the aspects of slump extension of barite concrete, v-box passing time, cubic compressive strength and gamma-ray shielding performance.

2. Experiment

2.1 Raw materials and experimental instruments

Main raw materials: P· O 42.5 grade ordinary Portland cement produced in shaofeng, hunan, Barite (particle size 5~20mm, apparent density4154kg/m³) and barite sand (after drying, the barite fine aggregate less than 0.15mm is screened out, fineness modulus 2.71, apparent density 4128kg/m³) produced in hengyang, hunan, Waste cathode ray tube glass fine aggregate (particle size <0.15mm), A concrete mixing station poly carboxylic acid high efficiency water reducing agent (water reducing efficiency was 25%), and a certain power plant II level low calcium fly ash.

Main instruments and equipment: HJW60 concrete test mixer, V-box, Slump cylinder, TYE-2000B pressure testing machine, BH1326 nuclear technology applied physics experiment platform.

2.2 Waste cathode ray tube glass fine aggregate

Before concrete mixing, waste cathode ray tube glass was put into a standard sieve for mechanical screening, and the fine aggregates of waste cathode ray tube glass with particle size below 0.15mm after screening were retained as experimental raw materials. According to the different content of waste cathode ray tube glass fine aggregates, five groups of tests Z0 (control group), Z4, Z6, Z8 and Z10 were determined (Z represents barite concrete, 4, 6, 8 and 10 represent the percentage of waste cathode ray tube glass fine aggregates in barite sand quality). The performance indexes of waste cathode ray tube glass fine aggregates are shown in table 1. The chemical composition of waste cathode ray tube glass fine aggregates is shown in table 2.

Table 1. Performance index of waste cathode ray tube glass fine aggregate.

| Group | Maximum particle size (mm) | Apparent density (kg/m³) |
|-------|----------------------------|--------------------------|
| Z4, Z6, Z8, Z10 | 0.15 | 2926 |

Table 2. Chemical composition of waste cathode ray tube glass fine aggregate.

| Chemical composition | SiO₂ | PbO | K₂O | CaO | Al₂O₃ | Na₂O | BaO | MgO |
|----------------------|------|-----|-----|-----|-------|------|-----|-----|
| Percentage (%)       | 43.08| 29.98| 10.44| 4.65| 2.70  | 1.82 | 1.39| 0.79|

2.3 Mix proportion design

First the designed strength of barite concrete is 30MPa, second the water-binder ratio is 0.42, third the sand rate is 45%, then the content of waste cathode ray tube glass fine aggregate is 0%, 4%, 6%, 8% and 10%, finally the content of fly ash is 23%. The C30 barite concrete mix proportion is shown in table 3.

Table 3. Mix proportions of concrete. (kg/m³)

| Group | Cement | Fly ash | Barite 5-10(mm) | Barite 10-20(mm) | Barite sand | CRT | Water | Water reducing agent |
|-------|--------|---------|-----------------|------------------|-------------|-----|-------|---------------------|
| Z0    | 319    | 95      | 540.7           | 1004.3           | 1264        | 0   | 172   | 8.28                |
| Z4    | 319    | 95      | 540.7           | 1004.3           | 1264        | 50.56| 172   | 8.28                |
| Z6    | 319    | 95      | 540.7           | 1004.3           | 1264        | 75.84| 172   | 8.28                |
| Z8    | 319    | 95      | 540.7           | 1004.3           | 1264        | 101.12| 172  | 8.28                |
| Z10   | 319    | 95      | 540.7           | 1004.3           | 1264        | 126.4| 172   | 8.28                |
3. Results and discussion

3.1 Slump extension

After the waste cathode ray tube glass fine aggregates with different contents were mixed into barite concrete and fully stirred, the slump expansion test was carried out for three times through the slump tube, and the average value was taken as the result. The slump expansion was shown in table 4. As can be seen from table 4, with the increase of the content of waste cathode ray tube glass fine aggregate, the slump extension of barite concrete mixture first increases and then decreases, and the fluidity of barite concrete first increases and then decreases. On the waste cathode ray tube glass fine aggregate content is less than 6%, the mobility of concrete mixture is small, when the waste cathode ray tube glass fine aggregate content is more than 8%, the slump extending of concrete mixture begins to decrease. For barite concrete, the optimal content of waste cathode ray tube glass fine aggregate is 6%~8%.

In the barite concrete system, the waste cathode ray tube glass fine aggregate with a certain content can enhance the slump expansion of the concrete mixture. There are two reasons for this effect: (1) the fineness of waste cathode ray tube glass fine aggregates is close to the cement, and the incorporation of waste cathode ray tube glass fine aggregates increases the total amount of slurry; (2) the surface of waste cathode ray tube glass fine aggregate is smooth, which can reduce the friction between barite coarse aggregate and barite sand and improve the working performance of concrete mixture. The above two points are the positive effect of waste cathode ray tube glass fine aggregate on barite concrete, while the negative effect is that waste cathode ray tube glass fine aggregate still adsorbs a certain amount of water, and when the water consumption is fixed, the fluidity of concrete will decrease. Therefore, when the mixing amount of waste cathode ray tube glass fine aggregate exceeds a certain critical point, the slump expansion of barite concrete mixture will be reduced.

| Group | Slump expansion       | Average    |
|-------|-----------------------|------------|
| Z0    | 540×545 540×535 535×540 | 540×540    |
| Z4    | 540×545 550×550 540×550 | 545×550    |
| Z6    | 555×560 560×560 560×555 | 560×560    |
| Z8    | 555×560 550×550 555×565 | 555×560    |
| Z10   | 545×540 540×550 550×545 | 545×545    |

3.2 Passage time of V-shaped box

As for the influence of waste cathode ray tube glass fine aggregate content on the passage time of barite concrete mixer V-shaped box, through the comparison of test results of different groups, it can be seen from table 5, with the increase of the content of waste cathode ray tube glass fine aggregate, the V-shaped box outflow time of the barite concrete mixture first decreased and then increased. When the content of waste cathode ray tube glass fine aggregate is between 6% and 8%, the V-shaped box has the shortest passing time, and the barite concrete mixture continuously flows out of the V-shaped box at a uniform speed, and there is no clogging at the outlet at the bottom; When the content of waste cathode ray tube glass fine aggregate exceeds 8%, the time of V-shaped box is gradually extended, and the mixing speed of barite concrete is gradually uneven, which is reflected in the beginning of fast, then gradually slows down, showing a discontinuous state, and finally the discharge port at the bottom is blocked.

| Group | Z0  | Z4  | Z6  | Z8  | Z10 |
|-------|-----|-----|-----|-----|-----|
| V-shaped box passage time | 22.80 | 19.88 | 17.56 | 18.65 | 20.35 |
3.3 Cube compressive strength

After curing barite concrete of different groups to different ages, the cube compressive strength test was carried out to obtain the compressive strength of cubes of 7d and 28d, as shown in table 6 and figure 1. As can be seen from table 6 and figure 1. In the right amount, with the increase of the content of waste cathode ray tube glass fine aggregate, the 7d and 28d cubic compressive strength of barite concrete increases gradually, and decreases after exceeding the optimal value, the range of fluctuation is roughly 1~3MPa. In terms of the maximum cubic compressive strength, the best waste cathode ray tube glass fine aggregate of barite concrete is 6%.

According to the change of cube compressive strength, in the barite concrete system, the main factors influencing cube compressive strength are as follows: (1) the fineness of waste cathode ray tube glass fine aggregate is close to the fineness of cement, which can fill barite concrete to a certain extent; (2) waste cathode ray tube glass fine aggregates can promote the hydration process of cement and make cement stone more compact, thus improving its cube compressive strength. The above two are mainly the positive effects of waste cathode ray tube glass fine aggregates on cubic compressive strength. However, when the content of waste cathode ray tube glass fine aggregates exceeds a certain limit, a certain amount of waste cathode ray tube glass fine aggregates will cause damage to the compact structure in concrete. When there are more cementing materials in concrete, the positive effect of waste cathode ray tube glass fine aggregate will decrease and the negative effect will increase. It is because of the large amount of cementitious materials in barite concrete that barite concrete has good hydration characteristics and compact structure. When too many waste cathode ray tube glass fine aggregates are added, the compactness of barite concrete is destroyed and cube compressive strength tends to decrease.

| Group | 7d          | Average     | 28d          | Average     |
|-------|-------------|-------------|--------------|-------------|
| Z0    | 22.6522     | 22.66       | 32.3032      | 32.33       |
| Z4    | 24.8824     | 24.87       | 34.5634      | 34.54       |
| Z6    | 26.4526     | 26.53       | 37.8137      | 37.76       |
| Z8    | 24.8724     | 24.84       | 35.7135      | 35.70       |
| Z10   | 23.2823     | 23.35       | 33.4833      | 33.48       |

![Figure 1. Different groups of 7d, 28d cube compressive strength.](image-url)
3.4 Gamma ray shielding performance

After testing on the BH1326 nuclear technology applied physics test platform, the shielding ability of different groups to gamma rays was obtained, as shown in table 7. From table 7, with the increase of waste cathode ray tube glass fine aggregate content, compared with the Z0 control group, the muons of the Z4, Z6, Z8 and Z10 groups first increased and then decreased, and the thickness of the semi-declination layer and ten-fold attenuation thickness first decreased and then increased, indicating that the waste cathode ray tube glass fine aggregate improved the gamma-ray shielding ability of barite concrete. The main reason for the above changes is that high content of Pb in waste cathode ray tube glass fine aggregates, which promotes gamma ray shielding, so it improves the gamma ray shielding ability of barite concrete.

| Group | Muon/cm$^2$ | Semi-declination thickness/cm | Ten-fold attenuation thickness/cm |
|-------|-------------|-------------------------------|----------------------------------|
| Z0    | 0.235       | 2.944                         | 9.798                            |
| Z4    | 0.238       | 2.912                         | 9.675                            |
| Z6    | 0.244       | 2.845                         | 9.437                            |
| Z8    | 0.242       | 2.864                         | 9.515                            |
| Z10   | 0.236       | 2.943                         | 9.757                            |

4. Conclusion

After waste cathode ray tube glass fine aggregates are added, the fluidity of barite concrete is improved, the slump expansion first increased and then decreased with the increase of waste cathode ray tube glass fine aggregate content. The passage time of v-shaped box first decreased and then increased with the increase of waste cathode ray tube glass fine aggregate content. The optimal dosage range of slump expansion degree and v-shaped box passage time was 6%~8%.

Under the condition where the content of waste cathode ray tube glass fine aggregate is not high, cube compressive strength first increases and then decreases. Compared with the Z0 control group, cube compressive strength increases, with an increase range of 1~3MPa. In terms of cubic compressive strength, the optimal content of waste cathode ray tube glass fine aggregate is 6%.

When the content of waste cathode ray tube glass fine aggregate is within a certain range, with the increase of the content, the linear absorption coefficient of barite concrete increases, the thickness of semi-declination layer and 10-fold attenuation thickness decreases, and the radiation protection performance is improved.

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