Study on optimum design and repair of fair-faced recycled concrete

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Abstract. Guided by strategies for renewable resources and sustainable development, in the mix ratio design of the fair-faced recycled concrete, use broken waste concrete test blocks, and replace natural coarse aggregate by 40 % equal amount. The optimum dosage of water reducer and foaming agent was 1.33 % and 1.5 %, respectively, and the optimal match ratio was put forward. At the same time, the improved vibration technology is proposed to treat the quality of surface air bubbles and holes in fair-faced recycled concrete. Finally, using the scale model of bridge structure and the reserved Honeycomb and hemp surface, the repairing technology of fair-faced recycled concrete is studied, which is an effective treatment of construction quality disease, providing reference for the design and repair of fair-faced recycled concrete.

1. Introduction
With the rapid development of China's economy and the advocating of the concept of green building, fair-faced concrete has a good development prospect in China. As an environmentally friendly concrete and due to its excellent architectural appearance, there are many examples of the use of fair-faced concrete in advanced developed countries such as the United States, Germany, and Japan [1]. However, in the construction of fair-faced concrete, there are air bubbles, hemp surfaces, honeycomb and other quality defects not only affect the beauty of a building, but also affect the durability of the structure. It is necessary to prevent and control it. In the production process of fair-faced concrete, the foaming is the main link that affects the quality of fair-faced concrete. Compared with the advanced developed countries abroad, the research on fair-faced concrete in China starts late, and there are imperfect specifications and standards of fair-faced concrete, gaps such as construction technology need to be improved [2-4], and the research is imminent. In this paper, natural coarse aggregate is replaced by recycled coarse aggregate in the design of the mix ratio of fair-faced concrete. The optimal mix ratio of fair-faced recycled concrete is determined by the way of adding water reducers and foaming agents. At the same time, by using the scale model, the improved vibration and repair technology is proposed, and the quality of the fair-faced recycled concrete is effectively processed, which provides a reference for the foaming and the repairing of fair-faced recycled concrete.

2. Optimization Design of Raw Material Selection and Compatibility Ratio

2.1. Selection of raw materials
The raw materials are selected on the basis of the principle of local materials and determined by comparative tests as follows.
(1) Cement: using the low-hydration heat "Yatai brand" P · O42 .5 ordinary silicate cement produced by Jilin Yatai Cement.
(2) Natural coarse and fine aggregate: the coarse aggregate is made of granite gravel with 5 to 25mm continuous grade, the fine aggregate is made of river sand and produced by Yanji, with a fine modulus of 2.5 and the grade area is Area II. When constructed in summer, the coarse and fine aggregate material need to be stored in a shed, and special personnel are arranged to water regularly to reduce the temperature of the concrete.

(3) Fly ash: add Grade I fly ash to reduce the heat of cement hydration and increase the strength of concrete in later stages.

(4) Water reducer: reduce water ash ratio and increase strength.

(5) Foaming agent: choose industrial foaming agent, with good water reduction enhancement effect and slow condensation and plastic protection performance.

(6) Water: selection of clean and uncontaminated groundwater for testing.

(7) Recycled coarse aggregate: the waste concrete test block of Yanbian County Residential Construction Testing Center is selected, and after being broken, it is sifted into the continuous grades including 5 to 15, 15 to 20 of recycled stone, and the natural coarse aggregate is replaced by a 3:1 ratio mixture.

2.2. Mix optimization design

The strength level of recycled concrete in this experiment is C35, first of all according to the formula of the mix ratio of fair-faced concrete[5], get benchmark match ratio; secondly, the optimal ratio of C35 fair-faced recycled concrete is optimized through repeated trial and adjustment. The technical route for the optimization design of the fair-faced recycled concrete is shown in Figure 1.

![Figure 1. Technical Route for Optimizing the Design of Fair-faced Recycled Concrete](image)

The experimental ratio of C35 fair-faced recycled concrete was six in total, and the experimental results were compared by changing the amount of water reducing agent and defoaming agent under the same conditions. The test results show that the first group is the best match ratio. The outer surface of the test block has the least bubbles, holes, smooth surface, and the highest strength. The parameters of the first group are water glue with a ratio 0.40, fly ash partial replacement cement content is 10%, design collapse degree is 30mm, water reducing agent admixture is 1.16% of water quality, and foaming agent admixture is 1.5%of water quality. The optimal match ratio is Cement: Fly ash: Water: Sand: Stone: Recycle coarse aggregate: Regenerated fine aggregate: Water reducer: Foaming agent = 312:31.2:114:769.6:692.64:346.32:155.44:13.26:1.71.
Table 1. Mix ratio of C35 fair-faced recycled concrete

| Group | Cement | Grade I fly ash | Water | Sand | Stone | Recycled coarse aggregate | Recycled fine aggregate | Water reducer | Foaming agent |
|-------|--------|-----------------|-------|------|-------|---------------------------|-------------------------|---------------|---------------|
| 1     | 312    | 31.2            | 114   | 769.6| 692.64| 346.32                    | 115.44                  | 1.326         | 1.71          |
| 2     | 312    | 31.2            | 114   | 769.6| 692.64| 346.32                    | 115.44                  | 1.326         | 1.14          |
| 3     | 312    | 31.2            | 114   | 769.6| 692.64| 346.32                    | 115.44                  | 1.326         | 0.965         |
| 4     | 312    | 31.2            | 114   | 769.6| 692.64| 346.32                    | 115.44                  | 1.14          | 1.71          |
| 5     | 312    | 31.2            | 114   | 769.6| 692.64| 346.32                    | 115.44                  | 1.14          | 1.14          |
| 6     | 312    | 31.2            | 114   | 769.6| 692.64| 346.32                    | 115.44                  | 1.14          | 0.965         |

3. The law of intensity development with age and comparative test

Optimal mix ratio of C35 fair-faced recycled concrete, that is innovative addition of limestone powder based on the first set of match ratios. Replacing the fly ash by 1%, 2%, and 3% of cement weight, and compares it with the test block made with the optimal match ratio, compare surface bubbles, holes and surface smoothness. Optimal mix ratio of C35 fair-faced recycled concrete (+limestone powder) is shown in table 2.

Table 2. Optimal mix ratio of C35 fair-faced recycled concrete (+limestone powder)

| Group | Cement | Grade I fly ash | Limestone powder | Sand | Stone | Recycled coarse aggregate | Recycled fine aggregate | Water | Water reducer | Foaming agent |
|-------|--------|-----------------|------------------|------|-------|---------------------------|-------------------------|-------|---------------|---------------|
| 1     | 312    | 28.08           | 3.12             | 769.6| 692.64| 346.32                    | 115.44                  | 114   | 1.326         | 1.71          |
| 2     | 312    | 24.96           | 6.24             | 769.6| 692.64| 346.32                    | 115.44                  | 114   | 1.326         | 1.71          |
| 3     | 312    | 21.84           | 9.36             | 769.6| 692.64| 346.32                    | 115.44                  | 114   | 1.326         | 1.71          |

Optimal mix ratio of C35 fair-faced recycled concrete (+limestone powder) to test block strength with age curve as shown in Figure 2. Through the analysis of ORIGIN software, we can see, the overall upward trend. The 3D to 7D interval of the first group satisfies the linear equation $y=1.11975x+19.32775$; The 7D to 28d interval satisfies the linear equation $y=0.438x+24.0993$; as a whole, that is, the change law of the 3D to 28d interval satisfies the binary primary equation $y=0.02727x^2+1.38071x+18.75516$ ($R^2=0.99$). The 3D to 7D interval of the second group satisfies the linear equation $y=1.125x+17.391$; 7D to 28d interval satisfies the linear equation $y=0.4857x+21.81866$; as a whole, that is, the change law of the 3D to 28d interval satisfies the binary primary equation $y=0.02557x^2+1.38071x+16.854$. The 3D to 7D interval of the third group satisfies the linear equation $y=1.185x+16.2905$; 7D to 28d interval satisfies the linear equation $y=0.5254x+20.7223$; Overall, that is, the change law of the 3D to 28d interval satisfies the binary primary equation $y=-0.02532x^2+1.41175x+15.75868$.

Optimal mix ratio of C35 fair-faced recycled concrete to test block strength over age curve as shown in Figure 3. Through the analysis of ORIGIN software, we can see, the overall upward trend. The 3D to 7D interval satisfies the linear equation $y=0.806x+21.12$; The 7D to 28d interval satisfies the linear equation $y=0.5584x+22853$; Overall, that is, the variation curve from 3D to 28d interval satisfies the binary primary equation $y=-0.0099x^2+0.90503x+20.91204$. 
Optimal mix ratio of C35 fair-facéd recycled concrete (+ limestone powder) is compared with the test block of the optimal mix ratio, and the conclusion is obtained:

- The strength of the 28d test block in the two groups meets the design strength requirements. In contrast, the strength of the optimal match is higher than that of the test block.
- After comparing and analyzing the bubbles, holes, and smoothness of the test blocks in the three groups, it is concluded that the 1 % of limestone powder is the best one, but its effect is still not as good as the optimal ratio.
- The strength of the test block in the optimal match ratio (+ limestone powder) test group increased rapidly in the early stage of the 3D to 7D range, but the intensity increased the speed in the 7D to 28d range slowed down. And the 28d strength was less than the optimal match ratio of 5.5 % of the test block.

In summary, taking the factors such as strength level, smoothness and economy of sightseeing into account, it was decided not to add limestone powder and eventually to use the optimal match ratio.

4. Construction technology of stratified vibration of fair-faced recycled concrete
The rolling process of fair-faced recycled concrete is the key point in the whole construction process. Even if the coordination ratio is optimal, if the vibration is not in place, it still cannot produce
excellent fair-faced recycled concrete. The vibration process directly affects the perceived quality of fair-faced recycled concrete. In this paper, an improved vibration process is proposed to further process air bubbles and holes in the surface of fair-faced recycled concrete.

It is proved that the concrete surface bubbles can be reduced effectively by using stratified vibration [6], this article is drawing lessons from layered vibration [7] thrust the 60 s again before the condensation time to further remove the bubbles. The improved vibration process has been proved to be effective. In this experiment, the vibration table of concrete test block is selected and the improved vibration technology is adopted. The improved vibration process proposed in this paper is as follows:

Brush waste oil inside the cube test block die at 150 * 150 * 150 during the preparation phase prior to the start of the test, oil should not be added too much, the surface of a layer of enough. The pouring stages, firstly, clear water recycled concrete hits 60s when poured to 1/4 of the mold height; secondly, when you pour to 1/2 position, vibrate 60s again; Again, when pouring to 3/4 position, vibrate 60s; then, pour it all and vibrate the 60s; finally, the 60s will be rocked again before the condensation time to further eliminate the bubbles. In particular, the last part of the casting should be poured to the upper end of the concrete overflow mold. Prevention of insufficient concrete in molds after vibration. In the process of final vibration, the concrete above the mold should be flattened as much as possible with a small shovel. If the vibration time is too short, it cannot eliminate the effect of bubbles. If the vibration time is too long, it is easy to produce segregation, so the time for vibration should be around 60s.

5. Scale Model and Repair Technology

Footnotes should be avoided whenever possible. If it is required that they should be used only for brief notes that do not fit conveniently into the scale model of the bridge used in this experiment, it is shown in Figure 4. Using the improved vibration process, laminated columns and beams, and in the process of pouring the column, we use a left and a right approach. Each column is poured 3 times and the rebar position is adjusted when poured to 1/3 of the height of the column on the left, and then pour the right column. And so on, adjust the position of the steel bar when the same height is poured to 1/3 of its height, and tinkering. 10 to 20 times with bars after each layer is poured. Can it effectively avoid leakage of gluten and overall model offset quality disease.

![Figure 4. Graph diagram of bridge scale model.](image)

In order to propose the regenerated concrete repair technology through the experiment, so when pouring the scale model, there was no deliberate tinkering at the 1/3 connection between the two pillars. Pot, honeycomb, hole reserved, for repair tests of fair-faced recycled concrete.

The production process of the bridge scale model is shown in Figure 5.
The repair test is carried out in three cases: ① The slight surface lacks cement mortar to form a Pebble surface, repair with cement slurry with the same composition of fair-faced recycled concrete; ② The lack of cement mortar on the concrete surface forms a honeycomb exposed by stones, repair with cement slurry with the same composition of fair-faced recycled concrete; ③ Holes in which the depth and length of holes in concrete exceed the thickness of the protective layer, Two layers of cement mortar repair use the same composition of fair-faced recycled concrete.

Wet the concrete surface before starting repair, then repair with prepared cement or cement mortar, Second repair of the hole after condensation. Finally, the surface is repaired with dry cement to make it similar in color to the surrounding concrete surface.

6. Conclusion
In this paper, the regenerated coarse aggregate is selected in the design of the regenerated concrete mix ratio, and the natural coarse aggregate is replaced by 40% equal amount. The optimum dosage of water reducer and foaming agent was 1.33% and 1.5% respectively. The optimal ratio is put forward to provide references for the design of fair-faced recycled concrete.

This paper proposes a new type of vibration technology and repair technology for recycled concrete construction. With the use of layered vibration, as an effective processing of hemp surface, honeycomb, holes and other quality defects, it provides references for the construction of the fair-faced recycled concrete.

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