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Mechanical Properties and Fluidity of Grouting Material with Recycled Fine Aggregate at Different Temperature

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Abstract. At the present stage, the demolition industry of old building has produced more and more wastes. From the perspective of environment, economy and society, the amount of waste has reached an unacceptable level. Therefore, the resource utilization of waste has become a research hotspot. At present, as cement-based materials are the most widely used building materials in the world, the production of recycled aggregate from waste materials is an effective way to reuse cement-based materials. The fluidity, flexural strength and compressive strength of recycled fine aggregate grouting materials at 20 ℃, 30 ℃ and 40 ℃ were studied in this paper. The water cement ratio of the three grouting materials is designed to be 0.29, 0.37 and 0.45. The amount of recycled fine aggregate is 0%, 25% and 50% respectively. The results revealed that both the replacement of recycled fine aggregate and the high temperature had an adverse effect on the fluidity of grouting material. When the replacement of recycled fine aggregate increased, the initial fluidity decreased, also the fluidity after 30min. A rise in temperature had a similar effect. At 20°C, there is no obvious evidence that the amount of recycled fine aggregate affects the compressive strength and the flexural strength. Under the condition of 40℃, when the recycled sand content is 50%, the flexural strength of 28 days decreases. At 40℃, when the recycled sand content is 50%, the compressive strength of 3 days and 28 days decreases.

Keywords: waste materials; grouting materials; recycled fine aggregate

1. Introduction

The construction and demolition waste (CD&W) causes various environmental impacts at a global level [1]. Furthermore, the construction sector has paid close attention to the shortage of natural resources. Nowadays, many traditional practices are changed, in order to reduce the environment impacts and mitigate the climate change [2-4].

Recycled coarse and fine aggregates from CD&W are the most often used materials that can be added to concrete mixes [5-7]. Using the CD&W to produce recycled aggregate is one of the effective ways to reuse residues, since the most widely used construction materials in the world are the cement-based materials [8-9].

The properties of grouting materials were studied in this paper, including the fluidity, the flexural strength and the compressive strength. The test temperature was controlled to be 20°C, 30°C and 40°C. In order to study the effect of recycled fine aggregate, three water cement ratios were designed, which are 0.29, 0.37, and 0.45. For every water cement ratio, the replacement of the recycled fine aggregate were 0, 25% and 50% respectively.

2. Experimental program

2.1 Materials

Ordinary Portland Cement was chosen as binding material, of which the type was Cement Ⅱ. The properties of cement could meet the requirement of China National Standard GB/175-2009. River sand was chosen as fine natural aggregate (NA), of which the fineness modulus was 2.9.

2.2 Mix proportions

0.29, 0.37, 0.45 were chosen as the water cement ratios in this study. Recycled fine aggregate

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was used in the study, in order to reduce the dosage of fine NA, and the decrement of NA was 0%, 25%, 50%. The mix proportions of the reference samples were given in Table 1.

Table 1. The proportions of grouting material. (kg/m^3)

Water cement ratio	Cement	Water	River sand	Expansive agent	Super plasticizer agent
0.29	952	305	952	95.2	9.5
0.37	952	390	952	95.2	3.8
0.45	952	476	952	95.2	1.9

2.3 Specimen preparation properties test

The raw material was cooled or heated to the setting temperatures which were 20°C, 30°C and 40°C in advance. Then, all materials were uniformly mixed for 120s at setting temperature. The fresh grouting material was cast into molds after its fluidity was measured. After demolding, the specimens were put in the curing room. When the specimens reached the corresponding age, several of test would be performed. For all tests, 3 specimens were prepared for every mix proportion, and the average value of these 3 specimens was reported. The measurement of fluidity was operated immediately after mixing according to Chinese standard GB/T 50448-2015. The compressive strength and the flexural strength of grouting material casing at different temperature was tested at 3-day age, 7-day age and 28-day age. Compressive specimens and flexural strength with size of 40mm×40mm×160mm were carried out in accordance with GB/T 50448-2015.

3. Results and Discussions

3.1 The fluidity

The fluidity of grouting material is affected by water cement ratio, times and evaporation, and the evaporation is affected by temperature. Therefore, the effect of recycled sand on the fluidity of grouting material which has different water cement ratio was studied at different temperature, and the resulted was given in Figure 1.

The recycled sand has more pores than natural sand, more water was absorbed while mixing. So all of the initial fluidity of grouting material which has different water cement ratio was decreased when the dosage of recycled sand increased. Meanwhile, all of the initial fluidity of grouting material which has different water cement ratio was decreased with the increasing of temperature. When the grouting material had higher water cement ratio, the influence of temperature was more obvious. For the fluidity after 30 min, the similar variation rule could be found from figure 1. In order to match the requirement of fluidity and fluidity after 30 min according to GB/T 50448-2015, the dosage of recycled sand should be lower than 30% using at 30°C and 40 °C.

3.2 Mechanical properties of Grouting Material

1) Flexural strength. Figure 2 to figure 4 exhibited the influence of dosage of recycled sand on the flexural strength of grouting material with different water cement ratio at 20°C, 30°C and 40 °C. For all groups, the flexural strength increased with increasing of the curing ages.

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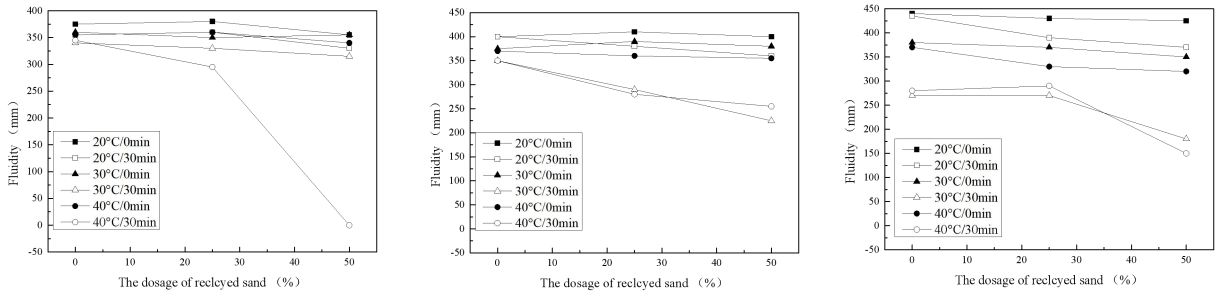
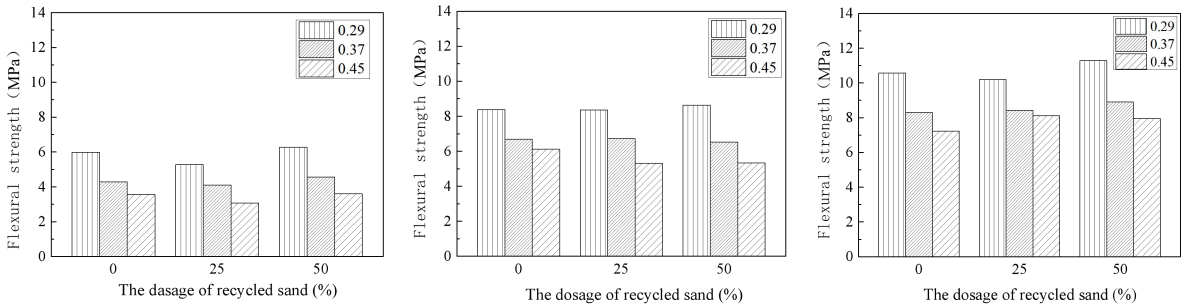


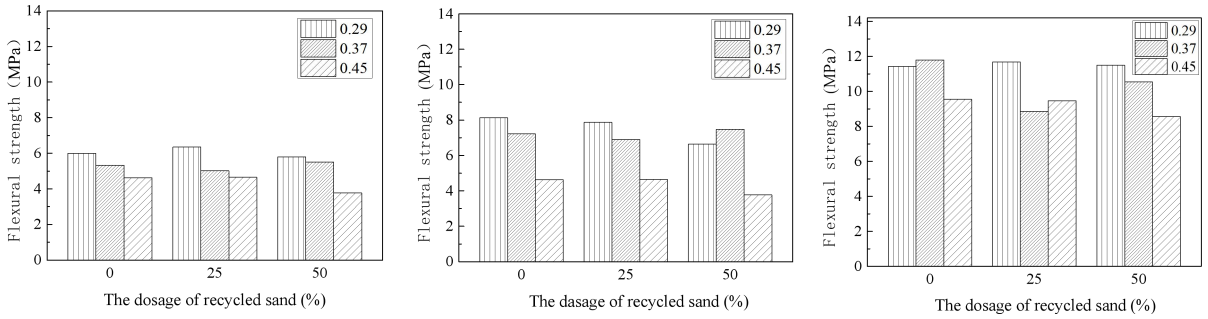
(a) The fluidity of grouting material(*w*/*c*=0.29) (b) The fluidity of grouting material (*w*/*c*=0.37) (c) The fluidity of grouting material (*w*/*c*=0.45)

Figure 1 The fluidity of grouting material



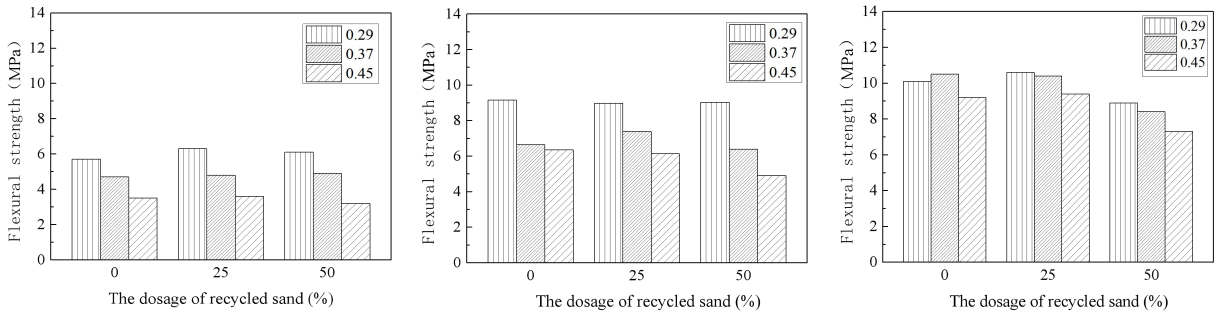
（a）Flexural strength (1d) （b）Flexural strength (3d) （c）Flexural strength (28d)

Figure 2 The flexural strength of grouting material at 20 °C



（a）Flexural strength (1d) （b）Flexural strength (3d) （c）Flexural strength (28d)

Figure 3 The flexural strength of grouting material ratio at 30 °C



（a） Flexural strength (1d) （b） Flexural strength (3d) （c）Flexural strength (28d)

Figure 4 The flexural strength of grouting material at 40 °C

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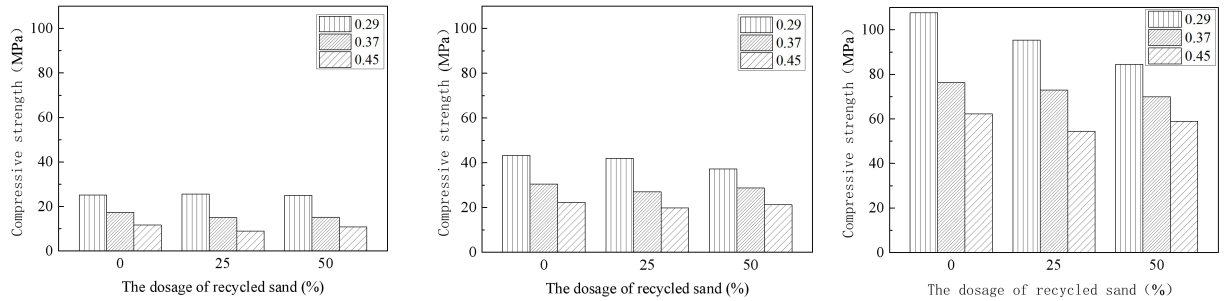
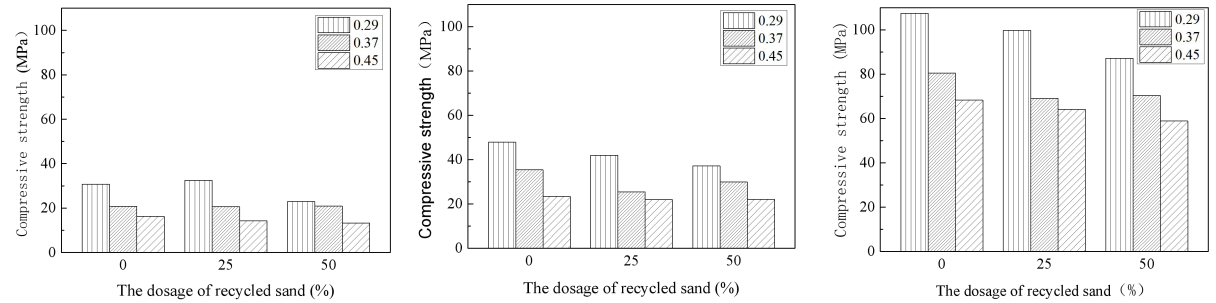


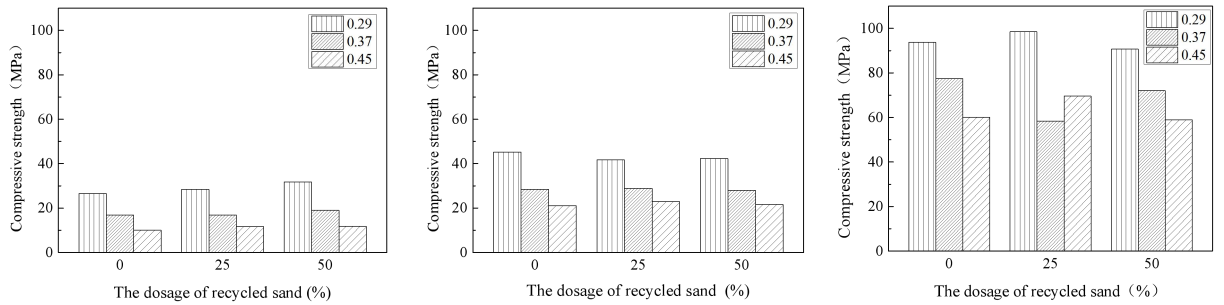
（a）Compressive strength (1d) （b）Compressive strength (3d) （c）Compressive strength (28d)

Figure 5 The compressive strength of grouting material at 20 °C



（a） Compressive strength (1d) （b） Compressive strength (3d) （c） Compressive strength (28d)

Figure 6 The compressive strength of grouting material at 30 °C



（a）Compressive strength (1d) （b）Compressive strength (3d) （c）Compressive strength (28d)

Fig 7 The compressive strength of grouting material at 40 °C

In the figure 2, the replacement of recycled sand has no remarkable influence on the flexural strength of grouting material which has different water cement ratio at 20°C. Water was absorbed while mixing by the recycled sand, and the recycled sand would work as self-curing materials. Therefore, the interfacial transition zone was improved during hydration. At the age of 28d, the flexural strength increased with the increase of the dosage of recycled sand.

Figure 3 showed the effect of the dosage of recycled sand on the flexural strength of grouting material which has different water cement ratio. When the test age was 28d, it was found that the flexural strength decreased when the replacement of recycled fine aggregate was 50% and the water cement ratio was 0.45. For other groups, the replacement of recycled sand has no remarkable influence on the flexural strength of grouting material at 30°C.

For all 3 water cement ratio, when the test age was 28d, the flexural strength decreased with when the dosage of recycled fine aggregate was 50%. While the water cement ratio was 0.45 and the dosage of recycled sand was 50%, the flexural strength at the age of 3d decreased. At 40°C, the

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decline of compressive was caused by poorer initial fluidity and the fluidity after 30min.

2) Compressive strength. Figure 5 to figure 7 exhibited the effect of r of recycled sand on the compressive strength of grouting material with different water cement ratio at 20°C, 30°C and 40 °C, and the water cement ratios were 0.29, 0.37 and 0.45. For all groups, the compressive strength increased with increasing of the curing ages.

In the figure 5, the replacement of recycled sand has no outstanding effect on the compressive strength of grouting material of which the water cement ratio was 0.37 and 0.45 at 20°C. When the level of water cement ratio was 0.29, the compressive strength of 28d decreased with the increasing of recycled sand.

In the Figure 6, the dosage of recycled sand has no noteworthy effect on the compressive strength of grouting material of which the water cement ratio was 0.45 at 30°C. For the samples with the water cement ratio of 0.29 and 0.37, the compressive strength of 3d and 28d decreased when the replacement of recycled sand increased.

In the Figure 7, for all three water cement ratios, when the replacement of recycled fine aggregate was 50%, the compressive strength of grouting material with the age of 3d and 28d decreased at 40°C. For the samples with the water cement ratio of 0.29 and 0.37, the compressive strength of 3d also decreased while the dosage of recycled fine aggregate was 25%.

4. Conclusions

Based on the above research and analysis, the following conclusions could be drawn:

Both the replacement of recycled fine aggregate and the high temperature had an adverse effect on the fluidity of grouting material. When the replacement of recycled fine aggregate increased, the initial fluidity decreased, also the fluidity after 30min. A rise in temperature had a similar effect.

For grouting material, at 20°C, the mechanical properties which include the flexural strength and the compressive strength had no significant change with the dosage of recycled fine aggregate. When the test age was 28d, the flexural strength of the grouting material with the recycled sand dosage of 50% and the water cement ratio of 0.45 at 30°C. The flexural strength of the samples with the age of 28d decreased while the replacement of recycled fine aggregate was 50%, and the temperature was 40°C.

For the grouting material with the water cement of 0.29, at the age of 28d, the compressive strength was decreased with the increasing of recycled fine aggregate at 30°C. When the test ages were 3d and 28d, the compressive strength decreased when the replacement of recycled fine aggregate was 50%, and the test temperature was 40°C.

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