Research on the Mechanical Properties of Self-compacting Waste Rubberised Aggregate Concrete

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Abstract: In order to study the changing regularity of rubber particles impact on self-compacting concrete deformation performance, with SCC30 strength of self-compacting concrete as the base, with different amount of rubber particles volume instead of fine aggregate in self-compacting concrete sample, preparation of rubber self compacted concrete prism test block test. The results show that, the rubber particles in self-compacting concrete in more uniform distribution, compared with the reference group, self-compacting concrete with the maximum tensile strain increase, reduce the maximum compressive strength, with the content of rubber particles increases the maximum tensile strain has the tendency of increase, in the admixture of 15% of the largest increases in. Bending tests on different mixing amount of rubber self-compacting concrete specimen. The results show that, the rubberized self-compacting concrete specimens under bending is generated in the process of plastic deformation is obvious, the specimen at ultimate load after plastic deformation ductility damage greatly, compared with the reference group limit deformation values are greatly improved.

Introduction

With the rapid development of the automobile industry, scrap tires also increased dramatically. China has become one of the largest waste rubber producing countries in the world. According to the development of China Rubber Industry Association organized the "Twelfth Five Year" development plan, from 2011 to 2015, China's output of powder particles will reach 300 million tons, more than 200% growth[1]. Rubber tire under natural conditions of refractory, landfill and stacked easily become mosquito breeding places, environmental pollution, the spread of the disease and may cause fire[2]. Waste rubber powder production process is simple, less energy consumption, no pollution to the environment, become developed countries using waste rubber, waste rubber powder in the use of waste rubber in China way accounted for only 7.5%, far below the reclaimed rubber 71.3%[3], and the important significance of how to use the growing waste tire for environmental problems in China's relief.

Self-compacting concrete (Self-Compacting is to study referred to SCC, also known as free vibration of self-compacting concrete) as early as in 1988, the first by a Japanese scholar Okamvra in 1986 proposed[4]; self-compacting concrete is significantly different from the characteristics of ordinary concrete[5], but with ordinary concrete, the tensile strength is low, brittleness, easy cracking.

In order to improve the crack resistance and deformation of concrete, some scholars have replaced the rubber particles in the concrete, so as to improve the deformation of concrete[6]. Although concrete with incorporation of rubber particles above the superior mechanical properties, but in the construction process of concrete, because the rubber particle proportion is light, resulting in in vibrating, floating of the rubber particles, the specimen internal rubber particle distribution uneven, which resulted in crumb rubber concrete in engineering practice is difficult to a wide range of applications. In order to improve the concrete deformation performance, promote the wide application of rubber concrete, the rubber particle applied to self-compacting concrete, make full use of the self-compacting concrete has its own characteristics, so as to improve the rubber particle in internal distribution uneven, in cracking requirements and strength to has a potential application prospect of Engineering fields, also dealing with growing of waste rubber tire is very effective way. In this paper, the deformation behavior of self-compacting concrete mixed with rubber particles is studied.


Fig. 1 rubber particles in experiment

Experimental materials and test method

Experimental material

Cement: Jiangxi conch brand 42.5 ordinary portland cement; coarse aggregate: Ganjiang river

pebbles, particle diameter of 5 ~ 20mm, well graded; fine aggregate: sand, river sand, well graded, physical parameters see Table 1. Water reducing agent, agent and solid content of 20% liquid polycarboxylate superplasticizer; fly ash: Jiangxi Hongda new materials 1 grade fly ash, the physical indexes of fly ash are shown in Table 2. Rubber particles: the production of Feng Jia plastic factory in Fengcheng City, Jiangxi Province, the abundant granulated rubber particles, the appearance of the product is like Figure 1. Water: tap water in the laboratory.

Table 1 The physical indexes of sand

Performance density kg/m³	Mica content （%）	Mud content （%）	Clay content （%）	Modulus of fineness
2610	0.4	0.4	0.3	2.32

Table 2 The physical performance of fly ash

Density （kg/m^3）	Fineness	Water requirement	Moisture content （%）	Loss on ignition （%）	SO3 （%）
2200	11	93.5	0.323	4.7	2.54

Optimization of mixing proportion in self-compacting concrete

According to the research group on the study of self-compacting concrete experiences[7] and many pre-mixed test determines basic cooperation such as self-compacting concrete in Table 3.

Table 3 Mix proportions of rubber Self-Compacting Concrete

No.	The amount of Rubber Self-Compact Concrete（kg/m³）					
	Aggregate(kg)	Sand (kg)	Cement (kg)	fly ash (kg)	Water (kg)	Rubber (%)
SCC-1	804	761.46	353.42	151.47	206.19	0.0
RSCC-2	804	692.93	353.42	151.47	206.19	5.0
RSCC-3	804	677.70	353.42	151.47	206.19	10.0
RSCC-4	804	662.47	353.42	151.47	206.19	15.0
RSCC-5	804	647.24	353.42	151.47	206.19	20.0
RSCC-6	804	632.01	353.42	151.47	206.19	25.0

Annotation: water cement ratio：0.41，Water reducing agent(%)：1.0

Test method of property

Test equipment

HJW60 concrete in the laboratory compulsory mixer for concrete mixing, moulding. Compressive stress-strain curve by WAW-1000 electro-hydraulic servo testing machine for testing, data acquisition system for SANS PowerTest V3.2 in Chinese, by hanging/0-10-type dial gauge collection beam deflection in the loading process to undermine the whole process.

Test plan

Equal amounts of rubber particles replace sand by volume, using 5 different proportions of the volume fraction of particles of rubber (respectively, 20%, 5%, 10%, 25%) self-compacting concrete pour rubber specimen (Rubber Self-Compact Concrete, RSCC for short), rubber particles and volume of 38.07, 76.15, 114.22 kg/m ³, and 152.29, and 190.37kg/m ³, the mix is shown in table 3. For determination of deformation test of RSCC component size is 100 mm*100 mm*450 mm, per group of 3 specimens. Test main test content including load contains displacement curve and concrete of stress-strain curve, concrete by pressure stress strain curve through WAW-1000 electric liquid servo test machine for test, data acquisition system for SANS PowerTest V3.2 Chinese version, the equipment and data acquisition system can test get concrete material stress strain full curve, test process in the, stress strain curve rose paragraph used stress control, curve declined paragraph used displacement control. By Hung/0-10-type dial gauge collection beam deflection in the loading process to undermine the whole process. Test process, loaded with displacement control, 0.01mm/min loading speed, WAW-1000 control of electro-hydraulic servo testing machine for displacement, stress 0.05Mpa for each additional data is collected. Test point arranged as shown in Figure 2.

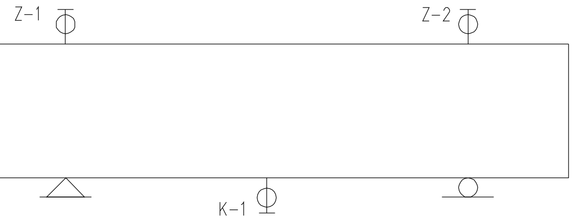

Fig. 2 Instrumentation plan

Test result analysis

Macro damage of self-compacting concrete

Evident from the failure pattern of concrete block, without the rubber SCC1, as the load increases, on a specimen vertical first produces a diagonal cracks, continues to load when it reached the limit load, sudden failure of the specimen without adding rubber particles exhibited characteristics of brittle failure of self-compacting concrete. With rubber powder particles of mixed into, in RSCC2~6 rubber since dense concrete try pieces in the, with loaded of increased, with SCC1 try pieces different, in RSCC2~6 all try pieces of surface first will produced more crack, continues to loaded reached limit load contains Shi, try pieces along more article crack damage, no appeared try pieces suddenly damage phenomenon, in this test phenomenon can obtained, rubber particles of mixed into, since dense concrete of damage nature occurred has significantly to changes, reduced has since dense concrete of brittle, improve has toughness.

Basic features of stress-strain curve of self-compacting concrete

Figure 3 for RSCC stress-strain relationship, as the chart show, RSCC stress-strain relation of stress-strain relationship of SCC is similar with the benchmark group, strain rose sort of elastic, elastic-plastic phase, crack-and destruction stages in four stages. By comparison with the benchmark group, RSCC elastic limit stress and crack are smaller, RSCC peak stress is smaller. With increasing strain, stress increased slowly, but at the cracking point, RSCC strain than the baseline group of SCC strain, and reaches the limit load, RSCC is not immediately destroyed, liquidated a certain toughness, show that deformation of the RSCC has better performance.

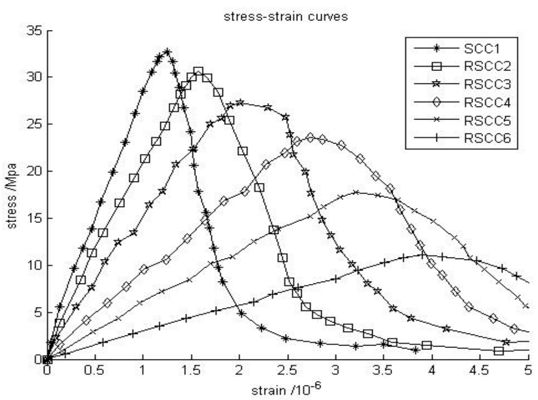

Fig. 3 stress-strain Relation of Rubber Self-Compact Concrete

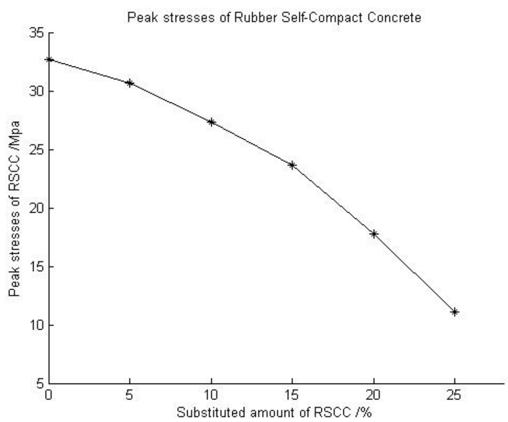

Fig. 4 Peak stresses of Rubber Self-Compact Concrete

Figure 4 for RSCC age 28 days of peak stress with the amount of rubber granules. The figure 4 shows that, with the increasing amount of rubber particles of peak stress decreases, but lower the level of the different. And when the content becomes 15%, the slope of the curve, indicating that when the rubber content is greater than 15%, peak stress increased, the rate of decline of the compressive strength of concrete. Curve changes as a whole show a certain regularity, and does not appear when a certain amount of stress peaks mutations, this differs from the research of rubber concrete such as Yuan Qun[8], this also indicates that the rubber in self-compacting concrete distribution is more uniform, little rubber particles agglomeration phenomenon. Figure 5 the RSCC was age 28 days of peak strain with the addition of rubber. Figure 5 shows that, with the increasing amount of rubber particles peak strain continues to increase, that is, deformation capacity of reinforced, as can be seen from the diagram, with the increase of amount of peak strain increment is the same. Amount of rubber particles in 15%, the strain increases most pronounced overall increasing curve of deformation capacity are increasing.

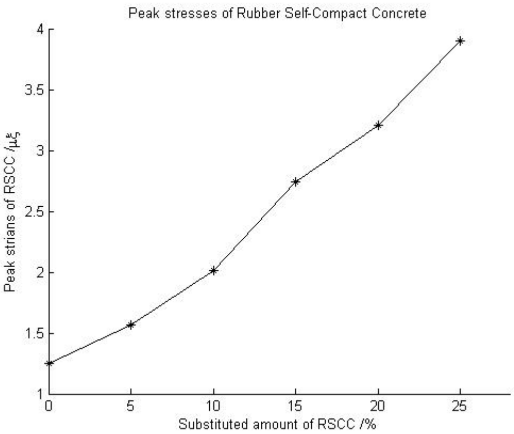

Fig. 5 Peak strains of Rubber Self-Compact Concrete

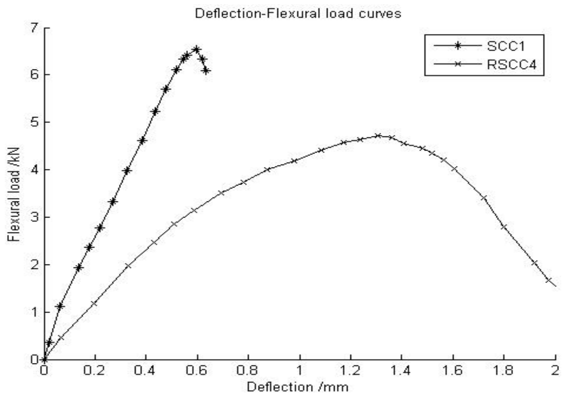

Fig.6 Flexural load-Deflection curves of Rubber Self-Compact Concrete

Bending deformation of self-compacting concrete

Ultimate tensile strain and flexural failure properties are deformation performance of concrete is characterized by two main indicators[9]. Figure 6 is a moment of load-deflection (Flexural load-Deflection curves of Rubber Self-Compact Concrete) curve. You can see from Figure 6, comparison group of self-compacting concrete rubber mixed and there is a clear difference between self-compacting concrete, SCC1, when the ultimate load is reached, rapid destruction of concrete, there are obvious characteristics of brittle failure. RSCC4, due to the rubber mix, after reaching the limit load, some deformation of the concrete.

Table4 Mechanical properties of Rubber Self-Compact Concrete

NO.	Compressive strength /Mpa			Reduction of Stress	Ultimate strain /με	Addition of Strain	Flexural load /kNm
	3d	7d	28d				
SCC-1	22.27	30.44	34.70	-	1.25	-	5.46
RSCC-2	21.20	27.91	32.64	2.06	1.57	0.32	5.12
RSCC-3	19.60	25.50	29.30	3.34	2.01	0.44	4.92
RSCC-4	17.15	21.31	25.62	3.68	2.74	0.73	4.67
RSCC-5	12.60	16.47	19.80	5.82	3.21	0.47	4.24
RSCC-6	7.90	10.23	13.10	6.70	3.90	0.69	3.92

From table 4, you can see the ultimate tensile strain of concrete with adding different amounts of different degrees of increase, from the SCC1-RSCC6 strain was 1.25, 1.57, 2.01, 2.74, 3.21 and 3.9 με, 15% groups are not mixed with rubber rubber content than strain 2.19 times times higher. With the increase of rubber granules, increased deformation properties of self-compacting concrete and compressive strength will decrease from table 4, by comparing the stress amplitude and increasing strain amplitude, RSCC4 stress amplitude in the least, increase of strain amplitude maximum.

Damage mechanism of self-compacting concrete of rubber

According to the theory of fracture mechanics, fracture of the material is produced by the progressive development of micro-cracks get bigger. Materials due to brittle fracture of material accumulated within the maximum flexibility to quickly shift before the material fracture critical fracture surface energy, rapid expansion of main cracks in a very short period of time and material failure. However, rubber in self-compacting concrete, Crumb rubber, surface roughness, waterproof and flexible, and very good bonding with the concrete; thus, rubber even distribution of self-compacting concrete in the form of flexible, scalability of the particle group, effective control of crack formation and development, improving the deformation properties of the material.

Conclusions

(1) Tests showed that rubber particles mixed in self-compacting concrete, effective peak strain of reinforced concrete, improve the deformation behavior of self-compacting concrete, but self-compacting concrete strength is reduced. With the increase in rubber mixing, peak strain increased peak stress decrease. Amount of rubber particles in 15%, the largest increase in peak strain and peak stress decrease rate of change is faster.

(2)Rubber particles mixed with self-compacting concrete, rubber granules evenly distributed over the specimen, improvement of uneven distribution of rubber particles in ordinary concrete, effectively delaying the cracking of the concrete, and after the cracks in concrete, different from the ordinary self compacting concrete, rubber self-compacting concrete is not immediately destroyed, show a certain degree of plastic deformation.

(3)This paper studies the rubber self-compacting concrete stress-strain and deformation performance of the preliminary discussion, there are still many issues to be further studied, like mixing different rubber particles or deformation of the rubber powder on self-compacting concrete performance and rubber for self-compacting concrete cracking resistance, frost resistance, and durability.

Acknowledgements

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