УДК 691

Ван Сяньпэн[1],руководитель-Леонович С.Н.[2]
(БНТУ, ГМ, РБ)

FAILURE MECHANISM AND STRENGTH EXPERIMENT DESIGN OF COIR FIBER AND STEEL FIBER RECYCLED CONCRETE

Due to the limited resources and environment of the Republic of Belarus, the development of renewable concrete to improve the economic and environmental value is the primary task of today's construction engineering scientific research. The mechanical properties of recycled concrete are lower than virgin concrete. How to improve the mechanical properties of recycled concrete and enhance its tensile, compressive and shear strength is the research goal of the majority of scientists. In order to solve this problem and reform the energy problem of the Republic of Belarus, it is proposed to use steel fibers and coir fibers to improve the toughness and tensile strength of concrete, adding rigid fibers and coir fibers to recycled concrete.

In order to study the mechanical properties of steel fiber and coir fiber recycled concrete under composite shearing state, with the substitution rate, normal stress and the content of steel fiber and coir fiber as the changing parameters, a standard cube specimen was designed for composite shearing test. The failure modes of steel fiber recycled concrete and coconut shell fiber concrete under the action of direct shear and compression shear were observed, and the shear stress-displacement curve of the whole process under the action of direct shear and compression shear was obtained. The effect of normal stress and the content of steel fiber and coir fiber on the shear strength and peak displacement of steel fiber recycled concrete and coir fiber concrete. The purpose of the experiment is to determine the optimum content of steel fiber and coir fiber, as well as the shear strength of steel fiber and coir fiber recycled concrete. The influence of the increase of normal stress and substitution rate on steel fiber and coir fiber concrete, so as to compare and analyze the mechanical properties and environmental protection and economic value of coconut shell concrete and steel fiber concrete. Steel fiber is shown in Figure 1 below, and coir fiber is shown in Figure 2 below.

The experimental materials are set as follows:

R42.5 ordinary Portland cement is used; the natural coarse aggregate is ordinary crushed stone, and the recycled coarse aggregate is obtained by crushing and screening the concrete in the construction waste by a jaw crusher, and the particle size of the coarse aggregate is 10~20mm.

continuous gradation, the fine aggregate is natural river sand in the Minsk Sea; the mixing water is laboratory tap water; corrugated steel fibers are used, with a length of 40mm, a width of 4mm, a diameter of 0.8mm, and a density of 7.8g/cm³; the tensile strength is greater than 1200MPa , the value is 8.5g. Coir fiber is 40mm long, 3-5mm wide, 0.45mm in diameter, and 1.12g/cm³[1] in density. The mixing ratio design is based on the substitution rate of 0%, and the target design strength is C40. Since the water absorption rate of recycled coarse aggregate is much higher than that of natural coarse aggregate, in order to ensure the workability of recycled concrete, when the replacement rate of recycled coarse aggregate is 100%, the water consumption per cubic meter of concrete is increased by 25kg, and the rest of the water consumption varies with the recycled coarse aggregate. increase with the increase in the substitution rate. The physical properties of the material are shown in Table 1、Table 2 - Mix ratio of steel fiber recycled concrete、

Fig.1 Steel fiber

Fig.2 Coconut fiber

Table 1 - Physical Properties of Materials

	Apparent density kg/m³	Bulk density kg/m³	crush indicator %	moisture content %	water absorption %
NCA	2703	1450	18	0.07	0.43
RCA	2560	1322	26	1.55	5.35
sand	2635	1640	-	0.45	-
steel fiber	2285	1290	-	0.35	0.2
Coconut fiber	2460	1202	16.3	0.60	4.8

PS： NCA-natural coarse aggregate、RCA-recycled coarse aggregate

Table 2 - Mix ratio of steel fiber recycled concrete

r/ %	W/C	Concrete material amount					
		cement	water	sand	NCA	RCA	SF
0	0.43	498	215.00	541	1153	0	78.5
30	0.45	498	222.95	541	807	346	78.5
50	0.46	498	227.87	541	577	577	78.5
70	0.47	498	232.79	541	346	807	78.5
100	0.48	498	240.00	541	0	1153	78.5

PS：NCA-Natural coarse aggregate、RCA-Recycled coarse aggregate、SF-Steel fiber

Table 3 - Mixing ratio of coir fiber recycled concrete

r/%	W/C	Concrete material amount					
		cement	water	sand	NCA	RCA	CF
0	0.28	498	240	541	1153	0	112
30	0.49	498	247.95	541	807	346	112
50	0.50	498	252.87	541	577	577	112
70	0.51	498	257.79	541	346	807	112
100	0.53	498	265	541	0	1153	112

PS：NCA-Natural coarse aggregate、RCA-Recycled coarse aggregate、CF-Coconut fiber

Taking normal stress, substitution rate, steel fiber and coir fiber content as changing parameters, we need to design 136 standard cube specimens with dimensions of 100mm×100mm×100mm. Considering three cases of normal stress (σu) 0MPa, 3MPa, 6MPa and five cases of substitution rate (r) 0%, 30%, 50%, 70%, 100%, steel fiber volume content (Vf) 0%, There are three cases of 0.5% and 1%, and three cases of 1%, 2% and 3% are considered for coir fiber, a total of 45 groups, 3 in each group, a total of 135 specimens, for direct shear and compression shear tests, refer to Belarusian concrete control sample test method GOST 10180-2012.[2]. The detailed parameters are shown in Table 4.

Referring to the "Belarusian Concrete Test Method Standard" GOST 13015.0-83 [3], the test uses a screw-type hand-held electric mixer to mix concrete, and the mixer is pre-wetted before feeding. The feeding sequence of steel fiber experimental group was in the order of coarse aggregate, fine aggregate and cement, and dry mixing for 2 minutes. After the aggregate and cement were evenly mixed, the steel fiber was continuously and uniformly added, dry mixing for 2 minutes, and then continuous and uniform. Add water, stir for 5-10 minutes and then pour, and the steel fibers are well dispersed during the stirring process. And vibrate the

specimen on the vibrating platform to make the bubbles completely emerge, cover the protective film and carry out the test after curing for 28 days under the standard curing conditions.

Table 4 - Specimen design parameter table

Number	RC			SFRC			CFC		
	σu/MPa	r/%	Vf/%	σu/MPa	r/%	Vf/%	σu/MPa	r/%	Vf/%
1	0	0	0	0	0	1	0	0	1
2	0	30	0	0	30	1	0	30	1
3	0	50	0	0	50	1	0	50	1
4	0	70	0	0	70	1	0	70	1
5	0	100	0	0	100	1	0	100	1
6	3	0	0	3	0	1	3	0	1
7	3	30	0	3	30	1	3	30	1
8	3	50	0	3	50	1	3	50	1
9	3	70	0	3	70	1	3	70	1
10	3	100	0	3	100	1	3	100	1
11	6	0	0	6	0	1	6	0	1
12	6	30	0	6	30	1	6	30	1
13	6	50	0	6	50	1	6	50	1
14	6	70	0	6	70	1	6	70	1
15	6	100	0	6	100	1	6	100	1
16	0	100	0.5	-	-	-	-	-	-

PS：RC-Recycled concrete、SFRC-Steel fiber reinforced concrete、CFC-Coconut fiber concrete

The coir fiber experimental group was fed in the order of coarse aggregate, fine aggregate, and cement in sequence, and the mixture was dry mixed for 2 minutes. Continuously and evenly add water, stir for 5-10 minutes, and then pour. During the stirring process, the coconut husk fibers are well dispersed, and vibrate the specimen on a vibrating platform to make air bubbles completely emerge, cover with a protective film, and under standard curing conditions Tests were carried out after 28 days of curing.

Experimental instruments and test methods：

The study was based on testing samples of 100mm×100mm×100mm prisms on a Controls 70-C0820/C tensile testing machine. The test was carried out for tensile bending according to a four-point loading scheme (GOST 10180). [4] And the combination of force control and position control The test was carried out with a combined loading system, the loading speed was 5 kN/min.s and 0.02 mm/s when the sample was damaged and sheared in millimeters The test was stopped when the amount of stress change was less than 2 % shear strength. As shown below Fig.3 and 4.

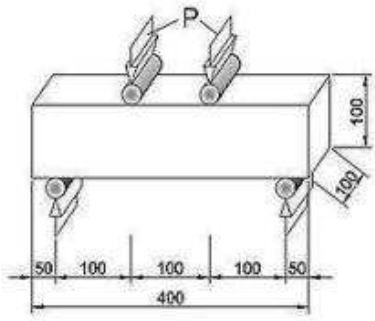

Fig.3 test scheme

Fig.4laboratory apparatus

References

[1] Ван М, Ван С. Койровый фибробетон бетонный композит[J]. 2020. https://rep.bntu.by/handle/data/84558

[2] ГОСТ 10180-2012.Бетоны. Методы определения прочности по контрольным образцам. https://normy.by/fond.php

[3] ГОСТ 13015.0-83.Конструкции и изделия бетонные и железобетонные сборные. Общие технические требования. https://normy.by/fond.php

[4]Садовская Е А, Леонович С Н, Будревич Н А. Вязкость разрушения нанофибробетона с фиброй из листовой стали на разрывной машине[J]. 2020. .https://rep.bntu.by/bitstream/handle/data/84048/265-272.pdf?sequence=1