Research on Failure Mode and Ductility of Waste Fiber Recycled Concrete Columns under Small Eccentricity

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Abstract. This paper studies small eccentric compression test of eight waste fiber recycled concrete columns with recycled coarse aggregate replacement ratio, waste fiber length, and waste fiber incorporation as parameters. The test is carried out on the failure mode and ductility of the waste fiber recycled concrete columns, which are also compared with those of the ordinary concrete column.

Introduction

During the past period of time, domestic and foreign scholars mainly studied the effects of the recycled coarse aggregate on the compression performance of recycled concrete columns[1,2], but researches rarely involved the content that the influence of waste fiber on the mechanical properties of waste fiber recycled concrete columns. On the basis of the research at home and abroad, this paper studies the stress process and failure pattern of the waste fiber recycled concrete columns. The conclusion is obtained through the research on the influence of recycled aggregate replacement ratio, waste fiber length and incorporation on the lateral deformation and ductility of waste fiber recycled concrete columns under small eccentricity.

Test Method

Mix Proportion of Waste Fiber Recycled Concrete

The recycled coarse aggregate is formed by concrete with the original strength grade C40 being artificially processed by way of crushing, washing and grading, and the particle size is between 5 and 25 mm. The natural coarse aggregate uses continuously graded rubble with the particle size between 5 and 25 mm. The fine aggregate uses the natural river sand. The cement uses P.O. 42.5 ordinary portland cement. The waste fiber is got from waste carpet after artificial treatment and polypropylene fiber is its main ingredients[3].

Tab. 1 Mix Proportion of Waste Fiber Recycled Concrete

Water-cement ratio w/c	cement [kg/m^3]	sand [kg/m^3]	gravel [kg/m^3]	recycled coarse aggregate [kg/m^3]	water [kg/m^3]
0.5	390	709	1156	0	195
0.5	390	709	578	578	205
0.5	390	709	0	1156	215

Specimen Design

The replacement rates of the recycled coarse aggregate are 0, 50% and 100%, the lengths of the waste fiber are 12mm, 19mm and 30mm, and the incorporation proportions are 0.08%, 0.12% and 0.16% in the test. While the specimens are being made, three test cubes are cast with the same sizes of 150 mm ×150 mm× 150 mm. Compressive strength of the cubes is tested in order to measure the

compressive strength of different concrete specimens.

Tab. 2 Grouping of Specimens and the Compressive Strength of Concrete

Specimen number	Waste fiber length [mm]	Waste fiber incorporation [%]	Recycled aggregate replacement ratio [%]	Compressive strength of cubes [MPa]
1	19	0.12	0	34.27
2	19	0.12	50	33.68
3	19	0.12	100	30.36
4	12	0.12	50	31.53
5	30	0.12	50	31.46
6	19	0.08	50	30.31
7	19	0.16	50	31.14
8	0	0	0	42.51

Reinforcement and Loading Method of the Specimens

The columns are loaded with vertical and eccentric pressure by using a jack, and the eccentricity is 60mm. Before cracking, the columns are loaded with 20% of the the pre-computed ultimate bearing capacity per level. When reaching 90% of the ultimate bearing capacity, the loads are reduced in half and taken about 10% of the ultimate bearing capacity per level in order to accurately measure the lateral deformation of the columns[4,5]. When the columns are nearly destroyed,the loads are slowly and continuously .

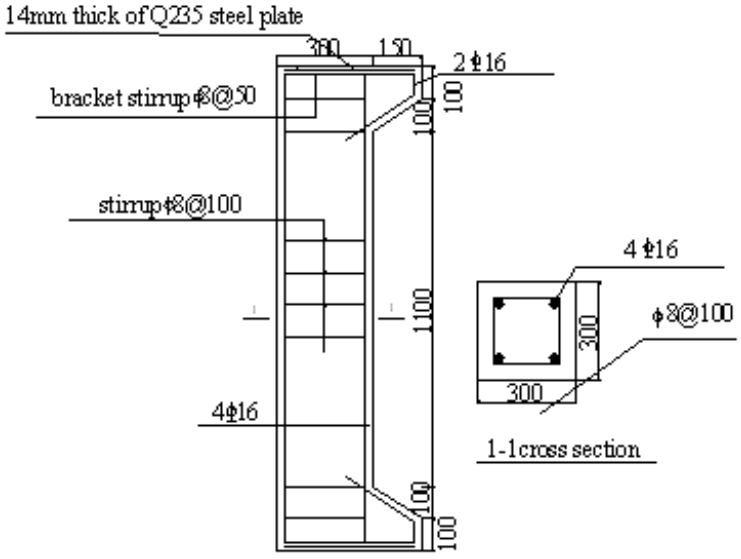

Fig.1 Reinforcement of the Specimens

Test Analysis

Failure Mode

In the test, all the eccentric compression columns have four same working stages, namely, elastic deformation stage, fracture stage, steel yield stage and failure stage. In the loading process, strain and displacement of the specimens take on a basic linear trend. Transverse crack first appears in the farther side of the loading point. When continued to load, these cracks develop crossly. When the specimens are close to be destroyed, these transverse cracks develop rapidly and the width of them increases. At this point, the reinforcement of tensile region has not yet yield and that of the

compressive area has yield. The deformation of compressive zone of the concrete also increases rapidly and the damage area of the concrete crushed by sudden is larger. Seen from these destruction, the conclusion can be drawn that it is a typical compression failure with small eccentricity. There is no obvious warning before the specimens are destroyed observing from the growth of the development of cracks, deformation and strain. It belongs to the typical brittle failure and the destruction form of the deformation is similar to the ordinary concrete column.

After the concrete fall off, it can be seen clearly from the fracture surface that the dispersion of the waste fibers in the concrete is homogeneous and only a tiny number of fibers poly group. The phenomenon that the fibers in the section are generally pulled to break instead of being pulled up suggests that there is a perfect bond property between the fibers and the concrete. Fibers between the cracks effectively stop the expansion and extension of the cracks, limit the cracks between the components of concrete and prevent the concrete cracks widening rapidly.

Fig.2 Load Condition and Failure Pattern of the Columns

Effects of Replacement Rate of Recycled Aggregate on Ductility

The mid-span lateral deformation of the specimens refers to the lateral deformation or the longitudinal bending deformation in the plane of small bias columns, and it is an important indicator representing ductility. The lateral deformation of the waste fiber recycled concrete columns and the ordinary concrete column have the characteristics in common, lateral deformation linearly varies with the load increasing in the elastic deformation stage at the beginning of loading. As the load increases, the lateral deformation of artifacts enters the nonlinear stage when the growth rate of the deformation is significantly greater than that of the load. When the specimens are close to be destroyed, the curve is basically horizontal, the load remains constant and the lateral deformation increases rapidly.

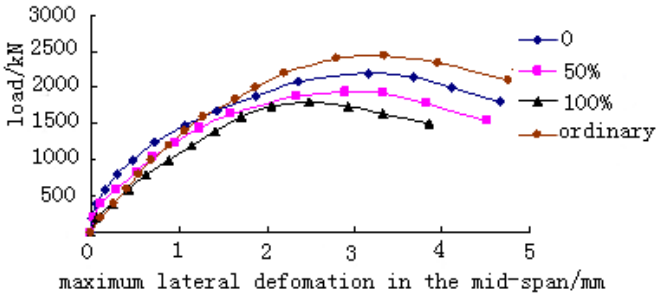

Fig.3 Load- midspan Lateral Displacement Curve of Different Replacement Rate of Recycled Aggregate

Seen from figure 3, the phenomenon that the lateral deformation of the waste fiber recycled concrete columns are generally greater than that of the ordinary one indicates that the ductility of

waste fiber recycled concrete columns is slightly better than the ordinary one. It is because in the process of recycling and broking, there are varying degrees of defects and micro cracks on the surface or inside of the recycled aggregate as a result of the accumulation of destruction and a large amount of hardened cement paste adhered to the surface. Therefore, unlike the dense combination of natural aggregate and mortar in the normal concrete, the strength of the recycled aggregate is lower and its ductility is better accordingly. The lateral deformation of the cross section of the columns increases with the increasing of recycled aggregates under the action of same load. When it is close to destruction, the lateral deformation of cross section has a substantial growth with the decreasing of replacement rate of recycled aggregate. It means that the ability of lateral deformation also increases with the increasing of the strength of the waste fiber recycled concrete.

Effects of Waste Fiber Length and Incorporation Proportion on Ductility

Seen from figure 4 and 5, it presents a trend that with the increasing of waste fiber length and incorporation the maximum lateral deformation of the specimens rise at first and then fall. Through the comparison and analysis above, the conclusion can be obtained that it is not the more the waste fiber mixed, the better to improve the performance and stress of the columns, but there is a critical value. When the waste fiber incorporation is lower than the critical value, the distributed fibers in the columns are broken and pulled out in the process of compression, assume the role of parts of steel, improve the ductility of the columns, and the mechanical performance of the columns also increases with the increasing of waste fiber length and incorporation. When the waste fiber incorporation is greater than the critical value, some fibers still play a role, but due to the large waste fiber incorporation, each phase in the concrete between the cohesive force decrease which leads to the reduction of overall stiffness and mechanical performance of the concrete. As for the test result, the performance of the waste fiber recycled concrete columns with the waste fiber length 19mm and incorporation proportion 0.12% gets the maximum amount of improvement.

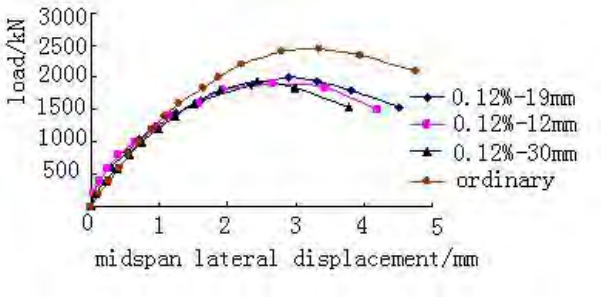

Fig.4 Load - midspan Lateral Displacement Curve of Different Fiber Length

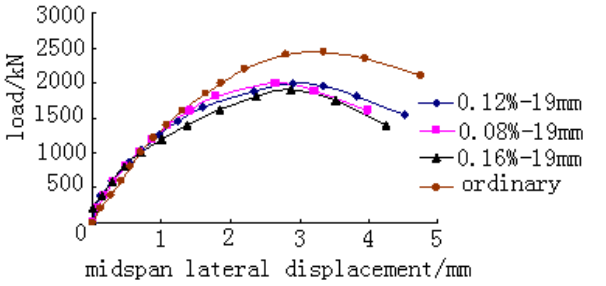

Fig.5 Load - midspan Lateral Displacement Curve of Different Fiber Incorporation Proportion

Summary

(1)The waste fiber recycled concrete columns have the similar failure process with the common concrete column, and there are elastic deformation stage, crack stage, steel yield stage and failure stage. Small eccentric compression failure has no obvious signs and belongs to brittle failure.

(2)The mixed waste fiber effectively improve the defects of ordinary concrete's poor ductility and make the ductility of the waste fiber recycled concrete columns increase significantly. Waste fiber recycled concrete columns still have good bearing capacity when specimens are close to destruction compared with the ordinary concrete column .

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