Journal of Civil Engineering and Urban Planning (2022)
Clausius Scientific Press, Canada

DOI: 10.23977/jceup.2022.040110
ISSN 2616-3969 Vol. 4 Num. 1

The Performance Analysis of Steel-fiber Concrete

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Keywords: Steel fiber; mechanical properties; cement-based composite material; material durability

Abstract: Steel fiber concrete because in the concrete mixed with steel fiber material, so that it compared with ordinary concrete, more anti-crack, wear resistance, freezing and thaw resistance and fatigue resistance and other advantages. This paper focuses on the special concrete, summarizes the effect of steel fiber mixing, steel fiber length and bone glue ratio on the performance of concrete, and based on the different objectives of steel fiber concrete mechanical properties test, finally summarized to improve the mechanical properties of steel fiber, and the future development of steel fiber concrete.

1. Introduction

Since the emergence of Portland cement in the 19th century, concrete materials have been applied in civil engineering with their excellent performance[1]. With the development of The Times, the construction industry has higher and higher requirements for building materials.Due to the disadvantages of easy cracking and large brittleness, its application is limited.Steel fiber concrete (Steel Fiber Reinforced Concerete, or SFRC) emerged, by the wide attention of scholars at home and abroad, has become a hot spot in the current concrete research[2], as shown in Fig.1.

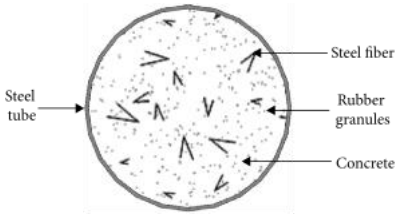

Figure 1: Section form of steel fiber reinforced rubber concrete filled steel tube column.

2. Performance of steel fiber concrete

Steel fiber concrete is hardened ordinary concrete, because of its special performance, this kind of concrete is widely used for road pavement, bridge structures and residential structures construction.Compared with conventional building materials, adding steel fiber in concrete not only improves the compressive strength and bending strength to a certain extent, but also can improve

the impact resistance[3]. Good physical and mechanical properties are very effective for the structural deformation caused by temperature and other reasons in road and bridge engineering, and can also significantly improve its anti-shrinkage performance[4]. Steel fiber concrete not only has the advantages of physical mechanics, but also has other advantages over ordinary concrete, for example, better than ordinary concrete better cracking and freezing resistance, as shown in Fig.2.

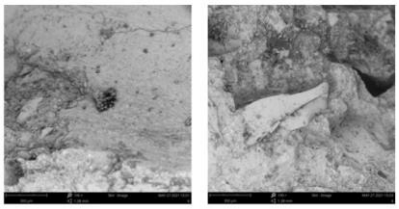

Figure 2: Concrete test block without steel fiber (a 1.2% steel concrete (b block SEM drawing)

2.1. Strong wear resistance

In the use process of cast-in-place prestressed concrete building, the building itself will bear a variety of friction, years of friction will lead to damage to all parts of the building, and the damage will be more and more large, after reaching a certain extent on the beauty and use of the building[5]. Steel fiber concrete strength is several times higher than the original ordinary concrete, under the same weight, the possibility of steel fiber concrete deformation is much less than the original ordinary concrete, which in practice, can effectively reduce the probability of crack rupture, but also to a certain extent to ensure the safety of people travel[6]. However, it should be noted that while the strength increases, its own weight has also been significantly improved.

2.2. Good crack resistance

Ordinary concrete and a certain number of short steel fiber fully mixed, forming steel fiber concrete, although compared with the original concrete weight, the weight of steel fiber concrete is heavier, but does not affect the construction situation, but can effectively reduce the deformation, cracks and other bad phenomena[7]. For the new steel fiber concrete, even if the weight of the building is increasing, but steel fiber concrete building deformation, the possibility of fracture than the original ordinary concrete made of building accident possibility, which not only effectively extended the building time, also escort for people's safety[8].

2.3. Good resistance to external impact force

Steel fiber concrete and compared with the original ordinary concrete, because the steel fiber concrete mixed with short steel fiber, which makes the steel fiber concrete resistance to pressure, resistance to external impact and other conditions has a significant improvement phenomenon[9]. Data show that when the content of short steel fiber in ordinary concrete accounted for 0.8%~2%, the mixed steel fiber concrete resistance to external impact will be better compared with the original short steel fiber resistance to the external impact of 50~100 times, which greatly improves the ability to resist external impact[10]. For example, in flood or earthquake and other natural disasters, road or bridge impact is what people cannot imagine, the impact will make ordinary concrete without short steel fiber in the moment of road or bridge rupture, so that appear unimaginable, irreparable casualty accident. However, if the construction of steel fiber concrete as a material to make a road or bridge, such a road or bridge is not only good quality, strong ability to resist external

impact, but also can effectively reduce the frequency of road or bridge problems, improve the use time of road or bridge[11].

2.4. Strong deformation ability

The original ordinary concrete did not add a certain number of short steel fiber, the advantage is that the weight of the building made of this material is relatively light, compared with ordinary steel fiber added steel fiber concrete, the concrete made of the building in the weight will be heavier, but this does not affect the construction situation[12]. At the same time, the elasticity of steel fiber concrete with short steel fiber is several times better than that of ordinary concrete, and the compression capacity of the building made of steel fiber concrete is also several times better than that of ordinary concrete[13].

2.5. Strong compression resistance, bending resistance and tensile resistance

Traditional concrete, when affected by external forces such as earthquakes, will be irreparable, directly unable to be used. But if steel-fiber concrete is used, it is much less damaged in the same case. Pressure resistance, bending resistance, tensile resistance is at least 1 / 2 of the traditional concrete[14].

3. Technical construction points of steel and fiber concrete

Steel fiber concrete from the production material can be divided into shear steel fiber concrete, cut steel fiber concrete, molten pumped steel fiber concrete and cut steel fiber concrete these four kinds[15]. Different types of steel fiber concrete are suitable for different engineering projects, and have their own specialized construction technology. These environmental conditions usually include: groundwater distribution, climate change characteristics, and geological structure composition[16]. According to the specific situation of the construction site and the actual requirements of the project itself to scientifically and reasonably determine the steel fiber concrete construction technology.It should be noted that, on the basis of meeting the technical requirements of steel and fiber concrete construction and ensuring the quality of road and bridge construction, the construction enterprises should maximize the procurement cost of construction materials[17].

4. Test scheme

4.1. Test materials and mix ratio

Ordinary Portland cement with strength grade of 42.5, coarse sand with fine aggregate with fineness modulus of 3.2 for fine aggregate, artificial gravel with continuous particle size of 5~20mm, and water reducing agent adopts polycarboxylic acid efficient water reducing agent.The fiber adopts polypropylene fiber (PP), polyvinyl alcohol fiber (PVA) and steel fiber (SF). The performance parameters of the fiber are shown in Table 1.

Table 1: Performance parameters of the fibers

fiber type	Length /mm	Diameter /mm	Density /(g/cm ^{3})	breaking strength/MPa	modulus of elasticity/GPa
PP	30	0.03	0.91	≥400	⩾3.5
PVA	18	0.025	1.3	1704	33.4
SF	50	0.75	7.8	1000⩽f⩽1200	

Three sets of steel fiber concrete specimens with different mixing levels were prepared. On this basis, and mixed with polypropylene fiber and polyvinyl alcohol fiber, three sets of mixed fiber concrete specimens were obtained, and a set of ordinary concrete specimens was set as a control, as shown in Table 2.

Table 2: Concrete mix ratio

number	Concrete material consumption						
	water	cement	sand	stone	SF	PP	PVA
NC35	204	408	715.2	1072.8	0	0	0
SFRC05	210	420	708	1062	39	0	0
SFRC10	216	432	700.8	1051.2	78	0	0
SFRC15	222	444	693.6	1040.4	117	0	0
HFRC05	210	420	708	1062	39	1	1
HFRC10	216	432	700.8	1051.2	78	1	1
HFRC15	222	444	693.6	1040.4	117	1	1

4.2. Test method

Referring to CECS13:89 "Test Method for Steel Fiber Concrete", RMT universal tester is used for cube compressive strength and split tensile strength test [18]. The size of the specimen is a standard cube, and 3 test blocks are made in each group, which are maintained under standard maintenance conditions for 28d.

The compressive strength of the cube was calculated according to Eq. (1), and the arithmetic mean value of each group was taken as the final test result.

$$f_{cu} = F_{\max} / A \tag{1}$$

In formula: fcuConcrete cube compressive strength (MPa), FmaxFor the specimen failure load (N), A is the specimen pressure area (mm2).

The split tensile strength was calculated according to Eq. (2), and the final test results were also taken the arithmetic mean.

$$f_{ts} = 0.6371 F_{\max} / A \tag{2}$$

5. Analysis of test results

5.1. Test phenomenon and damage form

The failure form of some specimens is shown in Figure 1, in which (a), (b) and (c) are compression failure forms of plain concrete, steel fiber concrete and mixed fiber concrete respectively, and (d) and (e) are split and pull failure forms of plain concrete and fiber concrete respectively[19], as shown in Fig.3.

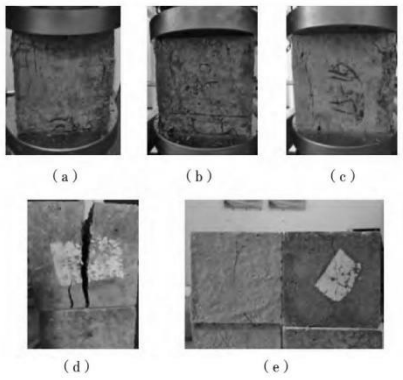

Figure 3: Destruction morphology of some specimens

In the cube compressive strength test, it can be seen that the plain concrete specimen first peeled at the corner, appeared multiple cracks on the surface, and finally quickly cracked under the action of load, showing obvious brittle characteristics[20]. And steel fiber concrete and mixed fiber concrete still maintain a certain integrity under the action of load, showing a multi-seam crack, crack but not broken destruction form, with obvious plastic characteristics[21].

In the split tensile strength test, it can be seen that the crack first appears at the bottom of the plain concrete test. Under the continuous action of load, the crack expands rapidly, the test is suddenly destroyed, and the split is in half.However, only a few cracks are observed on the surface of the fiber concrete specimens, and the fibers across the cracks play a good bridging role, limiting the extension and expansion of the cracks[22]. The damaged specimens were still connected together, with no sudden damage and split disconnection[23].

6. Conclusion

Since the emergence of steel fiber concrete technology, the technology has been mature and has been more and more used, it is often used in urban high-rise buildings, roads and Bridges, tunnels, as well as airport runway and other construction projects, has achieved high social and economic benefits.When this steel-fiber concrete technology is used in the construction of roads and Bridges, it not only reduces the cost of road construction, but also greatly improves the quality. In short, this technology plays a more beneficial role in promoting the healthy development of science and technology and modern technology.

References

[1] Khaloo, A.R., Nakseok Kim, N. (1997) Influence of Concrete and Fiber Characteristics on Behavior of Steel Fiber Reinforced Concrete under Direct Shear. Materials Journal, 94, 592-601.

[2] Gao, J., Sun, W. andMorino, K. (1997) Mechanical properties of steel fiber-reinforced, high-strength, lightweight concrete. Cement and Concrete Composites, 19, 307-313.

[3] Mirsayah, A.A., Banthia, N. (2002) Shear Strength of Steel Fiber-Reinforced Concrete.Materials Journal.99, 473-479.

[4] Wu, H., Wang, Z.D., Wang, L., Liu, Z.Y. and Zhan, P. (2017) Effects of steel fiber type and dosage on the fluidity of high-strength concrete. Low Temperature Building Technology, 39, 1-3.

[5] Li, Q.X., Gao, C.G. and Sun, Q.W. (2015) Influence of steel fiber blending on concrete performance. Jiangsu Building Materials, 3, 36-38.

[6] Zeng, M.G., Wu, Y. and Su, Q.T. (2022) Carbonic Anhydrase VII—A Potential Prognostic Marker in Gliomas. Journal of Jilin University, 1-10.

[7] Gai, T. (2022) Application of Steel-fiber Concrete in Highway Engineering . Engineering Construction and Design,, 108-110.

[8] Shang, G.F. (2022) Application of Steel Fiber Concrete in Highway Bridge Construction . Engineering Construction and Design, 110-112.
[9] Xu, J. (2022) Steel and fiber concrete construction technology in road and bridge construction. Transportation World, 22-23.
[10] Liu, G.C. (2022) Application of Steel-fiber Concrete technology in Highway Construction. Equipment Management and Maintenance,129-130.
[11] Lu, C.H., Wu, X.L., Xu, K. and Zhang, J.L. (2022) Calculation and analysis of cracks and deflection of ordinary / steel fiber concrete mixed reinforced beam. Journal of Nanjing University of Technology, 44, 197-206.
[12] Liu, S. (2022) The Application of Steel Fiber Concrete Technology in Highway Bridge Construction. Construction Machinery and Maintenance, 84-85.
[13] Guo, Y.J., Dong, C., Zhang, F. and Jiang, X.Q. (2022) Mechanical properties test of steel fiber concrete based on different optimization objectives . Jiangxi Metallurgy, 42, 69-78.
[14] Tong, W.G. and Fan, Y.B. (2022) Experimental Study on Mechanical Property of Steel fiber and Mixed fiber Concrete. Health, 13-15.
[15] Jin, Z.J. (2022) Application of steel fiber concrete construction technology in Road and Bridge Construction . Petrochemical Construction, 44, 114-115.
[16] Zhuang, Z.C. (2011) Construction technology of prefabricated armored force-bearing steel fiber concrete wear-resistant ground . Development of Construction Technology, 49, 64-66.
[17] Ma, Y. (2022) Analyze the application of steel fiber concrete construction technology in road and bridge construction. China Equipment Engineering, 253-255.
[18] Zeng, H.N. (2022) Application of steel fiber concrete technology in Road and Bridge Construction. Sichuan Cement, 222-223.
[19] Duan, X.F.,Yuan, J.J. (2021) Study on early mechanical properties and elastic modulus of plastic steel fiber concrete. Hydropower Energy Science, 39, 168-171.
[20] Zhang, C.T., Fu, M.L., Zeng, W.H. (2011) Analysis of bearing capacity of steel tube beam shear wall. Journal of Sanming College, 38, 109-113.
[21] Lin, G.C. (2021) Application of steel fiber concrete in the Treatment of Inspection well pavement diseases. Urban roads and bridges and flood control, 303-305.
[22] Tan, J., Yu, Y. (2021) Practice of steel fiber concrete technology in roads. Sichuan Building Materials, 47, 7-8.
[23] He, A.Y. (2021) The Research on Steel Fiber Concrete Technology in Bridge Structure Construction. Sichuan Building Materials,47, 173-174.