

Experimental study on durability of high-strength FC synthetic fiber reinforced pavement concrete

Yonggen Wu, Zeyao Zhang, Wenzhe Li

Department of Airfield Architecture Engineering, Air Force Engineering University, Xi'an 710038, China

Abstracts: In the durability experiment of the surface crack resistance, the impermeability, the abrasion resistance and frost resistance of high-strength FC synthetic fiber reinforced pavement concrete, the study explores its ruling law and functioning mechanism. The result shows that the FC fiber can markedly improve the durability of airport pavement concrete. The improvement varies according to the variation in the addition amount of FC fiber. When the amount rests approximately 1.2 kg/m^3 , the durability is optimal.

Keywords: airport pavement concrete, high-strength FC synthetic fibers, durability

1 Introduction

Airport pavement concrete exposes to natural environment, and withstands destruction of aircraft loads and natural environment long, such as aircraft gravity, aircraft tire abrasion, chemical corrosion, alternation of drying and wetting, freeze-thaw cycle, which may trigger burnishing, peeling off, hogging, crack and other durability damage phenomenon. Those cut the serviceable life of airport pavement concrete down^[1], make a serious impact on normal use of airport pavement concrete and safety of aircraft take-off and landing^[2]. At present, domestic and international study of concrete show that, it's an effective approach to improve the performance of pavement concrete that is in the concrete mix with fiber at a reasonable content, specification and other technical means. Fiber restrains the occurrence and development of concrete crack, that will effectively improve durability of pavement concrete, frost resistance and so on. In general, fiber reinforced technology has very important significance to improve the performance of pavement concrete. At present, the fiber that is commonly used in pavement concrete with steel fiber, basalt fiber, polypropylene fiber, polyacrylonitrile fiber, etc.

This test chooses high-strength FC synthetic fiber which is developed by Tsinghua University in the "national 863 research project", and confect five different pavement concrete specimens whose FC fiber contents are 0.8 kg/m^3 , 1.0 kg/m^3 , 1.2 kg/m^3 , 1.4 kg/m^3 and 1.6 kg/m^3 respectively. This study makes a comparative study of high-strength FC synthetic fiber reinforced pavement concrete and ordinary pavement concrete, explores the effect of FC fiber contents on pavement concrete performance of the surface crack resistance, the impermeability, the abrasion resistance and frost resistance. These provide basis for its application and popularization in airport pavement concrete.

2 The raw material of test and the mix proportion

2.1 The raw material of testing

1) Cement: 42.5R ordinary Portland cement that is manufacture by Xi'an Lantian Yaobai factory, 28d rupture strength is 9.18 MPa , 28d compressive strength is 46.8 MPa .

2) The aggregate: Shanxi Xianyang limestone, 5 ~ 10mm, 10 ~ 20mm, 20 ~ 40mm, 3 grading. apparent density 2780 kg/m^3 , packing density 1572 kg/m^3 .

3) Fine aggregate: Xi'an Chanba river sand, fineness modulus 2.64, apparent density 2630 kg/m^3 , packing density 1503 kg/m^3 , the mud content is 0.5%.

4) Water: tap-water.

5) Admixture: FDN high efficiency water reducing agent.

6) Fiber: a new type of high-strength synthetic fiber that is developed in "National 863 research project". Its abbreviation is FC fiber. The main performance of FC fiber is shown in table 1.

Table 1. The performance parameters of FC fiber

Length / mm	Specific gravity / (g/cm^3)	Elasticity modulus/ KPa	Elongation at break / %	Tensile strength/ MPa	Hydroscopicity/ %	Melting point/ $^{\circ}\text{C}$
5~20	1.38	6.1	24	497	0.7	257

2.2 Concrete mix proportion

According to GJB 1578-92 "Specification for mix proportion design of airport pavement cement concrete"^[3], ordinary airport pavement concrete rupture strength is 5 MPa , VeBe consistometer is 15s to 30s. In this test, the absolute volume method is adopted to design the mix proportion of pavement concrete. Through trial mix and adjustment, eventually determine pavement concrete mix proportion, shown in Table 2.

Table 2. Mix proportion of FC Fiber Reinforced Pavement Concrete

Specimen	Cement/ (kg/m ³)	Water/ (kg/m ³)	Sand/ (kg/m ³)	Stone/ (kg/m ³)	Water cement ratio	Sand ratio	Fiber content	Water reducer/ (kg/m ³)	Vebe consistometer/ s
P	320	147	545	1438	0.46	0.28	0	0	19
F1	320	147	545	1438	0.46	0.28	0.8%	0	21
F2	320	147	545	1438	0.46	0.28	1.0%	0	23
F3	320	147	545	1438	0.46	0.28	1.2%	0.48	21
F4	320	147	545	1438	0.46	0.28	1.4%	0.48	24
F5	320	147	545	1438	0.46	0.28	1.6%	0.64	23

3 Experimental investigation

3.1 Surface crack resistance test

Referring to GB/T 50082-2009 “Specification for ordinary concrete long-term performance and durability test method”^[5], the test makes specimen in the size of 800mm×600mm×100mm and adopts plate method. Then make surface crack resistance test with polyethylene plastic film on the base plate as the isolation layer, Test result of ordinary pavement concrete specimen: initial crack time is 180 mins, the maximum crack width is 0.5 mm, the total area of crack is 133.65 mm². Test results of other 5 groups pavement concrete specimens mixed with FC fiber are shown in figure 1.

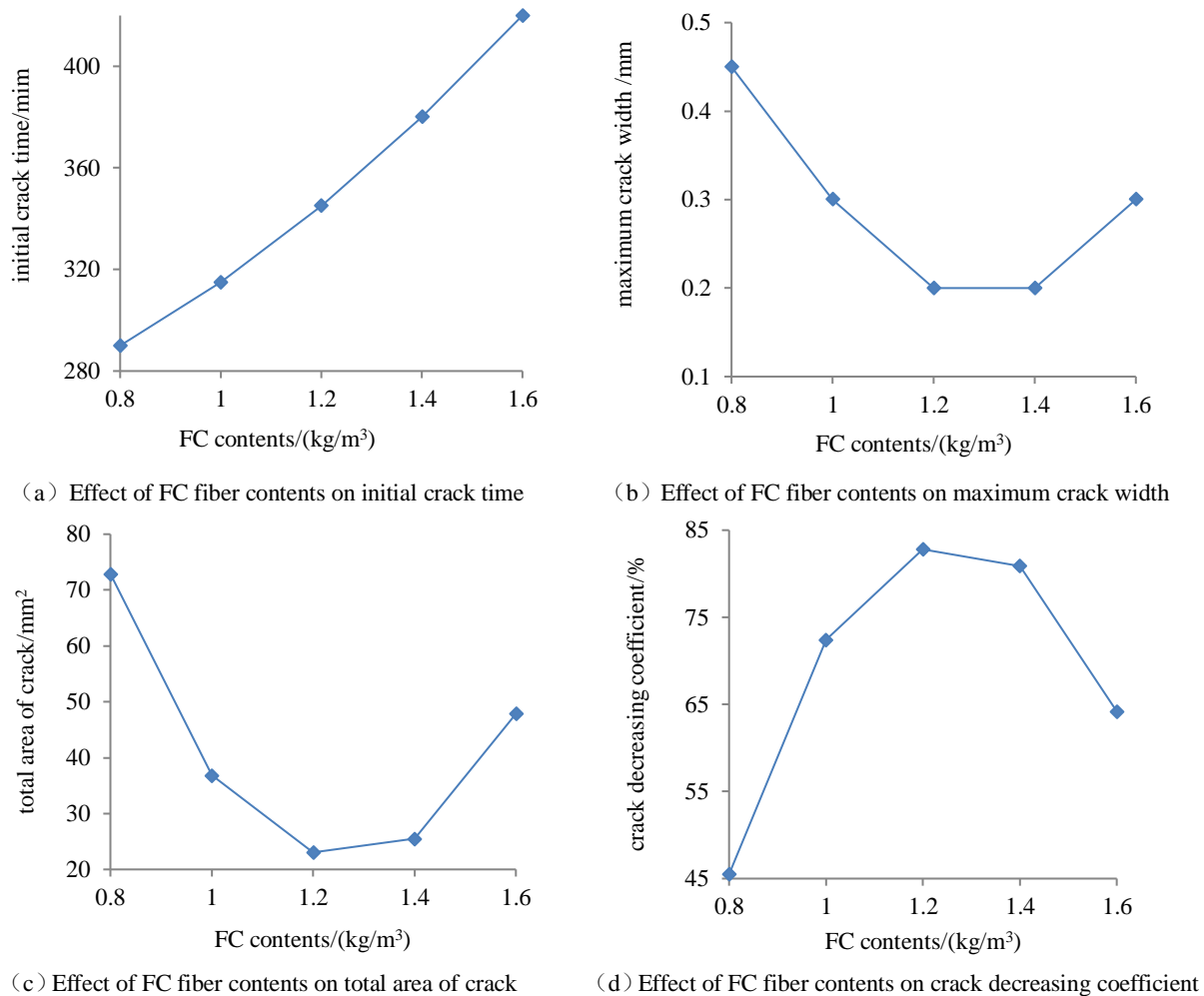


Figure.1. Effect of FC fiber contents on concrete surface crack resistance

Test results show that FC fiber improves the surface crack resistance of pavement concrete significantly, and surface crack of pavement concrete becomes “narrow”, “short” and “small” as mix with FC fiber. Under the condition of low content (0.8 ~ 1.2 kg/m³), pavement concrete surface crack resistance enhances with increasing content of FC fiber; When FC fiber content is 1.2 kg/m³, surface crack resistance of pavement concrete is optimal, the grade of pavement concrete surface crack resistance is I.

3.2 Impermeability test

According to GB/T 50082-2009 “Specification for ordinary concrete long-term performance and durability test method”^[5], make cone specimen in the size of 175mm×185mm×150mm . The test adopts pressure loding by degrees method and HP-40 permeability tester. Test results of impermeability of FC fiber airport pavement concrete are shown in Table 3 and figure 4.

Table 3. Impermeabilities test result

specimen	P	F1	F2	F3	F4	F5
Osmotic pressure/MPa	2.1	3.8	4.1	4.1	4.1	4.1
Impermeability grade	P20	P37	>P40	>P40	>P40	>P40

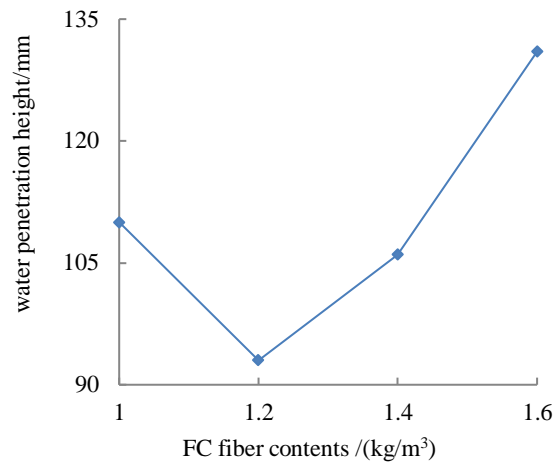


Figure 2. Effect of FC fiber contents on water penetration height

Table 3 shows that impermeability of pavement concretes enhances as mixing with FC fiber. By figure 2 knows that when FC fiber content is 1.2 kg/m³, the curve appears a turning point, impermeability of pavement concrete is optimal in this point; Then impermeability of pavement concrete degrades with increasing content of FC fiber,

3.3 Abrasion resistance

According to GB/T16925-1997 “concrete and its products abrasion resistance test method”^[6], make cube specimen in the size of 150 mm to test and adopts the NS-2 ball bearing abrasion tester. Test results of ordinary pavement concrete specimens: depth of grinding groove is 2.45mm, abrasion resistance index is 0.91, Test results of other 5 groups pavement concrete specimens mixed with FC fiber are shown in Figure 3.

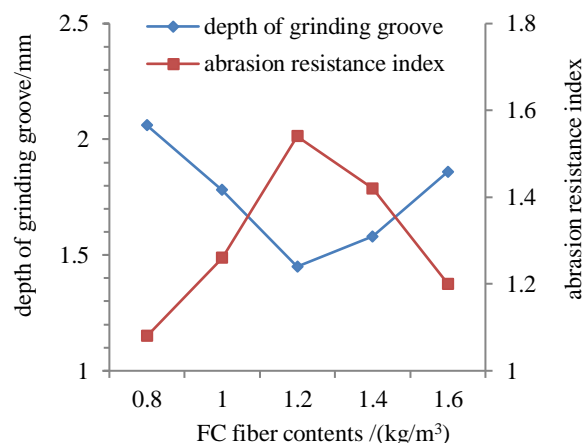


Figure 3. Effect of FC fiber contents on concrete abrasion resistance

Data in figure 3 in contrast with ordinary pavement concrete test data shows that abrasion resistance of pavement concrete enhance markedly as mixing with FC fiber. Test found that pavement concrete abrasion resistance index raised at first, then decreased in the process of FC fiber contents change from 0.8 kg/m³ to 1.6 kg/m³, and the peak appears at FC fiber content is 1.2 kg/m³. By this time, abrasion resistance index of pavement concrete is the highest, increased rate is as high as 70%.

3.4 Frost resistance test

On the basis of the above test, select P, F2, F3 three groups of FC fiber pavement concrete mix proportion, and make prism specimen in the size of 100 mm×100 mm×400 mm. The test adopts rapid freeze-thaw method with TDR-16V microcomputer control fast freezing and thawing tester, referring to GB/T 50082-2009 “Specification for ordinary concrete long-term performance and durability test method”^[5]. This test introduces damage model^[7], and defines damage degree D_n according to the theory of damage mechanics to:

$$D_n = \frac{E_0 - E_n}{E_0} \times 100\%$$

Where: D_n - damage degree of concrete after n times cycle, unit (%)

E_n - dynamic Young’s modulus of concrete after n times cycle, unit (MPa)

E_0 - initial dynamic Young’s modulus of concrete, unit (MPa)

The test results are shown in figure 4 and table 4.

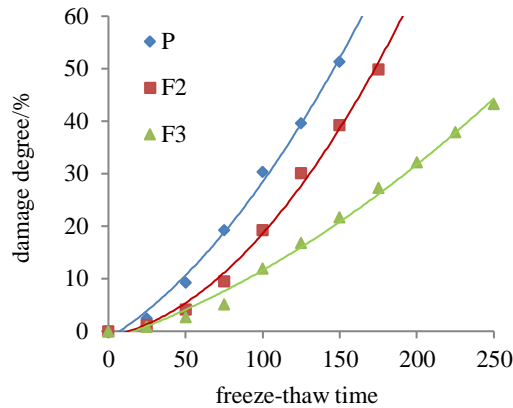


Figure 4. Approximate curve of impaired extent about repeat of freeze and thaw

Table 4. Grade of frost resistances

Specimen	P	F2	F3
Grade of frost resistances	F125	F150	F225

Table 4 shows that frost resistances grade of pavement concrete enhances as mixing with FC fiber, and when FC fiber content is 1.2 kg/m³, frost resistances grade of pavement concrete is the highest. By figure 4 shows: in the same cycles, damage degree of the three groups pavement concrete specimens is P>F2>F3. these illustrate that it retards the freeze-thaw damage of pavement concrete and improves the frost resistance of pavement concrete when FC fiber mixes into pavement concrete in a certain extent.

4 Conclusions

When airport pavement concrete mix with FC fiber, the surface crack resistance, the impermeability, the abrasion resistance and frost resistance of airport pavement concrete were improved markedly, and FC fiber can make an all-sided improvement on the durability of airport pavement concrete. The improvement of airport pavement concrete durability varies according to the variation in the addition amount of FC fiber. Comprehensive test results show that when the amount rests approximately 1.2 kg/m³, the durability of airport pavement concrete is optimal.

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