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Effect of Polypropylene Fiber on Properties of Aeolian-Sand Mortar

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Abstract. In this paper, the same consistency of aeolian sand mortar was prepared by blending polypropylene fibers of 0, 0.3Kg/m³, 0.7Kg/m³, 1.0Kg/m³, 1.3Kg/m³ and 1.8Kg/m³ respectively. Effects of fiber content on physical properties such as shrinkage, strength and crack resistance of aeolian sand dry mortar. The results show that polypropylene fiber can significantly improve the physical and mechanical properties of aeolian sand dry mortar. Polypropylene fiber content is within 1.3Kg/m³, and with the increase of fiber content, the effect of aeolian sand mortar is obvious; when the content exceeds 1.3Kg/m³, the shrinkage and mechanical properties are shrunk; the wind and sand accumulation mortar is aggregated. The suitable amount of propylene fiber is 1.3Kg/m³. Under this dosage, polypropylene fiber can not only improve the construction performance of aeolian sand mortar, but also improve its basic mechanical properties.

1. Introduction

With the accelerated implementation of China's "One Belt, One Road" policy, infrastructure projects have also increased rapidly, and the demand for raw materials such as construction mortar is increasing, while the raw materials of related areas, especially construction sand resources, are extremely scarce. The systematic study of aeolian sand to prepare dry-mixed mortar can not only utilize the aeolian sand resources along the "Belt and Road" area, but also avoid over-exploitation of local natural river sand resources and protect the ecological environment.

In China, Inner Mongolia Agricultural University and Ningxia University have conducted preliminary research on aeolian sand as a fine aggregate of mortar and concrete. Ma Lei [1] and other studies pointed out that aeolian sand can be used as a fine aggregate to replace part of natural sand for the preparation of mortar; Dong Wei [2] and other studies have shown that aeolian sand can significantly improve the early strength of mortar after replacing some ordinary sand. The fine particles of aeolian sand cause the aeolian sand mortar to have low toughness and dry shrinkage, which is easy to crack. Therefore, improving the anti-drying performance is the focus of research on aeolian sand mortar. Polypropylene fiber has obvious toughening and anti-drying effect on mortar [3]. Therefore, this paper studies the effect of polypropylene fiber content on the physical and mechanical properties of aeolian sand mortar and the suppression of shrinkage.

2. Test

2.1. Material

Cement: P 42.5 benchmark cement; Polypropylene fibers: proportion-0.91 , diameter 18-48μm,



young's modulus 3.65 GPa, ultimate elongation rate 17%, length 6 mm. Aeolian sand: it comes from the taklamakan desert in xinjiang region, modulus of fineness 0.54, and the water content of dry sand is 0.14%. Its main components are shown in table 1. The micro morphology and particle size distribution are shown in Figure ure 1 and Figure 2.

Table1. Main comuositions of aeolian sand

component	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	CaO	K ₂ O	MgO
Content/ %	65.63	9.84	2.28	2.3	7.92	2.17	1.73

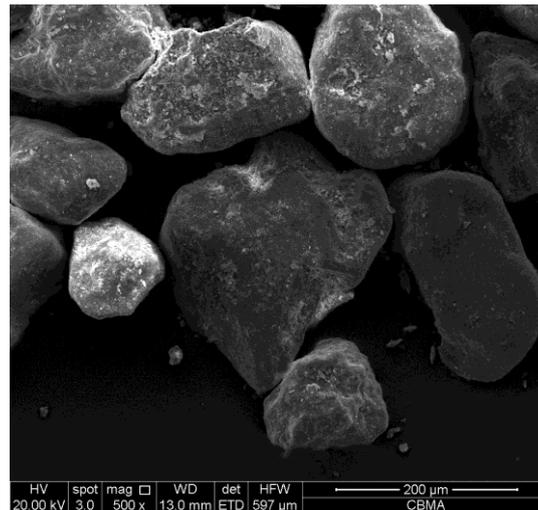


Figure 1. SEM image of aeolian sand

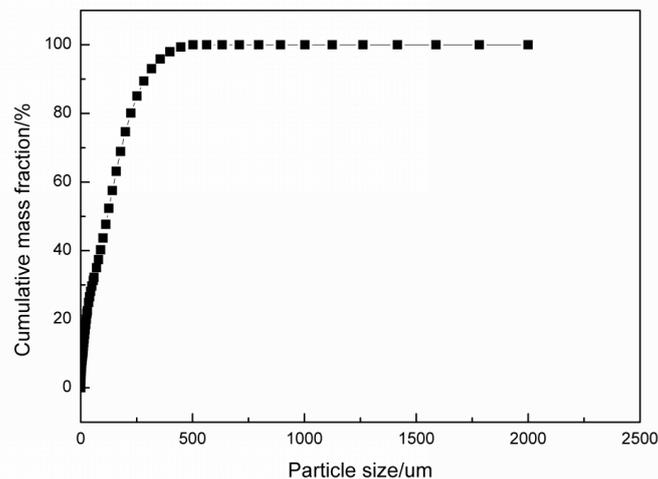


Figure 2. Particle size distributions of aeolian sand

It can be seen from Figure ure 1 that the aeolian sand particles are round, irregular in shape and with obviously edge angles. As shown in Figure ure 2, the aeolian sand particles are extremely fine and poorly graded, and their particle sizes are generally less than 500 μm.

2.2. Test Method

The general physical and mechanical properties of mortar were tested in accordance with “Method of testing cements-Determination of strength (ISO method)” and “Standard for test method of

performance on building mortar”.[4]

3. Test Results and Discussion

3.1. The Influence of the Content of Polypropylene Fiber on the Physical Mechanics and Dry Shrinkage Performance of Aeolian Sand Mortar

The effect of adding polypropylene fiber of different quality on the physical and mechanical properties and dry shrinkage of aeolian sand mortar (the ratio of cement to sand is 1:2) is shown in table 2.

Table 2. The effect on physical and dry-shrinking performance of aeolian sand mortar with different contents PP-fiber

Cement sand ratio	Fiber content Kg/m^3	Denseness s/mm	Segregation n/cm	Water cement ratio	breaking strength/ MPa	compression strength/ MPa	Tensile Strength/ MPa	shrinkage ratio/%
1:2	0	81	1.5	0.688	4.61	22.88	2.72	0.763
	0.3	80	2.0	0.695	4.72	22.87	2.78	0.684
	0.7	83	2.1	0.704	4.81	21.78	2.88	0.630
	1.0	84	2.1	0.728	4.94	21.89	2.92	0.575
	1.3	83	2.3	0.715	5.36	21.56	2.95	0.525
	1.8	81	2.3	0.733	4.68	20.68	2.83	0.598

The fiber overlaps with each other to form a network system in aeolian sand mortar, resulting in decreased flowability of the mortar. Under the same denseness, polypropylene fiber will increase the water demand of mortar, and the delamination of sand mortar will increase accordingly.

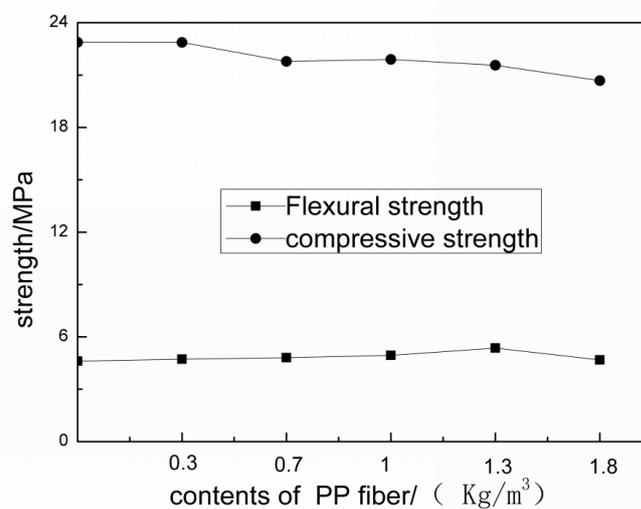


Figure 3. Compressive strength of aeolian sand mortar with different contents PP fiber

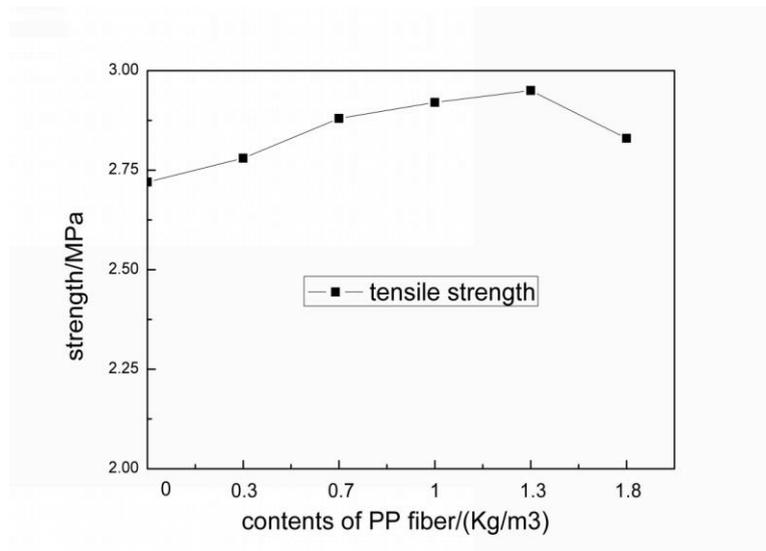


Figure 4. Tensile strength of Aeolian sand mortar with different contents PP fiber

It can be found from Figure 3 and Figure 4 that the compressive strength of mortar decreases gradually with the increase of the content of PP fiber. When the dosage is lower than 1.3kg /m³, the tensile strength and flexural strength of mortar increase slowly with the increase of fiber content. When the fiber content exceeds 1.3 Kg/m³, the tensile and flexural strength of the mortar show decline. With the increase of fiber content, the water consumption of mortar increases, at the same time, excessive fiber agglomerates in mortar, so the strength of mortar decreases under the corresponding amount of fiber content.

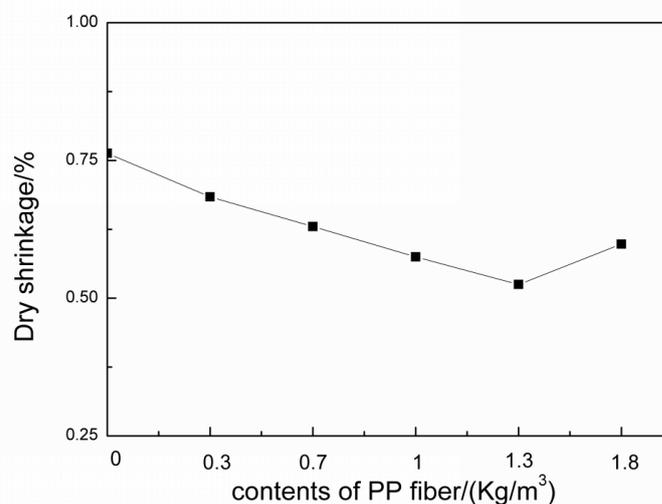


Figure 5. Dry shrinkage of aeolian sand mortar with different contents PP fiber

As shown in Figure 5, the dry shrinkage of sand slurry is large, and PP fiber has obvious inhibiting effect on the dry shrinkage of mortar. When the adding amount is 1kg/m³, the dry shrinkage rate of aeolian sand cement mortar is 24.6% lower than that of blank mortar without fiber. When 1.3kg/m³ fiber is added, the dry shrinkage rate of aeolian sand mortar reaches the minimum, this was 31.2% lower than undoped blank mortar. When the fiber content reaches 1.8kg/m³, because the fiber content is too large, the fiber agglomeration and dispersion are not uniform, so the shrinkage of mortar can not be effectively inhibited.

3.2. The Influence of PP Fiber on the Cracking Properties of Aeolian Sand Mortar

Table 3. Results of fracture on aeolian sand mortar

cement-sand ratio	content (Kg/m^3)	crack length(mm)			crack index	Relative cracking index
		<1	1-2	>2		
1:2	0	70	65	0	100	1
	0.3	62	32	0	62	0.62
	0.7	86	0	0	43	0.43
	1.0	54	0	0	27	0.27
	1.3	43	0	0	22	0.22
	1.8	72	0	0	36	0.36

It can be seen from Figure 6 that the adding of PP fiber can lead to the decrease of crack length and number, meanwhile, the the number of long cracks reduce. When 1.3kg/m^3 fiber is added, the relative cracking index of mortar is 22, and the total number of cracks is 78% less than the blank mortar without fiber. In other words, the anti-cracking of eolian sand mortar can be significantly improved by adding polypropylene fiber. As the fiber content continues to increase, the fiber aggregate and dispersion are not uniform, resulting in an increase of total number of mortar cracks.

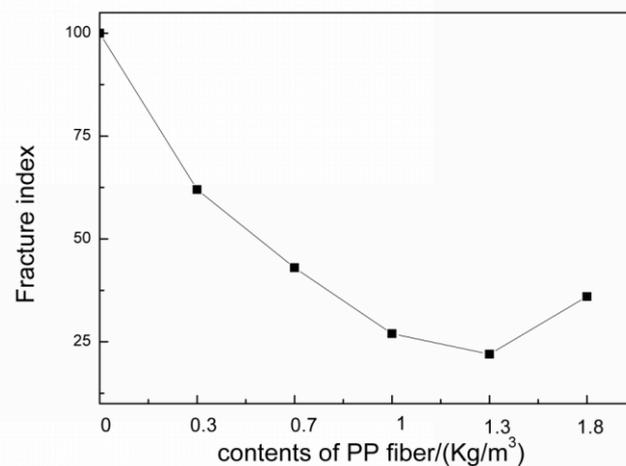


Figure 6. Fracture index of aeolian sand mortar with different contents PP fiber

3.3. Influence Mechanism of Fiber on Mortar Properties

The PP fiber is distributed uniformly in the mortar, which inhibits the sedimentation segregation of water and mortar aggregates, Reduces water evaporation, resulting in reducing the number of connecting holes of aeolian sand mortar. Meanwhile, after adding fibers, the fibers are kept on the surface of mortar, which slows down the evaporation rate of mortar water, improves the water-retaining performance of aeolian sand mortar, and further inhibits the dry shrinkage of mortar.

The PP fibers in aeolian sand mortar are randomly overlapping with each other, which have a significant inhibitory effect on mortar crack [5] [6] [7]. After adding PP fiber into the aeolian sand mortar, its tensile strength and toughness are improved, the total number of cracks is reduced, longer cracks are basically disappeared, and the tendency of crack refinement is obvious [8].

If the pp fiber is dispersed uniformly in aeolian sand mortar, the cracks in mortar encounters the PP fiber in expansion, and the presence of the fiber will force the crack to change its development direction or prevent the cracks from forming smaller micro-cracks, then the development trend of the mortar micro-cracks will be limited.

4. Conclusion

The fiber overlaps with each other to form a network system in aeolian sand mortar, resulting in decreased flowability of the mortar. Under the same denseness, polypropylene fiber will increase the water demand of mortar, and the delamination of sand mortar will increase accordingly. When $1.3\text{kg}/\text{m}^3$ fiber is added, the relative cracking index of mortar is 22, and the total number of cracks is 78% less than the blank mortar without fiber. The anti-cracking of aeolian sand mortar can be significantly improved by adding PP fiber.

The dry shrinkage of sand slurry is large, and PP fiber has obvious inhibiting effect on the dry shrinkage of mortar. With the increase of fiber content, dry shrinkage of aeolian sand mortar first decreases and then increases. When the adding amount is $1\text{kg}/\text{m}^3$, the dry shrinkage rate of aeolian sand cement mortar is 24.6% lower than that of blank mortar without fiber. When $1.3\text{kg}/\text{m}^3$ fiber is added, the dry shrinkage rate of aeolian sand mortar reaches the minimum, this was 31.2 percent lower than undoped blank mortar. When the fiber content reaches $1.8\text{kg}/\text{m}^3$, because the fiber content is too large, the fiber agglomeration and dispersion are not uniform, so the shrinkage of mortar can not be effectively inhibited.

In conclusion, polypropylene fiber can improve the toughness of aeolian sand mortar, effectively inhibit the mortar's dry shrinkage, and also enhance the mortar's anti-cracking properties. The adding amount of pp fiber in aeolian sand mortar is appropriate to be $1.3\text{kg}/\text{m}^3$.

Acknowledgments

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