Influence of Mixed Admixtures on Properties of Aeolian-sand Mortar

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Abstract. Using Aeolian sand as fine aggregate, adopt fixed lime sand ratio (1:2, Under the same consistency of mortar, the effect of single and compound doping of VAE and Water retaining agent(BS-W) on the working and physical properties of mortar was studied. Through the comparison of its properties with blank mortar, to get the best content of admixture and the best proportion of compound admixture, to provide ideas for the development and research of high proportion or total replacement of aeolian sand mortar. The results show that: VAE and water retaining agent can obviously improve the workability, construction and water retaining performance of the slurry, but the physical and mechanical properties of mortar are reduced. When VAE content is 0.7%, BS-W content is 0.15%, the overall performance of mortar mixed with them is better, the flexural strength and compressive strength of mortar reached 4.78Mpa and 15.3Mpa respectively in 28d.

Keywords: Materials; Aeolian-sand; Water retaining agent; VAE.

1. Introduction
Sand material is one of the necessary building materials for engineering construction, and aeolian sand in the desert is widely distributed. If the local resources, desert sand, can be used scientifically instead of the medium sand used in the construction market for a long time, it can not only solve the needs of engineering construction, save a lot of construction funds for the project construction, but also turn harm into benefit, which is beneficial to the prevention and control of desert aeolian sand. In view of the shortage of aggregate resources and high transportation costs in desert areas and sand areas, and combined with the advantages of desert resources, many engineers and technicians have conducted a lot of experiments and in-depth research on the application of aeolian sand in concrete and mortar, and achieved a lot of experimental research results, and their research results mainly focus on the road use characteristics, physical properties and other aspects of desert sand. Bangold has made the greatest contribution to the research.11 His classic work the physics of blow sand and desert dunes published in 1941 laid the foundation for the formation of the theoretical system of Aeolian geomorphology and aeolian sand physics. Since then, the study of Aeolian geomorphology has been gradually improved. Li genfeng et al. (2016) showed that the higher the replacement rate of aeolian sand, the larger the shrinkage deformation of concrete. When the content of aeolian sand is less than 60%, the shrinkage deformation of aeolian sand concrete is within the controllable range.
Li Yugen and other researchers pointed out that the content of aeolian sand in mortar should be 30%, too much aeolian sand will cause adverse effects on mortar workability[3]. Liu Yanhua et al. showed that the fluidity of mortar increased first and then decreased with the increase of desert sand content [4]. It can be seen that most of the research on aeolian sand in China stays in the stage of partial replacement of aggregate, which can not completely solve the application problem of aeolian sand in practical projects, and the aeolian sand particles are very fine, and the preparation of mortar with aeolian sand has poor cohesiveness, low water retention capacity and easy separation. Therefore, the key point of developing aeolian sand dry mixed mortar is to improve the cohesiveness and water retention capacity. Adding redispersible latex powder (VAE) into mortar can improve the bond strength of mortar, and adding water-retaining agent can improve the construction performance of the mortar, which can make the mortar have good water-holding capacity, reduce bleeding, and be difficult to delaminate and segregate. To this end, this article systematically studies the effects of single and multiple admixtures of VAE and water-retaining agent on the properties of aeolian sand dry-mixed mortar, in order to guide the development and research of aeolian sand mortar to provide ideas.

2. Test

2.1. Material
Cement: P·I42.5 benchmark cement; Redispersible powder: Ashland N2028; Water retaining agent: Homemade BS-W water retaining agent. Aeolian sand: Taken from the Taklimakan Desert, Xinjiang, the fineness modulus is 1.0, which belongs to ultra-fine sand. The moisture content of dry sand is 0.14%. The main components are shown in Tab1, and the microstructure of aeolian sand is shown in Fig.1.

| 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. Micromorphology of aeolian sand(SEM).
It can be seen that the aeolian sand particles are smooth, the shape and structure are irregular, and the edges and corners are obvious. Aeolian sand particles are very small, at the same time, the particle grading is very poor. The particle size of aeolian sand is less than 500 μm.

2.2. Test Method
The test in this paper is to control the consistency of mortar (80mm). Add a water-retaining agent and VAE to a blank mortar with a fixed lime-sand ratio (1:2), and then measure the changes in the working performance and physical properties of the mortar, to find out the best admixture amount of aeolian sand mortar. The preparation of mortar adopts the method of first dry mixing and then water mixing, that is as close as possible to the production process of dry mixed mortar. The general physical and mechanical properties of mortar shall be tested according to GB/T 17671《test method for strength of cement mortar (ISO method)》 and JGJ 70《test method for basic properties of building mortar》.

3. Experimental Results and Discussion

3.1. Effect of VAE on the Properties of Aeolian-sand Mortar

Table 2. Effect of VAE on the properties of aeolian-sand mortar.

| No. | VAE/ % | W/C | Consistency /mm | Stratification /mm | Flexural strength /Mpa | Compressive strength /Mpa |
|-----|--------|-----|-----------------|--------------------|------------------------|--------------------------|
|     |        |     |                 |                    | 7d | 28d | 7d | 28d |
| A-1 | 0      | 0.85| 80              | 22                 | 3.09 | 4.40 | 11.1 | 20.6 |
| A-2 | 0.3    | 0.85| 82              | 18                 | 2.79 | 4.19 | 9.3  | 14.9 |
| A-3 | 0.5    | 0.83| 82              | 21                 | 2.92 | 4.81 | 9.3  | 15.6 |
| A-4 | 0.7    | 0.83| 80              | 18                 | 3.16 | 5.10 | 9.6  | 14.6 |
| A-5 | 1.0    | 0.82| 85              | 16                 | 3.13 | 5.02 | 9.2  | 14.4 |
| A-6 | 1.2    | 0.82| 82              | 16                 | 3.24 | 5.38 | 9.2  | 14.3 |

We can see that the water demand of mortar gradually decreases with the increase of VAE content, which is reflected in the gradual decrease of water cement ratio. The reason may be that VAE has surface active ingredients, and it will cause a large amount of air entrainment of mortar mixture, which has a certain water reducing effect. With the increase of VAE content, the delamination degree of mortar decreases and the water retention of mortar increases. During the dispersion of VAE, a small amount of micro bubbles are introduced from the outside, which leads to the decrease of mortar density.
From Fig. 3, we can see that the physical properties of mortar have changed due to the addition of VAE. With the increase of VAE content, the compressive strength of mortar shows a trend of gradual decline, and the change trend of 7 days is more gentle than that of 28 days, which shows that the early influence of VAE on mortar is greater than that of later. When the content of VAE is less than 0.7%, the flexural strength of mortar decreases gradually; but when the content of VAE is more than this value, the flexural strength of mortar changes less.

### 3.2. Effect of BS-W on the Properties of Aeolian-sand Mortar

#### Table 3. Effect of BS-W on the properties of aeolian-sand mortar.

| No. | BS-W/ % | W/C | bleeding rate /% | Consistency /mm | Stratification /mm | Flexural strength /Mpa 7d | Flexural strength /Mpa 28d | Compressive strength /Mpa 7d | Compressive strength /Mpa 28d |
|-----|---------|-----|------------------|-----------------|-------------------|---------------------------|---------------------------|----------------------------|----------------------------|
| B-1 | 0       | 0.85| 7                | 80              | 22                | 3.09                      | 4.40                      | 11.1                       | 20.6                       |
| B-2 | 0.05    | 0.85| 3.8              | 82              | 19                | 2.66                      | 3.83                      | 8.7                        | 14.2                       |
| B-3 | 0.10    | 0.852| 2.1             | 81              | 14                | 2.69                      | 3.65                      | 8.5                        | 13.0                       |
| B-4 | 0.15    | 0.852| 0.6             | 81              | 10                | 2.71                      | 3.25                      | 7.2                        | 11.1                       |
| B-5 | 0.2     | 0.858| 0                | 82              | 5                 | 2.54                      | 3.13                      | 6.5                        | 10.6                       |
| B-6 | 0.3     | 0.858| 0                | 81              | 1                 | 2.29                      | 3.07                      | 5.3                        | 9.3                        |

The more BS-1 is adulterated, the higher the water consumption will be, and the water cement ratio increases gradually too. When BS-W is added to the mortar, the water retention performance of the mortar is greatly improved. When the content of BS-W reaches 0.1%, the delamination of mortar is greatly reduced compared with blank mortar. The bleeding rate of mortar also decreases with the increase of BS-W, when the content of BS-W reaches 0.15%, the mortar stops bleed. When the water retaining agent is added to the cement mortar, many tiny bubbles will be formed. These bubbles act like ball bearings in the mortar, improving the workability of the fresh mortar, and the bubbles still remain in the hardened mortar body, forming independent pores, and blocking the pores. The water retention agent can also improve the water retention of fresh mortar to a large extent, which can not only prevent the mortar from bleeding and segregation, but also prevent the water from evaporating too fast in the early stage of maintenance, so that the cement can be better hydrated, so that the bond strength can be improved.
Figure 4. Effect of BS-W content on mortar strength.

From Fig.4, it can be seen that the compressive strength of mortar is gradually reduced due to the addition of water retaining agent BS-W, and the slope of the curve is large within the range of 0.0% - 0.05%, which indicates that as long as the water retaining agent BS-W with small amount is added, it will have a great impact on the compressive mechanical properties of mortar. This is due to the fact that BS-W is a surfactant, which will lead to the introduction of a certain amount of gas into the mortar mixture and the formation of pore structure in the mortar system, resulting in the reduction of strength.

3.3. Effect of VAE and BS-W on the Properties of Aeolian-sand Mortar

The adhesive strength of mortar can be improved by adding VAE, and the construction performance of mortar can be improved by adding water retaining agent, which can make the mortar have good water retaining capacity, reduce bleeding, and is not easy to layer and separate.

According to the test results of 3.1 and 3.2, VAE was added with 0.5%, 0.7% and 1.0%, and water retaining agent was added with 0.15% and 0.2%.

Table 4. Effect of VAE and BS-W on the properties of aeolian-sand mortar.

| No. | BS-W/% | VAE/% | W/C | Consistency /mm | Stratification /mm | Flexural strength /Mpa | Compressive strength /Mpa |
|-----|--------|-------|-----|-----------------|---------------------|------------------------|--------------------------|
|     |        |       |     |                 |                     | 7d         | 28d         | 7d         | 28d         |
| C-1 | 0.15   | 0.5   | 0.652 | 80              | 6                   | 2.78       | 4.36       | 7.06       | 12.4        |
| C-2 | 0.15   | 0.7   | 0.651 | 82              | 8                   | 2.81       | 4.78       | 8.24       | 15.3        |
| C-3 | 0.15   | 1.0   | 0.654 | 81              | 8                   | 2.36       | 4.31       | 5.32       | 11.2        |
| C-4 | 0.2    | 0.5   | 0.651 | 81              | 7                   | 2.84       | 4.30       | 6.56       | 13.0        |
| C-5 | 0.2    | 0.7   | 0.652 | 82              | 8                   | 2.97       | 4.64       | 7.20       | 12.8        |
| C-6 | 0.2    | 1.0   | 0.652 | 81              | 11                  | 2.54       | 4.48       | 5.21       | 12.2        |

It can be seen that under the fixed lime-sand ratio and same BS-W content, the consistency of mortar has no obvious change with the increase of VAE content, but the delamination degree of mortar increases with the increase of VAE content. We can also see that when the content of BS-W in mortar reaches 0.2%, the delamination degree of mortar is larger than that when the content of BS-W is 0.15%.
From Fig.5, it can be seen that in the C-2 and C-5 groups, when the VAE content is 0.7%, the flexural strength of mortar reaches the maximum value, while the compressive strength of mortar reaches 15.3Mpa and 12.8Mpa. Considering comprehensively, under the 1:2 ratio of lime to sand, it can be seen that the overall performance of the mortar is better when the VAE content is 0.7% and the BS-W content is 0.15%, which also verifies the conclusion of the single mixing test in this paper.

4. Summary
Adding various external components into aeolian sand mortar and analyze the working performance and mechanical properties of the mortar, the summary is as follows:
(1) The workability of mortar can be improved obviously by adding redispersible latex powder and the cohesion and workability of mortar can also be improved; When the content of VAE is less than 0.7%, the flexural strength of mortar decreases gradually; but when the content of VAE is more than this value, the flexural strength of mortar changes less.
(2) When a water-retaining agent is added to the mortar, the water bleeding rate of the mortar decreases with the increase of the amount of the water-retaining agent BS-W. When the water-retaining agent content reaches 0.15%, the mortar has almost no bleeding, it can effectively improve the construction and water retention performance of the mortar, but other mechanical properties of the mortar are reduced.
(3) Under the fixed lime-sand ratio and same BS-W content, the consistency of mortar has no obvious change with the increase of VAE content, but the delamination degree of mortar increases with the increase of VAE content. When VAE content is 0.7% and BS-W content is 0.15%, the overall performance of mortar is better under 1:2 lime sand ratio. The 28 day flexural strength and compressive strength of mortar are 4.78Mpa and 15.3Mpa.

Acknowledgments
The authors thanks to the support of the National Key R&D Program of China (No. 2016YFC0701000).
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