Study on properties of sisal fiber modified foamed concrete

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Abstract. Sisal fiber modified foamed concrete was prepared with ordinary Portland cement and vegetable protein foaming agent as the base material and sisal fiber as the modifier. The distribution of fibers in the sample changes. The results show that when the fiber content is 0.75% and the fiber length is 5mm, the mechanical properties of foamed concrete are improved most obviously, and the respectively. Sisal fiber can effectively improve the shrinkage of foamed concrete. The longer sisal fiber is, the smaller the drying shrinkage of modified foamed concrete is. From the optical photos of concrete, it can be seen that at the same mixing amount (1%), fibers with lengths of 5mm and 10mm are more evenly dispersed than those with lengths of 15mm, which have little impact on the bubble holes.

1. Introduction
The use of plant fibers to prepare concrete construction materials can reduce the negative impact of traditional concrete materials on the environment to a certain extent. Plant fiber can enhance the mechanical properties of concrete, which is in line with the current concept of green and sustainable development. Due to the combination of cement and fiber, a mesh support system is formed inside the foamed concrete, thereby protecting the air holes. During the preparation of foamed concrete, the incorporation of fibers protects some of the bubbles and reduces the degree of damage, and at the same time reduces the solidification and sedimentation rate of the slurry, improves the overall stability of the foamed concrete, hinders the generation of cracks and Diffusion makes the strength and toughness of foamed concrete improved.

2. Test materials and schemes
2.1. Raw materials
The cement uses Shenyang Jidong Cement Plant Dunshi P · O42.5 grade cement, and the fiber uses 5mm, 10mm, 15mm sisal fiber, and the additives include foaming agent, water reducing agent, etc.
2.2. Hemp fiber processing
The sisal fibers with a length of 5mm, 10mm, and 15mm were washed and dusted, and then placed in a drying box at 80 °C and dried. The dried fibers were immersed in a 10% NaOH solution for 30 minutes.

2.3. Sample preparation
First, the mother liquid of the foaming agent is mixed with water in proportion to play a dilution role. The diluted mother liquid is added to a foaming machine to prepare a foam. After that, the pure slurry is mixed, and the pure slurry is prepared according to the test proportion and blended with plant fibers, and then the prepared foam is added, and the foamed concrete is prepared after uniform mixing.

2.4. Parameter test
For compressive and flexural strength testing, refer to "Testing Methods for Autoclaved Aerated Concrete Performance" (GB / T 11969-2008); For drying shrinkage performance, refer to "Foam Concrete" (JG / T 266-2011). The size of the test piece is 100mm × 100mm × 100mm, no less than three test blocks are selected for each group, and the dispersion of the test values meets the requirements of the specification.

3. Results and discussion

3.1. Hemp fiber processing method
Since the plant fiber contains lignin that has an inhibitory effect on cement hydration, sisal fiber must first be treated with alkali to remove a large amount of lignin. After the preliminary test, the sisal fiber was impregnated with NaOH solution at a concentration of 10-30%, and the immersion time was 10-60 minutes. It was found that with the increase of time and concentration, the mass loss of sisal fiber will tend to first a fixed value will then continue to decrease, as shown in Figure 1:

![Fig.1 Changes of fiber quality loss](image)

When the lignin in the fiber is basically removed, the mass loss of the fiber tends to a fixed value, and it will continue to decrease after the fixed value, because the internal structure of the fiber is also damaged. The ultra-deep microscope was used to observe the internal structural changes of 10% NaOH immersion for 30 minutes and 30% NaOH immersion for 60 minutes, as shown in Figure 2:
3.2. Effect of sisal fiber on the mechanical properties of foamed concrete

The effect of sisal fibers with different amounts and different lengths on the 28-day compressive strength of foamed concrete is shown in Figure 3:

As can be seen from Figure 3 (a): when the fiber length is 5mm, the 28d compressive strength increases with the increase in the amount of the fiber, and when the fiber content exceeds 0.75%, the 28d compressive strength is basically unchanged; When the fiber length is 10mm, the compressive strength at 28d first increases and then decreases with the content. When the fiber content is 0.75%, the compressive strength reaches the maximum. When the fiber length is 15mm, the compressive strength decreases, and when the content exceeds 0.75%, the decrease becomes slower; when the content remains the same, the shorter the fiber length is, the more obvious the compressive strength is.

The effect of sisal fibers with different amounts and different lengths on the flexural strength of foamed concrete is shown in Figure 4:

It can be seen from Figure 2 (a) that the surface of hemp fiber is smooth without obvious splitting, and the fiber integrity is better. It can be seen from Fig. 2 (b) that the internal structure of hemp fiber has been damaged after prolonged soaking, the surface of the fiber is cracked, and the branches generated are crisscross. Such a fibrous structure can easily blister bubbles in the cement slurry, causing a collapse phenomenon. It can be seen that soaking for 30 minutes is more suitable.

(a) 10% NaOH for 30 minutes (b) 30% NaOH for 60 minutes

Fig.2 3D ultradeep micrograph of sisal fibers
Fig. 4 Effect of fiber content on the flexural strength of foamed concrete

It can be seen from Fig. 4 that as the length and amount of sisal fibers increase, the flexural strength of the foamed concrete tends to increase first and then decrease. When the content of sisal fiber was 0.75%, the flexural strength of the test pieces with a length of 5mm and 10mm reached the maximum. When the content of sisal fiber is 0.5% and the length is 15mm, the compressive strength reaches the maximum. When the fiber length is 5mm and the blending amount is 0.75%, the flexural strength of the test pieces with a length of 5mm and 10mm reached the maximum, which is higher than the other two specifications of hemp fiber foam concrete.

The reason for the above situation is that the incorporation of fibers reduces the occurrence of some small cracks in the foamed concrete, which improves the integrity of the foamed concrete. When the cracks appear, the fibers can bear a part of the external force, thereby improving the flexural strength.

3.3 Effect on drying shrinkage of foamed concrete

The effect of different amounts and different lengths of sisal fibers on the dry shrinkage of foamed concrete is shown in Figure 5:

Fig. 5 Effect of fiber content on dry shrinkage of foamed concrete

It can be seen from Figure 5 that with the increase in the amount of hemp fiber and hemp fiber in the four specifications, the dry shrinkage value of foam concrete decreases. When the content is 0.5%, the dry shrinkage value of 10mm and 15mm fiber concrete is the smallest; The dry shrinkage value of
15mm fiber-reinforced concrete is the smallest when the content is 0.75; the dry shrinkage value of 5mm and 15mm fiber-reinforced concrete is the lowest when the content is 1.0%.

4. Conclusion

- Modified hemp fiber with alkali concentration of 10% NaOH and soaking time of 30 minutes has the best effect on improving the performance of foam concrete.
- When the fiber content is 0.75% and the fiber length is 5mm, the mechanical properties of the foam concrete are most improved, and the compressive and flexural strengths are increased by 17.8% and 47.6%, respectively.
- Sisal fiber can effectively improve the shrinkage performance of foamed concrete. Under the same content, the longer the sisal fiber, the smaller the shrinkage value of the modified foamed concrete.

5. Reference

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