

Modification of Wood Fiber for Use in Cement Board

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Abstract. When ordinary Portland cement is used for wood fiber cement (WFC) board, the setting time is too long, even hard to solidify. Three methods can be used for wood fiber modification, i.e., soaking in water, treated with alkali solution and coated with some substances on the fiber surface. The results show that the proper water-cement ratio of WFC paste is 1:1.3 in the case of wood cement ratio being 1:1. The WFC board from modified wood fiber and cement is better than the control samples, in which the combined treatment, i.e. soaking in hot water and then coating with alkali-BFS-EVA slurry, behaves best. It is proved that ordinary Portland cement can be used to produce WFC board, with the modified wood fiber, which can greatly reduce production costs.

1. Introduction

Since thousands years ago, natural fibers have been used as reinforced inorganic materials such as straw and reeds for brick and mortar. Among these fibers, wood fiber is strong, lightweight, abundant, non-hazardous and relatively inexpensive. Therefore, WFC composites have been used in the fabrication of building materials for more than 60 years, has been more popular recently [1,2].

Cement wood board is a kind of cementitious composites, with mostly rapid hardening cement as binder, wood fiber as lightweight strengthening materials[3]. WFC board is an environmentally friendly building material, with energy-saving, sound insulation, anti-fire, anti-freeze-thaw, and other advantages [4]. It is generally used for sound-absorbing, insulation, and concrete decoration materials in the construction and transportation sector. WFC board has become one of the most popular building materials on the market.

Considering the cost of rapid hardening cements are relatively high, ordinary Portland cement can be used instead. However, that imposed a serious problem: when wood fiber is mixed with OPC, the setting time becomes longer, which influence the production of WFC board. It is known that wood generally contains cellulose, hemicellulose and lignin composition [5]. Hemicellulose is mostly composed of glucose, mannose, galactose, xylose and arabinose and some water-soluble monosaccharides, which tends to form calglucon with calcium ions resulting from the hydration of cement, and covered in the cement surface, blocking the cement and water. As the reaction proceeds, the film slowly becomes thicker, the hydration reaction rate of the cement slows down, and the hardening rate of the cement is gradually prolonged [6].

The key of production of WFC board using OPC to replace rapid hardening cement is to solve the problem of the retarding effect of cement when mixed with wood fiber.



2. Modification method for wood fiber

Various treatments can be used to solve the problem of retarding effect, most of which are based on soaking in water, alkaline hydrolysis and retention of sugar and hemicelluloses[7]. These treatments will effectively improve the cement curing properties of the WFC paste, to some extent.

The first method is extraction with water to remove the water-soluble compounds which have retarding effect on cement hydration. The wood fibre is soaked in hot water for some time; the monosaccharide leach out from wood dissolved in hot water. This is suitable for extracting the water-soluble ingredients in the wood; the leaching efficiency is relatively low.

The second method is alkaline hydrolysis. Wood fibre is soaked in a certain concentration of NaOH solution, stirring, the monosaccharide dissolves out. In the presence of NaOH, hemicelluloses and sugar decomposed into non-retarding substances. This is the most common means in practice. It is simple and easy to operate, but will destroy celluloses, which contributes the strength of WFC board.

The third method is the retention of sugar and hemicelluloses. In this process, a thin coating on the surface of wood fibre forms, inhibiting the material to be released into the curing medium. It is the commonly used approach for WFC board production. A protective film on the surface of wood fibre provides a barrier between the retarding agents and cement, removing retardation effect and prolonging the setting time of paste. Some mineralisers as blast-furnace slag, fly ash and steel slag can be used for this purpose [8,9]. And the mineralisers in the coating layer not only have strong effect on early strength of cement board, but also improve durability and water resistance and other properties.

Wood fibre modification might reduce the final mechanical properties of WFC board, but the compensation obtained is the reduction of setting time of WFC paste. The combined use of different methods may bring the synergistic effect into play and obtain the optimal results.

3. Experimental

3.1. Materials

The wood fiber, granulated blast-furnace slag (BFS) and Portland cement are provided by Shijiazhuang Changanjiayi construction material Co. Ltd. Caustic soda and EVA are available on market.

3.2. Methods

Water-cement ratio. According to practice and initial test, the ratio of water and cement varies from 1:1 to 1:1.5. With fixed mass ratio of wood fiber and cement 1:4, three parallel tests are designed to obtain the proper water-cement ratio.

Wood fiber modification. Three modification methods are tested. The first is to treat wood fiber in hot water. The second is to treat wood fiber in alkali solution. The third is combined treatment of soaking in hot water and coating with alkali-BFS-EVA slurry.

(1) Soaking in hot Water. Take some wood fiber, soak it in hot water of 80°C for 1.5 h, filtering and washing, air dried.

(2) Soaking in alkali solution. Take some wood fiber, soak it in alkali solution at room temperature for 1.5 h, filtering and washing, air dried.

(3) Combined treatment. Take some wood fiber, the first soaking in water for 5 minutes, and then mixed with the mixture of NaOH solution, BFS and VAE emulsion, forming a thin layer film on the surface of the wood fiber, air dried.

Preparation of samples. The modified wood fiber is mixed with cement and water. Samples with the dimensions of 70×70×210 mm are molded, standard curing, and de-molded after 5 hours, as shown in Figure. 1.

**Figure 1** Test block sample

3.3. Results and discussion

3.3.1 Water-cement ratio Water-cement ratio is an important factor, which influence the de-molding and mechanical strength of WFC board. Table 1 shows the effect of water-cement ratio on WFC board samples after curing for 5 hours.

Table 1 Effect of water-cement ratio on hardness of the specimen

Experiment number	Wood cement ratio	Water-cement ratio	Hardness of the specimen
1	1:4	1:0.8	Soft
2	1:4	1:1	Soft
3	1:4	1:1.3	Hard
4	1:4	1:1.5	Hard+

From the Table 1 we can see that water-cement ratio has remarked effect on the hardness of WFC paste. When water-cement ratio is at and above 1:1, the specimen is soft. The proper amount of water not only affects the hydration of cement strength, but also makes cement and wood fiber mixed evenly; but excessive water will make the influence the hardening of the paste. The results show that the water-cement ratio of 1:1.3 is appropriate.

3.3.2 Modification of wood fiber Three modification methods were tested and compared with the blank. See Table 2.

Table 2 Comparison of various modification methods for wood fiber

Method	Hardness of the specimen	Cost estimation
blank	Soft	Low
Soaking in hot Water	Hard	Low
Soaking in alkali solution	Hard	Moderate
Combined treatment	Hard+	Moderate

As can be seen from the Table 2, the hardness of WFC specimen with modified fiber is higher than the blank, in which the combined treatment behaves best. For the blank sample, suppression of substances contained in wood fibers, which tends to form calglucon with calcium ions resulted from the hydration of cement, and covered in the cement surface, blocking the cement and water. Therefore, the hydration of cement is retarded. In the case of the combined treatment, alkali-BFS-VAE slurry formed a layer of dense protective film, covering the surface of the wood fiber, blocking the cement and the inhibitor. In this way, the retarding effect of wood fiber on cement is removed, obtaining normal setting time for WFC board. Besides, the cost is moderate. Based on the above factors, the method of combined treatment is suitable for WFC board.

4. Conclusions

- (1) Some organic materials in wood fiber inhibit the setting of the cement and reduce its suitability as WFC board. When wood fiber is modified, ordinary Portland cement can be used to produce WFC board instead of rapid hardening cement, thus reducing production cost.
- (2) Water-cement ratio is an important factor in WFC production. In the case of wood cement ratio being 1:1, as water-cement ratio is at and above 1:1, the paste is difficult to harden. The proper water-cement ratio is 1:1.3.
- (3) Three methods for wood fiber modification, soaking in water, alkaline hydrolysis treatment and the combined approach of soaking in hot water and then coating with alkali-BFS-EVA slurry, can be used to modify wood fiber. Among these, the combined method behaves best and the cost is moderate.

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