Research on Panels Fabricated by Fibers Derived from Kenaf Bast after Environmental Restoration

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Abstract. In this paper, Kenaf bast fiber were the research objective. The fiber morphology was studied, as well as the compatibility between fibers and cemented. At last, The manufacture technology for fiber reinforced cement-based panel was studied. The results are as follows: The average length of Kenaf bast fiber, which determines Kenaf bast fiber as long fibers. Effects of the influences of fiber to cement (w/c), water to cement (m/c) were significant. When the conditions of the process were following that the ratio of wood-cement ratio was 0.22, water-cement ratio of 0.42, the Kenaf bast fiber-cement panel met the requirement of excellence (MOR = 14 MPa, MOE = 3900 MPa, TS = 1.26%) specified in GB/T 24312-2009.

1. Introduction
Cement fiberboard is also called fiber cement board. It is a kind of composite material made of fiber and cement by mixing, molding, pressing and curing. Compared with traditional building materials, cement fiberboard has special advantages, such as moisture-proof, corrosion-proof, fire-proof, sound insulation, heat insulation and so on. A great deal of research has been done on the technology of manufacturing cement particleboard at home and abroad. But there are few reports about using wood fiber to produce cement fiberboard [1-4]. In recent years, the development and utilization of plant fiber is developing rapidly, but the research of using plant fiber to prepare cement fiberboard is not much. In addition, at present, the majority of domestic enterprises use the traditional wet method to produce fiber cement board, but the use of semi-dry method to prepare fiber cement board is rarely reported, only Japan uses this forming method. Compared with wet process, semi-dry process can not only save a lot of water, reduce water pollution, but also greatly improve the environment. Kenaf bast fiber is derived from Kenaf bast, which is used to enrich heavy metals in soil. In addition, it has a good interfacial bond between bleached fiber and cement, and alkali-resistant fiber can improve the alkali resistance of the board [5]. The purpose of this paper is to study the production process of cement fiberboard by semi-dry method, and to provide reference data for the large-scale production of domestic relevant industries with Kenaf bast fiber as the material.
2. Materials and methods

2.1. Materials
Kenaf bast fiber was purchased from China Paper Research Institute. Other materials including glucose, xylose and arabinose (standard product of Sigma company), and heat-ground fiber, etc. were all analytical grade.

2.2. Test methods

2.2.1. Determination of fibre morphology. First of all, cell separation of Kenaf bast fibers was performed by Franklin’s method. Take a small amount of fiber sample, put 30% hydrogen peroxide and glacial acetic acid mixture solution (volume ratio 1:1) in the dissociation solution, in the next 2-3 days, until the group of fibers just separated into a single fiber. The separated fibers were washed thoroughly with water and stained with safranine to make glass slides. The length of the fibers was measured by magnification of 10 times and the width of the fibers was measured by magnification of 40 times under the microscope. Repeat the length of the sample 50 times, repeat the width of the sample 30 times, take the test results of arithmetic mean for the measured value.

2.2.2. Fiber extract and sugar analysis. The extract and sugar of the two kinds of fiber were analyzed by comparing with those of Kenaf bast fiber.

2.2.3. Preparation of fiber cement board. The wood-cement ratio (a) and water-cement ratio (B) were selected as independent variables, and each factor adopted 3 levels. The experiments were arranged according to orthogonal table L9 (34) without considering the interaction between the factors. Factor levels are set as shown in Table 1, and each test is repeated twice.

| Table 1. Factors and levels |
|----------------------------|
| A  | B  |
| Level 1 | 0.18 | 0.38 |
| Level 2 | 0.20 | 0.40 |
| Level 3 | 0.22 | 0.42 |

Weighed the required weight of fiber into the mixing tank, added water, then added cement mixing until the mixture was uniform which could be paved. Sprinkle the mixture slowly and evenly onto the backing plate inside the forming frame. In order to facilitate demolding, the upper and lower add a layer of plastic film, manual shop finished, on the thickness gauge. Send the finished slab stack to the cold press, slowly pressurize, the maximum pressure is limited to constant speed pressurize to thickness gauge. To prevent the fiber cement board rebound, keep pressure for 48 hours. After pressure relief, place at room temperature for 4 weeks, the then the static bending strength, elastic modulus and swelling rate of water-absorbing thickness were measured according to GB/T 17657-1999 and GB/T 24312-2009.

3. Test results and discussion

3.1. Determination of fibre morphology
The results of determination of fiber morphological indexes of Kenaf bast fiber are shown in Table 2.

| Table 2. Fiber morphology |
|---------------------------|
| Species                  | Measuring root number | Fiber length (mm) | Fiber width (μm) | Aspect ratio |
|                          |                        | Max          | Minimums   | Average | So-so | Max          | Minimums   | Average | So-so | 71   |
| Kenaf bast fiber         | 150                     | 4.42         | 1.64       | 2.8     | 2.03-  | 2.97         | 67.7        | 21.9    | 39.7  | 26.1- | 56.4 |
As can be seen from Table 2, the fiber length range of Kenaf bast fibers is 2.03. Fiber length is longer than long fiber, medium fiber at 0.9 and short fiber at 0.9. So Kenaf bast fiber belongs to long fiber. The strength of the fiber itself and the bond between the fibers have a significant impact on the strength of the board. The longer the length of the fiber, the greater the strength of the fiber; The finer the fiber distribution, the higher the strength of the laminates [6, 7].

3.2. Hydration test of Kenaf bast fiber and cement
The test results of Kenaf bast fiber and cement hydration are shown in Table 3.

| Name                     | Maximum hydration temperature, T/c | Time to reach maximum hydration temperature, T/h |
|--------------------------|-----------------------------------|-----------------------------------------------|
| Cement                   | 46.67                             | 8                                             |
| Kenaf bast fiber/cement  | 43.84                             | 10                                            |

As can be seen from Table 3, the highest hydration temperature of pure cement is 8 h, and the time to reach the highest hydration temperature is 10 h when Kenaf bast fiber is added. This is due to the chemical treatment of the Kenaf bast fiber, which removed the sugar and other unfavorable components of the cement, so the Kenaf bast fiber has very little effect on the cement retarding, that is to say, the fiber has a good compatibility with the cement, it is suitable for the preparation of cement fiberboard directly.

3.3. Preparation and properties analysis of fiber cement board

3.3.1. Test results. The mechanical properties of the pressed sheet were tested after 4 weeks at room temperature. The test results were averaged, and the variance of the results was analyzed as shown in Table 4 and Table 4.

| Serial number | Wood to ash ratio | Water cement ratio | Density (g/cm³) | SBE(MPa) | MOE (MPa) | 24h water absorption thickness ratio (%) |
|---------------|-------------------|--------------------|-----------------|----------|-----------|------------------------------------------|
| 1             | 0.18              | 0.38               | 1.26            | 7.3      | 2328      | 2.13                                     |
| 2             | 0.18              | 0.40               | 1.28            | 9.0      | 3099      | 0.66                                     |
| 3             | 0.18              | 0.42               | 1.25            | 8.8      | 2802      | 1.25                                     |
| 4             | 0.20              | 0.38               | 1.21            | 7.6      | 2195      | 3.51                                     |
| 5             | 0.20              | 0.40               | 1.29            | 10.2     | 3129      | 2.17                                     |
| 6             | 0.20              | 0.42               | 1.33            | 11.0     | 3476      | 0.09                                     |
| 7             | 0.22              | 0.38               | 1.25            | 11.2     | 2988      | 3.16                                     |
| 8             | 0.22              | 0.40               | 1.29            | 13.4     | 3642      | 1.52                                     |
| 9             | 0.22              | 0.42               | 1.32            | 14.0     | 3958      | 1.26                                     |

The results show that it is feasible to use Kenaf bast fiber to produce cement panel by semi-dry process, and the static bending strength of the pressed fiber-cement panel can meet the requirements of the standard of cement particleboard (GB/T 24312-2009). The results of variance analysis (Table 5) show that the wood-cement ratio and water-cement ratio have significant effects on the properties of the board, and the optimum technological parameters are: wood-cement ratio 0.22, water-cement ratio 0.42.
### Table 5. Analysis of variance of orthogonal test

| Performance Factor               | Sum of squares of deviations | Degree of freedom | Shelby F critical value | Salience |
|---------------------------------|-----------------------------|-------------------|-------------------------|----------|
| **Static bending strength (MPa)** |                             |                   |                         |          |
| Wood to ash ratio               | 32.442                      | 2                 | 80.701                  | 19.000   | *        |
| Water cement ratio              | 11.442                      | 2                 | 28.463                  | 19.000   | *        |
| Error                           | 0.40                        | 2                 |                         |          |          |
| **Young's modulus (MPa)**       |                             |                   |                         |          |
| Wood to ash ratio               | 1009762.889                 | 2                 | 21.320                  | 19.000   | *        |
| Water cement ratio              | 1458273.556                 | 2                 | 30.790                  | 19.000   | *        |
| Error                           | 47361.56                    | 2                 |                         |          |          |
| **24 h water absorption thickness expansion rate (%)** |                             |                   |                         |          |
| Wood to ash ratio               | 0.737                       | 2                 | 0.542                   | 19.000   |          |
| Water cement ratio              | 6.812                       | 2                 | 5.009                   | 19.000   |          |
| Error                           | 1.36                        | 2                 |                         |          |          |

### 3.3.2. The effect of fiber-ash ratio on the properties of board.

In the cement panel, fiber and cement are the two main raw materials of cement panel. Cement is the cementitious material; wood fiber is the reinforcing material. With the increase of wood-cement ratio and fiber content, the volume ratio of fiber also increases, and the compression ratio of slab increases, which makes the contact between cement and fiber closer, and is favorable for the transfer of stress from cement to fiber, the load-bearing capacity and stress concentration of the cement matrix are reduced, and the static bending strength and elastic modulus of the cement panel increase with the increase of wood-cement ratio. It can also be seen that with the increase of wood-cement ratio, the expansion rate of water-absorbing thickness of the board increases. This is because, with the increase of wood fiber content, the board of water absorption capacity increased. The reason why the total water absorption thickness expansion rate is very small is that the board has rebound after compression, which makes the compression deformation of the fiber smaller, so that the expansion of the board is not significantly increased after water absorption. Based on the above analysis, the best wood-cement ratio is 0.22.

### 3.3.3. Influence of water-cement ratio on properties of sheet.

Water-cement ratio is also a main factor affecting the performance of cement-based fiberboard. If the water-cement ratio is too large, the fiber is easy to form a mass, and the fiber inside appears “Glue-deficient” now, and it will lead to uneven paving, which will adversely affect the strength of the board; if the water-cement ratio is too small, it will cause the fiber and cement to stick together and not well, the incomplete hydration of cement results in the decrease of the strength of the board. The water cement ratio from 0.38 to 0.40 has a significant effect on the ultimate mechanical properties of the board, such as static bending strength and elastic modulus. When the water cement ratio is 0.42, the static bending strength and elastic modulus are higher, and the water absorption rate and water absorption thickness expansion rate are lower. Therefore, the better water cement ratio is 0.42.

### 4. Conclusion

In this paper, Kenaf bast fiber were the research objective. The fiber morphology of The Kenaf bast fiber was studied, as well as the compatibility between Kenaf bast fiber and cemented. At last, the manufacture technology for fiber reinforced cement-based panel was studied. The results are as follows: The average length of Kenaf bast fiber, which determines Kenaf bast fiber as long fibers; Kenaf bast
fiber command good compatibility with citations of its little inhibition, which can be used to produce fiber reinforced panel. Effects of the influences of Kenaf bast fiber to cement (w/c), water to cement (m/c) were significant. When the conditions of the process were following that the ratio of wood-cement ratio is 0.22, water-cement ratio of 0.42, the Kenaf bast fiber-cement panel met the requirement of excellence specified in GB/T 24312-2009.

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5. References
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