# Application of modified rice straw/PP wood-plastic composite material in landscape

*Qinghui* Sun*, and *Boyang* Bai

School of Construction, Guangdong Institute of Technology, Guangdong, China

**Abstract.** Using rice straw powder as filler and polypropylene (pp) film as matrix,The rice straw/pp wood-plastic composites without and with the addition of antioxidant vitamin E were prepared by kneading and hot pressing.Study on the aging properties of rice straw/pp wood-plastic composites with and without the addition of antioxidant vitamin E using ultraviolet accelerated aging method,The effects of different content of vitamin E on the anti-aging properties of rice straw/pp wood-plastic composites were analyzed.Finally, the application of modified rice straw/pp wood-plastic composite materials is researched and summarized to help create a modern landscape of ecological and environmental protection.

**Keywords:** Polypropylene, Rice straw, Wood-plastic composite, Antioxidant, Landscape application.

## 1 Introduction

The material is the material foundation of landscape construction, and the wood is occupying the very important status, the excessive dependence on the natural wood, causes the forest resources to be scarce, thus is restricting the landscape design development.With the rapid development of composite materials, people found the substitute of natural wood, and wood-plastic composite materials came into being. The Wood-plastic composite is a new type of composite material which has sprung up at home and abroad in recent years. It uses Thermoplastic (polypropylene, polyethylene, polyvinyl chloride, etc.) as Matrix, wood powder and other waste fiber plants as filler, and then through hot extrusion, molding, injection and other processes produced by a number of plate[1-3] .Wood-plastic composite has both plastic and wood properties and has a good modulus of elasticity due to the presence of plastic inside.In addition, the internal fiber plants is fully mixed with the plastic, and thus has certain compressive, bending and other physical and mechanical properties, compared with Natural Wood surface hardness is higher, than ordinary wood 2-5 times. WPC also has good ultraviolet light stability, colorability, adjustable performance and so on[4-5].

* Corresponding author: 848766457@qq.com

In outdoor landscape applications, WPC is exposed to ultraviolet radiation and moisture in the air for a long time, which causes its surface to fade and its physical properties to decrease[6-8].Therefore, the aging problem of WPC has been widely concerned.

The recycled Rice straw/PP wood-plastic composite (WPC) was prepared by mixing and hot-pressing with recycled polypropylene (PP) as Matrix and rice straw powder modified by coupling agent KH550 as Filler and reinforcement,The effects of Antioxidant Vitamin E on the mechanical properties and surface color of rice straw/PP wood-plastic composite (WPC) during thermal aging were investigated.Widely used in modern outdoor landscape design.

## 2 The experimental part

### 2.1 Experimental material

Polypropylene (PP) powder, Guangzhou Huao Chemical Co. , Ltd. , density 0.92 g/cm3;
Rice Straw, grain size 60-80 Mesh, from Zhaoqing Hulu Village Farm;
Silane coupling agent KH550, Hangzhou Jessica Chemical Co. , Ltd;
Antioxidant vitamin E (Ve) , Sino Environmental Technology Co. , Ltd .

### 2.2 Major instruments and equipment

Electric drying oven: 101-1AB, Tianjin Ketaite Instrument Co. , Ltd;
Table crusher: LH-08B, Xinchang Chengguan Bonus CNC Manufacturing Factory;
Impact testing machine: XJJ-5, Chengde Jinjian Testing Instrument Co., LTD speed uv aging box;
QUV/SPRAY, Q-Lab, USA;
Precision color difference meter :HP-200, designed by Shanghai Hanpu Photoelectric Technology Co., LTD;
Fourier Transform Infrared Spectroscopy (FT-IR);
Microscope: SMZ1000, Nikon.

### 2.3 Sample preparation

In the composite materials, the mass ratio of rice straw powder to polypropylene (PP) was controlled at 5:5 to prepare the conventional PP composite sample (Control), and Ve was added to the sample. The addition amount of Ve was 0.2%, 0.4%, 0.6% and 1.2% of the total mass of rice straw powder and polypropylene (PP).The samples numbered VE0.2%, VE0.4%, VE0.6% and VE1.2% were mixed evenly in a high-speed mixer for 5min. After processing, the size of the samples was 70mm×40mm×10mm.

### 2.4 Test method

The light aging resistance of wood-plastic composite was studied by using UVB-313 fluorescent lamp with reference to ASTM G154-2012.The total aging time was 960h and the aging period was 12h, which was divided into two stages.First, the first phase simulates the effect of solar degradation on WPC in real environment. Secondly, the second stage is condensation, which is used to simulate the effect of dew on WPC. Finally, the specimens were taken out after accelerated aging for 240H, 480H, 720H and 960h.

By testing the surface color of rice straw/PP WPC, the parameters of lightness ( $L^*$ ) , red/green index ( $a^*$ ) , blue/yellow index ( $b^*$ ) were obtained. $L^*a^*b^*$ consists of a vertical axis indicating Luminance (Luminance) of all white to all black, two horizontal extended surfaces indicating color, one of which is red to green, and the other is blue to yellow [9] . $L^*$ completely white objects as 100, completely black objects as 0;The range of $a^*$ value and $b^*$ value WAS-100-100, the larger $a^*$ value indicated red color, and the smaller $a^*$ value indicated green color;A larger $b^*$ value indicates a yellow color, while a smaller $b^*$ value indicates a blue color. The degree of overall color change during aging is expressed by the color difference ( $\Delta E$ ) . The formula is as follows:

$$\Delta E = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

$\Delta L^*$ ------The difference of $L^*$ between the composites before and after aging

$\Delta a^*$ ------The difference of $a^*$ between the composites before and after aging

$\Delta b^*$ ------The difference of $b^*$ between the composites before and after aging.

The bigger the $\Delta E$ value of the surface color with time, the bigger the overall color change, the worse the anti-aging performance.

## 2.5 Results and analysis

### *2.5.1 Surface color analysis*

After accelerated aging of Rice Straw/PP WPC samples at different stages by ultraviolet irradiation, the change of surface brightness difference ( $\Delta L^*$ ) and total color difference ( $\Delta E$ ) of Rice STRAW/PP WPC samples is shown in Fig. 1. Overall, $\Delta L^*$ , $\Delta E$ both the value of aging with the extension of time.

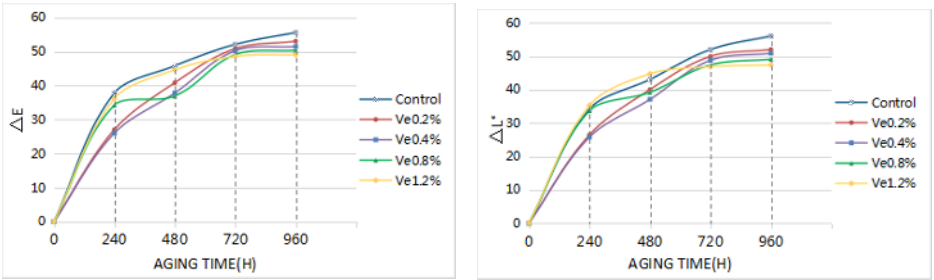


**Fig. 1.** Changes of surface lightness（ $\Delta L^*$ ）difference and color （ $\Delta E$ ）difference during aging of composite materials.

From figure 1, it can be seen that the values of $\Delta L^*$ and $\Delta E$ increase with the aging time, and the value of $\Delta E$ is basically determined by the value of $\Delta L^*$ .The change of $\Delta L^*$ value of rice Straw/PP WPC was obviously influenced by different Ve content.In the first stage 0-240h, the value of $\Delta L^*$ and $\Delta E$ increased the most, which was basically linear.The $\Delta L^*$ value of Control (blank sample) was significantly lower than that of VE0.2% and Ve0.4% , which indicated that a small amount of Ve could alleviate the fading and

Whiteness of the surface color of the material, at this stage, $\Delta L^*$ value of Control (blank sample) was higher than that of Ve (Ve0.8% , ve1.2%) , which may be due to the discoloration of Ve itself.After 240h, it rises slowly and tends to be stable from the overall trend.After aging to 960h, $\Delta L^*$ value of Control (blank sample) was 56.15 and $\Delta E$ value was 55.56, $\Delta L^*$ VALUE OF Ve0.2% was 52.08 $\Delta E$ value was 53.02,The $\Delta L^*$ value of Ve0.4% of the sample was 50.95 $\Delta E$ value was 51.43, $\Delta L^*$ value of Ve0.8% of the sample is 49.15 and $\Delta E$ value is 50.33,The $\Delta L^*$ value of VE1.2% was 47.45 $\Delta E$ value was 49.02.From this data, it can be seen that the color change of Control (blank sample) is the most obvious, followed by the sample Ve0.2%, Ve0.4%, Ve0.8%, Ve1.2%,The results showed that the oxidant Ve could inhibit the aging and fading of rice straw /PP WPC composites, and Ve0.8% and Ve1.2% had the best effect.

### *2.5.2 Analysis of bending property*

In the outdoor landscape design, the color of Rice Straw/pp wood-plastic composite will change after ultraviolet aging, which will lead to the decline of mechanical properties.This may be due to the presence of tertiary hydrogen in the polypropylene molecular chain, through ultraviolet irradiation and aerobic environment, oxidation reaction occurred, oxidation to produce carbonyl compounds and hydroperoxide, polypropylene molecular degradation, resulting in a loose composite structure [10-12].At the same time, more hydroxyl groups in rice straw fiber could accelerate the initiation rate of polypropylene chain, and then accelerate the break of polypropylene molecular chain, and the mechanical properties of the composite decreased.

**Table 1.** Flexural properties of all composites before weathering.

| Grouping | Flexural strength(MPa) | Bending modulus(GPa) |
|---|---|---|
| Control | 44.32 | 2.96 |
| Ve0.2% | 44.27 | 2.61 |
| Ve0.4% | 43.35 | 2.81 |
| Ve0.8% | 44.36 | 2.85 |
| Ve1.2% | 41.83 | 2.60 |

Table 1 shows the bending strength and Modulus of each group of Rice straw/PP WPC samples before aging.It can be seen from table 1 that the content of antioxidant Ve has a certain effect on the composite, and we can find that the effect of removing Rice straw/PP WPC is not obvious when the content of antioxidant Ve is low, when the content of Ve was 1.2% , the properties decreased slightly, which was about 5% relative to Control bending strength and bending modulus.This may be due to the effect of antioxidant Ve on the adhesion between Rice Straw powder and PP.As shown in Fig. 2, the retention rate of MOR of Rice straw/PP WPC shows a cyclic trend of first rising and then rising, which is caused by the degradation of PP on the surface of the composite and the decrease of its mechanical properties at the initial stage The mechanical properties of PP increased after the chain was broken.In this aging cycle, Rice straw/PP wood-plastic composite was degraded first and then recrystallized.The trend in MOE retention was also a cyclical trend of first rising and then rising, with a larger decline than for MOR retention.In the aging process of rice STRAW/PP WPC with antioxidant Ve, the retention rates of MOR and MOE are higher than Control (blank sample) , and increase with the content of antioxidant Ve.After aging for 960H, MOR of high VE0.8% and Ve1.2% samples had no obvious change, MOE decreased slightly, but the retention rate was about 93% . The results show that the

antioxidant Ve can effectively maintain the bending properties of Rice STRAW/PP WPC, and the best effect is when Ve content is 1.2% .

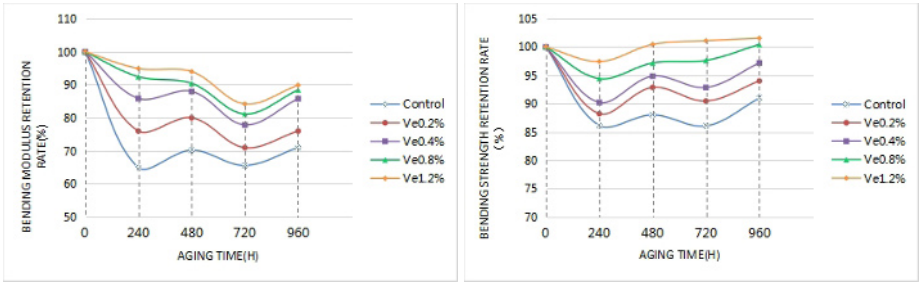


**Fig. 2.** The retention of bending strength of each group of Rice STRAW/PP WPC during aging.

## 3 Application of modified rice straw/PP wood-plastic composite in landscape

In modern urban landscape design, wood-plastic composite basically replaced natural wood, because wood-plastic composite has both the affinity of wood and plastic plasticity, in the landscape widely loved by people.The WPC has flexible formula adjustment in the manufacturing process. Studies have shown that the rice straw /PP WPC modified with antioxidant Ve is one of the most ideal landscape materials in modern landscape design, with environmental protection, anti-aging and pleasant characteristics [13-14].

### 3.1 Landscape boardwalk

Modified Rice straw /PP wood-plastic composite board is widely used in urban landscape design, such as courtyard paving, wetland park viewing platform, facade wall and so on.The reason why this kind of composite paving board occupies a place in the landscape materials of modern cities is that this kind of composite paving board is exposed to the outdoors all the year round and is influenced by natural environmental factors such as ultraviolet rays and moisture, not Easy to appear deformation, cracking, mildew, decay, fading and other problems, but also has the affinity of Natural wood effect [15] .

Take the application in the landscape plank road of Inkstone Lake Garden in the campus of Guangdong University of Technology as an example.This area is located in Zhaoqing City, which belongs to the subtropical monsoon climate. The average annual rainfall is about 1650 mm. Especially in the hot and humid summer, the solid wood plank is prone to mildew, rot and insects all year round under the influence of the environment.The modified rice straw/PP wood-plastic composite decking has unique anti-aging advantages. The application of this composite material not only provides convenience for the later maintenance of campus nurses, but also adds a beautiful ribbon to the campus.Modified rice straw/PP wood-plastic composite decking has various forms. From the product

form, there are solid type and hollow type. In this case, solid decking is used (as shown in Figure 3). Solid decking has high strength and can be used in natural environment. Under the influence of , the anti-aging performance is better, and it is more suitable for the ground pavement of the plank road.And the surface of the board is processed with realistic wood texture and color, which makes people feel warm and close (see Figure 4).

**Fig. 3.** Solid wood-plastic composite decking.

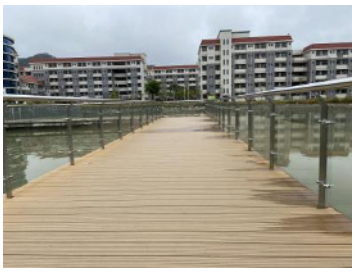

**Fig. 4.** Wood-plastic composite plank road.

**Fig. 5.** Effect of wood-plastic composite corridor.

### 3.2 Corridor

In modern landscape design, corridors mainly play the role of providing people with rest and guiding their sight.In the early days, wood or stone was generally used for construction. Due to the relatively poor aging resistance of wood and the inconvenience of stone construction, the shortcomings of the two are difficult to be recognized by the public.The wood-plastic composite material has good aging resistance and plasticity, and can change its required shape, texture and color according to different terrains and application scenarios, which helps to realize the ideal structure in the construction plan.(Picture 5) is to build the corridor in Yanhu Garden, using modified rice straw/PP wood-plastic composite material, the shape is very smooth and dynamic, creating a natural and ecological open space.

## 4 Conclusion

Modified rice straw/PP wood-plastic composite material is widely recognized in modern landscape applications for its excellent performance. While retaining the wood texture, this material has the characteristics of green environmental protection, anti-corrosion and moisture resistance, and is widely used in landscape design. as one of the commonly used materials.

By selecting antioxidant-vitamin E (Ve) as an additive, comparing the effect of different contents of Ve on the aging resistance of rice straw/PP wood-plastic composites under certain conditions, and analyzing through ultraviolet accelerated aging test, it is concluded that with aging With the prolongation of time, the $\Delta L^*$ and $\Delta E$ values are also increasing, and the value of $\Delta E$ is basically determined by the value of $\Delta L^*$.In the aging process of 960h, it can be found that the Ve reagent can effectively delay the photodegradation process of the material, and the two groups of samples with higher content of Ve0.8% and Ve1.2% have more significant aging resistance.

The addition of antioxidants (Ve) can not only reduce the fading phenomenon of rice straw/PP wood-plastic composites, but also help reduce the loss of mechanical properties.Through the experiment, it is concluded that the MOR and MOE retention rates of the samples with antioxidant Ve added in the aging process are higher than those of Control, and the samples after aging to 960h have higher content of Ve0.8% and Ve1.2%. There is basically no obvious change in the MOR of the sample, and the MOE is slightly reduced, and the retention rate is about 93%, and the effect is the best.thereby prolonging the service life of the material.

The application of modified rice straw/PP wood-plastic composite materials in modern landscapes reduces the environmental damage caused by excessive deforestation of the source of the forest, and at the same time provides great advantages for modern landscape design due to its anti-aging and plasticity advantages. creative space.

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