Application Analysis of WF / HDPE Composite in Landscape Design

Qinghui Sun\textsuperscript{1,*}, Yibing Lai\textsuperscript{2} and Huiquan Shi\textsuperscript{1}

\textsuperscript{1}School of Construction, Guangdong Institute of Technology, Guangdong, China
\textsuperscript{2}Foundation Department, Guangdong Institute of Technology, Guangdong, China
*Corresponding author e-mail: 201507563@gdlgxy.edu.cn

Abstract. Based on the brief introduction of the basic concept of landscape design, the anti-aging properties of WF / HDPE composite with UV-326 absorbent and WF / HDPE composite with UV-P absorbent were compared. It is concluded that the UV-P modified WF / HDPE composite can replace the UV-326 modified WF / HDPE composite in landscape design. The effects of UV-P and UV-326 contents on the aging resistance of WF / HDPE composites were analyzed. The application of UV-P modified WF / HDPE composite in modern landscape design is presented, and the structure and application place of paving board are introduced.

Keywords: Landscape Design, WF / HDPE Composite, Anti-Aging, UV Absorbent

1. Introduction

Landscape is an art, it created a beautiful human living space, to bring people comfortable and beautiful enjoyment. The creation of landscape design is constantly pushing the change of technology, and the change of technology also makes the form of landscape to be renewed.

With the rapid development of industrialization, environmental problems have become increasingly prominent. The excessive felling of the source of forest has caused the serious deterioration of ecological environment in our country, so it is very important to improve the utilization ratio of wood and look for the substitute of wood. Through people's continuous efforts, wood-plastic composite (WPC) came into being. WF / HDPE composites are extruded from Wood high-density polyethylene mixed with wood flour (WF) waste. But it is difficult for WF / HDPE composite products to meet the requirement of long-term outdoor landscape in the market at present.

UV-P and UV-326 are Benzotriazole light stabilizers that protect against sunlight and other UV Polymer degradation [1]. This kind of reagent is often used in the field of polymer materials, because benzotriazole light stabilizers have good compatibility with PE and can absorb UV [2].

2. Effect of Surface Color of Composite Materials after Addition of UV-P and UV-326 Reagents

In landscape design, people's awareness of environmental protection has increased, making wood-plastic composite materials by people's attention. But the limitation of anti-aging property has become the key problem that restricts its application. It was found that the ultraviolet radiation caused the surface of WPC to chemical reaction, the surface color to fade, and the mechanical properties to...
decrease. In order to improve the aging resistance of WPC, light stabilizers such as UV-P, UV-326 are usually added to WPC.

**Table 1.** Ultraviolet irradiation accelerated the aging of different time sample brightness difference

| Sample number | 500  | 1000 | 1500 | 2000  | 2500  |
|---------------|------|------|------|-------|-------|
| Control       | 5.1  | 11.25| 16.1 | 17.85 | 17.63 |
| 2%UV-326      | 7.5  | 9.6  | 8.52 | 9.73  | 9.4   |
| 2%UV-P        | 2.15 | 3.58 | 4.01 | 4.27  | 3.68  |

**Table 2.** Color difference of samples in different aging time accelerated by ultraviolet irradiation

| Sample number | 500  | 1000 | 1500 | 2000  | 2500  |
|---------------|------|------|------|-------|-------|
| Control       | 5.5  | 12.67| 16   | 18.52 | 18.4  |
| 2%UV-326      | 8.5  | 10.59| 10.47| 11.21 | 10.71 |
| 2%UV-P        | 2.65 | 4.58 | 4.51 | 4.27  | 3.98  |

According to tables 1 and 2, the anti-aging properties of WF / HDPE composites with UV-P and UV-326 are better than those of blank samples, and the color retention was better with the addition of UV-P than with UV-326. In this experiment, the lightness difference $\Delta L^*$ and Color Difference $\Delta E^*$ were investigated by changing the surface color with time. The bigger the value, the worse the anti-aging performance.

![Figure 1](image_url). Change of surface color of WF / HDPE composites before and after aging with addition of UV-326 and UV-P

The chromatic aberration test is based on the measured values of the unaged composites. As shown in figure 1, the $\Delta L'$ and $\Delta L'$ values of WF / HDPE composites with three different formulations are basically the same, and the change trend is basically the same. It can be concluded that the color fading on the surface of the sample is obvious, and the change of $\Delta a^*$ and $\Delta b^*$ is not obvious during the whole aging process. The results show that the fading of WF / HDPE composite can be effectively improved by adding ultraviolet absorbent, which has certain effect on the anti-aging of the composite.

As you can see from figure 1, the longer the aging time, the larger the values of $\Delta L'$ and $\Delta E^*$, And the value of $\Delta E^*$ is basically determined by the value of $\Delta L^*$.In the first stage 0-1000h, the value of $\Delta L'$ and $\Delta E^*$ increases the most, which is basically a linear increase, but after 1000h it rises slowly, but the overall trend tends to be stable. The $\Delta L'$ value of Control (blank sample) is 17.63 and $\Delta E^*$ value is 18.40 for three WF / HDPE composites aged for 2500h; The $\Delta L'$ value and $\Delta E^*$ value of 2% UV-326 were 9.40 and 10.71 respectively; The $\Delta L'$ value and $\Delta E^*$ value of 2% UV-P were 3.68 and 3.98 respectively. From this data, Control (blank sample) had the most obvious color change,
followed by formula 2% UV-326, and formula 2% UV-P had the least color change. The results show that the degradation of the molecular chain and WF can be inhibited by adding a certain amount of UV absorbers, thus the color change of WF / HDPE composite is weakened, finally, the color retention effect of WF / HDPE composite with 2% UV-P was better than that of 2% UV-326.

3. Effect of Addition of UV-P Reagent and UV-326 Reagent on Mechanical Properties of the Composites

In the outdoor landscape design, the color of WF / HDPE composite changes after ultraviolet aging, which will eventually lead to the decline of mechanical properties. Figure 2, shows the relationship between the bending properties and aging time. The three specimens are Control (blank), WF / HDPE composite with UV-326 and WF / HDPE composite with UV-P. The bending properties of WF / HDPE composites with three different formulations decreased after accelerated UV aging, and the bending strength and modulus decreased more obviously after aging time of 2000h. Many scholars believe that this is due to the existence of carbonyl group, and carbonyl group is the main reason for UV absorption, so that polyethylene photoinitiated reactions[3-5].

\[
\text{Density polyethylene I type photodegradation reaction:}
\]

\[
\text{Density polyethylene II type photodegradation reaction:}
\]

Figure 2. Effect of UV-326 and UV-P on flexural properties of WF / HDPE composites during aging

As can be seen from Fig. 2, the addition of UV absorbers helps to reduce the loss of mechanical properties. After UV aging, both MOR and MOE of WPC composites without UV absorbent were significantly reduced [6]. The bending strength of blank samples decreased continuously during the 0-1500h aging process accelerated by ultraviolet radiation, and the blank samples decreased 6% after 1500h aging. The flexural strength of WF / HDPE composites with 2% UV-326 and 2% UV-P had no significant change between 0-500h and 500-1000h. After 1500h, the flexural strength of WF / HDPE composites decreased by 10.2% and 3.9% respectively. This shows that UV absorbent can absorb a certain amount of UV light, and can protect the composite well, and 2% UV-P is better than 2% UV-
326, better protection WF / HDPE composite bending strength. In the aspect of Bending Modulus, WF / HDPE composite with ultraviolet absorbent added before aging was obviously higher than blank sample, and the bending modulus of all three samples decreased in different degree after ultraviolet acceleration[7]. At the beginning of aging, the bending modulus of WF / HDPE composite with UV absorbent sample increased from 0 to 500h, and the loss of bending modulus increased gradually at 500 to 1000h, and finally at 1500h, the flexural Modulus of WF-HDPE composite with 2% uv-326 and 2% UV-P decreased by 21.7% and 16.6% , respectively, while that of the blank sample decreased by 20.5%. It is concluded that the decrease of mechanical properties of WF / HDPE composites with 2% UV-P is the smallest after ultraviolet aging.

4. Application of WF / HDPE Composite in Modern Landscape Design

Wood-plastic composite products are popular because of their unique properties of both wood and plastic[8]. The results show that WF / HDPE composite with UV-P modifier is one of the most ideal landscape materials in modern landscape design, which has the characteristics of environmental protection, anti-aging and Amenity.

4.1. Floor Planking

WF / HDPE composite paving board is widely used in landscape architecture, such as garden road, dock, viewing platform, courtyard, boardwalk and so on. WF / HDPE composite paving board occupies a place in modern landscape materials because WF / HDPE composite paving board is exposed to outdoor all the year round, influenced by natural environmental factors such as ultraviolet rays and humidity, and is not easy to be deformed, cracked, mouldy and rotten, moth, discoloration, and so on. And the form of wood-plastic Paving Board is various, from the product form, have solid rectangular section, also have hollow section shape (figure 3). Surface can also be processed into realistic wood texture and color, making people feel warm, intimate feeling.

Solid WF / HDPE composite paving board has solid structure and high strength. Under the influence of natural environment, it is superior to hollow type in anti-aging. Therefore, it is more suitable to be used in landscape design for viewing platform with large flow of people, pavement of Boardwalk (figure 4). Compared with solid type WF / HDPE composite paving board, hollow type WF / HDPE Composite Paving Board has poor resistance to impact load, but it saves materials, reduces the quality of the floor and is easy to install. The hollow type WF / HDPE composite paving board is suitable for the construction of the garden road in the dry climate in the north of China because of the gap in the middle, which can easily accumulate water vapor under the relatively humid environment and lead to the accelerated aging of the floor.

Figure 3. Floor Plan
4.2. Landscape Flower Box
Flower boxes are an integral part of landscape design. Play the role of the finishing touch, Early flower boxes are mostly made of wood, can not stand the ultraviolet rays and the baptism of wind and rain, the aging phenomenon occurs over time. In order to meet the demand of road landscape, WF / HDPE composite flower box can be used. This kind of material has certain anti-aging ability, not easy to appear the phenomenon of decay, mildew, cracking, reducing the work pressure of garden maintenance workers. In addition, WF / HDPE composite flower boxes can effectively prevent the destruction of insect ants, common wood flower boxes for a long time moldy, there will be insect ants inside, very unsanitary, and WF / HDPE composite flower boxes effectively prevent this defect (figure 5)[9-10].

5. Conclusion
WF / HDPE composite is widely recognized for its excellent properties in landscape architecture. It is one of the most commonly used materials in landscape design because of its Green, anti-corrosion and moisture-resistant characteristics while retaining wood texture.

By comparing the properties of WF / HDPE composites with 2% uv-326 and UV-WF / HDPE composites with 2% UV-P before and after ultraviolet accelerated aging, the results show that: ΔL′ and ΔE′* values also increase with aging time, And the value of ΔE′* is basically determined by the value of ΔL′. After accelerated aging for 2500h, the color fading of 2% UV-WF / HDPE composites had little change. The results showed that 2% UV-P absorbent could play an important role in the aging process.
The addition of ultraviolet absorbent can not only reduce the color change of WF / HDPE composite, but also help to reduce the loss of mechanical properties. WF / HDPE composite without ultraviolet absorber, after ultraviolet aging, Both MOR and MOE showed a significant downward trend, The results showed that the MOR and MOE of WF/HDPE composite with 2% uv-p UV absorber decreased slightly after 1500h UV accelerated aging. The loss of mechanical properties is reduced and the service life of WF/HDPE composite is extended.

The application of WF / HDPE composite material in landscape reduces a great deal of demand for solid wood, and the advantage of its complex and various shapes provides a great space for landscape design, enable designers to create more beautiful than solid wood material chic landscape works of art.

Acknowledgments
The work has the strong support of the school.

References
[1] Ding Zhuming, Liu Lixiang, Zhou Shujing. Research progress of ultraviolet absorbents [J]. Fine and specialty chemicals. 13, 5-10, (2015). (in Chinese).
[2] Li Ying, Liu Jianzhong, Zhang Yang, Liu Tao, Zhou Yongsheng. Study on anti-aging properties of PVC based wood-plastic composites [J]. Application of engineering plastics. 06, 79-82, (2014). (in Chinese).
[3] Wang Haojiang, Hu Xiaoyong, Liu Yu, Yang Yunong. Progress in research on weatherability of polyethylene [J]. Aging and application of synthetic materials. 06, 21-25, (2012). (in Chinese).
[4] Silva A, Freing C, Morrell J J, et al. Effect of fungal attack on creep behavior and strength of wood plastic composites. The sixth international conference on wood fiber-plastic composites, 2001.
[5] Mankowski M., Morrell JJ. Patterns of fungal attack in wood-plastic composites following exposure in a soil block test [J]. Wood and Fiber Science, 32, 340-345, 2000.
[6] Cai Yanpeng, Wang Shifeng. Application and performance evaluation of waterborne wood coatings on wood-plastic composite substrate [J]. New Building Materials. 09,122-125 + 154, (2018). (in Chinese).
[7] Fan Wei, Li Jialu. Effect of thermo-oxidative aging on flexural properties of carbon fiber fabric reinforced polymer matrix composites [J]. Journal of Composite Materials. 05, 1260-1270, (2015).(in Chinese).
[8] Yin Rui, Zhao Liyuan. WPC industry is developing fast and the market is in high demand [J]. International Wood Industry. 07, 14-15, (2008). (in Chinese).
[9] Xue Wenyong. Application research of wood-plastic composites in Urban Landscape [J]. Plastic Science and Technology.12, 47-50, (2016). (in Chinese).
[10] Pu Bo. Application analysis of plastic Decoration materials in interior design [J]. Plastic Industry.02, 144-147, (2018). (in Chinese).