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The effect of xenon lamps radiation on artificial football turf

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Abstract. Weather behaviour is the main life cycle factor for football turf. Xenon lamps radiation can closely mimic the natural weather. This work investigated the artificial football turf exposed to xenon lamps, compared with the original turf, fastness and tensile strength were measured. Systematic testing method for synthetic turf were performed, the result showed the colour fastness could be 4, and the tensile strength decreased slowly during the light radiation period for 1000h and 2000h. The results indicate that the football turf wreathing and degradation behaviour is influenced by the xenon lamps radiation.

1. Introduction

With the good performance of artificial turf for the football sports, In February 2004, International Federation of Association Football (FIFA) decided that artificial turf can be used in international competition matches instead of traditional football turf. Currently, third generation (3G) artificial turf with underneath shock-absorbing layer is widely approved by FIFA, it is said that the best alternative to natural grass. It have five layer structures, contains yarn, performance infill, stabling infill, shock-absorbing layer and sub-base. The yarn layer is the top layer, and it is generally made from polypropylene (PP) or polyethylene (PE).

From the football turf material and its using environment, the biggest influence of football turf performance should be the weather, since it exposure on the sunshine and also with the rain. However, very few articles research on the influence of weather on PP or PE. Some researches focus on the toxic, due to health is import to human, for example, Volker et al [1] researched the heavy metal zinc (Zn) and polycyclic aromatic hydrocarbons (PAH), the results showed that release of Zn and PAH is leaching influenced by the coating. The research also studied the weathering and degradation behavior, and the found that the artificial weathering experiments are strongly recommended to achieve information on the aging and degradation behavior of artificial sports surfaces. Due to the long time of natural weather test, people always use artificial weather to simulate the sunlight environment. In FIFA test method, fluorescent UV lamp is used accordance with EN ISO 4892-3:2006 with irradiance of 0.80 W/m²/nm at 340 nm. The total exposure is 9600 ± 125 kJ/m²/340nm. UV test is focus on the 340 nm, which is commonly noted at polymer-damaging UV-A region. Such method is not exactly imitated the sunshine, which contains multi length of waves. Xenon lamps produce bright white light through the ionized xenon gas at high pressure, which closely mimics natural sunlight and widely used in ageing test. In GB/T 20394-2013, the turf test is used by xenon. However, such method is cited a textiles method, and such method only test for 168h, it just shows the short term of the influence on xenon lamps.



This aim of this work is to investigate on the xenon lamps radiation on artificial football turf, compared with the original turf, fastness and tensile strength is measured. Such work can supply detail data for xenon lamps radiation on football turf, and also can supply the reference to the manufacturer. Thus, the experiments are filled the gap of turf knowledge.

2. Materials and equipment

Football turf qualified by FIFA were used and cut into 70 mm×140 mm pieces to fit the sample holder, 5 parallel samples were measured. The samples are directly from the manufacture, without the infill materials or the glues. The colour of the samples is green, which is the common colour request by FIFA. X65 xenon lamp artificial weathering test chamber made by Guangzhou Composite Materials Research Institute Co. Ltd. The lamps washed every 24 h to keep the lamps clean, and check the irradiation energy every washing interval. Tension machine made by Gotech testing machines Co. Ltd. The method is measured by ISO 105-B02:2014, the colour fastness is tested by human eyes according the standard. Both the colour fastness and tensile force test is taken in 30min after the xenon radiation. The irradiance controlled at (42 ± 2) W/m² in the wavelength range 300 nm to 400 nm. Using the extreme high humidity condition, black standard temperature is (42 ± 3) °C and black panel temperature is (40 ± 3) °C. The samples were tested for 1000 h and 2000 h, then took out for fastness and tensile strength test.

3. Results

Figure 1 shows the fastness of the origin turf (0h), after 1000h and after 2000h. Generally, xenon lamps can destroy the colouring materials, lead the surface fading. From the result, it can clearly get that after the light radiation, the colour become duller. According the annex D in ISO 105-B02:2014, compared with the series of colour fastness references, which are pieces of wool cloth dyed with blue dyes of different degrees of fastness. Such result colour fastness could be 4 based on its behave.

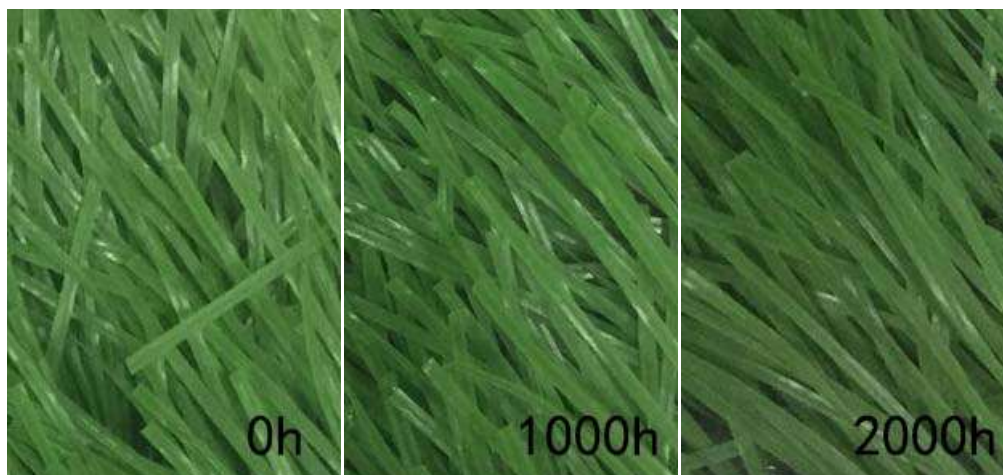


Figure 1. Colour fastness of the origin turf (0h), after 1000h and after 2000h

The tensile test is showed on Figure 2, the tensile strength of origin turf is 17.54N, after 1000h, the tensile strength decreases to 16.89N, and finally gets to 15.32N after 2000h. Converted to retention rate, it is 96.29% at 1000 h and 87.34% at 2000h. The tensile strength decreased slowly during the light radiation period. And from the error bar, the variance is increasing with the lighting time. 2000h is 1.5 times bigger than the original.

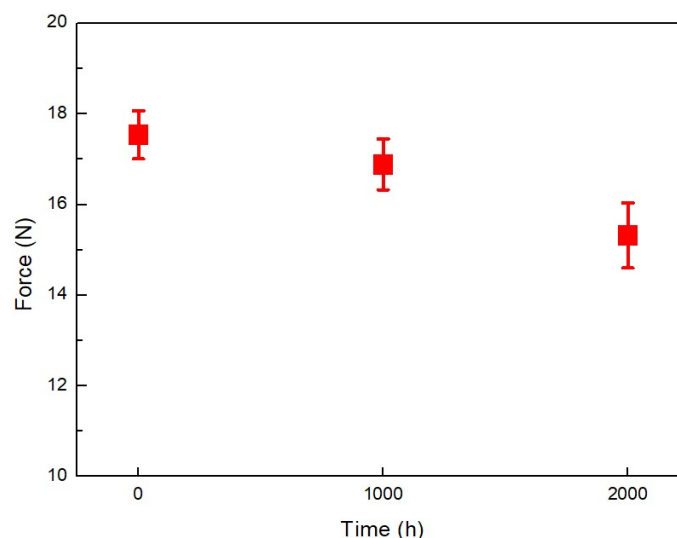


Figure 2. Tensile strength of the origin turf (0h), after 1000h and after 2000h

4. Discussion

The radiant energy can be calculated by the following formula:

$$Q = ET \times 10^{-3} \quad (1)$$

Q: Cumulative radiant energy, in units of kJ/m²

E: Average irradiance, in units of W/m²

T: Total exposure time, in units of s

In China, the annual solar radiation energy could be 2~4×10⁶kJ/m², the total time require approximately 1000~2000h. In artificial test, the temperature and humidity are severely controlled, and the condition is worse than the natural environment. So the test guarantee the football turf can be used at least for a year. And for GB/T 20394-2013, such standard is not proper the measure the football turf test due to its shorter exposure time, such time cannot break the structure of the turf materials, which mainly composited by PP or PE.

In fact, there should be exist infill material among the yarn layer in reality. Such material could be sand, but mostly use organic materials such as styrene-butadiene rubber (SBR), thermoplastic elastomers (TPE) or ethylene propylene diene monomer rubber (EPDM) [2]. SBR is quite cheap because it can be produced from discarded car tyres. Such infill material can slow down the degradation of football turf. Here in this test, the infill material was not used, because they may bring uncertain factor to the xenon lamp test.

The color change reason is the dye in the PP and PE, however, the result of color fastness is 4, which is not bad news for football turf. But the turf color get duller after test. That is because of the water and the xenon lamps together enhanced the color degradation. Football turf commonly uses green color as its main color, and green dye in polymer is stable among all the color in use [3,4].

For tensile test, the common force for single grass is about 16~20N according to its thickness, this turf is in the middle of the thickness and its original force is about 17N. After the xenon radiation, there should be many mini poles in the structure, which would destroy the total structure of the grass. Only for one year use, such turf would fine due to its retention rate about 87% after 2000h. However, it is not recommended using for a long time, according to the calculation, the cycle of the football turf should less than 2 years. FIFA quality also claimed that the usage of turf should be controlled in 40~60h per week. If that is for high performance and safety requirements for professional match, the time should be 20h per week. From the result, after xenon radiation, the variances get bigger and bigger. It indicated

that turf would not uniform at last, which lead the football performance bad, like the rebound get worse. FIFA recommended brushing the surface every 40 hours, which is only for 22 players on the pitch. If more players are on the pitch, it should brush in short periods.

Generally, It is quite complex to measure the exact performance of the football turf [5]. The most common method is just test the turf using natural weather, but the weather is random, so the result may diverse. And the most imported thing is natural weather is quite long; it may take years to check the performance. The advantage of xenon lamps is clearly, it is artificial weather, and it increased the testing. It is nearly 7 times faster than the natural weather. Compared with UV test, xenon lamps is more practical, because it not only contains the UV light, but also contains the long wave light, which is closer to the sunlight. Using xenon lamps could clearly check the performance of the football turf.

5. Conclusion

During the xenon lamps test for 1000h and 2000h, the colour fastness is 4 and the tensile force from 17.54N decreases to 16.89N at 1000h, and finally gets to 15.32N at 2000h. The xenon lamp has minor influence on its colour fastness, and it has effect on change the tensile force. Hence the dye in football turf is stable and the structure is easier influenced by the artificial weather.

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