Improved Accelerated Weathering Chamber Study for Geotextiles

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ABSTRACT

Geosynthetics have been widely used in the construction industry around the world. However there is still a concern about its ability to retain strength under the hot and humid conditions of the tropical climate in the South East Asia region. The objective of this research is to improve the existing indoor UV weathering chamber to simulate not only UV radiation degradation effect but also the effect of the humidity and rainfall. The simulated weathering process will be able to provide an indication of the degradation due to UV radiation exposure and rainfall. On top of that it also allows one to determine accurately the mechanisms at work since control can be made over the variables in environmental elements.

INTRODUCTION

The electromagnetic energy of sunlight is divided into ultraviolet (UV), visible and infrared energy. The UV range is the primary cause of degradation of polymers exposed outdoor. For any accelerated weathering device, there are a number of governing parameters, namely: the UV spectrum, radiation intensity, moisture, humidity and temperature (Hsuan Y.G., 2002). However, no single test device can perfectly reproduce all the variables found outdoor. The main usefulness of indoor weathering chamber is to give relative indications of which material performs best under specific sets of conditions. The existing chamber needs to be further improved in order to provide better simulation of actual weather conditions and enable prediction of the lifetime of geotextiles by means of accelerated weathering.

The relationship of the combined mechanical stresses induced by rain and UV radiation and the retain strength of the sample over a particular period of time can be quantified in this weathering chamber. Calibrations of the chamber efficiency in terms of its equivalent outdoor exposure and rainfall duration have been conducted. This will enable speeding up the long term weathering process in the actual situation.

THE EXISTING WEATHERING CHAMBER

In order to study UV radiation affects on the geotextiles, a simple UV weathering chamber was fabricated. The chamber comprises a wooded box encasing the specimen holder and the UV lamps. The central axle holds four UV lamps which are mounted back to back and equal distance from the specimen tested. The specimen rotates to ensure equal radiation on all the specimens. The speed of rotation was set at 20rev/hr power by a sleeve friction motor mounted at the bottom of the specimen cage.

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To effectively simulate the UV range of the solar spectrum, the lamps are selected emit radiation between 315 to 400 nm (UV-A). The measured radiation peaks at approximately 370nm which is within the mentioned range. The ambient temperature within the chamber was measured in the range of 40 -60 degree Celsius which is agreed with the temperate measured on the specimen exposed outdoor on the roof top.

THE MODIFIED WEATHERING CHAMBER

Singapore lies very near to the Equator. Because of its geographical location and maritime exposure, its climate is characterized by uniform high temperature, high humidity, abundant rainfall and sunshine. Typical temperature ranges between 23 to 33°C and a mean humidity of 84%. The annual rainfall in Singapore approximately 2400mm. The effect of rain and humidity in the weathering process should be included in the modification. To better simulate the actual weather conditions and enable prediction of the lifetime of geotextiles by means of accelerated weathering, a water spray system is incorporated (Figure 1). More UV lamps are also installed to achieve a more efficient UV radiation simulation.

The new water spray system comprises of two parts namely the reservoir and the chamber pipeline. The reservoir consists of a submersible pump and a fibre glass tank. The fibre glass tank serves the function as a reservoir to maintain sufficient water in the system. It also allows different type of liquid to be use for testing, example to study the effect of tape water or rainwater on the degradation of the sample. The submersible pump drives the water from the tank into the chamber, the energy source of the whole system. The chamber pipeline consists of a suction pump, pvc dropper and two control valves. The control valves can vary the forcefulness of the output from the small holes to simulate different raining condition. The water is then retains in the tank attached in the chamber before the suction pump drains the water out from the tank to the reservoir and the cycle repeats. A filter was used to trap fibres which are expected to be washed out after being broken down by ultraviolet light energy.

Four pairs of UV lamp are mounted back to back on the axle of the rotating drum. The lamps are mounted on a bracket that can vary the distance from the drum to simulate different degree of exposure. The rotating drum ensures the samples attached to the drum are evenly exposed. The lamps are water proof to protect them from short circuit due to intact with water. The distance between the lamps and samples are adjusted by to achieve highest intensity possible to accelerate the weathering process. Finally the nearest possible extended distance is found to be 30mm away from the rotating drum. It measures 70 watts/ m^2 at peak locations.

The temperature in the chamber is approximately 40 to 50 degree Celsius, which is slightly higher than the ambient temperature experienced outdoors. The humidity in the chamber is also around 100% when the water spray is activated. This is near to the humidity experienced during the rainy monsoon seasons in Singapore (Meteorological Service Singapore, 1996).

TEST RESULTS AND DISCUSSION

The material tested in this study is a mechanically bonded short fibre, non-woven with mass per unit area of 550 $g/m^{3.}$ It is a 100% polypropylene based material. Two different arrangement or scheme is conducted in this study. The sun only scheme (S) is for geotextiles subject to UV light only. The rain and sun scheme (RS) is for geotextiles subject to UV light and rainfall. The sun only (S) scheme was run in both the modified chamber as well as the original chamber. The total hours of bright sunshine per day is taken as 6 hours for the tropical region. The percentage of UV radiation with respect to total solar radiation is taken as 5.5%. For the RS scheme, the cycle timing derivation was done in a similar manner. However, an assumption was made in that whatever the rain action can do to the geotextiles is done in an hour. Hence the actual rain duration is not modeled. The summary of the cycle time is shown in Table 1. Wide width tensile strength test were conducted for geotextiles specimen without subjected to any weathering as well as those subjected to above cycles. The strength retained is the indication of its resistance to the weathering.

Table 1 Summary of Cycle timing

Outdoor Duration	UV Only	UV and Rain
1 month	360 hrs (15 days)	300 hrs (12 days and 12 hrs)
2 month	720 hrs (30 days)	600 hrs (25 days)
3 month	1080 hrs (45 days)	900 hrs (37 days and 12 hrs)

The test results can be summarized in the following two aspects:

1. Comparing indoor program exposure to sun only (S) sample result from the modified chamber with that from the old chamber

   From the current indoor program, the samples were placed in the 'old chamber' and 'new modified chamber' for a duration equivalent to 1, 2 and 3 months outdoor. The old chamber has a UV intensity of $8W/m^2$ while the new modified chamber has intensity between $8W/m^2$ and $70W/m^2$, an average of $40W/m^2$. Figure 2 shows the test results. The tensile strength retention in the MD and CD direction obtained in the modified chamber is similar to that obtained in the old chamber. Hence, from the indoor program, intensity does not seem to play a significant role in the degradation rate of geotextiles.

2. Comparing indoor program exposure to sun only (S) sample result and that of the exposure to Rain and Sun (RS) sample result both from the modified chamber

   The only difference between the two schemes (exposure to sun only (S) versus exposure to rain and sun (RS)) lies in the presence of rain simulation acting on the RS samples. Figure 3 shows the test results. The tensile strength and elongation at break retained is higher for the RS (rain and sun) samples than the S (sun only) samples, in both directions. Thus, the cooling effect of rain and its action results in better retention of strength and elongation at break. The positive effect observed in the sample, made of short fibers, would imply the interplay of the length of fibre and the temperature to fully comprehend the mechanism at work.

CONCLUSION

The improvement on the weathering chamber by implementing a water spray system to simulate the rainfall and humidity effect improved the performance of the chamber. It performed better and produced better simulation to outdoor weathering process. It also provided a better control to be made and allows for a means of determining the degradation rate of geotextiles in a shorter period.

REFERENCE

Hsuan Y.G. (2002), "Approach to the study of durability of reinforcement fibers and yarns in geosynthetic clay liners", *Geotextiles and Geomembranes, Volume 20, Issue 1, February 2002, Pages 63-76.*

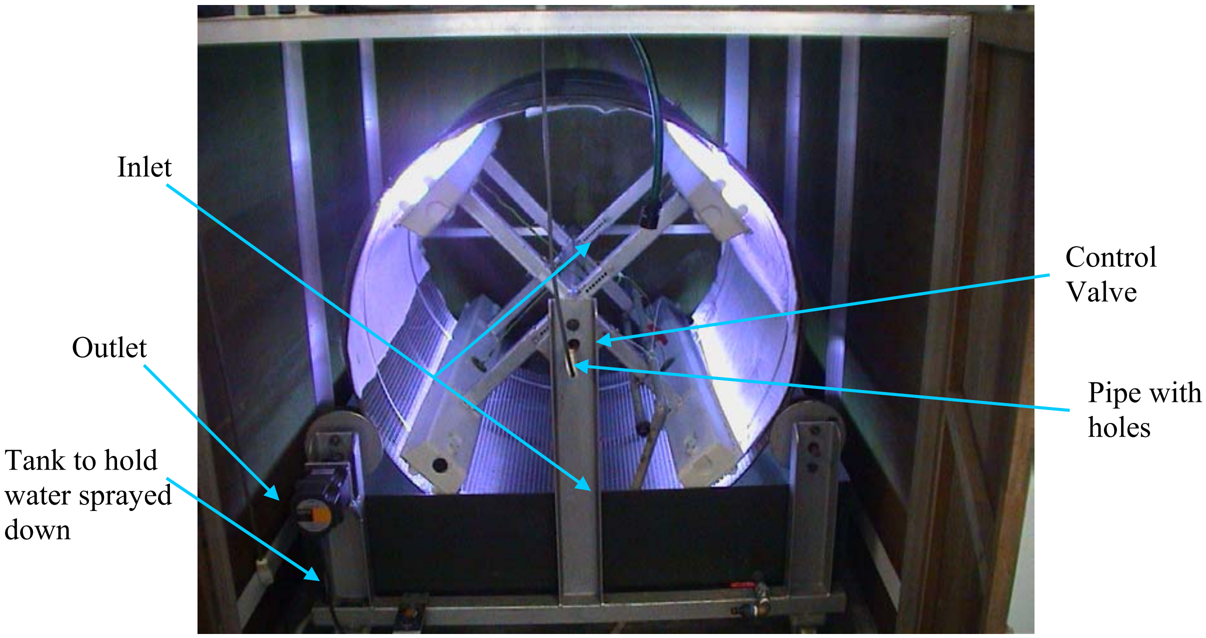

Figure 1. Water spray system

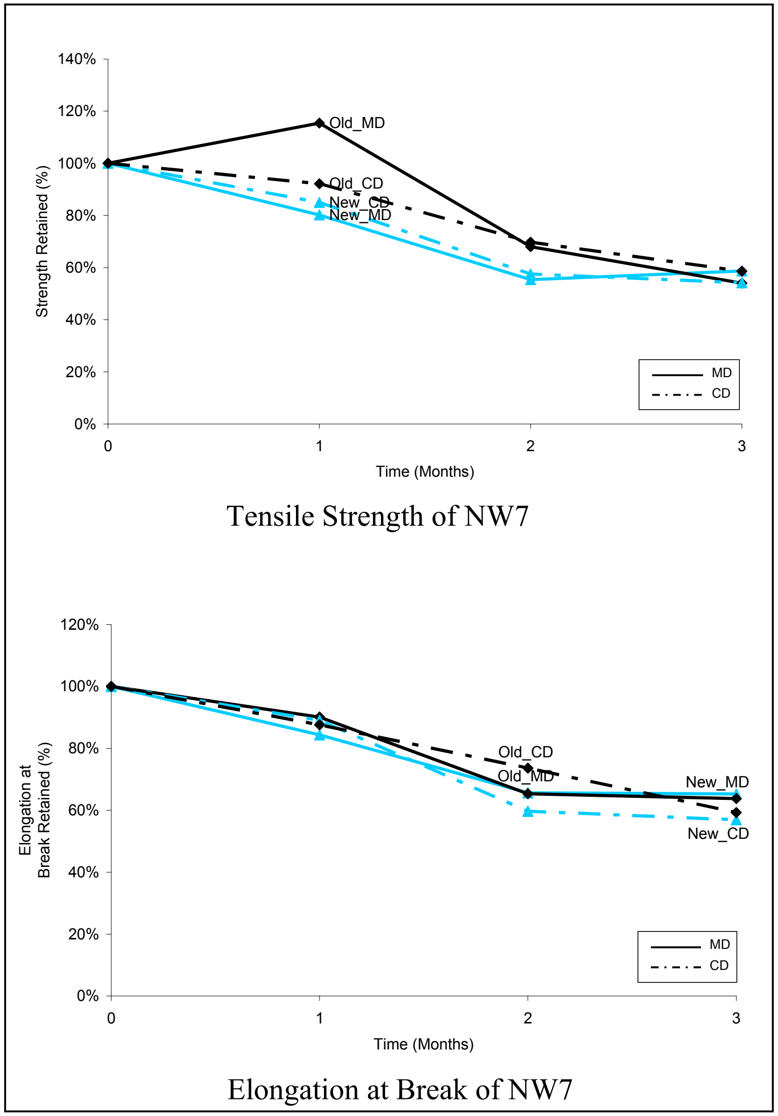

Figure 2. Comparison between modified and old chamber results

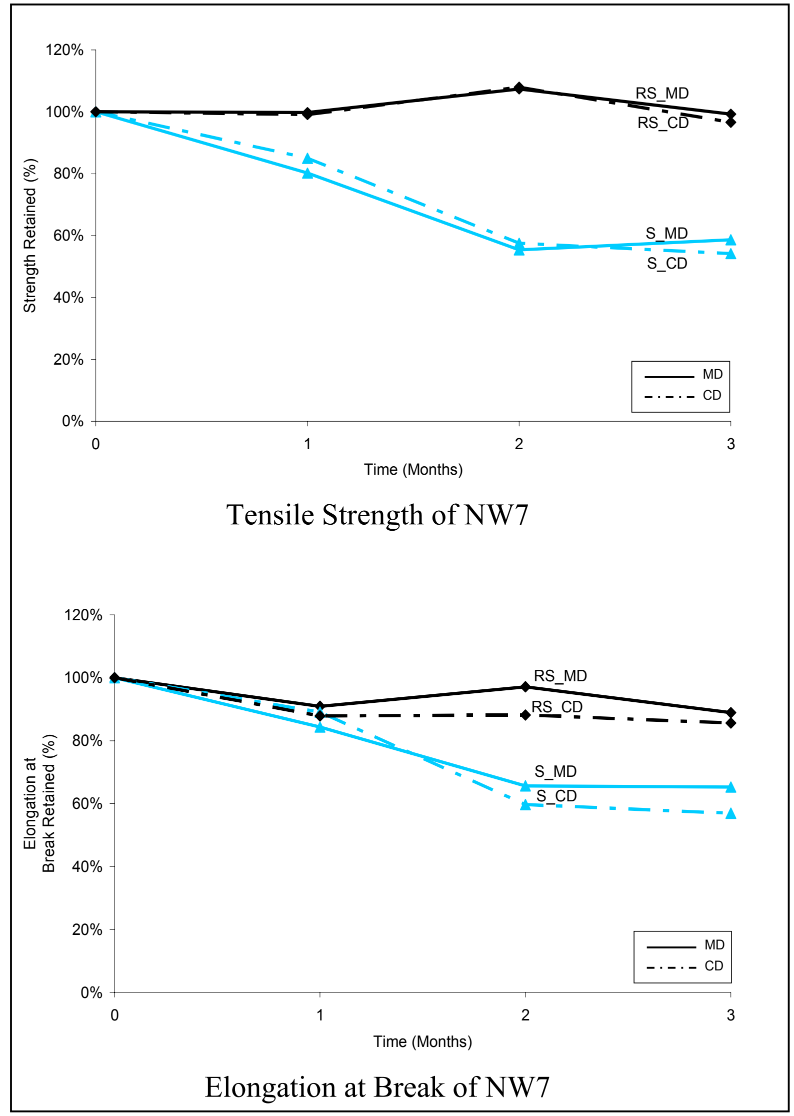

Figure 3. Comparison between Indoor UV only (S) and Rain plus UV (RS)