Water Absorption of Wooden Pallets

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Abstract

Wooden pallets are often left outdoors and subjected to rainwater. Water can seep upward and damage the packages stored on these pallets. A comprehensive study was performed using a total of 36 specimens taken from hardwood, heat-treated hardwood, softwood, and heat-treated softwood new pallets. Another four specimens, taken from softwood used pallets, were also used to compare with new pallet specimens. Findings include: water penetration height could penetrate up to the top deck board, water penetration data is more consistent in hardwood than in softwood, water penetrates faster and slightly higher in hardwood, heat treatment has only a little effect on water penetration, and little difference is found in used and new pallet specimens.

Keywords: Wooden pallets; water penetration.

Introduction

Pallets are the foundation of today's packaging industry. Any product could sit on a pallet for some time during its distribution process. According to Lorie King Rogers, Associate Editor of *Modern Materials Handling*magazine [1], there are nearly two billion pallets on the move across the United States at a given time. Wooden pallets have dominated the distribution industry for decades. A recent survey [1] based on 594 qualified responses from those employed at a facility that uses pallets, indicates that the use of wooden pallets remains the most popular.

Responses to "What type of pallets do you use?" were wood (95%), plastic (39%), wood composite (14%), cardboard/corrugated (8%), metal (7%), and other (2%).Most wooden pallets, so-called GMA(Grocery Manufacturers Association)pallets (Fig. 1), in the U.S. are either stringer or block pallets with 48"x40" footprint [2] and thickness about five inches, which is one of the six pallet footprints recognized by ISO 6780 [3].

Figure 1.Stringer pallets

Wooden pallets used to store boxes are often left outdoors. Even though boxes are covered from the top tothe sides, rainwater could penetrate up through a pallet and damage the bottom layer of the boxes. It was found that the water penetration rate depends on the porous structure of the wood and the reactivity of its chemical components [4].A preliminary study [5] on water absorption shows the maximum water penetration height is about three inches. A typical GMA pallet is about 5" thick, which is larger than the maximum penetration heights obtained from the experimental data. Thus, said pallets would be safe even with a sizeable water level, such as 1-inch rainfall. Keeping proper drainage in the pallet storage area would prevent rainwater accumulation. Wood properties, however, vary significantly due to many factors, including grain direction, defects, etc. More tests were needed to develop more accurate equations.

This paper presents results of a comprehensive study of water penetration in four types of new wooden pallets, namely, (1) softwood, (2) heat-treated softwood, (3) hardwood, and (4)heat-treated hardwood wooden pallets.Furthermore, used softwood pallets were used to compare with the new pallets. The Pallet Factory (www.thepalletfactory.com) in Memphis, Tennessee, donated pallets for this study.

Design of Experiment

A total of 36 specimens were cut from 12 pallets (i.e., 3 new softwood, 3 new heat treated softwood, 3 new hardwood, and 3 new heat treated hardwood) with only one specimen taken from a stringer as shown in Fig. 2. Hardwood pallets used in this study are made of mixed hardwood, while softwood pallets are all Southern yellow pine. The average moisture contents are: 5.9% for new softwood, 5.2% for new heat treated softwood, 6.1% for new hardwood, and 5.2% for new heat treated hardwood specimens.

Figure 2. Test specimens

Test specimens were placed in a pan positioned as they would be as part of the whole pallet. The initial water depth used was 1 cm (0.3937") as shown in Fig. 3a. Heights of the water marks on specimens were measured and recorded at various times as shown in Fig. 3b.

Figure 3.(a) Specimen with initial water level of 1 cm (left) and (b) water penetration height measurement (right)

Results

Water penetration heights (minus initial water height of 1 cm) were plotted against time for each specimen and fitted with two trend lines, as shown in Figure 4 for one of the softwood specimen.

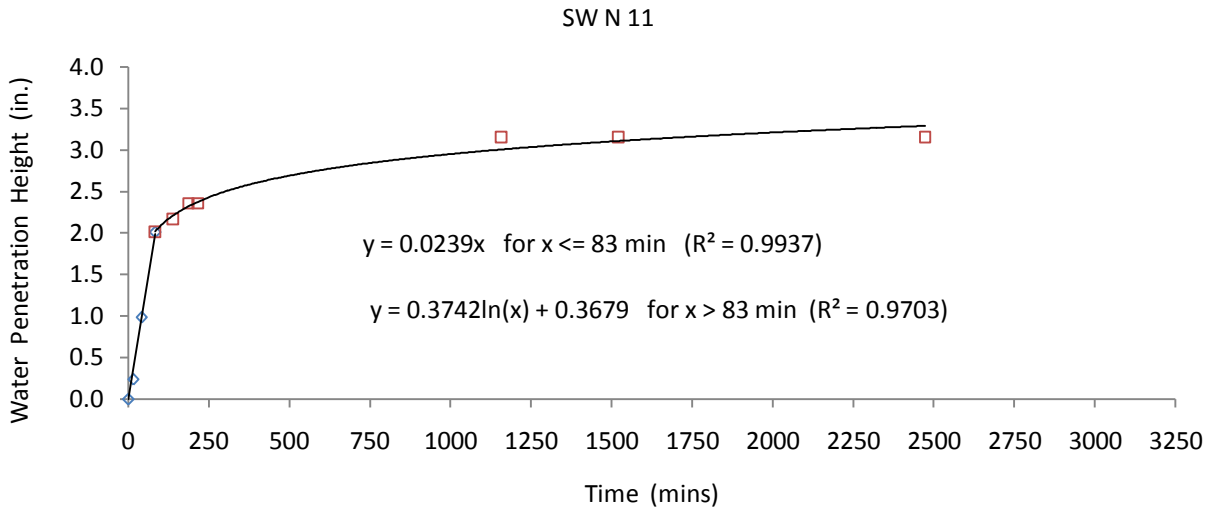

Figure 4. Water penetration height versus time for a specimen taken from new (N) softwood (SW) pallet number 1, stringer 1

Equations for these trend lines were then used to generate water penetration heights at various times. Average water penetration heights for nine specimens of each pallet type were used to generate average graphs as shown in Figs. 5 – 8.

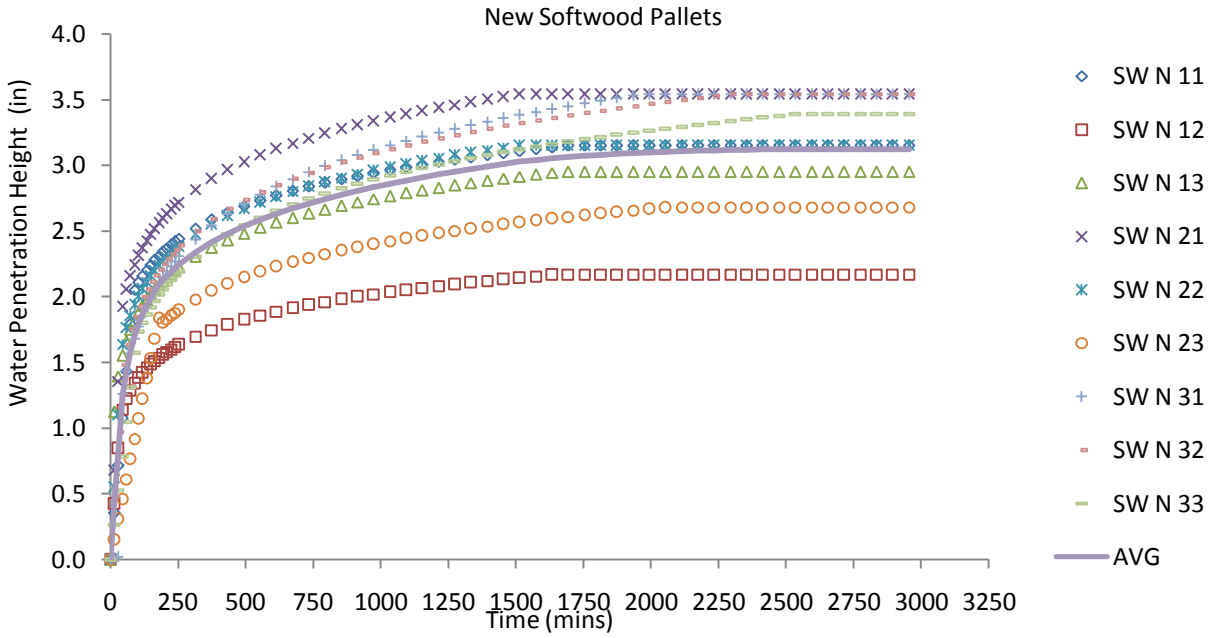

Figure 5.Water penetration graph for new softwood pallets

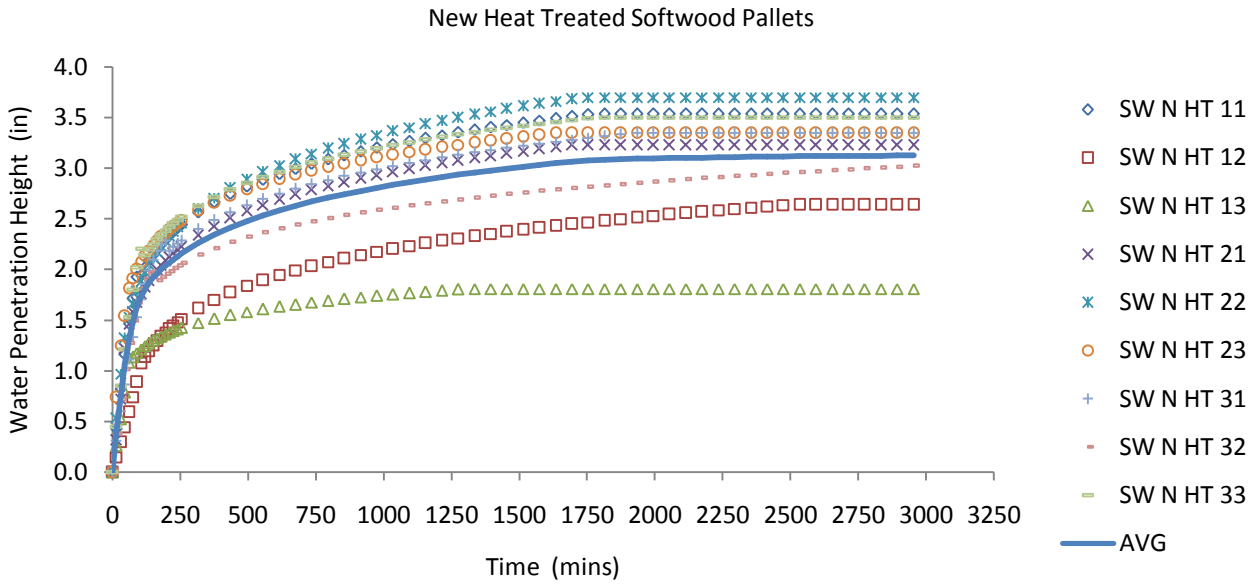

Figure 6.Water penetration graph for new heat treated softwood pallets

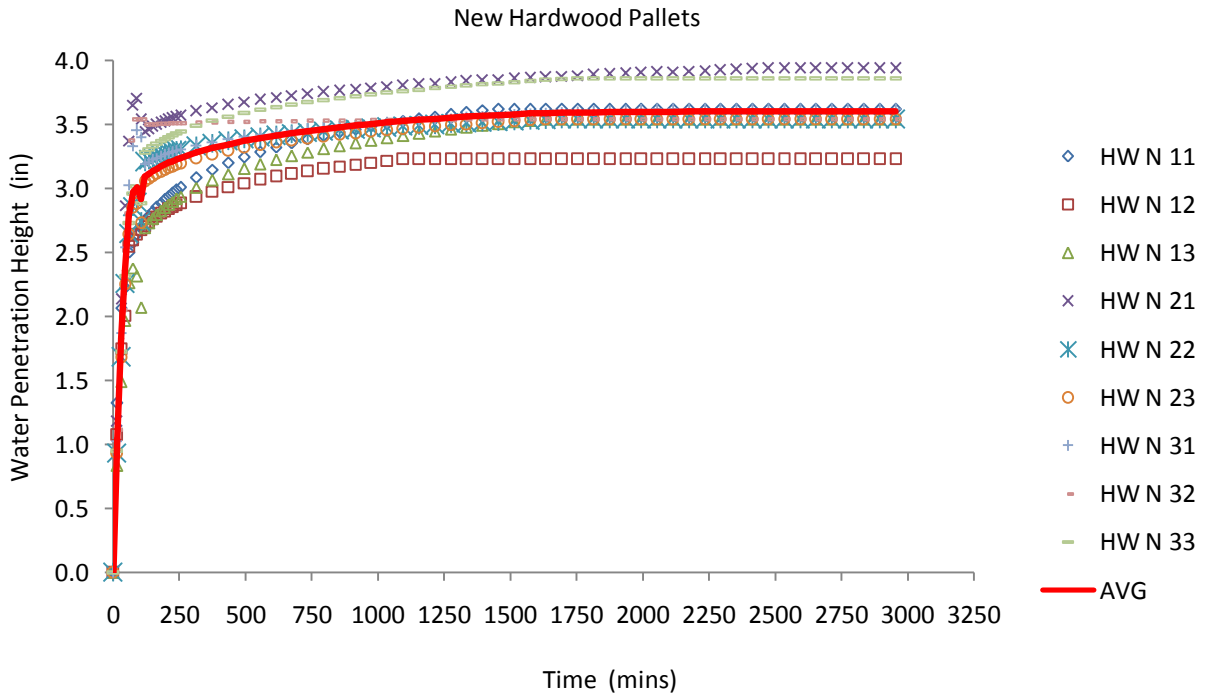

Figure 7.Water penetration graph for new hardwood pallets

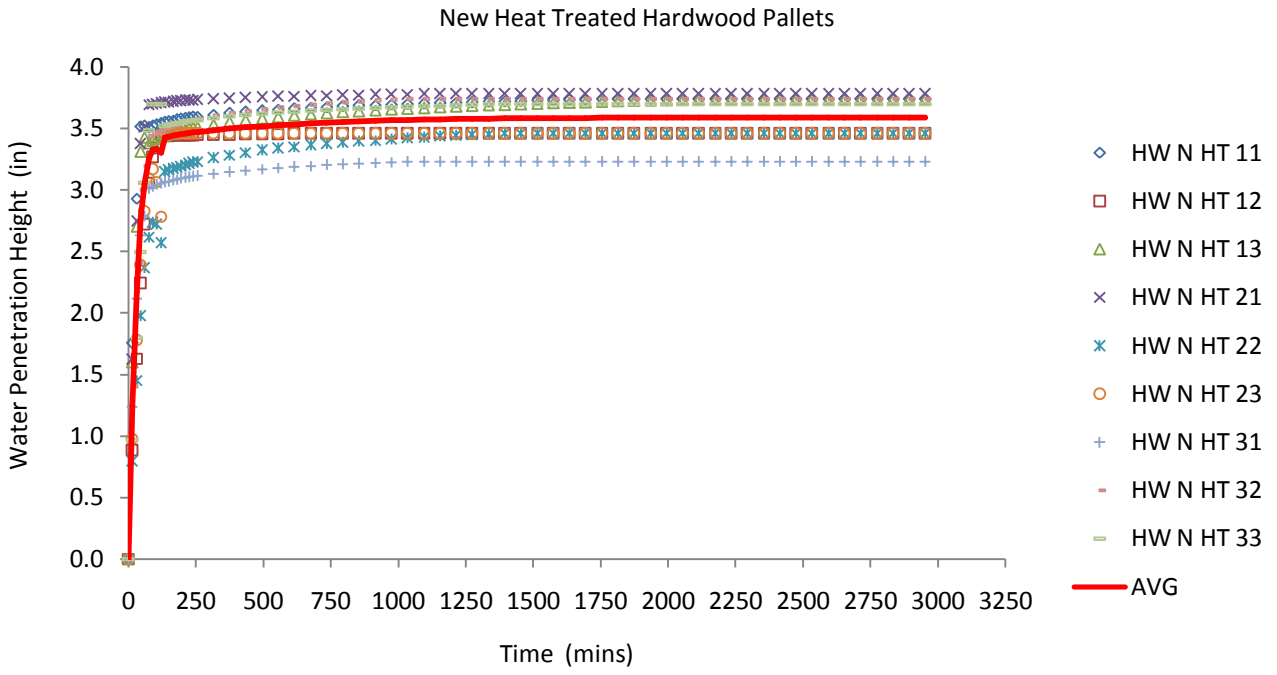

Figure 8.Water penetration graph for new heat treated hardwood pallets

These average water penetration graphs were used to generate equations and plotted against average maximum and minimum graphs as shown in Figs. 9 – 12. Finally the four average water penetration graphs were compared in Fig. 13.

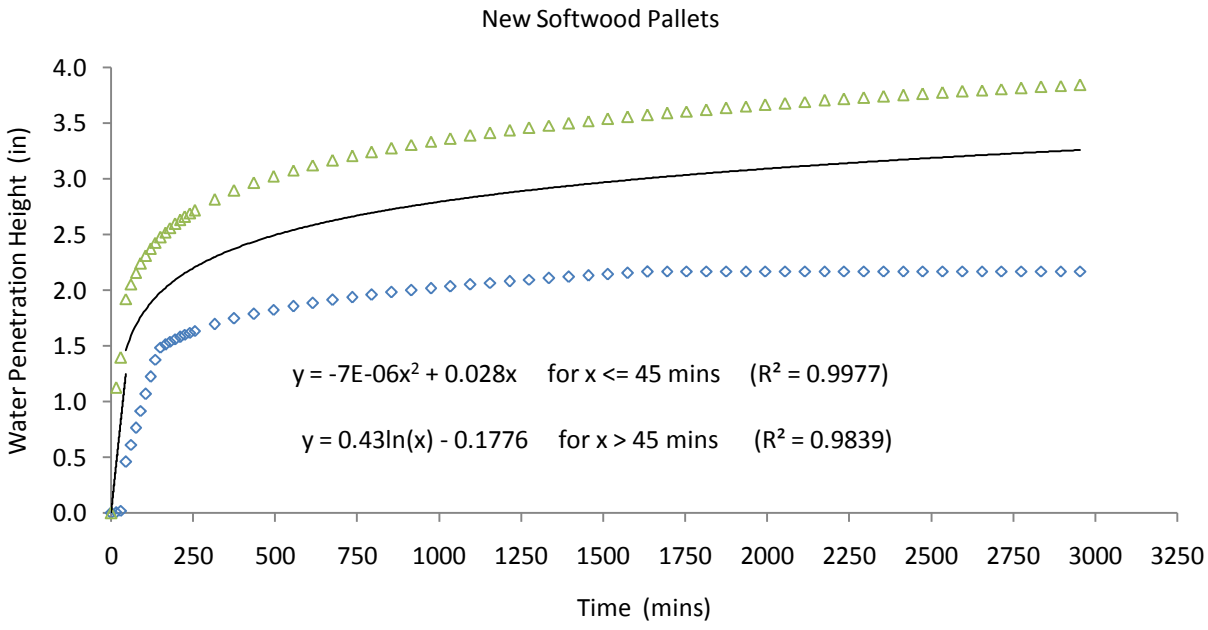

Figure 9.Average water penetration height graph for new softwood pallets with average maximum and minimum graphs

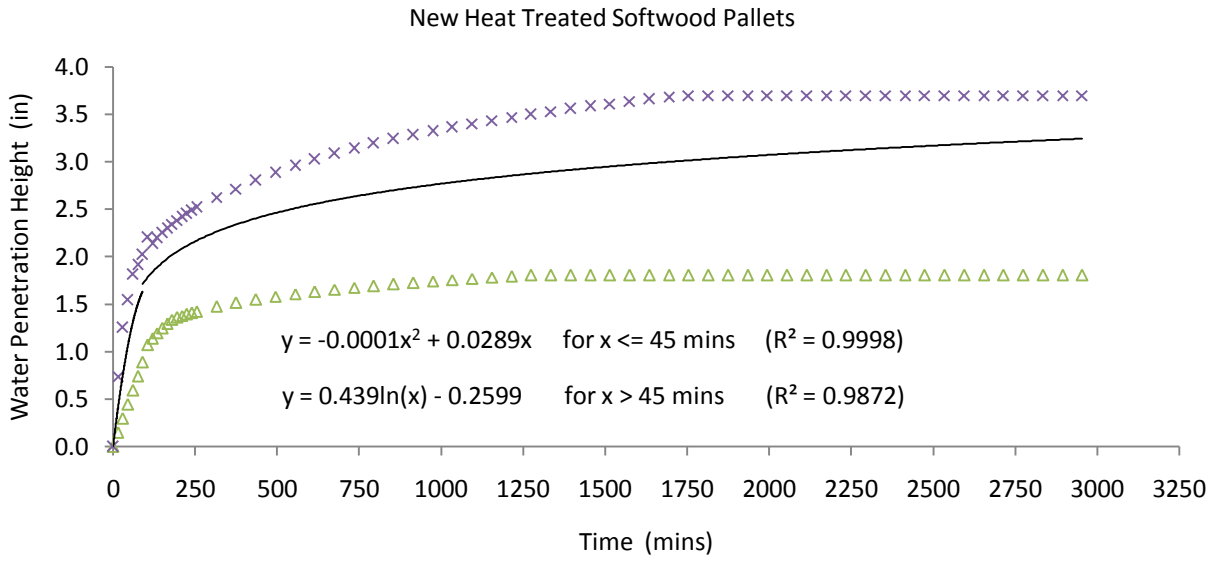

Figure 10.Average water penetration height graph for new heat treated softwood pallets with average maximum and minimum graphs

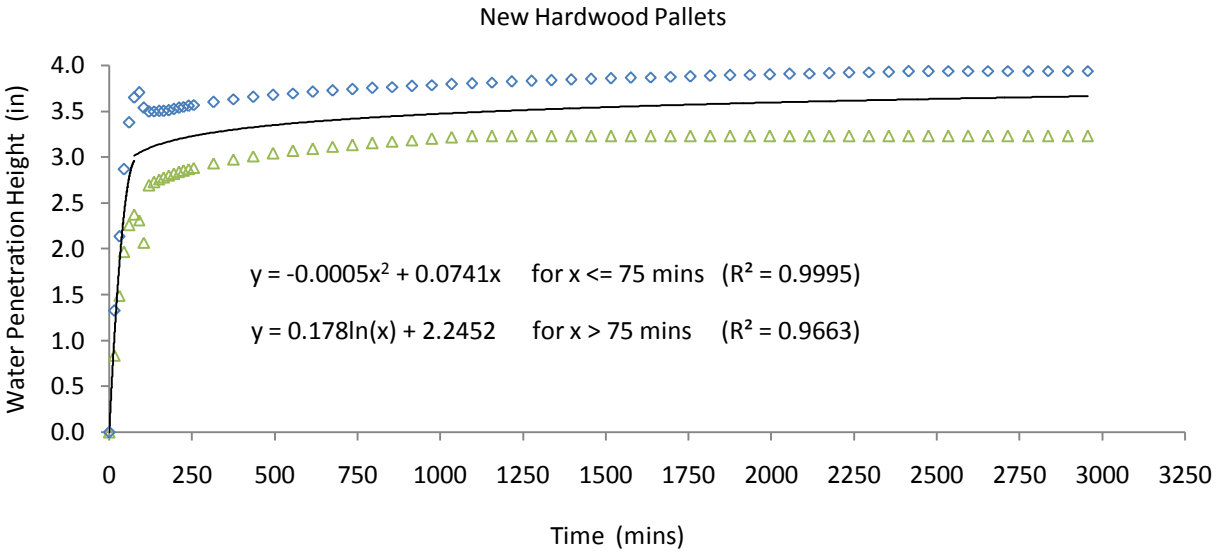

Figure 11.Average water penetration height graph for new hardwood pallets with average maximum and minimum graphs

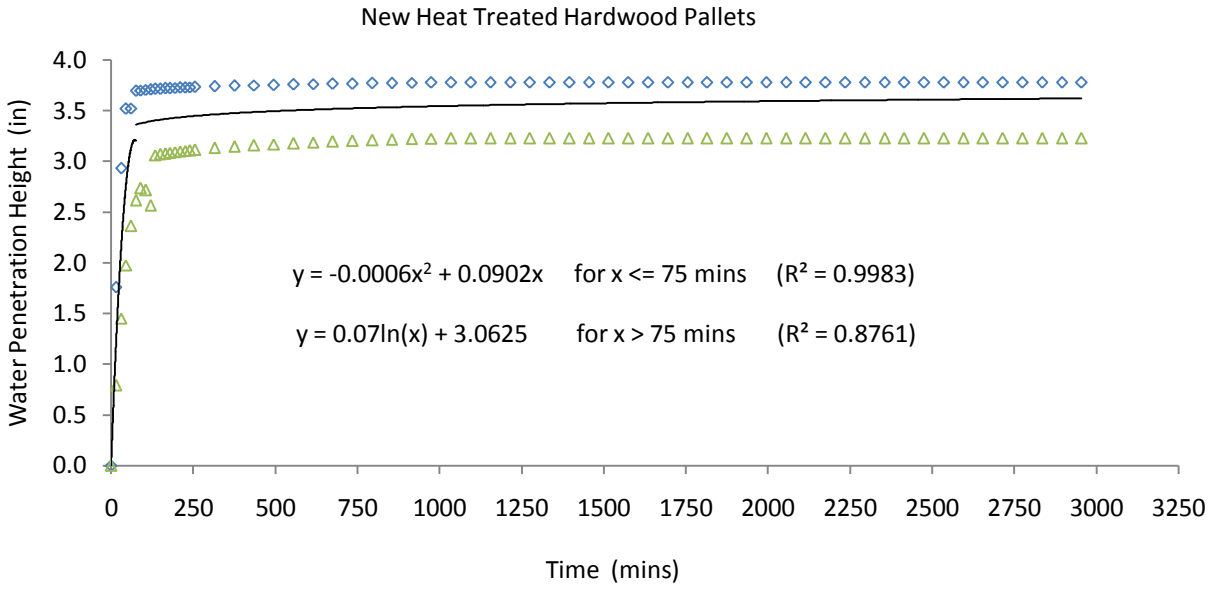

Figure 12.Average water penetration height graph for new heat treated hardwood pallets with average maximum and minimum graphs

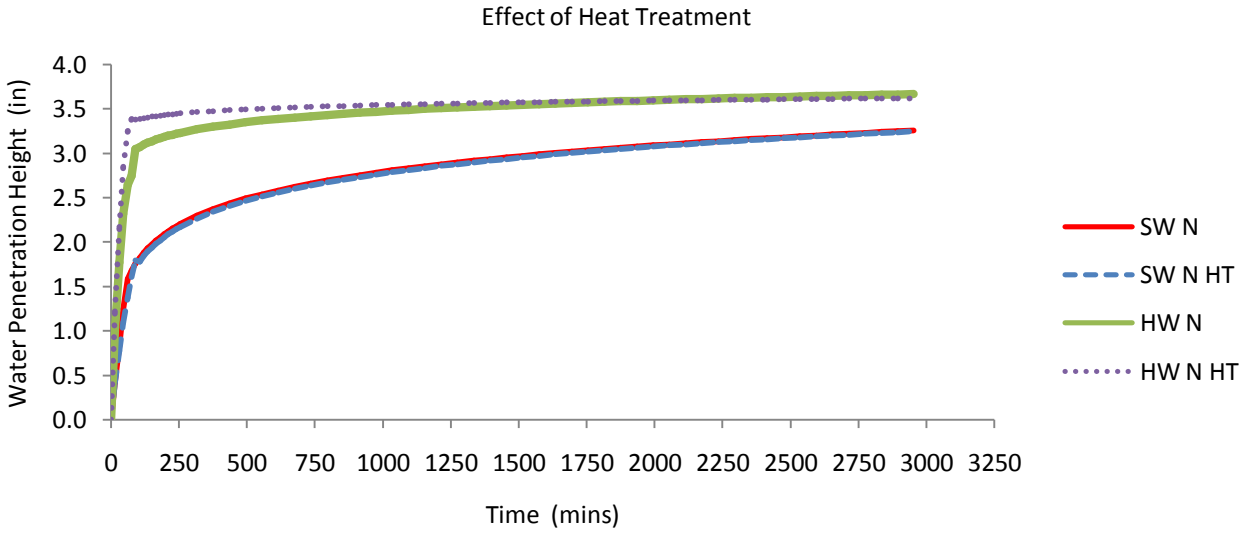

Figure 13. Effect of heat treatment

Four specimens taken from four used pallets were included in the study. Pallets are classified as used when they have completed a circulation process. Typically newer wood contains higher water content than older wood. Also, due to repairs made on used pallets, the structural properties may vary which in turn may change water absorption behavior. Fig. 14 shows a comparison of water absorption rates of new and used softwood pallet specimens used in this study.

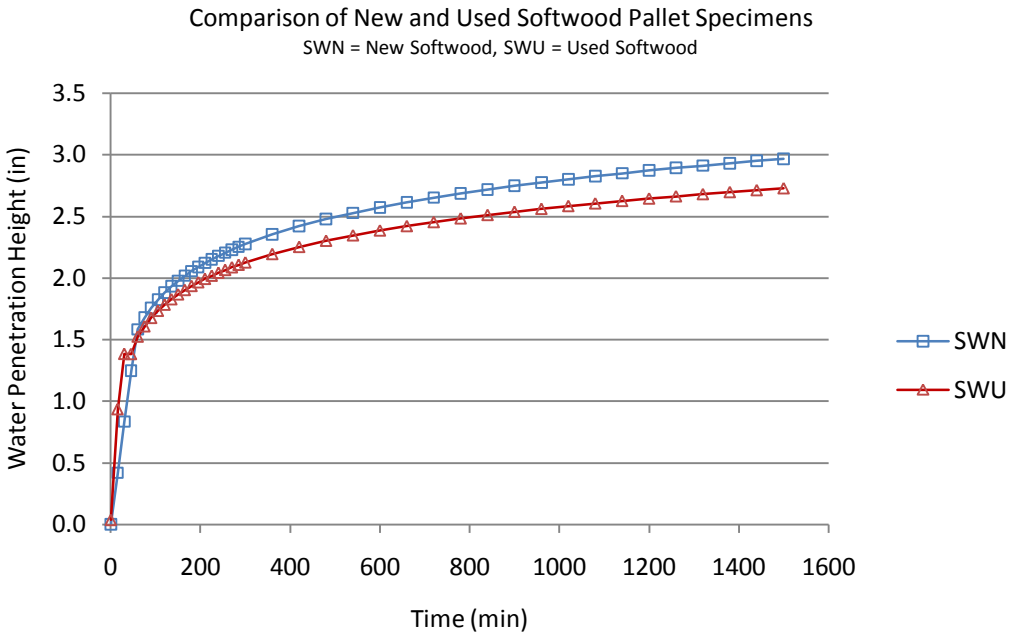

Figure 14. Comparison of New and Used Softwood Pallet Specimens

Discussions & Conclusions

Figs. 5 – 8 (summarized side by side in Fig. 15) indicate that the water absorption behavior of hardwood is more consistent than softwood and also, water penetrates slightly higher in hardwood than in softwood.Furthermore, water penetration height can go up to about 4" from ground water level. Often water penetration stops at the stringer top due to the gap between top of stringer and bottom of the top deck board. Load on pallets could narrow down this gap, thus allowing higher penetration. A possible solution is to have good drainage as it is very important to prevent water accumulation.

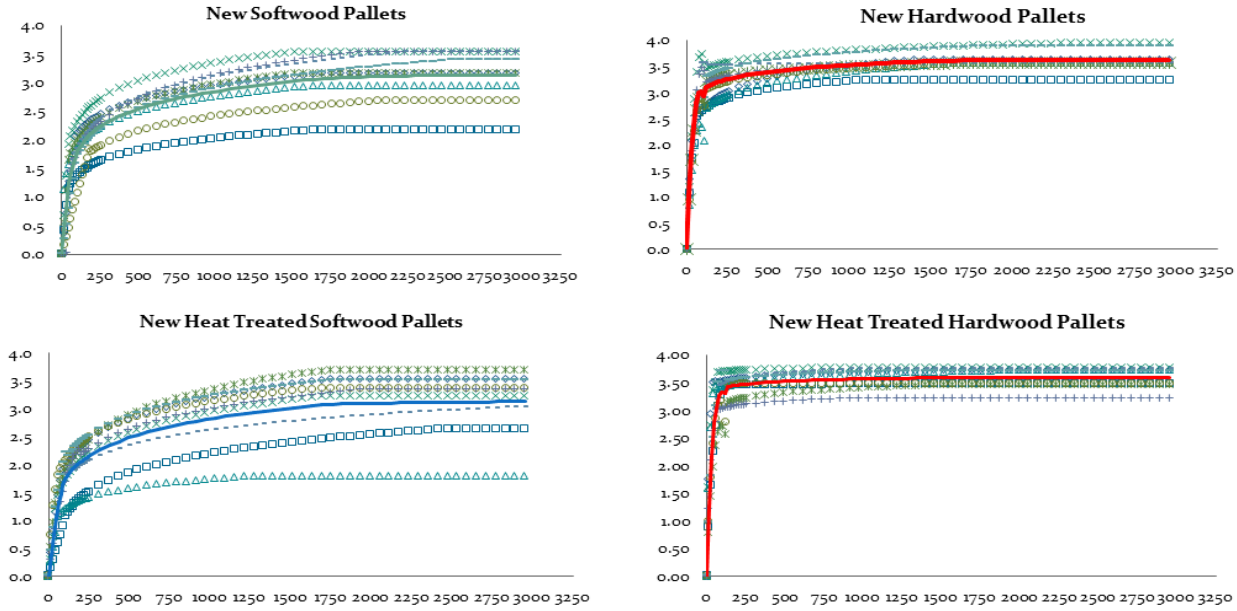

Figure 15. Side-by-side comparison of the four pallet types using individual specimens

Figs. 9 – 12 (replottedin Fig. 16 for the first three hours) indicate that hardwood has a faster water penetration rate than softwood. In addition, Fig. 13 shows that heat treatment has very little effect on the water penetration behavior of the new wooden pallets.

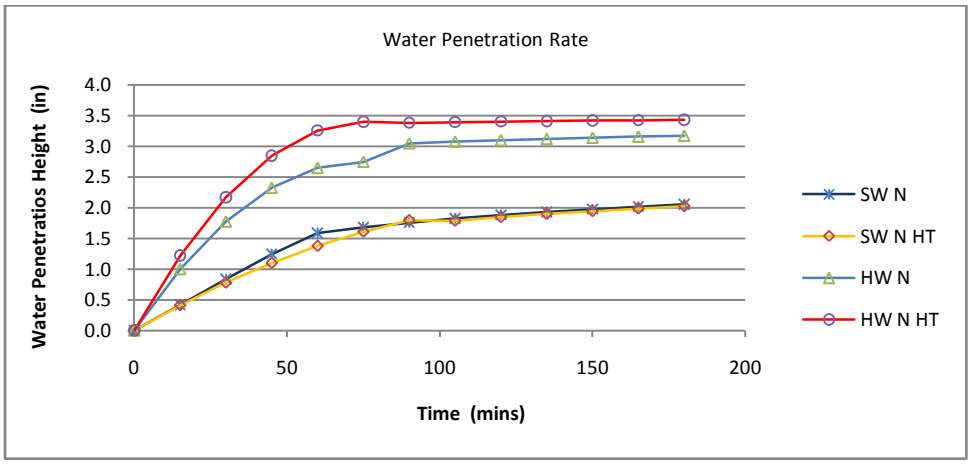

Figure 16. Comparison of the four pallet types using average graphs within the first three hours

Both new and used specimens were stored in CBU test lab for months, where they were conditioned under the same environment. Thus, there was little difference found between the new and used softwood specimens (Fig. 14).

The following general recommendations can be made:

(1) It is possible that water could penetrate up to the top of a wooden pallet. Thus, good drainage of the storage area would prevent water accumulation. This would reduce the chance of water penetrating up to the pallet top.
(2) When possible softwood pallets should be used if there is a potential water penetration problem. Water penetration height is lower and penetration rate is slower in softwood.
(3) There are many possible ways to stop the water from penetrating to the top of a pallet, including placing a layer of plastic sheet at the top of the pallet, coating a pallet with water sealant, etc. However, most pallets are shipped one way, thus shippers may hesitate to pay for an additional cost. Also, if a water sealant is used, a study on health hazard would be needed.

References

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