

Moisture performance of wood column in outdoor environment

Shun Ji Pan¹, Hui Lan Xu¹, Wook Kang¹, Woo Yang Chung¹

¹Div.of Forest Resources & Landscape Arch., Chonnam National Univ.,
GwangJu 500-757 Korean, panshunji@hotmail.com

ABSTRACT: Wood is a hygroscopic material influenced by the surrounding conditions. So the quantity of influence from the environment is important for us to understand. Especially moisture content is not only related to the wood rot but also the wood quality.

This study concerns the evaluation of moisture performance of air dried Douglas-fir columns in outdoor environment. The climatic conditions of the city of GwangJu (Longitude: 126°54' E; Latitude: 35°10' N; altitude: 74m) are employed for representative days from 1 August 2007 to 30 April 2008.

The results show that moisture performance is affected by thermal performance and rain is the main source of wood moisture in outdoor environment.

Keywords: outdoor environment; moisture performance; thermal performance; rain

1. INTRODUCTION

The widespread use of wood in construction of buildings has both an economic and an aesthetic basis. The ability to construct wood buildings with a minimal amount of equipment has kept the cost of wood-frame buildings competitive with other types of construction. On the other hand, where architectural considerations are important, the beauty and the warmth of exposed wood are difficult to match with other materials. Also, as a naturally produced organic material, wood may be subject to decay, fungal stains, insect infestation, and fire which can cause the useful life of a building or a product to be greatly reduced.

One of the important characters of wood is that as a hygroscopic material, wood can be influenced by the surrounding conditions. So the quantity of influence from the environment is important for us to understand.

Physical and optical properties of the materials collecting solar radiation as well as environmental factors such as ambient air temperature, solar radiation intensity, direction and velocity of wind, overcast, solar radiation angle, rainfall and potential air pollution significantly affect the efficiency of the solar heating systems [1]. Eban Saleh investigated the thermal performance of different insulation materials, thicknesses and arrangements in outdoor environment [2, 3]. Ozkan investigated the performance of flat roofs, water proofing and insulation under hot and dry climatic condition [4].

As the previous studies, driving rain is one of the most significant moisture sources that may cause premature deterioration of wood stud wall assemblies [5, 6]. Driving rain deposited on the surface of cladding may drain from the exterior surface of the cladding, be stored in the cladding by capillary absorption or penetrate further into the wall assembly [7].

The purpose of this study is to reveal the influences of solar radiation and precipitation on wood moisture performance.

Horizontal surface was investigated in the most of previous similar studies. In this study, vertical surfaces are investigated and the moisture performances of different surfaces are compared.

2. MATERIALS AND METHODS

2.1 Materials

Air dried Douglas-fir columns were used in this research. They were stored in an indoor environment for more than a half-year and conditioned to uniform moisture content. The long wood columns were cut into short ones of 700mm (L) × 200mm (R) × 200mm (T) (Fig. 1). Density of the wood column was 415 kg per stere. Initial moisture contents of wood columns were about 12 percent.

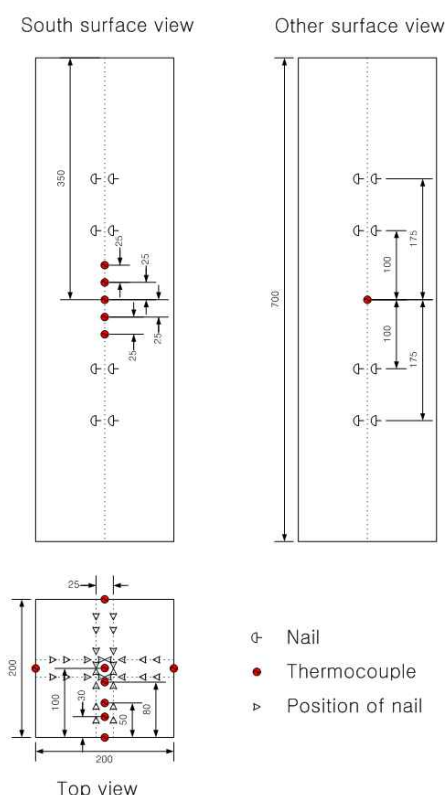


Figure 1: Schematic view of wood column and the positions of thermocouples and nails.

2.2 Experimental methods

Air dried Douglas-fir wood columns were exposed in outdoor environment (Fig. 2). The top and bottom parts of wood columns were insulated by aluminium foil and Styrofoam.

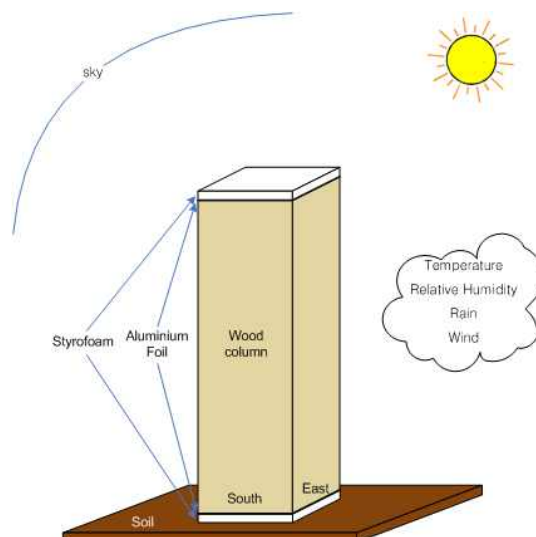


Figure 2: Schematic view of wood column in outdoor environment.

Weights of wood columns were measured per day to calculate time variation of average moisture contents.

Wood has the useful characteristic that it allows moisture content to be measured by measuring resistance and subsequently translating this electrical resistance into a moisture content reading. Therefore, thermocouples and nails were inserted into wood as 30mm, 50mm, 80mm and 100mm for measuring corresponding position temperatures and electric resistance. Four surfaces temperatures were also measured (Fig. 1). Electric resistance was measured three times per day and temperatures were set to be measured at 1-min interval. Then, moisture content was calculated using the following equation.

$$MC = \frac{1.009 - \log[\log(R) - 4]}{0.0322} - (T - 20) \times 0.1 \quad (1)$$

where MC is moisture content, R is electric resistance, T is corresponding temperature.

One wood column was cut into pieces to measure final moisture distribution after every month.

3. RESULTS AND DISCUSSION

Moisture performances of wood columns were investigated from 1 August 2007 to 30 April 2008. For more clearly understand the variation of moisture contents throughout a clear day, 16 May 2008 was selected as the representative.

3.1 Moisture performances throughout the clear day

In outdoor environment, moisture performances are affected by surrounding conditions, especially solar radiation. Solar radiation causes temperature different between each surface, which can affect moisture distribution in wood column.

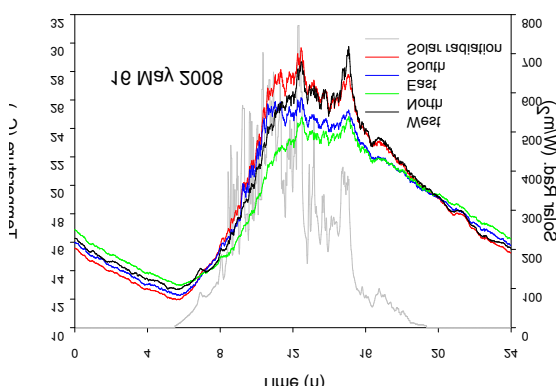


Figure 3: Comparison of surfaces temperatures and solar radiation on 16 May 2008.

As shown in Fig. 3, surfaces temperatures increase with solar radiation increases in daytime. In night time, north surface temperature is higher than south surface temperature. As previous studies, counter-radiation is greater from surrounding than from the sky and wood columns were placed at the south of a building, so south surface loses more energy than north surface in night time.

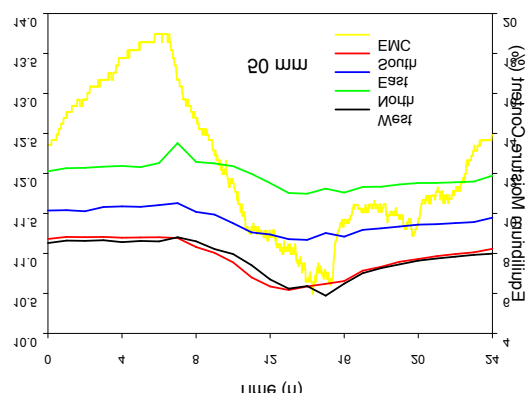


Figure 4: The time variation of EMC and moisture content of wood column at a depth of 50mm of different surfaces on 16 May 2008.

As shown in Fig. 4, wood column absorb moisture in night time and lose moisture in daytime. South and west directions have a bigger moisture fluctuation than north and east directions, which matches with temperatures variation.

Moisture content has a big fluctuation in the depth of 50mm and moisture contents increase from outside to inside (Fig. 5).

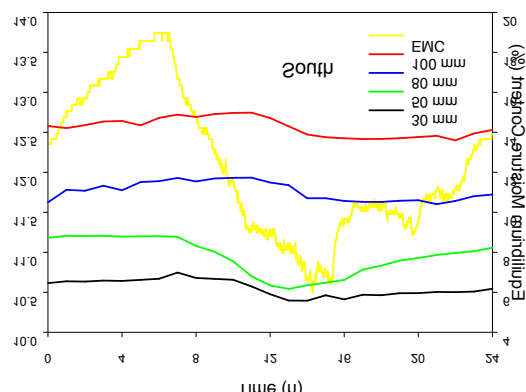


Figure 5: The time variation of EMC and south direction moisture distribution of wood column on 16 May 2008.

3.2 Moisture performances throughout the nine months

Wood columns absorbed moisture as a source of snow and rain in December and January, but rain in other months. Because the vertical surfaces were investigated in this research, so snow did not have much effect on wood moisture performance.

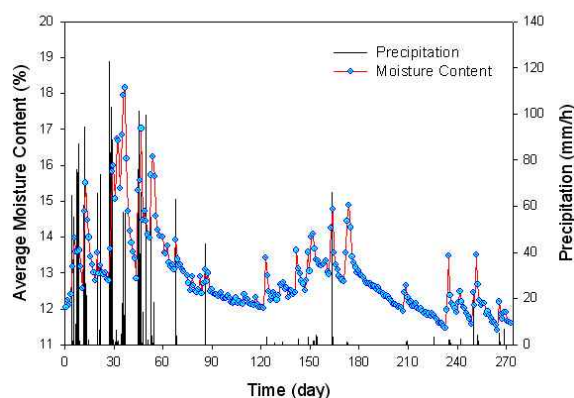


Figure 6: Comparison of average moisture content and precipitation from 1 August 2007 to 30 April 2008.

As shown in Fig. 6, the value of average moisture content tends to increase deeply during rainy time and decrease quickly after rain. As the previous studies, average moisture content should not change so sharply even though on rainy days. Actually, water on the surface of wood column was calculated as wood contains. The precipitation during summer is relatively high compared to that of in winter.

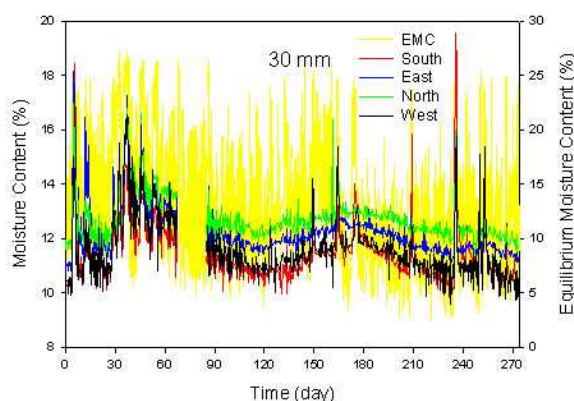


Figure 7: The time variation of EMC and moisture distribution in wood column at a depth of 30mm from 1 August 2007 to 30 April 2008.

As shown in Fig. 7, moisture distribution has the similar characters on clear days which have been explained in last part. On rainy days, driving rain causes some direction moisture content to increase more quickly than other directions. It is clear that

in the GwangJu region the driving rain has seasonal variations.

Moisture distribution of south direction throughout the nine months is shown in Fig. 8. From this figure, outside moisture contents of wood column tend to be lower than inside on clear days. On rainy days, outside moisture contents increase more quickly than inside.

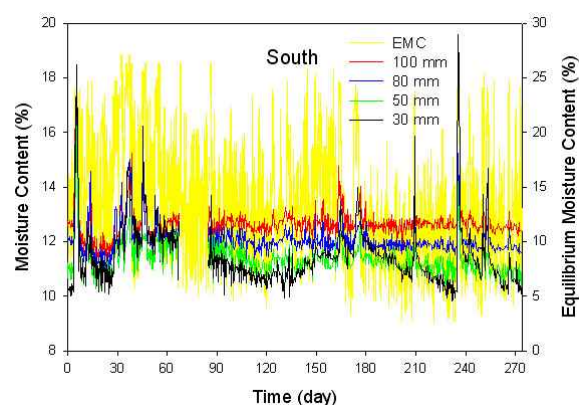


Figure 8: The time variation of EMC and south direction moisture distribution of wood column from 1 August 2007 to 30 April 2008.

3.3 Final moisture distribution

Oven-dry method was used to measure final moisture distribution. TECPLOT computer program was used to draw the 3-D figures. One of the figures is selected as the representative.

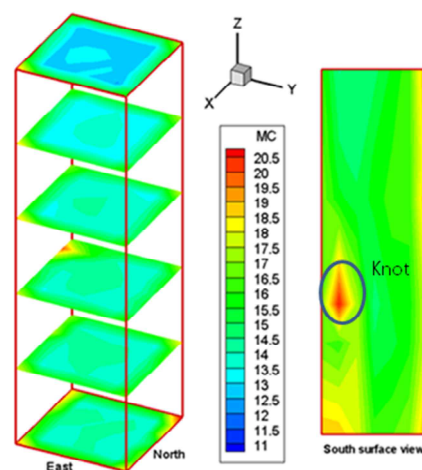


Figure 9: Final moisture distribution on 1 September 2007.

As shown in Fig. 9, outside moisture content is higher than inside. The reason of this phenomenon is that the last several days of August were rainy days, wood column absorbed moisture in that period. As the previous studies, knot content more resin than normal growth material. So, when the cut pieces were dried out, knot lost more resin which was thought to be moisture.

4. CONCLUSIONS

In this study, moisture performance of air dried Douglas-fir column in outdoor environment has been analysed. The results show that solar radiation is the key factor to thermal performance of wood column on clear days, moisture performance is affected by thermal performance and rain is the main source of wood moisture.

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