

Studies on Air Drying Characteristics of Garjan Sleepers

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Air drying characteristics of garjan *Dipterocarpus* spp. railway sleepers were investigated employing 1 x 5, 2 x 5, 1 x 7 and 2 x 7 piling methods. Although there was no significant difference among the drying periods in different methods, the 2 x 7 method appeared to be the most efficient one. This method exhibited a relatively shorter drying time irrespective of higher density and higher initial moisture content of sleepers as compared to those in other methods. The faster drying in the 2 x 7 method was attributed to better air circulation. Sleepers stacked in the month of April, dried down to 28% moisture content in about eight months on the average. It is recommended that garjan sleepers be air dried following the 2 x 7 method during the active drying season beginning November, instead of April, as was done in the present study, with a view to achieving further reduction in total drying time.

The moisture distribution inside the sleepers was highly variable ; the moisture gradient was steeper with increasing depth of the zone, but the steepness of the gradient decreased with increasing drying time.

১X৫, ২X৫, ১X৭, এবং ২X৭ স্তূপায়ন পদ্ধতি অবলম্বন করিয়া গর্জন রেলওয়ে স্লিপারের বাতাসে শুকানোর বৈশিষ্ট্যসমূহ নিরীক্ষা করা হইয়াছে। যদিও বিভিন্ন পদ্ধতিতে শুকানোর জন্য সময়ের কোন বিশেষ পার্থক্য পরিলক্ষিত হয় নাই, তথাপি ২X৭ পদ্ধতি সর্বাপেক্ষা কার্যকরী বলিয়া মনে হয়। প্রারম্ভিক জলীয় অংশ বেশী থাকা সত্ত্বেও এবং অধিক ঘনত্ব সম্পন্ন হওয়া স্বত্বেও এই পদ্ধতিতে তুলনামূলকভাবে অল্প সময়ে স্লিপার শুকাইয়াছে। অপেক্ষাকৃত উন্নত বায়ু সঞ্চালনের কারনেই ২X৭ পদ্ধতিতে দ্রুত স্লিপার শুকায়। এপ্রিল মাসে আরম্ভ করিয়া ২৮% জলীয় অংশ পর্যন্ত স্লিপারকে শুকাইতে গড়ে প্রায় আট মাস সময় লাগিয়াছে। বর্তমান পরীক্ষার প্রেক্ষিতে এপ্রিল মাসের পরিবর্তে নভেম্বরের প্রথমে আরম্ভ করিয়া ২X৭ পদ্ধতিতে গর্জন স্লিপার বাতাসে শুকাইবার জন্য সুপারিশ করা হইতেছে। ইহাতে শুষ্ককরণের সময় সামগ্রিকভাবে আরও হ্রাস পাইবে।

স্লিপারের ভিতরের বিভিন্ন স্থানে জলীয় অংশের পরিমাণে তারতম্য দেখা যায়। স্লিপারের ভিতরের দিকে এই জলীয় অংশের শতকরা হারের ক্রমবৃদ্ধি পরিলক্ষিত হইয়াছে। কিন্তু শুষ্ককরণ সময় বৃদ্ধির সাথে সাথে ইহা হ্রাস পায়।

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INTRODUCTION

Garjan (*Dipterocarpus* spp.) is the primary timber species which is being extensively used for railway sleepers in Bangladesh. Prior to preservative treatment by pressure methods, it is imperative that sleepers be properly air dried to a moisture content below the fibre saturation point. The present practice of drying freshly sawn sleepers by steaming seldom goes below the fibre saturation point unless the stock is partially air dried before hand. No information on air drying characteristics of garjan sleepers is available. It is, therefore, considered necessary to investigate the air drying characteristics of garjan sleepers in order to evolve a proper air drying method for satisfactory preservative treatment.

MATERIALS AND METHOD

Five hundred 4.5 inch x 8 inch freshly sawn Metre-Gauge garjan sleepers were procured from the commercial stock of Forest Industries Development Corporation at Kalurghat, Chittagong. These were ordered in 12.5 feet lengths, and were processed into standard 6 feet lengths at the Institute. Four piling methods, 1x5, 2x5, 1x7 and 2x7 were employed for this study. Fifty-six sleepers were randomly selected of which five sleepers were used for each pile as moisture loss samples, and two sleepers were used to determine moisture gradient samples for each pile. The remaining 444 sleepers were sorted into eight lots; 2 lots of 45 each, 2 lots of 52 each, 2 lots of 59 each and 2 lots of 66 each to evaluate, respectively, the 1x5, 2x5, 1x7 and 2x7 piling methods. One complete set of piles in duplicate was stacked in the open air drying yard of the Forest Research Institute, Chittagong in the month of April, 1962. The top of each pile was roofed with rejected sleepers to protect it against direct sun. The sleepers were stacked with the length in the east-west direction. The spacings between lateral and the front alleys were three feet.

Moisture loss samples were placed in tiers 1,2, 3, 5 and 6 with two moisture gradient samples in tier 4. All samples were end-coated with bitumin paint to inhibit end drying. The initial moisture content of individual sleepers was estimated by cutting one moisture section from each sample at the time of cross-cutting 12.5 feet sleepers into 6 foot lengths. The specific gravity of the sample

sleepers was determined from one-inch sections on the basis of green volume and oven dry weight.

Air drying was started from the beginning of April, 1962 and the observation was continued till the end of January, 1963. Moisture loss samples were weighed at one month intervals using a portable balance to the nearest 0.1 lb. Moisture gradient specimens were prepared at three month interval. Moisture gradients were studied in four periods, the first period being the initial one prior to drying while the second, third and fourth periods were, respectively, after 3, 6 and 9 months of drying. A one-inch strip was cut six inches apart from one end of each gradient sleeper and seven specimens comprising of four zones were prepared from this strip.

Of the four zones the first, second and third zone consisted each of a 0.5—inch thick strip and their distance from the surface was 0.5, 1.0 and 1.5 inches respectively. The fourth zone was the residual one-inch centre portion. The moisture content of each zone was determined by the oven dry method. At the end of drying, two moisture sections were cut from each moisture loss sample and the average moisture contents of individual samples were estimated. Based on these final moisture content values, the individual weights of moisture loss samples were converted to moisture contents.

RESULTS

The total air drying times of garjan sleepers from the green condition to a 28% moisture content were determined from moisture loss data for all types of piling methods. The mean values are given in Table 1.

TABLE 1. Mean total drying times of garjan sleeper for different piling methods.

Method	Sp. gr. (gr. vol.)	Initial m/c. (%)	Time required to attain 28% m/c.* (months)
1x5 piling	0.60	58.72	8.00
2x 5 piling	0.63	59.31	8.18
1x7 piling	0.62	54.49	8.03
2x7 piling	0.64	63.41	7.58

*Each figure is an average of ten observations.

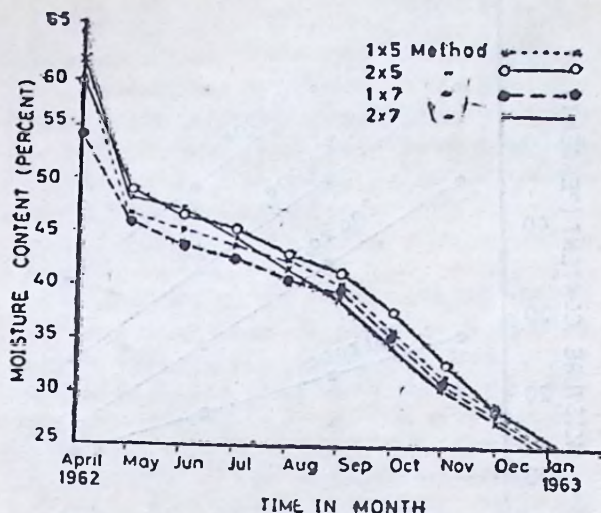


Fig. 1.—Drying curves of garjan sleepers under different methods.

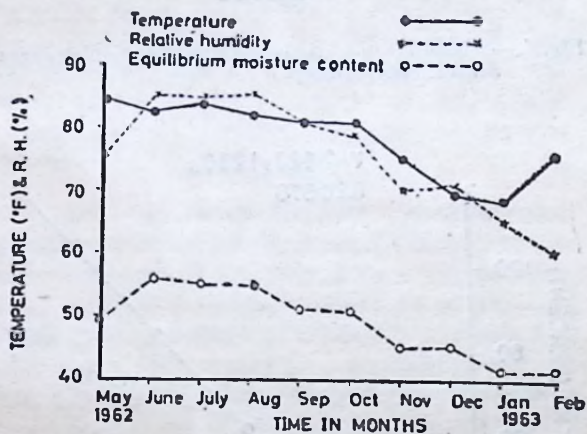


Fig. 2.—Climatological records at the Forest Research Institute for the period May, 1962 to February, 1963.

The 28% moisture level is below the fibre saturation point of garjan and drying upto this moisture content is considered to be adequate for satisfactory preservative treatment by pressure methods. Drying curves of sleepers under different methods were constructed from the mean monthly moisture content data. These curves are shown in Figure 1. The climatological data, as obtained from the Institute Meteorological station, are presented in

Figure 2. The wood equilibrium moisture content curve was based on the monthly mean temperature and relative humidity.

Analysis of variance was performed on moisture loss data to test the effects of piling method, tier and pile on total drying times. The results of this analysis are summarised in Table 2.

TABLE 2. Results of analysis of variance on moisture loss data.

Source	DF	SS	MSS	F	Significance
Method	3	5.1857	1.7285		NS*
Tier	4	2.5034	0.6259		NS
Pile	1	0.0457	0.0457		NS
Residual	31	616.2412	19.8787		
Total	39	623.9760			

*NS-Not significant.

Analysis of variance was also performed on moisture gradient data to note the effects of piling method, zone, period and pile on moisture gradient data. The summary of this analysis is given in Table 3.

TABLE 3. Results of analysis of variance on moisture gradient data.

Source	DF	SS	MSS	F	Significance
Method	3	3155.57	1051.86	22.58	*
Zone	3	32583.72	10861.24	233.72	***
Period	3	26968.01	8989.33	192.94	***
Pile	1	665.72	665.72	14.29	NS
Residual	245	11414.86	46.59		
Total :	255	74787.88			

*Significant at the 5% level

***Significant at the 0.1% level

NS-Not significant.

Linear moisture gradient regressions were computed for the zone moisture contents and for the moisture contents at different periods. The summary of these regressions is presented in Table 4.

TABLE 4. Summary of regressions for moisture gradient data at different zones and periods.

	a (intercept)	b (reg. coeff.)	r ² (Correlation Coefficient)
Period-wise			
First period	17.500	13.096	0.656
Second "	10.659	12.323	0.768
Third "	8.969	9.158	0.705
Fourth "	7.910	6.507	0.713
Zone-wise			
First zone	27.527	1.395	0.698
Second "	46.141	3.051	0.750
Third "	57.585	3.479	0.660
Fourth "	69.220	3.756	0.650

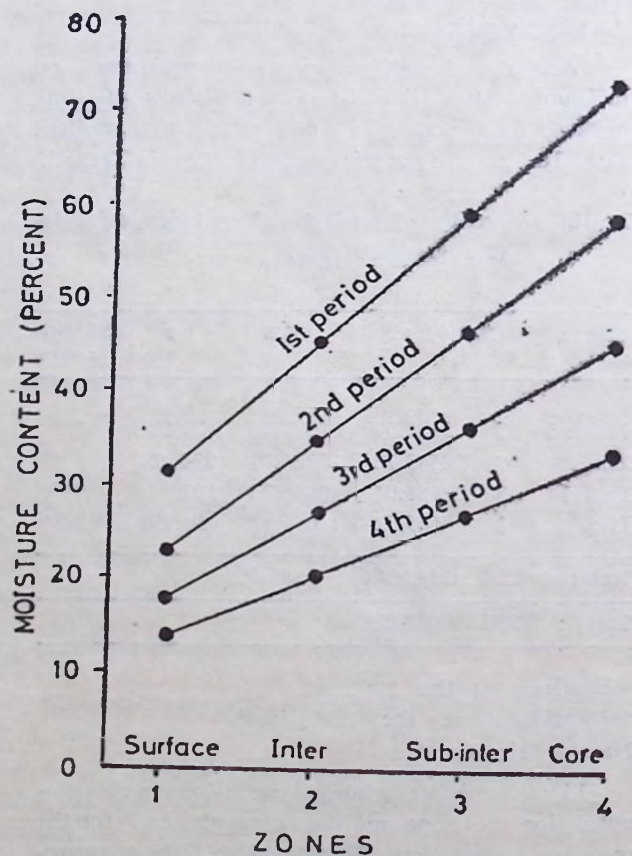


Fig. 3.—Distribution of moisture inside garjan sleepers during different periods.

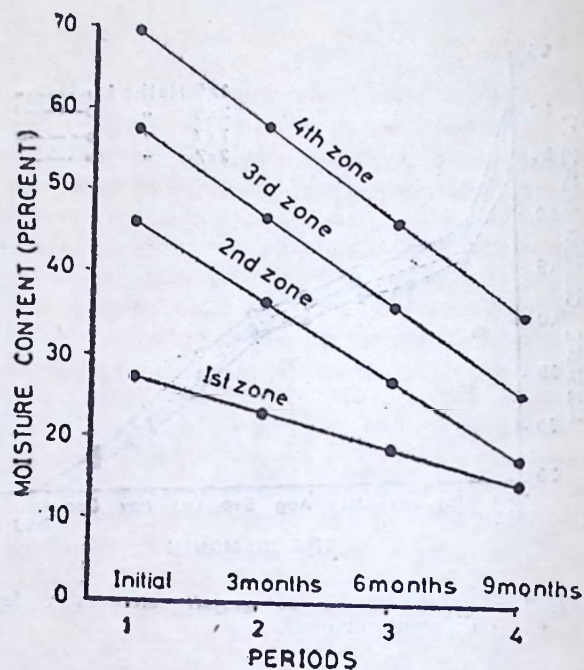


Fig. 4.—Distribution of moisture inside garjan sleepers in different zones,

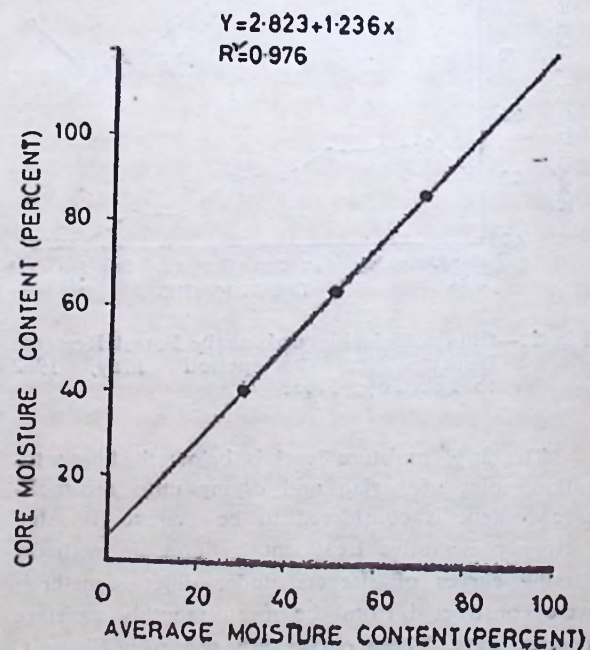


Fig. 5.—Average moisture content versus core moisture content of garjan sleeper.

On the basis of the estimated regression equations, the distribution of moisture inside the sleepers is shown in Figures 3 and 4 at different periods and zones respectively. Linear regression was also performed to determine the relation between the average moisture content and the core moisture content of garjan sleepers. This relation is shown in Figure 5.

DISCUSSION OF RESULTS

Total drying times

Figure 1 shows that garjan sleepers followed the same general pattern of drying in all the piling methods. Drying was, as usual, most rapid in the first month but it slowed down during the subsequent three months. From the fifth month onward, drying was found to be rapid. This difference of the drying rate may be attributed to the climatological effect. It is evident from Figure 2 that the wood equilibrium moisture content which is dependent on ambient air temperature and relative humidity, was highest during June, July and August. It was lower during April and May and lowest during the months of November to January. This fluctuation in wood equilibrium moisture content affected the drying rate of sleepers because air drying is, to a large extent, governed by the atmospheric conditions.

There is not much difference among the total drying times of sleepers in different methods. It took about 8 months to dry sleepers from the green condition to a 28% moisture content in all the cases (Table 1). The analysis of variance also shows that the piling method was not a significant factor and thus it could not affect the drying rate of sleepers significantly (Table 2). The effect of pile and tier was likewise found nonsignificant (Table 2). However, there is evidence to suggest that the 2x7 method was the most efficient among the methods studied. Although the initial moisture content and the specific gravity of sleepers in the 2x7 method were highest the drying time was found to be lowest in this method (Table 1). This relatively faster drying may be attributed to better air circulation. It is known that apart from the effect of air temperature and humidity on the drying behaviour, there is a third factor of considerable importance, i.e. air circulation. The movement of air through the timber surfaces, in particular, is essential to convey the heat required for the evaporation of moisture. In the

present study, the 2x7 and 2x5 methods provide comparatively more space between the sleepers than those of the 1x7 and 1x5 methods, which in turn help in better air circulation. It is thus understandable why the 2x7 method, despite highest saturation and density, exhibited the shortest drying time among the methods. There is, however, no apparent difference in the total drying times between the 2x5 method and the other two methods.

From the standpoint of drying, the year may be divided into four periods in Bangladesh (Ali *et al.* 1968). The monsoon period, from the first of June to the end of August, is characterised by heavy rainfall, high relative humidity and also high air temperature. The pre-monsoon period from the first of April to the end of May and the post-monsoon period from the first of September to the end of October are identical. Rain is moderate; relative humidity and air temperature are also moderate. The active drying period extends from the first of November to the end of March. Rain is very light, the relative humidity is low and the air temperature varies from 60 to 85 F. Considering this variation in the climatological conditions during a year, a study was conducted on air drying of one-inch garjan. Results showed that lumber stacked in February dried to a 15% moisture content in less than two months while the same stacked in May took nearly eight months due to the monsoon period (Sattar *et al.*, 1969). It therefore appears that if the sleepers in the present study had been stacked during the active drying season beginning November instead of April, the drying times of sleepers could have been considerably reduced.

Moisture gradients

A highly variable moisture distribution was observed inside the garjan sleepers (Figures 3 and 4). The moisture gradient was found to increase considerably with increasing depth of the zone from the surface to the core (Figure 3) while it was found to decrease with increasing time of drying (Figure 4). The analysis of variance also shows that the moisture gradient was significantly affected by the zone and drying period (Table 3). The piling method was also observed to be a significant factor and it thus affected the moisture gradient (Table 3). It is evident from the regression co-efficients that the moisture gradient was most steep in the first period,

and subsequent periods had progressively lesser steepness (Table 4). The regression lines in Figure 3 show that the difference in the moisture content between the surface and the core was 43% for the first, 36% for the second, 28% for the third and 20% for the fourth period. It suggests that as the drying progresses further and further, it tends to equalise the distribution of moisture.

Again, the regression lines in Figure 4 reveal that the highest amount of moisture was lost from the fourth zone, i.e. the core, and the lowest amount was lost from the first zone i.e. the surface during the entire period of drying. It is apparent that the first zone lost only 12% while the second, third and fourth zones, respectively, registered a loss of 27%, 31% and 34% in moisture content (Figure 4). It thus reaffirms the basic concept of wood drying. Drying is accomplished by establishing a gradient of moisture from the centre to the surface and the rate is accelerated by increasing this gradient. It may further suggest that to dry timber rapidly it is only necessary to dry the surface to a lower moisture content than that of the centre. But when the surface layers reach the fibre saturation point, shrinkage starts to take place, and the dried layer tends to contract upon the wetter interior. Stresses are thereby set up, and their intensity is increased as the gradients become steeper. These stresses may cause wood to split and check unless they are kept within limits. In the present investigation, drying degrade was not quantitatively measured and thus the effect of the moisture gradient cannot be correlated with the drying degrade. It is, however, observed that no serious drying degrade developed in the garjan sleepers. It is also seen that there was no noticeable difference in the overall quality of sleepers under different piling methods.

It is apparent from Figure 5 that a straight line relation was observed between the average and the core moisture content. It is thus possible to estimate the core moisture content of garjan sleepers during any point of air drying with the help of average moisture content.

CONCLUSIONS

The following conclusions were drawn from this study :

(i) Garjan sleepers followed the same general pattern of air drying in all the piling methods.

(ii) There was no statistically significant difference among the drying periods in different methods. It took about eight months to dry from green to a 28% moisture content in all the cases.

(iii) Among the four methods, the 2x7 method was found to ensure comparatively faster drying due to better air circulation. This method is recommended for air drying garjan sleepers during active air drying months.

(iv) There was a highly variable moisture distribution inside the sleepers. This variation was significantly affected by the zone and the period.

(v) Moisture gradient was found to be steeper with the increasing depth of the zone, but the steepness of the gradient decreased with increasing drying period.

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