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Comparisons of predicted and experimental charring rates at various moisture contents of selected Southern Nigerian structural wood species

Adetayo O.A.*[1)], Dahunsi B.I.O.[2)] and Oyelaran O.A.[3)]

[1)]Department of Civil Engineering, Faculty of Engineering, Federal University Oye Ekiti, Ekiti State, Nigeria
[2)]Department of Civil Engineering, Faculty of Technology, University of Ibadan, Ibadan, Oyo State, Nigeria
[3)]Department of Mechanical Engineering, Faculty of Engineering, Federal University Oye Ekiti, Ekiti State, Nigeria

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Abstract

Investigation of the performance of Nigerian structural wood species under fire exposure to predict structural collapse have not been adequately researched. In this study, the charring rate of six identified structural wood species were determined. They are *Terminalia superba* (Afara), *Milicia excelsa* (Iroko), *Khaya ivorensis* (Mahogany), *Mansonia altissima* (Mansonia), *Nauclea diderrichii* (Opepe), and *Tectona grandis* (Teak). The wood densities values at three moisture contents (MC), 9, 12, and 15%, were determined. Fifty-four wood samples, nine block specimens of dimensions 150 mm x150 mm x 510 mm from one board of each of the six species were tested in three groups. Fire exposure tests were carried out on the selected wood samples at three different controlled temperatures of 20 °C to 230 °C for 30 minutes, 230 °C to 600 °C for 30 minutes, and 20 °C to 300 °C for 60 minutes. Empirical statistical models using ANOVA at $\alpha = 0.05$ were developed for the experimental charring rate of the wood samples. The results were compared with the values of the predicted charring rates of the wood samples. At fire temperatures between 20 °C and 300 °C and fire exposure times of (0 - 60) minutes, the values of the coefficient of correlation, *R*, of the wood samples of 9%, 12%, and 15% MC, were 0.682, 0.582, and 0.578, respectively. The values indicated that there exist a strong positive correlation of actual charring rate that can be explained by the relationship to the predicted charring rate of the wood samples.

Keywords: Charring rate, Correlation coefficient, Moisture content, Nigeria woods, Structural collapse

1. Introduction

Wood is an essential engineering material that has historically served man. Humans used on wood for various needs from farming tools to building materials, fuel and weapons for hunting [1]. The Nigerian rain forest is blessed with abundant natural forests because the geographical location of the country in the tropics. It has naturally favored the growth of trees, which is an abundant source of wood in the country [2]. Wood as an ideal material for construction purposes. Although, it is flammable, it is not simply ignitable. Wood contains a combination of polysaccharides, hemicelluloses, and polymers that form an exceedingly complex network. Pyrolysis is the procedure by which materials deteriorate when exposed to high temperature. The constituent characteristic polymers in timber will decompose upon heating, producing inert and flammable gasses that depend on the char depth, liquid tars, and a strong carbonaceous scorch [3]. This can occur before dehydration is finished if the heating rate is quick enough, but after the sample has dried it will be quicker [4]. These pyrolysis of these materials will then endure additional transformation themselves under continuous heating due to the charring process and wood species [5].

Wood commonly experiences three primary phases of transmutation [6] because of its comparatively low thermal conduction, density and moderately high specific heat. These are dehydration and moderate pyrolysis below 200 °C, beginning of pyrolysis up to 300 °C, and speedy pyrolysis above 300 °C.

Typically, hemicellulose is the first component of wood to be thermally decomposed. The temperatures at which this response begins are reported to be from 120 °C to 180 °C [7], 200 °C to 260 °C [3, 6, 8], 220 °C to 315 °C [9-10], or from 200 °C to 300 °C [11]. This range of temperatures depends on the rate of burning, wood species, wood density, and moisture content of the wood [12].

Cellulose is the next component to break down, with deterioration temperatures within the same conditions as those of hemicellulose, cited as 240 °C to 350 °C [3, 6], 250 °C to 350 °C [3], 315 °C to 400 °C [9], 280 °C to 400 °C [7] or 300 °C to 350 °C [11].

Thermal conduction of solid wood depends on the moisture content as reported by numerous authors [13-16]. Due to a heat sink impact, the dampness of the wood is broadly acknowledged as hindering pyrolysis [12, 17-18].

*Corresponding author. Tel.: +234 803 365 9724
Email address: oluwaseun.adetayo@fuoye.edu.ng
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Table 1 Notational rates of charring for the calculation of residual section

Species	Charring in 30 min	Charring in 60 min
All structural wood species	20mm charred layer	40mm charred layer
Hardwoods having a nominal density not less than 650 kg/m^3 at 18% moisture content	15mm charred layer	30mm charred layer

The higher the moisture content, the greater the need to dissipate the water, and therefore the less accessible are wood components for pyrolysis.

In general, there is strong agreement that temperatures around 300 °C represent the beginning of rapid pyrolysis and char formation, though at longer heating periods, this will occur at considerably lower temperatures. There is considerable understanding between authors on which constituent polymers respond, their chemical reactions, and their char yields. However, there is wide scatter within the literature concerning properties such as disintegration temperatures. These variations are partly attributed to variations in wood species, the heating rate, and testing techniques.

The most important property of wood at elevated temperature is the formation of char after ignition [12]. The charring rate is the linear rate at which wood is converted into char [19]. A build-up of char tends to guard the unburnt wood from fast pyrolysis. Unburnt timber, serving as an insulator, is largely unaffected in the fireplace. The charring rate depends on variety of factors such as the wood species, wood density, wood thickness, wood moisture, and chemical composition [20].

Density is amongst the foremost of all the basic physical characteristics of wood [20-21]. Different woods char at various rates, mostly due to the role of their density. Greater density woods char more slowly [22].

The charring rate is strongly dependent on wood density [3, 11-12, 17, 23-24]. Numerous charring models use density as a key variable. In general, it has been found that the charring rate of wood under exposure to the standard temperature–time conditions [25] within which the bulk of recent research work has been undertaken will vary from around 0.8 mm/min for lightweight softwoods with densities larger than 290 kg/m^3, decreasing to 0.4 to 0.5 mm/min for dense hardwoods with densities greater than 450 kg/m^3, with 0.6 mm/min as an average value.

The charring rate is extremely variable and changes with wood density as has been observed by numerous authors from several countries [26]. Lizhong et al. [27] tested horizontal samples of elm, toon, and paulownia of densities 590 kg/m^3, 530 kg/m^3, 260 kg/m^3, respectively, in a radiation platform to constantly increasing heat exposures, ranging from 0.07 kW/m^{2}s to 0.425 kW/m^{2}s, to give consistent heating rates of 40 and 60 kW/m^2. Charring rates were derived by temperature measurements using K-type thermocouples at the surface, 2 mm, 6 mm, and 10 mm from the exposed surface. The charring rate with smaller densities increased in both instances. Tran and White [28] tested vertical samples of red oak, redwood, southern pine, and basswood with densities of 660 kg/m^3, 312 kg/m^3, 508 kg/m^3, and 420 kg/m^3, respectively, with consistent heat exposures of 15, 25, 35, and 50 kW/m^2. Of the species tested, redwood and southern pine were softwoods, and red oak and basswood were hardwoods. Redwood charred about 20% faster than southern pine for all the heat exposures. Samples of basswood charred about 60% faster than specimens of red oak. Surprisingly, the trend across all four specimens was inconsistent. Basswood samples charred consistently faster than red oak, despite having a higher density. In a review on timber charring rates, Friquin [12] discovered that charring rates decreased with increasing density. Furnace experiments [29-33] also investigated the impacts of density on the speed of wood charring. Of these, Lizhong et al. [27], Hugi et al. [29], Njankouo et al. [31], Tran and White [28] tested to the ISO 834 standard temperature–time curve [25]. White [30], White and Nordheim [34] and Schaffer [35] tested to the ASTM E 119 standard temperature–time curve [36]. Schaffer [35] also tested in 538 °C, 816 °C, and 927 °C constant furnace temperatures. For each situation, charring rates were determined from the 300 °C isotherm. Alternatively, Frangi and Fontana [32] derived the mean charring rates by estimating the residual sample height. Most authors discovered that charring rates diminished as anticipated from direct radiant heating experiments with increasing density. By and large, specimens with higher density will usually charred more slowly owing to their larger mass for pyrolysis. Therefore, more energy was required to fuel endothermic reactions.

2. Materials and methods

2.1 Experimental research into the selected structural woods

The rate of charring is based on an hour's exposure to heat. The depletion rates are reported as forty millimeters per hour for many structural woods and thirty millimeters per hour for denser hardwoods. This permits the fire resistance of timber to be calculated. The prognostic methodology is given in EN 1995-1-2, as shown in Table 1 [37].

In this study, we assumed the charring rate was a function of wood density, wood moisture content, and level of fire exposure of the wood. Samples of six totally different wood species out of ten samples principally used for structural purpose were tested to determine their charring rates. The six species tested were Afara (*Terminalia superba*), Iroko (*Milicia excelsa*), Mahogany (*Khaya ivorensis*), Mansonia (*Mansonia altissima*), Opepe (*Nauclea diderrichii*) and Teak (*Tectona grandis*). The samples were taken from the heartwood region of individual trees that were specially ordered from a lumber market.

2.2 Methodology of charring tests

The charring rate, β, is a crucial factor in the fire design of exposed structural timbers. It determines how quickly the dimensions of the bearing section decrease to a critical level. Design procedures for fire-retardant wood members within the U.S. model for building codes [38] based on unit area are supported the work done by Lie [39]. Lie assumed a continuous charring rate of 0.6 mm/min, no matter the wood species or its moisture content.

Figure 1 Samples being subjected to a fire test inside an electric-fired furnace

White performed in depth measurements of the charring rate of eight wood species exposed per ASTM E 119 [40]. He found that the charring information may be correlated as shown in equation (1).

$$t = mx_c^{1.23} \quad (1)$$

where: *'t'* is the time of fire exposure in (minutes),
'm' is the char rate coefficient (min/mm$^{1.23}$),
'x_c' is the depth of char (mm)

Based on the experimental information, an associated empirical model was developed that expresses 'm' as a function of wood density, wood moisture content, and a char contraction factor. The latter is a quantitative relation of the thickness of the char layer at the tip of the fire exposure divided by the initial thickness of the wood layer that burned.

Wood specimens were tested in a big vertical electrical-fired furnace. Fifty-four samples were tested in three groups. Nine specimens of overall block dimensions of 150 mm x 150 mm x 510 mm (0.15 m x 0.15 m x 0.51 m) from one board of each of the six species.

In the first group of 18 tests, three specimens from one board of each of the six species were tested at moisture contents of 9, 12, and 15 percent for 30 min in a furnace at temperatures ranging from 20 °C to 230 °C. The second group of 18 tests was also done for 30 minutes for temperatures ranging from 230 °C to 600 °C.

The last group of 18 samples was tested in a furnace for 60 minutes at temperatures ranging from 20 °C to 300 °C.

Just before the fire test, the data below data were recorded for the wood samples:

(i) wood sample species
(ii) wood sample moisture content (percent)
(iii) wood sample density
(iv) wood sample dimension
(v) wood sample weight
(vi) wood ring orientation

The specimens were held horizontally and subjected to a heat flux perpendicular to the wood grain inside an electric-fired furnace (Figure 1).

The specimens were in the furnace and the electric furnace was powered with a furnace temperature switched was 20 °C. At the time of burner ignition, the automatic temperature recorder, stop watches and chamber temperature controller were started.

- The first test of 18 wood samples were terminated when the electric furnace temperature reached 230 °C from an initial furnace temperature of 20 °C over a period of (0 – 30) minutes.
- Wood samples were subjected to higher temperatures of 230 °C to 600 °C for another 30 minutes for the second part of the test.
- In the third test, the last set of 18 wood samples were exposed to fire inside the furnace at an initial temperature of 20 °C, fire exposure time of 60 min. They terminated when the furnace temperature reached 300 °C.

When testing was completed, the charred wood was scrapped away from the samples. The thickness of the remaining uncharred wood samples was measured in millimeters and the depth of the charred layers were determined.

3. Results and discussion

3.1 Determination of wood moisture content

Moisture content of the wood was determined as the ratio of the mass of removable water in the damp wood sample to the dry mass of the wood sample. The dry mass is obtained by oven drying at 103 ± 2 °C for 24 hours as per ASTM D143-94 [41]. To obtain the moisture content as a percentage, the result is multiplied by 100% as shown in equation (2):

$$Moisture\ Content\ (MC) = \frac{m_{wet} - m_{dry}}{m_{dry}}\ (100\%) \quad (2)$$

where: m_{wet} is the mass of the damp wood sample, and
m_{dry} is the dry mass of the wood

3.2 Determination of wood density

Wood density is one of the most useful characteristics of wood, which is often seen as a main indicator of quality that influences other its physical and strength properties [42]. Wood density indicates the amount of actual wood substance contained in a unit volume [43]. Both the weight and volume of a wood sample are affected by the amount of moisture it contains [44].

At constant temperature, the density of materials that do not absorb moisture is constant. For materials that absorb moisture but do not change volume, such as stone and brick, the density depends upon moisture content. For these materials, the density can be calculated at any moisture content as the ratio of mass to volume, and the relationship between density and moisture content is linear. For wood density however, both mass and volume are dependent on its moisture content.

The densities of wood samples at each moisture content were taken for each species and their mean values were determined. Densities were determined by dividing the mass of the specimen by its volume as expressed in equation (3):

$$Density\ \rho = \frac{m}{v} \quad (3)$$

where: *'m'* is mass in grams, obtained from directly weighing a sample using a digital balance, and
'v' is the specimen volume, determined by multiplying its dimensions (510 x 150 x 150) mm³.

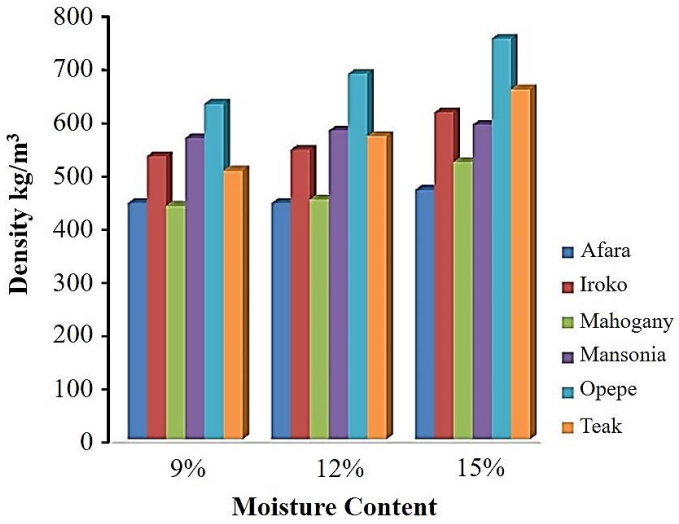

Figure 2 Density of selected species at their corresponding moisture contents

Table 2 Charring rate of samples at 9% MC with (0-30) minutes of fire exposure

Species	Mean Density (kg/m^3)	Mean Char Depth (mm)	Predicted Charring Rate (mm/min)	Mean Actual Charring Rate (mm/min)	Standard Deviation	Minimum (mm/min)	Maximum (mm/min)
Afara	444	25.20	0.66	0.84	0.02	0.80	0.86
Iroko	532	19.30	0.64	0.64	0.02	0.62	0.66
Mahogany	439	19.70	0.66	0.66	0.02	0.64	0.69
Mansonia	566	19.40	0.61	0.65	0.02	0.63	0.67
Opepe	630	14.30	0.58	0.48	0.02	0.45	0.50
Teak	505	19.50	0.64	0.65	0.02	0.62	0.67

The corresponding density value for each specimen was converted to kilograms cubic meter (kg/m³). The histogram in Figure 2 gives the values of density of each species at their corresponding moisture contents, 9, 12 and 15%. At 9% MC, Mahogany had the lowest density value of 439 ± 10.58 kg/m³. At 12 and 15% MC, Afara had the lowest density values of 444 ± 4.18 kg/m³ and 469 ± 7.07 kg/m³ respectively. At 9, 12 and 15% MC, Opepe had the highest density values of 630 ± 28.85 kg/m³, 686 ± 22.64 kg/m³ and 752 ± 17.22 kg/m³, respectively.

3.3 Charring rate results

As previously noted, the charring rates were determined by dividing char depth by the corresponding fire exposure time.

The predicted charring rates were calculated by assuming that the charring rate of hardwood decreases linearly with density, with a limit of 0.5 mm/min for densities greater than 450 kg/m^3.

They could also be determined based on existing linear models of Eurocode EC5 recommendations [ENV 1995] and the Australian standard AS 1720.4 [45].

The Eurocode EC5 model is given as equation (4):

$$d_{char} = \beta_o t \quad (4)$$

where: *'d_{char}'* is the charring depth (mm)
'β_o' is the charring rate (mm/min), usually between (0.5 to 0.8) mm/min
't' is the time of fire exposure in minutes

The nominal charring rate expressed as a function of wood density proposed by Australian standard AS 1720.4 is shown as equation (5):

$$\beta = 0.4 + [280/\rho]^2 \quad (5)$$

where: *'β'* is the nominal charring rate of wood in (mm/min)
'ρ' is the wood density at 12% moisture content (kg/m^3)

The experimental charring rates expressed in (mm/min) were determined as the ratio of the measured average depth of the char layer (mm) and the fire exposure time (min). The experimental charring test results compared well with both Eurocode EC5 and White's models, and were close to the Australian Standard AS1720.4 [46].

The mean charring rate results of fire tests for samples that were exposed for 0 to 30 minutes, and temperatures ranging from 20 °C to 230 °C for 9, 12 and 15% MC are illustrated in Tables 2 to 4, respectively.

The results of the mean experimental (actual) charring rates of the wood samples were plotted against their predicted charring rates values. The predicted charring rate results were derived based on EN 1995-1-2.

The correlation coefficient between the experimental (actual) charring rate and predicted charring was determined from the linear relationship between the actual charring rates and the predicted charring rates for each wood

Table 3 Charring rate of samples at 12% MC with (0-30) minutes of fire exposure

Species	Mean Density (kg/m^3)	Mean Char Depth (mm)	Predicted Charring Rate (mm/min)	Mean Actual Charring Rate (mm/min)	Standard Deviation	Minimum (mm/min)	Maximum (mm/min)
Afara	444	24.60	0.66	0.82	0.02	0.79	0.85
Iroko	544	19.60	0.64	0.65	0.02	0.63	0.68
Mahogany	451	19.50	0.66	0.65	0.02	0.63	0.67
Mansonia	580	18.70	0.62	0.62	0.03	0.58	0.65
Opepe	686	14.40	0.50	0.48	0.05	0.44	0.55
Teak	569	19.40	0.62	0.65	0.02	0.63	0.68

Table 4 Charring rate of samples at 15% MC with (0-30) minutes of fire exposure

Species	Mean Density (kg/m^3)	Mean Char Depth (mm)	Predicted Charring Rate (mm/min)	Mean Actual Charring Rate (mm/min)	Standard Deviation	Minimum (mm/min)	Maximum (mm/min)
Afara	469	24.80	0.64	0.82	0.02	0.79	0.85
Iroko	614	19.50	0.62	0.65	0.02	0.62	0.68
Mahogany	521	21.30	0.62	0.71	0.03	0.68	0.74
Mansonia	591	18.90	0.60	0.63	0.02	0.60	0.66
Opepe	752	14.10	0.50	0.47	0.03	0.45	0.51
Teak	657	19.40	0.50	0.65	0.02	0.62	0.68

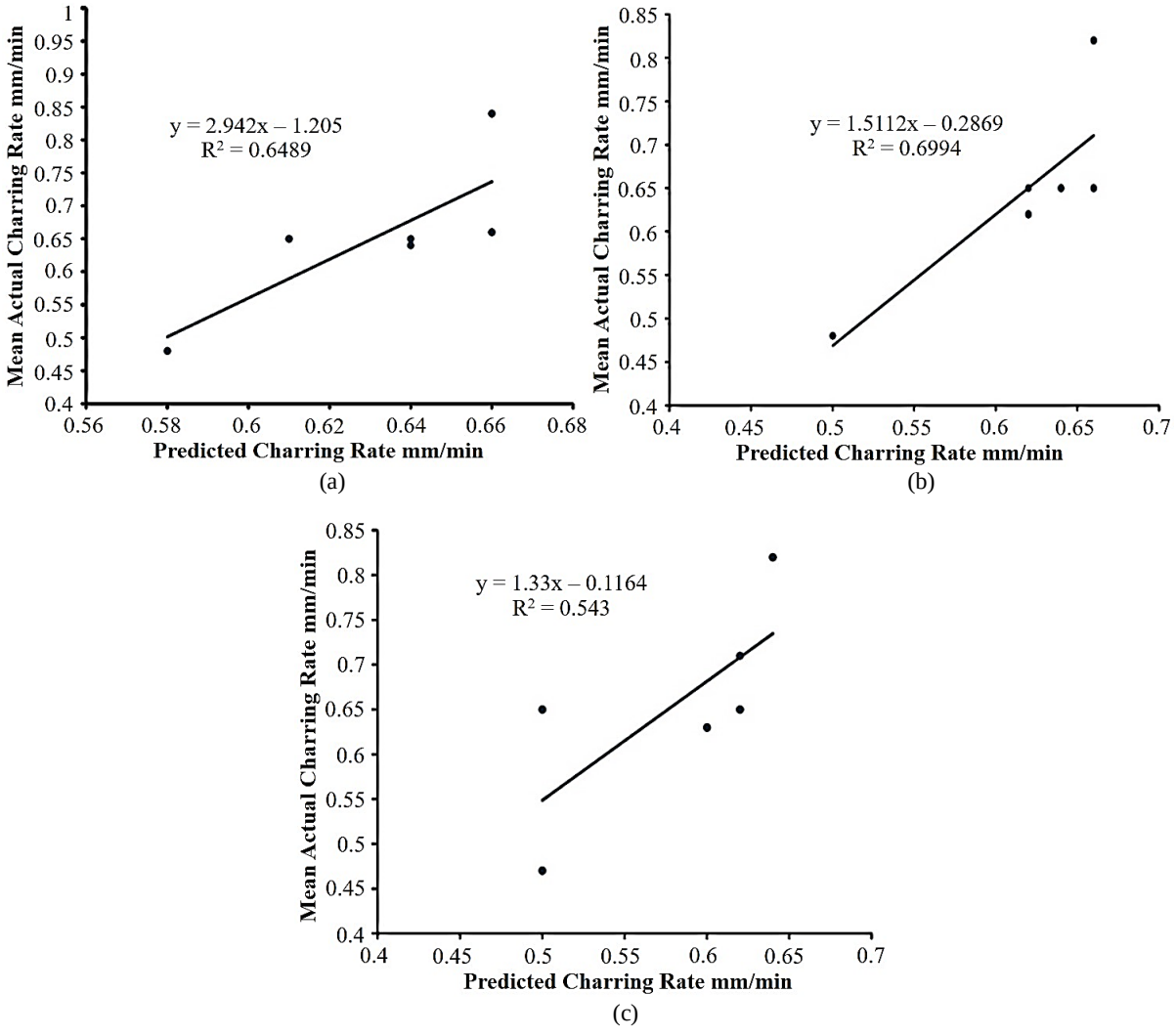

Figure 3 Linear regression for samples exposed to 20 °C to 230 °C at (a) 9% MC, (b) 12% MC, (c) 15% MC for (0-30 minutes).

sample as a function of moisture content, time of exposure and temperature range. The results are plotted in Figures 3 to 5. The coefficient of correlation is given as shown in equation (6):

$$r = \sqrt{R^2} \quad (6)$$

where: *'r'* is the correlation coefficient.
'R^2' is the coefficient of determination

Figures 3 (a) to (c) showed wood samples of 9, 12, and 15% moisture contents, exposed to fire tests at temperatures ranging from 20 °C to 230 °C and exposure times of (0 -30) min. At all MCs, the coefficients of determination, given in Figure 3(a-c), show that there is a positive correlation between predictions and actual charring rates.

A second test used wood samples at 9, 12, and 15% moisture contents exposed to fire tests at fire temperature ranging between 230 °C to 600 °C, with a fire exposure time of 30 minutes. Their mean charring rate results are illustrated in Tables 5 to 7.

Figures 4 (a-c), showed that there is a negligible correlation of the actual charring rate and predicted charring rate with r = 0.0387, r = 0.1746, and r = 0.0100, respectively.

The mean charring rate results for wood samples exposed to fire test at temperature of 20 °C to 300 °C with a fire exposure time of 60 minutes are illustrated in Tables 8 to 10.

Figures 5 (a) to (c), show results for wood samples of moisture contents 9, 12, and 15%, exposed to fire at temperatures from 20 °C to 300 °C and an exposure time of 60 minutes. There exists a strong positive correlation of actual charring rate to the predicted charring rate at, r = 0.682, r = 0.582, and r = 0.578, respectively.

Table 5 Charring rate of samples at 9% MC with 30 minutes of fire exposure

Species	Mean Density (kg/m^3)	Mean Char Depth (mm)	Predicted Charring Rate (mm/min)	Mean Actual Charring Rate (mm/min)	Standard Deviation	Minimum (mm/min)	Maximum (mm/min)
Afara	444	28.20	0.66	0.94	0.02	0.91	0.96
Iroko	532	21.30	0.64	0.71	0.03	0.67	0.74
Mahogany	439	24.60	0.66	0.82	0.03	0.80	0.86
Mansonia	566	26.70	0.61	0.89	0.05	0.83	0.94
Opepe	630	24.30	0.58	0.81	0.02	0.78	0.84
Teak	505	21.30	0.64	0.71	0.03	0.67	0.74

Table 6 Charring rate of samples at 12% MC with 30 minutes of fire exposure

Species	Mean Density (kg/m^3)	Mean Char Depth (mm)	Predicted Charring Rate (mm/min)	Mean Actual Charring Rate (mm/min)	Standard Deviation	Minimum (mm/min)	Maximum (mm/min)
Afara	444	27.90	0.66	0.93	0.02	0.91	0.95
Iroko	544	20.70	0.64	0.69	0.02	0.66	0.72
Mahogany	451	24.60	0.66	0.82	0.01	0.80	0.84
Mansonia	580	25.50	0.62	0.85	0.01	0.84	0.86
Opepe	686	23.70	0.50	0.79	0.03	0.77	0.84
Teak	569	20.70	0.62	0.69	0.02	0.66	0.72

Table 7 Charring rate of samples at 15% MC with 30 minutes of fire exposure

Species	Mean Density (Kg/m^3)	Mean Char Depth (mm)	Predicted Charring Rate (mm/min)	Mean Actual Charring Rate (mm/min)	Standard Deviation	Minimum (mm/min)	Maximum (mm/min)
Afara	469	26.40	0.64	0.88	0.05	0.80	0.94
Iroko	614	20.10	0.62	0.67	0.03	0.63	0.71
Mahogany	521	23.70	0.62	0.79	0.03	0.76	0.83
Mansonia	591	24.60	0.60	0.82	0.03	0.80	0.86
Opepe	752	23.40	0.50	0.78	0.03	0.75	0.82
Teak	657	20.70	0.62	0.69	0.02	0.67	0.71

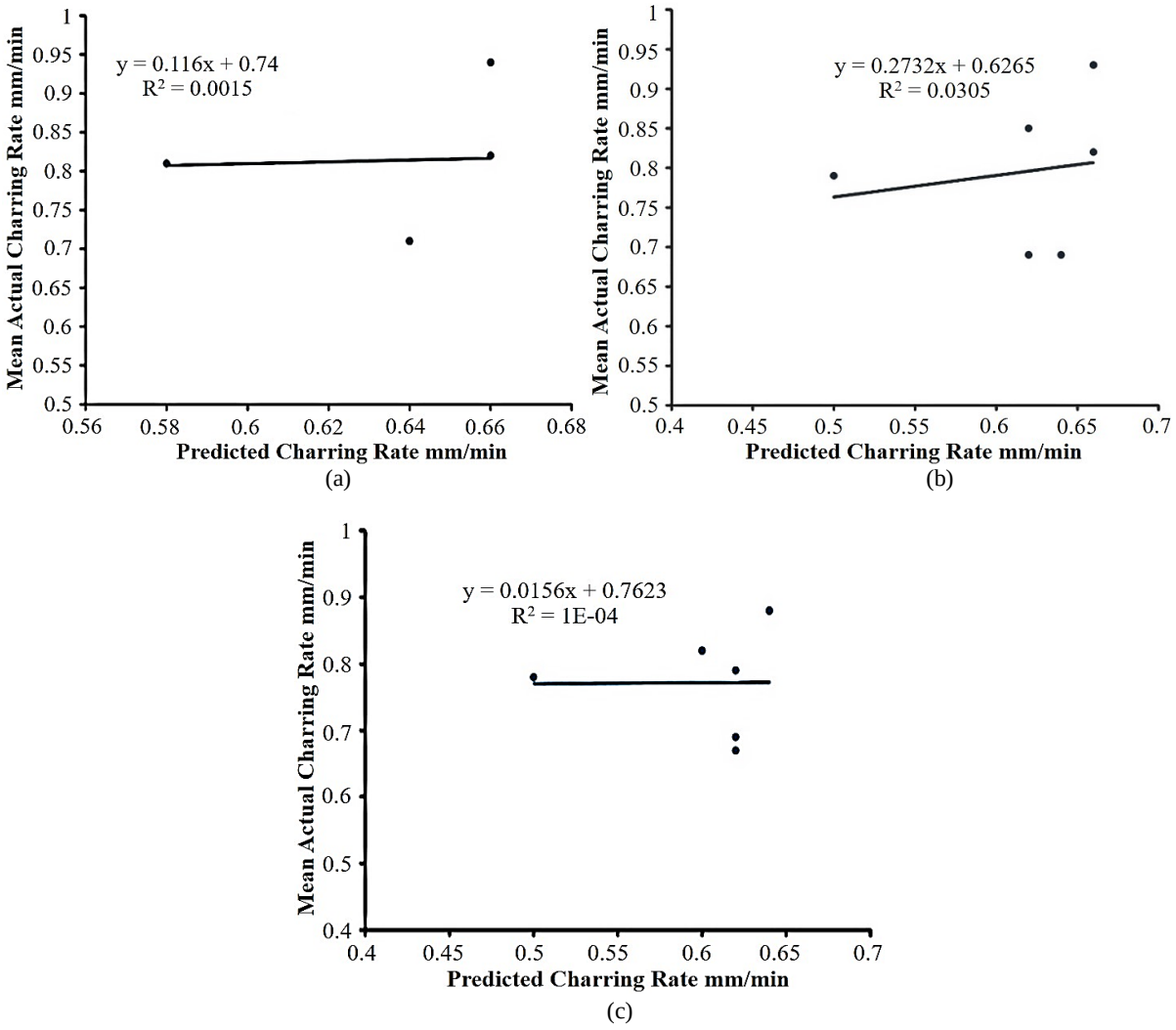

Figure 4 Linear regression for samples exposed to (230 °C to 600 °C) at various moisture contents, (a) 9% MC, (b) 12% MC and (c) 15%, for 30 minutes

Table 8 Charring rate of samples at 9% MC for 60 minutes of fire exposure

Species	Mean Density (Kg/m^3)	Mean Char Depth (mm)	Predicted Charring Rate (mm/min)	Mean Actual Charring Rate (mm/min)	Standard Deviation	Minimum (mm/min)	Maximum (mm/min)
Afara	444	44.50	0.66	0.74	0.02	0.71	0.77
Iroko	532	33.40	0.64	0.56	0.01	0.55	0.58
Mahogany	439	35.70	0.66	0.59	0.02	0.57	0.62
Mansonia	566	33.20	0.61	0.55	0.02	0.53	0.59
Opepe	630	28.30	0.58	0.47	0.03	0.44	0.50
Teak	505	29.40	0.64	0.49	0.03	0.46	0.54

Table 9 Charring rate of samples at 12% MC for 60 minutes of fire exposure

Species	Mean Density (Kg/m^3)	Mean Char Depth (mm)	Predicted Charring Rate (mm/min)	Mean Actual Charring Rate (mm/min)	Standard Deviation	Minimum (mm/min)	Maximum (mm/min)
Afara	444	44.50	0.66	0.74	0.02	0.71	0.76
Iroko	544	32.30	0.64	0.54	0.02	0.51	0.56
Mahogany	451	33.70	0.66	0.56	0.01	0.55	0.58
Mansonia	580	32.80	0.62	0.55	0.02	0.53	0.58
Opepe	686	28.60	0.50	0.48	0.05	0.44	0.55
Teak	569	29.20	0.62	0.49	0.02	0.47	0.52

Table 10 Charring rate of samples at 15% MC for 60 minutes of fire exposure

Species	Mean Density (Kg/m^3)	Mean Char Depth (mm)	Predicted Charring Rate (mm/min)	Mean Actual Charring Rate (mm/min)	Standard Deviation	Minimum (mm/min)	Maximum (mm/min)
Afara	469	40.80	0.64	0.68	0.02	0.65	0.71
Iroko	614	30.20	0.62	0.50	0.02	0.48	0.52
Mahogany	521	33.90	0.62	0.56	0.03	0.54	0.60
Mansonia	591	33.70	0.60	0.56	0.02	0.53	0.59
Opepe	752	28.40	0.50	0.47	0.03	0.45	0.51
Teak	657	29.20	0.62	0.49	0.02	0.46	0.52

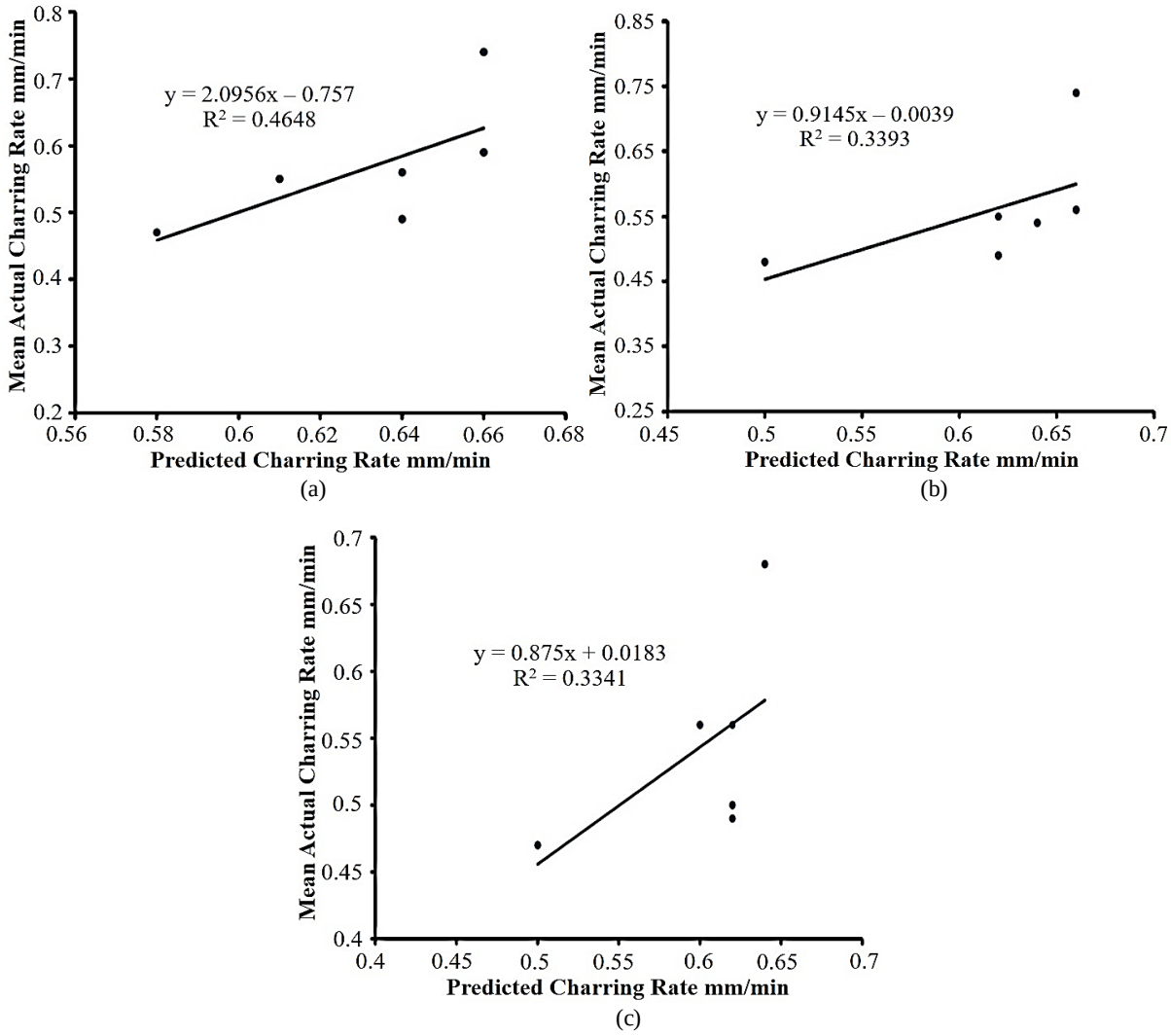

Figure 5 Linear regression for samples exposed to temperatures of 20 °C to 300 °C at various moisture contents, (a) 9% MC, (b) 12% MC, (c) 15% MC, for 60 minutes of fire exposure

4. Conclusions

Comparisons of the predicted and experimental charring rate behaviours of wood species used for structural purposes have been made through fire exposure experiments and existing theoretical models. The fire performance and charring rate of wood are most affected by the wood density, wood moisture content, wood species, and level of heat application. High density woods exhibit a lower charring rates. The rate of charring of wood is improved by increasing the residual char content. The fire resistive nature of wood is a combination of the insulating response of the charred wood with the slow rate at which flame will spread along the wood surface. Under conditions of severe fires, but not absolute worst-case conditions, denser wood members will char at similar rates to those found in electric-fired furnace tests, roughly 0.5 to 0.8 mm/min. This research showed that the charring rate of structural wood species can be predicted as there exist a strong positive correlation of actual charring rate to the predicted rate of the wood samples.

The charring rates of timber presented in this study were limited to only six species, those used for structural purposes in Southwestern Nigeria. Opepe had the lowest charring rate due to its higher density compared to Afara, with its low density and most rapid charring rate. There is the need to

consider the charring rates of other timber species at various dimensions to check their variation and similarities.

5. References

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