PREDICTION OF TEMPERATURE OF STANDARD FIRE EXPOSURE

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Abstract. This article describes equations derived to predict the duration of local pyrolytic charring under standard fire conditions. The equations consist of five variables: electrical capacity, electrical conductivity, calorific value, depth and rate of char. The equations are split up into two groups: one for the formation of non-impregnated carbonaceous residue, and one for impregnated carbonaceous residue during pyrolysis. This means that before predicting the local duration of charring, it is necessary to determine whether the wood has been impregnated with a fire retardant solution before the fire. Electrical conductivity and electrical capacity measurement methods were used for this purpose. The temperature of standard fire local exposure is calculated by predicting the duration of local pyrolytic charring according to the standard temperature and the time dependence of fire.

Keywords: wood, fire retardants, charring, prediction.

Introduction

Wood is a material used in many areas: technique, technologies and especially in construction engineering and its products. Wood has quite a number of advantages when compared to other materials; it is strong, able to withstand heavy loads, and is a lightweight material of low thermal-conductivity, which is easily processed. However, it also has some disadvantages: it absorbs large amounts of water, deforms when exposed to moisture, and rots. The main disadvantage of wood is its relatively fast ignition and combustion. The flammability of wood can be reduced by impregnating it with fire retardants.

Many works have been devoted to research on the efficiency and durability of fire retardants (Liodakis *et al.* 2002; Agueda *et al.* 2008; Pereyra, Giudice 2009; Hagen *et al.* 2009; Mačiulaitis *et al.* 2013a). The indicators of flammability in wood impregnated with a fire retardant depend on the chemical composition of the fire retardant used (Hassan *et al.* 2008; Liodakis *et al.* 2013; Czégény *et al.* 2013; Arao *et al.* 2014; Pabelina *et al.* 2012), its yield, impregnation method, and the structure and characteristics of the wood (Liodakis *et al.* 2002; Agueda *et al.* 2008; Pereyra, Giudice 2009; Mačiulaitis *et al.* 2013b).

Fire is a complex phenomenon, and its course and effects depend on many interrelated factors (Drysdale 1998). In the event of fire in wooden buildings, or buildings with wooden structures, the most notable feature of combustion is the charring of the wooden structures. This feature is important when determining the cause of a fire, and therefore it is necessary to associate the charring of wood products and structures with other important features of fire, such as its duration or temperature (Lipinskas, Mačiulaitis 2005; Lipinskas *et al.* 2006). Wood is a complex material as various factors affect its pyrolysis and combustion, including flame retardants that change the wood ignition temperature and charring rate. Therefore, during a fire investigation, it is important to determine whether the wood has been impregnated with a flame retardant before the fire (Lipinskas 2006).

To determine the point of origin and causes of a fire, objective and subjective methods can be used (Lipinskas 2006). The general principles for determining the point of origin of a fire are provided in Fedotov and Megorski's work (1978), and other methodological recommendations for the officers investigating fire causes (Smirnov *et al.* 1986; LTEI Methodical Recommendations 1994). These sources explain how to determine where the fire started (the point of origin of the fire) based on a visual inspection of the site, data gathered from witnesses', or technical and construction documentation of the object. These investigation methods may be defined as subjective methods used for determining the most important signs of the point of origin of a fire. In the case of severe damage to identical wooden structures, the signs of burning direction can also be seen, as the depth of charring on wooden

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structures increases when approaching the fire's point of origin, because its combustion time is longer. Considering the charring rate of wood, from 0.4 to 1.2 mm/min (Babrauskas 2004, 2005), the duration of combustion can be estimated, and this feature can be used to determine the fire's point of origin (Lipinskas 2006).

In the event of large and complex fires, data collected by using subjective, i.e. visual methods, are not enough. Additional studies using laboratory methods are needed. Such methods are called objective methods. These methods enable the use of measuring devices, which allow more accurate results to be obtained (Lipinskas 2006).

One of these methods is used in Lithuania, i.e. a method for measuring the electrical resistance of charcoal. This method was created in the Soviet Union and developed in Lithuania. The methodology is validated by the Fire Research Centre and is called 'GTC/GT 5 Fire Research Methodology – Determination of the Point of Origin of Fire in Buildings of Wooden Structures' (GTC/GT 5 2006). With the increasing processes of charring during the fire the resistance of charcoal decreases from 10 GΩ to 1 Ω (Lipinskas 2006).

In order to calculate the temperature and time according to GTC/GT 5 (2006), the following steps have to be carried out:

1. The reference temperature (T, K) has to be calculated at the place of sampling according to the following equation:

$$T = \frac{4540}{ln\dfrac{B \cdot H \cdot P}{10 - P} + 2.15}, \tag{1}$$

where: B is a coefficient evaluating the thickness of the structure; H – the wood char depth, mm; P – the decimal logarithm of the resistivity of the coal sample.

2. The coefficient (B) evaluating the thickness of the structure is calculated as follows:

$$B = \frac{\sqrt{h}}{6}, \tag{2}$$

where h is the initial thickness of the construction element considering the effect of heat flux, mm.

3. The wood char depth (H, mm) is calculated as follows:

$$H = h_a + h_n, \tag{3}$$

where: h_a is the carbon depth, mm; h_n – the thickness of the burnt structure, mm.

4. After calculation of the temperature (T, K) of the charred wood at the site of sampling (obtained value of temperature T, K is transformed to temperature T_s, °C), the external heat flux density (q_I, kW/m²) is determined as follows:

$$q_I = \left(\frac{T_s}{99.6}\right)^{2.07}, \tag{4}$$

where T_s is transformed temperature of wood charring at the site of sampling, °C.

5. The charring rate (β, mm/min) of a wooden structure is calculated at each location of sampling according to the following equation:

$$\beta = 60 \cdot \frac{1.234 q_I^{\,0.5}}{\rho\left(L_\upsilon + L_w \cdot w\right)} \cdot k_d, \tag{5}$$

where: q_I is the external heat flux density per surface of the material from an ignition source, kW/m²; ρ – wood density, kg/m³; L_υ – the amount of heat needed to evaporate the products of pyrolysis of completely dry wood, kJ/g; L_w – the heat of water evaporation equal to 2.258 kJ/g; w – the moisture content of wood in hundredths; k_d – the coefficient evaluating the oxygen concentration (= 1.2).

6. The indicative duration of wood charring (τ_a, min) is calculated according to the following equation:

$$\tau_a = \frac{H}{\beta}, \tag{6}$$

where H is the wood char depth, mm; β – charring rate, mm/min.

7. Fire duration (τ_b, min) at the site of charred wood sampling is calculated using the following equations:

$$\tau_b = \tau_a + \tau_0; \tag{7}$$

$$\tau_0 = 77 - 0.086T; \tag{8}$$

$$\tau_0 = 94 - 0.101T, \tag{9}$$

where: τ_a is wood char duration, min; τ_o – induction time, min; if wood is without protective materials, Eqn (8) is used; if wood is coated with protective materials, Eqn (9) is used.

$k_d = 1.2$ value of the coefficient evaluating the oxygen concentration selected according to prediction equation 5 of the charring rate of wood is questionable in GTC/GT 5 methodology (2006). The coefficient is selected using the SBI (LST EN 13823:2010) test method. When testing with SBI, the sample is affected thermally by the 30.7 ± 2.0 kW constant-power burner that is located at the bottom of the corner. Constant temperature is generated when wood samples are exposed to a constant-power burner, and there is also a free flow of air, which does not meet the normative standard fire conditions.

Parameter w of the moisture content of wood is used in Eqn (5) of the GTC/GT 5 methodology (2006) to calculate β, and it is not possible to determine it accurately and locally in the fire and pyrolysis zone, where the fire is extinguished using water or foam.

This method does not evaluate experimentally whether the wood has been impregnated against fire with flame retardant solutions or not.

The method for measuring electrical conductivity is used to determine the salinity of water (Moore *et al.* 2008). Electrical conductivity is determined by the

concentration of sodium, potassium, calcium, magnesium, chlorine and other ions (Juozaitienė *et al.* 2010; Barth, Worstorff 2000; Hamann, Gyodi 2000; Hamann, Gyodi 1999). It has been assumed that in order to establish impregnation with flame retardant solutions, methods of electrical capacity or electrical conductivity can be used, because flame retardants used in Lithuania are salt-based. Data from previous studies has shown that flame retardants affect the values of the electrical conductivity and the electrical capacity, and so these methods can be used to determine the impregnation of wood (Mačiulaitis *et al.* 2015).

The aim of the work is to derive prediction equations for local pyrolytic char duration and, according to them, to predict the standard fire local temperature.

1. Materials tested and testing methods

1.1. Materials used

Samples of impregnated and not impregnated pine, fir wood and its carbonaceous residues pyrolysed at different times were also used. The outer layer of charred wood (carbonaceous residue) selected from sites of fire was also used for testing.

1.2. The special one-side heating equipment

To identify the charring peculiarities of wood from different species when heating for different periods of time and reaching different temperatures, a special chamber for one-side heating of structures was employed (Lipinskas *et al.* 2006; Lipinskas, Mačiulaitis 2005). This equipment ensures the simulated one-side heating of the tested specimen up to 1200 °C, which is prevailing in most fires. The equipment used consisted of a one-side heating device, a heat controller, as well as instrumentation and equipment for recording measurements (Fig. 1). The principle of the experiment was to heat the specimen on one side based on the dependency of temperature on time specified in, and regulated, by LST EN 1363-1:2000. The test used up the standard temperature-time curve mathematical expression is as follows (LST ISO 834:1997):

$$T = 345 ln(8t + 1) + 20 , \qquad (10)$$

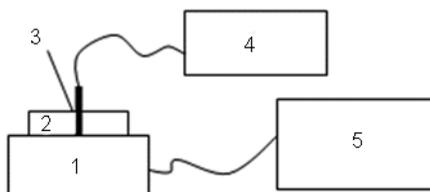where: t is duration of the tests, min; T – temperature, °C.

Fig. 1. The principal scheme of the one-side heating equipment that has been used for one side heating tests: 1 – the one-side heating apparatus; 2 – fragment of the tested structure; 3 – the temperature measuring equipment; 4 – the Eurotherm 401 recorder; 5 – the TR-5 controller for regulation of temperature in the heating chamber

The height and width of wood specimens was 210 mm and 150 mm, respectively, and the thickness varied from 47 mm to 59 mm. Both natural fir and pine wood was used, as well as fir and pine wood treated with fire retardant solutions.

1.3. Determination of charring rate and depth

The wood char depth was measured using a calliper at the sites of fire, as shown in Figure 2, by sticking a calliper in the middle of the carbon sample until a measuring instrument reached the unburnt part of the wood. If the sample was burnt, the thickness of the burnt layer will be measured. The sum of the depth of carbon and burnt layer of the sample is called the char depth (*H*, mm).

The charring rate (β_s, mm/min) was selected based on previous results (Mačiulaitis *et al.* 2012) according to the char depth.
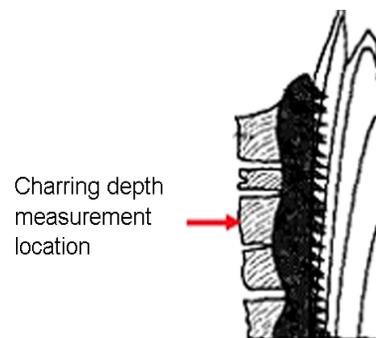

Fig. 2. Measurement of charring depth

1.4. Determination of electrical capacity of carbon

Equipment used for tests consisted of a device for measuring electrical capacity – RLC meter E7-13 connected by copper cables with stainless steel electrodes with a thickness of 1 mm, width – 12 mm, height – 30 mm, the distance between the electrodes – 24 mm and the device operating frequency – 1000 Hz.

The capacitance (*C*, nF/cm) of the medium (mixture) consisting of distilled water and dispersed (crushed) coal particles (having a diameter of no more than 250 μm) filled into a glass container with a diameter of 36 mm, and a depth of 58 mm was measured. The composition of the medium was 50 g of distilled water and 0.1 g of the dispersed testing material (Mačiulaitis *et al.* 2015).

1.5. Determination of electrical conductivity of carbon

The medium for the measurement of electrical conductivity (*J*, mS/cm) was prepared by analogy. The electrical conductivity of samples was measured using a multi-meter Hanna HI4521 (Mačiulaitis *et al.* 2015).

1.6. Determination of electrical resistance of carbon

The electrical resistance (*R*, Ω) of each carbon sample was measured by using special equipment.

In order to measure the electric resistance of the selected carbon sample, it is necessary to comply with the

order of priority. In particular, the surface of the samples must be clean. The mass of one sample must not be less than 1 g.

A sample was placed in a separate open container. The container together with the sample was conditioned in the laboratory chamber furnace. The furnace temperature should not exceed 105 °C. The samples must be conditioned to constant weight. Then, each sample was crushed with a pestle in the porcelain mortar. The diameter of crushed particles was less than 500 mm.

A resistance measurement device (ohmmeter), which measures the electrical resistance R, Ω of carbon samples, was used. The press was connected to the resistance measuring device by terminals.

Then the electrical resistance of each carbon sample was measured. The sequence of this procedure was as follows: a crushed carbon specimen (300–600 mg) was placed in a mould (Fig. 3) so that the original height of the mould without carbon would be increased to 4 mm; the mould was inserted into the press and compressed mechanically (by rotating the handle) to 3500 to 5000 kg/cm^2. Readings of the resistance-measuring device were recorded. Then, the mould was removed from the press and carbon was cleaned therefrom.
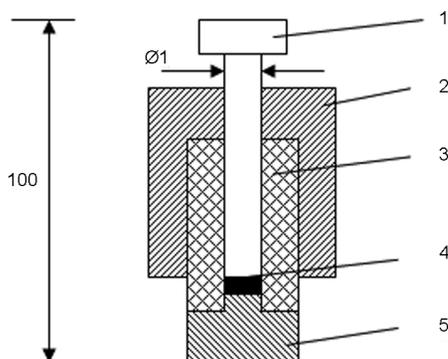

Fig. 3. Mould for char placing: 1 – plunger (HRC 55-60); 2 – guide bar; 3 – ebonite insert; 4 – char; 5 – base (HRC 55-60)

1.7. Determination of calorific value of carbon

The resulting carbon was examined using the test method described in the standard EN ISO 1716:2010 *Reaction to fire tests for products – determination of the gross heat of combustion (calorific value)*. The total combustion heat, which in the text below is referred to as the calorific value (*PCS*, MJ/kg), was determined during the tests. Special equipment was used for this purpose (Fig. 4).

1.8. Statistical data processing

A mathematical model with a breakpoint was used to determine the relationship between the duration of local wood charring under a modelled standard fire curve with an electrical capacity, electrical conductivity, calorific value, charring depth, and rate. The software STATISTICA 7 was used for statistical processing of experimental data (Sakalauskas 1998).
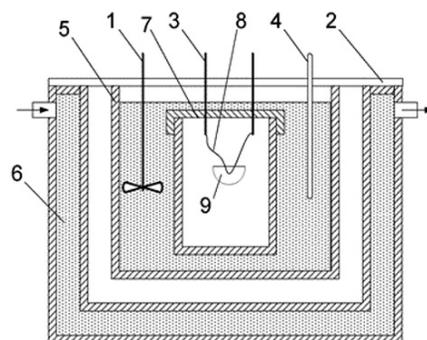

Fig. 4. Calorimeter parts: 1 – mixer for uniform mixing of water; 2 – jacket cover; 3 – fuse cables; 4 – water thermometer; 5 – calorimeter vessel; 6 – water in the jacket; 7 – calorimetric bomb; 8 – fuse wire; 9 – crucible containing the sample

2. Research results and discussion

Preliminary data showing the trends of the wood impregnation with flame retardants is listed in Table 1.

The pair correlation matrices from a group of carbonaceous residues from non-impregnated wood and from impregnated wood were compared according to the characteristics values of the duration of charring. The results showed (Tables 2 and 3) that the relationship between the electric capacity and electric conductivity is of opposite signs.

In the first case, this relationship was less close and directly proportional (Table 2), whereas in the second case it was closer and inversely proportional to the duration of charring (Table 3).

Meanwhile, the trends of the other three defined characteristics and values of the test time (duration of the standard fire local pyrolytic charring) and pair correlation coefficients were the same (directly proportional), although the absolute values of those pair correlation coefficients and other characteristics were different (Tables 2, 3).

This means that, before predicting the local duration of charring, it is necessary to determine whether the wood was impregnated or not with a fire retardant solution before the fire. This also means that in order to derive equations for predicting local wood charring under the said algorithm, data from both groups should be processed mathematically separately.

Equations (11)–(14) were derived for predicting the duration of local charring under a standard fire curve after processing the initial results of the two groups separately. Prediction equations of duration for formation of the non-impregnated carbonaceous residue (Eqns (11), (12)) and impregnated carbonaceous residue (Eqns (13), (14)) during the pyrolysis were identified.

Predicting the duration by Eqns (12) and (14) using the short, but less accurate method (Eqn (12): $R = 0.9939$; Eqn (14): $R = 0.9701$), is enough to determine the electrical conductivity and the charring depth. However, in order to predict accurately the duration of charring,

Table 1. Characteristic data of research carried out

t, min	C, nF/cm	J, mS/cm	PCS, MJ/kg	H, mm	β_s, mm/min
5*	0.038	0.008	20.53	1	0.20
5*	0.039	0.008	20.53	2	0.40
5*	0.004	0.011	20.53	1	0.20
5*	0.030	0.011	26.53	2	0.40
5*	0.040	0.012	26.53	1	0.20
5**	50.000	0.900	26.13	1	0.20
5**	42.000	1.600	26.13	1	0.20
5**	40.000	1.200	26.53	2	0.40
5**	44.000	1.200	26.53	1	0.20
5**	42.000	1.200	26.53	2	0.40
10*	0.040	0.011	30.98	5	0.50
10*	0.043	0.013	28.72	4	0.40
10*	0.052	0.015	29.77	5	0.50
10*	0.011	0.040	31.07	4	0.40
10*	0.025	0.050	30.82	6	0.60
10**	18.000	0.600	29.59	2	0.20
10**	22.000	0.600	29.25	1	0.10
10**	26.000	0.900	29.73	2	0.20
10**	18.000	0.800	30.82	6	0.60
10**	24.000	0.800	30.90	5	0.50
20*	0.029	0.030	33.50	13	0.65
20*	0.034	0.033	33.54	12	0.60
20*	0.036	0.036	33.52	15	0.75
20*	0.055	0.013	34.07	13	0.65
20*	0.068	0.014	34.09	15	0.75
20**	12.000	0.400	33.78	8	0.40
20**	14.000	0.500	33.49	6	0.30
20**	11.000	0.500	34.50	13	0.65
20**	12.000	0.600	34.52	15	0.75
20**	13.000	0.700	34.37	14	0.70
30*	0.070	0.020	33.78	20	0.67
30*	0.055	0.040	33.50	23	0.77
30*	0.067	0.030	33.44	22	0.73
30*	0.069	0.030	34.49	25	0.83
30*	0.073	0.030	33.75	22	0.73
30**	4.000	0.300	33.46	14	0.47
30**	4.300	0.500	33.84	12	0.40
30**	4.000	0.200	33.96	23	0.77
30**	4.500	0.300	33.95	23	0.77
30**	4.000	0.400	29.42	19	0.63
45*	0.700	0.060	33.62	37	0.82
45*	0.042	0.030	33.42	34	0.76
45*	0.200	0.035	33.62	33	0.73
45*	0.020	0.090	33.86	35	0.80
45*	0.040	0.032	33.85	31	0.73
45**	1.000	0.100	34.01	18	0.40
45**	1.300	0.400	34.00	22	0.49
45**	1.800	0.200	33.63	35	0.78
45**	1.400	0.100	32.69	37	0.82
45**	2.000	0.200	32.11	34	0.76

* – natural wood; ** – wood treated with fire.

Table 2. Pair correlation matrix of carbonic residual specimen group of natural wood characteristics

	t	C	J	PCS	H	β_s
t	1.00	0.51	0.61	0.71	0.99	0.82
C	0.51	1.00	0.40	0.25	0.53	0.35
J	0.61	0.40	1.00	0.50	0.62	0.54
PCS	0.71	0.25	0.50	1.00	0.71	0.88
H	0.99	0.53	0.62	0.71	1.00	0.85
β_s	0.82	0.35	0.54	0.88	0.85	1.00

prediction Eqns (11) and (13) (Eqn (11): $R = 0.9984$; Eqn (13): $R = 0.9958$) must be used for the non-impregnated and impregnated wood carbonaceous residue, respectfully. However, in this case it was necessary to determine experimentally the values of five characteristics: electrical capacitance, electrical conductivity, calorific value, char depth and rate.

Table 3. Pair correlation matrix of carbonic residual specimen group of treated wood characteristics

	t	C	J	PCS	H	β_s
t	1.00	−0.65	−0.76	0.60	0.95	0.63
C	−0.65	1.00	0.86	−0.33	−0.64	−0.66
J	−0.76	0.86	1.00	−0.47	−0.73	−0.63
PCS	0.60	−0.33	−0.47	1.00	0.55	0.48
H	0.95	−0.64	−0.73	0.55	1.00	0.78
β_s	0.63	−0.66	−0.63	0.48	0.78	1.00

The following prediction equations for the local pyrolytic char duration under standard fire conditions (t, min) are provided for the non-impregnated wood:

$$t = (0.4014 - 9.0834C + 9.5814J + 0.2718PCS + 1.3006H - 10.8459\beta_s)(t \le 22.0) + (-12.4963 - 1.6268C - 7.0775J + 1.4117PCS + 1.4485H - 50.1023\beta_s)(t > 22.0); \quad (11)$$

$$t = (3.5657 + 22.2559J + 1.1254H)(t \le 22.0) + (4.3801 - 48.8981J + 1.2565H)(t > 22.0). \quad (12)$$

The following prediction equations for the local pyrolytic char duration under standard fire conditions (t, min) are provided for the impregnated wood:

$$t = (6.9628 - 0.0408C - 2.1147J + 0.1763PCS + 1.3405H - 14.0165\beta_s)(t \le 22.0) + (37.7544 - 0.5757C - 1.3221J + 0.0389PCS + 1.3894H - 51.7520\beta_s)(t > 22.0); \quad (13)$$

$$t = (7.8059 - 3.4445J + 0.9487H)(t \le 22.0) + (22.2286 - 12.9190J + 0.7255H)(t > 22.0), \quad (14)$$

where: C – electrical capacity, nF/cm; J – electrical conductivity, mS/cm; PCS – calorific value, MJ/kg; H – char depth, mm; β_s – charring rate, mm/min.

Equations (11)–(14) consisted of two parts. The first part of the equation was applied when the depth of charring of coniferous wood was ≤16 mm. The second part of the equation was applied when the depth of charring of coniferous wood was >16 mm.

So far, the conclusion of whether the charred wood has been impregnated or not impregnated before fire has been based on documents or evidence from responsible persons. However, this is not appropriate in view of the aging process of flame retardant solutions (Grigonis *et al.* 2012). Therefore, the method of measuring the electrical conductivity and electrical capacity, which we have created for this purpose, is very important in order to determine more accurately the location the fire started and its causes.

If timber has been impregnated with fire-retardants before a fire, the electrical conductivity will be ≥0.1 mS/cm. Conversely, if timber has not been impregnated before a fire, the electrical conductivity will be <0.1 mS/cm. The electrical conductivity of a medium made up of impregnated charcoal and distilled water varies insignificantly when heating the timber for 30 minutes or longer, and the lowest value was 0.1 mS/cm, regardless of the type, output and extinguishing method of the flame-retardant solution used in Lithuania (Mačiulaitis *et al.* 2015).

Additionally, the results of comparative researches are given. Based on Eqns (11) and (13), the duration of local pyrolytic charring has been calculated (t, min) and using equation 10 the local impact temperature of the standard fire (T, °C) has been determined. To compare the results, the durations and temperatures according to the GTC/GT 5 methodology (2006) (described in Section 1) have been calculated as well.

Values of data needed for calculations are given in Table 4. According to our methodology, the second part of Eqn (11) was used for the calculation of the duration of local pyrolytic charring for the first object (No. 1.1,

No. 1.2 and No. 1.3) and for the third object (No. 3.1, No. 3.2 and No. 3.3) because electrical conductivity was <0.1 mS/cm, charring depth >16 mm. For the second object (No. 2.1, No. 2.2 and No. 2.3) the first part of equation 13 was used because electric conductivity >0.1 mS/cm, charring depth <16 mm. Calculation results are presented in Table 5.

Table 5 shows the predicted values of the standard local fire temperature and reference temperature at the sampling location.

Table 4. Definite values of characteristics necessary for forecasting

No.	C, nF/cm	J, mS/cm	PCS, MJ/kg	H, mm	β_s, mm/min	R, Ω
1.1	0.28	0.049	31.75	53	0.75	4400000
1.2	0.60	0.056	32.74	60	0.75	16700000
1.3	0.42	0.045	32.24	69	0.75	143
2.1	1.18	0.24	31.13	5	0.57	55000000
2.2	1.20	0.34	32.59	10	0.65	24
2.3	1.10	0.23	31.83	10	0.65	1131
3.1	0.15	0.027	32.31	27	0.73	69
3.2	0.28	0.045	32.86	31	0.75	51
3.3	0.12	0.018	31.33	20	0.70	1032

As we can see from the data presented in Table 5, the values of the standard fire local temperature predicted by our equations, and of the reference temperature at the sampling location predicted by the GTC/GT 5 methodology (2006), significantly differ when the charring depth is greater than 50 mm (Object No. 1). However, the values are similar when the charring depth ranges from 20 to 30 mm (Object No. 3). The greater difference between temperatures has been obtained in Object No. 2, where the depth of charring is between 5 and 10 mm. However, unlike in Objects No. 1 and No. 3, wood (pine) in Object No. 2 was impregnated with flame retardants, and this was confirmed by electrical conductivity measurements.

Table 5. Forecasted values of time and temperature

No.	Calculated according to our equations		Calculated according to GTC/GT 5 (2006)	
	The duration of local pyrolytic charring predicted by Eqns (11) and (13), respectively, min	Temperature of local standard fire exposure predicted by Eqn (10), °C	The duration of fire at the charred wood sampling location, by basic Eqn (7), min	The reference temperature at the sampling location, by basic Eqn (1),°C
1.1	69	965	424	309
1.2	78	983	551	282
1.3	89	1004	280	476
2.1	11	687	19	535
2.2	16	750	12	928
2.3	16	751	14	790
3.1	35	866	74	887
3.2	40	886	91	863
3.3	25	816	61	858

Conclusions

Broad and long lasting studies have shown that forecasting fire causes and locations in wooden buildings and structures is difficult and complex. It is necessary to impregnate the timber with fire retardants and experimentally confirm that fact in modern constructions.

A new and more accurate method for identifying the origin of a fire is by the prognostication of the duration of standard fire local pyrolytic charring and the impact temperature of the fire (by heating the timber from one side). For that reason, the relevant empirical equations were derived which were chosen based on the values of characteristic indicators of carbonaceous residues and the predicted duration of the local pyrolytic charring. In the next stage, the local impact temperature of the standard fire is predicted according to the duration values of local pyrolytic charring.

The complex use of the old method (GTC / GT 5 2006) and the new one created by us makes it possible to create a more accurate picture of fire development dynamics.

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