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Temperature influence on tyre/road noise on poroelastic road surface based on laboratory measurements

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Summary

The temperature effect on measured tyre/road noise is very important phenomena as it may lead to significant errors in measurement results due to substantial influence of this parameter on the obtained values. It depends mainly on the particular tyre-road combination. It is different for dense and porous as well as for bituminous and cement concrete pavements. It differs also depending on tested tyre. The correction procedure for normalizing measured noise levels to a reference air temperature of 20 °C is given in the recently published ISO Technical Specification ISO/TS 13471-1:2017 – Correction for temperature when testing with the CPX method.

The temperature correction coefficients defined in the Technical Specification differ to some extent depending on the main type and condition (porosity) of a road surface. They are equal for both standard reference tyres and they slightly depend linearly on speed.

An extensive study dealing with temperature influence on tyre/road noise on poroelastic road surface was conducted in the laboratory of Gdansk University of Technology in Poland. The aim of this study was to define the temperature correction coefficients for this special - extremely quiet road surface and for various tyres (including two standard reference tyres). Noise measurements using the CPX method were performed at roadwheel facilities equipped with poroelastic road surface for twelve passenger car and for two truck tyres within the air temperature range from 6 to 36 ºC. The results and findings of this experiment are presented and discussed in this paper.

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1. Introduction

The ambient air temperature influence on tyre/road noise was noticed already in the 1980's. Since that time it has been the focus of researches in many countries [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]. The ISO Working Group ISO/TC 43/SC 1/WG 27, established in 1992 with the task to develop temperature corrections to noise measurements, finally has proposed in the recently published ISO Technical Specification ISO/TS 13471-1:2017 [20] a correction procedure for normalizing obtained noise levels to a reference air temperature of 20 ºC. Each measured A-weighted CPX level shall be corrected using the following formula:

$$C_{T,\mathrm{t}} = -\gamma_{\mathrm{t}}\,(T - T_{\mathrm{ref}}) \qquad (1)$$

where:

- $C_{T,\mathrm{t}}$ - is the CPX level correction for temperature T for tyre t (in dB),
- γ_{t} - is the temperature coefficient for tyre t (in dB/ºC),
- T - is the air temperature during the measurement (in ºC),
- T_{ref} - is the reference air temperature (20 ºC).

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For the both standard reference tyres P1 and H1 specified in the ISO/TS 11819-3:2017 [21] the temperature coefficients γ_t are substantially equal [10] and they depend somewhat on speed (the relation is linear) [13, 16, 14]. The coefficients differ to some extent depending on the main type and condition (porosity) of a road surface [16, 3, 15, 10, 11]. The values of γ_t are given in the Technical Specification [20] by the following formulas (v is the test speed in km/h):

- for dense asphaltic surfaces (such as DAC, SMA, TAL with air voids typically below 18 % and surface dressings - chip seals):

$$\gamma_{P1} = \gamma_{H1} = -0.14 + 0.0006 \cdot v \qquad (2)$$

- for cement concrete surfaces (of all types):

$$\gamma_{P1} = \gamma_{H1} = -0.10 + 0.0004 \cdot v \qquad (3)$$

- for porous asphalt surfaces and high-porosity TAL (not seriously clogged):

$$\gamma_{P1} = \gamma_{H1} = -0.08 + 0.0004 \cdot v \qquad (4)$$

The temperature correction coefficients calculated using the formulas above for three reference test speeds of 50, 80 and 100 km/h are presented in Table 1 for easier comparison with obtained results.

Table 1. Values for the temperature coefficient calculated for the three reference test speeds

Road surface category	Temperature correction coefficient γ_t [dB/°C]			
	High precision case			Standard case
	50 km/h	80 km/h	100 km/h	Average
Dense asphaltic surfaces	-0,11	-0,09	-0,08	-0,10
Cement concrete surfaces	-0,08	-0,07	-0,06	-0,07
Porous asphalt surfaces	-0,06	-0,05	-0,04	-0,05

There is no doubt that the temperature correction should ideally be made based on frequency spectra. But actually collected data [4, 6, 7, 9, 10, 13, 17] are not sufficiently consistent and so far it is recommended to apply the same correction for all frequencies.

2. Poroelastic road surface

Poroelastic Road Surface (PERS) was developed within the EU project PERSUADE [23, 24]. It consists of a hard aggregate with max. size of 4 mm, a soft aggregate of rubber granules from recycled tyres (more than 40 % of the total solid volume) and a polyurethane binder. Air voids content is more than 25 % of the overall volume. The precise formula of the PERS mix used in this study is restricted.

3. Laboratory experiment

An extensive studies to determine the effect of temperature on tyre/road noise on the poroelastic road surface was conducted at Gdansk University of Technology in Poland. Measurements according to the CPX method [22] were performed in the laboratory on two roadwheel facilities equipped with PERS surface. The pre-casted PERS material manufactured and delivered by HET was placed on two drums having an outer diameter of 1.7 m (designed for passenger car tyres tests) and 2.0 m (for truck tyres).

Twelve passenger car tyres, including two sets of reference tyres (P1 and H1) of different tread rubber hardness, and two truck tyres were selected and tested in precisely controlled conditions. The data of tested tyres are presented in Table 2.

Table 2. Parameters of tyres selected for the experiment

Designation	Manufacturer	Tread	Size	Date code	Shore Hardness
1097 (P1-2)	UNIROYAL	TIGER PAW	P225/60R16 97S	0314	67
1087 (H1-2)	AVON	SUPERVAN AV4	195R14C 106/104N	0912	68
1077 (P1-1)	UNIROYAL	TIGER PAW	P225/60R16 97S	3612	72
1063 (H1-1)	AVON	SUPERVAN AV4	195R14C 106/104N	4911	73
1064	MICHELIN	Primacy HP	225/60R16 98V	0313	68
1066	WANLI	S-1200	195/60R15 88H	4812	71
1067	CONTINENTAL	ContiEcoContact 5	195/60R15 88H	1213	69
1071	VREDESTEIN	QUATRAC 3	195/60R15 88V	3712	69
1076	CONTINENTAL	Conti.eContact	195/50R18 90T	3512	65
1081	DUNLOP	Sport BlueResponse	195/65R15 91H	2413	71
1112	PIRELLI	CINTURATO P1	195/60R15 88H	0214	67
1120	BRIDGESTONE	ECOPIA EP 500	155/70R19 84Q	0614	62
1084	DUNLOP	SP242	385/65R22.5 160K	2108	70
1085	BRIDGESTONE	R168	385/65R22.5 160K	1109	70

The air temperature in the laboratory room was controlled using a climate control unit within a range from 6 to 36 ºC with a step of 10 ºC. The measured PERS road surface temperature was changing from 8 to 40 ºC. During the tests of truck tyres the PERS surface temperature was not acquired.

Tyre/road noise emission (SPL and third octave band frequency spectra) was measured using two microphones located near the test tyre in a position similar to that used in the CPX method according to ISO 11819-2:2017 [22]. Tests of passenger car tyres were performed at speeds of 50, 80 and 100 km/h. The tyres were loaded to 3200 N and inflated to 200 kPa in cold condition. Truck tyres were tested at 50 and 80 km/h. The load of the truck tyres was fixed at 30060 N and inflation pressure was adjusted to 600 kPa (cold).

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4. Relationship between laboratory and outdoor test conditions

Analyzing the temperature data acquired during numerous laboratory tests an almost perfect relationship between air and replica road surface temperatures was found [14]. But the slope of regression lines, of approximately 1.0, differs from the slope (of 1.4) obtained during the road measurements [12]. When performing tests on a roadwheel facility one should take into account that in a laboratory usually there is lack of sun radiation affecting road surface temperature in outdoor conditions. Also the cooling effect related to air flow around the test tyre and cooling effect by the tyre contact with the road surface differ from field test conditions. On the other hand, when performing road measurements one should consider surface albedo, sun and cloud conditions as well as rain history influencing the road surface temperature significantly [12]. It was found in the literature [15] that the temperature coefficient when using air is approximately 1.8 times the coefficient when using road surface temperatures. Based on the findings it was proposed by the authors in [14] to record both air and road temperatures and calculate a composite temperature correction coefficient for laboratory measurements to compare the derived values with correction coefficients obtained with the CPX method. This will compensate the values for the laboratory conditions like the lack of sun radiation in the laboratory room. It should be done according to the formula:

$$\gamma_c = (\gamma_a + \gamma_r \cdot 1.8) / 2 \tag{5}$$

where:

- γ_c - is the composite temperature correction coefficient (in dB/ºC),
- γ_a - is the temperature correction coefficient based on air temperature (in dB/ºC),
- γ_r - is the temperature correction coefficient based on road surface temperature (dB/ºC).

When only air temperature is acquired during laboratory measurements, then the composite temperature correction coefficient for laboratory measurements should be calculated according to the following simple formula:

$$\gamma_c = \gamma_a \cdot 1.4 \tag{6}$$

where:

- γ_c - is the composite temperature correction coefficient (in dB/ºC),
- γ_a - is the temperature correction coefficient based on air temperature (in dB/ºC).

5. Temperature effect on noise

The temperature correction factors presented in this paper were derived based on linear regression analysis. Correlations between temperature (air and surface) and overall A-weighted sound level for each tyre and speed combination was evaluated taking into account two criterions: first – the maximum tolerated standard error of the slope and the second – a minimum requirement for the correlation coefficient of determination R^2. The first criterion accepts all cases with little or no temperature effect on noise but well correlated. Fundamentally a correlation was considered as acceptable if the standard error was below or equal 0.5 dB/ºC. If this criterion was not met then a correlation was accepted if the coefficient of determination R^2 was above 0.9.

5.1. Passenger car tyres

The detailed measurement data recorded during the measurements for the ISO standard reference tyres P1-2 and H1-2 are shown in Figures 1 ÷ 4. The values obtained for the other set of reference tyres are very similar thus they are not presented here.

Summarized results of the experiment, the air and road surface temperature correction coefficients (γ_a and γ_r) together with the values of standard error and R^2, derived for passenger car tyres, separately for each tested tyre and for three test speeds, are presented in Table 3.

Analyzing the obtained results one can observe that the correlation between the air and road surface temperatures and recorded sound pressure levels was very good for all tested tyres. The average standard error of the slope for all tested tyres was 0.22 dB/ºC, for the two sets of standard reference tyres P1 and H1 was 0.23 dB/ºC and for other than reference tyres was 0.21 dB/ºC. The highest values of coefficient of determination R^2 were noted for standard reference tyres (average $R^2 = 0.93$), a little lower were observed for other tyres (average of 0.78) with the average for all tested tyres $R^2 = 0.83$.

In order to reference the obtained results of this experiment to any literature data, all the derived temperature correction coefficients have been converted from laboratory conditions to a “typical” outdoor test conditions according to formula (5) for passenger car tyres and using formula (6) for truck tyres (because only the air temperature was acquired in that case).

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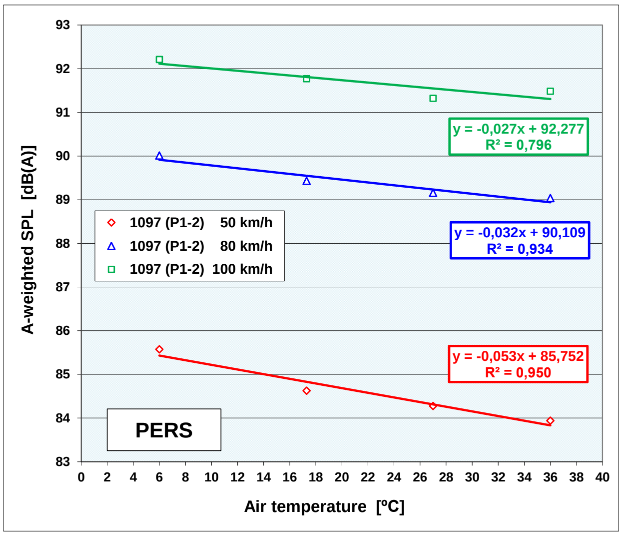

Figure 1. Air temperature influence on noise emission for 1097 (P1-2) reference tyre

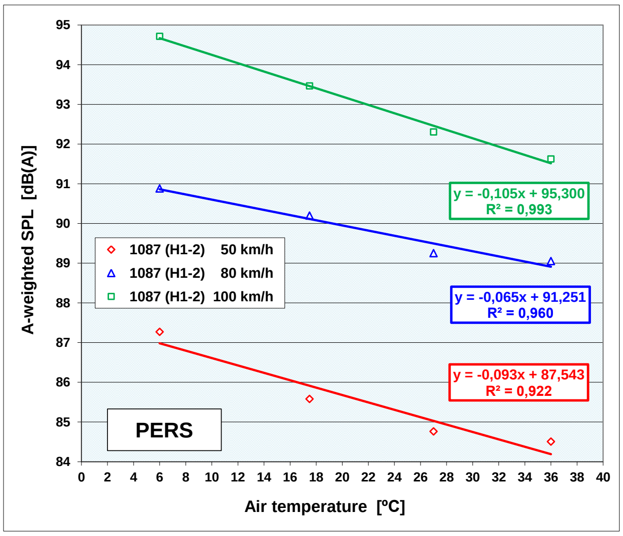

Figure 3. Air temperature influence on noise emission for 1087 (H1-2) reference tyre

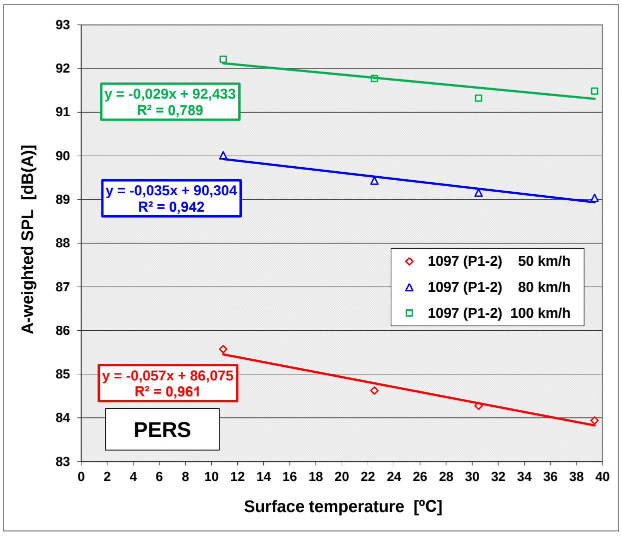

Figure 2. Road surface temperature influence on noise emission for 1097 (P1-2) reference tyre

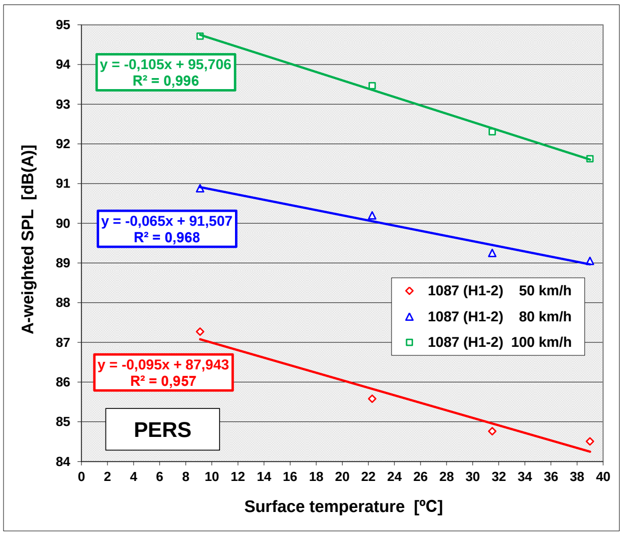

Figure 4. Road surface temperature influence on noise emission for 1087 (H1-2) reference tyre

Table 3. Air and road surface temperature correction coefficients derived for passenger car tyres

Tyre	Air temperature									Road surface temperature								
	50 km/h			80 km/h			100 km/h			50 km/h			80 km/h			100 km/h		
	γ_{at} [dB/°C]	Std. Error	R^2	γ_{at} [dB/°C]	Std. Error	R^2	γ_{at} [dB/°C]	Std. Error	R^2	γ_{rt} [dB/°C]	Std. Error	R^2	γ_{rt} [dB/°C]	Std. Error	R^2	γ_{rt} [dB/°C]	Std. Error	R^2
1097 (P1-2)	**-0,053**	**0,19**	**0,95**	**-0,032**	**0,14**	**0,93**	**-0,027**	**0,22**	**0,80**	**-0,057**	**0,17**	**0,96**	**-0,035**	**0,13**	**0,94**	**-0,029**	**0,22**	**0,79**
1087 (H1-2)	**-0,093**	**0,43**	**0,92**	**-0,065**	**0,21**	**0,96**	**-0,105**	**0,14**	**0,99**	**-0,095**	**0,32**	**0,96**	**-0,065**	**0,19**	**0,97**	**-0,105**	**0,10**	**1,00**
1077 (P1-1)	**-0,046**	**0,03**	**1,00**	**-0,048**	**0,16**	**0,95**	**-0,047**	**0,31**	**0,86**	**-0,046**	**0,06**	**0,99**	**-0,048**	**0,16**	**0,96**	**-0,047**	**0,32**	**0,85**
1063 (H1-1)	**-0,106**	**0,29**	**0,97**	**-0,087**	**0,40**	**0,92**	**-0,069**	**0,36**	**0,90**	**-0,113**	**0,19**	**0,99**	**-0,090**	**0,47**	**0,89**	**-0,071**	**0,43**	**0,86**
1064	-0,056	0,34	0,87	-0,011	0,07	0,87	-0,028	0,15	0,89	-0,060	0,35	0,86	-0,012	0,07	0,88	-0,031	0,15	0,90
1066	-0,050	0,06	0,99	-0,042	0,21	0,91	-0,008	0,08	0,71	-0,055	0,08	0,99	-0,047	0,19	0,93	-0,008	0,08	0,68
1067	-0,034	0,09	0,97	-0,027	0,08	0,97	-0,016	0,12	0,81	-0,037	0,11	0,96	-0,030	0,07	0,97	-0,017	0,14	0,77
1071	-0,056	0,32	0,89	-0,029	0,41	0,58	-0,026	0,45	0,47	-0,056	0,30	0,90	-0,030	0,39	0,60	-0,026	0,44	0,49
1076	-0,029	0,25	0,78	-0,016	0,18	0,65	-0,023	0,17	0,82	-0,031	0,22	0,83	-0,015	0,20	0,60	-0,024	0,15	0,87
1081	-0,020	0,10	0,92	-0,036	0,29	0,80	-0,036	0,17	0,92	-0,022	0,10	0,90	-0,039	0,30	0,78	-0,040	0,18	0,91
1112	-0,027	0,21	0,81	-0,019	0,36	0,44	0,013	0,42	0,20	-0,029	0,21	0,82	-0,021	0,35	0,45	0,014	0,42	0,19
1120	-0,025	0,29	0,69	-0,020	0,11	0,91	-0,034	0,16	0,93	-0,027	0,29	0,68	-0,022	0,12	0,90	-0,037	0,13	0,95
Average:	***-0,050***	***0,22***	***0,90***	***-0,036***	***0,22***	***0,82***	***-0,034***	***0,23***	***0,77***	***-0,052***	***0,20***	***0,90***	***-0,038***	***0,22***	***0,82***	***-0,035***	***0,23***	***0,77***

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The recalculated values of composite temperature coefficients separately for each individual tyre, averaged for the two P1 and two H1 tyres, averaged for all standard reference tyres, averaged for the eight other tested passenger car tyres and averaged for all twelve selected tyres are presented in Table 4.

Table 4. Calculated composite temperature coefficients for passenger car tyres

Tyre	Composite temperature coefficient γ_{ct} [dB/°C]			
	50 km/h	80 km/h	100 km/h	Average
1097 (P1-2)	-0,078	-0,047	-0,039	-0,055
1077 (P1-1)	-0,065	-0,067	-0,066	-0,066
Average for P1 tyres:	*-0,071*	*-0,057*	*-0,053*	*-0,060*
1087 (H1-2)	-0,132	-0,091	-0,147	-0,123
1063 (H1-1)	-0,155	-0,125	-0,099	-0,126
Average for H1 tyres:	*-0,143*	*-0,108*	*-0,123*	*-0,125*
Average for P1 & H1 tyres:	*-0,107*	*-0,083*	*-0,088*	*-0,093*
1064	-0,082	-0,017	-0,042	-0,047
1066	-0,074	-0,063	-0,011	-0,050
1067	-0,050	-0,041	-0,023	-0,038
1071	-0,079	-0,041	-0,037	-0,052
1076	-0,043	-0,021	-0,033	-0,032
1081	-0,030	-0,053	-0,054	-0,046
1112	-0,039	-0,029	0,019	-0,016
1120	-0,037	-0,030	-0,050	-0,039
Average for 8 other tyres:	*-0,054*	*-0,037*	*-0,029*	*-0,040*
Average for all 12 tested tyres:	*-0,072*	*-0,052*	*-0,049*	*-0,058*

For easier reference of the composite temperature coefficients obtained from the experiment to the values given in ISO/TS 13471-1:2017 [20] for porous asphalt surfaces, coefficients for all tested tyres are presented in Figure 5. The calculated averaged coefficients for P1, H1, P1 and H1, 8 other and all 12 tested tyres are shown in Figure 6.

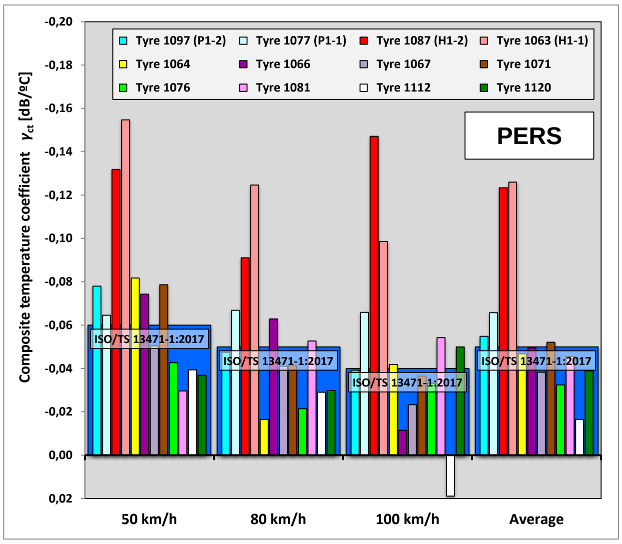

Figure 5. Composite temperature coefficients obtained from the experiment on the background of values from ISO Technical Specification for porous road surfaces

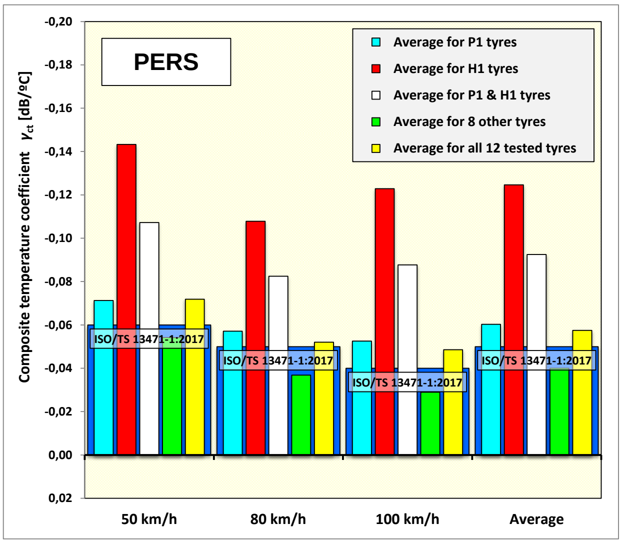

Figure 6. Averaged composite temperature coefficients for P1, H1, P1&H1, 8 other and all 12 tested tyres on the background of values from ISO Technical Specification for porous surfaces

The values of calculated composite temperature correction coefficient for passenger car tyres differ much depending on a selected tyre and test speed. The lowest obtained value (highest absolute one) is –0.155 dB/°C, the highest (lowest absolute) is +0.019 dB/°C. The coefficients for H1 standard reference tyres are about twice as high as for P1 tyres and as the coefficients given in the ISO Technical Specification. The calculated average coefficients for 8 tyres, other than the standard reference ones, are a little below absolute values given there, the average for all 12 tested tyres are a little above for all test speeds.

Concluding, for the poroelastic road surface only the composite temperature correction coefficients obtained for H1 tyres do not correspond with values given in the ISO Technical Specification. In general, coefficients calculated for P1 tyres correspond satisfactorily.

5.2. Truck tyres

Two truck tyres were tested on PERS road surface at two test speeds of 50 and 80 km/h. Only ambient air temperature was recorded during these measurements. The obtained temperature effect on noise emission is presented in Figures 7 ÷ 8.

Summarized results for the tested truck tyres, the air temperature correction coefficients (γ_a) together with the values of standard error and correlation coefficient of determination R^2 are presented in Table 5.

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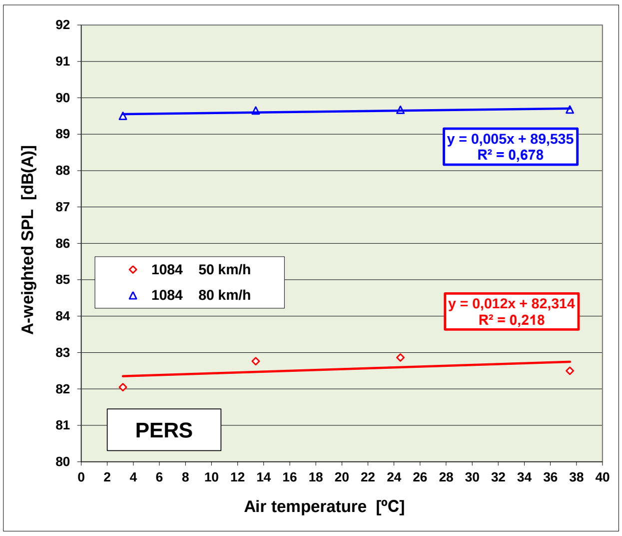

Figure 7. Air temperature influence on noise emission for the 1084 truck tyre

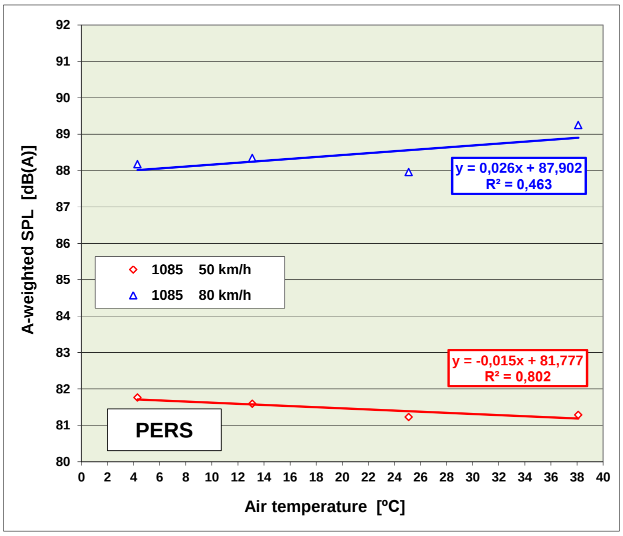

Figure 8. Air temperature influence on noise emission for the 1085 truck tyre

Table 5. Air temperature correction coefficients derived for truck tyres

Tyre	Air temperature					
	50 km/h			80 km/h		
	γ_{at} [dB/ºC]	Std. Error	R^2	γ_{at} [dB/ºC]	Std. Error	R^2
1112	0,012	0,39	0,22	0,005	0,06	0,68
1120	-0,015	0,14	0,80	0,026	0,50	0,46
Average:	***-0,002***	***0,27***	***0,51***	***0,015***	***0,28***	***0,57***

Analyzing the results obtained for truck tyres one can observe that the correlation between the air temperature and recorded sound pressure levels was rather good. The average standard error of the slope for two tested tyres was 0.27 dB/ºC. The average value of coefficient of determination R^2 was 0.54.

Similar to the coefficients for passenger car tyres, the derived temperature correction coefficients have been also converted to a "typical" outdoor test conditions according to formula (6).

The recalculated values of composite temperature correction coefficients for truck tyres are presented in Table 6.

Table 6. Calculated composite temperature correction coefficients for truck tyres

Tyre	Composite temperature coefficient γ_{ct} [dB/ºC]		
	50 km/h	80 km/h	Average
1084	0,016	0,006	0,011
1085	-0,022	0,037	0,008
Average:	***-0,003***	***0,022***	***0,009***

Analyzing the results it can be find out that the values of calculated composite temperature correction coefficient for truck tyres significantly differ depending on a selected tyre and test speed. The lowest value of the coefficient (highest absolute) is –0.022 dB/ºC, the highest (lowest absolute) is +0.037 dB/ºC and the average of all is +0.009 dB/ºC. Three of four values are positive and they do not correspond to the values obtained for passenger car tyres nor to the values given in ISO Technical Specification.

Concluding, the composite temperature correction coefficients obtained for truck tyres on the poroelastic road surface do not correspond at all to the values given in ISO Technical Specification.

5.3. Speed effect on the composite temperature correction coefficient

It was already proved that there is a speed influence on the temperature coefficient, and that this decreases with increasing speed [13, 18, 19].

The values of temperature correction coefficients γ_t presented in the ISO Technical Specification [20] are given by formulas (4), (5) and (6) described in chapter 1 depending on a road surface main type and its condition (e.g. porosity). The coefficients are dependent on a test speed. For porous pavements - formulae (6) - the slope of speed effect on temperature correction coefficient is equal 0.0004.

To find out what is the speed effect on temperature correction coefficient for the special poroelastic road surface the values of slope were derived for all tested tyres as well for several averages. The obtained results (slopes) together with calculated standard errors and coefficients of determination R^2 are presented in Table 7.

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Table 7. Speed effect on temperature correction coefficient for the poroelastic road surface

Tyre	Slope	Std. Error	R^2
Reference value according to ISO/TS 13471-1:2017	0,0004	0,0016	0,99
Tyre 1097 (P1-2)	0,0008	0,0059	0,96
Tyre 1077 (P1-1)	0,0000	0,0012	0,45
Average for P1 tyres	*0,0004*	*0,0023*	*0,97*
Tyre 1087 (H1-2)	-0,0002	0,0405	0,02
Tyre 1063 (H1-1)	0,0011	0,0029	0,99
Average for H1 tyres	*0,0005*	*0,0188*	*0,44*
Average for P1 & H1 tyres	*0,0004*	*0,0106*	*0,67*
Tyre 1064	0,0009	0,0335	0,48
Tyre 1066	0,0012	0,0213	0,80
Tyre 1067	0,0005	0,0056	0,92
Tyre 1071	0,0009	0,0099	0,91
Tyre 1076	0,0002	0,0126	0,30
Tyre 1081	-0,0005	0,0068	0,88
Tyre 1112	0,0011	0,0199	0,79
Tyre 1120	-0,0002	0,0121	0,30
Average for 8 other tyres	*0,0005*	*0,0018*	*0,99*
Average for 12 passenger car tyres	*0,0005*	*0,0047*	*0,93*
Truck tyre 1084	-0,0003	0,0000	1,00
Truck tyre 1085	0,0020	0,0000	1,00
Average for 2 truck tyres	*0,0008*	*0,0000*	*1,00*

Analyzing the obtained slopes, and validating them by taking into account the values of standard error and coefficient of determination R^2, it can be concluded that only the average for P1 tyres, albeit not the slopes for individual P1 tyres, shows the same speed effect on temperature correction coefficient for PERS as the slope for porous asphalt surfaces given in the ISO Technical Specification. Slightly different slope (0.0005) with acceptable standard error and correlation can be observed for tyre 1067 and for the average for 8 other tyres. Also the slope of average for 12 passenger car tyres shows satisfactory correlation with the reference value. Slopes calculated for truck tyres do not correlate at all to the slope in ISO specification.

6. Conclusions

The following conclusions can be drawn based on the results of experiment conducted to determine the temperature effect on tyre/road noise on a poroelastic road surface.

For the tested passenger car tyres:

- the correlation between air and poroelastic road surface temperatures and the recorded sound pressure levels is very good for all tested tyres,
- the average standard error of the slope for all tested tyres was 0.22 dB/ºC, for two sets of reference tyres P1 and H1 was 0.23 dB/ºC and for 8 other tyres was 0.21 dB/ºC,
- the average value of coefficient of determination R^2 for all tested tyres was 0.83; the highest values of this coefficient were noted for standard reference tyres with an average of 0.93, a little lower (0.78) were observed for other tyres,
- the values of calculated composite temperature correction coefficient differ significantly depending on a tyre/speed combination,
- there is a big difference in these coefficients for P1 and H1 standard reference tyres – values for P1 tyres are about a half of the values for H1 tyre,
- the average temperature coefficient for P1 standard reference tyres is –0.060 dB/ºC (–0.071, –0.057 and –0.053 dB/ºC correspondingly for speeds of 50, 80 and 100 km/h) and these values correspond in general to the coefficients given in ISO Technical Specification,
- the average temperature coefficient for H1 standard reference tyres is –0.125 dB/ºC, (–0.143, –0.108 and –0.123 dB/ºC correspondingly for speeds of 50, 80 and 100 km/h) and these values do not correspond to the coefficients given in ISO Technical Specification,
- the authors suggest to consider a different values for temperature coefficients for P1 and H1 tyres in the ISO temperature correction procedure,
- the average temperature coefficient for P1&H1 standard reference tyres is –0.093 dB/ºC,
- the average temperature coefficient for 8 other tyres is –0.040 dB/ºC, the average for all 12 tested tyres is –0.058 dB/ºC,
- the lowest obtained value (highest absolute one) is –0.155 dB/ºC, the highest (lowest absolute) is +0.019 dB/ºC.

For the tested truck tyres:

- the correlation between air temperature and the recorded sound pressure levels is rather good for both tested tyres,
- the average standard error of the slope for two tested tyres was 0.27 dB/ºC,
- the average value of coefficient of determination R^2 was 0.54,
- the values of calculated composite temperature correction coefficient significantly differ depending on a selected tyre and test speed,
- the lowest value of the coefficient (highest absolute) is –0.022 dB/ºC, the highest value (lowest absolute) is +0.037 dB/ºC and the average of all is +0.009 dB/ºC,
- three of four values of the temperature coefficient are positive and they do not

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correspond to the values obtained for passenger car tyres nor to the values in ISO specification,

- the calculated composite temperature correction coefficients obtained for truck tyres on the poroelastic road surface do not correspond at all to the values given in the ISO Technical Specification.

For speed effect on temperature coefficient:

- only the slope of the average for P1 tyres, albeit not the slopes for individual P1 tyres, shows the same speed effect on temperature coefficient for PERS as slopes given in ISO Technical Specification for porous asphalt surfaces,
- slightly different slope of 0.0005 was found for coefficients' average for 8 other tyres, the average for all 12 tested passenger car tyres and for individual tyre 1067,
- the slopes for truck tyres do not correspond at all to slope given in ISO Technical Specification.

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