EFFECT OF ELEVATED TEMPERATURE ENVIRONMENT ON ULTRASONIC PULSE VELOCITY IN CURING CONCRETE

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ABSTRACT

Quite often concrete strength parameters have to be determined at an early age. Due to the strong correlation existing between the mechanical and acoustic properties of concrete, ultrasonic devices can be used for this purpose. However, the ultrasonic pulse velocity (UPV) is affected by many factors, and it makes a great difference whether the concrete is subject to test at an earlier age or at a later time of exploitation. Since the elevated temperature of the environment promotes the shrinkage processes in hardening concrete, development of cracks and, therefore, a decrease of the UPV in concrete are to be expected. This paper describes the effect of non-isothermal high temperature (up to +30 °C) on the UPV in concrete. Influence of elevated temperature on the UPV in the concrete mass has been evaluated by determining the depth of the surface layer, at which the development of micro-cracks in the upper layers have no significant effect on the acoustic properties in concrete if an indirect transmission is applied for sounding.

Key words: concrete, nondestructive testing, ultrasonic pulse velocity, effect of elevated temperature

INTRODUCTION

Quite often concrete strength has to be determined at an early age, which happens due to the need to remove the formwork as quickly as possible and to perform an evaluation of the load carrying capacity. For that purpose most often the nondestructive research methods are used. It is known that a strong correlation exists between the mechanical and acoustic properties of concrete, however, the ultrasonic pulse velocity (UPV) is affected by many factors. Results of an earlier conducted research show that the ambient temperature within the range of +5...+30 °C does not produce any effect on the UPV in concrete. Specifically, when UPV is determined within that range, the UPV in concrete of any age will not demonstrate any significant change. Compared to the concrete placed in the environment with a temperature +20 °C, the difference in the UPV both in moisture saturated and dry concrete held at +40 °C is the least significant — up to 2 % (Malhotra and Carino, 2004; Guidebook, 2002). However, it should be taken into consideration that in such cases the discussion is of the concrete that is subject to sounding at the time when the active phase of the hydration processes of hydrated cement paste in concrete is finished. Namely, it makes a great difference whether the concrete is subject to the test at an earlier age or at a later point in time of exploitation.

Formerly, testing of cured concrete at an earlier age in an elevated temperature environment (by using the steaming method) with the help of ultrasonic equipment was performed mainly for the purpose of kinetic control of the compressive strength of concrete (Dzenis and Lapsa, 1972; Korotkov et al., 1963). As a result of concrete steaming, the strength of the massive structures grew at a lower rate, therefore, when the specimens of various bulk are tested, different results may be obtained. At the same time, it should be indicated that such curing method applied to products with similar geometrical parameters that came from the same batch also showed quite versatile results — a wide dispersion of data for concrete mechanical properties. (Dzenis and Lapsa, 1972). Therefore, it can be assumed that if concrete is simply subjected to an elevated temperature at earlier curing stages, determination of the UPV may also show a similar dispersion of data, which leads to an inaccurate interpretation of the measured results.

Similarly, the concrete at an earlier age was examined to determine the influence of isothermal and non-isothermal temperature (of up to +50 °C) in the hydration processes of hydrated cement paste. However, also in this case the main goal of the research was to determine the correlation between the strength and the UPV development kinetics during the first days of concrete hardening. It was determined that due to the effect produced by an isometric temperature of +35 °C during the first twelve hours, the UPV in the hydrated cement paste increases at a higher rate in comparison with the case when concrete curing happens at a lower temperature, whereas in 4-day old concrete the UPV is still lower compared to that in concrete that hardened in normal conditions, the difference in compression strength being ~ 20 % (Sun et al., 2005). Whereas, the results of another research show that in comparison with the temperature and shrinkage processes that develop in concrete, the changes in the UPV values are noticed at a later stage (Voigt, 2005). Therefore, it can be concluded that as a result of the influence of the above described physical processes, subsequent changes in the UPV are observable later, not during the first days of hydrated cement paste hardening.

Research conducted earlier proves that changes in moisture and temperature conditions can have quite a significant effect on the UPV in concrete (Alimov, 2007; Dzenis and Lapsa, 1972; Korotkov et al., 1963). Within the considered temperature range of +5...+30 °C the UPV in concrete decreases with a temperature increase. This may presumably happen because in the process of drying the specimens become increasingly dry and lose a certain percentage of moisture. It should be emphasized that the influence of the moisture factor on the UPV in concrete is much more significant, which was proved by the latest research in this area (Alimov, 2007; Fadragas and Gonzalez, 2011). Under the influence of elevated temperatures minor UPV and strength changes are observable in concrete with the comparatively lower strength as well as in the mixes with a lesser amount of coarse aggregates, which is largely explained by the higher homogeneity and greater porosity of the material (Glinchikov and Makagonov, 1974).

Regulations of the State standards do not contain specific guidance on the influence of temperature on the UPV propagation in concrete.

The currently existing Latvian standard and EU standard (Latvian Standard, 2004) stipulate that upon measuring the temperatures within the +10...+30 °C range, concrete is not supposed to show any significant changes in the strength or elastic properties. According to the regulations of the Standard, adjustments of the UPV measurements should be made only when sounding is carried out beyond a specified range of temperature. Furthermore, during testing the temperature of the concrete needs to be recorded in the test report only in this particular case. This standard does not contain any regulations regarding the influence of the shrinkage process on the UPV in concrete.

The existing Russian Federation standard highlights the possibility of UPV variations and, accordingly, the probability of inaccuracy in interpreting the measured results if the degree of moisture and influence of low temperatures on the tested concrete products are ignored (Russian Standard, 1988). At the same time, the standard does not contain any regulations regarding the influence of non-isothermal positive temperature on the UPV in concrete.

As it is known, during hardening the elevated temperature of the environment promotes the shrinkage processes in concrete, which normally causes development of cracks in the upper layer of the concrete and therefore a decrease of the UPV. It should be added that the influence of the shrinkage processes on the propagation of the UPV in concrete (especially in the upper layers of the material) has not been extensively studied. This work studies the effect, which the non-isothermal high temperature (of up to +30 °C) produces on the UPV in concrete if the ultrasonic testing method, the most frequently applied in practice, is used ― the indirect transmission with a longitudinal wave pulse.

For this research it was decided to manufacture concrete specimens that would be subsequently placed in various curing conditions — in a normal or elevated temperature environment. For part of the specimens the curing conditions were simulated to resemble the situation at the building site in hot summer. For the purpose of evaluation of the differences in the UPV and compressive strength up to a certain age, during hardening some specimens were kept in the formwork and some were released from the formwork to harden. The main task was to evaluate the influence of elevated temperatures on the UPV in the depth of the concrete mass and to determine the depth of the surface layer at which, given the respective hardening conditions, the development of micro-cracks in the upper layers of a specimen have no significant effect on the UPV in concrete.

MEASURING DEVICE, SPECIMENS FOR RESEARCH

For this research the ultrasonic tester "UK-1401" (made in Russia) was applied, which is a frequently used device for such kind of testing both in the laboratory and in building objects. This device has two built-in dry point contact (DPC) transducers to achieve the efficient emitting and reception of longitudinal pulses. The main technical parameters of the «UK-1401» device are as follows: path length (constant distance between the contact elements) — 15 cm, working frequency of the ultrasonic vibrations — 70 kHz, measuring error of the ultrasonic time and velocity — not more than ±1 %.

The object of the research — 27 concrete specimens (with the dimensions of 15×15×15 cm).

After manufacturing, the concrete specimens were kept for 2 days at room temperature in a metal formwork; the surface of the specimens was covered with polyethylene film. At the age of 2 days 18 specimens were released form the formwork, while 9 were left inside. 9 dismantled specimens were placed in a standard moist room, while 18 specimens were placed in the climatic chamber (9 dismantled and 9 undismantled specimens). The specimens placed in the climatic chamber were kept in conditions that corresponded to the situation at the building sites during a hot summer. For example, all faces of the undismantled specimens were partially protected to prevent moisture evaporation during concrete hardening (upper surface of the specimens was covered with polyethylene film). In the standard moist room a constant air temperature of +18 °C and a relative humidity of 95...100 % were maintained, while in the climatic chamber with constant ventilation and humidity control the following cyclic conditions were maintained over 24 hours — for 17 hours: at +10 °C, for 7 hours: at +30 °C, with the air humidity changing within a 20...50 % range subject to temperature alterations.

Depending on the environment, in which the hardening of concrete took place, the specimens were grouped as follows: N — in a standard moist room; K — in a climatic chamber (dismantled); K_V — in a climatic chamber (undismantled). Each specimen group contained 3 specimens.

Along with the three different groups of hardening environment, the specimens were further subdivided into three subgroups. Namely, for certain specimens hardening was discontinued, they were released from the formwork and had the side faces cut off at three different ages — 7, 14 and 28 days (at the age of 28 days the side face of the 3rd group of specimens was not cut off). Each specimen subgroup contained 9 specimens. Therefore, when the specimens reached each of the above indicated ages the following number of specimens were removed from the chambers: 3 — from the standard moist room; 6 — from the climatic chamber (3 dismantled and 3 undismantled). At the age of 84 days approximately a 1 cm thick layer was cut off the upper face of all specimens. Cutting off of the surface layers was carried out to evaluate the possible influence of the shrinkage process on the UPV in the concrete below the cut off layer. Sounding of the surface of concrete specimens was carried out by the ultrasonic tester at the age of 2, 7, 14, 64 and 84 days.

TESTING RESULTS

For each specimen the sounding was carried out in three faces that were marked according to concrete casting direction: U — top; S — side; L — bottom. Prior to sounding the mass of the specimens, weight was determined as well as surface moisture measured (with the help of the measuring device "Tramex Concrete Moisture Encounter"). 9 diagonal measurements of each specimen face were carried out with the tester.

After processing the UPV results on various faces of the concrete specimens, the following was established. For the cubic-shaped specimens due to their casting direction, top faces almost always showed a lower UPV compared with the side and bottom faces, see Table 1. To this day, this feature was mainly explained by segregation of the concrete being influenced by compacting. However, during this research it was established that mainly it was affected by the environment in which the hardening took place. It is known that moisture promotes the hydration processes that occur in hydrated cement paste. Therefore the concrete sections with a higher level of accumulated moisture showed also a higher UPV. However, it should be emphasized that in this case the UPV increase is influenced by the moisture present in concrete, which plays a role of the initiator of chemical processes taking place there rather than as a physical factor. During the research it was established that if the specimens dry up at a steady pace over the whole bulk, the proportion of the UPV determined for various faces is preserved, only the absolute values of the UPV decrease.

It should be noted that, during another research that was conducted earlier, it also was established that distribution of the velocity of ultrasonic longitudinal waves and the surface waves throughout the height of a concrete specimen is not uniform (Staviski, 1982). It was discovered that for concrete specimens that were subject to various steaming conditions the UPV at the top is comparatively lower than the same at the bottom, while in the sections very close to the top face of the concrete it appears to be considerably lower.

A very significant difference between the UPV results for the top and the bottom faces was found for the specimens, which during hardening were subject to a cyclical impact of an elevated temperature (nonisothermal conditions) and which were not released from the formwork — K_V group specimens. Although the upper faces of the specimens of this group were also covered with polyethylene film (thus, emission of heat in the process of concrete hardening caused an accumulation of moisture on the specimen surface), here the fixed UPV appears to be explicitly lower in comparison to the measurements taken at the side and at the bottom faces, see Table 1. Besides, the longer the specimen was subject to such hardening conditions, the larger the UPV difference was. The other two specimen groups did not demonstrate such a strongly explicit tendency in the UPV differences. At the same time it should be noted that as a result of the influence of similar curing conditions the UPV measured for the upper face of the K_V group specimens of various ages is almost identical to that of the K group specimens.

As it was already mentioned, the physical influence of the moisture factor on the UPV in concrete is not a determinant in this case. Where initially differences in the amount of moisture present in the upper and bottom sides of the 2, 7 and 14-day old concrete specimens were fixed, then, later, when the 64-daysold specimens were tested, the moisture became evenly distributed almost throughout the whole bulk of those specimens. Measurements performed for certain specimens, which were approximately 3 years old, support the above assumption. Specifically, it was determined that the difference in the UPV fixed for the side and bottom faces of the specimens remained on the same level as it had been fixed at the age of 2 day.

The results obtained for the UPV show a comparatively greater dispersion in the specimens of group K. Since these specimens were released from the formwork and hardened at an elevated temperature, the conditions under which the structure of the hydrated cement paste was formed to a certain extent appear to be similar to the specimens that hardened under steaming conditions, which also demonstrate greater dispersion of acoustic properties (Dzenis and Lapsa, 1972; Gorshkov et al., 1979).

Considering the above mentioned, the following conclusions can be drawn:—it is assumed that during the process of hardening in a hot environment (when the temperature during the day reaches at least +30 ^oC or exceeds this level) the porosity of the upper layers of hydrated cement paste and/or intensity of the quantity of microcracks in the undismantled concrete would be much higher compared with the rest of the mass, covered by the formwork.

In such cases, for examination of the structures with the help of nondestructive testing equipment, sclera-ometric devices as a rule are not useful because quite often the surface that stays free from the form-work has significant asperity. Therefore, quite often the method of acoustic testing is the only possible way to evaluate the degree of homogeneity of the concrete in the structure and, in addition, to deter-mine its strength parameters. Nevertheless, as seen from the results obtained in the course of the experiment, one should be especially careful when carrying out an assessment of general technical conditions of the concrete structures with the help of ultrasonic equipment. This is mainly because the concrete top surface, which in contrast to the rest of the faces (covered by the formwork) that hardened in a different environment, in warm weather conditions is subject to moisture evaporation even if the surface is covered with polyethylene film, which promotes moisture accumulation. Therefore, the UPV measured on the concrete surface freed from the formwork quite often proves to be lower in comparison with the rest of the concrete mass, and based on such results one may rush to the conclusions about the insufficient strength of con-crete structure. In turn, when measurements are taken for the bottom faces of the concrete that was released from the formwork, the opposite inaccuracy may be made — here obtained the UPV will be higher than the results shown for the rest of the structure in general. Accordingly, the concrete that was hardened in such an environment should be sounded in all available faces and, additionally, the moisture degree should be determined. Adherence to such a measuring method will lead to more a accurate interpretation of the UPV measurement results with relation to the results of concrete homogeneity and strength.

Table 1

Average results of the differences in the UPV propagation in the top, bottom and side faces of the concrete specimens, which were cured in various environments, at different ages

Speci-mens group	Designation of specimens	Specimen age at the time of testing / the face subject to measurements / UPV differences in relation to the top face							
		2 days		7 days		14 days		64 days	
		side	bottom	side	bottom	side	bottom	side	bottom
N	$10.^7$, $16.^7$, $17.^7$	+2%	+5%	+1%	+3%	0%	+5%	+2%	+5%
	$5.^{14}$, $6.^{14}$, $15.^{14}$	+2%	+6%	+2%	+5%	+2%	+5%	+5%	+6%
	$1.^{28}$, $2.^{28}$, $7.^{28}$	+2%	+8%	+1%	+5%	+1%	+5%	+2%	+6%
	average total*:	**+2%**	**+6%**	**+1%**	**+5%**	**+1%**	**+5%**	**+3%**	**+6%**
K	$4.^7$, $13.^7$, $18.^7$	0%	+5%	0%	+5%	+6%	+5%	+5%	+6%
	$3.^{14}$, $8.^{14}$, $14.^{14}$	0%	+3%	0%	+3%	-1%	+3%	+9%	+5%
	$9.^{28}$, $11.^{28}$, $12.^{28}$	+1%	+4%	0%	+4%	+1%	+3%	+1%	+4%
	average total*:	**0%**	**+4%**	**0%**	**+4%**	**+2%**	**+4%**	**+5%**	**+5%**
K_V	$22.^7$, $25.^7$, $27.^7$	–	–	+7%	+11%	+7%	+11%	+8%	+10%
	$20.^{14}$, $23.^{14}$, $26.^{14}$	–	–	–	–	+9%	+13%	+11%	+12%
	$19.^{28}$, $21.^{28}$, $24.^{28}$	–	–	–	–	–	–	+10%	+14%
	average total*:	–	–	**+7%**	**+11%**	**+8%**	**+12%**	**+10%**	**+12%**

Note:

1. For the purpose of numbering, each specimen is assigned a number in superscript, which shows the age in days at which hardening in the corresponding chamber was discontinued and the surface layer of the side face was cut off (however not at the age of 28 days);
2. * — the average results of the UPV difference in the side and bottom faces compared to the upper face.

In order to determine the possible influence of the shrinkage processes on the UPV in the deeper lay-ers of concrete mass, the surface layers of the speci-mens were cut off at various ages, and sounding was performed before and after the cutting.

Before cutting off the side face layer, each speci-men was inspected by using the below described method. First, the amount of moisture present in the side face was determined, afterwards 18 diagonal measurements were carried out with the help of an ultrasonic tester. Then, the specimens' dimensions and mass were measured to determine the density. Such preliminary work was necessary because the specimen was moistened during cutting, and while it dried it was necessary to control the two parameters — the surface moisture and density. Namely, it was necessary to ensure that these two parameters got back to the initial level fixed before the cutting. (It should be noted that after surface layers were cut off, repeated dimensioning of the specimens was done). When the surface moisture and density reached the required level, measurements of the side faces of the specimens were carried out with the help of an ultrasonic tester. Adherence to such a method is considered as a major prerequisite to ensure accurate comparison of the UPV results obtained before and after cutting off the surface layer.

At first, the average 0.15 cm thick surface layer was cut off the side face of the specimens, then, one day later, repeated cutting was carried out, the total thickness of the surface layer cut off of each specimen on the average constituted 1.5 cm, see Table 2.

Table 2

UPV changes obtained for the surface layers of various thicknesses cut off the side faces of the 7-day old concrete specimens

Designation of specimen	Specimens group	Cut thickness, cm*	UPV before cutting, m/s	UPV after cutting, m/s	UPV difference, m/s | %	Cut thickness, cm*	UPV before cutting, m/s	UPV after cutting, m/s	UPV difference, m/s | %
$4.^7$	*K*	0.31	4258	4337	+78 | +1.8	1.69	4258	4624	+366 | +8.6
$13.^7$		0.19	4489	4537	+47 | +1.1	1.45	4489	4524	+35 | +0.8
$18.^7$		0.15	4326	4354	+29 | +0.7	1.55	4326	4517	+192 | +4.4
average result:					**+51 | +1.2**	–	–	–	**+197 | +4.6**
$22.^7$	K_V	0.09	4648	4679	+31 | +0.7	1.63	4648	4722	+74 | +1.6
$25.^7$		0.15	4620	4617	-3 | -0.1	1.37	4620	4641	+21 | +0.4
$27.^7$		0.23	4608	4642	+34 | +0.7	1.78	4608	4750	+142 | +3.1
average result:					**+21 | +0.4**	–	–	–	**+79 | +1.7**
$10.^7$	*N*	0.05	4598	4564	-33 | -0.7	1.42	4598	4614	+17 | +0.4
$16.^7$		0.10	4599	4544	-56 | -1.2	1.39	4599	4545	-54 | -1.2
$17.^7$		0.09	4637	4612	-24 | -0.5	1.35	4637	4589	-48 | -1.0
average result:					**-38 | -0.8**	–	–	–	**-29 | -0.6**

<u>Note</u>: * — thickness of the surface layers cut off the side faces of concrete specimens.

After the 0.15 cm thick surface layer was cut off the side face of the 7-days old concrete, a slight increase in the UPV was fixed only for the *K* group specimens, see Table 2. At the same time, in the cases where the 1.5 cm thick surface layer was cut off, *K* group concrete specimens, which were released from the formwork before the cycling process and hardened in the elevated temperature environment, showed a much higher increase in the UPV results — by ~ 200 m/s or 5 % on the average. Similarly, specimens of group K_V, which hardened in the similar environment although being kept in the formwork, also showed an increase in the UPV, see Table 2. It should be added that, in the concrete that hardened under normal conditions, after the cutting of the surface layer was realized, no increase in the UPV was obtained.

Therefore, it can be concluded that the shrinkage processes, which developed in the upper layers of the concrete under the impact of the elevated temperature of nonisothermal nature hindered propagation of ultrasonic longitudinal waves. Namely, after cutting off the 1.5 cm thick surface layer the concrete specimens of *K* and K_V groups showed the UPV results, which were much closer to the results, obtained for the 7-day old concrete that cured under normal conditions.

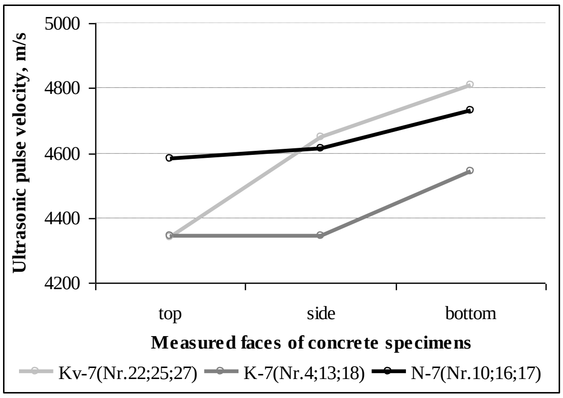
When a similar experiment was carried out for the 14-days old concrete, the specimens that were released from the formwork and hardened in the climatic chamber demonstrated even a higher increase of the UPV — approximately by 300 m/s or 7 %.

The above mentioned assumption is confirmed by the changes in the UPV shown in Fig. 1, which in the graphical form presents the data obtained for the specimens of various groups. Namely, after cutting off a ~ 1.5 cm thick surface layer the nature of the UPV curves for the 7 and 14-day old specimens cured in the standard moist room (*N*) and in the climatic chamber in formworks (K_V) is unchanged, while the side faces of the 14-day old specimens released from the formwork (*K*), which hardened in the climatic chamber, register a significant UPV increase. The nature of the UPV curves, as it in Fig. 1, *b*, for all specimen groups did not change also at the age of 64 days. Similar UPV curve changes are determined for the *K* group concrete specimens, when the results for the side face cuttings, i.e., for the data obtained at the age of 14 days are compared with the results fixed in 64 days.

By summarizing the data it was stated that concrete specimens of *K* group, after an approximately 1.5 cm thick surface layer was cut off the side face, for various initial UPV values, fixed before cutting, demonstrated a significant difference in the UPV increase that was measured after the cutting, see Fig. 2. Specifically, the lowest initial UPV (4258 m/s) showed the highest UPV increase — 8.6 % (4624 m/s). And conversely — the highest initial UPV (4489 m/s) corresponded to the lowest increase of UPV — 0.8 % (4524 m/s).

In addition to cutting off the side faces of specimens, all concrete specimens at the age of 84 days had the top face cut off as well.

In that case, the most significant differences in the UPV were obtained only for the 28-day old specimens that hardened in the climatic chamber. Specifically, for the specimens of the *K* and K_V groups, after they had an approximately 1 cm thick surface layer cut off, fixed an increase of the UPV compared to the UPV in the uncut surface: 171 m/s or 4.1 % and 184 m/s or 4.4 %, accordingly. In its turn, the specimens, which for 28 days hardened in the standard moist room (*N* group), demonstrated an increase of UPV by 54 m/s or 1.2 %.



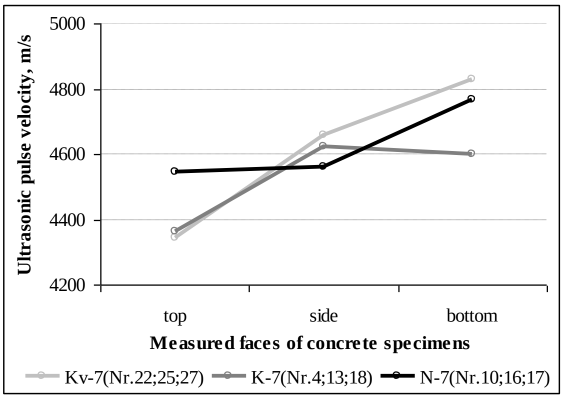


Figure 1. UPV changes obtained for the 7- (*a*) and 14- (*b*) days old concrete hardened in various environments after the surface layer of the side face was cut off

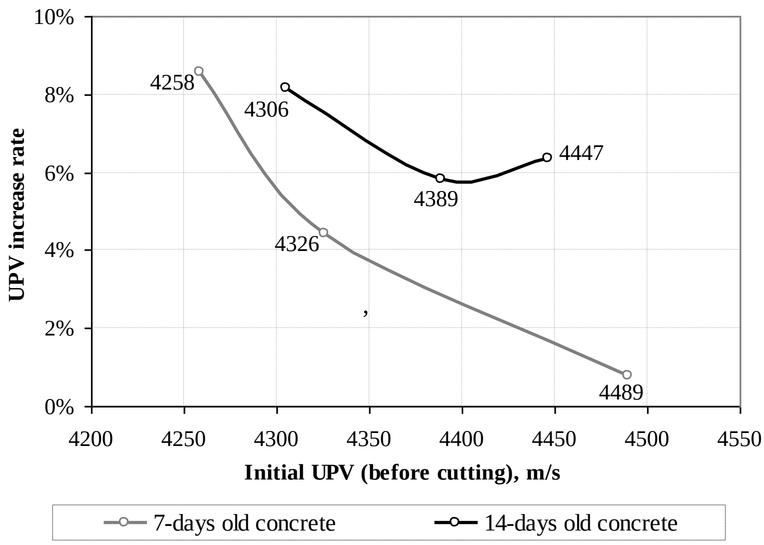


Figure 2. Differences in the UPV increase rate of the *K* group concrete specimens with different initial UPV, after approximately 1.5 cm thick surface layer was cut off the side faces

It should be emphasized that in contrast to the above determined relationships for the side faces of the concrete, in this case, the top faces of the *K* and K_V group specimens were subject to equal hardening conditions. Therefore, the obtained UPV differences also appear to be of similar nature.

For each of the specimens, after measuring and comparing the UPV data in various faces, different resulting trends have been obtained depending on the environment, in which hardening took place. Namely, the propagation of the UPV throughout the whole bulk of concrete specimen is best characterized by the data in its top face, after an approximately 1 cm thick surface layer has been cut off. However, such conditions can be referred only to the specimens, which hardened in the standard moist room or were kept in the formwork even in sufficiently hot weather conditions, whereas, for the concrete that was dismantled and placed in a hot environment, the optimal characteristic UPV value is medium-level, which is obtained by sounding the bottom and side faces.

Thus, it should be concluded that when ultrasonic measurements of concrete are carried out by using the indirect transmission method, the correlation of the acoustic and mechanical properties is to a great extent dependent upon the conditions in which hardening took place. Besides, the data obtained for the upper layer of concrete may not provide the correct characteristics of the concrete condition in general.

CONCLUSIONS

1. In relation to the concrete casting direction the top face of the specimens showed lower UPV in comparison to that obtained on the sides and at the bottom. This feature is the result of the concrete segregation occurring during compacting as well as influenced by the environment, in which hardening took place. Since moisture promotes the hydration processes in the hydrated cement paste, UPV also proves to be higher in the sections where more moisture is accumulated. In this case an increase of the UPV is contributed by moisture not as a physical factor but rather as the initiator for chemical reactions in concrete. In the 3-year old specimens after uniform drying throughout the whole bulk, the UPV for various sides was retained, only the absolute UPV values decreased.
2. A very significant difference between the UPV results for the upper and bottom faces was determined for the specimens that were not released from the formwork and during hardening were subject to the impact of the elevated nonisothermal temperature (K_V group). The UPV fixed in the top layer of the concrete is less by 15 % compared to the values measured at the sides and at the bottom.
3. The concrete that hardened in a hot environment (at the air temperature reaching +30 ^{o}C) usually has increased porosity of the hydrated cement paste in the upper layers and/or microcracks, which prevented propagation of ultrasonic waves. The average increase of the UPV determined at the depth of 1.5 cm at the side faces of concrete specimens of *K* group at the age of 14 days constituted 300 m/s or 7 %. At such a depth the UPV is much closer to the values, measured on the surface of the concrete, which hardened in normal conditions. The K_V group specimens also showed a noticeable UPV increase. In its turn, no UPV increase at the specified depth was obtained in the concrete that hardened in normal conditions. A similar correlation was determined when sounding of the top faces of the concrete specimens was carried out at a later age.
4. For concrete specimens of *K* group at the depth of 1.5 cm obtained significant difference in the UPV increase in comparison with the initial UPV values. Namely, a higher increase in the UPV corresponds to lower initial UPV value, and conversely — higher initial UPV corresponds to lower UPV increase.
5. It is concluded that when ultrasonic measurements of the concrete are carried out by using the indirect transmission method, the correlation between the acoustic and mechanical properties to a great extent depends on the environment, in which the concrete was cured. Besides, the data obtained for the upper layer of concrete may not provide correct characteristics of the concrete condition in general. The concrete which was hardened at the elevated temperature should be sounded in all available faces and at the same time it is important to determine the degree of the surface moisture. Such measuring methodology is going to significantly improve interpretation of the UPV measurement results in respect of homogeneity and strength parameters of concrete.

ACKNOWLEDGEMENT

The financial support of the ERAF project Nr. 2010/0286/2DP/2.1.1.1.0/10/APIA/VIAA/033 "High efficiency nanoconcretes" is acknowledged.

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