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EFFECT OF PRODUCTION TEMPERATURE ON STRENGTH OF POLYMER CONCRETE

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Abstract: *In our long-term research, the strength and physical characteristics of concretes with unsaturated polyester binder and their influencing factors are specified. This study is intended to determine how the values of compression strength and flexural strength are affected by the mixing temperature. Our experiments show, that the compression strength of polymer concrete is significantly decreased just by low temperatures (close to the melting point of catalyst). Flexural strength is not affected significantly by temperature. The reasons for this discrepancy should be further examined later on, by taking into consideration the factors influencing polyester polymerization.*

Key words: *polymer concrete, mixing temperature, compression strength, flexural strength*

1. Introduction

Concrete is an artificial stone which is a mixture of water, admixture, binding material and additives. The world concrete usually means cement concrete, in which the binder is Portland cement. If the binder is artificial resin (polymer), then we talk about artificial resin (polymer) concrete (hereinafter the currently accepted term 'polymer concrete' is to be used) [1]. Polymer concrete is a relatively young building material: it is primarily used for repairs, and for forming pavements and wear-resistant layers [2]. Research works in the literature [2] primarily test the properties of concrete intended for given purposes. In order to enable the spread of a new material, its mechanical and physical properties should be tested systematically. This research of several years aims to examine the properties of polymer concrete in detail, including compression strength, flexural strength, short-term and slow plasticity, fire resistance, and the connection between concrete and concrete, and between polymer concrete and reinforcement rods.

The strength and physical characteristics of polymer concrete primarily depend on the types of binder and admixture. Our research only and

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exclusively examines concrete whose binder is unsaturated polyester (UP polymer concrete) [3]. Earlier research and our tests performed so far both indicate that the properties of polymer concrete of identical composition and produced under identical circumstances are identical, and their quality is uniform.

2. Objectives

In case of Portland cement concretes, the strength and other physical properties of concrete are substantially determined by the circumstances of production [1]. The objective of our research is to examine how the strength characteristics (compression strength and flexural strength) of UP polymer concrete are affected by production temperature.

2. Material and Methods

For cement concretes, an important parameters of production conditions is ambient temperature. In wintertime, solidification does not start curing to the cold, and the mixture may get frozen; while in the summertime the hot weather can further enhance the temperature rise of concrete caused by the heat of hydration: concrete may get burnt and cracks may appear [1].

UP concrete of the composition corresponding to our earlier research is used [3]; the mixing composition is used in Table 1.

The specimens used for testing were produced at -11 °C, +12 °C and +20 °C, primarily modelling the impact of concreting during the winter. Mixture composition (Tab. 1.), compaction time (3 minutes) and the duration of mixing (2 minutes) were identical and corresponded to normal mixing.

For the compressive and for the flexural test 3-3 specimens were produced at the three different temperatures (Fig.1 and 2). Occasion 9 cubes of 150x150x150 mm were produced to perform standard compression tests [5], and 9 beam of 60x60x250 mm to produced to perform standard bending tests [6].

Mixing composition Table 1

Binder	POLIMAL 144-01 unsaturated polyester	16 w%
Aggregate	2-4 mm particle-size dried bulk graded quartz gravel	38 w%
	0-2 mm particle-size quartz sand	38 w%
Other components	Trigonox 44 B catalyst	3 w%
	CO-1 Cobalt initiator	
	Calcium-Carbonate	5 w%

Fig. 1. *Compression test specimens after failure*

Fig. 2. *Flexural test specimens after failure*

Compression tests were performed on the basis of the MSZ EN 12 390-3:2009 Standard [5], and bending tests on the basis of the MSZ EN 12 390-5:2009 Standard [6] at the Materials Testing Laboratory of the Department of Building Materials and Engineering Geology at BUTE Faculty of Civil Engineering, on an Alpha 3-3000 S (Fig. 3) and a WPM ZDM 10/91. (Fig. 4.) machines, at a load speed of 11 kN/sec.

Fig. 3. *Compression test*

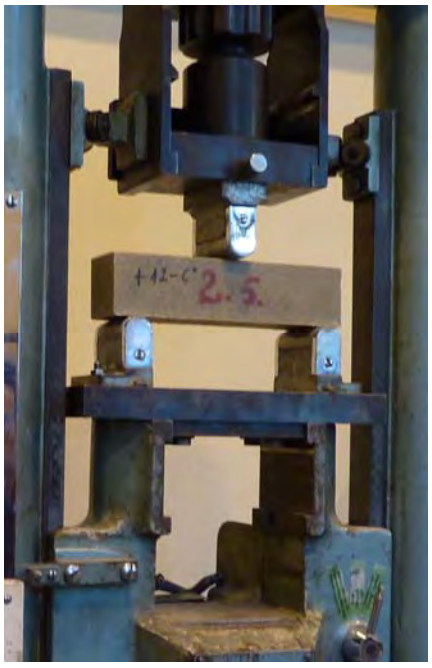

Fig. 4. *Flexural test*

In order to evaluate tests, group average and standard deviation figures were calculated from the results measured. An MS-EXCEL statistics software was used for making statistical comparisons of the results. An F-test was used for checking for the identical standard deviation of measured group results. A two-sample t-test was used for co mparing groups, the significance level was uniformly 0.05 [4].

3. Results and Conclusions

Figures 5 a nd 6 summarize test results. Compared to the compression strength of specimens mixed at 20°C, mixing performed at 12°C does n ot show any significant difference ($p_{12\text{-}20°C}$=0.61), while the strength of specimens mixed at -11°C showed a significant difference ($p_{\text{-}11\text{-}20°C}$=0.012).

This can be explained by the fact that the boundary temperature for the use of polyester is - 10°C according to the manufacturer's recommendations, polymerization at lower temperatures is assumed to be inadequate.

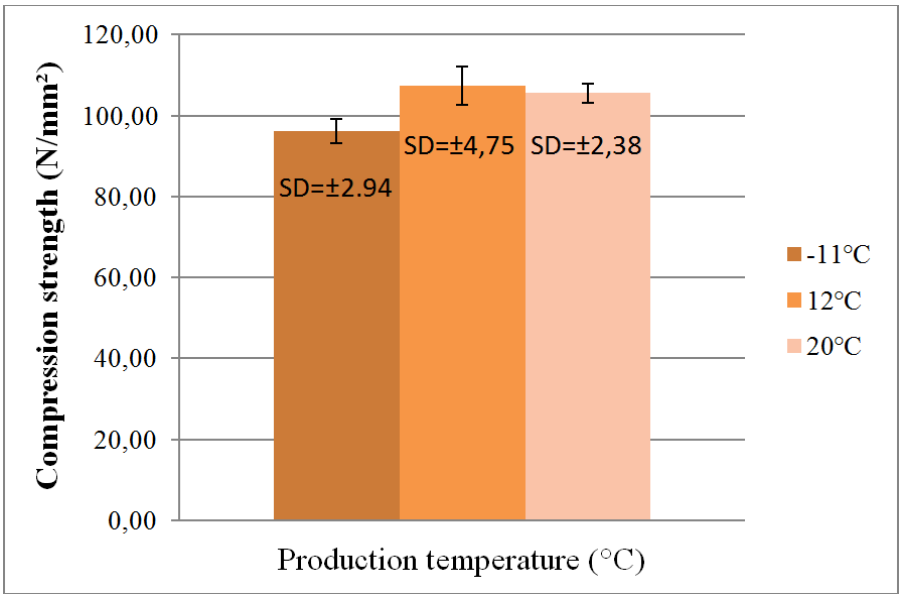

Fig. 5. *Compression strength*

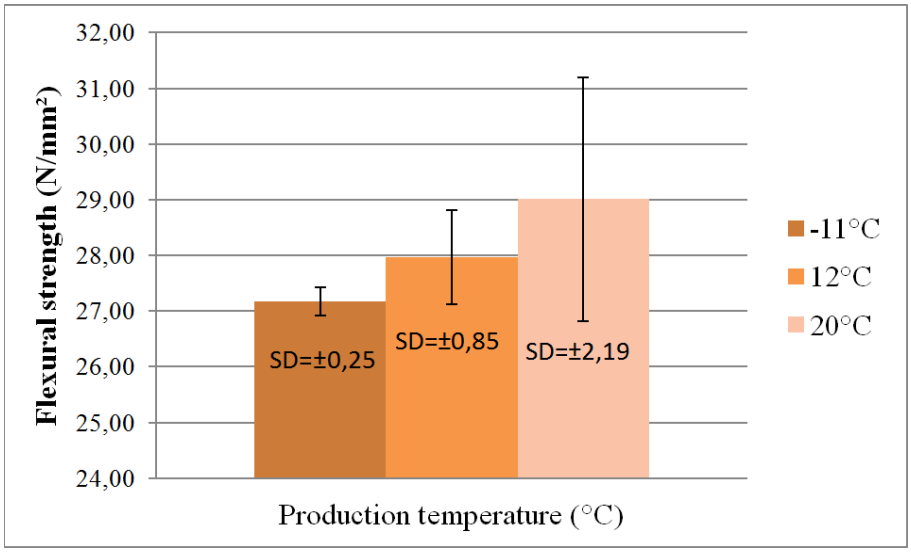

Fig. 6. *Flexural strength*

Nevertheless, the fl exural strength derived from the values of specimens mixed at -11°C ($p_{-11\text{-}20°C}$=0.223, $p_{12\text{-}20°C}$=0.484) does not differ from the strength values of concretes mixed in normal concreting circumstances. By analyzing standard deviations, it can be observed that relative standard

deviation figures are increasing as the temperature is falling ($SD_{-11°C}$=2.94 N/mm², $CV_{-11°C}$=3.06 %, $SD_{12°C}$=4.75 N/mm², $CV_{12°C}$=4.43 %, $SD_{20°C}$=2.38 N/mm², $CV_{20°C}$=2.25 %,). This is assumed to demonstrate the impact of very low temperature and consequently, of inadequate polymerization.

In summary of the analysis of production conditions, it can be stated that the compression strength is only affected by extreme cold.

The answer is not obvious in respect of flexural strength. No significant discrepancy is caused by temperature. For cement concrete, flexural strength highly depends on the moisture state of the specimen [1]. In case of polymer concrete, this cannot be an influencing factor as the basic mixture does not contain any water; the water intake of solidified specimens approximates zero. A possible reason for this discrepancy can be the different polymerization of polyester. This also shows that flexural strength is primarily determined by the properties of the polyester.

4. Conclusions

Compression strength is significantly reduced by very cold (temperatures approaching the melting point of catalyst).

Flexural strength is not significantly affected by temperature. The reason for the discrepancy is to be further investigated by taking factors affecting polyester polymerization into account.

The results show that, the mixing of polymer concrete could be happened until the melting point of catalyst.

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