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A discussion of the paper "The maturity method: Modifications to improve estimation of concrete strength at later age" by Yahia A. Abdel-Jawad

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Abstract

Two modifications have been proposed for the Nurse-Saul maturity function to get better estimates of compressive strength of concrete cured at different temperatures in this paper. The modifications account for the effect of w/c ratio on the temperature dependence of strength development and the effect of curing temperature on the long-term strength. This discussion focuses on strength development behaviour of concretes cured at different temperatures. Aiming to understand the strength development of cement based materials relevant experimental studies on mortar and concrete specimens in the literature are evaluated.

Keywords: Concrete; Maturity; Later age strength; Modification; Estimation

1. Introduction

To determine the development of strength of concrete with maturity, maturity-strength relationships were examined for concrete specimens produced with CEM II/B-M and CEM I 42.5 R at curing temperatures of 0, 23, 40 °C and testing age of 1, 3, 7, 14 and 28 days by Topçu and Karakurt [1]. The effect of curing temperature on strength development decreases with increasing age as slopes of the curves decreases for 1, 3, 7, 14 and 28 days in Fig. 1 below. Although a higher temperature at 1 and 3 days increases the strength, adversely the strength from about 7 days onwards decreased with the increasing temperature in concretes produced with CEM I 42.5 R. And a similar effect with a delay period observed in CEM II/B-M concretes.

Topçu and Toprak [2] investigated for the effect of early age curing time and temperature on later age strength. The cube concrete specimens produced with two different types of fine aggregate (RS, CS) gained early strength by application of two different cure cycles, 1-h preheating cure process, 6-h or 18-h cure process at 20, 40, and 60 °C at moisture over 50%. After the accelerated cure applications, 28-day specimens were kept in a curing tank at 20 °C until the time of the experiment. The cube compressive strength was obtained at the end of the cure applications and on the 28th day. The results are given in Fig. 2. It shows that the increase in curing temperature and time accelerates the early-strength gain of the concrete but affects the 28-day concrete strengths negatively.

Concrete specimens produced from the same mixture were kept at 1, 21, and 43 °C. Some of the specimens were kept in temperatures as above, and the others were kept at 21 °C after 6, 18, 30, and 48 h, respectively, and were tested in compression on the 1st, 3rd, 5th, 7th, and 28th days by Volz et al. [3]. From the results obtained, it was observed that the maturity-strength relationship, which was acquired after keeping the specimens at a normal temperature after

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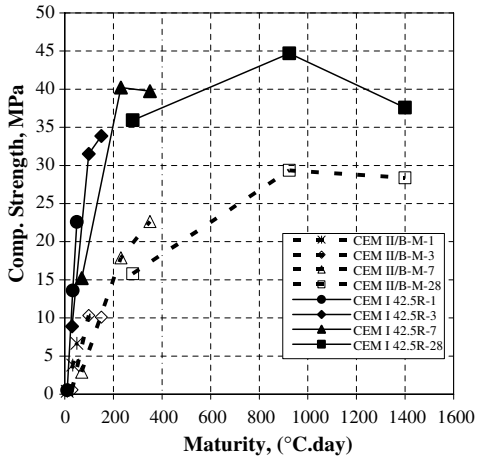

Fig. 1. Compressive strength–material relationship.

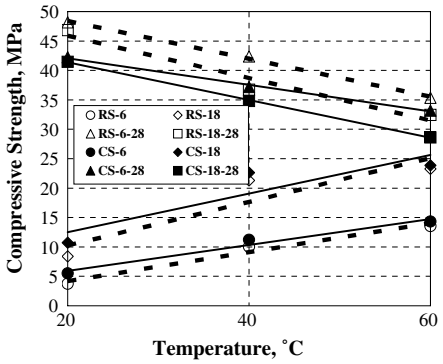

Fig. 2. Compressive strength–curing temperature relationship.

6, 18, 30, and 48 h, or at the first temperature, did not change permanently. Volz et al. explain that the curves form unity in themselves depending on the initial temperature, and that the initial curing temperature that lasts 6 h can affect the movement of the maturity-strength curve, and finally that late temperature variations do not change the curve.

The compressive results obtained for 24 h initial curing temperature and than standard moist curing at, 18 °C by Alou and Delisle [4] are given in Table 1 below. When the table evaluated negative effects of high temperature curing on compressive strength observed above 7 days and the decrease of strength ratio reaches considerable values for high temperatures. But in low temperatures except a delay of strength development up to 7 days, no significant effects on strength observed.

J. Ortiz , A. Aguado, L. Agullo, T. Garcı [5] studied the influence of mixing hour on the properties of concrete, such as workability and compressive strength, under hot and cold weather conditions. The variable focused on was the concrete mixing hour. Immediately after the concrete had been cast and compacted, the thermocouples were introduced into fresh concrete samples and thereafter the specimens were covered with plastic bags to prevent excessive water evaporation. When the concrete specimens had remained in the climatic chamber for 24 h (Series 1), 48 h (Series 2) and 72 h (Series 3), they were demolded and stored in the curing chamber at a constant temperature of 20 °C and a relative humidity of 95% for 7 or 28 days, at the end of which the compressive strength was tested. Climatic chamber and compressive strength results of specimens are given in Fig. 3. and Table 2. respectively. An increase in the early curing temperature makes the

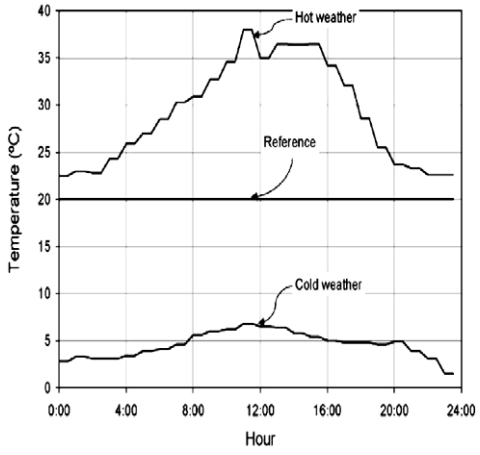

Fig. 3. Climatic chamber.

Table 1
Compressive strength-age results due to initial curing temperature

Time (day)	Cube compressive strength (MPa)							
	4 °C		18 °C		31 °C		55 °C	
	f_c	%	f_c	%	f_c	%	f_c	%
1	–	0	7.1	100	10.2	144	15.5	218
2	9.1	70	13.0	100	14.7	113	15.5	119
7	26.9	103	26.1	100	26.0	100	18.3	70
28	36.2	105	34.4	100	32.6	95	23.1	67
90	45.0	103	43.9	100	41.7	95	32.2	73
232	50.3	101	49.8	100	46.2	95	40.3	82

Table 2
Slump and compressive strength values for 7 and 28 days

Mixing hour	Slump (cm)	Compressive strength (MPa) (Coefficients of variation (%))	
		7 days	28 days
Hot weather conditions			
Reference	9.0	37.9 (0.2)	43.3 (4.6)
10.00	4.5	34.3 (2.5)	40.9 (5.2)
11:30	3.5	34.4 (3.2)	41.1 (2.9)
13:00	3.5	35.2 (4.6)	41.9 (2.8)
14:30	4.0	36.8 (3.6)	41.5 (3.5)
17:30	3.2	37.3 (3.2)	42.5 (6.6)
Cold weather conditions			
Reference	9.0	37.9 (0.2)	43.3 (4.6)
8:15	7.0	41.7 (2.2)	45.8 (2.8)
10.00	7.5	41.7 (4.4)	45.7 (1.5)