Technical Report

Testing Some Properties of Nanocements

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Prepared for

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DISCLAIMER

The contents of this report reflect the results of the tests conducted by the authors on the batches of two grades of nanocements, supplied to the laboratory of Ryerson University by Professor M.Ya Bickbau, Director General of Moscow IMET. The interpretation of results should be strictly applied to the specific nanocements only. Users are asked to conduct their own tests or consult company Moscow IMET International (www.globalimet.com) for results of specific nanocements for general use. This report does not constitute a standard, specification or regulation. For any additional information contact: info@globalimet.com.

Introduction

Two grades of nanocement (namely nanocement 45 and nanocement 75) produced by ZAO "IMETSTROY" Moscow were tested in the concrete laboratory of Ryerson University, Toronto to determine fresh and mechanical properties. Tests methods and results are described in the following sections.

Test Methods and Testing

Fresh state properties such as normal consistency, flow value, setting times (initial and final) as well as mechanical properties such as 2, 7, 14, 28 and 42 days compressive strength of nanocement 45 and nanocement 75 were investigated.

Flow values of nanocement mortars were tested as per ASTM C1437 - 15 (2015). The mortar used consisted of 1 part of nanocement and 2.75 parts of standard sand proportioned by mass and prepared at various water to cement ratio (w/c). A layer of freshly prepared mortar was inserted on the mould (70 mm top inside diameter, 100 mm bottom outside dia and 50 mm height as per ASTM C230/ C230M - 14 , 2014) placed at the centre of flow-table (having 255 mm diameter and tamped 20 times with the tamper (Fig. 1).

Fig.1: Flow table test set-up, flow and flow measurement

The tamping pressure should be just sufficient to ensure uniform filling of the mold. Then the mold was filled with mortar and tamped as specified for the first layer until filled. The mortar was cut off to a plane surface, flushed with the top of the mold, by drawing the straight edge of a trowel (held nearly perpendicular to the mold) with a sawing motion across the top of the mold. Wipe The table top was wiped clean and dried being especially careful to remove any water from around the edge of the flow mold. The mold was then lifted away from the mortar 1 min after completing the mixing operation. Immediately the table was dropped through a height of 13 mm, 25 times in 15 s. Using the calipers, the flow was determined by measuring the diameters of the mortar spread along the lines scribed in the table top (Fig. 1).

The compressive strength of nanocement mortars consisted of 1 part cement and 2.75 parts of standard sand proportioned by mass (as used in flow tests) was determined by using cube specimens (cubic moulds and specimens are shown in Fig. 2). Water content used for the mortars was that sufficient to obtain a desired flow in the flow table test for the nanocements. 50-mm cubes were compacted by tamping in two layers. The cubes were cured one day in the molds and stripped and immersed in lime water until tested in a compression testing machine as per ASTM C109 / C109M - 16 (2016) (Fig. 2).

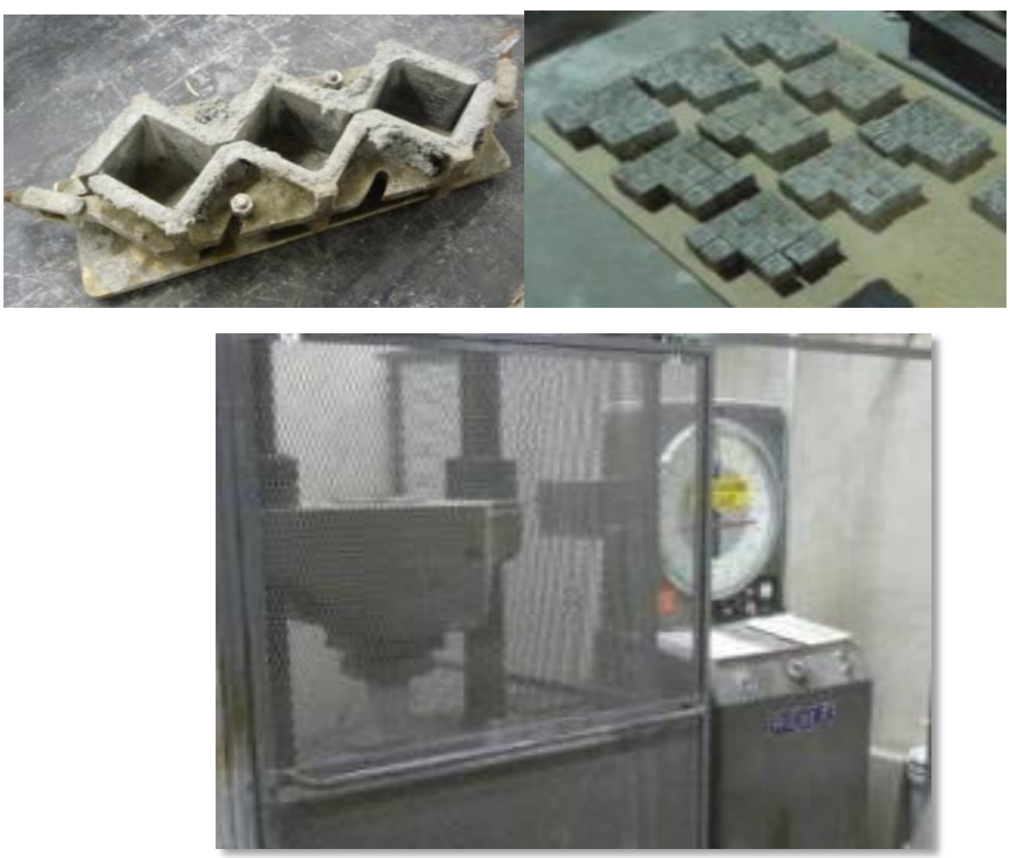

Fig. 2: Cubic mortar specimens and testing for compressive strength

The normal consistency of cement paste was conducted using Vicat apparatus (Fig. 3) as per ASTM C187-16 (2016). 650 g of nanocement with a measured quantity of distilled water following the procedure prescribed in the Procedure for Mixing Pastes of Practice as per ASTM C305-14(2014). The cement paste prepared was then quickly formed into the approximate shape of a ball with gloved hands. Then tossed six times through a free path of about 150 mm from one hand to another so as to produce a nearly spherical mass that could be easily inserted into the Vicat ring with a minimum amount of additional manipulation. The ball was pressed, resting in the palm of one hand, into the larger end of the conical Vicat ring (70 mm bottom inside diameter, 60 mm top inside diameter and 40 mm height), hold in the other hand, completely filling the ring with paste. The excess paste at the larger end was removed by a single movement of the palm of the hand. The ring was placed on its larger end on the base plate and sliced off the excess paste at the smaller end at the top of the ring by a single oblique stroke of a sharp-edged trowel hold at a slight angle with the top of the ring, and smoothed the top. The Vicat ring with the past inside was then centred at the Vicat Apparatus. The end of the 10 mm plunger rod was brought to the surface of the rod and released immediately. The paste shall be of normal consistency when the 10 mm dia plunger rod settles to a point 10 ± 1 mm below the original surface in 30 s after being released. The trial pastes with varying percentages of water were made until a paste with normal consistency was obtained.

Fig. 3: Vicat apparatus showing measurement of setting time

The setting time test was conducted (as per ASTM C191-13, 2013) using Vicat apparatus with the paste sample made with the percentage of mixing water required for normal consistency. The test specimen made with mix water satisfying normal consistency was used for the determination of time of setting by using 1 mm diameter Vicat needle (Fig. 3). The penetration of the 1-mm needle was determined every 15 min until a penetration of 25 mm or less was obtained in 30 s. The results of all penetration tests were recorded and then by interpolation, the time when a penetration of 25 mm was obtained. This was the initial setting time. The final setting time was when the needle did not sink visibly into the paste.

Results and Discussions

Table 1 summarises the fresh state and mechanical properties of nanocements. The normal consistency of both nanocements was 20% compared to between 26% and 33% of ordinary Portland cement. The mean initial and final setting time for nanocement 45 were 125 minutes and 350 minutes, respectively compared to 74.3 minutes and 186 minutes of nanocement 75.

Table 1: Fresh state and mechanical properties of nanocements

Properties		Nanocement 45**		Nanocement 75**	
Flow value (mm)	w/c ratio				
	0.18	116-125		135-138	
	0.21	129-132		144-148	
	0.24	135-138		154-155	
	0.27	140-145		160-162	
Setting time (min)	Initial	120		72	
		125	125*	75	74.3*
		130		76	
	Final setting	345		214	
		350	350*	126	186.0*
		355		218	
Compressive strength (MPa)	2days	32.1		48.1	
		34.2	34.1*	49.6	49.7*
		36.1		51.3	
	7days	42.1		61.2	
		43.1	42.5*	62.3	62.0*
		42.4		62.4	
	14 day	47.1		68.1	
		48.1	48.1*	68.5	71.1*
		49.2		69.3	
	28 days	58.1		77.4	
		59.3	59.6*	77.7	77.5*
		61.4		77.1	
	42 days	64.1		80.1	
		64.2	64.3*	80.3	80.3*
		64.5		80.5	

**mean value; ** Manufaturer: ZAO "IMETSTROY' Moscow*

Flow values of nanocement mortars with varying w/c are presents in Table 1. The w/c of 0.21 was required to achieve manufacturer's suggested flow value of 125-130 mm for nanocement 45 and 145-150 mm of nanocement 75. The water to cement ratio (w/c) of 0.21 was used to prepare mortar cube specimens for compressive strength tests as per ASTM C109, 2016). Thus the w/c of nanocement mortars was significantly lower than the w/c of 0.485 specified by ASTM C 109 (2016) for the preparation of Normal Portland cement mortar mixtures for compressive strength tests. This suggested substantially lower water requirement and high workability of nanocements compared to t Portland cement despite their high specific surface area. However, more investigations are necessary to clarify flow characteristics of nanocements with varying mixing parameters and water contents.

Table 1 and Figure 4 show the variation of compressive strength of nanocements based on mortar cubes with age of up to 42 days. Nanocement 45 and nancement 75 attained, respectively 57% and 64% of their 28 days strength of 59.6 MPa and 77.5 MPa in 2-days.

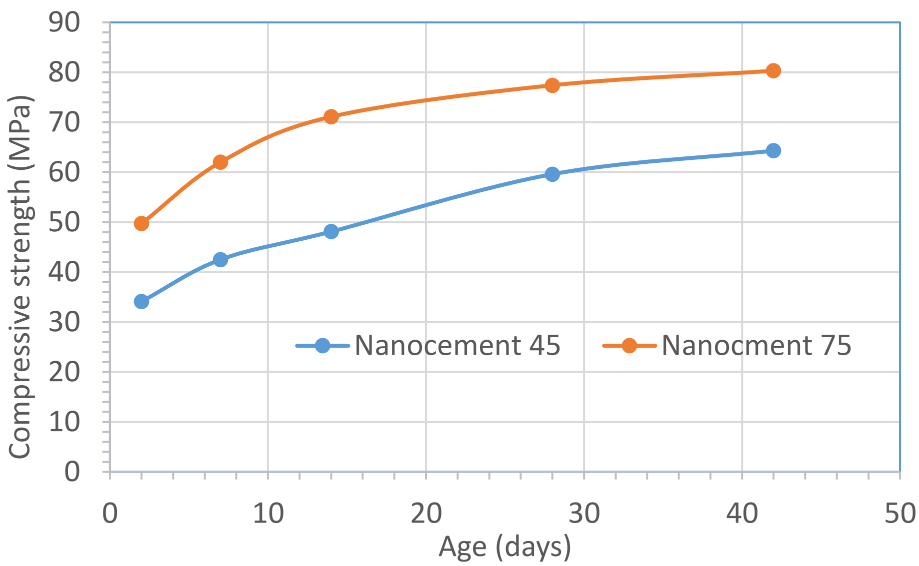

Fig. 4: Variation of compressive strength with age for nanocements

Conclusions

Developed nanocements with low water requirement and high strength development can provide a green and better alternative to commercially available Portland cements. More investigations can improve nanocement technology and efforts should be made for commercial production of such nanocements in association with Canadian industries.

Acknowledgement

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