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EFFECT OF SUPERPLASTICIZER ON PROPERTIES OF MORTAR

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Abstract: Superplasticizers are chemical admixtures used where well-dispersed particle suspension is required. They have become indispensable constituents of any designed cement mortar mix today. Property of fresh and hardened cement mortar is strongly influenced by the interaction of superplasticizers and cement which is essentially requiring a careful selection of SP dosage. The performance of superplasticizers in cementitious system is known to depend on cement fineness, cement composition mode of introduction to the mixture etc., as well as on the chemical composition of superplasticizers. This present study examined the effect of Plastiment –BV 40 and the effect of SP dosage on the properties of cement mortar was investigated. The test samples were subjected to elevated temperatures ranging from 200°C to 400°C. After exposure compressive strength test was conducted. The strength properties of cement mortars at different dosage of SP cement mortars were also investigated. The results show that 0.4-0.8 % more than dosage required to exhibits better workability and also strength for cement mortar.
Keywords: mortar, cement, superplasticizer, temperature, saturation dosage, strength

INTRODUCTION

Superplasticizers are chemical admixtures used where well-dispersed particle suspension is required (Ramachandran, 1995, Wikipedia, 2018). They have become indispensable constituents of any designed cement mortar mix today. Property of fresh and hardened cement mortar is strongly influenced by the interaction of superplasticizers and cement (Maheshwarappa et al., 2014) which is essentially requiring a careful selection of SP dosage (Ronneberg and Sandvik, 1990; Aitcin et al., 1991; Maheshwarappa et al., 2014).

The term cement-SP compatibility is used to represent the ability to achieve the desired result from a cement-SP combination in a concrete mix viz., improved workability for a given w/c or reduction in free water for a target workability (Maheshwarappa et al., 2014). An extensive literature had been carried out to study the effect of superplasticizer on the compressive strength of concrete and its workability. A study by Franklin (1976) reported that superplasticizers are organic polyelectrolytes, which belong to the category of polymeric dispersants.

The performance of superplasticizers in cementitious system is known to depend on cement fineness, cement composition mode of introduction to the mixture etc., as well as on the chemical composition of superplasticizers. Ozkul and Dogan (1999) carried out a study on the effect of an N-vinyl copolymer superplasticizer on the properties of fresh and hardened concretes.

Workability of concrete was measured by slump flow test and in situ tests were undertaken to find out the pumping ability of super plasticized concrete. The coarse aggregate was crushed stone with the maximum size of 25 mm. By using this chemical admixture, which was a little bit different from the conventional ones, the ability of water reduction was increased along with the retention of high workability for a longer time.

Roncero et al. (1999) evaluated the influence of two superplasticizers (a conventional melamine based product and a new-generation comb-type polymer) on the shrinkage of concrete exposed to wet and dry conditions. Tests of cylinders with embedded extensometers have been used to measure deformations over a period of more than 250 days after casting. In general, it was observed that the incorporation of superplasticizers increased the drying shrinkage of concretes when compared to conventional concretes, whereas it did not have any significant influence on the swelling and autogenous shrinkage under wet conditions.

Aitcin et al. (1991) reported that by choosing carefully, the combination of Portland cement and superplasticizer, it was possible to make a 0.17 water/binder ratio concrete with 230mm slump after an hour of mixing which gave a compressive strength of 73.1MPa at 24 hours but failed to increase more than 125MPa after long-term wet curing. During 1980s, by increasing the dosage of superplasticizers little by little over the range specified by the manufacturers, it is realized that superplasticizers can be used as high range water reducers (Ronneberg and Sandvik, 1990). In this current study, the strength properties of mortar have used as criteria for evaluating its performance. In the absence of proper quality control measures, the batch to batch variations in SPs can also add to the problems. Clearly, this is only a short-term solution.

For a more comprehensive approach, a thorough understanding of the causes and remedies of incompatibility is necessary. Since the problem is often region specific and project specific, it is necessary to identify possible source of variability and address the problem of incompatibility that can arise.

The chemical admixtures are very important components of modern concretes and mortars; they make it possible to modify certain properties of the mortar in the fresh or hardened state (Alsadey, 2015). Conventionally, researchers have used strength properties of mortar as criteria for evaluating its performance. A mortar having high strength does not necessarily imply that it will have a long- service life. Thus, it is clearly well known that mortar performance should be determined in terms of both strength and durability under anticipated environmental conditions. Various definitions exist for high-performance mortar (HPM). The objective of this current study is to investigate the effects of high temperatures on Superplasticizer Mortar performance. High-temperature resistance is defined as the ability of a structural element to withstand its load-bearing function under a high-temperature condition.

The mortar behaviour at high temperature is of concern in predicting the safety of building and construction in response to certain accidents or particular service conditions. The behaviour of mortar with respect to a high temperature where tested on groups of specimens to identical testing condition. Such investigation is aimed at studying the influence of exposing to high temperatures on some mechanical properties of mortar containing admixtures.

Most of the past studies had discussed the effect of temperature on concrete and the effect of admixtures on concrete independently but none of these studies had taken into consideration the effect of temperature on mortar containing admixtures which became the intention of the researchers to consider in this current study where it is expecting that each admixture dosage which will be added to mortar will have a different effect on the mechanical properties, under the influence of high temperatures.

METHOD AND MATERIALS

— Materials Used and Properties

The experimental investigation was carried out in the Concrete Laboratory of the faculty of Engineering at Bani Waleed University.

The cement used in mortar mixtures was the ordinary Portland cement type I manufacture in Zlitan. The fine aggregate was sea sand, with a fineness modulus of 2.86 and maximum size of less than 5 mm, and Ordinary drinking (tap) water from Bani Walid area was used in all cement mortar mixes of this study water.

Plastiment –BV 40 is the superplasticizer used in this study. Plastiment –BV 40 complied with requirements of ASTM (ASTM C494/C494M-04, 2004).

— Mix Proportions and Mixing Method

Five mortar mixes were prepared using the water-cement ratio as 0.42. The sea sand was used as fine aggregate. The mix design of the control mix (M1) was carried out according to the absolute volume method given by the ACI (ACI Committee 211, 1993) to achieve the criteria of flowing cement mortar.

The superplasticizer used in this study is Plastiment-BV 40. It is suitable for all types of cement mortar. One of its benefits is that it can improve both early and final strength. The superplasticizer dosages 0.4%, 0.8%, 1.2%, and 1.6% were used to prepare mixes: M2, M3, M4 & M5, respectively. Each batch of mortar was produced in a pan mixer.

The cement, sand, water and Plastiment-BV 40 were added to the mixer and mixed for 3 minutes. Each batch of cement mortar was produced in a pan mixer. Then after mixing process, the slump test was done. Then the mix was immediately poured into moulds by means of a scoop. Casting of the samples was carried out in two layers; each layer was compacted by using a small steel bar.

The complete compaction was determined by appearance of a film of cement mortar on the top, and the air void was no longer appearing. After compaction, the top surfaces of specimens were trowelled level for obtaining a smooth surface.

After casting, all specimens were kept under nylon sheets inside the laboratory for (24±2) hours to assure a humid air around the specimens and to prevent fast evaporation of water from the specimens, and then they were demoulded and cured until they were tested.

All specimens prepared for compressive were stored in tap water tanks until testing age of 28 days it was three cube samples of 50 mm were used for each mix. The compressive strength test was done immediately according to ASTM (ASTM C 192/C 192M, 2002) for each test mix.

— Mortar Heating and Cooling Process

The mortar specimens were heated to different levels of high temperatures; using an electrical furnace with a maximum temperature of (2400^{0}C). The furnace consists of wide chamber of a double metal containing auto-control thermal probes; with built in thermocouples.

The temperature of the furnace increases by an average value of (5^{0}C/min) at its primary stage up to (200^{0}C), becoming faster to about (10^{0}C/min) at the required temperature.

The mortar specimens were then placed inside the furnace for ten mints at a constant temperature; after that, the specimens were left for (10 min) to be air cooled.

RESULTS AND DISCUSSION

— Effect of Superplasticizer Compressive Strength

The change of the residual compressive strength in mortar mixes at an age of (28) days during the temperatures rise is shown in Figure (1).

In general, the compressive strength of different mortar mixes is decreased by various proportions as a result of exposure to high temperatures. As shown in Table (1), the highest stress was that for mortar containing the superplasticizer additive at 0^{0}C compared with reference mortar mix.

For reference mortar mix M1 at (28) days, the residual compressive strengths are about (41 N/mm^2, 40 N/mm^2) at a temperature of (200, 400)^{0}C respectively. The residual stresses for mortar containing additives are about (33 N/mm^2, 32 N/mm^2, 28 N/mm^2, and 27 N/mm^2) for (M2, M3, M4 and M5) respectively at a temperature of (200^{0}C). At a temperature of (400^{0}C), the residual compressive strength for mortar containing additive are about (32 N/mm², 30N/mm², 26 N/mm², and 24 N/mm²) for (M2, M3, M4, & M5) respectively.

Table 1. Effect of temperature on different properties of mortar

Mixture	Superplasticizer (SP) %	Slump (mm)	Compressive Strength (N/mm²)		
			0 C⁰	200 C⁰	400 C⁰
M1	0	145	43	41	40
M2	0.4	170	47	33	32
M3	0.8	173	49	32	30
M4	1.2	180	31	28	26
M5	1.6	210	31	27	24

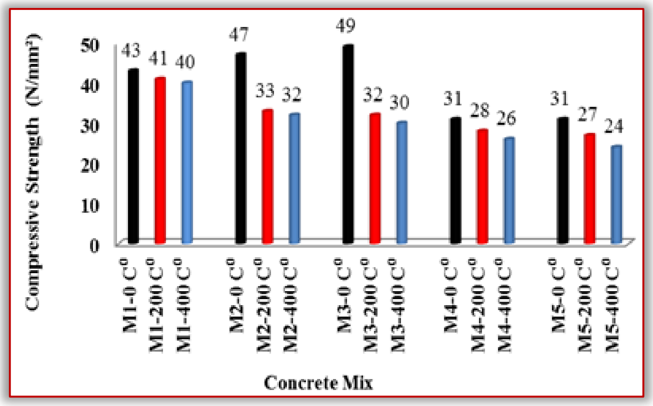

Figure 1. Effect of Temperature on Compressive Strength of Mortar

CONCLUSION

Based on these obtained results, this study concluded that the existence of additive in the mortar mix exposed to high temperatures resulting variable changes in compressive strength compared to the reference mix.

These changes –in general–varied from additive dosages for different temperatures; however it was limited to 200°C but was clear at 400°C.

It has also concluded that the mix containing a superplasticizer maintained the higher residual proportion of the compressive strength at a temperature of 0°C, while the mix containing the superplasticizer additive maintained the lowest residual compressive strength at temperatures of (200, 400)°C.

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