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EFFECT OF SUPERABSORBENT POLYMERS, SUPERPLASTICIZER AND ADDITIONAL WATER ON THE SETTING OF CEMENTITIOUS MATERIALS

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ABSTRACT

Superabsorbent polymers (SAPs) are particles which can take up a significant amount of fluid without dissolving and are already applied in cementitious materials. Water or superplasticizer needs to be added to compensate for the loss in workability, but both have an effect on several properties. In this paper, the effect on the setting of cementitious materials was compared for mixtures with (out) SAPs, with(out) superplasticizer and with(out) additional water. The mixing properties were quantified by means of flow tests, and the setting by ultrasonic transmission measurements and penetration tests. SAP particles reduce the flow but do not seem to influence the setting time. The used superplasticizer did have a pronounced effect on the setting, as the setting time was shifted for several hours. Additional water did not induce this effect and the setting was comparable to the reference mixture.

Keywords

Hydrogel; Workability; Retardation; Setting; Semi-adiabatic temperature

1.0 INTRODUCTION

Superabsorbent polymers (SAPs) are able to absorb up to 500 times their own weight in aqueous solutions due to osmotic pressure. Their long chains of linear polymers are interconnected at several points (crosslinks) and if an aqueous solution is absorbed, the chains will expand, causing the polymer to swell. Due to this interesting and useful feature, they are used in the hygiene, medical and building industry [1, 2]. In the building industry, they are used to mitigate autogenous shrinkage [3-6], to increase the freeze-thaw resistance [7, 8], and also for self-sealing [9-11] and self-healing [12, 13].

In these applications, mostly additional water is added to compensate for the loss in workability as the SAPs will absorb mixing water during mixing. The amount of additional water added is hereby dependent on the mixture composition, and the type and size of the SAP. A study of the rheological behaviour of the mixture can determine the additional water needed [3, 14]. The additional water is then held by the SAPs and released in time, which is useful for internal curing by maintaining the relative humidity and the reduction in autogenous shrinkage. Afterwards, as the SAPs shrink back to their original size, they leave macro pores behind. These voids are interesting for increasing the freeze-thaw resistance as the voids act in the same way as if an air-entraining agent is added.

Another way to compensate the loss in workability is the use of a superplasticizer. But the latter may influence the hydration. One of the characteristics influencing the practical application is the possible delayed hydration. If the mixture has a long setting time, the formwork cannot be removed early. This effect will therefore result in a delay in the construction process. Most types of superplasticizer do have this effect. A superplasticizer not only affects the fluidity of a cement paste, but also causes a stiffness like pseudo-setting or a remarkable retardation of setting [15]. For example, in literature, the initial setting was found to be delayed by 50% and the final setting by 10-30% in time when using 1.5 m% of cement weight of polycarboxylic ether, modified polycarboxylate or melamine formaldehyde [16]. A polycarboxylate-type superplasticizer retarded the initial set by 1 h and the final set by 2 h in slag pastes (1 m% of binder weight) [17]. A delay of 2 h in hydration time and an increase in heat evolution over several hours (3-17 h) was found when using 0.3v% of superplasticizer (experimental superplasticizers based on polycarboxylic acid). The time between the main hydration peak and the shoulder attributed to the consumption of calcium sulphate seemed to be prolonged as well [18]. Data on the degree of delayed hydration caused by SAPs are scarce in literature. Dudziak and Mechtcherine [19] showed that the final setting of specimens with SAPs, additional water – to compensate for the entrained water compared to SAP-less sample - and an increased amount of superplasticizer (0.37 w% of cement weight), was postponed by 2 to 4 h.

In this study, the effect of SAPs on the early age properties of cementitious materials will be studied. The fresh properties will be determined with slump tests and the setting will be studied by means of ultrasonic pulse velocity measurements and penetrations tests. This will give a general overview of the effects of SAPs, superplasticizer and additional water on the early-age properties of a cementitious composite. Hardening of a mixture determines the microstructural development, and this is a key parameter in the moisture transport processes. Microstructural properties then directly affect the strength and permeability characteristics of the cementitious material. These properties were already studied on the same mixtures in earlier research [20].

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EXPERIMENTAL AND NUMERICAL STUDY ON THE RESIDUAL STRENGTH OF DETERIORATED PRESTRESSED CONCRETE BRIDGE BEAMS AFFECTED BY CHLORIDE ATTACK

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ABSTRACT

In this research, corroded prestressed concrete beams, which had been in service for 35 years in coastal area, were selected as a research object. Four beam specimens were loaded in a flexural or in a shear test to investigate the residual load carrying capacity of corroded prestressed concrete beams. Not only maximum load but also failure mode depended on the distribution of corrosion. Through the measurement of weight loss of PC strands, it was clear that the strands were completely destroyed due to the corrosion in some positions. As a result of these experimental works, it is clear that the average weight loss of prestressing steel is somewhat correlated with the area of cracks per unit concrete area. Analytical studies were conducted to simulate the remaining strength. By taking the development length into consideration, both flexural failure load and shear strength are predicted reasonably.

Keywords

Chloride attack, Corrosion, Finite element analysis, Prestressed concrete bridge, Residual strength

1.0 INTRODUCTION

Prestressed concrete (PC) structures which were constructed in 1960's and 1970's are now deteriorated by chloride attack in Japanese coastal areas. To establish the maintenance strategy, the remaining strength should be estimated correctly. However, little research work has been done about the remaining strength of corroded PC structures. In this study, loading tests were carried out on the corroded PC beams which had been in service for 35 years in Japanese coastal area. Then, weight reduction of prestressing bars were measured and compared with the total area of cracks. Fiber analysis and Finite Element (FE) analysis were conducted to estimate the remaining strength of corroded PC members.

2.0 OUTLINE OF TEST PROGRAM

Urokozaki bridge which had been in service for 35 years near Japan sea was chosen to be loaded until failure because this bridge had deteriorated due to chloride attack (Figure 1). Urokozaki bridge consists of four pre-tensioned I-beams. The length of each beam is 10.4 m. Two of these beams (beam A and B) were tested in bending and the others (beam C and D) were tested in flexural shear (Figure 2). Figure 3 shows the cross-section of the I-beams. Each beam contains 32 PC strands, each consisting of 2 wires of 2.9 mm diameter and 2 single wires of 2.9 mm diameter in lower flange. The compressive strength of concrete is shown in Table 1. Compressive strength was measured with core-drilled cylindrical specimens of 70 mm diameter.

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Figure 1. Urokozaki bridge (Beam D)

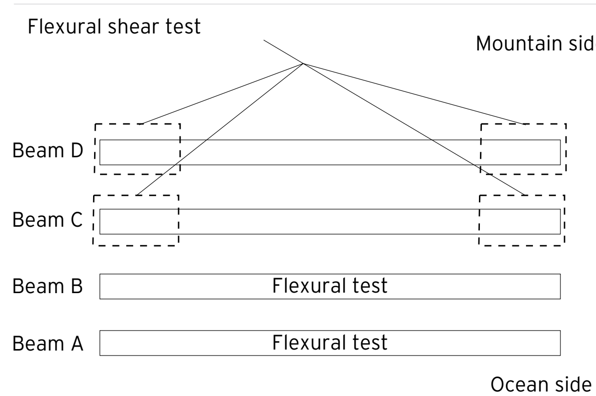

Figure 2. Loading types and positions

Table 1. Compressive strength of concrete

Beam	Comp. strength N/mm²	Elastic modulus X 10^3 N/mm²	Number of specimens
A	51.9	23.5	4
B	66.7	27.3	2
C	57.2	27.2	5/2
D	49.8	26.2	5/2

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PROPERTIES OF AMBIENT CURED UNSATURATED POLYESTER MORTAR AS BUILDING MATERIAL

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ABSTRACT

Unsaturated Polyester can be used as binder in making engineering materials. It can be used to bind the aggregates similar to that of conventional Portland cement. In this study, an attempt has been made to produce polymer mortar using polyester as the binder and natural river sand as the aggregate. The mortar was prepared using unsaturated isopolyester resin and river sand. It was cured by adding accelerator and initiator. The compressive, split tensile, flexural strengths of the mortar were determined. The stress-strain characteristics were studied for various parameters along with the modulus of elasticity. It was noticed that the compressive strength of the polyester mortar increases with the increase of polyester content for the given range. The compressive strength of the ambient cured mortar ranges from 3-56 MPa at the age of 7 days. The other mechanical properties of the mortar directly depend on the compressive strength like conventional cement mortar. Further, the mortar exhibited better ductile behaviour as compared to the Portland cement mortar.

Keywords

Polymer mortar, Iso-polyester, Compressive strength, Modulus of elasticity, FTIR analysis

1.0 INTRODUCTION

Polymers are being increasingly used as adhesives, modifiers, and matrix materials in concrete [1-4]. Polymeric composite materials are some of the recent building materials, and are continually appearing with new and optimized properties as new combinations and formulations are developed. Regardless of their significant advantages in comparison with conventional construction materials, the mechanical properties of polymer composites are related to the type and quantities of resin and reinforcement (or aggregate) used [5-10]. Polymer concrete (PC) is an example of such a composite having high performance. Its excellent mechanical strength and durability reduces the need for maintenance and frequent repairs required by the conventional concrete. An additional advantage of PC is its fast curing, which is an asset in the production of precast elements frequently used in the construction industry. It is most convenient as the PC elements can be demoulded in considerably short time [11].

Polymer concrete and mortar are compounds in which the aggregates are bound together by a polymer resin such as epoxy, unsaturated polyester, polymethylmethacrylate and other polymer resins. They possess better binding properties and excellent adhesion to aggregates compared to conventional cement. They have long chain structures which can cure or set through chemical reactions resulting in long range three dimensional structures. As a result, polymer usually provides superior compressive, tensile, flexural strength and chemical resistance to the concrete compared to Portland cement [12-15].

Unsaturated polyester resin is one of the widely used thermoset material with excellent properties and ease of processing in polymer composite industry [16-20]. Unsaturated polyesters (isophthalic based) are known for superior mechanical properties [21]. Their superior chemical and mechanical properties combined with low cost, make polyester resins the most widely used polymer in PC compositions [22]. There are no reports available on the study of such polyester resin mortars. To develop economical polymer mortar, a detailed study was undertaken to investigate the compressive, stress-strain behaviour, flexural and split tensile properties of polyester polymer mortar systems.

2.0 MATERIALS AND METHODS

2.1 Unsaturated Polyester

All materials used in the research were procured from commercial sources and were used as procured. An unsaturated polyester resin, Aropol 5334 was chosen as binder. It is a medium viscosity and medium reactive isophthalic resin with desirable mechanical properties and chemical resistance. The resin consists of 39 % of styrene monomer as a viscosity modifier which also serves as a cross linking agent. The viscosity of the resin used was 572 cps at 25^{o}C.

2.2 Curing Agents

Methy ethyl ketone peroxide (MEKP) and Cobalt napthenete

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CORRELATION BETWEEN COMPRESSIVE STRAIN AND ELECTRICAL RESISTANCE IN CARBON FIBER REINFORCED CEMENT COMPOSITES FOR EFFICIENT USE AS A SENSOR IN STRUCTURAL HEALTH MONITORING

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A B S T R A C T

To study the correlation between compressive strain and electrical resistance in carbon fiber reinforced cement composites, experimental investigation was conducted by preparing different cement mortar specimens by adding carbon fibres of different length with different volume fraction along with silica fume and superplasticizer. During the compression testing of cured samples the four electrode configuration was used for measurement of electrical resistance. Simultaneously with the compressive strength test, the potential difference between voltage electrodes of the sample was measured as while the potential difference across the reference resistance was measured. A strain gauge was used to monitor the strain of the sample. A strong correlation between the strain and electrical resistance change was found in cement matrix composite specimens. The study reveals that these smart materials of low cost, high sensitivity and highly durable can replace the normal sensors being used to measure the strain during the structural health monitoring in building industry.

K e y w o r d s

Cement composites, Carbon fiber, Smart materials, Self sensing, Strain

1.0 INTRODUCTION

Concrete structures are challenged by earthquakes, material degradations and other environmental factors. Concrete structures are frequently deteriorated within design life, while 30% of bridges were found to be structurally deficient in the USA [1]. Structural health monitoring is important to protect the lives and to manage the assets for repair and maintenance of concrete structures. Strain gauges which are used widely in structural health monitoring have low durability, low sensitivity and high cost which make their use limited [2, 3]. Integral smart materials which can sense strain and / or damage will reduce the cost of health monitoring of concrete structures and will be an important advancement in the construction industry.

By addition of carbon fibers, the electrical conductivity of the cement matrix composite material will be increased. The electrical resistance was found to be sensitive to strain [4-7]. Different electrode configurations and methods have been applied in several works for electrical properties of concrete measurements. Two and four electrode methods were used by different researchers [8, 9]. In cement based composites the electric conduction is achieved by either electrolytic conduction or electronic conduction [8].

A conductive tape or paint is pasted to the perimeter of the sample in the perimetral electrode configuration [1, 10-11]. In the embedded electrode method a conductive electrode is inserted into the composite. Carbon fiber reinforcement of cement matrix increases tensile strength and ductility while decreasing shrinkage cracking [12].

Cement composites were used as vehicle detectors [13]. The cement based barium titanate composites were investigated for different barium titanate concentrations for ferroelectric and piezoelectric properties [14]. Cement based composites were tested for piezoelectric strain factors and voltage factors [15]. The percolation theory was used in studying electrical conductivity of carbon fiber reinforced cement composites [16]. Geopolymers were studied for strain sensing [17]. Carbon black filled cement composites were studied for strain sensitivity [18, 19]. The cylinder splitting tensile test was used for determining the tensile strain sensitivity of the steel fiber reinforced cement matrix composites [20].

In this work, twenty one mixes with different carbon fiber lengths and volume ratios were studied. Apart from compressive strength, the strain and electrical properties were measured.

2.0 MATERIALS AND METHODS

Twenty-one different mixes were designed and tested. The aim of the tests was to find the mix that gives the strongest correlation between strain and electrical resistance change. The cement used was CEM I 42.5R, the ratio of sand to cement was 1 and w/c ratio was 0.4; 10% by mass of cement the silica fume was added; the superplasticizer Sika ViscoCrete High Tech 30 was applied in the quantity 2% by mass of cement in all mixes. The carbon fibers used were the polyacrylonitrile based