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UPVT measurements on effect of superplasticizers on early strength of cement mortars in normal and aggressive environments

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Abstract : *Cement mortar is a building material made by blending sand and cement with a predefined measure of water. This paper has made an attempt to make UPVT measurement on effects of superplasticizeron early strength of cement mortars in normal and acidic aggressive environments. In this test, the quality and nature of material is evaluated by measuring the speed of an ultrasonic pulse going through a solid structure. Superplasticizer is also added in cement mortars to study its effect via UPVT measurements. Superplasticizer is an admixture which reduces the water-cement ratio or increase the workability at the same water content. It can be concluded that ahigher speed demonstrates a better quality of the material.*

Keywords : *Superplasticizer, admixture, UPVT, aggressive environment.*

I. INTRODUCTION

Recently, the utilization of Nondestructive Testing (NDT) has become common for quality assessment. The NDT techniques such as impact-echo, pulse-echo, ultrasonic pulse velocity(UPVT), wave reflection etcintend to quantify the structure quality.The UPVT permits to quantify and to control a progression of fundamental parameters to decide the mortar quality.The pulse velocity in UPVT may be influenced by path length, lateral dimension of specimen to be tested in presence of reinforcement steel and moisture content of cement mortar etc.

Superplasticizers are frequently used in concrete technology inorder to improve the workability of mortar and concrete systemsfor demanding applications. The addition of superplasticizers isaiming at two objectives: first, the addition of superplasticizers allowscontrolling the flow properties, which are of major importancefor the design of, e.g., self-compacting concretes, andsecond, superplasticizers allow the reduction of the water to cementratio while maintaining workability in order to reach high strength and durability The cement–water system is highly sensitive to the addition ofsuperplasticizers. Already small amounts of superplasticizers enhancethe workability properties efficiently, but are often associatedwith strong, undesired retardation phenomena of the setting of the cement paste [2].

Superplasticizer is a type of water reducers, however, the difference between superplasticizer and water reducer is that superplasticizer will significantly reduce the water required for concrete mixing. Generally, there are four main categories of superplasticizer: sulfonated melamine formaldehyde condensates, sulfonated naphthalene formaldehyde condensaes, modified lignosulfonates and others such as sulfonic- acid esters and carbohydrate esters [1].In this study, polycarboxylate ether based superplasticizer is used.It consists of a carboxylic ether polymer with long side chains. At the beginning of the mixing process it initiates the same electrostatic dispersion mechanism as the traditional superplasticisers, but the side chains linked to the polymer backbone generates a steric hindrance which greatly stabilizes the cement particles ability to separate and disperse. Steric hindrance provides a physical barrier (alongside the electrostatic barrier) between the cement grains.

Impact of superplasticizer on compressive quality have been examined [3, 4, 5, 6].].Effect of ultrasonic pulse velocity tests on cementitiously stabilized materialshave been investigated [7, 8].Non-destructive testing of the CSMs were conducted using the CNS FARNELL PUNDIT 17 (Portable Ultrasonic Nondestructive Digital Indicating Tester)-Plus Ultrasonic Velocity Test System. This equipment was used to measure the propagation speed of a pulse of ultrasonic longitudinal stress waves .The device consists of a transducer and a receiver, which is connected to an electronic timing device for measuring the time interval between the initiation of a pulse generated at the transmitting transducer and its arrival at the receiver. The travel time through the specimen can be read from the PUNDIT-Plus digital display screen. The transducer and the receiver were contacted to the ends of the specimen. A water-based jelly (K-Y by Target) was used as the coupling agent to ensure full contact of the transducers and the surfaces. Travel time and the exact length of the specimens along the direction of testing were recorded for the calculation of Velocity. The P-wave velocity measurements were taken after curing. PUNDIT-Plus equipment was used

to record the time required for the ultrasonic P-wave to travel through the specimen. As the ultrasonic pulse velocity test is a non-destructive type of testing, these tests were conducted before the specimens were tested for the compressive test [8].Effect of ultrasonic pulse velocity tests on cementitiously stabilized materialshave been investigated [7, 8]. SP cause better scattering even at high water to concrete proportion and impact of superplasticizers on porosity have been seen[9,10,11].
Adsorption, fluidity and hydration property have been studies and it has been reported that use of superplasticizers improves the above described properties [12, 13, 14, 15, 16]. Durability, pore size distribution and rheological properties have been investigated and beneficial effect of superplasticizer have been reported [17, 18, 19, 20, 21, 22].

II. EXPERIMENTAL PROGRAMME

It was intended to observe the performance of superplasticizer via UPVT measurements on cement mortar mixes in different concentrations of acidic environments and compare the performances. The experimental programme included the consideration of effect of sulphuric acid environments on cement mortars in early age. The ratio in cement and sand in mortar were 1:4 and 1:6 by weight.
In present investigations, different superplasticizer dosages (1%, 2% of weight of cement) are mixed in mortar mix and mixes are prepared with different water cement ratio as per their achieved consistency.Abbreviations of some typical mortar mix designations are explained below in Table 1.
Mortar cube samples of 70.6 mm size were prepared as per standard procedure and immersed in two tanks of sulphuric acid of 1 N and 2 N concentrations respectively.The UPVT measurements are observed after 1 day curing in respective mediums.

Table 1 – Explanation of Some Mortar Mix Designations

Typical mix designation	Explanation
CM4W	Cement Mortar 1:4 Water cured
CM4N1	Cement Mortar 1:4 Normal 1 acid environment cured
CM4N2	Cement Mortar 1:4 Normal 2 acid environment cured
CM4S0%	Cement Mortar 1:4 with SP Dosage 0%
CM6W	Cement Mortar 1:6 Water cured
CM6N1	Cement Mortar 1:6 Normal 1 acid environment cured
CM6N2	Cement Mortar 1:6 Normal 2 acid environment cured
CM6S0%	Cement Mortar 1:6 with SP Dosage 0%

III. RESULTS AND DISCUSSION

UPVT measurements of both mortar mix designations 1:4 and 1:6 for 1 day with and without superplasticizer in all curing medium are shown in Table 2 and Table 3 respectively.
Generally, the effect of sulphuric acid to degrade the mortar specimens with time and the degradation depends on many factors such as concentration of sulphuric acid, time of exposure to aggressive environment etc.It has been investigated that the superplasticizer dosage will improve the pulse velocity, there is still an ideal farthest point for the utilization of admixture.

Table 2- UPVT measurements for mortar 1:4

Mortar Proportion [1:4]			
SP Dosage	CM4W (km/s)	CM4N1 (km/s)	CM4N2 (km/s)
CM4S0%	2.16	2.05	1.95
CM4S1%	2.42	2.27	2.01
CM4S2%	1.89	1.80	1.72

Table 3- UPVT measurements for mortar 1:6

Mortar Proportion [1:6]			
SP Dosage	CM4W (km/s)	CM4N1 (km/s)	CM4N2 (km/s)
CM4S0%	2.04	1.93	1.86
CM4S1%	2.30	2.13	1.90
CM4S2%	1.80	1.72	1.61

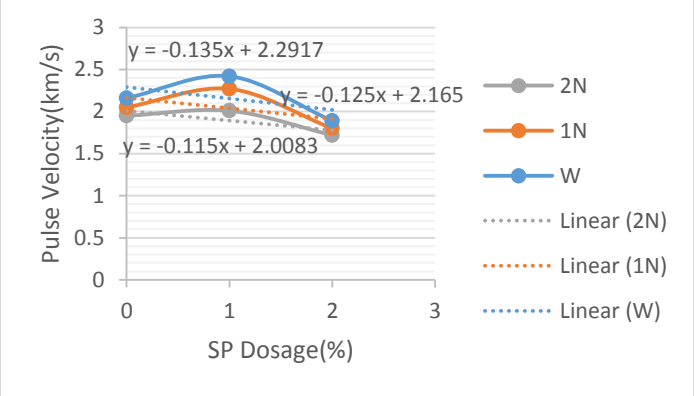

Figure 1 – Pulse Velocity for mortar 1:4

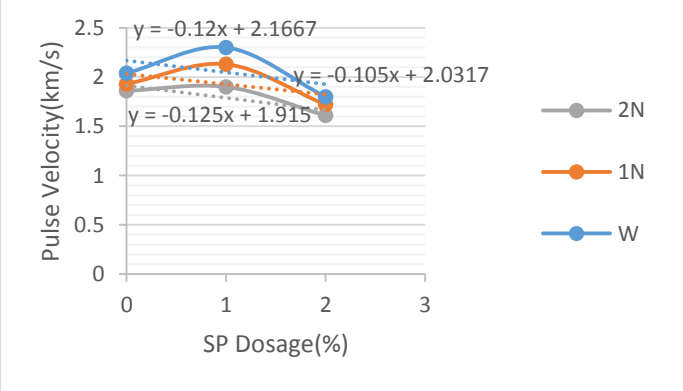

Figure 2 – Pulse Velocity for mortar 1:6

The figure shows all the above described results with trendline equations for both mortar mix designations 1:4 and 1:6. From the figure 1 it can be seen that there is approximately 12% increase in pulse velocity and degradation of 21% in increasing order of SP Dosage in mortar mix designation 1:4. However, there is decrease of approximately 5% pulse velocity when the curing medium changes from water to 1N and then finally to 2N concentrated sulphuric acid solution. It can also be concluded that there is

decrease of nearly 13% in pulse velocity when dosage increases directly to 2%

From the figure 2 it can be concluded that there is approximately 13% increase in pulse velocity and degradation of 18% in increasing order of SP Dosage in mortar mix designation 1:6. However, there is decrease of approximately 4% pulse velocity when the curing medium changes from water to 1N and then finally to 2N concentrated sulphuric acid solution. It can also be concluded that there is decrease of nearly 13% in pulse velocity when dosage increases directly to 2%. In 1N and 2N concentrated sulphuric acid curing, there is increase of 10% and degradation of 15% pulse velocity respectively with increment of SP Dosage.

IV. CONCLUSION

There is increase in pulse velocity when superplasticizer dosage are increased to 1%, however when dosage is increased to 2%, pulse velocity decreases.

Ultrasonic pulse velocity is a valuable technique for characterization of cement-based composites. This chapter shows that this technique has been used for different purposes over the years, e.g. setting and hydration of cement, detection of defects in structures, assessment of damage after high-temperature exposure, incorporation of different aggregates in concrete, among others. It continues to be an important non-destructive technique, which provides reliable results based on rapid measurements with relatively inexpensive equipment. Ultrasonic pulse velocity test is led by passing a beat of ultrasonic wave through cement to be tried and measuring the time taken by pulse to get past the structure. Higher speeds demonstrate great quality and progression of the material, while slower speeds may show cement mortar with many splits or voids.

This study indicates that UPV test is a sensitive tool to analyze variations in homogeneity and density of the concrete. UPV tests can supply important data about decision-making of concrete conditions. It can be concluded that, by means of UPV, it is possible to contribute with the control of deterioration and concrete structures quality.

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