International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, July 2017- Available at www.ijraset.com

Effect of Poly Vinyl Acetate and Poly Vinyl Alcohol as Cement Admixture on Strength of Concrete

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Abstract: This paper reviews the observations of addition of poly vinyl alcohol and poly vinyl acetate the poly fibers together to cement bond matrix. Polymer fiber serves as superplastitisizer which results in low rate of water absorption, high range water reducer greater strength and excellent in elasticity. The experimental study done was observed to determine the optimum dosage for the admixtures and to study the effect of over dosage. The elastic property of the polymer fiber reinforces its property to produce better earthquake resistance of building structure. Polymer fiber was dissolved in water in five different proportions as 2%to 10% with respect to cements weight in kg. The tested specimen was studied for curing and compressive strength on 7th, 14th, and 28th days. Results were studied which proved that concrete mix having polymer fiber gave greater strength than the standard mix.[1] It was further observed that out of five different proportions 2% mix of poly vinyl alcohol and poly vinyl acetate gave higher strength than other higher proportion. The result may improve further if proportions between 0.5% to 2% are taken.
KeyWords: Strength of concrete, superplastisizer, Poly vinyl acetate, Poly vinyl alcohol

I. INTRODUCTION

Concretes mainly consist of ordinary Portland cement (OPC), fillers such as sand, coarse aggregates, admixtures and water. This combination of materials allows concrete to be produced in a fluid form that can be pumped and moulded. Research activity in high performance and high strength concrete has always been a topic of interest to civil engineers. To reach the needs of modern civilization continuous research work are done for the development of new low cost materials with specific properties. Much advancement in the field of cement – based product which is related to the use of admixtures like polymer added in small quantities to modify the properties of cement products.

II. ADMIXTURES

Admixtures are those ingredients in concrete other than Portland cement, water, and aggregates which are added to the mixture immediately before or during mixing. Admixtures are classified by its function as Air-entraining admixtures, Water-reducing admixtures, Plasticizers, Accelerating admixtures, Retarding admixtures, Hydration-control admixtures, Corrosion inhibitors, shrinkage reducers, Alkali-silica reactivity inhibitors, coloring admixtures and miscellaneous admixtures.

Admixtures should have the following properties as to reduce the cost of concrete construction, to achieve certain properties in concrete more effectively, than by other means, to maintain the quality of concrete during the stages, of mixing, transporting, placing, and curing in adverse weather conditions, to overcome certain emergencies during concreting operations. Currently, there is an extensive use of chemical admixtures mainly to control/modify the fresh and hardened properties of concrete. The most common admixtures for cement and concrete include accelerators, set retarders, air entraining agents, and superplasticizers. Their successful use requires a basic knowledge of concrete technology, standard construction procedures, and familiarity with cement-admixture interactions. A particular challenge of interest to the authors is to optimize the use of dispersing agents such as superplasticizers in high performance concretes containing high volumes of supplementary cementing materials (SCMs). Dispersing agents such as superplasticizers are commonly used in these concretes. There are, however, practical problems such as loss of workability with time that are controlled by interactions with cement components. Controlling the timing of the availability of an admixture in cement systems is essential for its optimal performance.

A. Admixtures for Concrete

They are used in concrete generally serve as water reducers, accelerators, set retarders, or a combination. Types of admixtures its chemical composition and its advantages are known. High-range admixtures reduce the amount of water needed to produce a concrete of a specific consistency by 12% or more [2, 3].

III. CHEMICAL ADMIXTURES

B. Water-Reducing Admixtures

Decrease water requirements for a concrete mix by chemically reacting with early hydration products to form a monomolecular layer at the cement-water interface that lubricates the mix and exposes more cement particles for hydration.

C. Super Plasticizers

It 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 [4].

1) Chemicals:

a) Sulfonated melamine formaldehyde condensates
b) Sulfonated naphthalene formaldehyde condensates
c) Modified lignosulfonates
d) Others such as sulfonic acid esters and carbohydrate esters

2) Advantages:

a) Cement content can be reduced to a greater extent keeping the same water/cement ratio. This will lead to economy.
b) Water-cement ratio can be reduced significantly keeping same cement content and workability. This will lead to increase in strength.
c) Higher workability at very low water cement ratio like casting concrete with heavy reinforcement..
d) Reduction in permeability
e) Where early strength development is required in prestressed concrete or casting of floor, where early access for finishing equipment is required.

D. Air-Entraining Agents

Increase the resistance of concrete to frost action by introducing numerous tiny air bubbles into the hardened cement paste.

1) Chemicals:

a) Abietic and pimeric acid salts
b) Fatty Acid salts
c) Alkyl - aryl sulphonates
d) Alkyl sulphonates
e) Phenol ethoxylate

2) Advantages:

a) Durability
b) Reduced bleeding and segregation because of attachment of air bubbles with cement particle and linking them.
c) Increase in inter particle attraction caused by adsorption of air entrained.
d) Bubble acting as extra fine filler and increased total surface area of constituents relative to water volume.
e) Water flow between cement particles is restricted.
f) Workability increased due to action of air bubbles as ball bearing which assist movement of particles each other

E. Set-Accelerating Admixtures

They are used to decrease the time from the start of addition of water to cement to initial set and to increase the rate of strength gain of concrete. The most commonly used set-accelerating admixture is calcium chloride.

1) Chemicals:

a) Alkali Hydroxides, Silicates,
b) Fluoro-Silicates, Organic Compounds,
c) Calcium Formates, Calcium Nitrates,
d) Calcium Thio Sulphates,
e) Aluminium Chlorides, Potassium Carbonates,
f) Sodium Chlorides & Calcium Chlorides.

2) Advantages

a) Shortens the setting time of cement and therefore increases the rate of gain of strength.

b) Enables earlier release from precast moulds thus speeding.
c) Reduces segregation and increase density and compressive strength.
d) Cures concrete faster and therefore uniform curing in winter and summer can be achieved.
e) Early use of concrete floors by accelerating the setting of concrete.
f) Reduces water requirements, bleeding, shrinkage and time required for initial set.

F. Retarding Admixtures

They are used to retard the initial set of concrete. A Type B or D admixture will allow transport of concrete for a longer time before initial set occurs. Final set also is delayed. Hence, precautions should be taken if retarded concrete is to be used in walls

1) Chemicals:

a) Lignosulphonic acids and their salts. e.g. Na,Ca.
b) NH4,Hydro-carboxylic acids and their salts.
c) Carbohydrates including sugar. Inorganic salts based on flourates, phosphates, oxides, borax and magnesium salts.

2) Advantages:

a) Improves workability, cohesion and extends setting time, provides protection against delays and stoppages and facilitates keeping workable concrete for extended period.
b) In the large construction, good workability of the concrete throughout the placing period and prevention of cold joints is ensured by adding retarders in the concrete.
c) Extended setting time minimize risks of long distance delivery in hot weather, improves pumpability of concrete by extended setting period and improved workability of concrete.
d) Reduces bleeding and segregation where poor sand grading are unavoidable.
e) Reduces adverse environmental effects of various natures on concrete and embedded steel by considerable reduction in permeability.

G. Mineral Admixtures

These include fly ashes, pozzolans, and micro silicates. Natural cement is sometimes used as an admixture [5, 6].

1) *Corrosion Inhibitors:* They are sometimes added to a concrete mix to protect reinforcing steel. The steel usually is protected against corrosion by the high alkalinity of the concrete, which creates a passivation layer at the steel surface.
2) *Damp Proofing Admixtures:* They may be a waterproofing or a damp proofing compound or an agent that creates an organic film around the reinforcing steel, supplementing the passivation layer. The latter type of admixture may be added at a fixed rate regardless of expected chloride exposure.
3) *Gas-Forming Admixtures:* They are used to form lightweight concrete. They are also used in masonry grout where it is desirable for the grout to expand and bond to the concrete masonry unit. They are typically an aluminum powder.
4) *Coloring Admixtures:* They may be mineral oxides or manufactured pigments. Coloring requires careful control of materials, batching, and water addition in order to maintain a consistent color at the jobsite. Note that raw carbon black, commonly used for black color, greatly reduces the amount of entrained air in a mix.

IV. MISCELLANEOUS ADMIXTURES

A. Bonding Admixtures

They are organic polymer emulsions (sometimes called latexes). They usually increase the air content of mortars or concretes [2,7]. The principal organic polymer emulsions used in these admixtures are polyvinyl acetate, acrylic or styrene-butadiene. The polyvinyl acetate types may or may not be re-emulsifiable. The re-emulsifiable polyvinyl acetate types should be restricted to interior or other areas not subjected to immersion. Bonding admixtures tend to render plastic concretes sticky and more difficult to place and finish. Part of this characteristic is due to their air-entrainment and part to the nature of the latex itself.

B. Polymer in Concrete

When Portland cement is replaced by a polymer, the resulting concrete has a lower rate of water absorption, higher resistance to cycles of freezing and thawing, better resistance to chemicals, greater strength, and excellent adhesion qualities compared to most other cementitious materials [8,9]. The most commonly used resins (polyesters and acrylics) are mixed with aggregates as a monomer, with a cross-linking agent (hardener) and a catalyst, to reach full polymerization [10,11]. Polymer concretes are usually reinforced with metal fibers, glass fibers, or mats of glass fiber. Polymer-impregnated concrete (PIC) is cured Portland cement concrete that is impregnated with a monomer using pressure or a vacuum process. The monomer (most often an acrylic) is polymerized by a catalyst, heat, or ultraviolet radiation. A continuous surface layer is formed that waterproofs and strengthens and fills the voids.

C. Polymer Materials: As Admixture

The polymer materials which were used as admixtures in the experimental work done previously were Poly vinyl acetate and poly vinyl alcohol. The properties of which are as follows:

Material		**Properties**
Poly Vinyl Alcohol:	(PVA; PVOH) CAS: 9002-89-5 (-CH2CHOH-)	White to cream-colored powder. Properties depend on degree of polymerization and the percentage of alcoholysis, both of which are controllable in processing. Water solubility increases as molecular weight decreases; strength, elongation, tear resistance, and flexibility improve with increasing molecular weight. Tensile strength up to 22,000 psi; decomposes at 200°C. PVA has high impermeability to gases, is unaffected by oils, greases, and petroleum hydrocarbons. Attacked by acids and alkalies. It forms films by evaporation from water solution and combustible.
Poly Vinyl Acetate:	(PVAC) CAS: 9003-20-7 [CH2CH (OOCCH3)]	Colorless, odorless, transparent solid, insoluble in water, gasoline, oils, and fats; soluble in low molecular weight alcohols, esters, benzene, and chlorinated hydrocarbons, resistant to weathering and combustible.

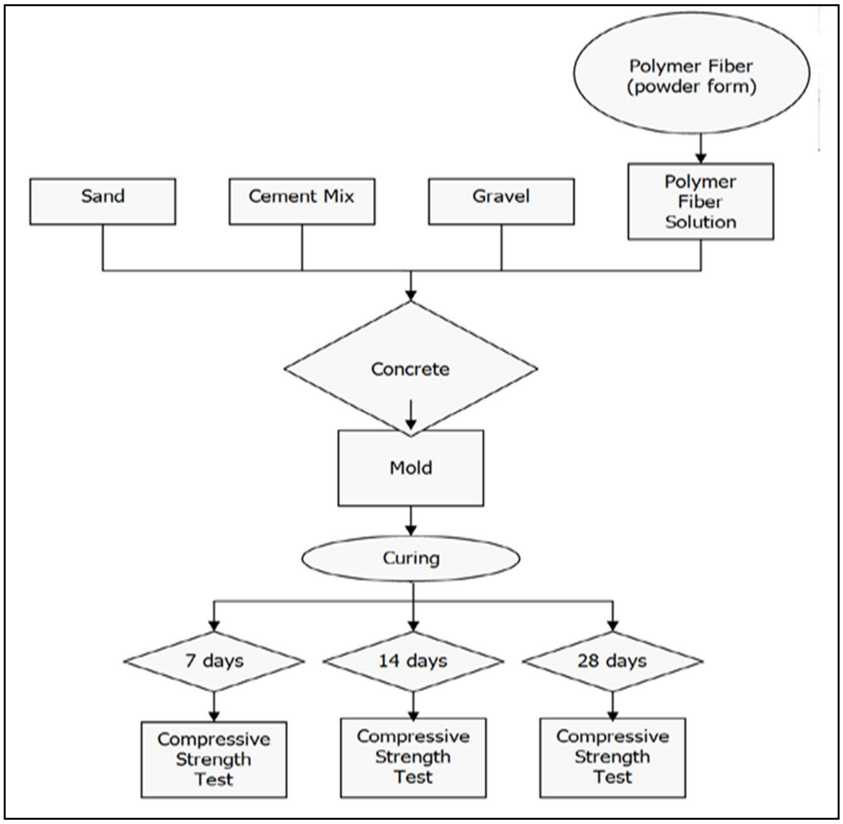
V. PREVIOUS EXPERIMENTAL INVESTIGATION

Tomas U. Ganiron has done the experiment in which the specimens were grouped according to the proportions of polymer fiber to cement (by weight in kg) such as 2% to 98%, 4% to 96%, 6% to 94%, 8% to 92%, and 10% to 90%, respectively.

The polymer fiber solution (polyvinyl acetate being dissolved in water) was mixed manually with a shovel to sand and gravel at constant mix proportion of class “A” at 1:2:4. It was noticed that the greater the polymer fiber the more viscous is the mix, which made it non-workable to place. The specimens were tested on the hydraulic press on the seventh, fourteenth and twenty-eighth days of curing to get the compressive strength. It was noted that the results taken from the standard mix was the same as the 6% to 94% proportions of polymer fiber to cement, respectively. Moreover, the 2% to 98% proportions of polymer fiber to cement gave the highest strength result.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, July 2017- Available at www.ijraset.com

The following flowchart is the methodology followed for finding out compressive strength of concrete.



Flowchart 1:Compressive strength methodologyhe results obtained for the previous work done were tabulated as follows:

Table1: 7th Day Curing

Specimen Type	Cement Content %	Polymer Fiber Content %	Compressive Strength kg / cm²	Compressive Strength lb. / in²
Standard (Control)	100	0	225	3194
With Polymer Fiber	98	2	275	3903
With Polymer Fiber	96	4	250	3548
With Polymer Fiber	94	6	225	3194
With Polymer Fiber	92	8	175	2484
With Polymer Fiber	90	10	175	2484

Table 2: 14th day Curing

Specimen Type	Cement Content %	Polymer Fiber Content %	Compressive Strength kg / cm²	Compressive Strength lb. / in²
Standard (Control)	100	0	250	3548
With Polymer Fiber	98	2	300	4258
With Polymer Fiber	96	4	275	3903
With Polymer Fiber	94	6	275	3903
With Polymer Fiber	92	8	225	3194
With Polymer Fiber	90	10	200	2839

Table3: 28th Days of Curing

Specimen Type	Cement Content %	Polymer Fiber Content %	Compressive Strength kg / cm²	Compressive Strength lb. / in²
Standard (Control)	100	0	300	4258
With Polymer Fiber	98	2	400	5677
With Polymer Fiber	96	4	350	4968
With Polymer Fiber	94	6	325	4613
With Polymer Fiber	92	8	275	3903
With Polymer Fiber	90	10	225	3194

VI. SUGGESTIONS

According to Tomas U. Ganiron , under compressive strength test with the use of the hydraulic press, the specimens were cracked as the concrete has reached its ultimate strength and recorded as listed above as shown in Tables 1, 2 and 3.The proportion of 2% to 98% gave the highest strength obtained from 7, 14 and 28 days of curing. Also, it was observed and inferred that the greater strength results are due to the bonded aggregates, which can be seen from the cracked specimens showing fine textures of aggregates. His experiment suggested that the results proved that polymer fiber satisfies strength requirements as it gives better results over the standard mix.

While analyzing the previous work done it was observed that as the percent of polymer was increased the concrete became more viscous which made it non workable to place. Moreover the compressive strength observed was more in the specimen of 2% to 98% polymer to cement ratio mix. The result may improve further if proportions between 0.5% to 2% of polymer to cement are taken.

VII. ACKNOWLEDGMENT

The authors are thankful to the reviewers for their valuable suggestions to enhance the quality of our article.

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