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Enhancement of Properties Polymer Modified Ferrocement

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***Abstract*-- In an effort to improve the performance of mortar, polymer is introduced into mortar. It has been reported that polymer-modified mortar (PMM) is more durable than conventional mortar due to higher strength. This research was carried out to establish the effects of polymer addition on compressive strength, flexural strength, modulus of elasticity of mortar and flexural strength and tensile strength values on polymer modified ferrocement samples with mortar of constant flow value. Two types of polymers were used i.e. SBR and VAE polymer. The mixes were prepared with polymer-cement ratio of 0%, 5%, 10%, 15% and 20% for each and a flow value of 110 +_ 5 is fixed for every mix of mortar.**

The flexure strength of ferrocement samples also increases on polymer addition for third point loading test. Polymer modification of cement paste increases its tensile and flexural strength and reduces its brittle nature. We will conclude by showing that future use of polymer modified cement composites will likely be in the area of durability and performance improvements of cement materials applied in thin sections.

***Keyword*-- SBR, VAE, Polymer Modified Ferrocement**

I. Introduction Structure Of Polymer

The word polymer comes from Greek words poly meres, where poly meaning "many" and meres mean "parts". In short, polymers are materials with long chain molecules that are composed of a large number of repeating units of identical structure. Polymers made up of one type of monomer are called photopolymers, while those made up of one or more monomers are called copolymers. "Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small diameter wire mesh; the mesh may be made of metallic or other suitable materials" [1].

Polymers can be divided into 3 main structures named linear polymers, branched polymers, and cross linked polymers. Linear polymer consists of monomers that are linked in a long chain. This structure cannot turn in any directions. Among the polymers found with this structure are polyethylene, polyvinyl alcohol and polyvinyl chloride (PVC) [2].

Branched polymers have another chain that is bonded to the long molecular chain. This chain is formed with the presence of monomer from reactive group. Cross linking polymers have two or more chains that are linked by short side chains. A more complex link will gives us a three dimensional structure while lowly linked chains will give a two dimensional structures.

Styrene-Butadiene Rubber Latex SBR

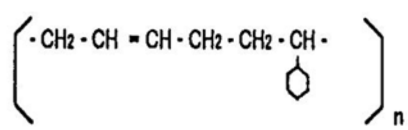

Figure: 1 Structure of VAE and SBR polymer

II. Principles Of Latex Modification

The co-matrix phase of latex modification of cement mortar and concrete is formed by both cement hydration and polymer film formation processes. Generally, the polymer film formation comes after the cement hydration process. Polymers Improve Mortars in Four Main Ways

1. More extensive cement cure. Cement/concrete strength depends on proper curing, a chemical reaction (hydration) between water and cement that causes crystals to grow and wrap around the mix components [3].

During the early stages of cure (roughly the first five to seven days), there must be enough water to maintain the hydration process or the cement/concrete will not harden properly. Polymers reduce the rate of water evaporation, allowing the crystal structure to keep growing and building strength during these critical early curing stages. This reduced water evaporation is especially important in thin applications, where the surface area for evaporation is high, relative to the volume of the mortar.

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2. Improved workability. Polymer modification noticeably improves application characteristics, making the mortar more fluid and easier to handle and apply. Certain polymers also prolong the hydration period, which can increase working time, an important characteristic in hot climates. This means contractors can use less water for workability purposes. The polymer acts as a water reducer, ultimately leading to a stronger mortar with fewer voids, or weak spots.
3. Improved adhesion. Polymer modifiers act as an adhesive to enable the modified mortar overlay to stick to a variety of surfaces such as concrete, masonry, brick, wood, rigid polystyrene and polyurethane foam, glass, and metals. Adhesion is an important property; especially in thin section overlay mortar applications such as spray coatings, stuccos, and underlayment's, and applications with excessive vibration and heavy traffic [4].
4. Improved strength and durability. Cured polymer-modified mortars generally have improved tensile strength, flexural strength, impact and abrasion resistance, water resistance, and chemical resistance versus unmodified mortars. Also, the polymer in the mortar helps restrain micro-crack propagation, which improves the overall toughness of the mortar.

III. Mechanism Of Polymer-Cement Co-Matrix Formation

First Step:

When polymer latexes are mixed with fresh cement mortar or concrete, the polymer particles are uniformly dispersed in the cement paste phase. In this polymer-cement paste, the cement gel is gradually formed by the cement hydration and the water phase is saturated with calcium hydroxide formed during the hydration, whereas the polymer particles deposit partially on the surfaces of the cement-gel-unhydrated cement particle mixtures [5]. It is likely that the calcium hydroxide in the water phase reacts with a silica surface of the aggregates to form a calcium silicate layer. It is confirmed that the formation of the calcium hydroxide and ettringite in the contact zone between the cement hydrates and aggregates is attributed to the bond between them.

Second Step:

With drainage due to the development of the cement gel structure, the polymer particles are gradually confined in the capillary pores.

As the cement hydration proceeds further and the capillary water is reduced, the polymer particles flocculate to form a continuous close-packed layer of polymer particles on the surfaces of the cement-gel-unhydrated cement particle mixtures and simultaneously adhere to the mixtures and the silicate layer over the aggregate surfaces. In this case, the larger pores in the mixtures are found to be filled by the adhesive and autohesive polymer particles.

Third Step:

Ultimately, with water withdrawal by cement hydration, the close-packed polymer particles on the cement hydrates coalesce into continuous films or membranes, and the films or membranes bind the cement hydrates together to form a monolithic network in which the polymer phase interpenetrates throughout the cement hydrate phase [6]. Such a structure acts as a matrix phase for latex-modified mortar and concrete, and the aggregates are bound by the matrix phase to the hardened mortar and concrete.

IV. Objectives

- To determine the workability of the fresh polymer modified mortar with different polymer cement ratio.
- To determine the effect of polymer addition on water cement ratio while maintaining the same workability.
- To obtain the compressive strength of ordinary mortar with polymer modified mortar with constant and varied water cement ratio.
- To obtain the flexure strength and modulus of elasticity of ordinary and polymer modified mortar with the varied water cement ratio.
- To obtain the flexure strength, tensile strength and corresponding deflection or elongation of the polymer modified ferrocement beams.

V. Experimental Work

Flow Test:

The flow test is conducted first to find the flow value of at constant and varied water cement ratio. The cement sand ratio was used as 1: 2. The constant flow value 110±5 was fixed at 0 % polymer. The effects of two polymers SBR and VAE was studied. It was find that flow of mortar increases by adding polymer at constant w/c ratio. The amount of polymer was added 5%, 10%, 15% and 20% for each. The SBR was used in latex form and VAE in powder form. It was found that SBR increases the flow value as compared to VAE polymer but these flow values are always more than the without addition of polymer.

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This is mainly interpreted in terms of improved consistency due to the ball bearing action of polymer particles and entrained air and the dispersing effect of surfactants in the latexes. Hence a fixed value of w/c ratio is found out at each particular addition of polymer.

Cubes	Size of cube (mm)	No. of cubes	Water- cement ratio	Cement: sand
At const. w/c ratio	70.6*70.6	27	Constant (0.58)	1:2
At varied w/c ratio	70.6*70.6	27	Varied	1:2

The compressive strength was calculated by following formula:

$$f = F/A$$

Where:
f = Compressive strength (MPa)
F= Ultimate load (N)

A = Cross-sectional area perpendicular to loading direction (mm)

It was found that compressive strength for the varied w/c ratio was more as compared to the constant w/c ratio.

VI. RESULTS

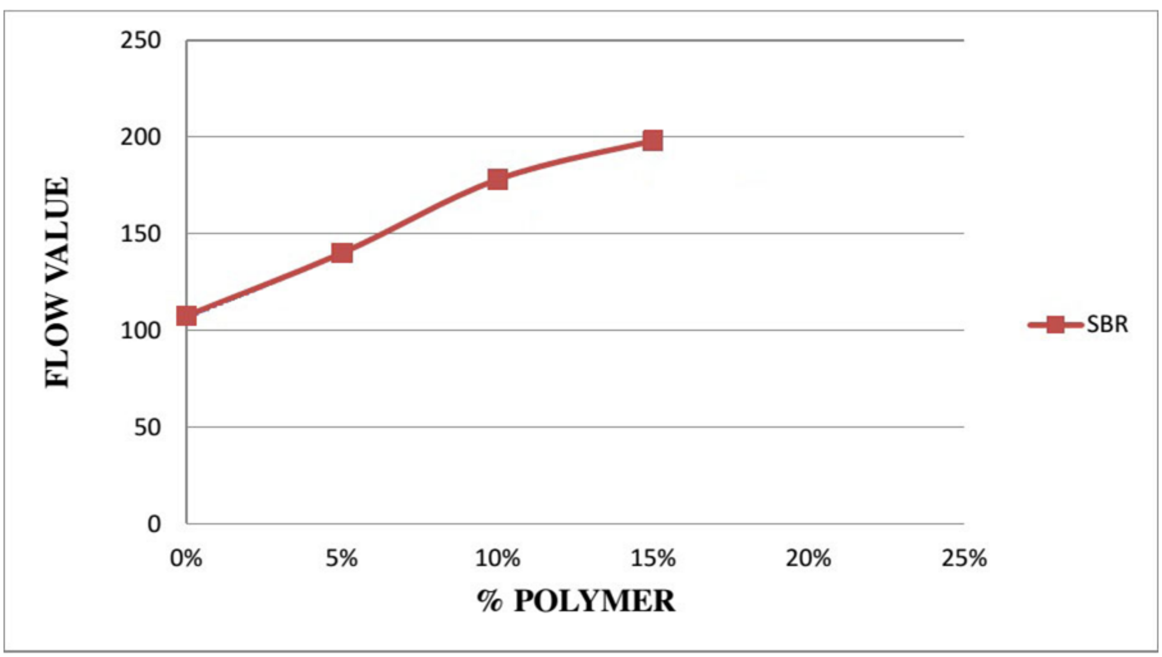

Figure: 2 Flow Value Vs Percentage Polymer at constant water cement ratio

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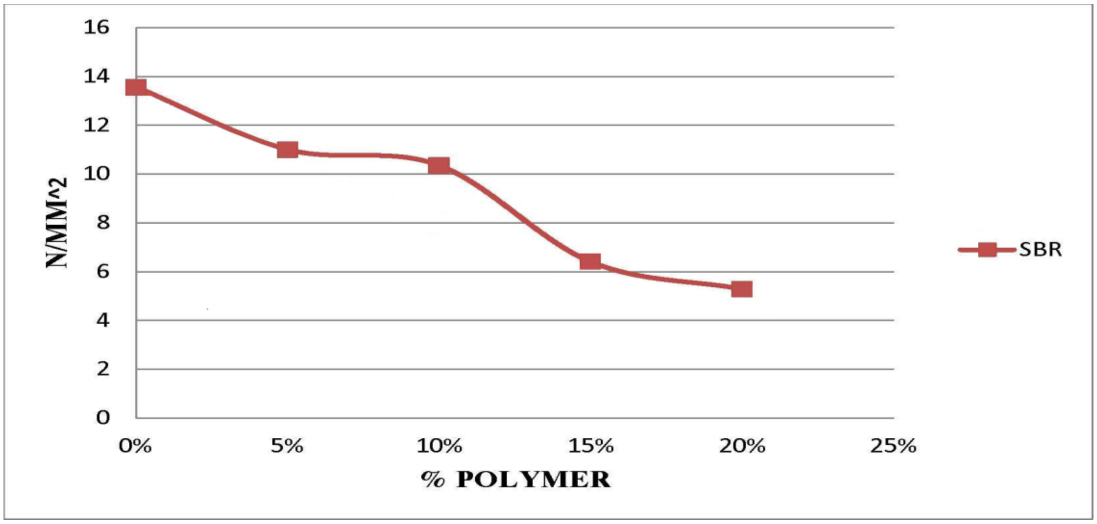

Figure: 3 Compressive Strength Vs % Polymer after 7 days at constant w/c ratio

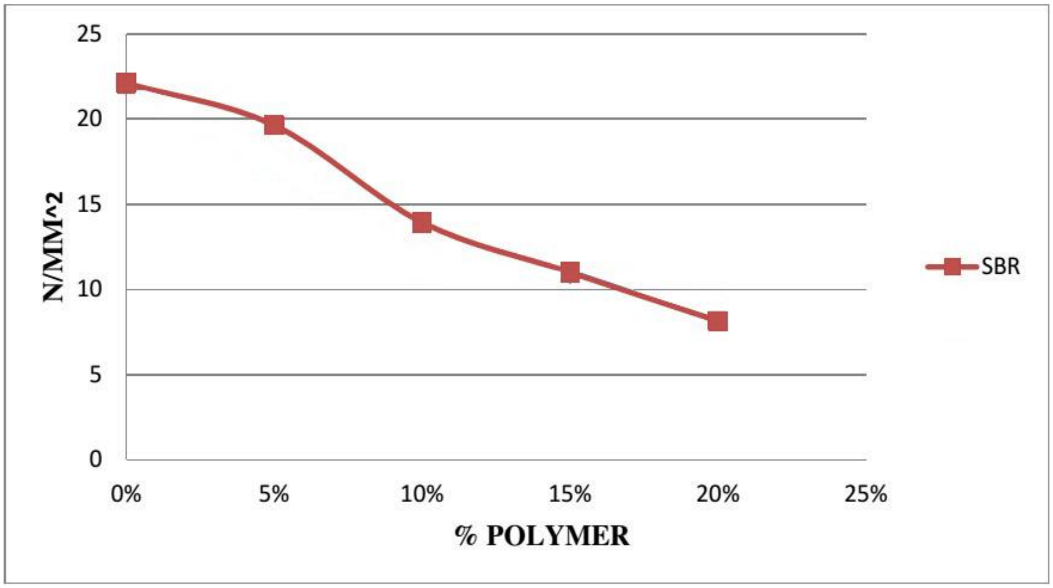

Figure: 4 Compressive Strength Vs % Polymer at constant w/c ratio after 28 days.

VII. CONCLUSIONS

The addition of VAE and SBR polymer in mortar increases the workability. At constant water cement ratio the workability can be increased up to 1.84 times at 15 to 20 % SBR addition.

The compressive strength of polymer modified cement decreases at constant water cement ratio. But at varied water cement ratio the compressive strength of polymer modified cement increases up to 10 % and then starts decreasing after 7 days.

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At varied water cement ratio the compressive strength of VAE modified mortars decreases but the compressive strength of SBR modified mortars increases both after 7 and 28 days.

The flexure strength of both VAE and SBR modified mortars increases but after 15 % the flexure strength of VAE modified mortars starts decreasing.

Modulus of elasticity of SBR modified mortars increases with increasing in polymer content up to 10 % and then starts decreasing but modulus of elasticity of VAE modified mortars decreases with increase in polymer content in mortar. The tensile strength of both VAE and SBR modified ferrocement samples increases with increase in polymer content. The elongation and load of three layered polymer modified ferrocement found more than the two layered. SBR modified ferrocement beams take more load than VAE for both flexure and tensile strength.

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