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EXPERIMENTAL INVESTIGATION ON STRENGTH PROPERTIES OF POLYMER MODIFIED CONCRETE

(PHASE-1)

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ABSTRACT:

The concept of polymer modification for cement mortar and concrete is not new, since considerable research and development of polymer modification have been performed for the past 75 years or more. As a result, various polymer-based admixtures have been developed, and polymer-modified mortar and concrete using them are currently popular construction materials because of their good cost-performance balance. This project summarizes the classification of polymer-based admixtures, the admixtures which consists of polymeric compound as a main ingredient effective at modifying or improving the properties of strength, deformability, adhesion, waterproof and durability of cement concrete and mortar.

The principles of polymer modification by the use of polymer latexes, redispersible polymer powders, water-soluble polymers and liquid polymers, the properties and applications of polymer- modified mortar and concrete. This study is also explain about the various literature study and their consolidation of that study. This study is mainly deals with the polymer modified concrete and their properties.

The future focus of this project is to utilize the SBR polymer in cube, cylinder, prism and beam in order to find their structural behaviour of polymer modified concrete. The various parameters such as stress-strain relation,

first crack load, deflection ductility have to be determined. The polymer modified concrete is also compare the structural behaviour with conventional concrete in order to determine the variation of the strength and the parameters.

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Keywords:

of strength, deformability, adhesion, waterproof, durability of cement concrete and mortar, SBR polymer, polymer modified concrete

CHAPTER -1

INTRODUCTION

1.1 GENERAL

Developing Countries are trying their best to achieve rapid progress in the fields of industry and housing. Progress involves large-scale construction activities. Cement concrete has been one of the important materials of construction, in spite of its many drawbacks, the newly developed "Polymer Concrete" possessing many superior properties over conventional cement concrete, renders itself as one of the most versatile construction materials. Polymer concrete in particular, is highly suitable in case of pre-fabricated building industry, irrigation structures, marine structures nuclear power production and desalination plants.

A polymer-based (or polymeric) admixture, also called a cement modifier, is defined as an admixture which consists of a polymeric compound as a main ingredient effective at modifying or improving the properties such as strength, deformability, adhesion, waterproofness and durability of cement mortar and concrete. Such a polymeric compound is a polymer latex, redispersible polymer powder, water-soluble polymer or liquid polymer. The cement mortar and concrete which are made by mixing with the polymer-based admixtures are called polymer-modified mortar (PMM) and concrete (PMC), respectively. In general, the properties of polymer-modified mortar and concrete depend significantly on the polymer content or polymer-cement ratio (defined as the mass ratio of the amount of polymer solids in a polymer-based admixture to the amount of cement in a polymer-modified mortar or concrete) rather than the water-cement ratio compared with ordinary cement mortar and concrete.

1.2 POLYMER LATEX

Polymer as admixture can improve the properties like higher strength and lower water permeability than the conventional concrete Polymer latexes which consist of very small (0.05-5 pm in diameter) polymer particles dispersed in water are usually produced by emulsion polymerization. The formulations for emulsion polymerization of typical polymer latexes is used as polymer-based admixtures.

1.3 OBJECTIVE

- To improve the adhesion or bond strength in the concrete
- To decrease the pores in the concrete, compare to the conventional concrete
- To increase the strength & durability of the concrete
- To improve the mechanical properties of repaired concrete
- To improve the corrosion resistance to the concrete

1.4 SCOPE

- To arrive the mix design of the polymer modified concrete with SBR as a admixture
- To study the behavior of polymer cement concrete in the hardened state. The variables studied include the grade of concrete and dosage of polymer.
- To study the various mechanical properties like compressive strength, splitting tensile strength, flexural strength, stress–strain characteristics, and modulus of elasticity and permeability characteristics of concrete
- To cast the polymer modified concrete.
- To compare the result between the conventional concrete and polymer modified concrete

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

In this literature review the main aim is to study the polymer modified concrete. Basically this study is mainly focus on polymer latex, in that polymer latex the SBR is add as the chemical admixture, but this study is also about the different type of latex and their physical properties, chemical properties and mechanical properties are reviewed. This study is also compare the structural behaviour of conventional and polymer modified concrete.

2.2 REVIEW OF LITERATURE

Indrajit Ray et al. (2004) focused about the four types of latexes of the vinyl polymer group and SBR latex in varying dosages was studied with respect to setting time, consistency of fresh cement pastes, subjective workability (surface texture, segregation), bleeding,air content, water reduction capacity and the flow-time relationship of fresh mortar. Vinylacetatveavo, Methylmethacrylate-butylacrylate and 2-ethylhexylacrylate,Vinylacetate-butylacrylateand 2-ethylhexylacrylate, Styrene-butadiene rubber are the latex is used. Sulphonated melamine and formaldehyde condensate, Sulphonated naphthalene and formaldehyde, Modified lignosulphonate, Sulphonated naphthalene formaldehyde and lignosulphonate condensate, Sulphonated melamine formaldehyde and naphthalene formaldehyde condensate are the superplasticiser. It has been observed that superplasticisers of melamine formaldehyde and a blend of melamine and naphthalene formaldehyde eliminated shortcomings like delayed setting, high air entrainment in the fresh latex-modified system whereas lignosulphonate and a blend of lignosulphonate and naphthalene formaldehyde aggravated it.

V. Bhikshma et al. (2010) studied about the polymer based admixture, Rheomix 141 is styrene-butadiene co–polymer latex, specifically designed for use with cement composites. It is used in mortar and concrete as an admixture to increase resistance to water penetration, improve abrasion resistance and durability. This study includes the behavior of polymer cement concrete in the hardened state. The variables studied include the grade of concrete and dosage of polymer. Five different grades of concrete M20 to M60 with polymer quantities starting from 5% to 10% were used in that work. The various mechanical properties like compressive strength, splitting tensile strength, flexural strength, stress–strain characteristics, and modulus of elasticity and permeability characteristics of concrete have been studied. The result shows that there is an increase in the workability of concrete as the polymer content increased, in all the grades of concretes from M20 to M60. There is an improvement in the strength of concrete as the polymer content increased in the mix for all grades of concretes tested in this investigation. The maximum increase in compressive strength at 10 % polymer content for low medium and high strength concretes varied from 16.25% to 33.4% while the increase in split tensile strength varied between 5.1 to 19.8%. However, the increase in flexural strength ranged between 13.2 to 18.4%.In general, it is observed that the overall performance of the concrete is improved with the addition of polymer, by weight of cement, for all the grades of concretes tested. However, the effect of polymer on performance of normal concrete is superior to its effect on high strength concrete.

M.A. Islam et al. (2011) reviewed about the potential of polymer modified concrete as a structural material. Polymers with different kinds of fillers are used as construction materials. They have good binding properties and good adhesion with aggregates. They have long-chain structure, which helps in developing long-range network structure of bonding. In contrast, cement materials provide short-range structure of bonding. As a result, polymer materials usually provide superior compressive, tensile and flexural strength to the concrete compared to Portland cement. Some polymer materials may selectively provide higher tensile and flexural strength to the structure comparedto compressive strength. In addition, they provide good adhesion to other materials as well as resistance to physical damage (abrasion, erosion, impact) and chemical attack. Structures in hostile environments, inaccessible for repair, or subject to impact, cyclic, or dynamic loading could benefit from PMC. Aging infrastructure can be repaired using PMC. Although polymer concrete might initially seem a bit more expensive when compared to conventional materials because of the monetary cost per unit weight it will appear extremely feasible when judged on its low maintenance requirements, its durability and other parameters.

Moetaz m. El-hawary et al. (2004) focused on corrosion and durability of polymer modified concrete. Polymer and cement may be used together to form what is known as Polymer Modified Concrete. One of the advantages of introducing polymer in concrete is to increase its corrosion resistance. Epoxy coated bars has been used to reduce corrosion but was found to localize corrosion in certain areas as they usually get scratched. The main objective of this proposed work is to investigate the corrosion resistance of reinforced Polymer Modified Concrete in the hot marine environment and the possibility of introducing epoxy in concrete to improve its durability. Different percentages (0, 10,20,40,60, 100%) of cement were replaced by epoxy. Cylinders, cubes and special reinforced prisms were utilized. Specimens were put in the testing tanks of a specially manufactured accelerated marine durability system, where they were exposed to cycles of sea water wetting and hot air drying. Specimens were examined after 90 and 150 cycles of exposure. The specimens were then tested to investigate the effect of different polymer percentage and number of exposure cycles on the compressive strength, absorption, chloride penetration and steel corrosion. Corrosion was investigated using the half-cell corrosion meter beside the actual determination of loss in bar weight and diameter. The introduction of epoxy in the concrete mix was found to increase the corrosion resistance, reduce permeability, reduce chloride penetration and increase strength. The improvements were found to increase with the increase in epoxy Percentage. The increase in the polymer percentage correspondingly increases the corrosion Resistance of the resulting polymer modified concrete .Introduction of epoxy increases the concrete durability in general as it reduces the concrete permeability. Chloride ions penetrability was also reduced as a result of introducing epoxy in concrete mixes. The reduction is proportional to the epoxy percentage as cement placement. The prices of polymers are diminishing and their use in construction is inevitable. The replacement of 20% of cement with epoxy is recommended to achieve acceptable corrosion resistance in hot marine environments.

Samir M. Shihada et al. (2013) studied on repair of pre-cracked rc beams Using the use of four cementitious repair materials in terms of restoring the flexural capacities of pre-cracked reinforced concrete shallow beams. Fifteen reinforced concrete beams are cast, pre-cracked, repaired and then tested under four point-loading. The repair materials used include Ultra High Performance Concrete (UHPC), Ultra High Performance Fiber Reinforced Concrete (UHPFRC), Normal Strength Concrete (NSC) and Cement-based Repair Material (CRM). Added to this, three beamsare cast, tested and considered as control beams. The outcome of this study shows that the four repair materials can achieve flexural capacities ranging from 97 % to 111% of the control beam capacities. It is recommended to use UHPFRC or CRM "BETONREP-250" for repair of beams damaged in the form of excessive cracking. Smaller mid-span deflections are recorded when UHPFRC and CRM repair materials are used. The crack patterns of the beams repaired using UHPFRC and CRM show less flexural cracks compared with the rest of the beams. It is not recommended to use NSC in repair of damaged beams. Future investigations are needed in order to assess the performance of repaired beams when submitted to blast loads.

L.K. Aggarwal et al (2007) studied about the properties of polymer-modified mortars using epoxy and acrylic emulsions. Water based polymer systems are often used for improvement in the properties of plain cement mortar or concrete. Presently, latexes of a single or combinations of polymers like polyvinyl acetate, copolymers of vinyl acetate–ethylene, styrene–butadiene, styrene–acrylic, and acrylic and styrene butadiene rubber emulsions are generally used. One of the limitations of these polymer systems is that they may re-emulsify in humid alkaline conditions. To overcome this problem, an epoxy emulsion based polymer system has been developed. This study the properties of the cement mortar modified with this newly developed epoxy emulsion are compared with those of the acrylic-modified mortar. The results of this study showed that the addition of polymer to cement mortar improves workability, increases flexural and compressive strengths, and decreases water absorption, carbonation and chloride ion penetration. However, at the same amount of polymer–cement ratio epoxy emulsion showed slightly better properties than acrylic emulsion. In addition, the epoxy emulsion based mortars have several advantages over solvent-based epoxy mortars. Thus, epoxy emulsion based mortar is a potential material that can be used for repair works in humid and industrial environments.

F.A. Shaker et al (2007) reviewed about the durability of styrene-butadiene latex modified concrete. The use of latex modified concrete (LMC) in construction has urged researchers to review and investigate its different properties. This study is part of a comprehensive investigation carried on the use of polymers in concrete. The main objective of this study to investigate and evaluate the main durability aspects of Styrene-Butadiene latex modified concrete (LMC) compared to those of conventional concrete. Also, the main microstructural characteristics of LMC were studied using a Scanning Electron Microscope (SEM). LMC was found to have a dense microstructure, smaller discontinuous pores, less porous transition zone, better bond between the aggregate and the cement matrix, and bridged microcracks with respect to conventional concrete. The water tightness of the LMC is superior to that of the conventional concrete as measured by the water penetration, absorption and sorptivity tests. The effect of using longer sorptivity test time on the test results of the LMC requires further investigations. The LMC provides better protection to steel reinforcement against chloride induced corrosion in structures exposed to severe chloride environment such as bridge overlays. The resistance of LMC to abrasion, and sulphate solution were found to be much improved compared to those of the conventional concrete. The cost of producing LMC should not be compared to the cost of the production of conventional concrete on short run. Although, LMC has higher initial production cost it should be compared with the sum of the initial production cost of conventional concrete plus the cost of the expected repair works during the service life of the structures, especially those exposed to severe aggressive environment. More research work is required to investigate the effect of the sulphate attack on the LMC, and also the effect of using different cement types on the performance of the LMC, LMC offers many advantages for structures where durability is the main concern.

S.H. Okba et al (1997) studied about the evaluation of the corrosion resistance of latex modified concrete (LMC). In recent years, various reinforced concrete structures worldwide have suffered rapid deterioration. Therefore, durability of concrete structures especially those exposed to aggressive environments is of great concern. Many deterioration causes and factors have been investigated. Corrosion of steel reinforcement was found to be one of the major deterioration problems. Penetration of chloride ions is one of the main causes which induces corrosion. The objective of this study is to evaluate the corrosion resistance of latex modified concrete (LMC) compared to conventional concrete using an accelerated corrosion cell. The corrosion cell proved to be a good and simple method to evaluate the durability of concretes especially with respect to chloride ion penetration, and the protection of reinforcement against corrosion. The latex modified concrete (LMC) has a much better corrosion resistance compared to the conventional concrete of almost the same strength level. The corrosion resistance of the latex modified concrete increases significantly with age while that of the conventional concrete has a marginal increase. This higher resistance offers a better protection for the steel reinforcement against corrosion and especially that induced by the penetration of the chloride ions, which recommends the use of such concrete in structures exposed to severe environments such as bridge decks overlays, and marine structures. Since the cost of production of latex modified concrete is higher compared to conventional concrete, the optimum latex modified concrete cover thickness for overlays should be investigated using the accelerated corrosion cell.

G. Barluenga et al (2004) focused about the sbr latex modified mortar rheology and mechanical behavior. The study deals with the influence of water-to-cement ratio (W/C) and percentage of polymer in the setting time, rheology and physical and mechanical properties of a Styrene–Butadiene–Rubber (SBR) Latex Modified Mortar (LMM). An experimental test program including setting time and consistency in the fresh state and porosity, density, ultrasonic modulus and compressive and flexural strength in the hardened state of a LMM at different ages was performed. Several W/C and percentages of latex were studied. The consistency of SBR Latex Modified Mortar (LMM) depends on both water-to-cement ratio (W/C) and percentage of latex (PL). The study presented allows prediction of the consistency as a function of both dosage parameters. The SBR LMM experimental results showed that the mechanical properties depend also on dosage parameters and the results obtained by keeping constant W/C or consistency cannot be compared. In the first case, compressive strength decreased as PL increased and the flexural strength does not depend on PL. In the second case, compressive strength does not depend on PL and flexural strength increased with PL. The mechanical properties of LMM can be predicted as a function of dosage parameters and physical properties obtained using nondestructive test methods such as the ultrasonic velocity pulse test. Dynamic modulus decreases and loss tangent increases when PL in SBR LMM increases. Both variables define SBR LMM dynamic behaviour.

Ru Wang et al (2006) studied about the influence of polymer on cement hydration in SBR-modified cement pastes. The influence of styrene–butadiene rubber (SBR) latex on cement hydrates $Ca(OH)_2$, ettringite, C_4AH_{13} and C–S–H gel and the degree of cement hydration is studied by means of several measure methods. The results of DSC and XRD show that the $Ca(OH)_2$ content in wet-cured SBR-modified cement pastes increases with polymer–cement ratio (P/C) and reaches a maximum when P/C is 5%, 10% and 10% for the pastes hydrated for 3 d, 7 d and 28 d, respectively. With wet cure, appropriate addition of SBR promotes the hydration of cement, while the effect of SBR on the content of $Ca(OH)_2$ and the degree of cement hydration is not remarkable in mixed-cured SBR-modified cement pastes. The content of $Ca(OH)_2$ in wet-cured SBR-modified cement pastes increases with P/C firstly and then declines after reaching a maximum, and in the longer hydration time the variation is more obvious. With wet cure, appropriate addition of SBR accelerates the cement hydration reaction, and the degree of cement hydration is maximal when P/C is 5%, 10% and 10% for the modified pastes hydrated for 3 d, 7 d and 28 d, respectively. While the influence of SBR on the Ca $(OH)_2$ content and the degree of cement hydration is slight inmixed-cured SBR-modified cement pastes. SBR promotes the reaction of calcium aluminate with gypsum and thus enhances the formation and stability of ettringite; meanwhile it restrains the formation of C_4AH_{13}. The $[AlO_4]^{5-}$ tetrahedron and $[AlO_6]^{9-}$ octahedron are the forms of aluminum oxide polyhedrons in SBR-modified cement pastes, and the octahedron is prominent. The $[SiO_4]^{4-}$ is tetrahedron monomer or dimer structure in SBR-modified cement pastes hydrated for 3 d, and three-tetrahedron polymer appears in themodified pastes hydrated for 28 d. The effect of a small SBR dosage on the structure of A_{l3+} and $[SiO_4]^{4-}$ in SBR-modified cement pastes is slight. However, the combination of A_{l3+} with $[SiO_4]^{4-}$ tetrahedron is restrained with above 12% SBR addition, and some $[AlO_6]^{9-}$ octahedron separates from the three dimensional structural net of $[SiO4]^{4-}$ tetrahedron .At the same time, the polymerization of $[SiO_4]^{4-}$ tetrahedron in C–S–H gel is affected and its polymerization degree depresses obviously.

M. Iqbal et al (2014) studied about the Behavior of Polymer Strengthened Plain Concrete. In this study, effectiveness of polymer modified mortar on the mechanical properties of repaired Plain Cement Concrete (PCC) was studied through laboratory testing. 69 specimens (18 x Prisms, 30 x cubes and 21 x cylinders) were cut in different ways including horizontal, vertical, single, double and inclined cuts. The cut specimens were then repaired using mortars modified with three polymers namely Styrene Butadiene Rubber Latex, ZUBA (latex of various polymers) and Polyvinyl Acetate polymers and were tested under compressive and flexural load and the strength was compared with reference specimen. Overall, ZUBA & SBR polymers were found more effective in restoring the compressive strength of concrete cubes. The compressive strength recovery ranging from 85% to 98% of cut specimens was achieved by ZUBA SBR polymers. The percentage recovery in flexure strength of moulds which were fractured was greater than those which were cut. This behavior was seen in concrete prisms. This is possibly due to the rough texture of the fractured surface, which facilitated in the formation of a stronger bond between the two surfaces as compared to the smooth surface of the moulds which were cut. Maximum recovery in flexural strength recovery was achieved by SBR polymer which is 55% of the original flexural strength. All the polymers were more effective in restoring the compression strength of concrete cubes as compared to cylinders in which recovery percentage was very low except ZUBA polymers. The reduced effectiveness of polymers in restoring the original strength of concrete cylinders may be attributed to reopening of repaired crack. In case of cubes the failure plane and the plane of cut were different in most of the cases, which means that the bond remained intact and instead the concrete failed. In case of cylinders failure occurred along the plane of repair which means that the repairing polymers were not effective in restoring the original compression strength. The recovery in compressive strength was more as compared to flexural strength in all polymers

Sivakumar.M.V.N (2010) focused on effect of Polymer modification on mechanical and structural properties of concrete. This study presents the effect of different polymers on structural and mechanical properties of concrete. The aim of this study is to investigate the mechanical and flexural properties of polymer modified concrete. Two different types of polymers are used at different dosages to modify the cement concrete matrix. Besides, a series of tests without modification was also carried out. By means of four-point loading method, the flexural strength and flexural properties of polymer modified concrete are measured. The influence of different polymers and its optimum dosage in respect of flow and strength characteristics are found. it is evident that the performance and structural characteristics of polymer modified concrete is superior to conventional concrete. It is observed that not only in hardened state but also in its fresh state. Compressive strength results envisage that the modification at optimum dosages is well advantageous and attaining superior results in early age. A dosage of 15% polymer is observed to be the optimum dosage in both the cases to achieve complete polymerization and subsequent improvement in performance.

Dr.G.D.Awchat et al (2010) studied about the experimental studies on polymer modified steel fibre reinforced recycled aggregate concrete. Waste concrete with a lower degree of contamination is a potential source for the production of aggregate for concrete mix. Recycled Course Aggregate (RCA) particles consist of substantial amount of relatively soft cement paste component also they are more porous and less resistant to mechanical actions. Since the era of using concrete for construction purposes, various researchers are continuously trying to improve the performance and various strengths of concrete by keeping options of economy in construction costs. One of the options is use of Polymer Modified Steel Fibre Reinforced Recycled Aggregate Concrete (PMSFRRAC). It is observed that experimental results PMSFRRAC with 30 kg/m3 and 5% polymer provides improvement in compressive strength up to 6.86%, split tensile strength by about 4.24% and flexural strength up to 5.43% as compared to corresponding properties of NC. The application of PMSFRRAC is more useful when strength criteria for the design of structures are more than economical aspect of design.

Ali Abd_Elhakam Aliabdo et al (2012) investigated on the properties of polymer modified SCC. Polymer modified self-compacting concrete achieves the advantages of both self- compacting concrete and polymer modified concrete. Polymer modified SCC may be used successfully in repair of concrete elements or construct new concrete elements especially when concrete subjected to sever conditions. There is no further information about properties of polymer modified SCC. The main aim is to study the interactions between main self-compacting concrete components (filler and high dose of chemical admixtures) and main components of polymer modified concrete which is polymer itself. The effect of polymer content, polymer type, filler type and base of chemical admixtures were studied. Cube compressive strength, tensile strength, dynamic modulus of elasticity, bond strength between concrete and steel reinforcement, bond strength between self-compacting concrete and old concrete, thermo-gravimetric and X-ray diffraction analysis were used to evaluate the effect of studied parameters. The increase of styrene butadiene rubber and polyvinyl acetate on polymer modified self- compacting concrete decreases the required dose of modified polycarboxylic ether and naphthalene based chemical admixtures. This behavior due to the plasticizing effect of polymer. Cube compressive strength of polymer modified self- compacting concrete with styrene butadiene rubber up to 10% by weight of cement is almost the same of traditional concrete and traditional self-compacting concrete while polymer modified self-compacting concrete with polyvinyl acetate has higher compressive strength compared to traditional concrete and traditional self-compacting concrete. At 90 days, concrete compressive strength of polymer modified self-compacting concrete is 25% higher than traditional self-compacting concrete.

M. M. Abdel-Aziz et al (1997) focused on thermal and mechanical properties of styrene-butadiene rubber/lead oxide composites as gamma-radiation shields. Styrene-butadiene rubber/lead oxide composites were prepared as y-radiation shields. The composites were prepared with three different types of lead oxide, namely lead mono-oxide (PbO), lead dioxide (PbO,) and red lead oxide (Pb304). Concentrations of about 87-88 weight % for the three lead oxides were used. The assessment of the linear attenuation coefficient of the SBR/lead oxide composites for y-rays from different y-radiation point sources was studied. The effect of radiation on physical, mechanical and electrical properties and with heating and consequent variation of the thermal properties due to absorption of radiation should be concerned with protecting structural shielding materials. Addition of lead oxides to the stock rubber composite as well as the exposure to high irradiation dose, resulted in hardening of the composites and increased electrical resistance.

J. Mirza et al (2002) studied about the laboratory and field performance of polymer-modified cement-based repair mortars in cold climates. Twenty-five selected commercially available polymer-modified products, seven containing styrene butadiene rubber (SBR) and 18 containing acrylics were evaluated. They were compared with those of a pure cement-based mortar containing 8% silica fume by weight of the cement, with a water cementitious materials (cementasilica fume) ratio (WyCM) of 0.31. All of the mortars were subjected to thermal compatibility with base concrete, drying shrinkage, permeability, abrasion-erosion resistance, bond strength, compressive strength and freezing and thawing cycling tests. The thermal compatibility with the base concrete at temperatures from -50 to +50 8C was used as a pre-selection test. Most of the polymer-modified cement-based mortars exhibited higher resistance to compression and abrasion, a lower permeability, as well as a higher bond strength than the reference cement mortar. The polymer-modified cement-based mortars generally demonstrated the best performance (compressive and bond strengths, resistance to abrasion and shrinkage) under wet curing conditions. Dry curing led to a higher shrinkage. No apparent effect of fibers was observed on the properties of repair mortars. Therefore, these materials should not be used for repairing damaged concrete surfaces.

J.C. Rubio-Avalos et al (2004) investigated about flexural behavior and microstructure analysis of a gypsum-SBR composite material. More flexible organic–inorganic composite material with low density has been obtained using low cost and flexible latex, SBR latex in a gypsum matrix. Because of this, the microstructure and flexural properties of the new composite were studied. In this study, using a well-defined crystalline ceramic structure, (monoclinic gypsum crystals), mechanical and microstructure analysis have shown how the development of a polymser network (PN) interwoven with ceramic matrix as well as a polymer film formation in such matrix, after the addition of a latex in gypsum, increases the elasticity or flexural behavior of the ceramic material development of a polymer network (PN) interwoven with ceramic matrix as well as a polymer film formation in such matrix, after the addition of a latex in gypsum, increases the elasticity or flexural behavior of the ceramic material Hence, it is considered that a more flexible or elastic hybrid ceramic material (with low density) has been developed for ceramic and building applications

`S. Ahmad et al (2011) studied to use of polymer modified mortar in controlling cracks in reinforced concrete beams. The proposed technique consists of applying locally available polymer modified mortar in cracked beams to increase the load carrying capacity. A total of six full scale RC beams were constructed with the same material using the same mix and water–cement ratio. Initially, beams were tested until the development of cracks with width reached a limiting value of 1 mm. The beams were then repaired with the application of polymer modified mortar technique. After 3 days of water curing the beams were tested again and loaded till the failure. An improvement in the load carrying capacity was observed in the beams after the retrofitting. RC beams can be strengthened by repairing the existing flexural and shear cracks with PMM application and this can lead to a considerable (36%) increase in the load carrying capacity. Most of the beams have failed in shear, which represents that PMM application injection is more effective for flexural control of cracks. One of the beams has failed due to opening of repaired cracked which strongly suggests that application of PMM is also efficient in the repair of cracked concrete structures.

Mohammad Ismal et al (2011) studied about the Behavior of Concrete with Polymer Additive at Fresh and Hardened States. Discarding waste materials from factories to landfills is becoming difficult lately as public awareness on their effects on earth is getting better. One of such material comes from paint factory (waste latex paint), which at the moment being tried as additive by many researchers. This study state that the results of laboratory work carried out on emulsion by-product polymer in order to evaluate its performance as an additive in concrete. Series of concrete mixes containing 1%, 2%, 3%, 5% and 10%

polymer contents by weight of cement were prepared, cured and tested for workability, mechanical and durability properties at 7, 28 and 60 days. Test parameters include compressive, indirect tensile and flexural strengths, water absorption and chemical resistance. Polymer does not help in enhancing the workability of fresh concrete as shown from slump and Vebe test, the data shows that. When more polymers were added, the workability decreases.Polymer does not contribute much in improving compressive strength of the concrete. However of polymer added in concrete provides the highest tensile strength and flexural strength. For chemical properties, when more polymers were added, water absorption was lower. In this research, the highest percentage of polymer content in concrete was 10%.

Bing Chen et al (2007) revieval Mechanical properties of polymer-modified concretes containing expanded polystyrene beads. In this study, styrene-butadiene rubber (SBR) latex as a polymeric admixture was applied in lightweight expanded polystyrene (EPS) concrete. The effects of curing conditions and polymer-cement ratio on the compressive and flexural strengths of polymer-modified EPS concretes were investigated. The strengths of EPS concretes, especially the flexural strength are greatly improved by polymer modification with SBR latex and by applying the adequate combination of wet-dry curings. During such combined wet-dry curing, the wet curing at the early curing period benefits the strength development of cement matrix, while the following of dry curing contributes to the SBR film formation and improves the adhesion between the cement matrix and EPS particles. Compared with normal EPS concretes, the compressive strength of polymer-modified EPS concretes increases gradually even after 28 days.

CHAPTER-3

METHODOLOGY

3.1 GENERAL

In this project methodology is classified in to two type of work, first phase work and the second phase work. In the first phase work the aim of the project should be studied in the second phase the process of the project should be carried out.

3.2 FLOW CHART

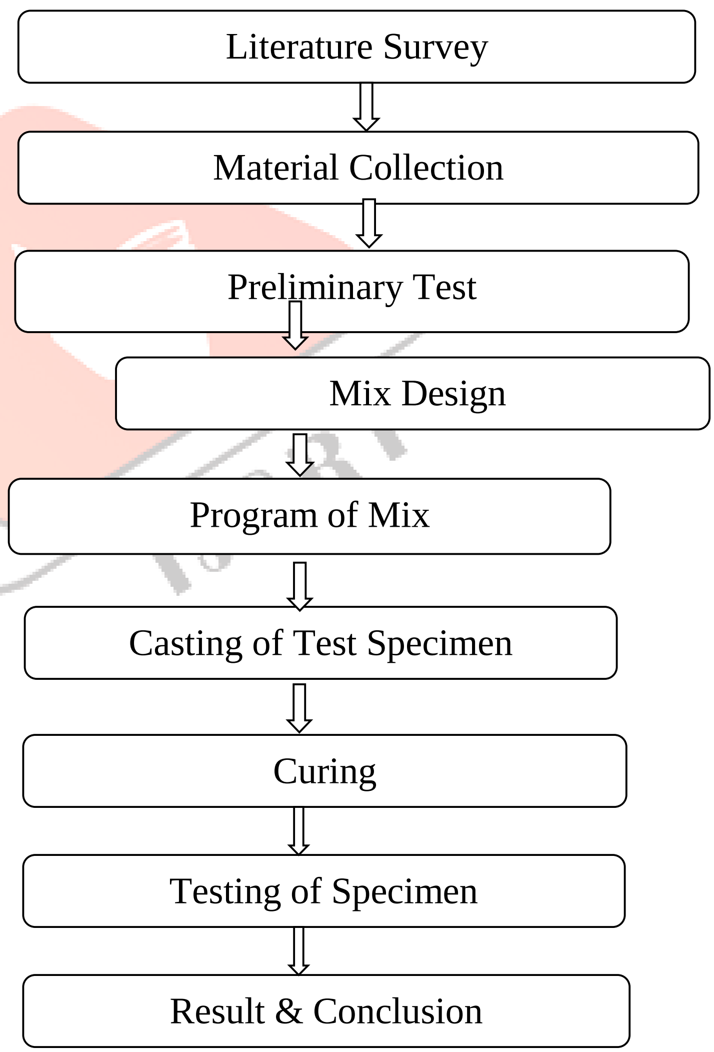

Fig.no 3.1 Flow chart for methodology description

CHAPTER 4

POLYMER BASED ADMIXTURE

4.1 CLASSIFICATION OF POLYMER-BASED ADMIXTURES

- POLYMER LATEXES
- REDISPERSIBLE POLYMER POWDERS
- WATER-SOLUBLE POLYMERS
- LIQUID POLYMERS

4.1.1 POLYMER LATEXES

Polymer latexes (or dispersions) which consist of very small (0.05-5 pm in diameter) polymer particles dispersed in water are usually produced by emulsion polymerization. Natural rubber latex and epoxy latex are not produced by such emulsion polymerization. The natural rubber latex is tapped from the rubber trees, and then concentrated to have the proper total solids. The epoxy latex is produced by emulsifying an epoxy resin in water by use of surfactants. Polymer latexes are generally classified into the following three types by the kind of electrical charges on polymer particles, which is determined by the type of surfactants used in the production of the latexes: cationic (positively charged), anionic (negatively charged) and nonionic (uncharged). In general, the polymer latexes are copolymer systems of two or more different monomers, and their total solids including polymers, emulsifiers, stabilizers, etc. are 40-50% by mass.

The general requirements for polymer latexes as polymer-based admixtures are as follows

○ Very high chemical stability towards the extremely active cations such as calcium ions (Ca^{2+}) and aluminum ions ($A1^{3+}$) liberated during cement hydration.

○ Very high mechanical stability under severe actions, especially high shear in mortar or concrete mixing and in metering and transfer pumps.

○ Low air-entraining action due to the use of suitable antifoaming agents during mortar or concrete mixing.

○

4.1.2 REDISPERSIBLE POLYMER POWDERS

In general, redispersible polymer powders as polymer-based admixtures are manufactured by a two-step process. Firstly, polymer latexes as raw materials are made by emulsion polymerization, and spray-dried to obtain the polymer powders. Before spray-drying, the latexes are formulated further with some ingredients such as bactericides, spray-drying aids and antifoaming agents. Anti-blocking aids such as clay, silica and calcium carbonate are added to the polymer powders during or after spray-drying to prevent 'caking' of the powders during storage. The redispersible polymer powders are usually free-flowing powders, and have ash contents of 5-15%, which primarily come from the anti-blocking aids. When the polymer powders are placed in water under agitation, they redisperse or re-emulsify easily, and provide the polymer latexes with polymer particle sizes of l-10 pm. Generally, redispersible polymer powders are dry blended with cement and aggregate mixtures, followed by wet mixing with water. During the wet mixing, the redispersible polymer powders are redispersed or re-emulsified. If necessary, powder or liquid antifoaming agents are added to the wet mix.

4.1.3 WATER-SOLUBLE POLYMERS

Water-soluble polymers as polymer-based admixtures are water-soluble powdered polymer, e.g., cellulose derivatives, polyvinyl alcohol (poval), polyacrylamide, etc., and are added in the form of powders or aqueous solutions to cement mortar or concrete during mixing. When added in the powder form, it is advisable to dry-blend the polymers with the cement aggregate mixtures, and then to mix them with water. Their main effect is to improve workability. The acrylates, such as calcium acrylate and magnesium acrylate, which are added in monomer form during mixing are included within this category because they are water-soluble.

4.1.4 LIQUID POLYMERS

Liquid polymers as polymer-based admixtures are viscous polymeric liquid such as epoxy resin and unsaturated polyester resin, and are added with the hardener or catalyst, and accelerator to cement mortar or concrete during mixing. However, the liquid polymers are less widely employed as polymer-based admixtures compared with the other admixtures such as polymer latexes, redispersible polymer powder sand water-soluble polymers.

4.2 PRINCIPLES OF POLYMER MODIFICATION

Although polymer-based admixtures in any form such as polymer latexes, water-soluble polymers and liquid polymers are used in cementitious composites such as mortar and concrete. It is very important that both cement hydration and polymer film formation proceeds well to yield a monolithic matrix phase with network structure in which the cement hydrate phase and polymer phase interpenetrate. In polymer-modified mortar and concrete structures, aggregates are bound by such co-matrix phase, resulting in superior properties compared with conventional cementitious composite. Polymer latex modification of cement mortar and concrete is governed by both cement hydration and polymer film formation. The cement hydration process generally precedes the polymer film formation process by the coalescence of polymer particles in polymer latexes. In due course both cement hydration and polymer film formation processes form a co-matrix phase.

4.2.1 MODIFICATION WITH POLYMER LATEXES

Polymer latex modification of cement mortar and concrete is governed by both cement hydration and polymer film formation processes in their binder phase. The cement hydration process generally precedes the polymer film formation process by the coalescence of polymer particles in polymer latexes. In due course, a co-matrix phase is formed by both cement hydration and polymer film formation processes. Some chemical reactions may take place between the particle surfaces of reactive polymers such as polyacrylic esters (PAE) and calcium ions (Ca"‘), Ca(OH)2 solid surfaces, or silicate surfaces over the aggregates, Such reactions are expected to improve the bond between the cement hydrates and aggregates, and to improve the properties of hardened latex-modified mortar and concrete.

As explained above, the properties of ordinary cement mortar and concrete are generally improved to a great extent by polymer latex modification. It appears that the microcracks in latex-modified mortar and concrete under stress are bridged by the polymer films or membranes formed, which prevent crack propagation, and that simultaneously a strong cement hydrate aggregate bond is developed. This aspect is evident in the scanning electron micrographs of cross-sections of SBR-, EVA- and PAE-modified mortars, such effects increase with an increase in the polymer content or polymer-cement ratio, P/C and lead to increased tensile strength and fracture toughness. However, excess air entrainment and polymer inclusion cause discontinuities of the formed monolithic network structure whose strength is then reduced, although some chemical reactions proceed effectively, The sealing effect due to the polymer films or membranes also provides a considerable increase in waterproofness or water tightness, resistance to moisture or air permeation, chemical resistance and freeze-thaw durability, and is promoted with increasing polymer-cement ratio up to certain limits.

4.3 STYRENE BUTADIENE RUBBER POLYMER (SBR)

Styrene butadiene rubber (SBR) is used as polymer modifier in this study. SBR Polymer is the most widely used in concrete. Styrene butadiene, an elastomeric polymer, is the copolymerized product of two monomers, styrene and butadiene. Latex is typically included in concrete in the form of a colloidal suspension polymer in water. This polymer is usually a milky-white fluid. It has high elasticity, good adhesion, water proofing and high chemical resistance. Co-polymers of butidine with styrene (styrene-butadine rubber (SBR)), are a group of large-volume synthetic rubbers. High adhesion occurs between the polymer films that form and cement hydrates. This action gives less strain compared to ordinary concrete and improves the properties of concrete such as flexural and compressive strength and gives also a higher durability. the chemical structure of Styrene butadiene Rubber latexes

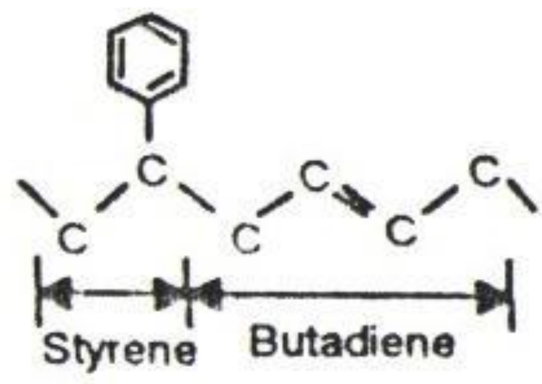

Fig no 4.1 Chemical structures of SBR polymer latexes

CHAPTER 5

MATERIAL SPECIFICATIONS

5.1 GENERAL

In the design of polymer modified concrete the selection of proper ingredients evaluating their properties and understanding the interaction between different materials plays a major role in performance of the concrete. The ingredients used are cement, silica, natural sand, Coarse aggregate, Styrene butadiene rubber (SBR). The performance requirements of concrete enhancements of the following

1.Ease of placement and compaction by no segregation.

2.Long term mechanical properties.

3.Early strength.

4.Toughness.

5.Volume stability.

6.Long term durability properties.

7.Longer service life.

The efficiency of high performance concrete is improved by proper selection controlling and proportioning the ingredients of polymer modified concrete.

5.2 CEMENT

Cement is a binding material in concrete that binds the ingredients into a compact mass. The chemistry of concrete is the chemistry of reaction between cement and water (i.e) hydration process. The hydration products are tricalcium silicate, calcium hydroxide and calcium aluminum hydrates which influence the proprties of concrete to a greater extent.

Ordinary Portland cement, 53 grade can be used.

Property	Values
Specific gravity	2.62
Bulk density (kg/cum) (a) Loose (b) Compacted	1601 1670
Fineness modulus	2.70
Grading	Conforming to Zone II
Water absorption (%)	1.64
Bulking of sand (%)	4

Table 5.1: Properties of cement

53 grade, cement may be utilized by builders of heavy infrastructure such as bridges, fly overs, large span structures and high rise structures. The common man's perception that 53 grade. Cement is the best cement is not only due to the aggressive marketing strategies of the cement manufacturers but also on the presumption that the heat generated during hardening of concrete is an index of its quality. When 53 grade, cement is used the heat generated is very high. Hence, consumers believe that it is a better cement when actually it is not so .Each cement has to be chosen for a particular use."

Property	Values
Normal consistency (%)	32
Specific gravity	3.15
Initial setting time (min)	90
Final setting time (min)	220
Fineness of cement %	6

Table 5.2: Properties of fine aggregate

5.3 FINE AGGREGATE

Fine aggregates can be natural or crushed sand . The grading must be uniform throughout the work. The moisture content or absorption characteristics must be closely monitored as quality of PMC will be sensitive to too such changes. Particles smaller than 0.125 mm natural sand are considered as fines which contribute to the powder content.

5.4 COARSE AGGREGATE

The maximum size of aggregates is generally limited to 20mm.Aggregate of size 16 to 20 mm is desirable for structures having congested reinforcement. Wherever possible size of aggregates higher than 20 mm could also be used. Well graded cubical or rounded aggregates are desirable. Aggregate should be of uniform quality with respect to shape and grading.

Property	Value
Specific gravity	2.65
Bulk density (kg/cum) (a) Loose (b) Compacted	 1592 1706
Fineness modulus	7.13
Water absorption (%)	20
Impact value (%)	18
Crushing value (%)	20
Voids (%) Loose compacted	39.20 35.60

Table 5.3: Properties of coarse aggregate

5.5 WATER

Water is an important ingredient in concrete. It is the expensive ingredients of concrete Water is used for hydration of cement. The hydartion products have cement value. It distributes the cement evenly so that every particle of gravel and sand is coated by it and brought into intimate amd gives workability to moisture.Cement needs about 0.25 times of weight of water for chemical reaction. But some more water is required for proper workability of concrete.

5.6 STYRENE BUTADIENE RUBBER (SBR)

Styrene butadiene, an elastomeric polymer, is the copolymerized product of two monomers, styrene and butadiene. Latex is typically included in concrete in the form of a colloidal suspension polymer in water.

Properties	Description
Appearance	White emulsion
Specific Gravity	1.03 ± 0.02@ 25°c
Freeze/Thaw Resistance	Excellent
Chloride Content	Nil
Flammability	Non-flammable
Compatibility	Can be used with all types of Portland cement

Table 5.4: Properties of Styrene Butadiene Rubber (SBR) polymer

5.7 MIX PROPORTION

FOR M20 CONCRETE

Unit "kg/m^3

Cement	W/c	Water	Sand	Aggregate
531.42	0.35	186	803.52	1421.01
1		0.35	1.512	2.674

Table 5.5: Mix proportion Cement: sand: coarse aggregate=1:1.512:2.674

Based on the trial mix the water cement ratio is 0.35.The SBR is added as a ratio by weight of cement of 5%7% and 10%

CHAPTER 6

WORK TO BE CARRIED OUT

This project summarizes the classification of polymer-based admixtures, the principles of polymer modification by the use of polymer latexes, redispersible polymer powders, water-soluble polymers and liquid polymers, the properties and applications of polymer- modified mortar and concrete, recent research and development activities, and standardization work.

This study given the idea about the use of polymer and their behavior in the various mechanical properties like compressive strength, splitting tensile strength, flexural strength.

This study is mainly focused on polymer modified concrete to have a dense microstructure, smaller discontinuous pores, less porous transition zone, better bond between the aggregate and the cement matrix, and bridged micro-cracks with respect to conventional concrete.

The cost of producing LMC should not be compared to the cost of the production of conventional concrete on short run. Although, LMC has higher initial production cost it should be compared with the sum of the initial production cost of conventional concrete plus the cost of the expected repair works during the service life of the structures, especially those exposed to severe aggressive environment.

According to the journal study the water tightness of the LMC is superior to that of the conventional concrete as measured by the water penetration, absorption and sorptivity tests. The effect of using longer sorptivity test time on the test results of the LMC requires further investigations. The LMC provides better protection to steel reinforcement against chloride induced corrosion in structures exposed to severe chloride environment such as bridge overlays. -The resistance of LMC to abrasion, and sulphate solution were found to be much improved compared to those of the conventional concrete.

The future study is to cast the four type of specimen, in which is one is controlled beam, Other three beams are 5%,7 %,10% of polymer is added as a admixture in order to increase the structural behavior and to compare the result between the conventional concrete and polymer modified concrete and to find the various mechanical properties like compressive strength, splitting tensile strength, flexural strength, stress–strain characteristics, and modulus of elasticity and permeability characteristics of concrete

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