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Review on Polymer Modified Concrete And Its Application To Concrete Structures

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Abstract- ***Use of polymer modified concrete as a construction material in structural applications has been increased in recent years. Polymer concrete has excellent strength and durability properties. Looking into the advantages of polymer modified concrete, an exhausted literature survey has been carried out to study its uses and effect on various properties of the concrete and presented in this paper an attempt has been made to present review on polymer modified concrete and its application to concrete structure which will be very useful to civil engineers to known its application in construction industry. It is well known that some concrete structures constructed with high performance materials start to deteriorate long before reaching their designed service life. In such cases cracks are caused after the structure has been completed for a few years. It leads to results in the shortening of service life and lowering in durability. Durability modification in concrete must be considered in construction. Moreover, other factors may be considered like cracking and debonding, which allows chloride, carbon dioxide or detoriative agents penetrate through structural members. Polymers have been employed as concrete admixtures. Based on the mode of their addition, polymer cement concrete is classified as- polymer modified cement concrete or mortars (PMC/PMM), polymer concrete or mortars (PC/PM), polymer impregnated concrete or mortars (PIC/PIM).***

Keywords: Polymer modified concrete, Deterioration, Strength and shrinkage, PMC, PMM.

1. Introduction

The Mortar and concrete has been a popular construction material in the world for the past 170 years or more. Cement mortar and concrete have some disadvantages such as delayed hardening, low tensile strength, large drying shrinkage, and low chemical resistance. To reduce these disadvantages, many attempts to use polymers have been made. One such attempt is polymer-modified (or polymer cement) mortar or concrete, which is made by the modifying ordinary cement mortar or concrete with polymer additives such as latexes, re-dispersible polymer powders, water-soluble polymers, liquid resins, and monomers. Polymer-modified mortars and concretes have a monolithic co-matrix in which the organic polymer matrix and the cement gel matrix are homogenized. The properties of polymer-modified mortar and concrete are characterized by such a co-matrix. In the systems modified with the latexes, re-dispersible polymer powders, and water-soluble polymers, the drainage of water from the systems along with the cement hydration leads to film or membrane formation. In the systems modified with the liquid resins and monomers, the addition of water induces the hydration of the cement and the polymerization of the liquid resins or monomers.[1] Concrete has high compressive strength but is relatively weak in tension and adhesion, and its porosity can lead to physical and chemical deterioration. Polymers, on the other hand, are weaker in compression but can have higher tensile capacities, and provide good adhesion to other materials as well as resistance to physical (i.e. abrasion, erosion, impact) and chemical attack. Combinations of these two materials can exploit the useful properties of both and yield composites with excellent strength and durability properties.[2]

2. History Of Polymers In Concrete.

Polymers have been used in construction as long ago as the fourth millennium B.C., when the clay brick walls of Babylonia were built using the natural polymer asphalt in the mortar. The temple of Ur-Nina (King of Lagash), in the city of Kish, had masonry foundations built with mortar made from 25 to 35% bitumen (a natural polymer), loam, and chopped straw or reeds. The walls of Jericho were built using bituminous earth in about 2500-2100 B.C. Other historic applications identified in the ancient Indus Valley cities of Mohenjo-Daro and Harappa around 3000 B.C., and near the Tigris River in 1300 B.C. Many natural polymers have been used in ancient mortar, including albumen, blood, rice paste, etc. The earliest use of polymers in PCC was in 1909, in the United States, & patent was granted to L. H. Backland; 1922 in France & patent was granted to M. E. Varegyas;1923 in Britain by L. Cresson's patent; in 1924 with V. Lefebure's patent for development of natural rubber latex cement; and in 1925 by S. H. Kirkpatrik's innovation on that product. Synthetic polymers were invented due to decline in the availability of natural rubber and increased demand for war effort in 1940. Synthetic polymers thereafter incorporated in Portland cement mortars and concrete in 1950ôs.

3.Microstructure Of Polymer

After mixing polymer firstly with fresh concrete, polymer particles suspended in the latex are dispersed throughout cement paste. During the cement hydration the solution is saturated with CH which leads to generation of ettringite & CH crystals adjacent to the aggregate zone which further forms a layer of calcium silicate on aggregates. Unhydrated Clinker particles and Gel products are covered by deposits of polymer particles. The polymer particles gradually concentrate in the capillary pores due to growth of hydration products since water is consumed in hydration process, this leads to formation of silicate layer over

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aggregate with a close pack layer on the gel product surface. Few capillary pores are filled with accumulating polymer particles coating the inner surface of pores. The closed pack polymer particles on gel product and in voids come together to form continuous film or membrane due to withdrawal of water by hydration or drying. These membranes form a co matrix mix with hydrated cement paste and binding the hydrates with the aggregates. Few polymers undergo chemical reactions with the cement hydration products to the detriment of the composite.[2]

4.Applications

i. Current applications of PMC are primarily for resurfacing, flooring, and patching. Overlays on roadways and bridges, both as new construction and as repairs of existing deteriorated structures. PMC is also being used in flooring, water tanks, swimming pools, septic tanks, silos, drains, pipes, and ship decks.[3,4,5]

ii. Relatively new applications of PMC are its use in combination with fiber reinforcing to yield improved tensile strength and reduced cracking.

iii. Its use as a pneumatically applied material or shotcrete.[6,7]

iv. Possible future applications of PMC mentioned in the literature include: in roller-compacted concrete (RCC) for airstrips, roadways, and parking lots; and in ductile concrete foundation and shear wall construction, as well as marine and offshore structures. [8]

v. PMC use has also been predicted in concrete structures wherever there is a need for its tensile strength resistance to cracking, bond strength ,higher flexural strength, and impermeability. [9,10,11]

vi. Polymer and sulfur concrete has been use for application requiring high acidic resistance and architectural finishesh, also useful bonding ceramic tile to floors. [11]

5.Effect of polymer on conventional concreter.

Brief details of the available literature over present study are presented in this section.

R.G. limaye (1992)[11] elaborated the experimental studies on polymer modification of cement mortar. In this comparative study of polymer modification using using six different type of polymer (M1 to M6) into cement mortar is attempted in the work. Similar dosage of ingredients such as surfactant stabilizers and antifoamers were used to render effective comparison. Mechanical properties such as flexure, tension compression, stress-strain behaviour were evaluated upto 28 days of air curing and 90 days curing. Preliminary investigation established that water curing of PMM (polymer modified mortar) system showed lower mechanical strength as compared to air cuing. Hence, water curing was eliminated from the study for the study for PMM system. Casting of six polymer combination in two dosages 10% and 20% with cement mortar. The five system based on epoxy resins and sixth one was SBR latex modified with all agents. The mechanical strength were evaluated after 3,7,28,45,60,75 and 90 curing. By the addition of polymer improves the toughness of cement mortar mix. Since PMM when used for the repairs of structure would not deteriorate under dynamic loadings, impact etc. The addition of latex and epoxy to cement to cement mortar make more workable. Latex has higher workability than epoxy. It observed that all type of polymer improvement in mechanical strength at later ages. Initially, upto 28 days the strength gained is at per or compared to control. At 90 days curing the increases strength especially in the flexure and tensile strength. In this study the rate of gain for specimens between 28 to 90 days 10-15%, where as it is 50-60% for the specimen.

Y.M.Ghugal(1994)[12] elaborated the experimental study with polymer modified cement mortars. The variables considered were polymer content, age of curing and type of curing. The effects of polymer admixture on compressive, split tensile, flexural strength and workability were studied. The dosages of polymer were varied from 0-25%. Also, the effects of wet and dry curing were observed at various ages of curing. results were compared with controlled mortar without polymer .The substantial increase in flexural, split tensile and compressive strength at the later age was observed for the air cured specimen in comparison to water cured specimens. The optimum polymer content was found to be 20%. The higher early strength and adhesion to old building materials enables the structures to be restored in the shortest possible time. In concrete buildings the loose concrete is removed and the resulting voids are filled with high early strength materials . the polymer r modified mortar and concretes could be employed in various techniques of repair ,restoration and strengthening of concrete and masonry structures depending upon the type and extent of damage caused by earthquake. Use of polymer in cement mortar make the mortar more workable with low water cement ratio improving strength. Air curing is preferred to increase higher rate strength at later ages. Materials due to its significant improvement in mechanical properties and durability were efficiently used as rehabilitation of distressed, damaged and detoriating concrete and masonry structures to be restored and strengthened in possible shortest time.

Moetaz M. El-Hawary et. al.(2004)[13] pepar states the 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. Corrosion of reinforcement is considered the main type of concrete deterioration in world as its rate increases with temperature, humidity and the presence of chloride. 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. Different percentages (0, 10,20,40,60, 100%) of cement were replaced by epoxy. Cylinders, cubes and special reinforced prisms were utilized. All 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 epoxy in the concrete mix was found to increase the corrosion resistance but reduce permeability and reduce chloride penetration as well as increase strength. The improvements were found to increase with the increase in epoxy percentage.

Chen et al (2007)[14] reports ñMechanical properties of polymer-modified concretes containing expanded polystyrene beadsò. In this SBR is applied in light weight expanded polystyrene concrete. In effect of polymer cement ratio and curing condition on compressive and flexure is investigated. The strength development of the polymer-modified EPS concretes strongly depends on the curing conditions. Combined dry and wet curing enable to develop both the strengths of cement matrix and SBR films together. In this study, the addition of SBR latex to EPS concrete is tried to improve the bonding between EPS particles and cement paste and the tensile and flexural strengths of EPS concrete. SBR latex as an aqueous polymer dispersion prefers dehydration and solidification under the dry conditions. In this water curing in early days will result in hydration of cement matrix and solidification of polymer is by dry curing. Hence adhesion and strength of both cement matrix and SBR film are developed well.

Radhakrishnan et.al.(2012)[14] this study explained the application of polymer for repairing existing concrete structures for repairing existing concrete structures. In order to repair structures for enhancing the service life number of methods and materials available, but the degree of success of any repair in concrete depends mainly on the correct choice and the method of application of repair material. Repair techniques mainly depend on resistance to water penetration and tensile cracking of structure. To study the effect of SBR latex with cementitious material. A mix proportion of mortar1:3 with added SBR at 20%by weight of cement were made. A comparative study was carried out carried between added SBR specimen and control specimen without SBR in terms of compressive strength and split tensile strength for repaired cylinder were tested. Also sorptivity test was carried along with the influence of thermal cycling on repaired concrete. From the study result it is interpreted that SBR modified cement mortar possess very good water penetration as well SBR as bonding agent possess good tensile strength compared to cement slurry . A SBR as a modifier and as a bonding agent to cement mortar satisfies the requirement by the standard of ASTM. SBR modifier upholds better performance after thermal cycling hence proved boon for structure in tropical climate.

Gupta et.al. (2009) [16] present the study of Fatigue Behaviour Of Polymer Modified Bituminous Concrete Mixtures. In this study the physical and mechanical properties of polymer modified and conventional binder mixes are evaluated. The main purpose of present work is to study the benefit of SBS (Styrene Butadiene Styrene) polymer modified bituminous mixes on fatigue performance. Fatigue failure is one of the main distress mechanisms causing degradation of pavements. It is caused by repeated traffic loadings, which result in crack initiation, crack propagation and eventually catastrophic failure of the material due to unstable crack growth. In this experiment mixes are compacted using both Marshall and Superpave Gyratory Compactor (SGC) and a comparison between the two is established in terms of the resilient modulus and fatigue life. It is observed in SGC specimens higher density values also due to the higher compaction effort and this specimens prepared using SGC are found to have higher fatigue life. The tensile strength of Marshall stability values of the SBS modified mixes were higher by 21 percent and 25 percentas well as The fatigue life of SBS Modified mix was 2.1 to 2.4 percent higher than the conventional mixes. Higher tensile strength ratio is observed polymer modified mixes which indicate better cohesive strength of these mixes as compared to conventional mixes. This research paper also describes the application of LEFM (linear elastic fracture mechanics) to characterize crack propagation using Indirect Tensile Fatigue Test (ITFT).

Soni et al (2014)[17] present the study of Performance Analysis of Styrene Butadiene Rubber-Latex on Cement Concrete Mixes. This paper states that improve the performance of concrete by using polymers are mixed with concrete. Polymer modified concrete (PMC) is more durable than conventional concrete due to superior strength and high durability. In this research, effect of Styrene Butadiene Rubber (SBR) latex on compressive strength and flexural strength of concrete has been studied and also the optimum polymer (SBR-Latex) content for concrete is calculated. This research was carried out to establish the effects of polymer addition on compressive and flexural strength using concrete with mix design of constant water-cement ratio at local ambient temperature. The mixes were prepared with Styrene-Butadiene Rubber (SBR) latex -cement ratio of 0 %, 5%, 10%, 15% and 20%. Slump test was conducted on fresh concrete while compressive strength and flexural strength were determined at different age. A locally available Perma-Latex is used as SBR Latex. It has been observed that SBR latex has negative effect at early age while at 28 days, the addition of SBR latex in concrete results in enhancement of compressive strength and Flexural Strength. Based on the results of this study, latex modified concrete made using Perma-Latex may be recommended to be used with various types of concrete structures. However, for the mixes rich in cement, the dosage of SBR latex needs to be adjusted to maintain required workability of concrete.

6.Conclusions

Addition of polymer in cement and aggregate act as an polymer modified concrete which has very effective results as compared to that of the conventional concrete. The addition of polymer improves workability, flexural strength tensile strength and bond strength. After addition of polymer there is dispersion effect of polymer in cement which will fill the pores present in the voids.

Polymer forms the layer on the cement and aggregate paste which result in the less permeability of concrete and therefore less water retention property. Because of less water retention property moisture in the concrete is reduced and there by there is reduction in the corrosion and environmental causes to the concrete.

Polymer is used for strengthening the cracked structure which results strength improvement in cracked structure after adding the polymer mortar in cracks of hardened concrete. As hydration and solidification are important part of polymer modified concrete both wet and dry curing is require for the better results in strength. Polymer form a skin or crust in the surface if it is in contact with air for more time which causes rapid hydration of the moisture from the surface and it will result in tearing of the surface. Water curing will impart less strength of concrete.

From the available literature on polymer concrete, it has been observed that addition of polymer improves the quality of concrete and hence it is advantageous to use polymer in concrete. The only disadvantage is its effect on human health.

REFERENCES

i. Ohama Y.,(1924) "Concrete Admixtures Handbook (Properties, Science and Technology)", Noyes publication, Park ridge, New Jersey,U.S.A.

ii. Kardon (1997) "Polymer-Modified Concrete: Review". Journal of Materials In Civil Engineering, Vol. 9, No.2, May pp.85-92.

iii. Geist, Amagna and Mellor (1953) "Study of Polyvinyl acetate in Modified Polymer mortar". Journal of Industrial and Engineering chemistry. Vol.45. pp.759-767.

iv. Ohama Y (1978), "Development of Concrete-Polymer Matrials in Japan, Proc.polymers in concrete, American Concrete Journal,1978,pp.121-137.

v. Darwin ,D,et.al (1984),Causes Evaluation And Repair Cracks In Concrete Structures,American Concrete Journal,vol.no. 9,1984, pp.224

vi. Gerwick, Ben C.Jr (1978) , "Application Of Polymers To Concrete Sea Structure", Proc.Polymers In Concrete , American Concrete Journal, pp.37-43.

vii. Schorn, H.(1985), "Epoxy Modified Shotcrete Polymer Concrete Uses ,Materials And Properties", American Concrete Material Journal, vol.no89, pp.249-260.

viii.

ix. Ohama Yoshihiko (1959) "Dow Latex 560 for Portland cement Composition", "Dow Chemical Co". Midland, Michigan.

x. Shibazaki (1964) "Properties of Masonry Cement Modified with water soluble Polymers", Journal of Japanese Concrete Institute. Vol.17, pp. 194-199.

xi. Bing, Liu (2007) "Mechanical properties of polymer-modified concretes containing expanded polystyrene beads", Construction and Building Materials, vol. 21 pp 7-11.

xii. D.W. Fowler (1999), "Polymers in concrete: a vision for the 21st century", Sheffeld Infrastructure Conf.- Cement & Concrete Composites vol. 21, pp 449-452

xiii. R.G. limaye and M.K. kamat (1992) "EXPRIMENTAL studies on polymer modification of cement mortar, the Indian concrete journal, March.

xiv. Y.M. Ghugal (1994), "Polymer modified mortar: A material for strengthening of earthquake damaged structures", Proc. Tenth Symposium On Earthquake Engineering, Roorkee,pp.16-18.

xv. Moetaz M. El-Hawary, Ali Abdul-Jaleel and Thamer AI Yaqoub (2004) "Corrosion and Durability of Polymer Modified Concrete", 29th Conference on Our World in Concrete & Structures, Singapore.

xvi. Bing Chen and Juanyu Liu(2007) "Mechanical properties of polymer-modified concretes containing expanded polystyrene beads". Construction and Building Materials, Vol. 21, pp. 7-11.

xvii. R. Radhakrishnan, Syam prakash. V, C.K.Prasad Verma Thampan. (2012) "Performance Of Styrene Butadiene Rubber As A Concrete Repairs Material In tropical Climate", International Journal of Advancement In Research And Technology,pp1-5

xviii. Shivangi Gupta & A. Veeraragavan (2009) "Fatigue Behaviour Of Polymer Modified Bituminous Concrete Mixtures", Journal Of The Indian Roads Congress, January-March. Paper No. 548.

xix. Er. Kapil Soni, Dr. Y.P Joshi (2014) " Performance Analysis of Styrene Butadiene Rubber-Latex on Cement Concrete Mixes", International Journal of Engineering Research and Applications , Vol. 4, Issue , March , pp.838-844.