International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 11 | Nov 2018 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL INVESTIGATION OF EPOXY POLYMER CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY ALCCOFINE

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Abstract - *Concrete is the most flexible, durable and reliable construction material in the world. Epoxy resins are more commonly used thermoset plastic in polymer matrix composites. Epoxy is an adhesive used for bonding concrete. Epoxy resin have good adhesion to other materials, good chemical, environmental resistance and insulating properties. Therefore the addition of epoxy resin into the concrete improves higher strength and adhesion and has lower permeability, better water resistance and chemical resistance. Replacement of cement with a more environment friendly alccofine will help to reduce the emission of carbon dioxide gas into the atmosphere. Alccofine is a new generation micro fine material of particle size much finer than other hydraulic material like cement, fly ash, silica etc. being manufactured in India. Concrete is highly durable due to pozzolanic action of alccofine leading to pores refinement and denser concrete matrix. Alccofine has unique properties to enhance performance of concrete in fresh and hardened stages due to its optimized particle size distribution. This project aims at evaluating the effectiveness and performance of concrete with OPC cement in addition of Alccofine 1203. In this experimental investigation, the epoxy resins are added and alccofine will be added in different proportions and their effect on mechanical properties of concrete will be studied.*

Key Words: **Epoxy Resin, Alccofine , Thermoset plastic, polymer matrix composites.**

1. INTRODUCTION

1.1 General

Concrete is the fundamental civil engineering material used in most of the civil engineering structures. Various materials are used to manufacture good quality concrete. Cement, fine aggregate, coarse aggregate, mineral admixtures, chemical admixtures and water are the constituents of concrete. The cement plays an important role. The most significant use of cement is the production of mortar and concrete. Portland cement is a primary ingredient of concrete, mortar and most non specialty grout. The production of concrete is the most common use of Portland cement. Cement is manufactured by calcining calcareous and argillaceous compounds at high temperature. However, manufacturing of cement emits about 0.8 tones of CO2 in to atmosphere for every tones of cement manufactured. Durability of concrete means that it will retain its original form, quality, and serviceability when exposed to environment. These materials comprise traditional Portland cement and other cementitious materials, such as Alccofine. Alccofine is either combined at the cement works or at the concrete mixer when the concrete is being produced. Cementitious materials for concrete are fine mineral powders. This material when mixed with water react chemically to form a strong rigid mass that binds aggregate particles together to make concrete. Alccofine is known as a new generation, micro fine material of particle size and is much finer than other hydraulic materials like cement, fly ash, silica etc. being manufactured in India. Alccofine has unique properties to enhance performance of concrete in fresh and hardened stages due to its optimized particle size distribution.

Normal concrete is known to be weak in tensile strength, brittle and easily erodible by chemicals and high velocity water flow. Epoxy resin has found a position in the concrete construction field because of its high compressive and tensile strengths as well as excellent adhesive properties. In recent years most of the applications have been in bonding concrete to concrete in repairing damaged or deteriorated construction. Although epoxy concrete, in which epoxy resin compound added with concrete materials, possesses high compressive and tensile strengths.

2. LITERATURE REVIEW

Abhishek Sachdeva and V. Rajesh Kumar (2018) Concrete is most widely used man made construction material in the world. Manufacturing of cement for concrete involves large amount of carbon dioxide emissions into the atmosphere, a major contributor for green house effect and global warming. Thus it becomes necessary to discover a substitute material for cement in concrete. A lot of Supplementary Cementitious Materials (SCM's) like fly ash, silica fumes, slag powder etc. have been identified in the past and also have been effectively used as a partial replacement to cement in the production of concrete. Boom in the infrastructure development is further demanding the production of High Performance Concrete (HPC) along with the eco- friendly and sustainable concrete. The production of high strength and durable eco-friendly concrete leads to the use of a new generation ultrafine supplementary cementitious material Alccofine as a partial replacement of cement in concrete. This new ultrafine pozzolonic material has become popular

in the construction industry and has brought a revolution in the field of civil engineering. This paper presents an overview of published literatures by various researchers who have aimed to replace cement with Alccofine in the production of concrete. A significant improvement in the properties of concrete at fresh and hardened stage has been observed by the partial replacement of cement with Alccofine in concrete.

B.Kaviya et.al., (2017) In this paper the mechanical properties of Alccofine has been studied. Alccofine 1203 is a specially processed product based on high glass content with high reactivity obtained through the process of controlled granulation. Concrete attains high strength at a very early age, due to the presence of alccofine material. The mechanical properties studied here are compressive strength on concrete cubes at 7 & 28 days of curing and split tensile on cylinders at 7 & 28 days of water curing. It is observed from the result that the alcoofine material increases the strength to a large extent at 15% replacement level of cement.

Davinder Sharma et.al., (2016) The strength development of concrete using Foundry Slag (FD) as partial replacement for conventional fine aggregates and Alccofine (AF) as partial replacement of cement were analyzed. A study was planned in which M100 grade of concrete was designed using water/binder ratio 0.239. In this mix, conventional fine aggregates were replaced with varying percentage of Foundry slag from 0% to 50% along with the optimum percentage of 15% Alccofine as a partial replacement to cement. The specimens were casted and tested for compressive strength(CS), tensile strength(TS) and flexural strength(FS) development at the age of 7, 14, 28, 56 and 90 days. From the results, it was concluded that Alccofine (AF), a commercially available product in combination with Foundry slag (FD) can be used to replace PPC and FA respectively to produce high strength concrete and thereby reducing the impact on environment by saving the natural resources. Reasonably high strength concrete mix can be designed by substituting fine aggregate with 10% to 45% of FD and partial replacement of cement with 15% of Alccofine. Optimum dosage of Alccofine due to its ultra fineness and optimized particle size distribution has resulted in developing higher early age strength. The hydration and pozzolonic reaction of Alccofine improved the pore structure of concrete. Replacement of fine aggregates with Foundry slag up to 45% reduced the permeability of concrete and showed that the concrete permeability decreased with the increase in FD content, age and strength.

Dr. M. Vijaya Sekhar Reddy et.al., (2016) This paper presents the results of an experimental investigation carried out to evaluate the compressive strength of standard concrete. Standard concrete is made by ternary blending with partial replacement of cement by bottom ash and blast furnace slag in fine aggregate. In this study the bottom ash used in various proportions 10%, 20%, 30% in partial replacement of cement and that of alccofine 10% constant to total weight of cement and blast furnace slag used in various proportions 20%, 30% and 40% in partial replacement of fine aggregate .The mix proportions of concrete had a constant water binder ratio of 0.4 and super plasticizer was added based on the required degree of workability. The concrete specimens were cured on normal moist curing under normal atmospheric temperature. The compressive strength was determined at 7 days and 28 days. The results indicate the concrete made with these proportions generally show excellent fresh and hardened properties.

Malvika Gautam & Dr. Hemant Sood (2017) In the present paper, the effect of alccofine on properties of concrete has been studied. The main aim of this study is to evaluate the strength or we can say high performance of concrete containing supplementary cementitious materials (SCM) such as Alccofine. In this paper literatures of various researchers who have researched on durability of high performance concrete with Alccofine are reviewed. Because of the demands in the construction industry, the necessity of high performance concrete is also increased. Over the past few years, the efforts which are made for improving the performance of concrete suggest that cement replacement materials along with the minerals and chemical admixtures can improve the strength and durability characteristics of concrete. The alccofine material is pozzolanic material which is becoming popular in the construction industry and has brought technical revolution in the field of Civil Engineering. For high strength, Alccofine is a new generation micro fine concrete material and which is important in respect of workability as well as strength. Also Alccofine is easy to use and it can be added directly with cement. The ultrafine particle of Alccofine provides better and smooth surface finish. As well as cost is concerned, for high strength concrete the cost of concrete mix prepared with alccofine is less than the concrete without Alccofine. The advantage of Alccofine other than strength is that it also lowers the water/binder ratio. Alccofine material increases the strength both in compression and flexure to a large extent.

Mr. Sunil Suthar et.al., (2013) This paper presents the results of an experimental investigation carried out for M-70 Grad Concrete and to evaluate the compressive strength and Flexural Strength of Concrete. High Performance Concrete is made by partial replacement of cement by alccofine, fly ash, silica fume. In this study the Class F fly ash used in various proportions 20 to 35%, alccofine 4 to 14% and silica fume 4% to 14% by weight of cement. The mix proportions of concrete had a water binder ratio for Alccofine mix concrete 0.30 and Silica-fume mix concrete 0.32.super plasticizer was added based on the required degree of workability. The total binder content was 600 kg/m3. The concrete specimens were cured on normal moist curing under normal atmospheric temperature. The compressive strength was determined at 7, 28, 56 days and flexural strength was

determined at 28 and 56 days .The addition of Alccofine, silica fume shows early strength gaining property and that of fly ash shows a long term strength. The ternary system that is Portland cement-fly ash-Alccofine concrete was found to increase the compressive strength of concrete on all age when compared to concrete made with Portland cement-fly ash-silica fume.

Natsuki Amanokura et.al., (2017) Imidazole derivatives and alkylamines are very useful as hardeners of epoxy resins. These amine compounds form inclusion complexes with 1,1,2,2-tetrakis(4-hydroxyphenyl) ethane (TEP). When these amine containing inclusion complexes are reacted with epoxy resins, curing acceleration, pot life extension, and higher curing temperatures are observed. An explanation for this curing behavior is that guest molecule ''amine compounds'' are trapped in inclusion complex crystals. X-Ray crystal structure data shows the existence of O-H–N hydrogen bonding between host and guest molecules. With the imidazole molecule in the inclusion complex, hydrogen bonding prevents easy attack of the epoxy ring. Amine-TEP inclusion complexes show these enhanced curing behaviors when reacted with epoxy resins.

S. Prema et.al., (2017) Polymer concrete was introduced in late 1950's and become well known in 1970's for its use in repair, thin overlays and floors, precast components. Because of it properties like high compressive strength, fast curing, high specific strength, resistance to chemical attack, polymer concrete has found application in very specialized domains. Simultaneously these materials have been used in machine construction also where the vibration damping property of polymer concrete has been exploited. Polymer mortar and concrete are related to new liquid resin such as Polyester, Epoxy as binding material with aggregates. The properties such as setting shrinkage, thermal properties, temperature dependence, lightweight are taken care in respect of light weight porous polymer mortar. This paper investigates the properties of the polymer concrete matrix with different percentages of Epoxy resin binder and light weight particulate fillers. The mixing proportion of particulate filled resin (PFR) was optimized while targeting a specific strength and workability. The content of epoxy resin was varied from 70% to100%, whereas the filler materials ranged from 0% to 30%.The tensile and compression performance of PFR was evaluated using the tensile and compressive strength tests and the most suitable mix proportion of different filler materials are determined based on the experimental results. To study and compare the characteristics of resin concrete containing different filler materials with conventional concrete

Saurabh Gupta et.al., (2015) Supplementary cementitious materials (SCM) are becoming popular in the construction industry as these materials are bringing technical revolution in the field of civil engineering. Alccofine is a new generation micro fine concrete material for high Strength Concrete which is important in respect of workability as well as strength. The aim of this paper is to highlight the importance of Alccofine as Supplementary cementitrious materials in construction industries. This can be used as a SCM due to its ultrafine size and high content of calcium oxide (Cao), Alccofine1203 is essential in terms of reducing heat of hydration and strength at all stages where as Alccofine 1101 can be used as a grouting purpose

V. Belyakov & L. Bannikova (2016) This article describes scientific studies carried out for production of polysterene concrete as modified with recent chemical admixtures. The purpose of work was to obtain physical-and-mechanical characteristics of the material that were necessary for use in the large-scale production of reinforced concrete wall panels, spandrels, flat slabs, short span slabs, etc. The performance test analyses offered rational ingredient compositions of a polysterene concrete mix and enabled obtaining the new information on its technological properties. Dependencies of the concrete strength, deformation and heat-insulation characteristics on percentage of chemical admixtures in the mix were determined. The scientific research are carried out by the employees of the FGAOU VPO 'Ural Federal University named after the 1st President of Russia B.N. Yeltsin''

Vikram K. Shadi & M.A. Banarase (2015) In the present paper, the effect of alccofine on properties of concrete has been studied. The aim of this Study is to evaluate the high performance of concrete containing supplementary cementations materials such as Alccofine. In this paper literatures of various researchers were stud ed on durability of high performance concrete with alccofine and fly ash .The necessity of high performance i concrete is increasing because of demands in the construction industry. Efforts for improving the performance of concrete over the past few years suggest that cement replacement materials along with Mineral & chemical admixtures can improve the strength and durability characteristics of concrete. This alccofine material is pozzolanic materials that are becoming popular in the construction industry as these materials bring technical revolution in the field of civil engineering. Alccofine is a new generation micro fine concrete material for high Strength Concrete which is important in respect of workability as well as strength. Alccofine is easy to use and can be added directly with cement, ultrafine particle of alccofine provide better and smooth surface finish. For high strength concrete the cost of the concrete mix prepared with alccofine is lesser than the concrete without alccofine. It also lowers the water/binder ratio. It was found that the results of alccofine material increases the strength (both in compression and in flexure) to a large extent. If the percentage level of alccofine is increased beyond that level it acts as a filler material and yields good workability to the concrete.

Young Kug Jo and Jeongyun Do (2016) Due to the major advantages of an epoxy-modified system suitable for constantly wet conditions, epoxy-modified cement composites are considered very competitive construction materials compared to latexmodified cement composites. Various performance factors of epoxy-modified cement composites, including strength, are strongly dependent on the hardening degree of epoxy resin, which affects the cost effectiveness of epoxy-modified cement composites. To meet the requirements and control the quality of epoxy-based construction products, the hardening degree of epoxy resin without hardener in cement composites needs to be analytically investigated. Thus, this study quantitatively characterized the hardening degree of epoxy resin with no hardener incorporated into the composites. In this study, the hardening degree and morphology of epoxy resin without hardener were characterized through various analytical approaches, including IR spectral analysis, gel permeation chromatography (GPC), thermo gravimetric analysis-differential thermal analysis (TG-DTA), X-ray diffraction analysis of powder, and scanning electron microscopy (SEM). From the results of this study it was concluded that the hardening properties of epoxy resin in cement composites were efficiently characterized by the suggested analytical method, and the optimal polymer: cement ratio was found to be in the range from 10% to 20%.

3. PROPERTIES AND MATERIAL USED

3.1 Cement

ISI marked OPC 53 Grade cement was used in this work with specific gravity of 3.15 and standard consistency 26%.

3.2 Fine aggregate

Sand used in his work confirming to Zone-III, with fineness modulus of 2.75 and specific gravity 2.6.

3.3 Coarse aggregate

Crushed stone with a maximum size of 10mm and uniform quality having specific gravity 2.74, conforming to IS 383-1970.

3.4. Alccofine 1203

Table 3.1- Physical properties of alccofine 1203

Properties	Value
Specific gravity	2.85
Fineness modulus	6%
Initial setting time	5 minutes
Consistency	28%

Table 3.2- General properties of alccofine 1203

Average Particle Size	4 – 6
Fineness(cm^2/gm)	12000
Bulk Density (Kg/m^3)	600 – 700
CaO	31 – 33 %
Glass Content	>90%
SiO_2	33 – 35%
Al_2O_3	23 – 25%

3.5 Epoxy Resin

Table 3.3- physical properties of Epoxy Resin

Properties	Value
Epoxide Equivalent	185
Molecular Weight	380
Density (20 °C,g/cm3)	1.17
Specific Gravity	1.18
Viscosity(20 °C, mPa×s)	13100

4. MIX DESIGN

4.1 Mix Proportion

Cement = 594.3 Kg
Fine aggregate = 736.87 Kg
Coarse aggregate = 875.67 Kg
Water cement ratio = 0.35
Mix proportion in M_{30} = 1:1.2:1.5

5. CONCLUSION

Different views of various authors on epoxy polymer concrete and partial replacement of cement by alccofine have been analyzed. The study gives the theoretical knowledge about the utilization of alccofine and epoxy resin into the conventional concrete. From the literatures it is understood that alccofine being used in the concrete mix increases the initial strength of concrete than the ordinary concrete. The concrete posses high workability for sufficient time. Ultrafine particle of alccofine gives better and smooth surface finish. By the addition of epoxy resin the epoxy-modified system develops higher strength and adhesion and has lower permeability, better water resistance and chemical resistance. And it also increases the split tensile strength and compressive strength of harden concrete. Therefore based on these literature studies the major conclusion is that alccofine can be used to partially replace cement in epoxy polymer concrete.

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