A Review on Experimental Analysis of Natural Resource of Sisal Fiber on High Performance Concrete

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***Abstract*— The Construction Industry is very large consumer of natural resources like sand, gravel, crushed rock, etc. as building material. Aggregate is the main constituent of concrete, occupying more than 70% of the concrete matrix. The global consumption of natural sand is very high, due to the extensive use of concrete, concrete and plastering material. Sisal fiber is durable material with low maintenance it can be easily recycle it exhibits good sound and impact absorbing properties it has a very good fire resisting properties. This research will study the behavior of eco-friendly high-performance concrete (HPM) that is used for producing ferrocement. This research will analyse the behavior of HPM reinforced with different percentages (5 %–15 %) of natural sisal fibers (NSF), And test cast cube with size of 150*150*150 mm with (Silica Fume(SF) Concrete, Metakaolin (MK) Concrete) including different percentage of natural sisal fibers then perform Compressive Strength, Split Tensile Strength, Flexural Strength, Durability Test on it.**

***Keyword*:. Natural Sisal Fibers, Metakaolin, Concrete**

I. INTRODUCTION

The global consumption of natural sand is very high, due to the extensive use of concrete, concrete and plastering material. Environmental restrictions of sand extraction from river beds have resulted in search for alternative sources of fine aggregate, particularly near the larger metropolitan areas. In past decade variable cost of natural sand used as fine aggregate in concrete increased the cost of construction.

A. Natural sisal fibers (NSF)

The use of natural fibers in composites is becoming increasingly important due to the high mechanical properties, availability, environmental friendliness, and significant processing advantages. Natural fibers are lighter, less expensive, and renewable as well as environmentally friendly.

B. Silica fume

Microsilica, commonly referred to as silica fume, is an amorphous (non-crystalline) form of silicon dioxide, generally known as silica. It is an ultrafine powder with an average particle diameter of 150 nm that is gathered as a waste product from the manufacturing of silicon and ferrosilicon alloy.

C. Metakaolin

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Metakaolin is commonly used in the production of ceramics, but is also used as cement replacement in concrete. The calcined anhydrous form of the clay mineral kaolinite is known as metakaolin. Minerals high in kaolinite are referred to as kaolin or kaolin, and they have historically been used to make porcelain

II. STATE OF DEVELOPMENT

Dr. B. Krishna Rao et. al (2016) Due to constant sand mining, the natural sand is depleting at an alarming rate. So, there is a need to find alternative to natural sand. The aim of the present study is to evaluate the effect of replacing cement with metakaolin and fine aggregate with waste foundry sand. For this study M25 grade concrete is prepared and is evaluated for fresh concrete properties and hardened concrete properties like compressive, split tensile, flexural strength and modulus of elasticity. Ordinary Portland cement is replaced with metakaolin keeping10% constant, while the fine aggregate is replaced with waste foundry sand at 0, 10, 20, 30 and 40% by weight. The compressive, split tensile and flexural strength properties are compared among all the mixes at periods of 7, 28 and 56 days. The results show that the use of metakaolin and waste foundry sand improves the mechanical properties of concrete. The

optimum results were observed at 10% and 30% replacements of metakaolin and waste foundry sand respectively. The increase in compressive strength at 28 and 56 days was found to be 29% and 28.9%, which is 40.1MPa and 41MPa when compared to the nominal mix which is 31MPa and 31.8MPa respectively

R. Selvapriya et. al. (2019) In the recent past, there have been considerable attempts for improving the properties of concrete with respect to strength and durability, especially in aggressive environments. High performance concrete appears to be better choice for a strong and durable structure. A large amount of by-product or wastes such as fly-ash, copper slag, silica fume etc. Are generated by industries, which causes environmental as well as health problems due to dumping and disposal. Proper introduction of silica fume in concrete improves both the mechanical and durability characteristics of the concrete. This paper present literature review on replacement of Cement by Silica Fume which includes current and future trends of research

M. Balasubramanian et. al. (2016) Acceleration in the cost of repair and analysis of concrete structure which enlarge distress much in advance than the design service life has twisted the meeting point on the durability aspect of concrete. Headed for decide the chemical conflict of sisal fibre in Portland cement concrete elements. An investigational study result conducted to evaluate the durability character of plain and fibre reinforced special concrete and its association with Portland cement based humdrum concrete is accessible in this paper. The durability test measured in this study includes water absorption, saturated water absorption (SWA), impact load, rapid chloride penetrability test (RCPT). The experimental Test results discovered that plain and fibre reinforced special concrete possesses higher durability character than conformist concrete of the similar grade with respect to most of the durability tests.

Hamid Souzandeh et. al The interfacial shear strength (IFSS) between natural sisal fiber and zein protein resin was explored using the microbond test. Commercially available zein protein was processed into resins and their IFSS with sisal fiber was measured. Effects of sorbitol plasticizer content and micro fibrillated cellulose (MFC) reinforcement loading on the IFSS with the resin were studied. Scanning electron microscopy (SEM) was used to characterize the fracture surfaces before and after the microbond test. Energy dispersive X-ray spectroscopy (EDX) was utilized to map the residual resin on the sisal fiber surface after the microbond test. The results showed that sisal fiber/ zein IFSS decreased with sorbitol content. At 20 wt% sorbitol content 53% decrease in IFSS was observed. IFSS increased with MFC loading from 1.32 MPa (control) to 2.40 MPa for resin containing 15 wt% MFC. Physical entanglements between sisal fibers and MFC are believed to be responsible for this enhancement in the IFSS.

Jian-Tong Ding et. al (2002) Metakaolin is a relatively new mineral admixture for concrete. It is comparable to silica fume in pozzolanic reactivity, but is lower in price. The effects of metakaolin and silica fume on various properties of concrete were investigated and compared in this study. Seven concretes were cast at a water/binder ratio of 0.35 with 0, 5, 10,and 15% cement replaced by either metakaolin or silica fume. The concretes were tested for slump, compressive strength, free shrinkage, restrained shrinkage cracking, and chloride diffusivity by ponding. Metakaolin-modified concrete showed a better workability than silica fume-modified concrete. As the replacement level was increased, the strength of the metakaolin-modified concrete increased at all ages similarly to that of the silica fume-modified concrete. Both mineral admixtures reduced free drying shrinkage and restrained the shrinkage cracking width. However, the cracking time was earlier for these two concretes. The two admixtures also greatly reduced the chloride diffusivity of the concrete.

Daman K.Panesar et. al. (2019) Supplementary cementing materials (SCMs) exhibit pozzolanic and/or cementations properties and are used in concrete to partially replace the Portland cement component. SCMs differ in source, physical properties, and chemical composition. This chapter discusses four types of SCMs, namely, (1) fly ash, a by-product from coal combustion, (2) slag cement, a by-product of the steel industry, (3) silica fume, a by-product from elemental silicon production, and (4) metakaolin, produced from the calcination of kaolinite clay. Part of the motivation to incorporate SCMs in concrete stems from their potential to reduce greenhouse gas emissions, energy use, and waste disposal to landfill sites. Beyond the environmental benefits, the use of SCMs as a partial cement replacement can achieve similar or improved fresh, mechanical, and transport properties compared to concrete without SCMs.

Concrete containing fly ash, slag cement, silica fume, or metakaolin can improve the resistance to chloride ingress, alkali–silica reaction, freeze–thaw damage, and sulfate attack, compared to concrete without SCMs. However, concrete containing SCMs are typically more vulnerable to carbonation processes and can exhibit greater de-icer salt scaling mass loss than concrete without SCMs.

M. Glavind et. al. Metakaolin is a highly reactive pozzolana formed by the calcinations of kaolinite (China clay). It has to be processed in a burning process like cement, although the temperature of production is between 700 and 900 °C as opposed to 1450 °C in the case of cement. Therefore, considerable CO2 emissions are associated with the production of metakaolin. Taking this into consideration, and also bearing in mind that metakaolin is rather expensive and that only limited production is taking place, it seems unlikely that metakaolin will be a source of positive environmental impact in connection with concrete production. It might be economic in countries such as Brazil and Malaysia where the clay mineral is widely available. This paper contains information about sustainability issues relating to concrete from a life cycle perspective, with a special focus on cement and cement replacement materials. The life cycle of concrete includes the production of raw materials for concrete, production of concrete and optimization of the mix design, construction, use, and demolition and recycling of concrete. A guideline for the application of new materials is presented. Case studies show the effect of CO2 uptake (carbonation) on the life cycle CO2 emissions, different green solutions for a concrete bridge and how concrete reduces the energy need for heating and cooling.

Biju C Thomas et. al. (2020) Strengthening and enhancing of Reinforced Concrete (RC) structural components are important to broaden its administration period, overcoming the first structure limits and to limit the impact of construction defects as well as the design defects. In this work, Fiber Reinforced Polymers (FRPs) is utilized as to strengthen RC structures. In this paper, the utilization of FRP such as Sisal, Jute, and Coir in concrete structures is being examined for its viability in upgrading structural execution both regarding strength and ductility. The structural behavior of FRP specimen is examined by experimental and numerical examination by estimating the parameters, for example, compressive strength, tensile strength, ductility, and deflection. Here, we utilized the Fuzzy Neural Network (FNN) procedure to test the strength of specimen. At the point, when compared with existing work, the proposed FNN model achieves the greatest performance in terms of all parameters for the fiber reinforced specimen under various loaded condition.

CH Jyothi Nikhila et. al. (2015) Among many mineral admixtures available, Metakaolin (MK) is a mineral admixture, whose potential is not yet fully tested and only limited studies have been carried out in India on the use of MK for the development of high strength concrete. MK is a supplementary cementetious material derived from heat treatment of natural deposits of kaolin. MK shows high pozzolana reactivity due to their amorphous structure and high surface area. The experimental work has been carried out as partial replacement of cement with MK in M70 grade of concrete at 0%, 10%, 15%, 20%, 25% and 30% of replacements. The mix design was made making the use of Erntroy empirical Shacklock's method. Cubes are tested for durability studies with H2SO4 and HCL of 0.5% and 1% concentrations. Cubes, cylinders and prisms are tested for temperature study at 15% replacement. The specimens were heated to different temperatures of 100oC, 200oC, 300oC, 400oC and 500oC for three different durations of 1, 2 and 3 h at each temperature. Conclusions are made from the various results and the discussions there on to identify the effect of partial replacement of cement by MK in the design concrete mix. The results conclude that, the use of Metakaolin Concrete (MKC) has improved the performance of concrete under various conditions.

K. Mounika et. al. (2015) This paper deals with the study of impact resistance and flexural performance of reinforced ferrocement specimens with layers of welded mesh and varying percentages of steel fibers. The main objective of this work is to study the effects on specimens casted by using single and double layers of welded mesh and varying percentages of steel fibers 0.5%, 1 %, 1.5%, 2%. Mainly concentrated on energy absorption properties and flexural performance of ferrocement specimens. The size of impact test specimens is 500x500x25mm and the flexural test specimens is 700x300x25mm.Flexural specimens were tested under two point loading system in UTM machine and impact specimens were tested by conducting a low velocity impact test. The results indicated that impact energy increases with increase in

steel fibers and flexural strength increases with increase in number of mesh layers and percentage of steel fibers (0.5%-2%).

A. Kaur et. al. (2016) To achieve sustainability in construction world number of substitutions materials are used. Metakaolin is widely used green pozzolanas. Metakaolin is calcinied clay (koalite). It is obtained from raw material i.e. Kaolin Clay (very fine, white). There is very little emission of carbon dioxide whiles the production of Metakaolin as compared to cement hence it is called as green pozzolanas. The chemical properties of cement were compared with Metakaolin, so that we can replace cement with Metakaolin. In this study partial replacement of cement with Metakaolin at 0%, 3%, 6%, 9% and 12% was done. Mix design was prepared with grade M30 concrete. The compressive strength and split tensile strength of concrete was achieved at 12% addition of Metakaolin. Earlier research also indicate that effect of blended Metakaolin on the properties of cement such as consistency, setting time, soundness remains within the acceptable ranges at different standards. It also solve ecological and environmental problems because cheaper production of Metakaolin and more durable. Therefore this paper provides a scope for more research which is required for green and durable concrete.

Pradeep Kuhar et. al. (2023) The exploitation of modern by-products has become a necessity rather than their disposal due to their probable adverse effect and enlarged ecological alertness. Real evidence prompts micro-silica to be mixed into concrete for durability and strength. While doing this research, silica fume is used instead of some part of cement in concrete as a fractional replacement. In the analysis, silica fume is used at various percentages like 0, 4.5, 7, 9.5, and 12% by the mass of cement in M35 grade of mix proportion with water–cement ratio 0.49. The experimental specimens were analyzed for workability, durability, and mechanical properties of the concrete, subjected to various curing regimes. A mathematical regression model with elements of concrete mix is used as a variable is planned and developed, which yielded excellent regression coefficients for the calculation of mechanical properties at several curing stages which further strengthens the findings of the work.

Himmi Gupta et. al. (2019) Study of the advanced composites and the fundamental understanding of their behaviour has picked great momentum in the field of civil engineering in the past few decades. Use of High Performance Fiber Reinforced Concrete (HPFRCC) eliminates the transverse reinforcement with its higher energy dissipation, ductility, thermal resistance and slower stiffness degradation capabilities. The increasing development and availability of HPFRCC is providing enormous opportunities in structural applications particularly where improved damage tolerance is desirable. The stress distribution in the anchorage zone of a post tensioned beam is complicated and can depend on several factors such as the location of prestress force, the magnitude of prestress force, the transfer length, the quantity and arrangement of stirrups, presence of cracks and the size of the beam cross-section. Cracks developed in the anchorage zone pose severe strength and serviceability issues and their repair is costly, time consuming and few repair options exist. From an ownership and inspection standpoint, it is highly desirable to have minimal crack formation. A lot of research has been done on the application of HPFRCC in this zone. The paper provides a comprehensive review of the developments in the field of HPFRCC and its application in the anchorage zone of post-tensioned concrete girders.

Malathy Ramalingam et. al. (2022) Geopolymer mortar is the best solution as an alternative to cement mortar in civil engineering. This paper deals with the effect of geopolymer mortar on the strength and microstructural properties under ambient curing conditions. In this research, geopolymer mortars were prepared with fly ash and steel slag (in the ratio 1:2.0, 1:2.5 and 1:3.0) as precursors with NaOH and Na2SiO3 as activator solution solutions (in the ratios of 0.5, 0.75 and 1.0) with concentrations of NaOH as 8 M, 10 M, 12 M and 14 M to study the compressive strength behaviour. From the experimental results, it was observed that the geopolymer mortar mix with the ratio of fly ash and steel slag 1:2.5, 12 M NaOH solution and the ratio of NaOH and Na2SiO3 0.5 exhibits the maximum compressive strength results in the range of 55 MPa to 60 MPa. From the optimized results, ferrocement panels of size 1000 mm 1000 mm 50 mm were developed to study the flexural behaviour. The experimental results of the flexural strength were compared with the analytical results developed through ABAQUS software. It was observed that the Trough-shaped geopolymer ferrocement panel exhibits 56% higher value in its

ultimate strength than the analytical work. In addition to the strength properties, microstructural analysis was carried out in the form of SEM, EDAX and XRD from the tested samples.

S.F.A. Rafeeqi et. al. (2012) Cast in situ Ferro-mesh layers and precast Ferrocement Laminate have been investigated on the basis of ease in application for local rural personnel without special skills and tools. Ten (10) RC beams including one control beam are intentionally designed and detailed in flexure using steel percentage of 0.968. Beams have been tested under two-point loading till service limit, then unloaded and have been strengthened in flexural dominant region using above mentioned flexural strengthening techniques and tested again under same loading arrangement till failure. Results showed that application of precast Ferrocement Laminate is more promising as it is easy for a local rural unskilled person to apply and enhancing load carrying capacity, stiffness and ductility.

Temitope F. Awolusi et. al. (2023) Fibre-reinforced ferroconcrete is a new-generation type of concrete that has been found to have adequate performance. Global emissions of CO2 as a result of concrete production have damaged the earth's atmosphere. These emissions, together with construction waste, such as ceramic powder and aluminium waste, are considered one of the most harmful wastes to the environment, eventually leading to pollution. In this study, the fibre-reinforced ferroconcrete (FRFC) contained waste aluminium fibre, cement, ceramic waste powder, corrugated wire mesh, and fine and coarse aggregate. The cement content in the concrete mix was partially replaced with Ceramic Powder (CP) in proportions of 0%, 10%, and 20%, while the Aluminum Fibers (AF) were added in proportions 0, 1, and 2% to the concrete mix. The variation of ceramic powder and aluminium fibres was done using the central composite design of Response Surface Methodology (RSM) to create experimental design points meant to improve the fibre-reinforced ferroconcrete's mechanical performance. The results conclude that the mechanical performance of the FRFC was slightly improved more than conventional concrete, where at 20% replacement of ceramic powder and 1% addition of aluminium fibre to the concrete mix. There was more compressive, flexural, and split tensile strength increase than conventional concrete, with control concrete having strengths of 13.060, 5.720, and 3.110 N/mm2 and ferroconcrete 15.88, 6.68, and 3.83 N/mm2 respectively. This was further confirmed with microstructural images. The RSM model, with parameters such as; contour plots, analysis of variance, and optimisation, was used to effectively predict and optimise the responses of the ferroconcrete based on the independent variables (Aluminum fibre and Ceramic Powder) considered. The results of the predicted data show a straight-line linear progression as the coefficient of determination (R2) tends to 1, indicating that the RSM model is suitable for predicting the response of the variables on the FRFC.

Hamid Souzandeh et. al. (2018) The interfacial shear strength (IFSS) between natural sisal fiber and zein protein resin was explored using the microbond test. Commercially available zein protein was processed into resins and their IFSS with sisal fiber was measured. Effects of sorbitol plasticizer content and microfibrillated cellulose (MFC) reinforcement loading on the IFSS with the resin were studied. Scanning electron microscopy (SEM) was used to characterize the fracture surfaces before and after the microbond test. Energy dispersive X-ray spectroscopy (EDX) was utilized to map the residual resin on the sisal fiber surface after the microbond test. The results showed that sisal fiber/ zein IFSS decreased with sorbitol content. At 20 wt% sorbitol content 53% decrease in IFSS was observed. IFSS increased with MFC loading from 1.32 MPa (control) to 2.40 MPa for resin containing 15 wt% MFC. Physical entanglements between sisal fibers and MFC are believed to be responsible for this enhancement in the IFSS.

Sanjeev Salot et. al. Now a day’s concrete industry becomes a well-known reason for leaving enormous ecological footprint. Firstly a huge quantum of material needed every year for the production of concrete around the world. Together with the energy requirement and water consumption, concrete industry is also responsible for emission of greenhouse gasses. To enable worldwide growth of infrastructure with least harmful impact on environment, it becomes essential to use Eco-friendly materials. Metakaolin is a most viable option for the partial replacement of OPC because it along with-reduction in CO2emissionsalsoenhances the useful life span of the buildings by improving strength properties and durability of concrete. This study was done for the partial replacement of cement (OPC43 grade) with metakaolin (MK) at 0%, 6%, 9%, 12%, 15% by using treated waste water (TWW) and potable water (PW)

individually as mixing water. The influence of this partial replacement was studied on strength properties (compressive strength, flexural strength and split tensile strength) of concrete grade M35 and a comparative study was made on concrete mix produced using two different waters i.e. TWW & PW. From the experimental work 12% replacement level comes out as optimum limit for the improved performance of concrete. Strength of concrete made with TWW is also comparable for most of the proportions and it can be recommended to use TWW as a replacement of PW.

III. CONCLUSION

This paper focuses only on the literature review of previously published studies. A large amount of by-product or wastes such as fly-ash, copper slag, silica fume etc. Are generated by industries, which causes environmental as well as health problems due to dumping and disposal. Proper introduction of silica fume in concrete improves both the mechanical and durability characteristics of the concrete An investigational study result conducted to evaluate the durability character of plain and fibre reinforced special concrete and its association with Portland cement based humdrum concrete. For further study The Plain cement Concrete with Normal Sisal Strands (NSF), Silica Rage, and Metakaolin was put through an exploratory evaluation to see if it was adequate and reliable in the climatic conditions of India. For the present assessment, three distinctive products from leading market producers were compared to a control concrete

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