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A Review Paper on Strength and Durability Study of Concrete by Using Rice Husk Ash and Coconut Fiber

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Abstract: Performance enhancement of non-engineered infra-structural systems in rural areas with locally available materials has become necessary in current day technology, mainly to counter unanticipated loads like Earthquake. In many smaller towns and villages in southern parts of India, materials result in the form of fibers and granular materials as waste. The industrial by products such as Fly Ash, Rice Husk Ash, Silica Fume, and Slag etc can be used as cementing materials because of their pozzolanic behavior. The agricultural by product such as natural fibers like jute fiber, Coconut fiber, Rice husk can be used to increase the tensile strength of concrete, which otherwise require large tracts of lands for dumping, thus the concrete industry offers an ideal method to integrate and utilize a number of waste materials, which are easily available, and economically within the buying powers of an ordinary man. Presence of such materials in cement concrete not only reduces the carbon dioxide emission, but also imparts significant improvement in workability, Split Tensile strength, Compressive strength.In this paper the basic aim is to review the research paper on the use of waste material in concrete.
Keywords: Coconut Fiber, Rice husk ash, Green concrete, Cement replacement, Cement additive

I. INTRODUCTION

The concept of environmentally friendly technology has inspired the researchers to do more in protecting the environment. Utilization of waste materials as alternative building materials has become the popular way to overcome the environmental problem in most developing countries. Waste materials such as Rice Husk have great potential to be used as building materials. The high silica content from Rice Husk Ash has pozzolanic behaviour which influence the concrete strength [2].

The annual production of rice from across the globe is around 600 million tons per year. Thailand alone produces approximately 5 million tons annually. The outer shell of rice grain, often called as rice husk, generated from the rice milling industries is a well known agro industrial by-product in many parts of the world. Raw rice husk (RRH) consists of about 40% cellulose, 30% lignin group and 20% silica. The RRH normally used as a fuel in the parboiling process in rice milling industries. On combustion, the cellulose–lignin matrix of RRH burns away and leaves only a porous silica skeleton. Therefore, RHA contains a large volume of silica. After grinding the porous silica skeleton of rice husk a fine powder with high surface area, called rice husk ash (RHA). Due to its high silica content, RHA is considered as a highly reactive pozzolanic material in the production of concrete. The reactivity of RHA is attributed to the high amorphous silica content and the very large surface area governed by the porous structure of the particles. Highly reactive RHA is found when it is burnt under controlled conditions. The RHA contains high silica content in the amorphous form of silica up to 95% or even 100%.Its reactivity is also favored by increasing its fineness [11].

The enhancement in the mechanical properties and durability of concrete due to the addition of RHA is caused by the reaction of RHA with $Ca(OH)_2$ during the hydration process to form additional C–S–H gel. It was confirmed by the findings of Yu et al. that at temperatures around 40 ^{0}C and in the presence of water, the amorphous silica contained in RHA can react with Ca(OH)2 to form one kind of C–S–H gel ($Ca_{1.5}SiO_{3.5}.xH_2O$) [17].

In other conditions, a residual RHA is produced with a lower quality due to high carbon content. The high carbon content leads to an increase in water demand and produces a darker color in mortar and concrete. However, the filler effect has been demonstrate as being even more pronounced than the pozzolanic effect [8].

Coconut fibre is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fibre were coir, cocos nucifera and arecaceae (Palm), respectively. There were two types of coconut fibres, brown fibre extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance, while white fibres are smoother and finer, but also weaker. Coconut fibres are commercially available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated(mixed fibres). These different types of fibres have different uses depending upon the requirement. In engineering, brown fibres are mostly used. According to official website of International Year for Natural Fibres approximately, 500,000 tonnes of coconut fibres were produced annually worldwide, mainly in India and Sri Lanka. Its total value is estimated at $100 million. India and Sri Lanka are also the main exporters, followed by Thailand, Vietnam, the Philippines and Indonesia. Around half of the coconut fibres produced is exported in the form of raw fibre [10].

Coconut fiber, extracted from the husk of coconuts, was cheap and locally available in many tropical and semitropical countries. Coconut fiber was capable of taking strain 4–6 times as compared to other natural fibers. The potential of using coconut fiber to improve the performance of cementitious materials has received increasing attention from researchers in recent years. Coconut fiber was currently widely used in boards, roofing materials, concrete, and other building materials. Cementitious composites that have been reinforced with coconut fiber and cast under 1–2 MPa of pressure are presently used as low-cost roofing materials. Previous research has found that coconut fiber reinforced cementitious mixtures exhibit decreased workability due to the strong water absorptive and retentive nature of coconut fiber[5].

II. LITERATURE REVIEW

Ade Sri Wahyuni et al. [2] carried out an experimental research on the performance of concrete with rice husk ash, sea shell ash and bamboo fiber addition. The aim of that research was to investigate the tensile strength of concrete with 0.50% addition of bamboo fibre based on cement weight. To increase the strength of concrete, the mixture of rice husk ash (RHA) and sea shell ash (SSA) was used as partial replacement of fine aggregate. Their replaced was divided into four different percentages namely 10%, 20%, 30% and 40% based on the weight of fine aggregate. The experimental work consisted of casting 13 different types of concrete to be compared in term of splitting tensile strength at the age of 28 and 90 days. In general, the tensile strength of bamboo fibre reinforced concrete is comparable to that of Normal Concrete. It was clear from the graph that the tensile strength of 20% replaced by RHA was higher than that of normal concrete by age of 28 days.

M. Jamil et al. [11] experimentally studied the Pozzolanic contribution of rice husk ash in cementitious system. Replacement percentages of RHA used in various previous studies were chosen arbitrarily like 5%, 10%, 20% and so on to determine the total effect of RHA. But the unique filler effect or pozzolanic effect of RHA in cementitious system was yet to be investigated comprehensively by the scientific community. The study was carried out to find the maximum pozzolanic (chemical) contribution of RHA in cementitious system in terms of replacement percentage. The determination was analytical and based on the hydration reaction of cement and the pozzolanic reaction of RHA with the hydration product. They achieved 42.5N/mm^2 compressive strength at 20% Replacement compared to 37.1 N/mm^2 Compressive strength of normal concrete.

S.N. Raman et al.[17] carried out an experimental research on high-strength rice husk ash concrete incorporating quarry dust as a partial substitute for sand. The experimental work undertaken to evaluate the suitability of quarry dust as a partial substitute for sand in high-strength concrete (HSC) containing rice husk ash (RHA). Two grades of HSC mixes, to achieve 60 MPa and 70 MPa at 28 days, were designed with and without the incorporation of RHA. Quarry dust was then used in the mixes containing RHA as a partial substitute for sand, in quantities ranging from 10% to 40%.They achieved compressive strength higher at 10% replacement compared to compressive strength of normal concrete. Similarly, 10% RHA was used to replaced the cement in the remaining mixes with mixes contains quarry dust as a replacement for sand at 10%, 20%, 30% and 40% respectively decrease the compressive strength then use only RHA.

Divy chopra[7] experimentally studied about Strength, permeability and microstructure of self-compacting concrete containing rice husk ash. Self-compacting concrete (SCC) was characterized by deformability and segregation resistance. It flows under its own weight while remaining homogeneous in composition. The effect of replaced cement content with rice husk ash (RHA) as supplementary cementitious materials (SCM's) in SCC and observing fresh flow (slump flow, V-Funnel, U-box, L-Flow), mechanical strength (compressive and split tensile) and durability properties (porosity and rapid chloride permeability test) at 7, 28 and 56 d. Concrete specimens were prepared with 0,10, 15 and 20% RHA replace cement. 20% RHA replaced showed minimum specified workability. An increase of about 25% strength at 7 d, 33% at 28 d and 36% at 56 d was observed with RHA content of 15% RHA when compared to control mix. Maximum split tensile strength was 3.8 N/mm^2 at 28 d and 4.0 N/mm^2 at 56 d for 15% RHA replacement. The inclusion of RHA as partial replaced to cement improved the strength properties and durability properties that remained within limits up to 20% replaced.

Hwang Chao-Lung et al.[8] carried out the research work on effect of rice husk ash on the strength and durability characteristics of concrete. The work investigated the effects of adding residual rice husk ash (RHA) from South Vietnam, generated when burning rice husk pellets in the boiler, to cement. To improve pozzolanic reactivity, RHA was ground for 1 h. The non-ground RHA and ground RHA were used to test strength activity index according to ASTM C311. The properties of the concrete were investigated, including compressive strength, concrete electrical resistivity, and ultrasonic pulse velocity. Results showed that the non-ground RHA can be applied as a pozzolanic material. Decreasing the non-ground RHA average particle size provides a positive effect on the compressive strength of mortar. Compressive strength of cylindrical concrete in the 47–66 MPa range was obtained in this study. The results also indicated that up to 20% of ground RHA could be advantageously blended with cement without adversely affecting the strength and durability properties of concrete. The achieved compressive strength 66 N/mm2 AT 10% Replaced compared to 56 N/mm2 Compressive strength of normal concrete. Same replaced RHA but increase w/b ratio result decrease strength.

Saeid Hesami et al.[15] carried out the research work on effects of rice husk ash and fiber on mechanical properties of pervious concrete pavement. The use of pervious concrete pavement was significantly increasing due to reduction of road runoff and absorption of noise. However, the type of pavement cannot be used for heavy traffic due to a high amount of voids and consequently low strength of pervious concrete. The rice husk ash (RHA) was used in order to strengthen pozzolanic cement paste and the effect of 0%, 2%, 4%, 6%, 8%,10% and 12% weight percentages as a cement replaced in concrete mixtures on the mechanical properties was studied. Moreover, 0.2% Vf of glass (where Vf is the proportion of fiber volume to total volume of concrete), 0.5% Vf of steel and 0.3% Vf of polyphenylene sulfide (PPS) fibers were used to improve the mechanical properties of the pervious concrete. Also, several water to cement (w/c) ratios were made and then, physical and mechanical properties of hardened concrete including porosity, permeability, compressive strength, tensile strength and flexural strength were investigated. The results indicated a significant increase in compressive, tensile and flexural strengths. Also, in all of w/c ratios, a similar trend was observed in the compressive, tensile and flexural strengths of concrete containing RHA and fibers but the optimum percentage of RHA was different so that, it increases rapidly to the optimization point but gradually decreases after this point. The w/c ratio of 0.33 significantly increased the mechanical properties of the pervious concrete and reduces the amounts of voids and its permeability.

Chao-Lung Hwang et al.[5] carried out the study on effects of short coconut fiber on the mechanical properties, plastic cracking behavior, and impact resistance of cementitious composites. The study examines the effect of adding random, short coconut fibers to various cementitious composites on the mechanical properties, plastic cracking, and impact resistance of these composites. Fibers underwent a washing and boiling pre-treatment prior to being added to the composite mixture. Mixtures of the cementitious composites designed by Densified Mixture Design Algorithm (DMDA) method were made using different volume fractions of random, short coconut fiber (0%, 1%, 2.5%, and 4%) and different water-to-binder (W/B) ratios (0.3, 0.35, and 0.45). Furthermore, fly ash (FA) was used to fill the void between sand particles and ground blast furnace slag (GBFS) was used to substitute forthe cement in the mix proportions. A variety of tests were conducted in accordance with the relevant standards to determine the properties of these coconut fiber cementitious composites. The findings show that higher volumes of coconut fiber in the mortar tend to reduce the density and to increase the superplasticizer dosage. The addition of coconut fiber and higher W/B ratios were associated with lower compressive strength and higher absorption. The 28-day flexural strength of cementitious sheets and the modulus of rupture, respectively, increased from 5.2 to 7.4 MPa and from 6.8 to 8.8 MPa, as the coconut fiber- to-mortar ratio ranged from 0% to 4%. Adding coconut fiber positively influenced first-crack deflection, toughness indices, plastic cracking, and impact resistance in the composites.

Majid Ali et al.[10] carried out study on mechanical and dynamic properties of coconut fibre reinforced concrete. Coconut fibres have the highest toughness amongst natural fibres. They have potential to be used as reinforcement in low-cost concrete structures, especially in tropical earthquake regions. For this purpose, the mechanical and dynamic properties of coconut fibre reinforced concrete (CFRC) members need to be well understood. In the work, in addition to mechanical properties, damping ratio and fundamental frequency of simply supported CFRC beams were determined experimentally. A comparison between the static and dynamic moduli was conducted. The influence of 1%, 2%, 3% and 5% fibre contents by mass of cement and fibre lengths of 2.5, 5 and 7.5 cm was investigated. To evaluate the effect of coconut fibres in improving the properties of concrete, the properties of plain concrete were used as a reference. Damping of CFRC beams increases while their fundamental frequency decreases with structural damage. CFRC with higher fibre content has a higher damping but lower dynamic and static modulus of elasticity. They were found that CFRC with a fibre length of 5 cm and a fibre content of 5% has the best properties.

M. Sivarajas. Kandasamy[12] carried out the study on Potential reuse of waste rice husk as fibre composites in concrete. The aim of that paper was to characterize the structure related properties of concrete composite with locally available rice husk fibers, for achieving reasonable energy absorbing capacity. Experimental investigations were performed to find the mechanical, shear, impact and flexural properties of concrete with and without rice husk composites. Microstructure of as received and reacted rice husk fibers with concrete for two years are also studied for durability considerations. The achieved tensile strength of 3.48 N/mm^2 and compressive strength 27.98N/mm^2 at 1.5% replacement compared to 2.86 N/mm^2 Tensile strength and 27 N/mm^2 Compressive strength of normal concrete.

III. CRITICAL REMARKS

Following critical remarks can be drawn from the literature review:

To use both RHA and CF in concrete in varying proportions , As RHA increases the compressive strength of concrete, but it decreases the tensile strength of concrete.

Use of CF in concrete will increase the tensile strength.

As a result both the compressive and tensile strength of concrete increases,Cost of concrete decreases, and amount of waste decreases.

Requires increase in water cement ratio due to increase in percentage of RHA and CF, because RHA is highly porous material and CF absorbs more water.

The workability of RHA and CF concrete has been found to decrease with increase in RHA and CF replacement.

The significant increase compressive strength about 10% to 15% when RHA replaced by cement weight.

The significant increase split tensile strength about 2% to 3% CF adding by cement weight.

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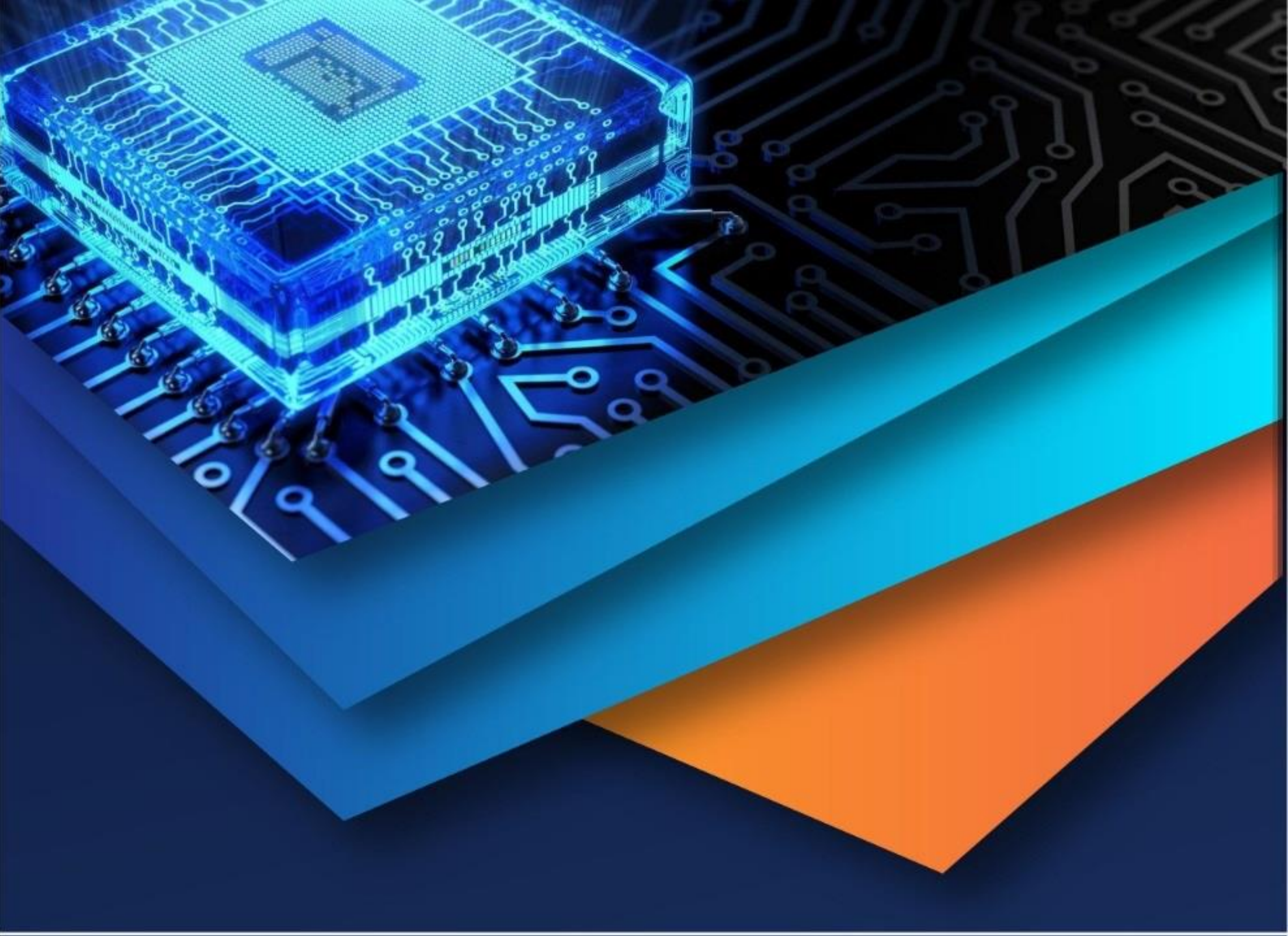

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