"Comparative Study of Replacement of Cement by Biomass and Silica Fume"

Sushil D. Shepal[1]
Department of Civil Engineering
Shivajirao S. Jondhle College of Engineering & Technology
Asangaon-421601
sushilshepal@gmail.com

Prof. R. M. Swamy[2]
Department of Civil Engineering
Shivajirao S. Jondhle College of Engineering & Technology
Asangaon-421601
rmswamy68@gmail.com

Abstract -This paper presents results about the characterization of the biomass fly ashes sourced from a thermal power plant and from a co-generation power plant located in Portugal, and the study of new cement formulations incorporated with the biomass fly ashes. The study includes a comparative analysis of the phase formation, setting and mechanical behavior of the new cement–fly ash formulations based on these biomass fly ashes. Techniques such as X-ray diffraction (XRD), X ray fluorescence spectroscopy (XRF), thermal gravimetric and differential thermal analysis (TG/DTA), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM) and environmental scanning electron spectroscopy (ESEM) were used to determine the structure and composition of the formulations. Fly ash F1 from the thermal power plant contained levels of SiO2, Al2O3 and Fe2O3 indicating the possibility of exhibiting pozzolanic properties. . The fly ashes are similar to class C fly ashes according to EN 450 on the basis of chemical composition. The hydration rate and phase formation are greatly dependent on the samples' alkali content and water to binder (w/b) ratio. In cement based mortar with fly ash the basic strength was maintained, however, when fly ash was added the mechanical strength was around increase of the reference cement mortar. The fly ashes contained significant levels of chloride and sulphate and it is suggested that the performance of fly ash–cement binders could be improved by the removal or control of these chemical species.

Keywords – *fly ash, silica fume, wood ash*

*****

I. INTRODUCTION

Concrete as is surely understood is a heterogeneous blend of bond, water and totals. The admixtures might be included cement keeping in mind the end goal to upgrade a percentage of the properties sought exceptionally. In its most straightforward structure, cement is a blend of glue and totals. Different materials are included; for example, fly powder, rice husk, and admixture to get cement of sought property. The character of the solid is dictated by nature of the glue. The way to accomplishing a solid, tough solid rests in the cautious proportioning, blending and compacting of the fixings.

In the present years, the worry of our worldwide surroundings and expanding vitality instability has prompted an expanding request in renewable vitality and their sources. Among these assets, biomass assets (ranger service and horticultural squanders) and power plants energized by them are a promising wellspring of renewable vitality with a financially low operational expense and ceaselessly recovery of the fuel. Additionally it is viewed as a CO2 impartial vitality asset as utilization rate is lower than development rate. Also, the utilization of backwoods and timber industry by items, for example, sawdust, woodchips, wood bark, saw factory scraps and hard chips in the generation of force introduces an effective strategy for the transfer of the previously stated modern by items. The warm incineration fundamentally lessens the mass and the volume of the waste in this manner giving ecologically and monetarily safe strong waste administration. It is a typical practice in the timber item fabricating industry to draw power for the modern procedures from the wood squanders by growing little scale boilers units and utilizing wood squanders as boss wellsprings of vitality. Also in the nearness of appropriate outflow controls, for example, electrostatic precipitator, there is for all intents and purposes practically no emanation, in this manner rendering it an ecologically safe fuel. Wood squanders' energizes are favoured more than different biomasses (herbaceous and horticultural) because of decreased fly cinder and other build-up generation.

India is the seventh biggest nation on the planet covering a zone of 32, 87,590 square kilometres. It is a critical nation in South – Asia which offers land fringes with Pakistan toward the west; China, Nepal and Bhutan toward the north-east; Myanmar and Bangladesh toward the east. Spread over a sum of 35 States and Union Territories, the number of inhabitants in India is evaluated to be 1.21 billion. Farming is the backbone of Indian economy in view of its high partakes in work and employment creation. Around 52% of Indian populace depends specifically on agribusiness and it represents around 18.1% of GDP. Farming gets its significance from the way that it has essential supply and request joins with the assembling division. Amid the previous five years, this area has seen stupendous advances in the creation and profitability of sustenance grains, oilseeds, business crops, organic products, vegetables, nourishment grains, poultry and dairy. India has risen as the second biggest maker of foods grown from the ground on the planet notwithstanding being the biggest abroad exporter of cashews and flavors. Further, India is the most elevated maker of milk on the planet Agriculture represents around 10% of the aggregate fare income and gives crude material to countless. "Fares of farming items are relied upon to cross US$ 22 billion imprint by 2014 and record for 5% of the world's horticulture sends out," as per the Agricultural and Processed Food Products Export Development Authority (APEDA).

Figure 1.1: Portland cement

Concrete as is surely understood is a heterogeneous blend of bond, water and totals. The admixtures might be included cement keeping in mind the end goal to upgrade a portion of the properties sought uncommonly. In its easiest structure, cement is a blend of glue and totals. Different materials are included; for example, fly fiery debris, rice husk, and admixture to acquire cement of coveted property. The character of the solid is controlled by nature of the glue. The way to accomplishing a solid, tough solid rests in the cautious proportioning, blending and compacting of the fixings.

The waste materials locally accessible are proficiently conveyed to enhance the working of the provincial based businesses. Structural Engineers are dependably looking for waste materials that can be utilized as a mixing segment as a part of concretes to enhance its quality and to diminish the expense. A few examinations have been completed to use waste material in development. Aside from disposing of these materials, their utilization in development shields nature from sullying. Modern and agrarian squanders are utilized for the generation of minimal effort building materials. Agro-modern squanders, for example, tobacco waste, non-palatable oil cake and hyacinth have been utilized effectively to install bio-gas plants. Rural build-ups, for example, bagasse, rice husk and rice straw are used in the generation of light weight dirt blocks. Mechanical squanders, for example, impact heater slag, manure squanders, fly fiery remains, silica exhaust and incinerators powder are silica-based materials having pozzolanic properties. These are utilized for the advancement of novel low temperature bonds and added to port area concrete as supplementary cementitious materials with enhanced properties contrasted with Portland concrete. Notwithstanding the above mechanical squanders, the agro squanders, for example, rice husk fiery remains, sugarcane bagasse slag, rice straw cinder, wheat straw powder, hazel nutshell fiery remains are having pozzolanic properties and utilized as concrete substitution materials. As a bond substitution material, numerous exceptional properties of these silica-based materials have been accounted for by a few agents.

Human exercises on earth produce in impressive amounts of squanders more than 2,500 million tons for every year, including mechanical and agrarian squanders from country and urban social orders. This makes major issues to the earth, wellbeing furthermore the area filling. Presently a day the solid is most utilized synthetic material as a part of the world. The Indian development industry alone expends roughly 400 million tons of cement each year and the relative measure of mortar as well. Thusly the interest of the solid and the required crude materials are high. This causes the climb in the expenses of concrete, fine and coarse totals. All the time the lack of these materials is likewise happened. To evade the issues like cost climb and cuts in supply of cement and mortar, the substitute material or the halfway trades for the concrete and total ought to be produced by reusing of waste materials.

In the old period, development work was generally completed with help of mudstone from industry. Fly fiery remains is a result of smoldered coal from force station and rice husk cinder is the side effect of blazed rice husk at higher temperature from paper plant counterfeit filaments are usually utilized these days as a part of request to enhance the mechanical properties of cement. Significant endeavors are being taken worldwide to use characteristic waste and bye item as supplementary establishing materials to enhance the properties of bond cement. Rice husk ash (RHA) and Fly ash (FA) with utilizing Steel fiber is such materials. RHA is bye-result of paddy industry. Rice husk fiery debris is a profoundly receptive pozzolanic material delivered by controlled smoldering of rice husk. FA is finely partitioned delivered by coal-let go power station. Fly slag has pozzolonic properties like normally happening pozzolonic material. In the late years, developing awareness about worldwide environment and expanding vitality security has prompted expanding interest for renewable vitality assets and to differentiate current strategies for vitality generation. Among these assets, biomass (ranger service and rural squanders) is a promising wellspring of renewable vitality. In the present patterns of vitality creation, power plants which keep running from biomass have low operational cost and have nonstop supply of renewable fuel. It is viewed as that these vitality assets will be the CO2 nonpartisan vitality asset when the utilization rate of the fuel is lower than the development rate. Likewise, the utilization of squanders created from the biomass commercial enterprises (sawdust, woodchips, wood bark, saw factory scraps and hard chips) as fuel offer a route for their protected and proficient transfer. The warm burning enormously decreases the mass and the volume of the waste hence giving an earth safe and financially productive approach to deal with the strong waste. More often than not, timber item fabricating units grows little scale heater units which utilize wood waste created in the unit itself as fundamental fuel to deliver heat vitality for their different procedures like drying the completed items. Wood squanders are normally favored as energizes over different herbaceous and rural squanders as their incineration creates equivalently less fly fiery debris and other leftover material. A noteworthy issue emerging from the utilization of horticultural and timber waste item as fuel is identified with the slag delivered in critical sum after the burning of such squanders. It is usually watched that the hardwood deliver more fiery debris than softwood and the bark and leaves by and large create more powder when contrasted with the internal part of the trees. On a normal blazing of wood produces 6–10% of cinder by the heaviness of wood smoldered and its arrangement can be profoundly variable relying upon land area and modern procedures. The most winning strategy for transfer of the slag is area filling which represents 70% of the fiery remains produced, rest being either utilized as soil supplement (20%)or different random occupations (10%). The attributes of the cinder rely on biomass qualities (herbaceous material, wood or bark), burning innovation (altered bed or fluidized bed) and the area where a fiery remains is gathered. As wood fiery remains fundamentally comprises of fine particulate matter which can without much of a stretch get air borne by winds, it is a potential peril as it might bring about respiratory wellbeing issues to the inhabitants close to the landfill site or can bring about ground water tainting by draining poisonous components in the water. As the transfer expense of the fiery debris is rising and volume of slag is expanding, a feasible cinder administration which incorporate the powder inside the normal cycles should be utilized.

Silica smoke is by result of delivering silicon metal or ferrosilicon compounds. A standout amongst the most valuable uses for silica smoke is in cement. On account of its synthetic and physical properties, it is extremely responsive pozzolan. Concrete containing silica smoke can have high quality and can be exceptionally strong. Silica smoke is accessible from suppliers of solid admixture and, when determined, is basically include amid solid generation. Setting, completing and curing silica-smolder concrete required uncommon consideration with respect to the solid temporary worker. Silicon metal and amalgams are created in electric heater. The crude materials are quartz, coal and wood chips. The smoke that outcomes from heater operation is gathered and sold as silica smoke, rather than being area filled. Maybe the most essential utilization of this material is as a mineral admixture in cement.

Silica Fume (SF) is a result process in the silicon and ferrosilicon industry. The diminishment of high immaculateness quartz to silicon at temperatures up to2000°C produces SiO_2 vapors, which oxidized and consolidate in the low temperature zone to minor particles comprising of non-crystalline silica. By-item by result of the creation of silicon metal and the ferrosilicon compound having silicon contains of 75% or more contain 85-95% non-crystalline silica. The by-result of the creation of ferrosilicon having half silica has much lower silica content and is less ozzolanic. Along these lines. Sio_2 substance of the silica smoke is identified with the kind of amalgam being delivered.

Silica smoke is otherwise called smaller scale silica; contain silica rage, volatiles silica or silica dust. Silica seethe, otherwise called small scale silica (CAS number 69012-64-2, EINESCS number 273-761-1) is a nebulous (non crystalline) polymer structure silicon dioxide, silica. It is an ultrafine powder gathered as a side effect of the silicon and ferrosilicon composite creation and comprises of circular molecule with a normal molecule width of 150nm. The primary field of use is a pozzolanic material for elite cement.

The utilization of Silica Fume (SF) in cement enhances the mechanical properties in pressure and flexure through pozzolanic action as filling voids between the concrete particles. The utilization of SF likewise enhances the rheological qualities of the glue. An undensified SF was utilized as a part of the present study, having producer determined properties as: more noteworthy than 98.9% SiO_2, greatest molecule size 0.1 μm and mass thickness 250-300 kg/m3.

II. Objectives

1. Study different Biomass suitable for mixing with cement.
2. Mixing of various biomasses in different percentage with cement.
3. Estimation of compressive strength.
4. Selecting optimum mixture.
5. Study of different silica fume suitable for with mixing with cement.
6. Study to taking silica fume percentage with cement and biomass is constant.

III. LITERATURE REVIEW

Satish H. Sathawane [1] studied the detailed experimental investigation on effect of partial replacement of cement by Fly Ash (FA) and Rice Husk Ash (RHA) in combine proportion started from 30% FA and 0% RHA mix together in concrete by replacement of cement with the gradual increase of RHA by 2.5% and simultaneously gradual decrease of FA by 2.5%. Last proportion was taken 15%FA and 15% RHA. The tests on hardened concrete were destructive in nature which includes compressive test on cube for size (150 x 150 x 150 mm) at 7,14,28,56 and 90 days of curing as per IS: 516 1959, Flexural strength on beam (150 x 150 x700 mm) at 28 days of curing as per IS: 516 1959 and split tensile strength on cylinder (150 mm ø x 300mm) at 28 days of curing as per IS: 5816 1999. The work presented in this paper reports the effects on the behavior of concrete produced from cement with combination of FA and RHA at different proportions on the mechanical properties of concrete such as compressive strength, flexural strength, and split tensile strength. Investigation reported that compressive strength increases by 30.15% in compared with targeted strength and reduces by 8.73% compared with control concrete at 28 days, flexural strength increases by 4.57% compared with control concrete at 28 days, split tensile strength decreases by 9.58% compared with control concrete at 28 days, were obtained at combination of 22.5% FA and 7.5% RHA. Partial replacement of FA and RHA reduces the environmental effects, produces economical and eco-friendly concrete.

Dale P. Bentz [2] worked on the influence of water-to-cement mass ratio (*w/c*) on early-age a property of cement-based materials is investigated using a variety of experimental techniques. Properties that are critical to the early-age performance of these materials are tested, including heat release, semi-adiabatic temperature, setting time, autogenous deformation, and strength development. Measurements of these properties using single cement are presented for four different *w/c*, ranging from 0.325 to 0.425. Some of the measured properties are observed to vary widely within this range of *w/c* ratios. The heat release and setting time behaviors of cement pastes are contrasted. While early-age heat release is relatively independent of *w/c*, the measured setting times vary by several hours between the four *w/c* investigated in this study, indicating the fundamental differences between a physical process such as setting and heat release which is purely a quantification of chemical reaction. While decreasing *w/c* certainly increases compressive strength at equivalent ages, it also significantly increases autogenous shrinkage and may increase semi-adiabatic temperature rise, both of which can increase the propensity for early-age cracking in cement-based materials.

D.V. Reddy [3] carried out study on the potential use of Rice Husk Ash (RHA) as a cementitious material in concrete mixes. RHA is produced from the burning of rice husk which is a by-product of rice milling. The ash content is about 18-22% by weight of the rice husks. Research has shown that concrete made with RHA as a partial cement substitute to levels of 10% to 20% by weight of cement has superior performance characteristics compared to normal concrete. Also, the use of RHA would result in a reduction of the cost of concrete construction, and the reduction of the environmental greenhouse effects. This paper reviews the research investigations during the past three decades. The significant findings from these include higher compressive strength, and the lower chloride-ion penetrability of RHA modified concrete compared to normal concrete. Further research is being conducted by the authors to determine the resistance to accelerated corrosion in the marine environment, shrinkage and durability, and resistance to chloride ion penetrability of concrete mixes with different percentages of RHA and different water-binder ratios. This project, funded by the National Science Foundation, is a joint effort with a parallel investigation of restricted scope, at Chulalongkorn University, Bangkok, Thailand.

Dhiraj Agrawal [4]carried out study on the waste generated from industries is the huge concern for the environment, health, and cause for land filling. Recycling of such wastes and using them in construction materials appears to be viable solution not only to the pollution problem but also an economical option in construction. In view of utilization of industrial waste in construction material, the present paper reviews various waste materials at different levels in construction material. Compressive strength of concrete and mortar incorporating different waste materials is reviewed and recommendations are suggested at the outcome of the study. The reviewed approach for development of new construction material using industrial waste is useful to provide a potential sustainable source.

Amir Juma [5] review an experimental behavior of SCC with RHA (Rice husk ash) as a partial replacement of cement, due to the high increase in construction which has brought a heavy demand for ingredients of concrete such as cement and sand, and these materials are becoming costly and scarce. The cost of cement is also steadily increasing With ever-increasing environmental problems because of industrial waste products comes a great need to use these products in an appropriate manner to reduce health and environmental problems. RHA is a waste material its use in the production of concrete may prove to be advantageous in an agriculture driven economy like India. RHA has been used as a highly reactive pozzolanic material to improve the microstructure of the interfacial transition zone (ITZ) between the cement paste and the aggregate in self-compacting concrete. Mechanical experiments of RHA blended Portland cement concretes revealed that in addition to the pozzolanic reactivity of RHA (chemical aspect), the particle grading (physical aspect) of cement and RHA mixtures also exerted significant influences on the blending efficiency. The basic objective of the research is to understand the rheological and strength characteristics of the self-compaction mixes with different compositions of RHA. Different replacements percentages of RHA with cement and different water cementitious material ratio are determined for both normal concrete and SCC.

S. Chowdhury [6] studied; Wood Ash (WA) prepared from the uncontrolled burning of the saw dust is evaluated for its suitability as partial cement replacement in conventional concrete. The saw dust has been acquired from a wood polishing unit. The physical, chemical and mineralogical characteristics of WA is presented and analysed. The strength parameters (compressive strength, split tensile strength and flexural strength) of concrete with blended WA cement are evaluated and studied. Two different water-to-binder ratio (0.4 and 0.45) and five different replacement percentages of WA (5%, 10%, 15%, 18% and 20%) including control specimens for both water-to-cement ratio is considered. Results of compressive strength, split tensile strength and flexural strength showed that the strength properties of concrete mixture decreased marginally with increase in wood ash contents, but strength increased with later age. The XRD test results and chemical analysis of WA showed that it contains amorphous silica and thus can be used as cement replacing material. Through the analysis of results obtained in this study, it was concluded that WA could be blended with cement without adversely affecting the strength properties of concrete. Also using a new statistical theory of the Support Vector Machine (SVM), strength parameters were predicted by developing a suitable model and as a result, the application of soft computing in structural engineering has been successfully presented in this research paper.

Rejini Rajamma [7] presents results about the characterization of the biomass fly ashes sourced from a thermal power plant and from a co-generation power plant located in Portugal, and the study of new cement formulations incorporated with the biomass fly ashes. The study includes a comparative analysis of the phase formation, setting and mechanical behaviour of the new cement–fly ash formulations based on these biomass fly ashes. Techniques such as X-ray diffraction (XRD), X-ray fluorescence spectroscopy (XRF), thermal gravimetric and differential thermal analysis (TG/DTA), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM) and environmental scanning electron spectroscopy (ESEM) were used to determine the structure and composition of the formulations. Fly ash F1 from the thermal power plant contained levels of SiO_2, Al_2O_3 and Fe_2O_3 indicating the possibility of exhibiting pozzolanic properties. Fly ash F2 from the co-generation plant contained a higher quantity of CaO (~25%). The fly ashes are similar to class C fly ashes according to EN 450 on the basis of chemical composition. The hydration rate and phase formation are greatly dependent on the samples' alkali content and water to binder (w/b) ratio. In cement based mortar with 10% fly ash the basic strength was maintained, however, when 20% fly ash was added the mechanical strength was around 75% of the reference cement mortar. The fly ashes contained significant levels of chloride and sulphate and it is suggested that the performance of fly ash–cement binders could be improved by the removal or control of these chemical species.

Deshmukh S.A.[8]Effect of Salinity of Water on Strength of Cement Concrete and Geo-polymer Concrete. Concrete users around the world are second only to water consisting main ingredient as cement. Ordinary Portland cement is conventionally used as the primary binder to produce concrete production of cement, produce one ton of emission of CO_2 every ton of cement produced. To produce cement, electricity is also required to run the cement production plant. Generation of electrical power produces fly ash as a waste material in thermal power plants thin cycle is causing environmental pollution, waste disposal problem also. The project aims at replacing the cement. Besides the government has restricted to use the river sand in concrete [8].

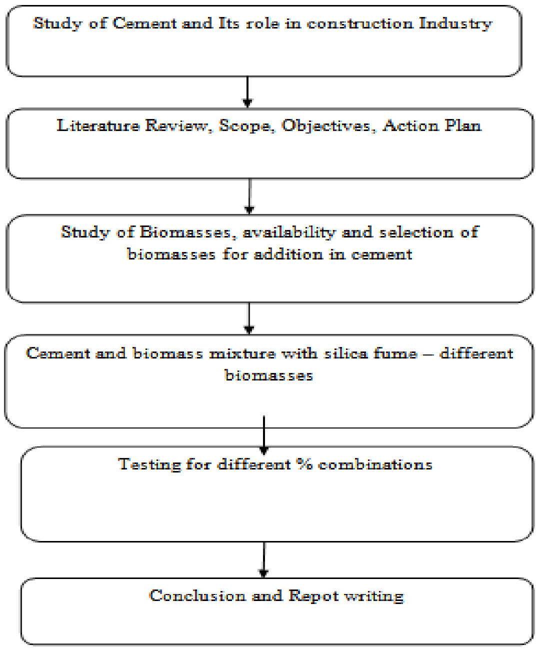
IV. METHODOLOGY

1. Comparative Study
2. Experimental Validation

Steps of Work:

1. Survey for suitable biomasses available in local region
2. Comparative study for mixing with cement
3. Preparation of cement and biomass mixture and silica fume
4. Experimental comparison for various percentage of biomass and silica fume in mixture.
5. Estimation of Compressive strength.
6. Selection of most effective biomass and it's percentage with silica fume for mixing with cement.

Action Plan –



V. CONCLUSIONS AND FUTURE SCOPE

Development industry is one of the greatest business where concrete is required at high volume. So generation of bond at such enormous volume will make issues in future as concrete (cinder) is going to vanish sometime in the not so distant future. Thus there is necessity of framework where the material is to be find as an option or as an added substance (in some %). Likewise there are substantial agribusiness wastages (biomass) accessible so utilization of that likewise conceivable as an added substance. Henceforth work is longing to consider the impact of expansion of biomasses in bond and their impact on quality of concrete. There is to bringing biomass with silica smoke to augment tying property of cement. Silica smoke is material is to be blending with bond with biomass concider as steady rate.

ACKNOWLEDGMENT

We pay our immense pleasure to acknowledge our President, Vighnaharta Trust's **Dr. Shivajirao S. Jondhale** & also our Secretary **Mrs. Geeta Khare** for their great support as they provided us with huge facilities and also gave us such a great opportunity to express ourselves. We also like to appreciate our Head of Department **Mrs. R. Raji** as he inspired and motivated us at each and every steps.

REFERENCES

[1] Satish H. Sathawane, Vikrant S. Vairagade and Kavita S Kene "Combine Effect of Rice Husk Ash and Fly Ash on Concrete by 30% Cement Replacement" at Elsevier, Chemical, Civil and Mechanical Engineering Track of 3rd Nirma University International Conference.

[2] Dale P. Bentz, Max A. Peltz, "Early-Age Properties of Cement-Based Material s: II. Influence of Water-to-Cement

ISSN: 2321-8169
229 - 234

Ratio" at ASCE Journal of Materials in Civil Engineering, 21(9), 512-517, 2009.

[3] Reddy D.V. 2006, Marine Durability "Characteristics of Rice Husk Ash- Modified Reinforced Concrete" Fourth LACCEI International Latin American and Caribbean Conference for Engineering and Technology (LACCET'2006) June 2006, Mayagüez, Puerto Rico.

[4] DhirajAgrwal, Pawan Hinge "Utilization of industrial waste in construction material –A review" at IJIRSET, Vol. 3, Issue 1, January 2014.

[5] Amir Juma, D.V.A.K.Prakash, A Review on Experimental Behavior of Self Compaction Concrete Incorporated with Rice Husk Ash at International Journal of Science and Advanced Technology Volume 2 No 3 March 2012.

[6] S. Chowdhury "Strength development in concrete with wood ash blended cement and use of soft computing models to predict strength parameters" at "Journal of Advanced Research (2015) 6, 907–913"

[7] RejiniRajamma ,"Characterisation and use of biomass fly ash in cement-based materials" at "Journal of Hazardous Materials 172 (2009) 1049–1060".

[8] Maharashtra energy development agency (www.mahaurja.com)