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EFFECTS OF TERNARY CEMENTITIOUS SYSTEMS CONTAINING SILICA FUME AND FLY ASH IN CONCRETE: AN EXPERIMENTAL STUDY

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Abstract: Concrete may take on the most energising forms while withstanding the harshest surroundings. With the help of contemporary admixtures and supplemental cementation materials, engineers are continually working to increase its performance (SCMs). Several supplemental cementations materials, which produce a portion of the cementations ingredient, are currently included in concrete mixtures. The primary benefit of SCM is its ability to partially replace cement in concrete while preserving the cementation properties. The qualities of concrete in its fresh and hydrated phases are enhanced by the use of waste material as SCM, which also aids in the consumption of these waste resources. Fly ash and silica fume are the most significant SCMs that are used most commonly because they increase the compressive strength and durability of concrete.

***Index Terms* - Concrete, admixtures, supplemental, cementation, cement.**

Introduction

Ground granulated blast furnace slag (GGBS or GGBFS) [10] is achieved by quenching molten iron slag, a by-product of iron and steel made from a blast furnace in water, to generate a glossy and granular product that is dried and get converted into a fine powder. [7] Ground granulated blast furnace slag has been used for several decades as a supplementary cementitious material in cement concretes. It can be used as a mineral admixture or as a part of blended cement. The use of GGBFS as a fractional replacement of ordinary Portland cement enhances the strength and durability of concrete by creating a denser matrix and thereby increasing the durability of concrete structures. It has a elevated proportion of the strength- enhancing calcium silicate hydrates (CSH) than concrete made with Portland cement only,[12] and a reduced content of free lime, which does not contribute to concrete strength. Fly ash is pozzalanic SC material one of the residues produced in the combustion of coal. Fly ash is generally confined from the chimneys of [14] power plants. Relying upon the source of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial Since the worldwide production of Portland cement is expected to reach nearly 2 billion tons by 2010, replacement of any large portion of this cement by fly ash could significantly reduce carbon emissions associated with construction It has been experimentally proved to replace Portland cement up to 30% by mass, [13] without harmfully affecting the strength and durability of concrete. Several laboratory and field investigations have reported to reveal excellent strength and durability properties. However, the strength development occurs only at later period. Due to the spherical shape of fly ash particles, it can also increase workability of cement while reducing water demand.

I. LITERATURE REVIEW

Chandru et al. (2020) This chapter examines the viability of using steel slag-based aggregates and binders in place of standard concrete-making ingredients, as well as the impact they have on the initial, mechanical, and long-term durability of concrete. The types of steel slag acknowledged in this study are the ladle furnace slag (LFS), basic oxygen furnace slag (BOFS), and electric arc furnace slag (EAFS). Several attempts have been made to include these steel slags as a binder, filler, fine aggregates, and coarse aggregates to the concrete. The use of steel slag as filler, fine and coarse aggregate in concrete is deduced from those many endeavours to be a major solution to address sustainability challenges in the building sector and also to pave the road for solid waste management. Yet, the fundamental qualities of concrete are only marginally altered when steel slag is substituted for both coarse and fine material. Steel slag's poor pozzolanic activity and sluggish rate of hydration sometimes had a negative impact on the early strength of concrete or mortar, but it improved the mechanical qualities as the material aged.

Manjunatha et al. (2021) The level of living for people has increased as industrialization grows steadily. Due to difficulties with disposal brought on by waste byproducts, it is now environmentally hazardous. Copper-based product manufacturing uses up energy and natural resources, releases a variety of greenhouse gases into the atmosphere, and results in natural resource depletion. Contrarily, the building sector uses abundant natural resources to produce cement, including river sand, aggregate, wood, lime, and clay, to mention a few. The authors of this study used discarded copper slag to lessen resource consumption and to address environmental problems brought on by waste byproducts. In an attempt to make M40 grade concrete, the authors tried using waste copper slag (WCS) in place of river sand. The impact of fibres on concrete made with WCS is also investigated using polypropylene fibres (PPF). This study focuses on the mechanical and new properties of concrete made with and without PPF when using WCS as a substitute for some of the river sand. According to experimental results, using WCS enhances concrete's new qualities linearly. Moreover, the mechanical qualities of concrete made with up to 60% WCS by weight of sand somewhat increase the strength of concrete. The cost of making concrete and the use of natural resources are reduced when WCS is used as a substitute for river sand. With the use of WCS, this research aids academics and professionals in creating sustainable and environmentally friendly concrete.

Hashim and Tantray(2021) The manufacture of foam concrete requires a significant amount of cement and sand, which has prompted research into other materials. This study examines foam concrete made from quarry dust and alocofine. Its workability, density stability, water absorption, initial rate of absorption, compressive strength, and split tensile strength features were tested. Target density for the foam concrete was 1200 50 kg/m3. Alcofine and quarry dust were substituted for cement and sand to varied degrees. The results demonstrate that using alccofine improved foam concrete's workability and strength metrics. It has been demonstrated that adding quarry dust to foam concrete reduces its workability and physical qualities while increasing its mechanical properties. The greatest compressive strength produced by the 15% alccofine and 20% quarry dust mixture was 8.81 N/mm2, or 27.8% more than the control mix. Experimental observation has shown that the waste elements were helpful in the creation of foam concrete.

Alqarni(2022) Non-renewable resources have been largely converted into renewable resources thanks to recent advancements in recycling processes. In order to limit additional waste going to landfills, the role of supplemental cementitious materials (SCMs) in concrete is crucial. Many items and wastes play a significant role in the production of eco-friendly concrete. These items can be divided into several categories, including natural minerals, dust, powders, ashes, and waste from industry, agriculture, and aquaculture. Literature has highlighted the enormous potential of using volcanic pumice powder ash (VPPA) in the creation of green concrete as a partial replacement or as cement admixtures when it comes to the application of such wastes. Reducing carbon dioxide emissions is the main objective of using SCMs because carbon dioxide has a positive relationship with both climate change and other types of environmental damage. Reusing wastes and byproducts also aids in reducing issues related to the disposal of waste materials. With regard to the use of VPPA in concrete and its effects on properties such as workability, compressive strength, flexural strength, splitting tensile strength, and durability performance, this article aims to provide a thorough review of the literature that has already been published in this area. Also, by using a scanning electron microscope to investigate the microstructure of concrete, this article seeks to determine how VPPA affects sustainability (SEM). The study's findings showed that using VPPA with partial substitution decreased workability and compressive strength, but enhanced performance in split tensile strength, flexural strength, and durability characteristics. This essay also emphasises the need for additional developments in this area of research.

Alghamdi (2022) The use of second-hand raw materials in the planning and construction of new structures constitutes one of the environmental requirements for sustainable improvement in manufacturing. The need to build new structures is currently increasing

quickly, particularly in the developed world. The fact that all C&D garbage is dumped in open landfills in easily accessible locations causes a number of environmental issues. The use of this garbage in concrete will promote sustainable and environmentally friendly development. Reducing carbon dioxide emissions, which contribute to environmental pollution and climate change, and improving waste exploitation, which creates disposal issues that can be partially or completely resolved, are the main objectives of using waste, byproducts, and recycled materials to develop sustainable concrete replacing concrete components. This paper aims to provide a thorough overview of the published literature on the replacement of cement in concrete using materials
like rice husk ash (RHA), olive stone biomass ash (OBA), recycled coal bottom ash (CBA), and recycled palm oil fuel ash (POFA), as well as its effects on concrete's workability, density, compressive strength, splitting tensile strength, flexural strength, shrinkage, and durability. This essay also tries to examine the effects of cement substitution on sustainability. Also, the author has offered suggestions for additional study.

Sangmesh et al. (2023) Natural building materials are in short supply and are restricted due to the growth of the construction industry. Several studies have looked into how the construction material affects the environment. Building construction and use account for about 40% of total CO_2 emissions, 15% of which are linked to the manufacture of building supplies. Thus, it has been crucial that the building sector transition to a greener method of construction. Also, the unsustainable use of natural and river sand—likely utilised as fine aggregate in concrete—has a negative impact on the environment. Moreover, the production of agricultural waste and residues has detrimental ecological repercussions. After harvest, agro-waste invariably develops and is burned to clean up the landfill. Paddy husk, sugarcane, and red gramme crops all produce agro-waste that is 10-15 times more abundant than the real products. In fact, it is preferable to embrace local and environmentally friendly alternative construction materials in order to meet the need for constructing construction materials. Agro-waste has opened up the idea of using environmentally friendly substitute materials in building construction. We discussed the many agro-waste applications for building construction in this paper. Also, we have provided an evaluation of the ecological, methodological, thermomechanical, and physical impacts. The use of agricultural wastes as building materials has been shown to be a commercially viable technological option that might reduce the usage of energy from natural resources safety.

III RESEARCH METHODOLOGY

The process of selecting suitable ingredients for concrete and to determine their relative amounts with the objective of producing a concrete of the required workability, strength and durability as economically as possible, is termed the concrete mix design. The proportioning of the ingredient of the concrete is governed by the required performance of concrete in plastic and hardened states. If the plastic concrete is non workable, it cannot be properly compacted and placed. The actual cost of concrete is related to cost of material required for producing mean strength called characteristic strengthof concrete, that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt on the quality control adds to the cost of concrete. The extent of quality control is often an economic compromise, and depends on the type of job and its size. The cost of labour depends on the workability of mix for example- a concrete mix of inadequate workability may result in high cos of labour to obtain a degree of compaction with available equipments.

There are two types of concrete mix design-

1. Nominal concrete mix- Nominal concrete mixes are those specified by standard codes for common construction works. These mix takes into consideration the margin for quality control, material quality and workmanship in concrete construction.M10, M15, M20 are the commonly used nominal mixes used in construction. For higher grade of concrete, i.e. M25 and above, it is advised to have designed mix concrete.

2. Designed concrete mix- Designed mix concrete suggests proportions of cement, sand, aggregates and water (and sometimes admixtures) based on actual material quality, degree of quality control, quality of materials and their moisture content for given concrete compressive strength required for the project. Designed mix concrete are carried out in laboratory and based on various tests and revisions in mix designs, the final mix proportions are suggested.

Sometimes admixtures are also required to enhance some properties of concrete such as workability, setting time etc. These admixtures also need to be considered during concrete mix design calculations for its optimum use. Their overdose can affect the properties of concrete and can cause harm to strength and durability.

Concrete mix design is the method of proportioning of ingredients of concrete to enhance its properties during plastic stage as well as during hardened stage, as well as to find economical mix proportions

IV RESULTS AND DISCUSSION

Normal consistency of different binder mixes has been determined using the procedure as given by IS 4031: part 4 (1988). Two types of blended mix with cement and fly ash ration 1:0.5 (CF1) and 1:1 (CF2) has been prepared. In these two types of concrete mix, silica fume (SF) in different proportions has been mixed.

(1) 300gm of sample coarser than 150 micron sieve has been considered.

(2) Optimum quantity of water has been mixed to the sample and blended comprehensively for 2-3 minutes.

(3) Cement paste has been placed in the Vicat's apparatus and tested under the needles of Vicat's apparatus between 5 to 7 mm.

(4) The percentage of water which satisfies the above condition is normal consistency.

From the below table Normal consistency of different binder mixes it is revealed that water requirement increases with enhance in quantity of replacement of fly ash blended cement by silica fume and fly ash cement consumes more water due to its fineness. Water requirement of normal consistency of a binder mix increases with increased silica fume replacement

Table No. 1. Normal consistency of different binder mixes

Mix	**Description**	**Cement + fly ash (grams)**	**ica fume (grams)**	**Consistency (%)**
M1	CF1	300	00	31.5
M2	CF1 with 5% SF	285	15	35
M3	CF1 with 10% SF	270	30	37.5
M4	CF1 with 15% SF	255	45	40
M5	CF1 with 20% SF	240	60	41.5
M6	CF2	300	00	34
M7	CF2 with 5% SF	285	15	36.5
M8	CF2 with 10% SF	270	30	39.5
M9	CF2 with 15% SF	255	45	42.5
M10	CF2 with 20% SF	240	60	45.5

From the graphs 1. and 2. it is concluded that water requirement increased with increase inpercentage of replacement by silica fume.

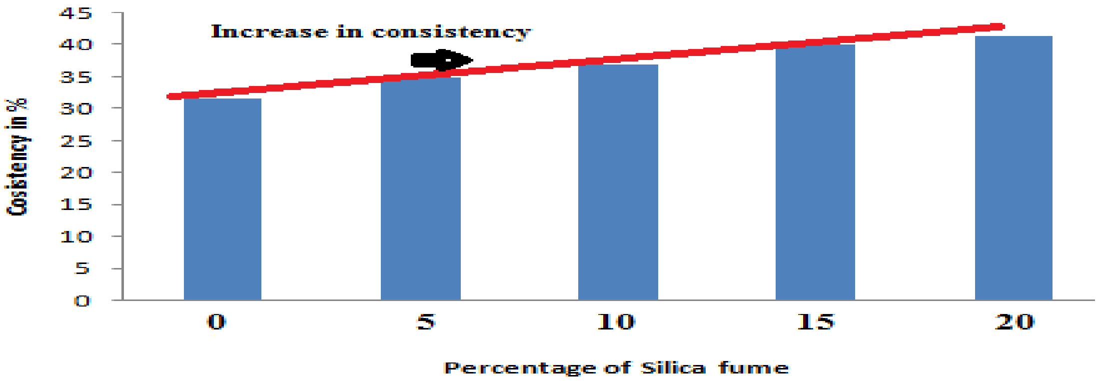

Figure. 1. Consistency of CF1 category

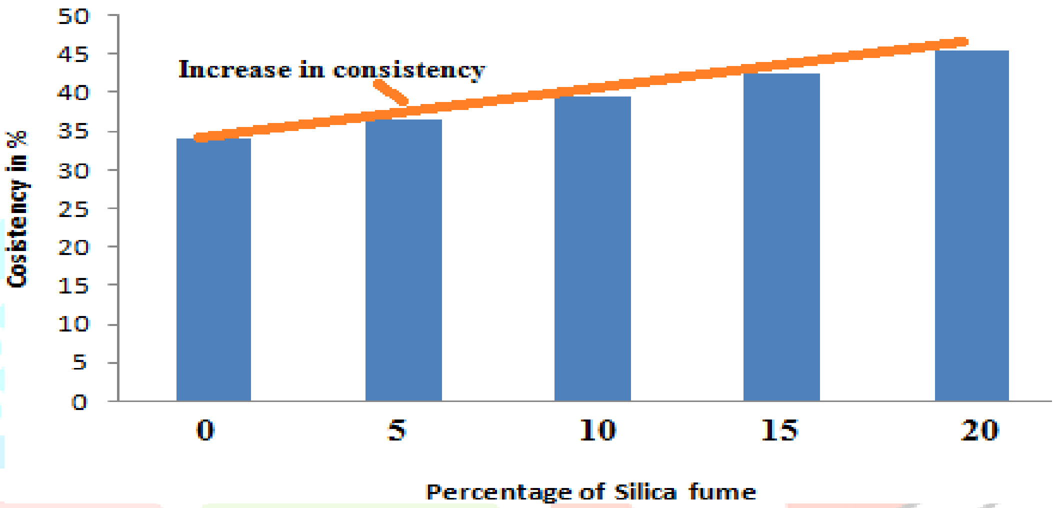

Figure 2. - Consistency of CF2 category

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