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A Literature Review on Study of Wheat Straw Ash Along with Silica Fume and Steel Fibers as Partial Replacement of Cement in Concrete

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ABSTRACT

There have been numerous experiments in recent years to improve the properties of concrete in terms of strength and durability, particularly in severe conditions. For a durable and hard structure, high-Strength concrete appears to be the preferable option. Industries generate a considerable amount of by-products or wastes, such as fly-ash, copper slag, silica fume, wheat straw ash etc., which cause environmental and health hazards due to dumping and disposal. When silica fume, wheat straw is added to concrete, this improves the concrete's mechanical and durability properties. This paper present literature review on replacement of Cement by Wheat Straw Ash along with silica fumes and steel fibers which includes current and future trends of research.

Keywords - Silica fume, Steel Fibres, wheat straw ash.

INTRODUCTION

Directly dumping waste items into the environment can result in environmental issues. As a result, the reuse of industrial waste has been recommended by authorities. Waste can be recycled to make new products or used as admixtures in other products to save natural resources and protect the environment from waste. The present industrial wastes trend is to dump on surrounding land which destroys the soil's natural fertility.

As an artificial pozzlanic admixture silica fume also known as micro silica or condensed silica fume, which is produced by reducing quartz with coal in an electric arc furnace to produce silicon or ferrosilicon alloy. Silica fume has a chemical composition that contains more than 90% silicon dioxide. Carbon, sulphur, aluminium oxides, iron, calcium, magnesium, sodium, and potassium are other constituents of silica fumes.

Wheat straw waste is a major agricultural by-product obtained from cereal production, which causes environmental pollution because the farmers burn it directly in open fields. When wheat straw waste is properly burnt under controlled situation it gives cementing properties and that can be used as supplementary cementing material, which contains higher percentage of silica. Therefore it is considered as supplementary cementing material. Using wheat straw ash as cement replacement material in concrete this increases compressive strength when replaced between 5% to 10% . Researchers are also investigating on the durability aspects of concrete while using WSA as replacement material because durability is one of the important properties of concrete. It was found that durability is improved due to the pozzolanic and filler property of Wheat Straw Ash in concrete. Additionally, Researchers also utilizes wheat straw ash as filler material in concrete because of fineness of particles.

REVIEWS OF ARTICLES

- **N.M. Al-Akhras, B.A. Abu-Alfoul (2002):**The influence of wheat straw ash (WSA) on the mechanical strength of autoclaved mortar is investigated in this study. Compressive, tensile, and flexural strengths of mortar are among the mechanical properties tested. Natural silica, wadi (local sand), and crushed limestone fine aggregates were used to make mortar mixes with a w/c ratio of 0.6. Mortar specimens were autoclaved for 2.5 hours at 2 MPa pressure. The study used three percentages of wheat straw ash replacement levels by weight of sand (3.6 percent, 7.3 percent, and 10.9 percent). The study found that substituting wheat straw ash for sand improves the mechanical strength of autoclaved mortar. As compared to control mortar specimens, limestone aggregate with a replacement amount of 10.9 % wheat straw ash showed an average increase in compressive, tensile, and flexural strength of 87 percent, 67 percent, and 71 percent, respectively. [1]
- **Perumal& Sundararajan (2004):**The Effect of partial cement replacement with silica fume on the strength and durability properties of high-grade concrete, according to the study. Investigations were conducted to determine the strength and durability properties of high performance concrete trial mixes in the M60, M70, and M110 grades, as well as the maximum amounts of cement substitution with Silica fume. These mixes are compared to those that do not contain SF in terms of strength and durability. By replacing 10% of the cement with SF, compressive strengths of 60 N/mm^2, 70 N/mm^2, and 110 N/mm^2were attained after 28 days. The SF concretes also have better durability, according to the findings. [2]
- **A S Santhi et al. (2011):**The results of an experimental investigation into the compressive strength of High Strength Concrete are presented in this publication. Fly ash (FA) and silica fume are used to partially substitute cement in high-strength concrete (SF). In this investigation, Class C

fly ash was utilised in various quantities of 30%, 40%, and 50% by weight of cement, while silica fume was employed at 6% and 10% by weight of cement. The concrete mix proportions had a constant water binder ratio of 0.4, and super plasticizer was added according to the degree of workability necessary. The total binder content per square meter was 450 kg/m3. The concrete specimens were cured using standard moist curing methods at room temperature. The compressive strength was determined at various ages up to 90 days. The addition of 6% SF to different FA replacements has a high compressive strength than 10% SF. The optimum and high strength concrete can be obtained with 6% SF and 40% FA.[3]

- **Roy &Sil (2012):**According to the study, when 10% of the cement is replaced with silica fume, maximum compressive strength (both cube and cylinder) is noted, and the values are higher (by 19.6 percent and 16.82 percent, respectively) than normal concrete (for cube and cylinder), whereas split tensile strength and flexural strength of the silica fume concrete (3.61N/mm2 and 4.93 N/mm2, respectively) are increased by about 38.58 percent and 21.13 percent, respectively.[4]
- **Sabale V. D et al. (2014):**In this research, the properties of high-strength concrete were investigated by varying the quantity of silica fume added to the cement weight. Concrete has compressive strength for 7 and 28 days, as well as splitting tensile strength and flexural strength. The experiment was conducted out on M60 grade concrete with a water cement ratio of 0.3 and silica fume in varying percentages of 0 percent, 5 percent, 10 percent, and 15 percent to the weight of cement. Concrete's compressive strength, splitting tensile strength, and flexural strength all rise when up to 10% of the cement is replaced with silica fume. After that, the concrete's compressive strength, splitting tensile strength, and flexural strength all decrease. There is a decrease in workability as the replacement level increases, and hence water Consumption will be more for higher replacements.[5]
- **Swati Choudhary et al. (2014):**The paper contains a detailed study of current breakthroughs in high-performance concrete, with a focus on earthquake-prone areas. It emphasises the benefits and significance of High Performance concrete above normal concrete, as well as the impact of mineral and chemical additives used to increase concrete performance. When compared to normal weight concrete, the use of structural high performance light weight concrete reduces the dead load by around 25 to 35 percent, resulting in significant cost savings. Longer spans, thinner sections, less reinforcing steel, and lower foundation costs, as well as reduced trucking and placement costs. [6]
- **Zhang qiang, et al. (2014):**They found that early on, straw ash high performance concrete has a lesser strength. Silicon powder has a higher ash activity and filling effect than other materials. Under the conditions of adding a reasonable amount of straw ash and varying amounts of silicon powder, the mechanical characteristics and workability of the double mixing cement were tested. The results demonstrate that as the amount of silicon powder is increased, the concrete work performance improves progressively; for example, when the amount of silicon powder reaches 10%, the compressive strength of concrete increases by 24%. However, due to the high cost of silicon powder, future studies should focus on using rice husk ash, fly ash, and other options to minimise the cost of concrete.[7]
- **Rahul D. Pandit&Abhijeet P. Wadekar (2015):** Experimental study is carried out to assess mechanical properties of high strength fibre reinforced concrete (HSFRC) of grade M80. In addition to normal materials, silica fume, fly Ash and fibres (polypropylene fibre and flat steel fibre) are used. The content of silica fume and fly ash is 5% and 10% respectively by weight of cement. Water to cementitious material ratio was 0.25. Different types of fibres are used to make the mixes, and their volume fractions range from 0.5 percent to 4.0 percent by weight of cementitious materials, with a 0.5 percent increment. To investigate the influence of fibre type and volume fraction on compressive strength, split tensile strength, and flexural strength of HSFRC, 153 specimens of cubes (100*100*100mm), cylinders (100*200mm), and prisms (100*100*500mm) are examined. Compressive strength maximum values for PF and FSF at 3% fibre volume fraction are 97 N/mm2 and 97.67 N/mm2, respectively. The maximum split tensile strength of polypropylene Fibres is 7.21 N/mm2, which is higher than that of other types of Fibres. When compared to conventional concrete, the 3.0% fibre content resulted in the greatest increase in split tensile. In comparison to regular concrete, the presence of 3.5 percent fibres has resulted in a significant gain in flexural strength. The maximum split tensile strength of Flat Steel Fibres is 19.16 N/mm2, which is higher than that of other types of Fibres.[8]
- **Kumar A., et al. (2015):**Partially replacing cement in M-30 concrete with silica fume and fly ash is the subject of a research paper. Silica Fume was used to replace 0 %, 2.5 %, 5 %, and 7.5 % of OPC, whereas Fly Ash was used to replace 0 %, 5%, 10%, and 15 % of Ordinary Portland cement by weight. All test specimens contained 1% super-plasticizer to improve workability at lower water cement ratios and to detect the distinct impacts of Silica Fume and Fly Ash on concrete characteristics. In all cases, the water-to-cement ratio was fixed at 0.43. Cement with a replacement level of 7.5 percent by weight of SF and 20 percent by weight of FA had the highest compressive strength of 43.1 N/mm2. The greatest flexural strength of 6.47 N/mm2 was achieved using cement at a replacement level of 7.5 percent by weight of SF and 20 percent by weight of FA. The greatest split tensile strength of 2.573 N/mm2 was obtained with cement at a replacement level of 7.5 percent by weight of SF and 20 percent by weight of FA.[9]
- **N. A. Hamiruddin et al. (2018):** The purpose of this research is to find out how well steel fibre reinforced concrete performs in compression (FRC).A 100 mm^3 cube sample was used to measure compressive strength, elastic modulus, and HSFRC crack pattern, and the data was analysed to estimate compressive strength, elastic modulus, and HSFRC crack pattern. This research investigates three alternative high strength fibre reinforced concrete (HSFRC) combinations with compressive strengths of 60-85 MPa and steel fibre volumes of 0.5-1.5 percent. The compressive strength of 0.5 percent steel fibre volume at 28 days is 82.1 MPa, according to HSFRC data. As a result, compared to the control sample, using a low steel fibre volume can increase compressive strength (CS).This clearly demonstrates that the low steel fibre volume has improved compressive strength mechanical qualities. The compressive strength of HSFRC has shown to be superior to that of steel fibre composites based on experimental data (HSC). It has been found that adding fibre makes the material more ductile than it would be without it. [10]
- **Yuanxun Zheng et al. (2018):**In this research, the levels of steel fibre additive were 0.5%, 1%, 1.5% and 2% respectively, in two types of high-strength concrete, C50 and C60. All of these mechanical qualities, such as compression strength, flexural strength, and splitting tensile strength, improve gradually as steel fibre content increases; the steel fibre reinforcing effect is especially obvious for flexural strength and splitting tensile strength. The reinforcement impact of mechanical characteristics of high-strength concrete is better at the same fibre content. [11]

- **Nur Ain Hamiruddin et al. (2018):** The influence of varying steel fibre contents by volume (Vf = 0, 0.5, 1 percent, and 1.5 percent)on mechanical characteristics of High Strength Fibre Reinforced Concrete was examined in this study (HSFRC). Flowability, compressive strength, and direct tensile strength were among the qualities tested. According to the findings, increasing the steel fibre content affects the flowability of HSFRC. After 28 days, adding 0.5 percent steel fibre to HSFRC increased compressive strength by approximately 102.5 MPa and direct tensile strength by approximately 7.07 MPa. The compressive strength of steel fibre contents of 1.0 percent and 1.5 percent is 87.51 MPa and 80.75 MPa, respectively, whereas direct tensile strength of steel fibre contents of 1 percent and 1.5 percent is 6.54 MPa and 5.66 MPa. The findings demonstrates that the compressive strength and direct tensile strength are greater at 0.5 percent steel fibre content. [12]
- **Irfan Ali Shar et al. (2019):** In this study, wheat straw ash, an agricultural waste, is used as a cement replacement material. The percentages of cement substitution are 0 percent, 5%, 10%, 15%, and 20%. A cubical specimens were cast, cured, and evaluated at curing ages of 7, 28, and 90 days to assess concrete compressive strength. The maximum compressive strength at 10% cement replacement is 40 N/mm^2at 28 days, while the minimum strength at 20% cement replacement is 34 N/mm^2at 28 days, according to the findings. [13].
- **Muhammad Shoaib Khan et al. (2019):**In order to identify the best percentage of wheat straw ash as a partial replacement for cement in this study, a series of tests were done using 10%, 20%, and 30% wheat straw ash replacement by weight of cement. Due to ash's considerable water absorption capacity, the slump and compaction factor tests demonstrate a decline in workability as the ash level increases. One of the most key results is the wheat straw ash's high water absorption capacity, which helps to prevent concrete shrinkage over time. The results reveal that when the percentage of wheat straw ash in concrete increases, the strength of the concrete decreases. The conventional concrete was comparable to the 10% replacement. A decrease in strength is noted for 20% and 30% replacement of cement by wheat straw ash.[14]
- **Yanxia Ye et al. (2020):**In this paper, three different types of steel fibres, micro (M), end-hooked (H), and corrugated (C), are added to high strength light weight aggregate concrete (HLAC) to investigate the effects of steel fibre and fibre volume content ratio on the compressive, splitting tensile, and flexural strength of HLAC. Steel fibre volume content fractions were examined in the range of 0.5 percent to 2.0 percent. Different varieties of steel fibre have different effects on the mechanical characteristics and toughness of HLAC, according to the research. On mechanical parameters, M steel fibres have the best reinforcing performance.M steel fibres have the best toughness with the same fibre content, according to the study. H and C steel fibres can only toughen to 2/3 and 1/2 the strength of M steel fibres, respectively.[15]

CONCLUSIONS

Based on the existing research, it has been observed that replacing cement with silica fume, steel fibre and wheat straw ash has been done separately. The Compressive strength, Split tensile strength and flexural strength has been conducted. But a combination of all the ingredient for high grade concrete is yet to be done.

Based upon the literature reviews, following are the conclusion-

1) The replacement of cement with Wheat straw ash by small quantity(upto10%) in concrete may enhances the properties[1,13,14] (compressive strength, split tensile strength & flexural strength) of concrete.
2) Adding wheat straw ash lowers workability[14] of the concrete, due to the fineness of wheat straw ash particles as compared to cement particles.
3) Adding silica fume also lowers the workability[5,7] of the material.
4) Adding silica fumes[2,3] and steel fibers[10] increases the strength characteristics of concrete.
5) Wheat straw ash helps in increasing the properties of concrete and also help to make it economical[14].
6) The Density of concrete is also affected by adding silica fumes[5] in concrete, it decreases the density of concrete.
7) The optimum percentage of steel fiber[10,12] was found to be 1% to 1.5%.
8) The optimum percentage of silica fumes[2,9] was found to be in between 5% to 10%.
9) The optimum percentage of wheat straw ash[1,14] is in between 5% to 10%.
10) The cost of Wheat straw ash is very low(negligible), as compared to the cost of cement. Hence, the replacement of cement with Wheat straw ash can be economical for mass concreting. It helps in reducing the problem of dumping the Wheat straw ash.
11)

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