International Journal of Scientific Research & Engineering Trends
Volume 9, Issue 3, May-Jun-2023, ISSN (Online): 2395-566X

A Review on Recent Advancement on the Use of Fly Ash and E-Waste in Partial Replacement of Cement

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Abstract- Concrete is one of the most popular building materials available. Dams, bridges, skyscrapers, sewage and water systems, and public buildings—all of these and more are shaped by the design and construction of concrete. Fly ash, with its round, smooth particles, enhances workability right out of the gate. The improved workability allows for a lower water-to-cement ratio, which in turn leads to increased compressive strength. Utilizing industrial and agricultural waste resources is crucial for achieving sustainable growth and producing a greener concrete material in the building sector. There are a variety of factors contributing to the unsustainable nature of today's concrete construction market. Therefore, a review on recent advancement on the use of fly ash and e-waste in partial replacement of cement has been done.

Keywords- Fly ash, E-waste, construction, cement.

I. INTRODUCTION

Historically, mudstones from the mudstone industry were used in building projects. Fly ash is a byproduct of coal, created when coal is burnt at high temperatures in thermal plants, resulting in finely fragmented particles. “Efforts are being made around the world to make better use of industrial, agricultural waste, and mineral byproducts as a supplementary cementatious component to enhance the strength, workability, and other attributes of concrete, including Fly Ash, a by-product of burnt coal from power stations.”

As a mineral byproduct of thermal power plants, fly ash consists of tiny particles that have been broken apart. Similar pozzolanic characteristics can be found in fly ash as those seen in naturally occurring pozzolanic materials. Economic and technical benefits accrue to structural concrete from the use of fly ash, and social benefits accrue to society from the use of fly ash concrete, which reduces the amount of fly ash disposed of directly into the environment and the amount of carbon dioxide released into the atmosphere.

Fly ash, silica fume, and other industrial waste products are now often used in concrete manufacturing. There are two types of electronic and electrical waste: those that pose a risk to health and those that don't. E-waste, or inert waste, is the term used to describe broken, old, or otherwise unusable electronics. It's a huge hassle to get rid of all the electronic debris. Fly ash, silica fume, and other industrial waste products are now often used in concrete manufacturing. There are two types of electronic and electrical waste: those that pose a health risk and those that don't. Common methods of disposing of E-waste include dumping, incineration, reusing, and recycling. These methods of disposal come at a hefty price and pose risks to our environment. A recycling procedure that is both affordable and kind to the environment is a having to respond.

II. FLY ASH

Sustainable green materials has gained a lot of attention in the construction and building material areas over the past several decades because of their potential to reduce the need for quarrying limestone for cement production. Massive cement production that has been pushed by the rising need for both residential and industrial construction is a major contributor to rising CO_2 levels. It was believed that as much as 7% of the world's CO_2 output was released by the cement industry [1]. To alleviate this problem, it is essential to employ additional cementitious materials.

The large quantities of coal fly ash (FA) generated by thermal power stations form an ideal complement to POC aggregate, which can mitigate air pollution and disposal problems [7]. Because of its capacity to cause widespread air and water pollution, FA is a waste item which may cause disposal and environmental degradation issues [8]. By reducing the amount of fly ash trash disposed of and the amount of cement used in concrete production, using this industrial waste as an ingredient will help to create a cleaner environment [9]. To date, using FA as a cement replacement in tiny amounts has resulted in concrete with respectable mechanical and durability characteristics [10]. Due to differences in fly ash characteristics that are established by its origin and the way a power plant is run, its usage is restricted to no more than 20% [11].

What we call "fly ash" is essentially the inert mineral fraction of coal. Coal is often powdered before being burned in a power plant. Carbon is burned off in the boiler of the power plant, leaving particles rich in silica, alumina, and calcium that have been blown in. The name "fly ash" comes from the fact that the particles form into tiny glassy spheres in the exhaust of power plants before they can escape. Typically, you'll encounter one of two fly ash variants: Classes F and C. "According to ASTM C618, fly ash belongs to Class F if ($SiO_2+Al_2O_3+Fe_2O_3$) > 70% and belongs to Class C if 70% > ($SiO_2+Al_2O_3+Fe_2O_3$) > 50%."These fly ashes, along with the lime (Calcium hydroxide) produced during cement hydration, generate a calcium silicate hydrate analogous to cement through a pozzolanic reaction. The pozzolanic reaction with lime from cement hydration isn't the only way in which certain Class C fly ashes may cement themselves.

By reacting with free lime, fly ash can create the same cementitious chemicals that result from the hydration of Portland cement through a process known as pozzolanic activity. Fly ash concrete experiences a slower rate of strength growth at younger ages of curing than conventional concrete does because of this chain of chemical reactions. Pozzolana Portland Cement, a type of cement made from fly ash, has gained some traction in recent years, although total percentage usage remains relatively low, and most fly ash is discarded at landfills.

Fly ash is a thin, glassy powder that is captured from the gases produced during the combustion of coal to generate electricity. As a byproduct of their operations, power plants generate millions of tonnes of fly ash every year, most of which is disposed of in landfills. Fly ash can be used as a reduced alternative to Portland cement in concrete without sacrificing strength or compression strength. Brick, blocks, pavement, and structural reinforcements can all benefit from using fly ash as a material.

III. E-WASTE

Disposal of E-waste is a common chore in many parts of the world. The disposal of electronic trash in landfills results in the release of toxic leachates that seep into the earth and contaminate the groundwater. Congealed computer chips contain acids and sludge that, if disposed of on the ground, would form sulfuric acid the soil. Recovering electronic trash can help alleviate some ecological and environmental issues. In this project, we recycle electronic trash by using printed circuit boards.

In recent years, there has investigation into the potential of electronic waste to improve the characteristics of concrete. As a result of the wide variety of materials and components used in their creation, as well as the complexity of the manufacturing process, WEEE is a high variability and complicated waste stream. The absence of recycling Humans and the ecosystem are in grave danger from the pollution caused by trash. Therefore, it is important to think of other, more efficient methods of waste management. In the concrete business, people have tried using non-biodegradable E-waste components as a substitute for either the coarse or fine aggregates. Recent decades have seen an uptick in the usage of electronic waste from a variety of sources as a replacement for cement, fine and coarse aggregate, and other components of concrete. Because of environmental regulations on their proper disposal, these items are increasingly being used in concrete production. The use of E-waste materials in cement, concrete, and other building materials has several immediate benefits, including the reduction of cement and concrete manufacturing costs and the saving of energy and the prevention of environmental damage caused by landfill trash.

Printed circuit boards have recently been considered as a potential replacement for aggregate in concrete due to their ability to increase air content, enhance water retention properties, and decrease bulk density in hardened mortar.

Every year, millions of tonnes of electronic garbage are produced, mostly from outdated computers and other gadgets. Unless appropriately disposed of, the thousands of different compounds and chemicals included in e-waste can have devastating effects on human and environmental health. Many harmful chemicals, such as heavy metals including lead, cadmium, mercury, arsenic, selenium, hexavalent chromium, etc. are also found in discarded electronic equipment. In most dumps, electronic trash accounts for around 70 percent of the mercury and cadmium found there. The majority of the lead found in landfills comes from consumer electronics. In addition to triggering allergic responses and cancer, these poisons have been linked to permanent brain damage. Gold, copper, and other common metals may be found in abundance in discarded electronics.

The common, colloquial term for electronics that have reached the end of their "useful life" is "e-waste." e-waste is defined as "Waste Electrical and Electronic Equipment comprising all components, sub- assembly" in the Hazardous Wastes Management and Handling Rules, 2003. Old computers, televisions, refrigerators, radios, and other electrical or electronic appliances that have reached the end of their useful lifespan are all examples of electronic garbage, often known as E-waste.

Every year, the globe generates over 50 million tonnes of electronic garbage. An estimated 1, 46,180 tonnes of electronic garbage is produced each year in India. Environmental Protection Agency (EPA) estimates that about 15–20% of E-waste gets recycled, with the remainder ending up in landfills or incinerators. Since electronic equipment sometimes includes harmful pollutants like lead, cadmium, Beryllium, etc., its processing in underdeveloped nations often results in major health and pollution issues.

Because of environmental regulations on their proper disposal, these items are increasingly being used in concrete production. Utilizing E-waste materials in cement, concrete, and other building materials not only helps reduce the cost of cement and concrete manufacture, but also offers many other indirect advantages, such as lowering landfill costs, conserving energy, and preventing environmental damage.


Fig 1. E-waste.

IV. PAST STUDIES

Gupta and Singh (2021) experimented with M35 grade concrete specimens (without E-waste particles and pp fibres) “and those with partial substitution of course aggregates with E-waste particles at 0%, 10%, 20%, and 30% with respect to the weight of aggregate, and at 0%, 0.2%, 0.4%, and 0.6% with respect to the weight of cement. Experiments comparing the compressive strength, tensile strength, and flexural strength of fibrous concrete made using E-waste materials to the same concrete made without using e-waste materials as coarse particles showed a significant increase in all three measures of strength.”

Sapehiya and Kumar (2020)explored the feasibility of using FA and PWF in concrete as cement replacements and additions, respectively, to reduce the expense of concrete construction while simultaneously solving the disposal issues associated with FA and PWF. As an experimental medium, M20 grade concrete is utilised in this study. FA is mixed in with the cement at varying percentages (by weight) of 0%, 5%, 10%, and 15%. All concrete mixtures maintained a moisture ratio of 0.5. For the purpose of determining the concrete's compressive and split tensile strengths, 48 specimens were created with sizes of 150mm*150mm*150mm and 300mm*150mm. After 7 and 28 days, specimens are cured, their strength is evaluated. The results suggest that using FA as a partial replacement for cement increases the strength of concrete compared to using only cement. Compressive and split tensile strengths are maximised for additions of 0.5%, 1%, and 1.5% PWF when FA replaces 10% of the cement. In addition, when FA is used in place of cement, the flexibility of the resulting concrete is much improved.

Bouaissi et al. (2020) offered an overview of the usage of fly ash as both a primary material in geopolymer. Fly ash allows for the realisation of superior mechanical qualities as a result of its plentiful supplies, relatively inexpensive, exceptional workability, and superior physical properties. In countries like China, India, and the United States, where it is produced in enormous quantities, fly ash is well recognised as a major source of industrial solid waste. Fly ash has the properties needed to be used as a geotechnical material in the manufacture of geopolymer cement or concrete in place of regular Portland cement. Fly ash is the primary focus of several efforts to develop a viable mix design for a geopolymer built mostly from this byproduct. In this survey work, researchers examine and assess the physical characteristics, chemical compositions, and chemical activation of fly ash. Different ASTM standards, ACI guidelines, and other geopolymer-related studies have been referenced.

Ariff et al. (2019) examined the strength characteristics of fly ash mixed concrete to determine if it may be utilised in concrete preparation as both a partial replacement for cement. The effects of replacing a portion of the cement in concrete with fly ash are investigated in terms of the material's strength qualities. After 21 days, samples with cement replacement percentages of 10%, 20%, 30%, 40%, and 50% are evaluated in a laboratory. Samples of fly ash mixed concrete are tested for their workability, tensile strength, compressive strength, and shear strength. A control group of concrete without any fly ash is subjected to the same tests, as well as the results are compared to determine how much fly ash may be added to the mix without negatively impacting the concrete's quality.

Divya et al. (2019) exhibited the results of incorporating fly ash (0-30%) into concrete. Fly ash, which is collected from thermal power plants, is a waste substance with a pozzolanic character. The percentage of fly ash used to the concrete can range from 0% to 30%. “At room temperature and at 200 ^{o}C, 400 ^{o}C, and 800 ^{o}C, the material's compressive strength and ultrasonic pulse velocity (UPV) were measured. Samples are kept at high temperatures for 2 hours.” The F15 concrete has the maximum compressive strength at room temperature. F15 concrete shows the maximum compressive strength at all the aimed-for increased temperatures. The UPV values of the cube specimens of concrete were of very high quality at room temperature across all replacement levels of fly ash in concrete. Good concrete quality as defined by IS 13311 (Part 1): 1992 was observed in cube specimens exposed to 200 ^{o}C.

Sabarish et al. (2019) argued that promoting sustainable development should be the top priority for nations today.

Fly ash is a product being produced in enormous quantities by thermal power plants, and it has both negative effects on the environment and on people's health. The environmental impact of fly ash, a byproduct of thermal power plants, is significant. Scientific experiments were conducted to determine the precise extent toward which fly ash may substitute sand in mortar. Compressive and tensile strengths of cement mortar made with both pond types and bottom fly ash in varying percentages was evaluated. As an alternative to regular concrete, the use of fly ash as a cementitious ingredient was tried out. For both the M-25 and M-40 mixes, the cement has already been replaced with varying percentages of fly ash, from 0% (no fly ash) to10%, 20%, 30% and 40% (most of the cement). "The findings of the tests for compressive strength up to 28 days and split strength for 56 days are used to make inferences about the mechanical characteristics."

Masuduzzaman et al. (2018) provided a synopsis of research into the potential uses of e-waste in concrete; results show that this waste has both positive and negative effects on the environment when added to aggregate. By incorporating various by-products into concrete, researchers may reduce our reliance on natural aggregates. And recycling old stuff is a lot more crucial.

Moen et al. (2021) The specimens were tested for tensile and compressive strength at 7, 14, 21, and 28 days after treatment using a variety of fly ashes in an effort to reduce waste and improve environmental conditions. Coal ash, Vachellianilotica (Kikar) ash, and Dalbergia sisso (shisham) ash, all with percentages varying from 10% to 50%, were used in place of cement. Coal ash, Vachellianilotica (kikar) ash, and Dalbergia sisso (shisham) were all shown to raise the tensile and compressive strengths of concrete and mortar by a similar amount after being utilised for a healing period of 28 days. While the severity decreased in samples with proportions of 20, 30, 40, and 50% after the same amount of time had passed for healing. Similarly, the strength and weight of samples made using coal, Vachellianilotica (Kikar) ash, and Dalbergia sissoo (shisham) ash also decreased with time. Coal ash, when used in concrete at a concentration of 10% or more, can cut the price by 13.5 percent without compromising the concrete's strength. These materials are ideal for use in constructing lightweight structures, such as poultry and dairy buildings.

Liyanage et al. (2018) showed that fly ash may be used to replace some of the fine aggregate in concrete without compromising the strength of the finished product when subjected to various curing conditions. Up to 40% of the fine aggregate was swapped out for Class F fly ash. Two types of combinations, one containing simply cement and the other including cement and 15% fly ash, were tested. The research utilised accelerated heat curing for one day in addition to isothermal heat curing at temperatures of 300C, 500C, and 700C. Testing was done on compressive strength at 1, 3, 7, and 28 days. The results of the tests show that the compressive strength of concrete made with fly ash as a partial fine aggregate replacing material is higher than that of concrete made with fly ash as a partial cement replacing material. Mixes including fly as a partial fine aggregate replacement material outperformed the control mixture and mixtures containing fly ash as a partial cement replacing material across the board in terms of compressive strength at all ages evaluated. Fly ash as a fine aggregate replacement material coupled with enhanced temperature curing leads to strong early-age and later-age compressive strength.

Singh (2015) In the present investigation, fly ash is employed as a partial replacement for Portland pozzolanic material (PPC) in concrete. During the hydration of cement, fly ash combines with the free lime to form calcium-silicate-hydrate (C-S-H). The outcomes of experiments conducted to determine the workability and compressive strength of concrete at varying replacements of PPC are shown below. Concrete of the M-25 grade (1:1.53:3) was formulated using a water-to-cement ration of 0.42 in accordance with the guidelines established by the international standard (IS-10262-2009). Conclusion: Fly ash may be used to replace up to 20% of PPC in concrete without affecting its compressive strength.

V. CONCLUSION

Concrete is one of the most popular building materials available. Dams, bridges, skyscrapers, water and sewage systems, and public buildings—all of these and more are shaped by the design and construction of concrete. Concrete seems to be the prototypical building material since it is poured in a liquid state and then cures over time, much like natural rock.

As things stand now, it's impossible to conceive of a construction movement occurring without the use of concrete. In the world of architecture, concrete reigns supreme as the material most regularly utilized. For the simple reason that its strength and longevity are so remarkable. Too much change is occurring in our surroundings and in the world at the moment. The rate of technological development and environmental change inside the modern world is too great.

So, people are starting to pay more attention to recycling and reusing their trash instead of throwing it away. Since the concrete industry is among the greatest consumers of natural raw materials, it is no surprise that the manufacturing sector is also a leading producer of carbon dioxide emissions alongside deforestation and fossil fuel combustion (Amit et. Al). Reducing carbon dioxide emissions and recycling waste materials are two of the biggest challenges facing sustainable industrial production in the twenty-first century. The construction industry and cement manufacturing companies want an alternative supply of sustainable building materials to meet rising demand while minimising financial and environmental costs.

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